

Diabetes Care[®]

WWW.DIABETES.ORG/DIABETES CARE

JANUARY 2019

SUPPLEMENT
1

AMERICAN DIABETES ASSOCIATION

STANDARDS OF MEDICAL CARE IN DIABETES—2019

American Diabetes Association
**Standards of
Medical Care in
Diabetes—2019**



Diabetes Care[®]

January 2019 Volume 42, Supplement 1

THE JOURNAL OF CLINICAL AND APPLIED RESEARCH AND EDUCATION

[T]he simple word *Care* may suffice to express [the journal's] philosophical mission. The new journal is designed to promote better patient care by serving the expanded needs of all health professionals committed to the care of patients with diabetes. As such, the American Diabetes Association views *Diabetes Care* as a reaffirmation of Francis Weld Peabody's contention that "the secret of the care of the patient is in caring for the patient."

—Norbert Freinkel, *Diabetes Care*, January-February 1978

EDITOR IN CHIEF

Matthew C. Riddle, MD

ASSOCIATE EDITORS

George Bakris, MD
Lawrence Blonde, MD, FACP
Andrew J.M. Boulton, MD
David D'Alessio, MD
Eddie L. Greene, MD
Korey K. Hood, PhD
Frank B. Hu, MD, MPH, PhD
Steven E. Kahn, MB, ChB
Sanjay Kaul, MD, FACC, FAHA
Derek LeRoith, MD, PhD
Robert G. Moses, MD
Stephen Rich, PhD
Julio Rosenstock, MD
Judith Wylie-Rosett, EdD, RD

EDITORIAL BOARD

Andrew J. Ahmann, MD
Vanita R. Aroda, MD
Linda A. Barbour, MD, MSPH
Roy W. Beck, MD, PhD
Gianni Bellomo, MD
Geremia Bolli, MD
John B. Buse, MD, PhD
Sonia Caprio, MD
Jessica R. Castle, MD
Robert J. Chilton, DO, FACC, FAHA
Kenneth Cusi, MD, FACP, FACE
J. Hans DeVries, MD, PhD
Ele Ferrannini, MD
Thomas W. Gardner, MD, MS
Jennifer Green, MD
Meredith A. Hawkins, MD, MS
Petr Heneberg, RNDr, PhD
Norbert Hermanns, PhD, MSc
Irl B. Hirsch, MD, MACP
Reinhard W. Holl, MD, PhD
Philip Home, DM, DPhil
George S. Jeha, MD
Lee M. Kaplan, MD, PhD
M. Sue Kirkman, MD
Ildiko Lingvay, MD, MPH, MSCS
Maureen Monaghan, PhD, CDE
Kristen J. Nadeau, MD, MS
Gregory A. Nichols, PhD, MBA
Kwame Osei, MD
Kevin A. Peterson, MD, MPH, FRCS(Ed),
FAAFP
Ravi Retnakaran, MD, MSc, FRCPC
Elizabeth Seaquist, MD
Guntram Schernthaner, MD
Jan S. Ulbrecht, MB, BS
Ram Weiss, MD, PhD
Deborah Wexler, MD, MSc
Vincent C. Woo, MD, FRCPC
Bernard Zinman, CM, MD, FRCPC, FACP

AMERICAN DIABETES ASSOCIATION OFFICERS

CHAIR OF THE BOARD

Karen Talmadge, PhD

PRESIDENT, MEDICINE & SCIENCE

Jane Reusch, MD

PRESIDENT, HEALTH CARE & EDUCATION

Felicia Hill-Briggs, PhD, ABPP

SECRETARY/TREASURER

Michael Ching, CPA

CHAIR OF THE BOARD-ELECT

David J. Herrick, MBA

PRESIDENT-ELECT, MEDICINE & SCIENCE

Louis Philipson, MD

PRESIDENT-ELECT, HEALTH CARE & EDUCATION

Gretchen Youssef, MS, RD, CDE

SECRETARY/TREASURER-ELECT

Brian Bertha, JD, MBA

CHIEF EXECUTIVE OFFICER

Tracey D. Brown, MBA, BChE

CHIEF SCIENTIFIC, MEDICAL & MISSION OFFICER

William T. Cefalu, MD



The mission of the American Diabetes Association
is to prevent and cure diabetes and to improve
the lives of all people affected by diabetes.

Diabetes Care[®]

THE JOURNAL OF CLINICAL AND APPLIED RESEARCH AND EDUCATION

Diabetes Care is a journal for the health care practitioner that is intended to increase knowledge, stimulate research, and promote better management of people with diabetes. To achieve these goals, the journal publishes original research on human studies in the following categories: Clinical Care/Education/Nutrition/ Psychosocial Research, Epidemiology/Health Services Research, Emerging Technologies and Therapeutics, Pathophysiology/Complications, and Cardiovascular and Metabolic Risk. The journal also publishes ADA statements, consensus reports, clinically relevant review articles, letters to the editor, and health/medical news or points of view. Topics covered are of interest to clinically oriented physicians, researchers, epidemiologists, psychologists, diabetes educators, and other health professionals. More information about the journal can be found online at care.diabetesjournals.org.

Copyright © 2018 by the American Diabetes Association, Inc. All rights reserved. Printed in the USA. Requests for permission to reuse content should be sent to Copyright Clearance Center at www.copyright.com or 222 Rosewood Dr., Danvers, MA 01923; phone: (978) 750-8400; fax: (978) 646-8600. Requests for permission to translate should be sent to Permissions Editor, American Diabetes Association, at permissions@diabetes.org.

The American Diabetes Association reserves the right to reject any advertisement for any reason, which need not be disclosed to the party submitting the advertisement.

Commercial reprint orders should be directed to Sheridan Content Services, (800) 635-7181, ext. 8065.

Single issues of *Diabetes Care* can be ordered by calling toll-free (800) 232-3472, 8:30 A.M. to 5:00 P.M. EST, Monday through Friday. Outside the United States, call (703) 549-1500. Rates: \$75 in the United States, \$95 in Canada and Mexico, and \$125 for all other countries.

Diabetes Care is available online at care.diabetesjournals.org. Please call the numbers listed above, e-mail membership@diabetes.org, or visit the online journal for more information about submitting manuscripts, publication charges, ordering reprints, subscribing to the journal, becoming an ADA member, advertising, permission to reuse content, and the journal's publication policies.

Periodicals postage paid at Arlington, VA, and additional mailing offices.

PRINT ISSN 0149-5992
ONLINE ISSN 1935-5548
PRINTED IN THE USA

AMERICAN DIABETES ASSOCIATION PERSONNEL AND CONTACTS

ASSOCIATE PUBLISHER,
SCHOLARLY JOURNALS
Christian S. Kohler

EDITORIAL OFFICE DIRECTOR
Lyn Reynolds

PEER REVIEW MANAGER
Shannon Potts

ASSOCIATE MANAGER, PEER REVIEW
Larissa M. Pouch

DIRECTOR, SCHOLARLY JOURNALS
Heather Norton Blackburn

EDITORIAL CONTENT MANAGER
Nancy C. Baldino

TECHNICAL EDITORS
Theresa Cooper
Donna J. Reynolds

DIRECTOR, MEMBERSHIP/SUBSCRIPTION
SERVICES
Donald Crowl

SENIOR ADVERTISING MANAGER
Julie DeVoss Graff
jgraff@diabetes.org
(703) 299-5511

ADVERTISING REPRESENTATIVES

American Diabetes Association
Paul Nalbandian
Associate Publisher, Advertising &
Sponsorships
pnalbandian@diabetes.org
(703) 549-1500, ext. 4806

Tina Auletta
Senior Account Executive
tauletta@diabetes.org
(703) 549-1500, ext. 4809

PHARMACEUTICAL/DEVICE DIGITAL ADVERTISING
The Walchli Tauber Group
Maura Paoletti
National Sales Manager
maura.paoletti@wt-group.com
(443) 512-8899, ext. 110

Standards of Medical Care in Diabetes—2019

- S1 Introduction**
- S3 Professional Practice Committee**
- S4 Summary of Revisions: *Standards of Medical Care in Diabetes—2019***
- S7 1. Improving Care and Promoting Health in Populations**
Diabetes and Population Health
Tailoring Treatment for Social Context
- S13 2. Classification and Diagnosis of Diabetes**
Classification
Diagnostic Tests for Diabetes
A1C
Type 1 Diabetes
Prediabetes and Type 2 Diabetes
Gestational Diabetes Mellitus
Cystic Fibrosis–Related Diabetes
Posttransplantation Diabetes Mellitus
Monogenic Diabetes Syndromes
- S29 3. Prevention or Delay of Type 2 Diabetes**
Lifestyle Interventions
Pharmacologic Interventions
Prevention of Cardiovascular Disease
Diabetes Self-management Education and Support
- S34 4. Comprehensive Medical Evaluation and Assessment of Comorbidities**
Patient-Centered Collaborative Care
Comprehensive Medical Evaluation
Assessment of Comorbidities
- S46 5. Lifestyle Management**
Diabetes Self-management Education and Support
Nutrition Therapy
Physical Activity
Smoking Cessation: Tobacco and e-Cigarettes
Psychosocial Issues
- S61 6. Glycemic Targets**
Assessment of Glycemic Control
A1C Goals
Hypoglycemia
Intercurrent Illness
- S71 7. Diabetes Technology**
Insulin Delivery
Self-monitoring of Blood Glucose
Continuous Glucose Monitors
Automated Insulin Delivery
- S81 8. Obesity Management for the Treatment of Type 2 Diabetes**
Assessment
Diet, Physical Activity, and Behavioral Therapy
Pharmacotherapy
Medical Devices for Weight Loss
Metabolic Surgery
- S90 9. Pharmacologic Approaches to Glycemic Treatment**
Pharmacologic Therapy for Type 1 Diabetes
Surgical Treatment for Type 1 Diabetes
Pharmacologic Therapy for Type 2 Diabetes
- S103 10. Cardiovascular Disease and Risk Management**
Hypertension/Blood Pressure Control
Lipid Management
Antiplatelet Agents
Cardiovascular Disease
- S124 11. Microvascular Complications and Foot Care**
Chronic Kidney Disease
Diabetic Retinopathy
Neuropathy
Foot Care
- S139 12. Older Adults**
Neurocognitive Function
Hypoglycemia
Treatment Goals
Lifestyle Management
Pharmacologic Therapy
Treatment in Skilled Nursing Facilities and Nursing Homes
End-of-Life Care
- S148 13. Children and Adolescents**
Type 1 Diabetes
Type 2 Diabetes
Transition From Pediatric to Adult Care
- S165 14. Management of Diabetes in Pregnancy**
Diabetes in Pregnancy
Preconception Counseling
Glycemic Targets in Pregnancy
Management of Gestational Diabetes Mellitus
Management of Preexisting Type 1 Diabetes and Type 2 Diabetes in Pregnancy
Pregnancy and Drug Considerations
Postpartum Care
- S173 15. Diabetes Care in the Hospital**
Hospital Care Delivery Standards
Glycemic Targets in Hospitalized Patients
Bedside Blood Glucose Monitoring
Antihyperglycemic Agents in Hospitalized Patients
Hypoglycemia
Medical Nutrition Therapy in the Hospital
Self-management in the Hospital
Standards for Special Situations
Transition From the Acute Care Setting
Preventing Admissions and Readmissions
- S182 16. Diabetes Advocacy**
Advocacy Statements
- S184 Disclosures**
- S187 Index**

This issue is freely accessible online at care.diabetesjournals.org/content/42/Supplement_1.

Keep up with the latest information for *Diabetes Care* and other ADA titles via Facebook ([/ADAJournals](https://www.facebook.com/ADAJournals)) and Twitter ([@ADA_Journals](https://twitter.com/ADA_Journals)).

Introduction: *Standards of Medical Care in Diabetes—2019*

Diabetes Care 2019;42(Suppl. 1):S1–S2 | <https://doi.org/10.2337/dc19-SINT01>

Diabetes is a complex, chronic illness requiring continuous medical care with multifactorial risk-reduction strategies beyond glycemic control. Ongoing patient self-management education and support are critical to preventing acute complications and reducing the risk of long-term complications. Significant evidence exists that supports a range of interventions to improve diabetes outcomes.

The American Diabetes Association's (ADA's) "Standards of Medical Care in Diabetes," referred to as the Standards of Care, is intended to provide clinicians, patients, researchers, payers, and other interested individuals with the components of diabetes care, general treatment goals, and tools to evaluate the quality of care. The Standards of Care recommendations are not intended to preclude clinical judgment and must be applied in the context of excellent clinical care, with adjustments for individual preferences, comorbidities, and other patient factors. For more detailed information about management of diabetes, please refer to *Medical Management of Type 1 Diabetes* (1) and *Medical Management of Type 2 Diabetes* (2).

The recommendations include screening, diagnostic, and therapeutic actions that are known or believed to favorably affect health outcomes of patients with diabetes. Many of these interventions have also been shown to be cost-effective (3).

The ADA strives to improve and update the Standards of Care to ensure that clinicians, health plans, and policy makers can continue to rely on them as the most authoritative and current guidelines for diabetes care. To improve access, the Standards of Care is now available through ADA's new interactive app, along with tools and calculators that can help guide patient care. To download the app, please visit professional.diabetes.org/SOCapp. Readers who wish to comment on the 2019 Standards of Care are invited to do so at professional.diabetes.org/SOC.

ADA STANDARDS, STATEMENTS, REPORTS, and REVIEWS

The ADA has been actively involved in the development and dissemination of diabetes care standards, guidelines, and related documents for over 25 years. The ADA's clinical practice recommendations are viewed as important resources for health care professionals who care for people with diabetes.

Standards of Care

This document is an official ADA position, is authored by the ADA, and provides all of the ADA's current clinical practice recommendations.

To update the Standards of Care, the ADA's Professional Practice Committee (PPC) performs an extensive clinical diabetes literature search, supplemented with input from ADA staff and the medical community at large. The PPC

updates the Standards of Care annually. However, the Standards of Care is a "living" document, where notable updates are incorporated online should the PPC determine that new evidence or regulatory changes (e.g., drug approvals, label changes) merit immediate inclusion. More information on the "living Standards" can be found on DiabetesPro at professional.diabetes.org/content-page/living-standards. The Standards of Care supersedes all previous ADA position statements—and the recommendations therein—on clinical topics within the purview of the Standards of Care; ADA position statements, while still containing valuable analysis, should not be considered the ADA's current position. The Standards of Care receives annual review and approval by the ADA Board of Directors.

ADA Statement

An ADA statement is an official ADA point of view or belief that does not contain clinical practice recommendations and may be issued on advocacy, policy, economic, or medical issues related to diabetes.

ADA statements undergo a formal review process, including a review by the appropriate national committee, ADA mission staff, and the ADA Board of Directors.

Consensus Report

A consensus report of a particular topic contains a comprehensive examination and is authored by an expert panel (i.e.,

"Standards of Medical Care in Diabetes" was originally approved in 1988. Most recent review/revision: December 2018.

© 2018 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. More information is available at <http://www.diabetesjournals.org/content/license>.

Table 1—ADA evidence-grading system for “Standards of Medical Care in Diabetes”

Level of evidence	Description
A	<p>Clear evidence from well-conducted, generalizable randomized controlled trials that are adequately powered, including</p> <ul style="list-style-type: none"> • Evidence from a well-conducted multicenter trial • Evidence from a meta-analysis that incorporated quality ratings in the analysis <p>Compelling nonexperimental evidence, i.e., “all or none” rule developed by the Centre for Evidence-Based Medicine at the University of Oxford</p> <p>Supportive evidence from well-conducted randomized controlled trials that are adequately powered, including</p> <ul style="list-style-type: none"> • Evidence from a well-conducted trial at one or more institutions • Evidence from a meta-analysis that incorporated quality ratings in the analysis
B	<p>Supportive evidence from well-conducted cohort studies</p> <ul style="list-style-type: none"> • Evidence from a well-conducted prospective cohort study or registry • Evidence from a well-conducted meta-analysis of cohort studies <p>Supportive evidence from a well-conducted case-control study</p>
C	<p>Supportive evidence from poorly controlled or uncontrolled studies</p> <ul style="list-style-type: none"> • Evidence from randomized clinical trials with one or more major or three or more minor methodological flaws that could invalidate the results • Evidence from observational studies with high potential for bias (such as case series with comparison with historical controls) • Evidence from case series or case reports <p>Conflicting evidence with the weight of evidence supporting the recommendation</p>
E	Expert consensus or clinical experience

consensus panel) and represents the panel’s collective analysis, evaluation, and opinion.

The need for a consensus report arises when clinicians, scientists, regulators, and/or policy makers desire guidance and/or clarity on a medical or scientific issue related to diabetes for which the evidence is contradictory, emerging, or incomplete. Consensus reports may also highlight gaps in evidence and propose areas of future research to address these gaps. A consensus report is not an ADA position and represents expert opinion only but is produced under the auspices of the Association by invited experts. A consensus report may be developed after an ADA Clinical Conference or Research Symposium.

Scientific Review

A scientific review is a balanced review and analysis of the literature on a scientific or medical topic related to diabetes.

A scientific review is not an ADA position and does not contain clinical practice recommendations but is produced under the auspices of the Association

by invited experts. The scientific review may provide a scientific rationale for clinical practice recommendations in the Standards of Care. The category may also include task force and expert committee reports.

GRADING OF SCIENTIFIC EVIDENCE

Since the ADA first began publishing practice guidelines, there has been considerable evolution in the evaluation of scientific evidence and in the development of evidence-based guidelines. In 2002, the ADA developed a classification system to grade the quality of scientific evidence supporting ADA recommendations. A 2015 analysis of the evidence cited in the Standards of Care found steady improvement in quality over the previous 10 years, with the 2014 Standards of Care for the first time having the majority of bulleted recommendations supported by **A-** or **B-** level evidence (4). A grading system (Table 1) developed by the ADA and modeled after existing methods was used to clarify and codify the evidence

that forms the basis for the recommendations. ADA recommendations are assigned ratings of **A**, **B**, or **C**, depending on the quality of evidence. Expert opinion **E** is a separate category for recommendations in which there is no evidence from clinical trials, in which clinical trials may be impractical, or in which there is conflicting evidence. Recommendations with an **A** rating are based on large well-designed clinical trials or well-done meta-analyses. Generally, these recommendations have the best chance of improving outcomes when applied to the population to which they are appropriate. Recommendations with lower levels of evidence may be equally important but are not as well supported.

Of course, evidence is only one component of clinical decision making. Clinicians care for patients, not populations; guidelines must always be interpreted with the individual patient in mind. Individual circumstances, such as comorbid and coexisting diseases, age, education, disability, and, above all, patients’ values and preferences, must be considered and may lead to different treatment targets and strategies. Furthermore, conventional evidence hierarchies, such as the one adapted by the ADA, may miss nuances important in diabetes care. For example, although there is excellent evidence from clinical trials supporting the importance of achieving multiple risk factor control, the optimal way to achieve this result is less clear. It is difficult to assess each component of such a complex intervention.

References

1. American Diabetes Association. *Medical Management of Type 1 Diabetes*. 7th ed. Wang CC, Shah AC, Eds. Alexandria, VA, American Diabetes Association, 2017
2. American Diabetes Association. *Medical Management of Type 2 Diabetes*. 7th ed. Burant CF, Young LA, Eds. Alexandria, VA, American Diabetes Association, 2012
3. Li R, Zhang P, Barker LE, Chowdhury FM, Zhang X. Cost-effectiveness of interventions to prevent and control diabetes mellitus: a systematic review. *Diabetes Care* 2010;33:1872–1894
4. Grant RW, Kirkman MS. Trends in the evidence level for the American Diabetes Association’s “Standards of Medical Care in Diabetes” from 2005 to 2014. *Diabetes Care* 2015;38:6–8

Professional Practice Committee: *Standards of Medical Care in Diabetes—2019*

Diabetes Care 2019;42(Suppl. 1):S3 | <https://doi.org/10.2337/dc19-SPPC01>

The Professional Practice Committee (PPC) of the American Diabetes Association (ADA) is responsible for the “Standards of Medical Care in Diabetes,” referred to as the Standards of Care. The PPC is a multidisciplinary expert committee comprised of physicians, diabetes educators, and others who have expertise in a range of areas, including adult and pediatric endocrinology, epidemiology, public health, lipid research, hypertension, preconception planning, and pregnancy care. Appointment to the PPC is based on excellence in clinical practice and research. Although the primary role of the PPC is to review and update the Standards of Care, it may also be involved in ADA statements, reports, and reviews.

The ADA adheres to the National Academy of Medicine Standards for Developing Trustworthy Clinical Practice Guidelines. All members of the PPC are required to disclose potential conflicts of interest with industry and/or other relevant organizations. These disclosures are discussed at the onset of each Standards of Care revision meeting. Members of the committee, their employers, and their disclosed conflicts of interest are listed in the “Disclosures: *Standards of Medical Care in Diabetes—2019*” table (see pp. S184–S186). The ADA funds development of the Standards of Care out of its general revenues and does not use industry support for this purpose.

For the current revision, PPC members systematically searched MEDLINE for human studies related to each section and published since 15 October 2017. Recommendations were revised based on new evidence or, in some cases, to clarify the prior recommendation or match the strength of the wording to the strength of the evidence. A table linking the changes in recommendations to new evidence can be reviewed at professional.diabetes.org/SOC. The Standards of Care was approved by ADA’s Board of Directors, which includes health care professionals, scientists, and lay people.

Feedback from the larger clinical community was valuable for the 2018 revision of the Standards of Care. Readers who wish to comment on the 2019 Standards of Care are invited to do so at professional.diabetes.org/SOC.

The PPC would like to thank the following individuals who provided their expertise in reviewing and/or consulting with the committee: *Ann Albright, PhD, RD; Pamela Allweiss, MD, MPH; Barbara J. Anderson, PhD; George Bakris, MD; Richard Bergenstal, MD; Stuart Brink, MD; Donald R. Coustan, MD; Ellen D. Davis, MS, RN, CDE, FADE; Jesse Dinh, PharmD; Steven Edelman, MD; Barry H. Ginsberg, MD, PhD; Irl B. Hirsch, MD; Scott Kahan, MD, MPH; David Klonoff, MD; Joyce Lee, MD, MPH; Randie Little, PhD; Alexandra Migdal, MD; Anne Peters, MD; Amy Rothberg, MD; Jennifer Sherr, MD, PhD; Hood Thabit, MB, BCh, MD, PhD; Stuart Alan Weinzimer, MD; and Neil White, MD.*

Members of the PPC

Joshua J. Neumiller, PharmD, CDE, FASCP* (Chair)
Christopher P. Cannon, MD
Jill Crandall, MD
David D’Alessio, MD
Ian H. de Boer, MD, MS*
Mary de Groot, PhD
Judith Fradkin, MD
Kathryn Evans Kreider, DNP, APRN, FNP-BC, BC-ADM
David Maahs, MD, PhD
Nisa Maruthur, MD, MHS
Medha N. Munshi, MD*
Maria Jose Redondo, MD, PhD, MPH
Guillermo E. Umpierrez, MD, CDE, FACE, FACP*
Jennifer Wyckoff, MD
*Subgroup leaders

ADA Nutrition Consensus Report Writing Group—Liaison

Melinda Maryniuk, MEd, RDN, CDE

American College of Cardiology—Designated Representatives (Section 10)

Sandeep Das, MD, MPH, FACC
Mikhail Kosiborod, MD, FACC

ADA Staff

Erika Gebel Berg, PhD
(corresponding author: eberg@diabetes.org)
Mindy Saraco, MHA
Matthew P. Petersen
Sacha Uelmen, RDN, CDE
Shamera Robinson, MPH, RDN
William T. Cefalu, MD

Summary of Revisions: *Standards of Medical Care in Diabetes—2019*

Diabetes Care 2019;42(Suppl. 1):S4–S6 | <https://doi.org/10.2337/dc19-srev01>

GENERAL CHANGES

The field of diabetes care is rapidly changing as new research, technology, and treatments that can improve the health and well-being of people with diabetes continue to emerge. With annual updates since 1989, the American Diabetes Association (ADA) has long been a leader in producing guidelines that capture the most current state of the field. To that end, the “Standards of Medical Care in Diabetes” (Standards of Care) now includes a dedicated section on Diabetes Technology, which contains preexisting material that was previously in other sections that has been consolidated, as well as new recommendations. Another general change is that each recommendation is now associated with a number (i.e., the second recommendation in Section 7 is now recommendation 7.2). Finally, the order of the prevention section was changed (from Section 5 to Section 3) to follow a more logical progression.

Although levels of evidence for several recommendations have been updated, these changes are not addressed below as the clinical recommendations have remained the same. Changes in evidence level from, for example, E to C are not noted below. The 2019 Standards of Care contains, in addition to many minor changes that clarify recommendations or reflect new evidence, the following more substantive revisions.

SECTION CHANGES

Section 1. Improving Care and Promoting Health in Populations

Additional information was included on the financial costs of diabetes to individuals and society.

Because telemedicine is a growing field that may increase access to care for patients with diabetes, discussion was added on its use to facilitate remote delivery of health-related services and clinical information.

Section 2. Classification and Diagnosis of Diabetes

Based on new data, the criteria for the diagnosis of diabetes was changed to include two abnormal test results from the same sample (i.e., fasting plasma glucose and A1C from same sample).

The section was reorganized to improve flow and reduce redundancy.

Additional conditions were identified that may affect A1C test accuracy including the postpartum period.

Section 3. Prevention or Delay of Type 2 Diabetes

This section was moved (previously it was Section 5) and is now located before the Lifestyle Management section to better reflect the progression of type 2 diabetes.

The nutrition section was updated to highlight the importance of weight loss for those at high risk for developing type 2 diabetes who have overweight or obesity.

Because smoking may increase the risk of type 2 diabetes, a section on tobacco use and cessation was added.

Section 4. Comprehensive Medical Evaluation and Assessment of Comorbidities

On the basis of a new consensus report on diabetes and language, new text was added to guide health care professionals' use of language to communicate about diabetes with people with diabetes and

professional audiences in an informative, empowering, and educational style.

A new figure from the ADA-European Association for the Study of Diabetes (EASD) consensus report about the diabetes care decision cycle was added to emphasize the need for ongoing assessment and shared decision making to achieve the goals of health care and avoid clinical inertia.

A new recommendation was added to explicitly call out the importance of the diabetes care team and to list the professionals that make up the team.

The table listing the components of a comprehensive medical evaluation was revised, and the section on assessment and planning was used to create a new table (**Table 4.2**).

A new table was added listing factors that increase risk of treatment-associated hypoglycemia (**Table 4.3**).

A recommendation was added to include the 10-year atherosclerotic cardiovascular disease (ASCVD) risk as part of overall risk assessment.

The fatty liver disease section was revised to include updated text and a new recommendation regarding when to test for liver disease.

Section 5. Lifestyle Management

Evidence continues to suggest that there is not an ideal percentage of calories from carbohydrate, protein, and fat for all people with diabetes. Therefore, more discussion was added about the importance of macronutrient distribution based on an individualized assessment of current eating patterns, preferences, and metabolic goals. Additional considerations were added to the eating

patterns, macronutrient distribution, and meal planning sections to better identify candidates for meal plans, specifically for low-carbohydrate eating patterns and people who are pregnant or lactating, who have or are at risk for disordered eating, who have renal disease, and who are taking sodium–glucose cotransporter 2 inhibitors. There is not a one-size-fits-all eating pattern for individuals with diabetes, and meal planning should be individualized.

A recommendation was modified to encourage people with diabetes to decrease consumption of both sugar sweetened and nonnutritive-sweetened beverages and use other alternatives, with an emphasis on water intake.

The sodium consumption recommendation was modified to eliminate the further restriction that was potentially indicated for those with both diabetes and hypertension.

Additional discussion was added to the physical activity section to include the benefit of a variety of leisure-time physical activities and flexibility and balance exercises.

The discussion about e-cigarettes was expanded to include more on public perception and how their use to aide smoking cessation was not more effective than “usual care.”

Section 6. Glycemic Targets

This section now begins with a discussion of A1C tests to highlight the centrality of A1C testing in glycemic management.

The self-monitoring of blood glucose and continuous glucose monitoring text and recommendations were moved to the new Diabetes Technology section.

To emphasize that the risks and benefits of glycemic targets can change as diabetes progresses and patients age, a recommendation was added to reevaluate glycemic targets over time.

The section was modified to align with the living Standards updates made in April 2018 regarding the consensus definition of hypoglycemia.

Section 7. Diabetes Technology

This new section includes new recommendations, the self-monitoring of blood glucose section formerly included in Section 6 “Glycemic Targets,” and a discussion of insulin delivery devices (syringes, pens, and insulin pumps), blood glucose meters, continuous glucose monitors (real-time and

intermittently scanned [“flash”]), and automated insulin delivery devices.

The recommendation to use self-monitoring of blood glucose in people who are not using insulin was changed to acknowledge that routine glucose monitoring is of limited additional clinical benefit in this population.

Section 8. Obesity Management for the Treatment of Type 2 Diabetes

A recommendation was modified to acknowledge the benefits of tracking weight, activity, etc., in the context of achieving and maintaining a healthy weight.

A brief section was added on medical devices for weight loss, which are not currently recommended due to limited data in people with diabetes.

The recommendations for metabolic surgery were modified to align with recent guidelines, citing the importance of considering comorbidities beyond diabetes when contemplating the appropriateness of metabolic surgery for a given patient.

Section 9. Pharmacologic Approaches to Glycemic Treatment

The section on the pharmacologic treatment of type 2 diabetes was significantly changed to align, as per the living Standards update in October 2018, with the ADA-EASD consensus report on this topic, summarized in the new **Figs. 9.1** and **9.2**. This includes consideration of key patient factors: *a)* important comorbidities such as ASCVD, chronic kidney disease, and heart failure, *b)* hypoglycemia risk, *c)* effects on body weight, *d)* side effects, *e)* costs, and *f)* patient preferences.

To align with the ADA-EASD consensus report, the approach to injectable medication therapy was revised (**Fig. 9.2**). A recommendation that, for most patients who need the greater efficacy of an injectable medication, a glucagon-like peptide 1 receptor agonist should be the first choice, ahead of insulin.

A new section was added on insulin injection technique, emphasizing the importance of technique for appropriate insulin dosing and the avoidance of complications (lipodystrophy, etc.).

The section on noninsulin pharmacologic treatments for type 1 diabetes was

abbreviated, as these are not generally recommended.

Section 10. Cardiovascular Disease and Risk Management

For the first time, this section is endorsed by the American College of Cardiology. Additional text was added to acknowledge heart failure as an important type of cardiovascular disease in people with diabetes for consideration when determining optimal diabetes care.

The blood pressure recommendations were modified to emphasize the importance of individualization of targets based on cardiovascular risk.

A discussion of the appropriate use of the ASCVD risk calculator was included, and recommendations were modified to include assessment of 10-year ASCVD risk as part of overall risk assessment and in determining optimal treatment approaches.

The recommendation and text regarding the use of aspirin in primary prevention was updated with new data.

For alignment with the ADA-EASD consensus report, two recommendations were added for the use of medications that have proven cardiovascular benefit in people with ASCVD, with and without heart failure.

Section 11. Microvascular Complications and Foot Care

To align with the ADA-EASD consensus report, a recommendation was added for people with type 2 diabetes and chronic kidney disease to consider agents with proven benefit with regard to renal outcomes.

The recommendation on the use of telemedicine in retinal screening was modified to acknowledge the utility of this approach, so long as appropriate referrals are made for a comprehensive eye examination.

Gabapentin was added to the list of agents to be considered for the treatment of neuropathic pain in people with diabetes based on data on efficacy and the potential for cost savings.

The gastroparesis section includes a discussion of a few additional treatment modalities.

The recommendation for patients with diabetes to have their feet inspected at every visit was modified to only include those at high risk for ulceration. Annual

examinations remain recommended for everyone.

Section 12. Older Adults

A new section and recommendation on lifestyle management was added to address the unique nutritional and physical activity needs and considerations for older adults.

Within the pharmacologic therapy discussion, deintensification of insulin regimens was introduced to help simplify insulin regimen to match individual's self-management abilities. A new figure was added (**Fig. 12.1**) that provides a path for simplification. A new table was also added (**Table 12.2**) to help guide providers considering medication regimen simplification and deintensification/deprescribing in older adults with diabetes.

Section 13. Children and Adolescents

Introductory language was added to the beginning of this section reminding the reader that the epidemiology, pathophysiology, developmental considerations, and response to therapy in pediatric-onset diabetes are different from adult diabetes, and that there are also differences in recommended care for children and adolescents with type 1 as opposed to type 2 diabetes.

A recommendation was added to emphasize the need for disordered eating

screening in youth with type 1 diabetes beginning at 10–12 years of age.

Based on new evidence, a recommendation was added discouraging e-cigarette use in youth.

The discussion of type 2 diabetes in children and adolescents was significantly expanded, with new recommendations in a number of areas, including screening and diagnosis, lifestyle management, pharmacologic management, and transition of care to adult providers. New sections and/or recommendations for type 2 diabetes in children and adolescents were added for glycemic targets, metabolic surgery, nephropathy, neuropathy, retinopathy, nonalcoholic fatty liver disease, obstructive sleep apnea, polycystic ovary syndrome, cardiovascular disease, dyslipidemia, cardiac function testing, and psychosocial factors. **Figure 13.1** was added to provide guidance on the management of diabetes in overweight youth.

Section 14. Management of Diabetes in Pregnancy

Women with preexisting diabetes are now recommended to have their care managed in a multidisciplinary clinic to improve diabetes and pregnancy outcomes.

Greater emphasis has been placed on the use of insulin as the preferred medication for treating hyperglycemia in gestational diabetes mellitus as it does not cross the placenta to a measurable extent and how metformin and glyburide should not be used as first-line agents as both cross the placenta to the fetus.

Section 15. Diabetes Care in the Hospital

Because of their ability to improve hospital readmission rates and cost of care, a new recommendation was added calling for providers to consider consulting with a specialized diabetes or glucose management team where possible when caring for hospitalized patients with diabetes.

Section 16. Diabetes Advocacy

The "Insulin Access and Affordability Working Group: Conclusions and Recommendations" ADA statement was added to this section. Published in 2018, this statement compiled public information and convened a series of meetings with stakeholders throughout the insulin supply chain to learn how each entity affects the cost of insulin for the consumer, an important topic for the ADA and people living with diabetes.

1. Improving Care and Promoting Health in Populations: *Standards of Medical Care in Diabetes—2019*

American Diabetes Association

Diabetes Care 2019;42(Suppl. 1):S7–S12 | <https://doi.org/10.2337/dc19-S001>

The American Diabetes Association (ADA) “Standards of Medical Care in Diabetes” includes ADA’s current clinical practice recommendations and is intended to provide the components of diabetes care, general treatment goals and guidelines, and tools to evaluate quality of care. Members of the ADA Professional Practice Committee, a multidisciplinary expert committee, are responsible for updating the Standards of Care annually, or more frequently as warranted. For a detailed description of ADA standards, statements, and reports, as well as the evidence-grading system for ADA’s clinical practice recommendations, please refer to the Standards of Care Introduction. Readers who wish to comment on the Standards of Care are invited to do so at professional.diabetes.org/SOC.

DIABETES AND POPULATION HEALTH

Recommendations

- 1.1 Ensure treatment decisions are timely, rely on evidence-based guidelines, and are made collaboratively with patients based on individual preferences, prognoses, and comorbidities. **B**
- 1.2 Align approaches to diabetes management with the Chronic Care Model, emphasizing productive interactions between a prepared proactive care team and an informed activated patient. **A**
- 1.3 Care systems should facilitate team-based care, patient registries, decision support tools, and community involvement to meet patient needs. **B**
- 1.4 Efforts to assess the quality of diabetes care and create quality improvement strategies should incorporate reliable data metrics, to promote improved processes of care and health outcomes, with simultaneous emphasis on costs. **E**

Population health is defined as “the health outcomes of a group of individuals, including the distribution of health outcomes within the group”; these outcomes can be measured in terms of health outcomes (mortality, morbidity, health, and functional status), disease burden (incidence and prevalence), and behavioral and metabolic factors (exercise, diet, A1C, etc.) (1). Clinical practice recommendations for health care providers are tools that can ultimately improve health across populations; however, for optimal outcomes, diabetes care must also be individualized for each patient. Thus, efforts to improve population health will require a combination of system-level and patient-level approaches. With such an integrated approach in mind, the American Diabetes Association (ADA) highlights the importance of *patient-centered care*, defined as care that is respectful of and responsive to individual patient preferences, needs, and values and that ensures that patient values guide all clinical decisions (2). Clinical practice recommendations, whether based on evidence or expert opinion, are

Suggested citation: American Diabetes Association. 1. Improving care and promoting health in populations: Standards of Medical Care in Diabetes—2019. Diabetes Care 2019;42(Suppl. 1): S7–S12

© 2018 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. More information is available at <http://www.diabetesjournals.org/content/license>.

intended to guide an overall approach to care. The science and art of medicine come together when the clinician is faced with making treatment recommendations for a patient who may not meet the eligibility criteria used in the studies on which guidelines are based. Recognizing that one size does not fit all, the standards presented here provide guidance for when and how to adapt recommendations for an individual.

Care Delivery Systems

The proportion of patients with diabetes who achieve recommended A1C, blood pressure, and LDL cholesterol levels has increased in recent years (3). The mean A1C nationally among people with diabetes declined from 7.6% (60 mmol/mol) in 1999–2002 to 7.2% (55 mmol/mol) in 2007–2010 based on the National Health and Nutrition Examination Survey (NHANES), with younger adults less likely to meet treatment targets than older adults (3). This has been accompanied by improvements in cardiovascular outcomes and has led to substantial reductions in end-stage microvascular complications.

Nevertheless, 33–49% of patients still did not meet general targets for glyce-mic, blood pressure, or cholesterol control, and only 14% met targets for all three measures while also avoiding smoking (3). Evidence suggests that progress in cardiovascular risk factor control (particularly tobacco use) may be slowing (3,4). Certain segments of the population, such as young adults and patients with complex comorbidities, financial or other social hardships, and/or limited English proficiency, face particular challenges to goal-based care (5–7). Even after adjusting for these patient factors, the persistent variability in the quality of diabetes care across providers and practice settings indicates that substantial system-level improvements are still needed.

Diabetes poses a significant financial burden to individuals and society. It is estimated that the annual cost of diagnosed diabetes in 2017 was \$327 billion, including \$237 billion in direct medical costs and \$90 billion in reduced productivity. After adjusting for inflation, economic costs of diabetes increased by 26% from 2012 to 2017 (8). This is attributed to the increased prevalence of diabetes and the increased cost per person with diabetes. Ongoing population

health strategies are needed in order to reduce costs and provide optimized care.

Chronic Care Model

Numerous interventions to improve adherence to the recommended standards have been implemented. However, a major barrier to optimal care is a delivery system that is often fragmented, lacks clinical information capabilities, duplicates services, and is poorly designed for the coordinated delivery of chronic care. The Chronic Care Model (CCM) takes these factors into consideration and is an effective framework for improving the quality of diabetes care (9).

Six Core Elements. The CCM includes six core elements to optimize the care of patients with chronic disease:

1. Delivery system design (moving from a *reactive* to a *proactive* care delivery system where planned visits are coordinated through a team-based approach)
2. Self-management support
3. Decision support (basing care on evidence-based, effective care guidelines)
4. Clinical information systems (using registries that can provide patient-specific and population-based support to the care team)
5. Community resources and policies (identifying or developing resources to support healthy lifestyles)
6. Health systems (to create a quality-oriented culture)

Redefining the roles of the health care delivery team and empowering patient self-management are fundamental to the successful implementation of the CCM (10). Collaborative, multidisciplinary teams are best suited to provide care for people with chronic conditions such as diabetes and to facilitate patients' self-management (11–13).

Strategies for System-Level Improvement

Optimal diabetes management requires an organized, systematic approach and the involvement of a coordinated team of dedicated health care professionals working in an environment where patient-centered high-quality care is a priority (7,14,15). While many diabetes processes of care have improved nationally in the past decade, the overall quality of care for patients with diabetes remains

suboptimal (3). Efforts to increase the quality of diabetes care include providing care that is concordant with evidence-based guidelines (16); expanding the role of teams to implement more intensive disease management strategies (7,17,18); tracking medication-taking behavior at a systems level (19); redesigning the organization of the care process (20); implementing electronic health record tools (21,22); empowering and educating patients (23,24); removing financial barriers and reducing patient out-of-pocket costs for diabetes education, eye exams, diabetes technology, and necessary medications (7); assessing and addressing psychosocial issues (25,26); and identifying, developing, and engaging community resources and public policies that support healthy lifestyles (27). The National Diabetes Education Program maintains an online resource (www.betterdiabetescare.nih.gov) to help health care professionals design and implement more effective health care delivery systems for those with diabetes.

The care team, which centers around the patient, should avoid therapeutic inertia and prioritize timely and appropriate intensification of lifestyle and/or pharmacologic therapy for patients who have not achieved the recommended metabolic targets (28–30). Strategies shown to improve care team behavior and thereby catalyze reductions in A1C, blood pressure, and/or LDL cholesterol include engaging in explicit and collaborative goal setting with patients (31,32); identifying and addressing language, numeracy, or cultural barriers to care (33–35); integrating evidence-based guidelines and clinical information tools into the process of care (16,36,37); soliciting performance feedback, setting reminders, and providing structured care (e.g., guidelines, formal case management, and patient education resources) (7); and incorporating care management teams including nurses, dietitians, pharmacists, and other providers (17,38). Initiatives such as the Patient-Centered Medical Home show promise for improving health outcomes by fostering comprehensive primary care and offering new opportunities for team-based chronic disease management (39).

Telemedicine is a growing field that may increase access to care for patients with diabetes. Telemedicine is defined as the use of telecommunications to

facilitate remote delivery of health-related services and clinical information (40). A growing body of evidence suggests that various telemedicine modalities may be effective at reducing A1C in patients with type 2 diabetes compared with usual care or in addition to usual care (41). For rural populations or those with limited physical access to health care, telemedicine has a growing body of evidence for its effectiveness, particularly with regard to glycemic control as measured by A1C (42–44). Interactive strategies that facilitate communication between providers and patients, including the use of web-based portals or text messaging and those that incorporate medication adjustment, appear more effective. There is limited data available on the cost-effectiveness of these strategies.

Successful diabetes care also requires a systematic approach to supporting patients' behavior change efforts. High-quality diabetes self-management education and support (DSMES) has been shown to improve patient self-management, satisfaction, and glucose outcomes. National DSMES standards call for an integrated approach that includes clinical content and skills, behavioral strategies (goal setting, problem solving), and engagement with psychosocial concerns (26). For more information on DSMES, see Section 5 "Lifestyle Management."

In devising approaches to support disease self-management, it is notable that in 23% of cases, uncontrolled A1C, blood pressure, or lipids were associated with poor medication-taking behaviors ("medication adherence") (19). At a system level, "adequate" medication taking is defined as 80% (calculated as the number of pills taken by the patient in a given time period divided by the number of pills prescribed by the physician in that same time period) (19). If medication taking is 80% or above and treatment goals are not met, then treatment intensification should be considered (e.g., uptitration). Barriers to medication taking may include patient factors (financial limitations, remembering to obtain or take medications, fear, depression, or health beliefs), medication factors (complexity, multiple daily dosing, cost, or side effects), and system factors (inadequate follow-up or support). Success in overcoming

barriers to medication taking may be achieved if the patient and provider agree on a targeted approach for a specific barrier (12).

The Affordable Care Act has resulted in increased access to care for many individuals with diabetes with an emphasis on the protection of people with preexisting conditions, health promotion, and disease prevention (45). In fact, health insurance coverage increased from 84.7% in 2009 to 90.1% in 2016 for adults with diabetes aged 18–64 years. Coverage for those ≥ 65 years remained near universal (46). Patients who have either private or public insurance coverage are more likely to meet quality indicators for diabetes care (47). As mandated by the Affordable Care Act, the Agency for Healthcare Research and Quality developed a National Quality Strategy based on the triple aims that include improving the health of a population, overall quality and patient experience of care, and per capita cost (48,49). As health care systems and practices adapt to the changing landscape of health care, it will be important to integrate traditional disease-specific metrics with measures of patient experience, as well as cost, in assessing the quality of diabetes care (50,51). Information and guidance specific to quality improvement and practice transformation for diabetes care is available from the National Diabetes Education Program practice transformation website and the National Institute of Diabetes and Digestive and Kidney Diseases report on diabetes care and quality (52,53). Using patient registries and electronic health records, health systems can evaluate the quality of diabetes care being delivered and perform intervention cycles as part of quality improvement strategies (54). Critical to these efforts is provider adherence to clinical practice recommendations and accurate, reliable data metrics that include sociodemographic variables to examine health equity within and across populations (55).

In addition to quality improvement efforts, other strategies that simultaneously improve the quality of care and potentially reduce costs are gaining momentum and include reimbursement structures that, in contrast to visit-based billing, reward the provision of appropriate and high-quality care to achieve metabolic goals (56) and incentives that

accommodate personalized care goals (7,57).

TAILORING TREATMENT FOR SOCIAL CONTEXT

Recommendations

- 1.5** Providers should assess social context, including potential food insecurity, housing stability, and financial barriers, and apply that information to treatment decisions. **A**
- 1.6** Refer patients to local community resources when available. **B**
- 1.7** Provide patients with self-management support from lay health coaches, navigators, or community health workers when available. **A**

Health inequities related to diabetes and its complications are well documented and are heavily influenced by social determinants of health (58–62). Social determinants of health are defined as the economic, environmental, political, and social conditions in which people live and are responsible for a major part of health inequality worldwide (63). The ADA recognizes the association between social and environmental factors and the prevention and treatment of diabetes and has issued a call for research that seeks to better understand how these social determinants influence behaviors and how the relationships between these variables might be modified for the prevention and management of diabetes (64). While a comprehensive strategy to reduce diabetes-related health inequities in populations has not been formally studied, general recommendations from other chronic disease models can be drawn upon to inform systems-level strategies in diabetes. For example, the National Academy of Medicine has published a framework for educating health care professionals on the importance of social determinants of health (65). Furthermore, there are resources available for the inclusion of standardized sociodemographic variables in electronic medical records to facilitate the measurement of health inequities as well as the impact of interventions designed to reduce those inequities (66–68).

Social determinants of health are not always recognized and often go undiscussed in the clinical encounter (61). A

study by Piette et al. (69) found that among patients with chronic illnesses, two-thirds of those who reported not taking medications as prescribed due to cost never shared this with their physician. In a more recent study using data from the National Health Interview Survey (NHIS), Patel et al. (61) found that half of adults with diabetes reported financial stress and one-fifth reported food insecurity (FI). One population in which such issues must be considered is older adults, where social difficulties may impair their quality of life and increase their risk of functional dependency (70) (see Section 12 “Older Adults” for a detailed discussion of social considerations in older adults). Creating systems-level mechanisms to screen for social determinants of health may help overcome structural barriers and communication gaps between patients and providers (61). In addition, brief, validated screening tools for some social determinants of health exist and could facilitate discussion around factors that significantly impact treatment during the clinical encounter. Below is a discussion of assessment and treatment considerations in the context of FI, homelessness, and limited English proficiency/low literacy.

Food Insecurity

FI is the unreliable availability of nutritious food and the inability to consistently obtain food without resorting to socially unacceptable practices. Over 14% (or one of every seven people) of the U.S. population is food insecure. The rate is higher in some racial/ethnic minority groups, including African American and Latino populations, in low-income households, and in homes headed by a single mother. The risk for type 2 diabetes is increased twofold in those with FI (64) and has been associated with low adherence to taking medications appropriately and recommended self-care behaviors, depression, diabetes distress, and worse glycemic control when compared with individuals who are food secure (71,72). Risk for FI can be assessed with a validated two-item screening tool (73) that includes the statements: 1) “Within the past 12 months we worried whether our food would run out before we got money to buy more” and 2) “Within the past 12 months the food we bought just didn’t last and we didn’t have money

to get more.” An affirmative response to either statement had a sensitivity of 97% and specificity of 83%.

Treatment Considerations

In those with diabetes and FI, the priority is mitigating the increased risk for uncontrolled hyperglycemia and severe hypoglycemia. Reasons for the increased risk of hyperglycemia include the steady consumption of inexpensive carbohydrate-rich processed foods, binge eating, financial constraints to the filling of diabetes medication prescriptions, and anxiety/depression leading to poor diabetes self-care behaviors. Hypoglycemia can occur as a result of inadequate or erratic carbohydrate consumption following the administration of sulfonylureas or insulin. See **Table 9.1** for drug-specific and patient factors, including cost and risk of hypoglycemia, for treatment options for adults with FI and type 2 diabetes. Providers should consider these factors when making treatment decisions in people with FI and seek local resources that might help patients with diabetes and their family members to more regularly obtain nutritious food (74).

Homelessness

Homelessness often accompanies many additional barriers to diabetes self-management, including FI, literacy and numeracy deficiencies, lack of insurance, cognitive dysfunction, and mental health issues. Additionally, patients with diabetes who are homeless need secure places to keep their diabetes supplies and refrigerator access to properly store their insulin and take it on a regular schedule. Risk for homelessness can be ascertained using a brief risk assessment tool developed and validated for use among veterans (75). Given the potential challenges, providers who care for homeless individuals should be familiar with resources or have access to social workers that can facilitate temporary housing for their patients as a way to improve diabetes care.

Language Barriers

Providers who care for non-English speakers should develop or offer educational programs and materials in multiple languages with the specific goals of preventing diabetes and building diabetes awareness in people who cannot easily read or write in English. The National

Standards for Culturally and Linguistically Appropriate Services in Health and Health Care provide guidance on how health care providers can reduce language barriers by improving their cultural competency, addressing health literacy, and ensuring communication with language assistance (76). The site offers a number of resources and materials that can be used to improve the quality of care delivery to non-English-speaking patients.

Community Support

Identification or development of community resources to support healthy lifestyles is a core element of the CCM (9). Health care community linkages are receiving increasing attention from the American Medical Association, the Agency for Healthcare Research and Quality, and others as a means of promoting translation of clinical recommendations for lifestyle modification in real-world settings (77). Community health workers (CHWs) (78), peer supporters (79–81), and lay leaders (82) may assist in the delivery of DSMES services (66), particularly in underserved communities. A CHW is defined by the American Public Health Association as a “frontline public health worker who is a trusted member of and/or has an unusually close understanding of the community served” (83). CHWs can be part of a cost-effective, evidence-based strategy to improve the management of diabetes and cardiovascular risk factors in underserved communities and health care systems (84).

References

1. Kindig D, Stoddart G. What is population health? *Am J Public Health* 2003;93:380–383
2. Institute of Medicine Committee on Quality of Health Care in America. *Crossing the quality chasm: a new health system for the 21st century* [Internet], 2001. Washington, DC, The National Academies Press. Available from <http://www.nap.edu/catalog/10027>. Accessed 22 October 2018
3. Ali MK, Bullard KM, Saaddine JB, Cowie CC, Imperatore G, Gregg EW. Achievement of goals in U.S. diabetes care, 1999–2010. *N Engl J Med* 2013;368:1613–1624
4. Wang J, Geiss LS, Cheng YJ, et al. Long-term and recent progress in blood pressure levels among U.S. adults with diagnosed diabetes, 1988–2008. *Diabetes Care* 2011;34:1579–1581
5. Kerr EA, Heisler M, Krein SL, et al. Beyond comorbidity counts: how do comorbidity type and severity influence diabetes patients’ treatment priorities and self-management? *J Gen Intern Med* 2007;22:1635–1640

6. Fernandez A, Schillinger D, Warton EM, et al. Language barriers, physician-patient language concordance, and glycemic control among insured Latinos with diabetes: the Diabetes Study of Northern California (DISTANCE). *J Gen Intern Med* 2011;26:170–176
7. TRIAD Study Group. Health systems, patients factors, and quality of care for diabetes: a synthesis of findings from the TRIAD study. *Diabetes Care* 2010;33:940–947
8. American Diabetes Association. Economic costs of diabetes in the U.S. in 2017. *Diabetes Care* 2018;41:917–928
9. Stelfox M, Diparine K, Stopka C. The Chronic Care Model and diabetes management in US primary care settings: a systematic review. *Prev Chronic Dis* 2013;10:E26
10. Coleman K, Austin BT, Brach C, Wagner EH. Evidence on the Chronic Care Model in the new millennium. *Health Aff (Millwood)* 2009;28:75–85
11. Piatt GA, Anderson RM, Brooks MM, et al. 3-year follow-up of clinical and behavioral improvements following a multifaceted diabetes care intervention: results of a randomized controlled trial. *Diabetes Educ* 2010;36:301–309
12. Katon WJ, Lin EHB, Von Korff M, et al. Collaborative care for patients with depression and chronic illnesses. *N Engl J Med* 2010;363:2611–2620
13. Parchman ML, Zeber JE, Romero RR, Pugh JA. Risk of coronary artery disease in type 2 diabetes and the delivery of care consistent with the chronic care model in primary care settings: a STARNet study. *Med Care* 2007;45:1129–1134
14. Tricco AC, Ivers NM, Grimshaw JM, et al. Effectiveness of quality improvement strategies on the management of diabetes: a systematic review and meta-analysis. *Lancet* 2012;379:2252–2261
15. Schmittiel JA, Gopalan A, Lin MW, Banerjee S, Chau CV, Adams AS. Population health management for diabetes: health care system-level approaches for improving quality and addressing disparities. *Curr Diab Rep* 2017;17:31
16. O'Connor PJ, Bodkin NL, Fradkin J, et al. Diabetes performance measures: current status and future directions. *Diabetes Care* 2011;34:1651–1659
17. Jaffe MG, Lee GA, Young JD, Sidney S, Go AS. Improved blood pressure control associated with a large-scale hypertension program. *JAMA* 2013;310:699–705
18. Peikes D, Chen A, Schore J, Brown R. Effects of care coordination on hospitalization, quality of care, and health care expenditures among Medicare beneficiaries: 15 randomized trials. *JAMA* 2009;301:603–618
19. Raebel MA, Schmittiel J, Karter AJ, Konieczny JL, Steiner JF. Standardizing terminology and definitions of medication adherence and persistence in research employing electronic databases. *Med Care* 2013;51(Suppl. 3):S11–S21
20. Feifer C, Nemeth L, Nietert PJ, et al. Different paths to high-quality care: three archetypes of top-performing practice sites. *Ann Fam Med* 2007;5:233–241
21. Reed M, Huang J, Graetz I, et al. Outpatient electronic health records and the clinical care and outcomes of patients with diabetes mellitus. *Ann Intern Med* 2012;157:482–489
22. Cebul RD, Love TE, Jain AK, Hebert CJ. Electronic health records and quality of diabetes care. *N Engl J Med* 2011;365:825–833
23. Battersby M, Von Korff M, Schaefer J, et al. Twelve evidence-based principles for implementing self-management support in primary care. *Jt Comm J Qual Patient Saf* 2010;36:561–570
24. Grant RW, Wald JS, Schnipper JL, et al. Practice-linked online personal health records for type 2 diabetes mellitus: a randomized controlled trial. *Arch Intern Med* 2008;168:1776–1782
25. Young-Hyman D, de Groot M, Hill-Briggs F, Gonzalez JS, Hood K, Peyrot M. Psychosocial care for people with diabetes: a position statement of the American Diabetes Association. *Diabetes Care* 2016;39:2126–2140
26. Beck J, Greenwood DA, Blanton L, et al.; 2017 Standards Revision Task Force. 2017 National standards for diabetes self-management education and support. *Diabetes Care* 2017;40:1409–1419
27. Pullen-Smith B, Carter-Edwards L, Leathers KH. Community health ambassadors: a model for engaging community leaders to promote better health in North Carolina. *J Public Health Manag Pract* 2008;14(Suppl.):S73–S81
28. Davidson MB. How our current medical care system fails people with diabetes: lack of timely, appropriate clinical decisions. *Diabetes Care* 2009;32:370–372
29. Selby JV, Uratsu CS, Fireman B, et al. Treatment intensification and risk factor control: toward more clinically relevant quality measures. *Med Care* 2009;47:395–402
30. Raebel MA, Ellis JL, Schroeder EB, et al. Intensification of antihyperglycemic therapy among patients with incident diabetes: a Surveillance Prevention and Management of Diabetes Mellitus (SUPREME-DM) study. *Pharmacoepidemiol Drug Saf* 2014;23:699–710
31. Grant RW, Pabon-Nau L, Ross KM, Youatt EJ, Pandiscio JC, Park ER. Diabetes oral medication initiation and intensification: patient views compared with current treatment guidelines. *Diabetes Educ* 2011;37:78–84
32. Tamhane S, Rodriguez-Gutierrez R, Hargraves I, Montori VM. Shared decision-making in diabetes care. *Curr Diab Rep* 2015;15:112
33. Schillinger D, Piette J, Grumbach K, et al. Closing the loop: physician communication with diabetic patients who have low health literacy. *Arch Intern Med* 2003;163:83–90
34. Rosal MC, Ockene IS, Restrepo A, et al. Randomized trial of a literacy-sensitive, culturally tailored diabetes self-management intervention for low-income Latinos: Latinos en control. *Diabetes Care* 2011;34:838–844
35. Osborn CY, Cavanaugh K, Wallston KA, et al. Health literacy explains racial disparities in diabetes medication adherence. *J Health Commun* 2011;16(Suppl. 3):268–278
36. Garg AX, Adhikari NKJ, McDonald H, et al. Effects of computerized clinical decision support systems on practitioner performance and patient outcomes: a systematic review. *JAMA* 2005;293:1223–1238
37. Smith SA, Shah ND, Bryant SC, et al.; Evidens Research Group. Chronic care model and shared care in diabetes: randomized trial of an electronic decision support system. *Mayo Clin Proc* 2008;83:747–757
38. Stone RA, Rao RH, Sevick MA, et al. Active care management supported by home telemonitoring in veterans with type 2 diabetes: the DiaTel randomized controlled trial. *Diabetes Care* 2010;33:478–484
39. Bojadziewski T, Gabbay RA. Patient-centered medical home and diabetes. *Diabetes Care* 2011;34:1047–1053
40. American Telemedicine Association. About telemedicine [Internet]. Available from <http://www.americantelemed.org/main/about/about-telemedicine/telemedicine-faqs>. Accessed 2 October 2018
41. Lee SWH, Chan KY, Chua SS, Chaiyakunapruk N. Comparative effectiveness of telemedicine strategies on type 2 diabetes management: a systematic review and network meta-analysis. *Sci Rep* 2017;7:12680
42. Faruque LI, Wiebe N, Ehteshami-Afshar A, et al.; Alberta Kidney Disease Network. Effect of telemedicine on glycosylated hemoglobin in diabetes: a systematic review and meta-analysis of randomized trials. *CMAJ* 2017;189:E341–E364
43. Marcolino MS, Maia JX, Alkmim MBM, Boersma E, Ribeiro AL. Telemedicine application in the care of diabetes patients: systematic review and meta-analysis. *PLoS One* 2013;8:e79246
44. Heitkemper EM, Mamykina L, Travers J, Smaldone A. Do health information technology self-management interventions improve glycemic control in medically underserved adults with diabetes? A systematic review and meta-analysis. *J Am Med Inform Assoc* 2017;24:1024–1035
45. Myerson R, Laiteerapong N. The Affordable Care Act and diabetes diagnosis and care: exploring the potential impacts. *Curr Diab Rep* 2016;16:27
46. Casagrande SS, McEwen LN, Herman WH. Changes in health insurance coverage under the Affordable Care Act: a national sample of U.S. adults with diabetes, 2009 and 2016. *Diabetes Care* 2018;41:956–962
47. Doucette ED, Salas J, Scherrer JF. Insurance coverage and diabetes quality indicators among patients in NHANES. *Am J Manag Care* 2016;22:484–490
48. Stiefel M, Nolan K. Measuring the triple aim: a call for action. *Popul Health Manag* 2013;16:219–220
49. Agency for Healthcare Research and Quality. About the National Quality Strategy [Internet], 2017. Available from <https://www.ahrq.gov/workingforquality/about/index.html>. Accessed 22 October 2018
50. National Quality Forum. Home page [Internet], 2017. Available from <http://www.qualityforum.org/home.aspx>. Accessed 22 October 2018
51. Burstin H, Johnson K. Getting to better care and outcomes for diabetes through measurement [article online], 2016. Available from <http://www.ajmc.com/journals/evidence-based-diabetes-management/2016/march-2016/getting-to-better-care-and-outcomes-for-diabetes-through-measurement>. Accessed 22 October 2018
52. National Institute of Diabetes and Digestive and Kidney Diseases. Practice transformation for physicians & health care teams [Internet]. Available from <https://www.niddk.nih.gov/health-information/health-communication-programs/ndep/health-care-professionals/practice-transformation/Pages/resourcedetail.aspx>. Accessed 22 October 2018

53. National Institute of Diabetes and Digestive and Kidney Diseases. Diabetes care and quality: past, present, and future [Internet]. Available from <https://www.niddk.nih.gov/health-information/health-communication-programs/ndep/health-care-professionals/practice-transformation/defining-quality-care/diabetes-care-quality/Pages/default.aspx>. Accessed 22 October 2018
54. O'Connor PJ, Sperl-Hillen JM, Fazio CJ, Averbek BM, Rank BH, Margolis KL. Outpatient diabetes clinical decision support: current status and future directions. *Diabet Med* 2016;33:734–741
55. Centers for Medicare & Medicaid Services. CMS Equity Plan for Medicare [Internet]. Available from <https://www.cms.gov/About-CMS/Agency-Information/OMH/equity-initiatives/equity-plan.html>. Accessed 22 October 2018
56. Rosenthal MB, Cutler DM, Feder J. The ACO rules—striking the balance between participation and transformative potential. *N Engl J Med* 2011;365:e6
57. Washington AE, Lipstein SH. The Patient-Centered Outcomes Research Institute—promoting better information, decisions, and health. *N Engl J Med* 2011;365:e31
58. Hutchinson RN, Shin S. Systematic review of health disparities for cardiovascular diseases and associated factors among American Indian and Alaska Native populations. *PLoS One* 2014;9:e80973
59. Borschuk AP, Everhart RS. Health disparities among youth with type 1 diabetes: a systematic review of the current literature. *Fam Syst Health* 2015;33:297–313
60. Walker RJ, Strom Williams J, Egede LE. Influence of race, ethnicity and social determinants of health on diabetes outcomes. *Am J Med Sci* 2016;351:366–373
61. Patel MR, Piette JD, Resnicow K, Kowalski-Dobson T, Heisler M. Social determinants of health, cost-related nonadherence, and cost-reducing behaviors among adults with diabetes: findings from the National Health Interview Survey. *Med Care* 2016;54:796–803
62. Steve SL, Tung EL, Schlichtman JJ, Peek ME. Social disorder in adults with type 2 diabetes: building on race, place, and poverty. *Curr Diab Rep* 2016;16:72
63. World Health Organization Commission on Social Determinants of Health. Closing the gap in a generation: health equity through action on the social determinants of health [Internet], 2008. Geneva, Switzerland, World Health Organization. Available from http://www.who.int/social-determinants/final_report/csdh_finalreport_2008.pdf. Accessed 22 October 2018
64. Hill JO, Galloway JM, Goley A, et al. Socioecological determinants of prediabetes and type 2 diabetes. *Diabetes Care* 2013;36:2430–2439
65. National Academies of Sciences, Engineering, and Medicine. A Framework to Address the Social Determinants of Health [Internet], 2016. Washington, DC, The National Academies Press. Available from <https://www.nap.edu/catalog/21923/a-framework-for-educating-health-professionals-to-address-the-social-determinants-of-health>. Accessed 22 October 2018
66. Institute of Medicine. Capturing social and behavioral domains and measures in electronic health records: phase 2 [Internet], 2014. Washington, DC, The National Academies Press. Available from <https://www.nap.edu/catalog/18951/capturing-social-and-behavioral-domains-and-measures-in-electronic-health-records>. Accessed 22 October 2018
67. Chin MH, Clarke AR, Nocon RS, et al. A roadmap and best practices for organizations to reduce racial and ethnic disparities in health care. *J Gen Intern Med* 2012;27:992–1000
68. National Quality Forum. National voluntary consensus standards for ambulatory care—measuring healthcare disparities [Internet], 2008. Available from https://www.qualityforum.org/Publications/2008/03/National_Voluntary_Consensus_Standards_for_Ambulatory_Care%20%80%94Measuring_Healthcare_Disparities.aspx. Accessed 22 October 2018
69. Piette JD, Heisler M, Wagner TH. Cost-related medication underuse among chronically ill adults: the treatments people forgo, how often, and who is at risk. *Am J Public Health* 2004;94:1782–1787
70. Laiterapong N, Karter AJ, Liu JY, et al. Correlates of quality of life in older adults with diabetes: the Diabetes & Aging Study. *Diabetes Care* 2011;34:1749–1753
71. Heerman WJ, Wallston KA, Osborn CY, et al. Food insecurity is associated with diabetes self-care behaviours and glycaemic control. *Diabet Med* 2016;33:844–850
72. Silverman J, Krieger J, Kiefer M, Hebert P, Robinson J, Nelson K. The relationship between food insecurity and depression, diabetes distress and medication adherence among low-income patients with poorly-controlled diabetes. *J Gen Intern Med* 2015;30:1476–1480
73. Hager ER, Quigg AM, Black MM, et al. Development and validity of a 2-item screen to identify families at risk for food insecurity. *Pediatrics* 2010;126:e26–e32
74. Seligman HK, Schillinger D. Hunger and socioeconomic disparities in chronic disease. *N Engl J Med* 2010;363:6–9
75. Montgomery AE, Fargo JD, Kane V, Culhane DP. Development and validation of an instrument to assess imminent risk of homelessness among veterans. *Public Health Rep* 2014;129:428–436
76. U.S. Department of Health and Human Services. Think cultural health [Internet]. Available from <https://www.thinkculturalhealth.hhs.gov/>. Accessed 22 October 2018
77. Agency for Healthcare Research and Quality. Clinical-community linkages [Internet]. Available from <http://www.ahrq.gov/professionals/prevention-chronic-care/improve/community/index.html>. Accessed 22 October 2018
78. Shah M, Kaselitz E, Heisler M. The role of community health workers in diabetes: update on current literature. *Curr Diab Rep* 2013;13:163–171
79. Heisler M, Vijan S, Makki F, Piette JD. Diabetes control with reciprocal peer support versus nurse care management: a randomized trial. *Ann Intern Med* 2010;153:507–515
80. Long JA, Jahnle EC, Richardson DM, Loewenstein G, Volpp KG. Peer mentoring and financial incentives to improve glucose control in African American veterans: a randomized trial. *Ann Intern Med* 2012;156:416–424
81. Fisher EB, Boothroyd RI, Elstad EA, et al. Peer support of complex health behaviors in prevention and disease management with special reference to diabetes: systematic reviews. *Clin Diabetes Endocrinol* 2017;3:4
82. Foster G, Taylor SJC, Eldridge SE, Ramsay J, Griffiths CJ. Self-management education programmes by lay leaders for people with chronic conditions. *Cochrane Database Syst Rev* 2007;4:CD005108
83. Rosenthal EL, Rush CH, Allen CG; Project on CHW Policy & Practice. Understanding scope and competencies: a contemporary look at the United States community health worker field: progress report of the Community Health Worker (CHW) Core Consensus (C3) Project: building national consensus on CHW core roles, skills, and qualities [Internet], 2016. Available from <http://files.ctctcdn.com/a907c850501/1c1289f0-88cc-49c3-a238-66def942c147.pdf>. Accessed 22 October 2018
84. U.S. Department of Health and Human Services. Community health workers help patients manage diabetes [Internet]. Available from <https://www.thecommunityguide.org/content/community-health-workers-help-patients-manage-diabetes>. Accessed 22 October 2018

2. Classification and Diagnosis of Diabetes: *Standards of Medical Care in Diabetes—2019*

American Diabetes Association

Diabetes Care 2019;42(Suppl. 1):S13–S28 | <https://doi.org/10.2337/dc19-S002>

The American Diabetes Association (ADA) “Standards of Medical Care in Diabetes” includes ADA’s current clinical practice recommendations and is intended to provide the components of diabetes care, general treatment goals and guidelines, and tools to evaluate quality of care. Members of the ADA Professional Practice Committee, a multidisciplinary expert committee, are responsible for updating the Standards of Care annually, or more frequently as warranted. For a detailed description of ADA standards, statements, and reports, as well as the evidence-grading system for ADA’s clinical practice recommendations, please refer to the Standards of Care Introduction. Readers who wish to comment on the Standards of Care are invited to do so at professional.diabetes.org/SOC.

CLASSIFICATION

Diabetes can be classified into the following general categories:

1. Type 1 diabetes (due to autoimmune β -cell destruction, usually leading to absolute insulin deficiency)
2. Type 2 diabetes (due to a progressive loss of β -cell insulin secretion frequently on the background of insulin resistance)
3. Gestational diabetes mellitus (GDM) (diabetes diagnosed in the second or third trimester of pregnancy that was not clearly overt diabetes prior to gestation)
4. Specific types of diabetes due to other causes, e.g., monogenic diabetes syndromes (such as neonatal diabetes and maturity-onset diabetes of the young [MODY]), diseases of the exocrine pancreas (such as cystic fibrosis and pancreatitis), and drug- or chemical-induced diabetes (such as with glucocorticoid use, in the treatment of HIV/AIDS, or after organ transplantation)

This section reviews most common forms of diabetes but is not comprehensive. For additional information, see the American Diabetes Association (ADA) position statement “Diagnosis and Classification of Diabetes Mellitus” (1).

Type 1 diabetes and type 2 diabetes are heterogeneous diseases in which clinical presentation and disease progression may vary considerably. Classification is important for determining therapy, but some individuals cannot be clearly classified as having type 1 or type 2 diabetes at the time of diagnosis. The traditional paradigms of type 2 diabetes occurring only in adults and type 1 diabetes only in children are no longer accurate, as both diseases occur in both age-groups. Children with type 1 diabetes typically present with the hallmark symptoms of polyuria/polydipsia, and approximately one-third present with diabetic ketoacidosis (DKA) (2). The onset of type 1 diabetes may be more variable in adults, and they may not present with the

Suggested citation: American Diabetes Association. 2. Classification and diagnosis of diabetes: Standards of Medical Care in Diabetes—2019. Diabetes Care 2019;42(Suppl. 1):S13–S28

© 2018 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. More information is available at <http://www.diabetesjournals.org/content/license>.

classic symptoms seen in children. Occasionally, patients with type 2 diabetes may present with DKA, particularly ethnic minorities (3). Although difficulties in distinguishing diabetes type may occur in all age-groups at onset, the true diagnosis becomes more obvious over time.

In both type 1 and type 2 diabetes, various genetic and environmental factors can result in the progressive loss of β -cell mass and/or function that manifests clinically as hyperglycemia. Once hyperglycemia occurs, patients with all forms of diabetes are at risk for developing the same chronic complications, although rates of progression may differ. The identification of individualized therapies for diabetes in the future will require better characterization of the many paths to β -cell demise or dysfunction (4).

Characterization of the underlying pathophysiology is more developed in type 1 diabetes than in type 2 diabetes. It is now clear from studies of first-degree relatives of patients with type 1 diabetes that the persistent presence of two or more autoantibodies is an almost certain predictor of clinical hyperglycemia and diabetes. The rate of progression is dependent on the age at first detection of antibody, number of antibodies, antibody specificity, and antibody titer. Glucose and A1C levels rise well before the clinical onset of diabetes, making diagnosis feasible well before the onset of DKA. Three distinct stages of type 1 diabetes can be identified (Table 2.1) and serve as a framework for future research and regulatory decision making (4,5).

The paths to β -cell demise and dysfunction are less well defined in type 2 diabetes, but deficient β -cell insulin secretion, frequently in the setting of insulin resistance, appears to be the common denominator. Characterization

of subtypes of this heterogeneous disorder have been developed and validated in Scandinavian and Northern European populations but have not been confirmed in other ethnic and racial groups. Type 2 diabetes is primarily associated with insulin secretory defects related to inflammation and metabolic stress among other contributors, including genetic factors. Future classification schemes for diabetes will likely focus on the pathophysiology of the underlying β -cell dysfunction and the stage of disease as indicated by glucose status (normal, impaired, or diabetes) (4).

DIAGNOSTIC TESTS FOR DIABETES

Diabetes may be diagnosed based on plasma glucose criteria, either the fasting plasma glucose (FPG) value or the 2-h plasma glucose (2-h PG) value during a 75-g oral glucose tolerance test (OGTT), or A1C criteria (6) (Table 2.2).

Generally, FPG, 2-h PG during 75-g OGTT, and A1C are equally appropriate for diagnostic testing. It should be noted that the tests do not necessarily detect diabetes in the same individuals. The efficacy of interventions for primary prevention of type 2 diabetes (7,8) has primarily been demonstrated among individuals who have impaired glucose tolerance (IGT) with or without elevated fasting glucose, not for individuals with isolated impaired fasting glucose (IFG) or for those with prediabetes defined by A1C criteria.

The same tests may be used to screen for and diagnose diabetes and to detect individuals with prediabetes. Diabetes may be identified anywhere along the spectrum of clinical scenarios: in seemingly low-risk individuals who happen to have glucose testing, in individuals tested based on diabetes risk assessment, and in symptomatic patients.

Fasting and 2-Hour Plasma Glucose

The FPG and 2-h PG may be used to diagnose diabetes (Table 2.2). The concordance between the FPG and 2-h PG tests is imperfect, as is the concordance between A1C and either glucose-based test. Compared with FPG and A1C cut points, the 2-h PG value diagnoses more people with prediabetes and diabetes (9).

A1C

Recommendations

- 2.1** To avoid misdiagnosis or missed diagnosis, the A1C test should be performed using a method that is certified by the NGSP and standardized to the Diabetes Control and Complications Trial (DCCT) assay. **B**
- 2.2** Marked discordance between measured A1C and plasma glucose levels should raise the possibility of A1C assay interference due to hemoglobin variants (i.e., hemoglobinopathies) and consideration of using an assay without interference or plasma blood glucose criteria to diagnose diabetes. **B**
- 2.3** In conditions associated with an altered relationship between A1C and glycemia, such as sickle cell disease, pregnancy (second and third trimesters and the postpartum period), glucose-6-phosphate dehydrogenase deficiency, HIV, hemodialysis, recent blood loss or transfusion, or erythropoietin therapy, only plasma blood glucose criteria should be used to diagnose diabetes. **B**

The A1C test should be performed using a method that is certified by the NGSP (www.ngsp.org) and standardized or traceable to the Diabetes Control and

Table 2.1—Staging of type 1 diabetes (4,5)

	Stage 1	Stage 2	Stage 3
Characteristics	<ul style="list-style-type: none"> • Autoimmunity • Normoglycemia • Presymptomatic 	<ul style="list-style-type: none"> • Autoimmunity • Dysglycemia • Presymptomatic 	<ul style="list-style-type: none"> • New-onset hyperglycemia • Symptomatic
Diagnostic criteria	<ul style="list-style-type: none"> • Multiple autoantibodies • No IGT or IFG 	<ul style="list-style-type: none"> • Multiple autoantibodies • Dysglycemia: IFG and/or IGT • FPG 100–125 mg/dL (5.6–6.9 mmol/L) • 2-h PG 140–199 mg/dL (7.8–11.0 mmol/L) • A1C 5.7–6.4% (39–47 mmol/mol) or $\geq 10\%$ increase in A1C 	<ul style="list-style-type: none"> • Clinical symptoms • Diabetes by standard criteria

Table 2.2—Criteria for the diagnosis of diabetesFPG ≥ 126 mg/dL (7.0 mmol/L). Fasting is defined as no caloric intake for at least 8 h.*

OR

2-h PG ≥ 200 mg/dL (11.1 mmol/L) during OGTT. The test should be performed as described by the WHO, using a glucose load containing the equivalent of 75-g anhydrous glucose dissolved in water.*

OR

A1C $\geq 6.5\%$ (48 mmol/mol). The test should be performed in a laboratory using a method that is NGSP certified and standardized to the DCCT assay.*

OR

In a patient with classic symptoms of hyperglycemia or hyperglycemic crisis, a random plasma glucose ≥ 200 mg/dL (11.1 mmol/L).

*In the absence of unequivocal hyperglycemia, diagnosis requires two abnormal test results from the same sample or in two separate test samples.

Complications Trial (DCCT) reference assay. Although point-of-care A1C assays may be NGSP certified or U.S. Food and Drug Administration approved for diagnosis, proficiency testing is not always mandated for performing the test. Therefore, point-of-care assays approved for diagnostic purposes should only be considered in settings licensed to perform moderate-to-high complexity tests. As discussed in Section 6 “Glycemic Targets,” point-of-care A1C assays may be more generally applied for glucose monitoring.

The A1C has several advantages compared with the FPG and OGTT, including greater convenience (fasting not required), greater preanalytical stability, and less day-to-day perturbations during stress and illness. However, these advantages may be offset by the lower sensitivity of A1C at the designated cut point, greater cost, limited availability of A1C testing in certain regions of the developing world, and the imperfect correlation between A1C and average glucose in certain individuals. The A1C test, with a diagnostic threshold of $\geq 6.5\%$ (48 mmol/mol), diagnoses only 30% of the diabetes cases identified collectively using A1C, FPG, or 2-h PG, according to National Health and Nutrition Examination Survey (NHANES) data (10).

When using A1C to diagnose diabetes, it is important to recognize that A1C is an indirect measure of average blood glucose levels and to take other factors into consideration that may impact hemoglobin glycation independently of glycemia including HIV treatment (11,12), age, race/ethnicity, pregnancy status, genetic background, and anemia/hemoglobinopathies.

Age

The epidemiological studies that formed the basis for recommending A1C to diagnose diabetes included only adult populations (10). However, a recent ADA

clinical guidance concluded that A1C, FPG, or 2-h PG can be used to test for prediabetes or type 2 diabetes in children and adolescents. (see p. S20 SCREENING AND TESTING FOR PREDIABETES AND TYPE 2 DIABETES IN CHILDREN AND ADOLESCENTS for additional information) (13).

Race/Ethnicity/Hemoglobinopathies

Hemoglobin variants can interfere with the measurement of A1C, although most assays in use in the U.S. are unaffected by the most common variants. Marked discrepancies between measured A1C and plasma glucose levels should prompt consideration that the A1C assay may not be reliable for that individual. For patients with a hemoglobin variant but normal red blood cell turnover, such as those with the sickle cell trait, an A1C assay without interference from hemoglobin variants should be used. An updated list of A1C assays with interferences is available at www.ngsp.org/interf.asp.

African Americans heterozygous for the common hemoglobin variant HbS may have, for any given level of mean glycemia, lower A1C by about 0.3% than those without the trait (14). Another genetic variant, X-linked glucose-6-phosphate dehydrogenase G202A, carried by 11% of African Americans, was associated with a decrease in A1C of about 0.8% in homozygous men and 0.7% in homozygous women compared with those without the variant (15).

Even in the absence of hemoglobin variants, A1C levels may vary with race/ethnicity independently of glycemia (16–18). For example, African Americans may have higher A1C levels than non-Hispanic whites with similar fasting and postglucose load glucose levels (19), and A1C levels may be higher for a given mean glucose concentration when measured with continuous glucose monitoring (20). Though conflicting data exists, African

Americans may also have higher levels of fructosamine and glycated albumin and lower levels of 1,5-anhydroglucitol, suggesting that their glycemic burden (particularly postprandially) may be higher (21,22). The association of A1C with risk for complications appears to be similar in African Americans and non-Hispanic whites (23,24).

Other Conditions Altering the Relationship of A1C and Glycemia

In conditions associated with increased red blood cell turnover, such as sickle cell disease, pregnancy (second and third trimesters), glucose-6-phosphate dehydrogenase deficiency (25,26), hemodialysis, recent blood loss or transfusion, or erythropoietin therapy, only plasma blood glucose criteria should be used to diagnose diabetes (27). A1C is less reliable than blood glucose measurement in other conditions such as postpartum (28–30), HIV treated with certain drugs (11), and iron-deficient anemia (31).

Confirming the Diagnosis

Unless there is a clear clinical diagnosis (e.g., patient in a hyperglycemic crisis or with classic symptoms of hyperglycemia and a random plasma glucose ≥ 200 mg/dL [11.1 mmol/L]), diagnosis requires two abnormal test results from the same sample (32) or in two separate test samples. If using two separate test samples, it is recommended that the second test, which may either be a repeat of the initial test or a different test, be performed without delay. For example, if the A1C is 7.0% (53 mmol/mol) and a repeat result is 6.8% (51 mmol/mol), the diagnosis of diabetes is confirmed. If two different tests (such as A1C and FPG) are both above the diagnostic threshold when analyzed from the same sample or in two different test samples, this also confirms the diagnosis. On the other hand, if a patient has discordant results

from two different tests, then the test result that is above the diagnostic cut point should be repeated, with consideration of the possibility of A1C assay interference. The diagnosis is made on the basis of the confirmed test. For example, if a patient meets the diabetes criterion of the A1C (two results $\geq 6.5\%$ [48 mmol/mol]) but not FPG (<126 mg/dL [7.0 mmol/L]), that person should nevertheless be considered to have diabetes.

Since all the tests have preanalytic and analytic variability, it is possible that an abnormal result (i.e., above the diagnostic threshold), when repeated, will produce a value below the diagnostic cut point. This scenario is likely for FPG and 2-h PG if the glucose samples remain at room temperature and are not centrifuged promptly. Because of the potential for preanalytic variability, it is critical that samples for plasma glucose be spun and separated immediately after they are drawn. If patients have test results near the margins of the diagnostic threshold, the health care professional should follow the patient closely and repeat the test in 3–6 months.

TYPE 1 DIABETES

Recommendations

- 2.4** Plasma blood glucose rather than A1C should be used to diagnose the acute onset of type 1 diabetes in individuals with symptoms of hyperglycemia. **E**
- 2.5** Screening for type 1 diabetes risk with a panel of autoantibodies is currently recommended only in the setting of a research trial or in first-degree family members of a proband with type 1 diabetes. **B**
- 2.6** Persistence of two or more autoantibodies predicts clinical diabetes and may serve as an indication for intervention in the setting of a clinical trial. **B**

Diagnosis

In a patient with classic symptoms, measurement of plasma glucose is sufficient to diagnose diabetes (symptoms of hyperglycemia or hyperglycemic crisis plus a random plasma glucose ≥ 200 mg/dL [11.1 mmol/L]). In these cases, knowing the plasma glucose level is critical because, in addition to confirming that symptoms are due to diabetes, it will inform management decisions. Some providers may also want to know the A1C to

determine how long a patient has had hyperglycemia. The criteria to diagnose diabetes are listed in **Table 2.2**.

Immune-Mediated Diabetes

This form, previously called “insulin-dependent diabetes” or “juvenile-onset diabetes,” accounts for 5–10% of diabetes and is due to cellular-mediated autoimmune destruction of the pancreatic β -cells. Autoimmune markers include islet cell autoantibodies and autoantibodies to GAD (GAD65), insulin, the tyrosine phosphatases IA-2 and IA-2 β , and ZnT8. Type 1 diabetes is defined by the presence of one or more of these autoimmune markers. The disease has strong HLA associations, with linkage to the *DQA* and *DQB* genes. These HLA-DR/DQ alleles can be either predisposing or protective.

The rate of β -cell destruction is quite variable, being rapid in some individuals (mainly infants and children) and slow in others (mainly adults). Children and adolescents may present with DKA as the first manifestation of the disease. Others have modest fasting hyperglycemia that can rapidly change to severe hyperglycemia and/or DKA with infection or other stress. Adults may retain sufficient β -cell function to prevent DKA for many years; such individuals eventually become dependent on insulin for survival and are at risk for DKA. At this latter stage of the disease, there is little or no insulin secretion, as manifested by low or undetectable levels of plasma C-peptide. Immune-mediated diabetes commonly occurs in childhood and adolescence, but it can occur at any age, even in the 8th and 9th decades of life.

Autoimmune destruction of β -cells has multiple genetic predispositions and is also related to environmental factors that are still poorly defined. Although patients are not typically obese when they present with type 1 diabetes, obesity should not preclude the diagnosis. People with type 1 diabetes are also prone to other autoimmune disorders such as Hashimoto thyroiditis, Graves disease, Addison disease, celiac disease, vitiligo, autoimmune hepatitis, myasthenia gravis, and pernicious anemia (see Section 4 “Comprehensive Medical Evaluation and Assessment of Comorbidities”).

Idiopathic Type 1 Diabetes

Some forms of type 1 diabetes have no known etiologies. These patients have

permanent insulinopenia and are prone to DKA, but have no evidence of β -cell autoimmunity. Although only a minority of patients with type 1 diabetes fall into this category, of those who do, most are of African or Asian ancestry. Individuals with this form of diabetes suffer from episodic DKA and exhibit varying degrees of insulin deficiency between episodes. This form of diabetes is strongly inherited and is not HLA associated. An absolute requirement for insulin replacement therapy in affected patients may be intermittent.

Screening for Type 1 Diabetes Risk

The incidence and prevalence of type 1 diabetes is increasing (33). Patients with type 1 diabetes often present with acute symptoms of diabetes and markedly elevated blood glucose levels, and approximately one-third are diagnosed with life-threatening DKA (2). Several studies indicate that measuring islet autoantibodies in relatives of those with type 1 diabetes may identify individuals who are at risk for developing type 1 diabetes (5). Such testing, coupled with education about diabetes symptoms and close follow-up, may enable earlier identification of type 1 diabetes onset. A study reported the risk of progression to type 1 diabetes from the time of seroconversion to autoantibody positivity in three pediatric cohorts from Finland, Germany, and the U.S. Of the 585 children who developed more than two autoantibodies, nearly 70% developed type 1 diabetes within 10 years and 84% within 15 years (34). These findings are highly significant because while the German group was recruited from offspring of parents with type 1 diabetes, the Finnish and American groups were recruited from the general population. Remarkably, the findings in all three groups were the same, suggesting that the same sequence of events led to clinical disease in both “sporadic” and familial cases of type 1 diabetes. Indeed, the risk of type 1 diabetes increases as the number of relevant autoantibodies detected increases (35–37).

Although there is currently a lack of accepted screening programs, one should consider referring relatives of those with type 1 diabetes for antibody testing for risk assessment in the setting of a clinical research study (www.diabetestrialnet.org). Widespread clinical testing of asymptomatic low-risk individuals is not currently

recommended due to lack of approved therapeutic interventions. Individuals who test positive should be counseled about the risk of developing diabetes, diabetes symptoms, and DKA prevention. Numerous clinical studies are being conducted to test various methods of preventing type 1 diabetes in those with evidence of autoimmunity (www.clinicaltrials.gov).

PREDIABETES AND TYPE 2 DIABETES

Recommendations

- 2.7** Screening for prediabetes and type 2 diabetes with an informal assessment of risk factors or validated tools should be considered in asymptomatic adults. **B**
- 2.8** Testing for prediabetes and/or type 2 diabetes in asymptomatic people should be considered in adults of any age who are overweight or obese (BMI ≥ 25 kg/m² or ≥ 23 kg/m² in Asian Americans) and who have one or more additional risk factors for diabetes (**Table 2.3**). **B**
- 2.9** For all people, testing should begin at age 45 years. **B**
- 2.10** If tests are normal, repeat testing carried out at a minimum of 3-year intervals is reasonable. **C**
- 2.11** To test for prediabetes and type 2 diabetes, fasting plasma glucose, 2-h plasma glucose during 75-g oral glucose tolerance test, and A1C are equally appropriate. **B**
- 2.12** In patients with prediabetes and type 2 diabetes, identify and, if

appropriate, treat other cardiovascular disease risk factors. **B**

- 2.13** Risk-based screening for prediabetes and/or type 2 diabetes should be considered after the onset of puberty or after 10 years of age, whichever occurs earlier, in children and adolescents who are overweight (BMI ≥ 85 th percentile) or obese (BMI ≥ 95 th percentile) and who have additional risk factors for diabetes. (See **Table 2.4** for evidence grading of risk factors.)

Prediabetes

“Prediabetes” is the term used for individuals whose glucose levels do not meet the criteria for diabetes but are too high to be considered normal (23,24). Patients with prediabetes are defined by the presence of IFG and/or IGT and/or A1C 5.7–6.4% (39–47 mmol/mol) (**Table 2.5**). Prediabetes should not be viewed as a clinical entity in its own right but rather as an increased risk for diabetes and cardiovascular disease (CVD). Criteria for testing for diabetes or prediabetes in asymptomatic adults is outlined in **Table 2.3**. Prediabetes is associated with obesity (especially abdominal or visceral obesity), dyslipidemia with high triglycerides and/or low HDL cholesterol, and hypertension.

Diagnosis

IFG is defined as FPG levels between 100 and 125 mg/dL (between 5.6 and 6.9 mmol/L) (38,39) and IGT as 2-h PG during 75-g OGTT levels between 140 and 199 mg/dL (between 7.8 and 11.0 mmol/L) (40). It should be noted that the

World Health Organization (WHO) and numerous other diabetes organizations define the IFG cutoff at 110 mg/dL (6.1 mmol/L).

As with the glucose measures, several prospective studies that used A1C to predict the progression to diabetes as defined by A1C criteria demonstrated a strong, continuous association between A1C and subsequent diabetes. In a systematic review of 44,203 individuals from 16 cohort studies with a follow-up interval averaging 5.6 years (range 2.8–12 years), those with A1C between 5.5 and 6.0% (between 37 and 42 mmol/mol) had a substantially increased risk of diabetes (5-year incidence from 9 to 25%). Those with an A1C range of 6.0–6.5% (42–48 mmol/mol) had a 5-year risk of developing diabetes between 25 and 50% and a relative risk 20 times higher compared with A1C of 5.0% (31 mmol/mol) (41). In a community-based study of African American and non-Hispanic white adults without diabetes, baseline A1C was a stronger predictor of subsequent diabetes and cardiovascular events than fasting glucose (42). Other analyses suggest that A1C of 5.7% (39 mmol/mol) or higher is associated with a diabetes risk similar to that of the high-risk participants in the Diabetes Prevention Program (DPP) (43), and A1C at baseline was a strong predictor of the development of glucose-defined diabetes during the DPP and its follow-up (44).

Hence, it is reasonable to consider an A1C range of 5.7–6.4% (39–47 mmol/mol) as identifying individuals with prediabetes. Similar to those with IFG and/or IGT, individuals with A1C of 5.7–6.4% (39–47 mmol/mol) should be informed of their increased risk for diabetes

Table 2.3—Criteria for testing for diabetes or prediabetes in asymptomatic adults

- Testing should be considered in overweight or obese (BMI ≥ 25 kg/m² or ≥ 23 kg/m² in Asian Americans) adults who have one or more of the following risk factors:
 - First-degree relative with diabetes
 - High-risk race/ethnicity (e.g., African American, Latino, Native American, Asian American, Pacific Islander)
 - History of CVD
 - Hypertension ($\geq 140/90$ mmHg or on therapy for hypertension)
 - HDL cholesterol level < 35 mg/dL (0.90 mmol/L) and/or a triglyceride level > 250 mg/dL (2.82 mmol/L)
 - Women with polycystic ovary syndrome
 - Physical inactivity
 - Other clinical conditions associated with insulin resistance (e.g., severe obesity, acanthosis nigricans)
- Patients with prediabetes (A1C $\geq 5.7\%$ [39 mmol/mol], IGT, or IFG) should be tested yearly.
- Women who were diagnosed with GDM should have lifelong testing at least every 3 years.
- For all other patients, testing should begin at age 45 years.
- If results are normal, testing should be repeated at a minimum of 3-year intervals, with consideration of more frequent testing depending on initial results and risk status.

Table 2.4—Risk-based screening for type 2 diabetes or prediabetes in asymptomatic children and adolescents in a clinical setting

Testing should be considered in youth* who are overweight ($\geq 85\%$ percentile) or obese ($\geq 95\%$ percentile) **A** and who have one or more additional risk factors based on the strength of their association with diabetes:

- Maternal history of diabetes or GDM during the child's gestation **A**
- Family history of type 2 diabetes in first- or second-degree relative **A**
- Race/ethnicity (Native American, African American, Latino, Asian American, Pacific Islander) **A**
- Signs of insulin resistance or conditions associated with insulin resistance (acanthosis nigricans, hypertension, dyslipidemia, polycystic ovary syndrome, or small-for-gestational-age birth weight) **B**

*After the onset of puberty or after 10 years of age, whichever occurs earlier. If tests are normal, repeat testing at a minimum of 3-year intervals, or more frequently if BMI is increasing, is recommended.

and CVD and counseled about effective strategies to lower their risks (see Section 3 "Prevention or Delay of Type 2 Diabetes"). Similar to glucose measurements, the continuum of risk is curvilinear, so as A1C rises, the diabetes risk rises disproportionately (41). Aggressive interventions and vigilant follow-up should be pursued for those considered at very high risk (e.g., those with A1C $>6.0\%$ [42 mmol/mol]).

Table 2.5 summarizes the categories of prediabetes and **Table 2.3** the criteria for prediabetes testing. The ADA diabetes risk test is an additional option for assessment to determine the appropriateness of testing for diabetes or prediabetes in asymptomatic adults. (**Fig. 2.1**) (diabetes.org/socrisktest). For additional background regarding risk factors and screening for prediabetes, see pp. S18–S20 (SCREENING AND TESTING FOR PREDIABETES AND TYPE 2 DIABETES IN ASYMPTOMATIC ADULTS and SCREENING AND TESTING FOR PREDIABETES AND TYPE 2 DIABETES IN CHILDREN AND ADOLESCENTS).

Type 2 Diabetes

Type 2 diabetes, previously referred to as "noninsulin-dependent diabetes" or "adult-onset diabetes," accounts for 90–95% of all diabetes. This form encompasses individuals who have relative (rather than absolute) insulin deficiency and have peripheral insulin resistance. At least initially, and often throughout their lifetime, these individuals may not need insulin treatment to survive.

There are various causes of type 2 diabetes. Although the specific etiologies

are not known, autoimmune destruction of β -cells does not occur and patients do not have any of the other known causes of diabetes. Most but not all patients with type 2 diabetes are overweight or obese. Excess weight itself causes some degree of insulin resistance. Patients who are not obese or overweight by traditional weight criteria may have an increased percentage of body fat distributed predominantly in the abdominal region.

DKA seldom occurs spontaneously in type 2 diabetes; when seen, it usually arises in association with the stress of another illness such as infection or with the use of certain drugs (e.g., corticosteroids, atypical antipsychotics, and sodium–glucose cotransporter 2 inhibitors) (45,46). Type 2 diabetes frequently goes undiagnosed for many years because hyperglycemia develops gradually and, at earlier stages, is often not severe enough for the patient to notice the classic diabetes symptoms. Nevertheless, even undiagnosed patients are at increased risk of developing macrovascular and microvascular complications.

Whereas patients with type 2 diabetes may have insulin levels that appear normal or elevated, the higher blood glucose levels in these patients would be expected to result in even higher insulin values had their β -cell function been normal. Thus, insulin secretion is defective in these patients and insufficient to compensate for insulin resistance.

Insulin resistance may improve with weight reduction and/or pharmacologic treatment of hyperglycemia but is seldom restored to normal.

The risk of developing type 2 diabetes increases with age, obesity, and lack of physical activity. It occurs more frequently in women with prior GDM, in those with hypertension or dyslipidemia, and in certain racial/ethnic subgroups (African American, American Indian, Hispanic/Latino, and Asian American). It is often associated with a strong genetic predisposition or family history in first-degree relatives, more so than type 1 diabetes. However, the genetics of type 2 diabetes is poorly understood. In adults without traditional risk factors for type 2 diabetes and/or younger age, consider antibody testing to exclude the diagnosis of type 1 diabetes (i.e., GAD).

Screening and Testing for Prediabetes and Type 2 Diabetes in Asymptomatic Adults

Screening for prediabetes and type 2 diabetes risk through an informal assessment of risk factors (**Table 2.3**) or with an assessment tool, such as the ADA risk test (**Fig. 2.1**) (diabetes.org/socrisktest), is recommended to guide providers on whether performing a diagnostic test (**Table 2.2**) is appropriate. Prediabetes and type 2 diabetes meet criteria for conditions in which early detection is appropriate. Both conditions are common and impose significant clinical and public health burdens. There is often a long presymptomatic phase before the diagnosis of type 2 diabetes. Simple tests to detect preclinical disease are readily available. The duration of glycemic burden is a strong predictor of adverse outcomes. There are effective interventions that prevent progression from prediabetes to diabetes (see Section 3 "Prevention or Delay of Type 2 Diabetes") and reduce the risk of diabetes complications

Table 2.5—Criteria defining prediabetes*

FPG 100 mg/dL (5.6 mmol/L) to 125 mg/dL (6.9 mmol/L) (IFG)

OR

2-h PG during 75-g OGTT 140 mg/dL (7.8 mmol/L) to 199 mg/dL (11.0 mmol/L) (IGT)

OR

A1C 5.7–6.4% (39–47 mmol/mol)

*For all three tests, risk is continuous, extending below the lower limit of the range and becoming disproportionately greater at the higher end of the range.

ARE YOU AT RISK FOR TYPE 2 DIABETES?



Diabetes Risk Test

1 How old are you? *Write your score in the box.*

Less than 40 years (0 points)
 40—49 years (1 point)
 50—59 years (2 points)
 60 years or older (3 points)

2 Are you a man or a woman?

Man (1 point) Woman (0 points)

3 If you are a woman, have you ever been diagnosed with gestational diabetes?

Yes (1 point) No (0 points)

4 Do you have a mother, father, sister, or brother with diabetes?

Yes (1 point) No (0 points)

5 Have you ever been diagnosed with high blood pressure?

Yes (1 point) No (0 points)

6 Are you physically active?

Yes (0 points) No (1 point)

7 What is your weight status? (see chart at right)

Height	Weight (lbs.)		
4' 10"	119-142	143-190	191+
4' 11"	124-147	148-197	198+
5' 0"	128-152	153-203	204+
5' 1"	132-157	158-210	211+
5' 2"	136-163	164-217	218+
5' 3"	141-168	169-224	225+
5' 4"	145-173	174-231	232+
5' 5"	150-179	180-239	240+
5' 6"	155-185	186-246	247+
5' 7"	159-190	191-254	255+
5' 8"	164-196	197-261	262+
5' 9"	169-202	203-269	270+
5' 10"	174-208	209-277	278+
5' 11"	179-214	215-285	286+
6' 0"	184-220	221-293	294+
6' 1"	189-226	227-301	302+
6' 2"	194-232	233-310	311+
6' 3"	200-239	240-318	319+
6' 4"	205-245	246-327	328+
	(1 Point)	(2 Points)	(3 Points)

You weigh less than the amount in the left column (0 points)

If you scored 5 or higher:
 You are at increased risk for having type 2 diabetes. However, only your doctor can tell for sure if you do have type 2 diabetes or prediabetes (a condition that precedes type 2 diabetes in which blood glucose levels are higher than normal). Talk to your doctor to see if additional testing is needed.

Add up your score.

Type 2 diabetes is more common in African Americans, Hispanics/Latinos, American Indians, and Asian Americans and Pacific Islanders.

Higher body weights increase diabetes risk for everyone. Asian Americans are at increased diabetes risk at lower body weights than the rest of the general public (about 15 pounds lower).

For more information, visit us at diabetes.org or call 1-800-DIABETES (1-800-342-2383)

Adapted from Bang et al., Ann Intern Med 151:775-783, 2009. Original algorithm was validated without gestational diabetes as part of the model.

Lower Your Risk

The good news is that you can manage your risk for type 2 diabetes. Small steps make a big difference and can help you live a longer, healthier life.

If you are at high risk, your first step is to see your doctor to see if additional testing is needed.

Visit diabetes.org or call 1-800-DIABETES (1-800-342-2383) for information, tips on getting started, and ideas for simple, small steps you can take to help lower your risk.

Visit us on Facebook
[Facebook.com/AmericanDiabetesAssociation](https://www.facebook.com/AmericanDiabetesAssociation)

Figure 2.1—ADA risk test (diabetes.org/socrisktest).

(see Section 10 “Cardiovascular Disease and Risk Management” and Section 11 “Microvascular Complications and Foot Care”).

Approximately one-quarter of people with diabetes in the U.S. and nearly half

of Asian and Hispanic Americans with diabetes are undiagnosed (38,39). Although screening of asymptomatic individuals to identify those with prediabetes or diabetes might seem reasonable, rigorous clinical trials to prove the

effectiveness of such screening have not been conducted and are unlikely to occur.

A large European randomized controlled trial compared the impact of screening for diabetes and intensive

multifactorial intervention with that of screening and routine care (47). General practice patients between the ages of 40 and 69 years were screened for diabetes and randomly assigned by practice to intensive treatment of multiple risk factors or routine diabetes care. After 5.3 years of follow-up, CVD risk factors were modestly but significantly improved with intensive treatment compared with routine care, but the incidence of first CVD events or mortality was not significantly different between the groups (40). The excellent care provided to patients in the routine care group and the lack of an unscreened control arm limited the authors' ability to determine whether screening and early treatment improved outcomes compared with no screening and later treatment after clinical diagnoses. Computer simulation modeling studies suggest that major benefits are likely to accrue from the early diagnosis and treatment of hyperglycemia and cardiovascular risk factors in type 2 diabetes (48); moreover, screening, beginning at age 30 or 45 years and independent of risk factors, may be cost-effective (<\$11,000 per quality-adjusted life-year gained) (49).

Additional considerations regarding testing for type 2 diabetes and prediabetes in asymptomatic patients include the following.

Age

Age is a major risk factor for diabetes. Testing should begin at no later than age 45 years for all patients. Screening should be considered in overweight or obese adults of any age with one or more risk factors for diabetes.

BMI and Ethnicity

In general, BMI ≥ 25 kg/m² is a risk factor for diabetes. However, data suggest that the BMI cut point should be lower for the Asian American population (50,51). The BMI cut points fall consistently between 23 and 24 kg/m² (sensitivity of 80%) for nearly all Asian American subgroups (with levels slightly lower for Japanese Americans). This makes a rounded cut point of 23 kg/m² practical. An argument can be made to push the BMI cut point to lower than 23 kg/m² in favor of increased sensitivity; however, this would lead to an unacceptably low specificity (13.1%). Data from the WHO also suggest that a BMI of ≥ 23 kg/m² should be used to define increased risk in Asian Americans

(52). The finding that one-third to one-half of diabetes in Asian Americans is undiagnosed suggests that testing is not occurring at lower BMI thresholds (53,54).

Evidence also suggests that other populations may benefit from lower BMI cut points. For example, in a large multi-ethnic cohort study, for an equivalent incidence rate of diabetes, a BMI of 30 kg/m² in non-Hispanic whites was equivalent to a BMI of 26 kg/m² in African Americans (55).

Medications

Certain medications, such as glucocorticoids, thiazide diuretics, some HIV medications, and atypical antipsychotics (56), are known to increase the risk of diabetes and should be considered when deciding whether to screen.

Testing Interval

The appropriate interval between screening tests is not known (57). The rationale for the 3-year interval is that with this interval, the number of false-positive tests that require confirmatory testing will be reduced and individuals with false-negative tests will be retested before substantial time elapses and complications develop (57).

Community Screening

Ideally, testing should be carried out within a health care setting because of the need for follow-up and treatment. Community screening outside a health care setting is generally not recommended because people with positive tests may not seek, or have access to, appropriate follow-up testing and care. However, in specific situations where an adequate referral system is established beforehand for positive tests, community screening may be considered. Community testing may also be poorly targeted; i.e., it may fail to reach the groups most at risk and inappropriately test those at very low risk or even those who have already been diagnosed (58).

Screening in Dental Practices

Because periodontal disease is associated with diabetes, the utility of screening in a dental setting and referral to primary care as a means to improve the diagnosis of prediabetes and diabetes has been explored (59–61), with one study estimating that 30% of patients ≥ 30 years of age seen in general dental

practices had dysglycemia (61). Further research is needed to demonstrate the feasibility, effectiveness, and cost-effectiveness of screening in this setting.

Screening and Testing for Prediabetes and Type 2 Diabetes in Children and Adolescents

In the last decade, the incidence and prevalence of type 2 diabetes in adolescents has increased dramatically, especially in racial and ethnic minority populations (33). See **Table 2.4** for recommendations on risk-based screening for type 2 diabetes or prediabetes in asymptomatic children and adolescents in a clinical setting (13). See **Tables 2.2 and 2.5** for the criteria for the diagnosis of diabetes and prediabetes, respectively, which apply to children, adolescents, and adults. See Section 13 "Children and Adolescents" for additional information on type 2 diabetes in children and adolescents.

Some studies question the validity of A1C in the pediatric population, especially among certain ethnicities, and suggest OGTT or FPG as more suitable diagnostic tests (62). However, many of these studies do not recognize that diabetes diagnostic criteria are based on long-term health outcomes, and validations are not currently available in the pediatric population (63). The ADA acknowledges the limited data supporting A1C for diagnosing type 2 diabetes in children and adolescents. Although A1C is not recommended for diagnosis of diabetes in children with cystic fibrosis or symptoms suggestive of acute onset of type 1 diabetes and only A1C assays without interference are appropriate for children with hemoglobinopathies, the ADA continues to recommend A1C for diagnosis of type 2 diabetes in this cohort (64,65).

GESTATIONAL DIABETES MELLITUS

Recommendations

- 2.14** Test for undiagnosed diabetes at the first prenatal visit in those with risk factors using standard diagnostic criteria. **B**
- 2.15** Test for gestational diabetes mellitus at 24–28 weeks of gestation in pregnant women not previously known to have diabetes. **A**
- 2.16** Test women with gestational diabetes mellitus for prediabetes

or diabetes at 4–12 weeks postpartum, using the 75-g oral glucose tolerance test and clinically appropriate nonpregnancy diagnostic criteria. **B**

2.17 Women with a history of gestational diabetes mellitus should have lifelong screening for the development of diabetes or prediabetes at least every 3 years. **B**

2.18 Women with a history of gestational diabetes mellitus found to have prediabetes should receive intensive lifestyle interventions or metformin to prevent diabetes. **A**

Definition

For many years, GDM was defined as any degree of glucose intolerance that was first recognized during pregnancy (40), regardless of whether the condition may have predated the pregnancy or persisted after the pregnancy. This definition facilitated a uniform strategy for detection and classification of GDM, but it was limited by imprecision.

The ongoing epidemic of obesity and diabetes has led to more type 2 diabetes in women of childbearing age, with an increase in the number of pregnant women with undiagnosed type 2 diabetes (66). Because of the number of pregnant women with undiagnosed type 2 diabetes, it is reasonable to test women with risk factors for type 2 diabetes (67)

(**Table 2.3**) at their initial prenatal visit, using standard diagnostic criteria (**Table 2.2**). Women diagnosed with diabetes by standard diagnostic criteria in the first trimester should be classified as having preexisting pregestational diabetes (type 2 diabetes or, very rarely, type 1 diabetes or monogenic diabetes). Women found to have prediabetes in the first trimester may be encouraged to make lifestyle changes to reduce their risk of developing type 2 diabetes, and perhaps GDM, though more study is needed (68). GDM is diabetes that is first diagnosed in the second or third trimester of pregnancy that is not clearly either preexisting type 1 or type 2 diabetes (see Section 14 “Management of Diabetes in Pregnancy”). The International Association of the Diabetes and Pregnancy Study Groups (IADPSG) GDM diagnostic criteria for the 75-g OGTT as well as the GDM screening and diagnostic criteria used in the two-step approach were not derived from data in the first half of pregnancy, so the diagnosis of GDM in early pregnancy by either FPG or OGTT values is not evidence based (69).

Because GDM confers increased risk for the development of type 2 diabetes after delivery (70,71) and because effective prevention interventions are available (72,73), women diagnosed with GDM should receive lifelong screening for prediabetes and type 2 diabetes.

Diagnosis

GDM carries risks for the mother, fetus, and neonate. Not all adverse outcomes are of equal clinical importance. The Hyperglycemia and Adverse Pregnancy Outcome (HAPO) study (74), a large-scale multinational cohort study completed by more than 23,000 pregnant women, demonstrated that risk of adverse maternal, fetal, and neonatal outcomes continuously increased as a function of maternal glycemia at 24–28 weeks of gestation, even within ranges previously considered normal for pregnancy. For most complications, there was no threshold for risk. These results have led to careful reconsideration of the diagnostic criteria for GDM. GDM diagnosis (**Table 2.6**) can be accomplished with either of two strategies:

1. “One-step” 75-g OGTT or
2. “Two-step” approach with a 50-g (nonfasting) screen followed by a 100-g OGTT for those who screen positive

Different diagnostic criteria will identify different degrees of maternal hyperglycemia and maternal/fetal risk, leading some experts to debate, and disagree on, optimal strategies for the diagnosis of GDM.

One-Step Strategy

The IADPSG defined diagnostic cut points for GDM as the average fasting, 1-h, and 2-h PG values during a 75-g OGTT in

Table 2.6—Screening for and diagnosis of GDM

One-step strategy

Perform a 75-g OGTT, with plasma glucose measurement when patient is fasting and at 1 and 2 h, at 24–28 weeks of gestation in women not previously diagnosed with diabetes.

The OGTT should be performed in the morning after an overnight fast of at least 8 h.

The diagnosis of GDM is made when any of the following plasma glucose values are met or exceeded:

- Fasting: 92 mg/dL (5.1 mmol/L)
- 1 h: 180 mg/dL (10.0 mmol/L)
- 2 h: 153 mg/dL (8.5 mmol/L)

Two-step strategy

Step 1: Perform a 50-g GLT (nonfasting), with plasma glucose measurement at 1 h, at 24–28 weeks of gestation in women not previously diagnosed with diabetes.

If the plasma glucose level measured 1 h after the load is ≥ 130 mg/dL, 135 mg/dL, or 140 mg/dL (7.2 mmol/L, 7.5 mmol/L, or 7.8 mmol/L, respectively), proceed to a 100-g OGTT.

Step 2: The 100-g OGTT should be performed when the patient is fasting.

The diagnosis of GDM is made if at least two* of the following four plasma glucose levels (measured fasting and 1 h, 2 h, 3 h during OGTT) are met or exceeded:

	Carpenter-Coustan (86)	or	NDDG (87)
• Fasting	95 mg/dL (5.3 mmol/L)		105 mg/dL (5.8 mmol/L)
• 1 h	180 mg/dL (10.0 mmol/L)		190 mg/dL (10.6 mmol/L)
• 2 h	155 mg/dL (8.6 mmol/L)		165 mg/dL (9.2 mmol/L)
• 3 h	140 mg/dL (7.8 mmol/L)		145 mg/dL (8.0 mmol/L)

NDDG, National Diabetes Data Group. *ACOG notes that one elevated value can be used for diagnosis (82).

women at 24–28 weeks of gestation who participated in the HAPO study at which odds for adverse outcomes reached 1.75 times the estimated odds of these outcomes at the mean fasting, 1-h, and 2-h PG levels of the study population. This one-step strategy was anticipated to significantly increase the incidence of GDM (from 5–6% to 15–20%), primarily because only one abnormal value, not two, became sufficient to make the diagnosis (75). The anticipated increase in the incidence of GDM could have a substantial impact on costs and medical infrastructure needs and has the potential to “medicalize” pregnancies previously categorized as normal. A recent follow-up study of women participating in a blinded study of pregnancy OGTTs found that 11 years after their pregnancies, women who would have been diagnosed with GDM by the one-step approach, as compared with those without, were at 3.4-fold higher risk of developing prediabetes and type 2 diabetes and had children with a higher risk of obesity and increased body fat, suggesting that the larger group of women identified by the one-step approach would benefit from increased screening for diabetes and prediabetes that would accompany a history of GDM (76). Nevertheless, the ADA recommends these diagnostic criteria with the intent of optimizing gestational outcomes because these criteria were the only ones based on pregnancy outcomes rather than end points such as prediction of subsequent maternal diabetes.

The expected benefits to the offspring are inferred from intervention trials that focused on women with lower levels of hyperglycemia than identified using older GDM diagnostic criteria. Those trials found modest benefits including reduced rates of large-for-gestational-age births and preeclampsia (77,78). It is important to note that 80–90% of women being treated for mild GDM in these two randomized controlled trials could be managed with lifestyle therapy alone. The OGTT glucose cutoffs in these two trials overlapped with the thresholds recommended by the IADPSG, and in one trial (78), the 2-h PG threshold (140 mg/dL [7.8 mmol/L]) was lower than the cutoff recommended by the IADPSG (153 mg/dL [8.5 mmol/L]). No randomized controlled trials of identifying and treating GDM using the IADPSG

criteria versus older criteria have been published to date. Data are also lacking on how the treatment of lower levels of hyperglycemia affects a mother’s future risk for the development of type 2 diabetes and her offspring’s risk for obesity, diabetes, and other metabolic disorders. Additional well-designed clinical studies are needed to determine the optimal intensity of monitoring and treatment of women with GDM diagnosed by the one-step strategy (79,80).

Two-Step Strategy

In 2013, the National Institutes of Health (NIH) convened a consensus development conference to consider diagnostic criteria for diagnosing GDM (81). The 15-member panel had representatives from obstetrics/gynecology, maternal-fetal medicine, pediatrics, diabetes research, biostatistics, and other related fields. The panel recommended a two-step approach to screening that used a 1-h 50-g glucose load test (GLT) followed by a 3-h 100-g OGTT for those who screened positive. The American College of Obstetricians and Gynecologists (ACOG) recommends any of the commonly used thresholds of 130, 135, or 140 mg/dL for the 1-h 50-g GLT (82). A systematic review for the U.S. Preventive Services Task Force compared GLT cutoffs of 130 mg/dL (7.2 mmol/L) and 140 mg/dL (7.8 mmol/L) (83). The higher cutoff yielded sensitivity of 70–88% and specificity of 69–89%, while the lower cutoff was 88–99% sensitive and 66–77% specific. Data regarding a cutoff of 135 mg/dL are limited. As for other screening tests, choice of a cutoff is based upon the trade-off between sensitivity and specificity. The use of A1C at 24–28 weeks of gestation as a screening test for GDM does not function as well as the GLT (84).

Key factors cited by the NIH panel in their decision-making process were the lack of clinical trial data demonstrating the benefits of the one-step strategy and the potential negative consequences of identifying a large group of women with GDM, including medicalization of pregnancy with increased health care utilization and costs. Moreover, screening with a 50-g GLT does not require fasting and is therefore easier to accomplish for many women. Treatment of higher-threshold maternal hyperglycemia, as

identified by the two-step approach, reduces rates of neonatal macrosomia, large-for-gestational-age births (85), and shoulder dystocia, without increasing small-for-gestational-age births. ACOG currently supports the two-step approach but notes that one elevated value, as opposed to two, may be used for the diagnosis of GDM (82). If this approach is implemented, the incidence of GDM by the two-step strategy will likely increase markedly. ACOG recommends either of two sets of diagnostic thresholds for the 3-h 100-g OGTT (86,87). Each is based on different mathematical conversions of the original recommended thresholds, which used whole blood and nonenzymatic methods for glucose determination. A secondary analysis of data from a randomized clinical trial of identification and treatment of mild GDM (88) demonstrated that treatment was similarly beneficial in patients meeting only the lower thresholds (86) and in those meeting only the higher thresholds (87). If the two-step approach is used, it would appear advantageous to use the lower diagnostic thresholds as shown in step 2 in **Table 2.6**.

Future Considerations

The conflicting recommendations from expert groups underscore the fact that there are data to support each strategy. A cost-benefit estimation comparing the two strategies concluded that the one-step approach is cost-effective only if patients with GDM receive postdelivery counseling and care to prevent type 2 diabetes (89). The decision of which strategy to implement must therefore be made based on the relative values placed on factors that have yet to be measured (e.g., willingness to change practice based on correlation studies rather than intervention trial results, available infrastructure, and importance of cost considerations).

As the IADPSG criteria (“one-step strategy”) have been adopted internationally, further evidence has emerged to support improved pregnancy outcomes with cost savings (90) and may be the preferred approach. Data comparing population-wide outcomes with one-step versus two-step approaches have been inconsistent to date (91,92). In addition, pregnancies complicated by GDM per the IADPSG criteria, but not recognized as such, have comparable

outcomes to pregnancies diagnosed as GDM by the more stringent two-step criteria (93,94). There remains strong consensus that establishing a uniform approach to diagnosing GDM will benefit patients, caregivers, and policy makers. Longer-term outcome studies are currently underway.

CYSTIC FIBROSIS–RELATED DIABETES

Recommendations

- 2.19** Annual screening for cystic fibrosis–related diabetes with an oral glucose tolerance test should begin by age 10 years in all patients with cystic fibrosis not previously diagnosed with cystic fibrosis–related diabetes. **B**
- 2.20** A1C is not recommended as a screening test for cystic fibrosis–related diabetes. **B**
- 2.21** Patients with cystic fibrosis–related diabetes should be treated with insulin to attain individualized glycemic goals. **A**
- 2.22** Beginning 5 years after the diagnosis of cystic fibrosis–related diabetes, annual monitoring for complications of diabetes is recommended. **E**

Cystic fibrosis–related diabetes (CFRD) is the most common comorbidity in people with cystic fibrosis, occurring in about 20% of adolescents and 40–50% of adults (95). Diabetes in this population, compared with individuals with type 1 or type 2 diabetes, is associated with worse nutritional status, more severe inflammatory lung disease, and greater mortality. Insulin insufficiency is the primary defect in CFRD. Genetically determined β -cell function and insulin resistance associated with infection and inflammation may also contribute to the development of CFRD. Milder abnormalities of glucose tolerance are even more common and occur at earlier ages than CFRD. Whether individuals with IGT should be treated with insulin replacement has not currently been determined. Although screening for diabetes before the age of 10 years can identify risk for progression to CFRD in those with abnormal glucose tolerance, no benefit has been established with respect to

weight, height, BMI, or lung function. Continuous glucose monitoring or HOMA of β -cell function (96) may be more sensitive than OGTT to detect risk for progression to CFRD; however, evidence linking these results to long-term outcomes is lacking, and these tests are not recommended for screening (97).

CFRD mortality has significantly decreased over time, and the gap in mortality between cystic fibrosis patients with and without diabetes has considerably narrowed (98). There are limited clinical trial data on therapy for CFRD. The largest study compared three regimens: premeal insulin aspart, repaglinide, or oral placebo in cystic fibrosis patients with diabetes or abnormal glucose tolerance. Participants all had weight loss in the year preceding treatment; however, in the insulin-treated group, this pattern was reversed, and patients gained 0.39 (\pm 0.21) BMI units ($P = 0.02$). The repaglinide-treated group had initial weight gain, but this was not sustained by 6 months. The placebo group continued to lose weight (99). Insulin remains the most widely used therapy for CFRD (100).

Additional resources for the clinical management of CFRD can be found in the position statement “Clinical Care Guidelines for Cystic Fibrosis–Related Diabetes: A Position Statement of the American Diabetes Association and a Clinical Practice Guideline of the Cystic Fibrosis Foundation, Endorsed by the Pediatric Endocrine Society” (101) and in the International Society for Pediatric and Adolescent Diabetes’s 2014 clinical practice consensus guidelines (102).

POSTTRANSPLANTATION DIABETES MELLITUS

Recommendations

- 2.23** Patients should be screened after organ transplantation for hyperglycemia, with a formal diagnosis of posttransplantation diabetes mellitus being best made once a patient is stable on an immunosuppressive regimen and in the absence of an acute infection. **E**
- 2.24** The oral glucose tolerance test is the preferred test to make a diagnosis of posttransplantation diabetes mellitus. **B**

2.25 Immunosuppressive regimens shown to provide the best outcomes for patient and graft survival should be used, irrespective of posttransplantation diabetes mellitus risk. **E**

Several terms are used in the literature to describe the presence of diabetes following organ transplantation. “New-onset diabetes after transplantation” (NODAT) is one such designation that describes individuals who develop new-onset diabetes following transplant. NODAT excludes patients with pretransplant diabetes that was undiagnosed as well as posttransplant hyperglycemia that resolves by the time of discharge (103). Another term, “posttransplantation diabetes mellitus” (PTDM) (103, 104), describes the presence of diabetes in the posttransplant setting irrespective of the timing of diabetes onset.

Hyperglycemia is very common during the early posttransplant period, with ~90% of kidney allograft recipients exhibiting hyperglycemia in the first few weeks following transplant (103–106). In most cases, such stress- or steroid-induced hyperglycemia resolves by the time of discharge (106,107). Although the use of immunosuppressive therapies is a major contributor to the development of PTDM, the risks of transplant rejection outweigh the risks of PTDM and the role of the diabetes care provider is to treat hyperglycemia appropriately regardless of the type of immunosuppression (103). Risk factors for PTDM include both general diabetes risks (such as age, family history of diabetes, etc.) as well as transplant-specific factors, such as use of immunosuppressant agents (108). Whereas posttransplantation hyperglycemia is an important risk factor for subsequent PTDM, a formal diagnosis of PTDM is optimally made once the patient is stable on maintenance immunosuppression and in the absence of acute infection (106–108). The OGTT is considered the gold standard test for the diagnosis of PTDM (103,104,109, 110). However, screening patients using fasting glucose and/or A1C can identify high-risk patients requiring further assessment and may reduce the number of overall OGTTs required.

Few randomized controlled studies have reported on the short- and long-term

use of antihyperglycemic agents in the setting of PTDM (108,111,112). Most studies have reported that transplant patients with hyperglycemia and PTDM after transplantation have higher rates of rejection, infection, and rehospitalization (106,108,113).

Insulin therapy is the agent of choice for the management of hyperglycemia and diabetes in the hospital setting. After discharge, patients with preexisting diabetes could go back on their pre-transplant regimen if they were in good control before transplantation. Those with previously poor control or with persistent hyperglycemia should continue insulin with frequent home self-monitoring of blood glucose to determine when insulin dose reductions may be needed and when it may be appropriate to switch to noninsulin agents.

No studies to date have established which noninsulin agents are safest or most efficacious in PTDM. The choice of agent is usually made based on the side effect profile of the medication and possible interactions with the patient's immunosuppression regimen (108). Drug

dose adjustments may be required because of decreases in the glomerular filtration rate, a relatively common complication in transplant patients. A small short-term pilot study reported that metformin was safe to use in renal transplant recipients (114), but its safety has not been determined in other types of organ transplant. Thiazolidinediones have been used successfully in patients with liver and kidney transplants, but side effects include fluid retention, heart failure, and osteopenia (115,116). Dipeptidyl peptidase 4 inhibitors do not interact with immunosuppressant drugs and have demonstrated safety in small clinical trials (117,118). Well-designed intervention trials examining the efficacy and safety of these and other antihyperglycemic agents in patients with PTDM are needed.

MONOGENIC DIABETES SYNDROMES

Recommendations

2.26 All children diagnosed with diabetes in the first 6 months of

life should have immediate genetic testing for neonatal diabetes. **A**

2.27 Children and adults, diagnosed in early adulthood, who have diabetes not characteristic of type 1 or type 2 diabetes that occurs in successive generations (suggestive of an autosomal dominant pattern of inheritance) should have genetic testing for maturity-onset diabetes of the young. **A**

2.28 In both instances, consultation with a center specializing in diabetes genetics is recommended to understand the significance of these mutations and how best to approach further evaluation, treatment, and genetic counseling. **E**

Monogenic defects that cause β-cell dysfunction, such as neonatal diabetes and MODY, represent a small fraction of patients with diabetes (<5%). **Table 2.7** describes the most common causes of

Table 2.7—Most common causes of monogenic diabetes (119)

Gene	Inheritance	Clinical features
MODY		
<i>GCK</i>	AD	GCK-MODY: stable, nonprogressive elevated fasting blood glucose; typically does not require treatment; microvascular complications are rare; small rise in 2-h PG level on OGTT (<54 mg/dL [3 mmol/L])
<i>HNF1A</i>	AD	HNF1A-MODY: progressive insulin secretory defect with presentation in adolescence or early adulthood; lowered renal threshold for glucosuria; large rise in 2-h PG level on OGTT (>90 mg/dL [5 mmol/L]); sensitive to sulfonylureas
<i>HNF4A</i>	AD	HNF4A-MODY: progressive insulin secretory defect with presentation in adolescence or early adulthood; may have large birth weight and transient neonatal hypoglycemia; sensitive to sulfonylureas
<i>HNF1B</i>	AD	HNF1B-MODY: developmental renal disease (typically cystic); genitourinary abnormalities; atrophy of the pancreas; hyperuricemia; gout
Neonatal diabetes		
<i>KCNJ11</i>	AD	Permanent or transient: IUGR; possible developmental delay and seizures; responsive to sulfonylureas
<i>INS</i>	AD	Permanent: IUGR; insulin requiring
<i>ABCC8</i>	AD	Permanent or transient: IUGR; rarely developmental delay; responsive to sulfonylureas
6q24 (<i>PLAGL1, HYMA1</i>)	AD for paternal duplications	Transient: IUGR; macroglossia; umbilical hernia; mechanisms include UPD6, paternal duplication or maternal methylation defect; may be treatable with medications other than insulin
<i>GATA6</i>	AD	Permanent: pancreatic hypoplasia; cardiac malformations; pancreatic exocrine insufficiency; insulin requiring
<i>EIF2AK3</i>	AR	Permanent: Wolcott-Rallison syndrome: epiphyseal dysplasia; pancreatic exocrine insufficiency; insulin requiring
<i>FOXP3</i>	X-linked	Permanent: immunodysregulation, polyendocrinopathy, enteropathy X-linked (IPEX) syndrome: autoimmune diabetes; autoimmune thyroid disease; exfoliative dermatitis; insulin requiring

AD, autosomal dominant; AR, autosomal recessive; IUGR, intrauterine growth restriction.

monogenic diabetes. For a comprehensive list of causes, see *Genetic Diagnosis of Endocrine Disorders* (119).

Neonatal Diabetes

Diabetes occurring under 6 months of age is termed “neonatal” or “congenital” diabetes, and about 80–85% of cases can be found to have an underlying monogenic cause (120). Neonatal diabetes occurs much less often after 6 months of age, whereas autoimmune type 1 diabetes rarely occurs before 6 months of age. Neonatal diabetes can either be transient or permanent. Transient diabetes is most often due to overexpression of genes on chromosome 6q24, is recurrent in about half of cases, and may be treatable with medications other than insulin. Permanent neonatal diabetes is most commonly due to autosomal dominant mutations in the genes encoding the Kir6.2 subunit (*KCNJ11*) and SUR1 subunit (*ABCC8*) of the β -cell K_{ATP} channel. Correct diagnosis has critical implications because most patients with K_{ATP} -related neonatal diabetes will exhibit improved glycemic control when treated with high-dose oral sulfonylureas instead of insulin. Insulin gene (*INS*) mutations are the second most common cause of permanent neonatal diabetes, and, while intensive insulin management is currently the preferred treatment strategy, there are important genetic considerations, as most of the mutations that cause diabetes are dominantly inherited.

Maturity-Onset Diabetes of the Young

MODY is frequently characterized by onset of hyperglycemia at an early age (classically before age 25 years, although diagnosis may occur at older ages). MODY is characterized by impaired insulin secretion with minimal or no defects in insulin action (in the absence of coexistent obesity). It is inherited in an autosomal dominant pattern with abnormalities in at least 13 genes on different chromosomes identified to date. The most commonly reported forms are GCK-MODY (MODY2), HNF1A-MODY (MODY3), and HNF4A-MODY (MODY1).

Clinically, patients with GCK-MODY exhibit mild, stable, fasting hyperglycemia and do not require antihyperglycemic therapy except sometimes during pregnancy. Patients with HNF1A- or HNF4A-MODY usually respond well to low doses of sulfonylureas, which are

considered first-line therapy. Mutations or deletions in *HNF1B* are associated with renal cysts and uterine malformations (renal cysts and diabetes [RCAD] syndrome). Other extremely rare forms of MODY have been reported to involve other transcription factor genes including *PDX1* (*IPF1*) and *NEUROD1*.

Diagnosis of Monogenic Diabetes

A diagnosis of one of the three most common forms of MODY, including GCK-MODY, HNF1A-MODY, and HNF4A-MODY, allows for more cost-effective therapy (no therapy for GCK-MODY; sulfonylureas as first-line therapy for HNF1A-MODY and HNF4A-MODY). Additionally, diagnosis can lead to identification of other affected family members.

A diagnosis of MODY should be considered in individuals who have atypical diabetes and multiple family members with diabetes not characteristic of type 1 or type 2 diabetes, although admittedly “atypical diabetes” is becoming increasingly difficult to precisely define in the absence of a definitive set of tests for either type of diabetes. In most cases, the presence of autoantibodies for type 1 diabetes precludes further testing for monogenic diabetes, but the presence of autoantibodies in patients with monogenic diabetes has been reported (121). Individuals in whom monogenic diabetes is suspected should be referred to a specialist for further evaluation if available, and consultation is available from several centers. Readily available commercial genetic testing following the criteria listed below now enables a cost-effective (122), often cost-saving, genetic diagnosis that is increasingly supported by health insurance. A biomarker screening pathway such as the combination of urinary C-peptide/creatinine ratio and antibody screening may aid in determining who should get genetic testing for MODY (123). It is critical to correctly diagnose one of the monogenic forms of diabetes because these patients may be incorrectly diagnosed with type 1 or type 2 diabetes, leading to suboptimal, even potentially harmful, treatment regimens and delays in diagnosing other family members (124). The correct diagnosis is especially critical for those with GCK-MODY mutations where multiple studies have shown that no complications ensue in

the absence of glucose-lowering therapy (125). Genetic counseling is recommended to ensure that affected individuals understand the patterns of inheritance and the importance of a correct diagnosis.

The diagnosis of monogenic diabetes should be considered in children and adults diagnosed with diabetes in early adulthood with the following findings:

- Diabetes diagnosed within the first 6 months of life (with occasional cases presenting later, mostly *INS* and *ABCC8* mutations) (120,126)
- Diabetes without typical features of type 1 or type 2 diabetes (negative diabetes-associated autoantibodies, nonobese, lacking other metabolic features especially with strong family history of diabetes)
- Stable, mild fasting hyperglycemia (100–150 mg/dL [5.5–8.5 mmol/L]), stable A1C between 5.6 and 7.6% (between 38 and 60 mmol/mol), especially if nonobese

References

1. American Diabetes Association. Diagnosis and classification of diabetes mellitus. *Diabetes Care* 2014;37(Suppl. 1):S81–S90
2. Dabelea D, Rewers A, Stafford JM, et al.; SEARCH for Diabetes in Youth Study Group. Trends in the prevalence of ketoacidosis at diabetes diagnosis: the SEARCH for Diabetes in Youth Study. *Pediatrics* 2014;133:e938–e945
3. Newton CA, Raskin P. Diabetic ketoacidosis in type 1 and type 2 diabetes mellitus: clinical and biochemical differences. *Arch Intern Med* 2004;164:1925–1931
4. Skyler JS, Bakris GL, Bonifacio E, et al. Differentiation of diabetes by pathophysiology, natural history, and prognosis. *Diabetes* 2017;66:241–255
5. Insel RA, Dunne JL, Atkinson MA, et al. Staging presymptomatic type 1 diabetes: a scientific statement of JDRF, the Endocrine Society, and the American Diabetes Association. *Diabetes Care* 2015;38:1964–1974
6. International Expert Committee. International Expert Committee report on the role of the A1C assay in the diagnosis of diabetes. *Diabetes Care* 2009;32:1327–1334
7. Knowler WC, Barrett-Connor E, Fowler SE, et al.; Diabetes Prevention Program Research Group. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med* 2002;346:393–403
8. Tuomilehto J, Lindström J, Eriksson JG, et al.; Finnish Diabetes Prevention Study Group. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. *N Engl J Med* 2001;344:1343–1350
9. Meijnikman AS, De Block CEM, Dirinck E, et al. Not performing an OGTT results in significant

- underdiagnosis of (pre)diabetes in a high risk adult Caucasian population. *Int J Obes* 2017;41:1615–1620
10. Cowie CC, Rust KF, Byrd-Holt DD, et al. Prevalence of diabetes and high risk for diabetes using A1C criteria in the U.S. population in 1988–2006. *Diabetes Care* 2010;33:562–568
 11. Eckhardt BJ, Holzman RS, Kwan CK, Baghdadi J, Aberg JA. Glycated hemoglobin A_{1c} as screening for diabetes mellitus in HIV-infected individuals. *AIDS Patient Care STDS* 2012;26:197–201
 12. Kim PS, Woods C, Georgoff P, et al. A1C underestimates glycemia in HIV infection. *Diabetes Care* 2009;32:1591–1593
 13. Arslanian S, Bacha F, Grey M, Marcus MD, White NH, Zeitler P. Evaluation and management of youth-onset type 2 diabetes: a position statement by the American Diabetes Association. *Diabetes Care* 2018;41:2648–2668
 14. Lacy ME, Wellenius GA, Sumner AE, Correa A, Carnethon MR, Liem RI, et al. Association of sickle cell trait with hemoglobin A1c in African Americans. *JAMA* 2017;317:507–515
 15. Wheeler E, Leong A, Liu C-T, et al.; EPIC-CVD Consortium; EPIC-InterAct Consortium; Lifelines Cohort Study. Impact of common genetic determinants of hemoglobin A1c on type 2 diabetes risk and diagnosis in ancestrally diverse populations: a transethnic genome-wide meta-analysis. *PLoS Med* 2017;14:e1002383
 16. Ziemer DC, Kolm P, Weintraub WS, et al. Glucose-independent, black-white differences in hemoglobin A1c levels: a cross-sectional analysis of 2 studies. *Ann Intern Med* 2010;152:770–777
 17. Kumar PR, Bhansali A, Ravikiran M, et al. Utility of glycated hemoglobin in diagnosing type 2 diabetes mellitus: a community-based study. *J Clin Endocrinol Metab* 2010;95:2832–2835
 18. Herman WH. Are there clinical implications of racial differences in HbA_{1c}? Yes, to not consider can do great harm! *Diabetes Care* 2016;39:1458–1461
 19. Herman WH, Ma Y, Uwaifo G, et al.; Diabetes Prevention Program Research Group. Differences in A1C by race and ethnicity among patients with impaired glucose tolerance in the Diabetes Prevention Program. *Diabetes Care* 2007;30:2453–2457
 20. Bergenstal RM, Gal RL, Connor CG, et al.; T1D Exchange Racial Differences Study Group. Racial differences in the relationship of glucose concentrations and hemoglobin A1c levels. *Ann Intern Med* 2017;167:95–102
 21. Selvin E, Steffes MW, Ballantyne CM, Hoogeveen RC, Coresh J, Brancati FL. Racial differences in glycemic markers: a cross-sectional analysis of community-based data. *Ann Intern Med* 2011;154:303–309
 22. Herman WH, Dungan KM, Wolfenbutter BHR, et al. Racial and ethnic differences in mean plasma glucose, hemoglobin A1c, and 1,5-anhydroglucitol in over 2000 patients with type 2 diabetes. *J Clin Endocrinol Metab* 2009;94:1689–1694
 23. Selvin E, Rawlings AM, Bergenstal RM, Coresh J, Brancati FL. No racial differences in the association of glycated hemoglobin with kidney disease and cardiovascular outcomes. *Diabetes Care* 2013;36:2995–3001
 24. Selvin E. Are there clinical implications of racial differences in HbA_{1c}? A difference, to be a difference, must make a difference. *Diabetes Care* 2016;39:1462–1467
 25. Paterson AD. HbA1c for type 2 diabetes diagnosis in Africans and African Americans: personalized medicine NOW! *PLoS Med* 2017;14:e1002384
 26. Cappellini MD, Fiorelli G. Glucose-6-phosphate dehydrogenase deficiency. *Lancet* 2008;371:64–74
 27. Picón MJ, Murri M, Muñoz A, Fernández-García JC, Gomez-Huelgas R, Tinahones FJ. Hemoglobin A_{1c} versus oral glucose tolerance test in postpartum diabetes screening. *Diabetes Care* 2012;35:1648–1653
 28. Göbl CS, Bozkurt L, Yarragudi R, Tura A, Pacini G, Kautzky-Willer A. Is early postpartum HbA1c an appropriate risk predictor after pregnancy with gestational diabetes mellitus? *Acta Diabetol* 2014;51:715–722
 29. Megia A, Näf S, Herranz L, et al. The usefulness of HbA1c in postpartum reclassification of gestational diabetes. *BJOG* 2012;119:891–894
 30. Welsh KJ, Kirkman MS, Sacks DB. Role of glycated proteins in the diagnosis and management of diabetes: research gaps and future directions. *Diabetes Care* 2016;39:1299–1306
 31. Kim C, Bullard KM, Herman WH, Beckles GL. Association between iron deficiency and A1C levels among adults without diabetes in the National Health and Nutrition Examination Survey, 1999–2006. *Diabetes Care* 2010;33:780–785
 32. Selvin E, Wang D, Matsushita K, Grams ME, Coresh J. Prognostic implications of single-sample confirmatory testing for undiagnosed diabetes: a prospective cohort study. *Ann Intern Med* 2018;169:156–164
 33. Dabelea D, Mayer-Davis EJ, Saydah S, et al.; SEARCH for Diabetes in Youth Study. Prevalence of type 1 and type 2 diabetes among children and adolescents from 2001 to 2009. *JAMA* 2014;311:1778–1786
 34. Ziegler AG, Rewers M, Simell O, et al. Seroreversion to multiple islet autoantibodies and risk of progression to diabetes in children. *JAMA* 2013;309:2473–2479
 35. Sosenko JM, Skyler JS, Palmer JP, et al.; Type 1 Diabetes TrialNet Study Group; Diabetes Prevention Trial-Type 1 Study Group. The prediction of type 1 diabetes by multiple autoantibody levels and their incorporation into an autoantibody risk score in relatives of type 1 diabetic patients. *Diabetes Care* 2013;36:2615–2620
 36. Steck AK, Vehik K, Bonifacio E, et al.; TEDDY Study Group. Predictors of progression from the appearance of islet autoantibodies to early childhood diabetes: The Environmental Determinants of Diabetes in the Young (TEDDY). *Diabetes Care* 2015;38:808–813
 37. Orban T, Sosenko JM, Cuthbertson D, et al.; Diabetes Prevention Trial-Type 1 Study Group. Pancreatic islet autoantibodies as predictors of type 1 diabetes in the Diabetes Prevention Trial-Type 1. *Diabetes Care* 2009;32:2269–2274
 38. Genuth S, Alberti KG, Bennett P, et al.; Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. Follow-up report on the diagnosis of diabetes mellitus. *Diabetes Care* 2003;26:3160–3167
 39. American Diabetes Association. Diagnosis and classification of diabetes mellitus. *Diabetes Care* 2011;34(Suppl. 1):S62–S69
 40. Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. *Diabetes Care* 1997;20:1183–1197
 41. Zhang X, Gregg EW, Williamson DF, et al. A1C level and future risk of diabetes: a systematic review. *Diabetes Care* 2010;33:1665–1673
 42. Selvin E, Steffes MW, Zhu H, et al. Glycated hemoglobin, diabetes, and cardiovascular risk in nondiabetic adults. *N Engl J Med* 2010;362:800–811
 43. Ackermann RT, Cheng YJ, Williamson DF, Gregg EW. Identifying adults at high risk for diabetes and cardiovascular disease using hemoglobin A1c National Health and Nutrition Examination Survey 2005–2006. *Am J Prev Med* 2011;40:11–17
 44. Diabetes Prevention Program Research Group. HbA_{1c} as a predictor of diabetes and as an outcome in the Diabetes Prevention Program: a randomized clinical trial. *Diabetes Care* 2015;38:51–58
 45. Umptierrez G, Korytkowski M. Diabetic emergencies - ketoacidosis, hyperglycaemic hyperosmolar state and hypoglycaemia. *Nat Rev Endocrinol* 2016;12:222–232
 46. Fadini GP, Bonora BM, Avogaro A. SGLT2 inhibitors and diabetic ketoacidosis: data from the FDA Adverse Event Reporting System. *Diabetologia* 2017;60:1385–1389
 47. Griffin SJ, Borch-Johnsen K, Davies MJ, et al. Effect of early intensive multifactorial therapy on 5-year cardiovascular outcomes in individuals with type 2 diabetes detected by screening (ADDITION-Europe): a cluster-randomised trial. *Lancet* 2011;378:156–167
 48. Herman WH, Ye W, Griffin SJ, et al. Early detection and treatment of type 2 diabetes reduce cardiovascular morbidity and mortality: a simulation of the results of the Anglo-Danish-Dutch Study of Intensive Treatment in People with Screen-Detected Diabetes in Primary Care (ADDITION-Europe). *Diabetes Care* 2015;38:1449–1455
 49. Kahn R, Alperin P, Eddy D, et al. Age at initiation and frequency of screening to detect type 2 diabetes: a cost-effectiveness analysis. *Lancet* 2010;375:1365–1374
 50. Araneta MRG, Kanaya A, Fujimoto W, et al. Optimum BMI cut-points to screen Asian Americans for type 2 diabetes: The UCSF Filipino Health Study and the North Kohala Study [Abstract]. *Diabetes* 2014;63(Suppl. 1):A20
 51. Hsu WC, Araneta MRG, Kanaya AM, Chiang JL, Fujimoto W. BMI cut points to identify at-risk Asian Americans for type 2 diabetes screening. *Diabetes Care* 2015;38:150–158
 52. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* 2004;363:157–163
 53. Menke A, Casagrande S, Geiss L, Cowie CC. Prevalence of and trends in diabetes among adults in the United States, 1988–2012. *JAMA* 2015;314:1021–1029
 54. Centers for Disease Control and Prevention. National diabetes statistics report: estimates of diabetes and its burden in the United States, 2017 [Internet]. Available from <https://www.cdc.gov/diabetes/data/statistics/statistics-report.html>. Accessed 20 September 2018

55. Chiu M, Austin PC, Manuel DG, Shah BR, Tu JV. Deriving ethnic-specific BMI cutoff points for assessing diabetes risk. *Diabetes Care* 2011;34:1741–1748
56. Erickson SC, Le L, Zakharyan A, et al. New-onset treatment-dependent diabetes mellitus and hyperlipidemia associated with atypical antipsychotic use in older adults without schizophrenia or bipolar disorder. *J Am Geriatr Soc* 2012;60:474–479
57. Johnson SL, Tabaei BP, Herman WH. The efficacy and cost of alternative strategies for systematic screening for type 2 diabetes in the U.S. population 45–74 years of age. *Diabetes Care* 2005;28:307–311
58. Tabaei BP, Burke R, Constance A, et al. Community-based screening for diabetes in Michigan. *Diabetes Care* 2003;26:668–670
59. Lalla E, Kunzel C, Burkett S, Cheng B, Lamster IB. Identification of unrecognized diabetes and pre-diabetes in a dental setting. *J Dent Res* 2011;90:855–860
60. Lalla E, Cheng B, Kunzel C, Burkett S, Lamster IB. Dental findings and identification of undiagnosed hyperglycemia. *J Dent Res* 2013;92:888–892
61. Herman WH, Taylor GW, Jacobson JJ, Burke R, Brown MB. Screening for prediabetes and type 2 diabetes in dental offices. *J Public Health Dent* 2015;75:175–182
62. Buse JB, Kaufman FR, Linder B, Hirst K, El Ghormli L, Willi S; HEALTHY Study Group. Diabetes screening with hemoglobin A_{1c} versus fasting plasma glucose in a multiethnic middle-school cohort. *Diabetes Care* 2013;36:429–435
63. Kapadia C, Zeitler P; Drugs and Therapeutics Committee of the Pediatric Endocrine Society. Hemoglobin A1c measurement for the diagnosis of type 2 diabetes in children. *Int J Pediatr Endocrinol* 2012;2012:31
64. Kester LM, Hey H, Hannon TS. Using hemoglobin A1c for prediabetes and diabetes diagnosis in adolescents: can adult recommendations be upheld for pediatric use? *J Adolesc Health* 2012;50:321–323
65. Wu E-L, Kazzi NG, Lee JM. Cost-effectiveness of screening strategies for identifying pediatric diabetes mellitus and dysglycemia. *JAMA Pediatr* 2013;167:32–39
66. Lawrence JM, Contreras R, Chen W, Sacks DA. Trends in the prevalence of preexisting diabetes and gestational diabetes mellitus among a racially/ethnically diverse population of pregnant women, 1999–2005. *Diabetes Care* 2008;31:899–904
67. Poltavskiy E, Kim DJ, Bang H. Comparison of screening scores for diabetes and prediabetes. *Diabetes Res Clin Pract* 2016;118:146–153
68. Hughes RCE, Rowan J, Williman J. Prediabetes in pregnancy, can early intervention improve outcomes? A feasibility study for a parallel randomised clinical trial. *BMJ Open* 2018;8:e018493
69. McIntyre HD, Sacks DA, Barbour LA, et al. Issues with the diagnosis and classification of hyperglycemia in early pregnancy. *Diabetes Care* 2016;39:53–54
70. Noctor E, Crowe C, Carmody LA, et al.; ATLANTIC-DIP investigators. Abnormal glucose tolerance post-gestational diabetes mellitus as defined by the International Association of Diabetes and Pregnancy Study Groups criteria. *Eur J Endocrinol* 2016;175:287–297
71. Kim C, Newton KM, Knopp RH. Gestational diabetes and the incidence of type 2 diabetes: a systematic review. *Diabetes Care* 2002;25:1862–1868
72. Ratner RE, Christophi CA, Metzger BE, et al.; Diabetes Prevention Program Research Group. Prevention of diabetes in women with a history of gestational diabetes: effects of metformin and lifestyle interventions. *J Clin Endocrinol Metab* 2008;93:4774–4779
73. Aroda VR, Christophi CA, Edelstein SL, et al.; Diabetes Prevention Program Research Group. The effect of lifestyle intervention and metformin on preventing or delaying diabetes among women with and without gestational diabetes: the Diabetes Prevention Program Outcomes Study 10-year follow-up. *J Clin Endocrinol Metab* 2015;100:1646–1653
74. Metzger BE, Lowe LP, Dyer AR, et al.; HAPO Study Cooperative Research Group. Hyperglycemia and adverse pregnancy outcomes. *N Engl J Med* 2008;358:1991–2002
75. Sacks DA, Hadden DR, Maresh M, et al.; HAPO Study Cooperative Research Group. Frequency of gestational diabetes mellitus at collaborating centers based on IADPSG consensus panel-recommended criteria: the Hyperglycemia and Adverse Pregnancy Outcome (HAPO) Study. *Diabetes Care* 2012;35:526–528
76. Lowe WL Jr, Scholtens DM, Lowe LP, et al.; HAPO Follow-up Study Cooperative Research Group. Association of gestational diabetes with maternal disorders of glucose metabolism and childhood adiposity. *JAMA* 2018;320:1005–1016
77. Landon MB, Spong CY, Thom E, et al.; Eunice Kennedy Shriver National Institute of Child Health and Human Development Maternal-Fetal Medicine Units Network. A multicenter, randomized trial of treatment for mild gestational diabetes. *N Engl J Med* 2009;361:1339–1348
78. Crowther CA, Hiller JE, Moss JR, McPhee AJ, Jeffries WS, Robinson JS; Australian Carbohydrate Intolerance Study in Pregnant Women (ACHOIS) Trial Group. Effect of treatment of gestational diabetes mellitus on pregnancy outcomes. *N Engl J Med* 2005;352:2477–2486
79. Tam WH, Ma RCW, Ozaki R, et al. In utero exposure to maternal hyperglycemia increases childhood cardiometabolic risk in offspring. *Diabetes Care* 2017;40:679–686
80. Landon MB, Rice MM, Varner MW, et al.; Eunice Kennedy Shriver National Institute of Child Health and Human Development Maternal-Fetal Medicine Units (MFMU) Network. Mild gestational diabetes mellitus and long-term child health. *Diabetes Care* 2015;38:445–452
81. Vandersten JP, Dodson WC, Espeland MA, et al. NIH consensus development conference: diagnosing gestational diabetes mellitus. *NIH Consens State Sci Statements* 2013;29:1–31
82. Committee on Practice Bulletins—Obstetrics. Practice Bulletin No. 190: gestational diabetes mellitus. *Obstet Gynecol* 2018;131:e49–e64
83. Donovan L, Hartling L, Muise M, Guthrie A, Vandermeer B, Dryden DM. Screening tests for gestational diabetes: a systematic review for the U.S. Preventive Services Task Force. *Ann Intern Med* 2013;159:115–122
84. Khalafallah A, Phuah E, Al-Barazan AM, et al. Glycosylated haemoglobin for screening and diagnosis of gestational diabetes mellitus. *BMJ Open* 2016;6:e011059
85. Horvath K, Koch K, Jeitler K, et al. Effects of treatment in women with gestational diabetes mellitus: systematic review and meta-analysis. *BMJ* 2010;340:c1395
86. Carpenter MW, Coustan DR. Criteria for screening tests for gestational diabetes. *Am J Obstet Gynecol* 1982;144:768–773
87. National Diabetes Data Group. Classification and diagnosis of diabetes mellitus and other categories of glucose intolerance. *Diabetes* 1979;28:1039–1057
88. Harper LM, Mele L, Landon MB, et al.; Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) Maternal-Fetal Medicine Units (MFMU) Network. Carpenter-Coustan compared with National Diabetes Data Group criteria for diagnosing gestational diabetes. *Obstet Gynecol* 2016;127:893–898
89. Werner EF, Pettker CM, Zuckerwise L, et al. Screening for gestational diabetes mellitus: are the criteria proposed by the International Association of the Diabetes and Pregnancy Study Groups cost-effective? *Diabetes Care* 2012;35:529–535
90. Duran A, Sáenz S, Torrejón MJ, et al. Introduction of IADPSG criteria for the screening and diagnosis of gestational diabetes mellitus results in improved pregnancy outcomes at a lower cost in a large cohort of pregnant women: the St. Carlos Gestational Diabetes Study. *Diabetes Care* 2014;37:2442–2450
91. Wei Y, Yang H, Zhu W, et al. International Association of Diabetes and Pregnancy Study Group criteria is suitable for gestational diabetes mellitus diagnosis: further evidence from China. *Chin Med J (Engl)* 2014;127:3553–3556
92. Feldman RK, Tieu RS, Yasumura L. Gestational diabetes screening: the International Association of the Diabetes and Pregnancy Study Groups compared with Carpenter-Coustan screening. *Obstet Gynecol* 2016;127:10–17
93. Ethridge JK Jr, Catalano PM, Waters TP. Perinatal outcomes associated with the diagnosis of gestational diabetes made by the International Association of the Diabetes and Pregnancy Study Groups criteria. *Obstet Gynecol* 2014;124:571–578
94. Mayo K, Melamed N, Vandenberghe H, Berger H. The impact of adoption of the international association of diabetes in pregnancy study group criteria for the screening and diagnosis of gestational diabetes. *Am J Obstet Gynecol* 2015;212:224.e1–224.e9
95. Moran A, Pillay K, Becker D, Granados A, Hameed S, Acerini CL. ISPAD Clinical Practice Consensus Guidelines 2018: management of cystic fibrosis-related diabetes in children and adolescents. *Pediatr Diabetes* 2018;19(Suppl. 27):64–74
96. Mainguy C, Bellon G, Delaup V, et al. Sensitivity and specificity of different methods for cystic fibrosis-related diabetes screening: is the oral glucose tolerance test still the standard? *J Pediatr Endocrinol Metab* 2017;30:27–35

97. Ode KL, Moran A. New insights into cystic fibrosis-related diabetes in children. *Lancet Diabetes Endocrinol* 2013;1:52–58
98. Moran A, Dunitz J, Nathan B, Saeed A, Holme B, Thomas W. Cystic fibrosis-related diabetes: current trends in prevalence, incidence, and mortality. *Diabetes Care* 2009;32:1626–1631
99. Moran A, Pekow P, Grover P, et al.; Cystic Fibrosis Related Diabetes Therapy Study Group. Insulin therapy to improve BMI in cystic fibrosis-related diabetes without fasting hyperglycemia: results of the Cystic Fibrosis Related Diabetes Therapy Trial. *Diabetes Care* 2009;32:1783–1788
100. Onady GM, Stolfi A. Insulin and oral agents for managing cystic fibrosis-related diabetes. *Cochrane Database Syst Rev* 2016;4:CD004730
101. Moran A, Brunzell C, Cohen RC, et al.; CFRD Guidelines Committee. Clinical care guidelines for cystic fibrosis-related diabetes: a position statement of the American Diabetes Association and a clinical practice guideline of the Cystic Fibrosis Foundation, endorsed by the Pediatric Endocrine Society. *Diabetes Care* 2010;33:2697–2708
102. Moran A, Pillay K, Becker DJ, Acerini CL; International Society for Pediatric and Adolescent Diabetes. ISPAD Clinical Practice Consensus Guidelines 2014. Management of cystic fibrosis-related diabetes in children and adolescents. *Pediatr Diabetes* 2014;15(Suppl. 20):65–76
103. Sharif A, Hecking M, de Vries APJ, et al. Proceedings from an international consensus meeting on posttransplantation diabetes mellitus: recommendations and future directions. *Am J Transplant* 2014;14:1992–2000
104. Hecking M, Werzowa J, Haidinger M, et al. Novel views on new-onset diabetes after transplantation: development, prevention and treatment. *Nephrol Dial Transplant* 2013;28:550–566
105. Ramirez SC, Maaske J, Kim Y, et al. The association between glycemic control and clinical outcomes after kidney transplantation. *Endocr Pract* 2014;20:894–900
106. Thomas MC, Moran J, Mathew TH, Russ GR, Rao MM. Early peri-operative hyperglycaemia and renal allograft rejection in patients without diabetes. *BMC Nephrol* 2000;1:1
107. Chakkerla HA, Weil EJ, Castro J, et al. Hyperglycemia during the immediate period after kidney transplantation. *Clin J Am Soc Nephrol* 2009;4:853–859
108. Wallia A, Illuri V, Molitch ME. Diabetes care after transplant: definitions, risk factors, and clinical management. *Med Clin North Am* 2016;100:535–550
109. Sharif A, Moore RH, Baboolal K. The use of oral glucose tolerance tests to risk stratify for new-onset diabetes after transplantation: an underdiagnosed phenomenon. *Transplantation* 2006;82:1667–1672
110. Hecking M, Kainz A, Werzowa J, et al. Glucose metabolism after renal transplantation. *Diabetes Care* 2013;36:2763–2771
111. Galindo RJ, Fried M, Breen T, Tamler R. Hyperglycemia management in patients with posttransplantation diabetes. *Endocr Pract* 2016;22:454–465
112. Jenssen T, Hartmann A. Emerging treatments for post-transplantation diabetes mellitus. *Nat Rev Nephrol* 2015;11:465–477
113. Thomas MC, Mathew TH, Russ GR, Rao MM, Moran J. Early peri-operative glycaemic control and allograft rejection in patients with diabetes mellitus: a pilot study. *Transplantation* 2001;72:1321–1324
114. Kurian B, Joshi R, Helmuth A. Effectiveness and long-term safety of thiazolidinediones and metformin in renal transplant recipients. *Endocr Pract* 2008;14:979–984
115. Budde K, Neumayer H-H, Fritsche L, Sulowicz W, Stompör T, Eckland D. The pharmacokinetics of pioglitazone in patients with impaired renal function. *Br J Clin Pharmacol* 2003;55:368–374
116. Luther P, Baldwin D Jr. Pioglitazone in the management of diabetes mellitus after transplantation. *Am J Transplant* 2004;4:2135–2138
117. Strøm Halden TA, Åsberg A, Vik K, Hartmann A, Jenssen T. Short-term efficacy and safety of sitagliptin treatment in long-term stable renal recipients with new-onset diabetes after transplantation. *Nephrol Dial Transplant* 2014;29:926–933
118. Lane JT, Odegaard DE, Haire CE, Collier DS, Wrenshall LE, Stevens RB. Sitagliptin therapy in kidney transplant recipients with new-onset diabetes after transplantation. *Transplantation* 2011;92:e56–e57
119. Carmody D, Støy J, Greeley SA, Bell GI, Philipson LH. A clinical guide to monogenic diabetes. In *Genetic Diagnosis of Endocrine Disorders*. 2nd ed. Weiss RE, Refetoff S, Eds. Philadelphia, PA, Elsevier, 2016
120. De Franco E, Flanagan SE, Houghton JAL, et al. The effect of early, comprehensive genomic testing on clinical care in neonatal diabetes: an international cohort study. *Lancet* 2015;386:957–963
121. Urbanová J, Rypáčková B, Procházková Z, et al. Positivity for islet cell autoantibodies in patients with monogenic diabetes is associated with later diabetes onset and higher HbA1c level. *Diabet Med* 2014;31:466–471
122. Naylor RN, John PM, Winn AN, et al. Cost-effectiveness of MODY genetic testing: translating genomic advances into practical health applications. *Diabetes Care* 2014;37:202–209
123. Shields BM, Shepherd M, Hudson M, et al.; UNITED study team. Population-based assessment of a biomarker-based screening pathway to aid diagnosis of monogenic diabetes in young-onset patients. *Diabetes Care* 2017;40:1017–1025
124. Hattersley A, Bruining J, Shield J, Njolstad P, Donaghue KC. The diagnosis and management of monogenic diabetes in children and adolescents. *Pediatr Diabetes* 2009;10(Suppl. 12):33–42
125. Rubio-Cabezas O, Hattersley AT, Njolstad PR, et al.; International Society for Pediatric and Adolescent Diabetes. ISPAD Clinical Practice Consensus Guidelines 2014. The diagnosis and management of monogenic diabetes in children and adolescents. *Pediatr Diabetes* 2014;15(Suppl. 20):47–64
126. Greeley SAW, Naylor RN, Philipson LH, Bell GI. Neonatal diabetes: an expanding list of genes allows for improved diagnosis and treatment. *Curr Diab Rep* 2011;11:519–532

3. Prevention or Delay of Type 2 Diabetes: *Standards of Medical Care in Diabetes—2019*

American Diabetes Association

Diabetes Care 2019;42(Suppl. 1):S29–S33 | <https://doi.org/10.2337/dc19-S003>

The American Diabetes Association (ADA) “Standards of Medical Care in Diabetes” includes ADA’s current clinical practice recommendations and is intended to provide the components of diabetes care, general treatment goals and guidelines, and tools to evaluate quality of care. Members of the ADA Professional Practice Committee, a multidisciplinary expert committee, are responsible for updating the Standards of Care annually, or more frequently as warranted. For a detailed description of ADA standards, statements, and reports, as well as the evidence-grading system for ADA’s clinical practice recommendations, please refer to the Standards of Care Introduction. Readers who wish to comment on the Standards of Care are invited to do so at professional.diabetes.org/SOC.

For guidelines related to screening for increased risk for type 2 diabetes (prediabetes), please refer to Section 2 “Classification and Diagnosis of Diabetes.”

Recommendation

3.1 At least annual monitoring for the development of type 2 diabetes in those with prediabetes is suggested. **E**

Screening for prediabetes and type 2 diabetes risk through an informal assessment of risk factors (**Table 2.3**) or with an assessment tool, such as the American Diabetes Association risk test (**Fig. 2.1**), is recommended to guide providers on whether performing a diagnostic test for prediabetes (**Table 2.5**) and previously undiagnosed type 2 diabetes (**Table 2.2**) is appropriate (see Section 2 “Classification and Diagnosis of Diabetes”). Those determined to be at high risk for type 2 diabetes, including people with A1C 5.7–6.4% (39–47 mmol/mol), impaired glucose tolerance, or impaired fasting glucose, are ideal candidates for diabetes prevention efforts. Using A1C to screen for prediabetes may be problematic in the presence of certain hemoglobinopathies or conditions that affect red blood cell turnover. See Section 2 “Classification and Diagnosis of Diabetes” and Section 6 “Glycemic Targets” for additional details on the appropriate use of the A1C test.

At least annual monitoring for the development of diabetes in those with prediabetes is suggested.

LIFESTYLE INTERVENTIONS

Recommendations

3.2 Refer patients with prediabetes to an intensive behavioral lifestyle intervention program modeled on the Diabetes Prevention Program (DPP) to achieve

Suggested citation: American Diabetes Association. 3. Prevention or delay of type 2 diabetes: Standards of Medical Care in Diabetes—2019. Diabetes Care 2019;42(Suppl. 1):S29–S33

© 2018 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. More information is available at <http://www.diabetesjournals.org/content/license>.

and maintain 7% loss of initial body weight and increase moderate-intensity physical activity (such as brisk walking) to at least 150 min/week. **A**

3.3 Based on patient preference, technology-assisted diabetes prevention interventions may be effective in preventing type 2 diabetes and should be considered. **B**

3.4 Given the cost-effectiveness of diabetes prevention, such intervention programs should be covered by third-party payers. **B**

The Diabetes Prevention Program

Several major randomized controlled trials, including the Diabetes Prevention Program (DPP) (1), the Finnish Diabetes Prevention Study (DPS) (2), and the Da Qing Diabetes Prevention Study (Da Qing study) (3), demonstrate that lifestyle/behavioral therapy featuring an individualized reduced calorie meal plan is highly effective in preventing type 2 diabetes and improving other cardiometabolic markers (such as blood pressure, lipids, and inflammation). The strongest evidence for diabetes prevention comes from the DPP trial (1). The DPP demonstrated that an intensive lifestyle intervention could reduce the incidence of type 2 diabetes by 58% over 3 years. Follow-up of three large studies of lifestyle intervention for diabetes prevention has shown sustained reduction in the rate of conversion to type 2 diabetes: 45% reduction at 23 years in the Da Qing study (3), 43% reduction at 7 years in the DPS (2), and 34% reduction at 10 years (4) and 27% reduction at 15 years (5) in the U.S. Diabetes Prevention Program Outcomes Study (DPPPOS). Notably, in the 23-year follow-up for the Da Qing study, reductions in all-cause mortality and cardiovascular disease-related mortality were observed for the lifestyle intervention groups compared with the control group (3).

The two major goals of the DPP intensive, behavioral, lifestyle intervention were to achieve and maintain a minimum of 7% weight loss and 150 min of physical activity similar in intensity to brisk walking per week. The DPP lifestyle intervention was a goal-based intervention: all participants were given the same weight loss and physical activity goals, but individualization was permitted in the

specific methods used to achieve the goals (6).

The 7% weight loss goal was selected because it was feasible to achieve and maintain and likely to lessen the risk of developing diabetes. Participants were encouraged to achieve the 7% weight loss during the first 6 months of the intervention. However, longer-term (4-year) data reveal maximal prevention of diabetes observed at about 7–10% weight loss (7). The recommended pace of weight loss was 1–2 lb/week. Calorie goals were calculated by estimating the daily calories needed to maintain the participant's initial weight and subtracting 500–1,000 calories/day (depending on initial body weight). The initial focus was on reducing total dietary fat. After several weeks, the concept of calorie balance and the need to restrict calories as well as fat was introduced (6).

The goal for physical activity was selected to approximate at least 700 kcal/week expenditure from physical activity. For ease of translation, this goal was described as at least 150 min of moderate-intensity physical activity per week similar in intensity to brisk walking. Participants were encouraged to distribute their activity throughout the week with a minimum frequency of three times per week with at least 10 min per session. A maximum of 75 min of strength training could be applied toward the total 150 min/week physical activity goal (6).

To implement the weight loss and physical activity goals, the DPP used an individual model of treatment rather than a group-based approach. This choice was based on a desire to intervene before participants had the possibility of developing diabetes or losing interest in the program. The individual approach also allowed for tailoring of interventions to reflect the diversity of the population (6).

The DPP intervention was administered as a structured core curriculum followed by a more flexible maintenance program of individual sessions, group classes, motivational campaigns, and restart opportunities. The 16-session core curriculum was completed within the first 24 weeks of the program and included sections on lowering calories, increasing physical activity, self-monitoring, maintaining healthy lifestyle behaviors, and psychological, social, and motivational challenges. For further details on the core curriculum sessions, refer to ref. 6.

Nutrition

Structured behavioral weight loss therapy, including a reduced calorie meal plan and physical activity, is of paramount importance for those at high risk for developing type 2 diabetes who have overweight or obesity (1,7). Because weight loss through lifestyle changes alone can be difficult to maintain long term (4), people being treated with weight loss therapy should have access to ongoing support and additional therapeutic options (such as pharmacotherapy) if needed. Based on intervention trials, the eating patterns that may be helpful for those with prediabetes include a Mediterranean eating plan (8–11) and a low-calorie, low-fat eating plan (5). Additional research is needed regarding whether a low-carbohydrate eating plan is beneficial for persons with prediabetes (12). In addition, evidence suggests that the overall quality of food consumed (as measured by the Alternative Healthy Eating Index), with an emphasis on whole grains, legumes, nuts, fruits and vegetables, and minimal refined and processed foods, is also important (13–15).

Whereas overall healthy low-calorie eating patterns should be encouraged, there is also some evidence that particular dietary components impact diabetes risk in observational studies. Higher intakes of nuts (16), berries (17), yogurt (18,19), coffee, and tea (20) are associated with reduced diabetes risk. Conversely, red meats and sugar-sweetened beverages are associated with an increased risk of type 2 diabetes (13).

As is the case for those with diabetes, individualized medical nutrition therapy (see Section 5 “Lifestyle Management” for more detailed information) is effective in lowering A1C in individuals diagnosed with prediabetes (21).

Physical Activity

Just as 150 min/week of moderate-intensity physical activity, such as brisk walking, showed beneficial effects in those with prediabetes (1), moderate-intensity physical activity has been shown to improve insulin sensitivity and reduce abdominal fat in children and young adults (22,23). On the basis of these findings, providers are encouraged to promote a DPP-style program, including its focus on physical activity, to all individuals who have been identified

to be at an increased risk of type 2 diabetes. In addition to aerobic activity, an exercise regimen designed to prevent diabetes may include resistance training (6,24). Breaking up prolonged sedentary time may also be encouraged, as it is associated with moderately lower postprandial glucose levels (25,26). The preventive effects of exercise appear to extend to the prevention of gestational diabetes mellitus (GDM) (27).

Technology-Assisted Interventions to Deliver Lifestyle Interventions

Technology-assisted interventions may effectively deliver the DPP lifestyle intervention, reducing weight and, therefore, diabetes risk (28–31). Such technology-assisted interventions may deliver content through smartphone and web-based applications and telehealth (28). The Centers for Disease Control and Prevention (CDC) Diabetes Prevention Recognition Program (DPRP) (www.cdc.gov/diabetes/prevention/lifestyle-program) does certify technology-assisted modalities as effective vehicles for DPP-based interventions; such programs must use an approved curriculum, include interaction with a coach (which may be virtual), and attain the DPRP outcomes of participation, physical activity reporting, and weight loss. The selection of an in-person or virtual program should be based on patient preference.

Cost-effectiveness

A cost-effectiveness model suggested that the lifestyle intervention used in the DPP was cost-effective (32,33). Actual cost data from the DPP and DPPOS confirmed this (34). Group delivery of DPP content in community or primary care settings has the potential to reduce overall program costs while still producing weight loss and diabetes risk reduction (35–37). The use of community health workers to support DPP efforts has been shown to be effective with cost savings (38) (see Section 1 “Improving Care and Promoting Health in Populations” for more information). The CDC coordinates the National Diabetes Prevention Program (National DPP), a resource designed to bring evidence-based lifestyle change programs for preventing type 2 diabetes to communities (www.cdc.gov/diabetes/prevention/index.htm). Early results from the CDC’s National DPP during the first 4 years of implementation

are promising (39). In an effort to expand preventive services using a cost-effective model that began in April 2018, the Centers for Medicare & Medicaid Services has expanded Medicare reimbursement coverage for the National DPP lifestyle intervention to organizations recognized by the CDC that become Medicare suppliers for this service (<https://innovation.cms.gov/initiatives/medicare-diabetes-prevention-program/>).

Tobacco Use

Smoking may increase the risk of type 2 diabetes (40); therefore, evaluation for tobacco use and referral for tobacco cessation, if indicated, should be part of routine care for those at risk for diabetes. Of note, the years immediately following smoking cessation may represent a time of increased risk for diabetes (40–42) and patients should be monitored for diabetes development and receive evidence-based interventions for diabetes prevention as described in this section. See Section 5 “Lifestyle Management” for more detailed information.

PHARMACOLOGIC INTERVENTIONS

Recommendations

- 3.5** Metformin therapy for prevention of type 2 diabetes should be considered in those with prediabetes, especially for those with BMI ≥ 35 kg/m², those aged <60 years, and women with prior gestational diabetes mellitus. **A**
- 3.6** Long-term use of metformin may be associated with biochemical vitamin B12 deficiency, and periodic measurement of vitamin B12 levels should be considered in metformin-treated patients, especially in those with anemia or peripheral neuropathy. **B**

Pharmacologic agents including metformin, α -glucosidase inhibitors, glucagon-like peptide 1 receptor agonists, thiazolidinediones, and several agents approved for weight loss have been shown in research studies to decrease the incidence of diabetes to various degrees in those with prediabetes (1,43–49), though none are approved by the U.S. Food and Drug

Administration specifically for diabetes prevention. One has to balance the risk/benefit of each medication. Metformin has the strongest evidence base (50) and demonstrated long-term safety as pharmacologic therapy for diabetes prevention (48). For other drugs, cost, side effects, and durable efficacy require consideration.

Metformin was overall less effective than lifestyle modification in the DPP and DPPOS, though group differences declined over time (5) and metformin may be cost-saving over a 10-year period (34). It was as effective as lifestyle modification in participants with BMI ≥ 35 kg/m² but not significantly better than placebo in those over 60 years of age (1). In the DPP, for women with history of GDM, metformin and intensive lifestyle modification led to an equivalent 50% reduction in diabetes risk (51), and both interventions remained highly effective during a 10-year follow-up period (52). In the Indian Diabetes Prevention Programme (IDPP-1), metformin and the lifestyle intervention reduced diabetes risk similarly at 30 months; of note, the lifestyle intervention in IDPP-1 was less intensive than that in the DPP (53). Based on findings from the DPP, metformin should be recommended as an option for high-risk individuals (e.g., those with a history of GDM or those with BMI ≥ 35 kg/m²). Consider monitoring vitamin B12 levels in those taking metformin chronically to check for possible deficiency (54) (see Section 9 “Pharmacologic Approaches to Glycemic Treatment” for more details).

PREVENTION OF CARDIOVASCULAR DISEASE

Recommendation

- 3.7** Prediabetes is associated with heightened cardiovascular risk; therefore, screening for and treatment of modifiable risk factors for cardiovascular disease is suggested. **B**

People with prediabetes often have other cardiovascular risk factors, including hypertension and dyslipidemia (55), and are at increased risk for cardiovascular disease (56). Although treatment goals for people with prediabetes are the same as for the general population (57), increased vigilance is warranted to identify

and treat these and other cardiovascular risk factors (e.g., smoking).

DIABETES SELF-MANAGEMENT EDUCATION AND SUPPORT

Recommendation

3.8 Diabetes self-management education and support programs may be appropriate venues for people with prediabetes to receive education and support to develop and maintain behaviors that can prevent or delay the development of type 2 diabetes. **B**

As for those with established diabetes, the standards for diabetes self-management education and support (see Section 5 “Lifestyle Management”) can also apply to people with prediabetes. Currently, there are significant barriers to the provision of education and support to those with prediabetes. However, the strategies for supporting successful behavior change and the healthy behaviors recommended for people with prediabetes are comparable to those for diabetes. Although reimbursement remains a barrier, studies show that providers of diabetes self-management education and support are particularly well equipped to assist people with prediabetes in developing and maintaining behaviors that can prevent or delay the development of diabetes (21,58).

References

- Knowler WC, Barrett-Connor E, Fowler SE, et al.; Diabetes Prevention Program Research Group. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med* 2002;346:393–403
- Lindström J, Ilanne-Parikka P, Peltonen M, et al.; Finnish Diabetes Prevention Study Group. Sustained reduction in the incidence of type 2 diabetes by lifestyle intervention: follow-up of the Finnish Diabetes Prevention Study. *Lancet* 2006;368:1673–1679
- Li G, Zhang P, Wang J, et al. Cardiovascular mortality, all-cause mortality, and diabetes incidence after lifestyle intervention for people with impaired glucose tolerance in the Da Qing Diabetes Prevention Study: a 23-year follow-up study. *Lancet Diabetes Endocrinol* 2014;2:474–480
- Knowler WC, Fowler SE, Hamman RF, et al.; Diabetes Prevention Program Research Group. 10-year follow-up of diabetes incidence and weight loss in the Diabetes Prevention Program Outcomes Study. *Lancet* 2009;374:1677–1686
- Nathan DM, Barrett-Connor E, Crandall JP, et al. Long-term effects of lifestyle intervention or metformin on diabetes development and microvascular complications over 15-year follow-up: the Diabetes Prevention Program Outcomes Study. *Lancet Diabetes Endocrinol* 2015;3:866–875
- Diabetes Prevention Program (DPP) Research Group. The Diabetes Prevention Program (DPP): description of lifestyle intervention. *Diabetes Care* 2002;25:2165–2171
- Hamman RF, Wing RR, Edelstein SL, et al. Effect of weight loss with lifestyle intervention on risk of diabetes. *Diabetes Care* 2006;29:2102–2107
- Salas-Salvadó J, Bulló M, Babio N, et al.; PREDIMED Study Investigators. Reduction in the incidence of type 2 diabetes with the Mediterranean diet: results of the PREDIMED-Reus nutrition intervention randomized trial. *Diabetes Care* 2011;34:14–19
- Salas-Salvadó J, Guasch-Ferré M, Lee C-H, Estruch R, Clish CB, Ros E. Protective effects of the Mediterranean diet on type 2 diabetes and metabolic syndrome. *J Nutr* 2016;146:920S–927S
- Bloomfield HE, Koeller E, Greer N, MacDonald R, Kane R, Wilt TJ. Effects on health outcomes of a Mediterranean diet with no restriction on fat intake: a systematic review and meta-analysis. *Ann Intern Med* 2016;165:491–500
- Estruch R, Ros E, Salas-Salvadó J, et al.; PREDIMED Study Investigators. Primary prevention of cardiovascular disease with a Mediterranean diet supplemented with extra-virgin olive oil or nuts. *N Engl J Med* 2018;378:e34
- Noto H, Goto A, Tsujimoto T, Noda M. Long-term low-carbohydrate diets and type 2 diabetes risk: a systematic review and meta-analysis of observational studies. *J Gen Fam Med* 2016;17:60–70
- Ley SH, Hamdy O, Mohan V, Hu FB. Prevention and management of type 2 diabetes: dietary components and nutritional strategies. *Lancet* 2014;383:1999–2007
- Jacobs S, Harmon BE, Boushey CJ, et al. A priori-defined diet quality indexes and risk of type 2 diabetes: the Multiethnic Cohort. *Diabetologia* 2015;58:98–112
- Chiuve SE, Fung TT, Rimm EB, et al. Alternative dietary indices both strongly predict risk of chronic disease. *J Nutr* 2012;142:1009–1018
- Afshin A, Micha R, Khatibzadeh S, Mozaffarian D. Consumption of nuts and legumes and risk of incident ischemic heart disease, stroke, and diabetes: a systematic review and meta-analysis. *Am J Clin Nutr* 2014;100:278–288
- Mursu J, Virtanen JK, Tuomainen T-P, Nurmi T, Voutilainen S. Intake of fruit, berries, and vegetables and risk of type 2 diabetes in Finnish men: the Kuopio Ischaemic Heart Disease Risk Factor Study. *Am J Clin Nutr* 2014;99:328–333
- Chen M, Sun Q, Giovannucci E, et al. Dairy consumption and risk of type 2 diabetes: 3 cohorts of US adults and an updated meta-analysis. *BMC Med* 2014;12:215
- Dehghan M, Mente A, Rangarajan S, et al.; Prospective Urban Rural Epidemiology (PURE) study investigators. Association of dairy intake with cardiovascular disease and mortality in 21 countries from five continents (PURE): a prospective cohort study. *Lancet*. 11 September 2018 [Epub ahead of print]. DOI: 10.1016/S0140-6736(18)31812-9
- Mozaffarian D. Dietary and policy priorities for cardiovascular disease, diabetes, and obesity: a comprehensive review. *Circulation* 2016;133:187–225
- Parker AR, Byham-Gray L, Denmark R, Winkle PJ. The effect of medical nutrition therapy by a registered dietitian nutritionist in patients with prediabetes participating in a randomized controlled clinical research trial. *J Acad Nutr Diet* 2014;114:1739–1748
- Fedewa MV, Gist NH, Evans EM, Dishman RK. Exercise and insulin resistance in youth: a meta-analysis. *Pediatrics* 2014;133:e163–e174
- Davis CL, Pollock NK, Waller JL, et al. Exercise dose and diabetes risk in overweight and obese children: a randomized controlled trial. *JAMA* 2012;308:1103–1112
- Sigal RJ, Alberga AS, Goldfield GS, et al. Effects of aerobic training, resistance training, or both on percentage body fat and cardiometabolic risk markers in obese adolescents: the healthy eating aerobic and resistance training in youth randomized clinical trial. *JAMA Pediatr* 2014;168:1006–1014
- Thorp AA, Kingwell BA, Sethi P, Hammond L, Owen N, Dunstan DW. Alternating bouts of sitting and standing attenuate postprandial glucose responses. *Med Sci Sports Exerc* 2014;46:2053–2061
- Healy GN, Dunstan DW, Salmon J, et al. Breaks in sedentary time: beneficial associations with metabolic risk. *Diabetes Care* 2008;31:661–666
- Russo LM, Nobles C, Ertel KA, Chasan-Taber L, Whitcomb BW. Physical activity interventions in pregnancy and risk of gestational diabetes mellitus: a systematic review and meta-analysis. *Obstet Gynecol* 2015;125:576–582
- Grock S, Ku J-H, Kim J, Moin T. A review of technology-assisted interventions for diabetes prevention. *Curr Diab Rep* 2017;17:107
- Sepah SC, Jiang L, Peters AL. Translating the Diabetes Prevention Program into an online social network: validation against CDC standards. *Diabetes Educ* 2014;40:435–443
- Bian RR, Piatt GA, Sen A, et al. The effect of technology-mediated diabetes prevention interventions on weight: a meta-analysis. *J Med Internet Res* 2017;19:e76
- Sepah SC, Jiang L, Peters AL. Long-term outcomes of a Web-based diabetes prevention program: 2-year results of a single-arm longitudinal study. *J Med Internet Res* 2015;17:e92
- Herman WH, Hoerger TJ, Brandle M, et al.; Diabetes Prevention Program Research Group. The cost-effectiveness of lifestyle modification or metformin in preventing type 2 diabetes in adults with impaired glucose tolerance. *Ann Intern Med* 2005;142:323–332
- Chen F, Su W, Becker SH, et al. Clinical and economic impact of a digital, remotely-delivered intensive behavioral counseling program on Medicare beneficiaries at risk for diabetes and cardiovascular disease. *PLoS One* 2016;11:e0163627
- Diabetes Prevention Program Research Group. The 10-year cost-effectiveness of lifestyle intervention or metformin for diabetes prevention: an intent-to-treat analysis of the DPP/DPPOS. *Diabetes Care* 2012;35:723–730
- Ackermann RT, Finch EA, Brizendine E, Zhou H, Marrero DG. Translating the Diabetes

- Prevention Program into the community. The DEPLOY Pilot Study. *Am J Prev Med* 2008;35:357–363
36. Balk EM, Earley A, Raman G, Avendano EA, Pittas AG, Remington PL. Combined diet and physical activity promotion programs to prevent type 2 diabetes among persons at increased risk: a systematic review for the Community Preventive Services Task Force. *Ann Intern Med* 2015;163:437–451
37. Li R, Qu S, Zhang P, et al. Economic evaluation of combined diet and physical activity promotion programs to prevent type 2 diabetes among persons at increased risk: a systematic review for the Community Preventive Services Task Force. *Ann Intern Med* 2015;163:452–460
38. The Community Guide. Diabetes prevention: interventions engaging community health workers [Internet], 2016. Available from <https://www.thecommunityguide.org/findings/diabetes-prevention-interventions-engaging-community-health-workers>. Accessed 25 September 2018
39. Ely EK, Gruss SM, Luman ET, et al. A national effort to prevent type 2 diabetes: participant-level evaluation of CDC's National Diabetes Prevention Program. *Diabetes Care* 2017;40:1331–1341
40. Yeh H-C, Duncan BB, Schmidt MI, Wang N-Y, Brancati FL. Smoking, smoking cessation, and risk for type 2 diabetes mellitus: a cohort study. *Ann Intern Med* 2010;152:10–17
41. Oba S, Noda M, Waki K, et al. Smoking cessation increases short-term risk of type 2 diabetes irrespective of weight gain: the Japan Public Health Center-Based Prospective Study [published correction appears in *PLoS One* 2013;8:10.1371/annotation/23aa7c42-9a4d-42a7-8f50-9d0ac4b85396]. *PLoS One* 2012;7:e17061
42. Hu Y, Zong G, Liu G, et al. Smoking cessation, weight change, type 2 diabetes, and mortality. *N Engl J Med* 2018;379:623–632
43. Chiasson J-L, Josse RG, Gomis R, Hanefeld M, Karasik A, Laakso M; STOP-NIDDM Trial Research Group. Acarbose for prevention of type 2 diabetes mellitus: the STOP-NIDDM randomised trial. *Lancet* 2002;359:2072–2077
44. Torgerson JS, Hauptman J, Boldrin MN, Sjöström L. XENical in the prevention of Diabetes in Obese Subjects (XENDOS) study: a randomized study of orlistat as an adjunct to lifestyle changes for the prevention of type 2 diabetes in obese patients. *Diabetes Care* 2004;27:155–161
45. le Roux CW, Astrup A, Fujioka K, et al.; SCALE Obesity Prediabetes NN8022-1839 Study Group. 3 years of liraglutide versus placebo for type 2 diabetes risk reduction and weight management in individuals with prediabetes: a randomised, double-blind trial. *Lancet* 2017;389:1399–1409
46. Gerstein HC, Yusuf S, Bosch J, et al.; DREAM (Diabetes REduction Assessment with ramipril and rosiglitazone Medication) Trial Investigators. Effect of rosiglitazone on the frequency of diabetes in patients with impaired glucose tolerance or impaired fasting glucose: a randomised controlled trial. *Lancet* 2006;368:1096–1105
47. DeFronzo RA, Tripathy D, Schwenke DC, et al.; ACT NOW Study. Pioglitazone for diabetes prevention in impaired glucose tolerance. *N Engl J Med* 2011;364:1104–1115
48. Diabetes Prevention Program Research Group. Long-term safety, tolerability, and weight loss associated with metformin in the Diabetes Prevention Program Outcomes Study. *Diabetes Care* 2012;35:731–737
49. Garvey WT, Ryan DH, Henry R, et al. Prevention of type 2 diabetes in subjects with prediabetes and metabolic syndrome treated with phentermine and topiramate extended release. *Diabetes Care* 2014;37:912–921
50. Moin T, Schmittiel JA, Flory JH, et al. Review of metformin use for type 2 diabetes prevention. *Am J Prev Med* 2018;55:565–574
51. Ratner RE, Christophi CA, Metzger BE, et al.; Diabetes Prevention Program Research Group. Prevention of diabetes in women with a history of gestational diabetes: effects of metformin and lifestyle interventions. *J Clin Endocrinol Metab* 2008;93:4774–4779
52. Aroda VR, Christophi CA, Edelstein SL, et al.; Diabetes Prevention Program Research Group. The effect of lifestyle intervention and metformin on preventing or delaying diabetes among women with and without gestational diabetes: the Diabetes Prevention Program Outcomes Study 10-year follow-up. *J Clin Endocrinol Metab* 2015;100:1646–1653
53. Ramachandran A, Snehalatha C, Mary S, Mukesh B, Bhaskar AD, Vijay V; Indian Diabetes Prevention Programme (IDPP). The Indian Diabetes Prevention Programme shows that lifestyle modification and metformin prevent type 2 diabetes in Asian Indian subjects with impaired glucose tolerance (IDPP-1). *Diabetologia* 2006;49:289–297
54. Aroda VR, Edelstein SL, Goldberg RB, et al.; Diabetes Prevention Program Research Group. Long-term metformin use and vitamin B12 deficiency in the Diabetes Prevention Program Outcomes Study. *J Clin Endocrinol Metab* 2016;101:1754–1761
55. Ali MK, Bullard KM, Saydah S, Imperatore G, Gregg EW. Cardiovascular and renal burdens of prediabetes in the USA: analysis of data from serial cross-sectional surveys, 1988–2014. *Lancet Diabetes Endocrinol* 2018;6:392–403
56. Huang Y, Cai X, Mai W, Li M, Hu Y. Association between prediabetes and risk of cardiovascular disease and all cause mortality: systematic review and meta-analysis. *BMJ* 2016;355:i5953
57. Bress AP, King JB, Kreider KE, et al.; SPRINT Research Group. Effect of intensive versus standard blood pressure treatment according to baseline prediabetes status: a post hoc analysis of a randomized trial. *Diabetes Care* 2017;40:1401–1408
58. Butcher MK, Vanderwood KK, Hall TO, Gohdes D, Helgersson SD, Harwell TS. Capacity of diabetes education programs to provide both diabetes self-management education and to implement diabetes prevention services. *J Public Health Manag Pract* 2011;17:242–247

4. Comprehensive Medical Evaluation and Assessment of Comorbidities: *Standards of Medical Care in Diabetes—2019*

American Diabetes Association

Diabetes Care 2019;42(Suppl. 1):S34–S45 | <https://doi.org/10.2337/dc19-S004>

The American Diabetes Association (ADA) “Standards of Medical Care in Diabetes” includes ADA’s current clinical practice recommendations and is intended to provide the components of diabetes care, general treatment goals and guidelines, and tools to evaluate quality of care. Members of the ADA Professional Practice Committee, a multidisciplinary expert committee, are responsible for updating the Standards of Care annually, or more frequently as warranted. For a detailed description of ADA standards, statements, and reports, as well as the evidence-grading system for ADA’s clinical practice recommendations, please refer to the Standards of Care Introduction. Readers who wish to comment on the Standards of Care are invited to do so at professional.diabetes.org/SOC.

PATIENT-CENTERED COLLABORATIVE CARE

Recommendations

- 4.1** A patient-centered communication style that uses person-centered and strength-based language and active listening, elicits patient preferences and beliefs, and assesses literacy, numeracy, and potential barriers to care should be used to optimize patient health outcomes and health-related quality of life. **B**
- 4.2** Diabetes care should be managed by a multidisciplinary team that may draw from primary care physicians, subspecialty physicians, nurse practitioners, physician assistants, nurses, dietitians, exercise specialists, pharmacists, dentists, podiatrists, and mental health professionals. **E**

A successful medical evaluation depends on beneficial interactions between the patient and the care team. The Chronic Care Model (1–3) (see Section 1 “Improving Care and Promoting Health in Populations”) is a patient-centered approach to care that requires a close working relationship between the patient and clinicians involved in treatment planning. People with diabetes should receive health care from an interdisciplinary team that may include physicians, nurse practitioners, physician assistants, nurses, dietitians, exercise specialists, pharmacists, dentists, podiatrists, and mental health professionals. Individuals with diabetes must assume an active role in their care. The patient, family or support people, physicians, and health care team should together formulate the management plan, which includes lifestyle management (see Section 5 “Lifestyle Management”).

The goals of treatment for diabetes are to prevent or delay complications and maintain quality of life (**Fig. 4.1**). Treatment goals and plans should be created

Suggested citation: American Diabetes Association. 4. Comprehensive medical evaluation and assessment of comorbidities: Standards of Medical Care in Diabetes—2019. Diabetes Care 2019;42(Suppl. 1):S34–S45

© 2018 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. More information is available at <http://www.diabetesjournals.org/content/license>.

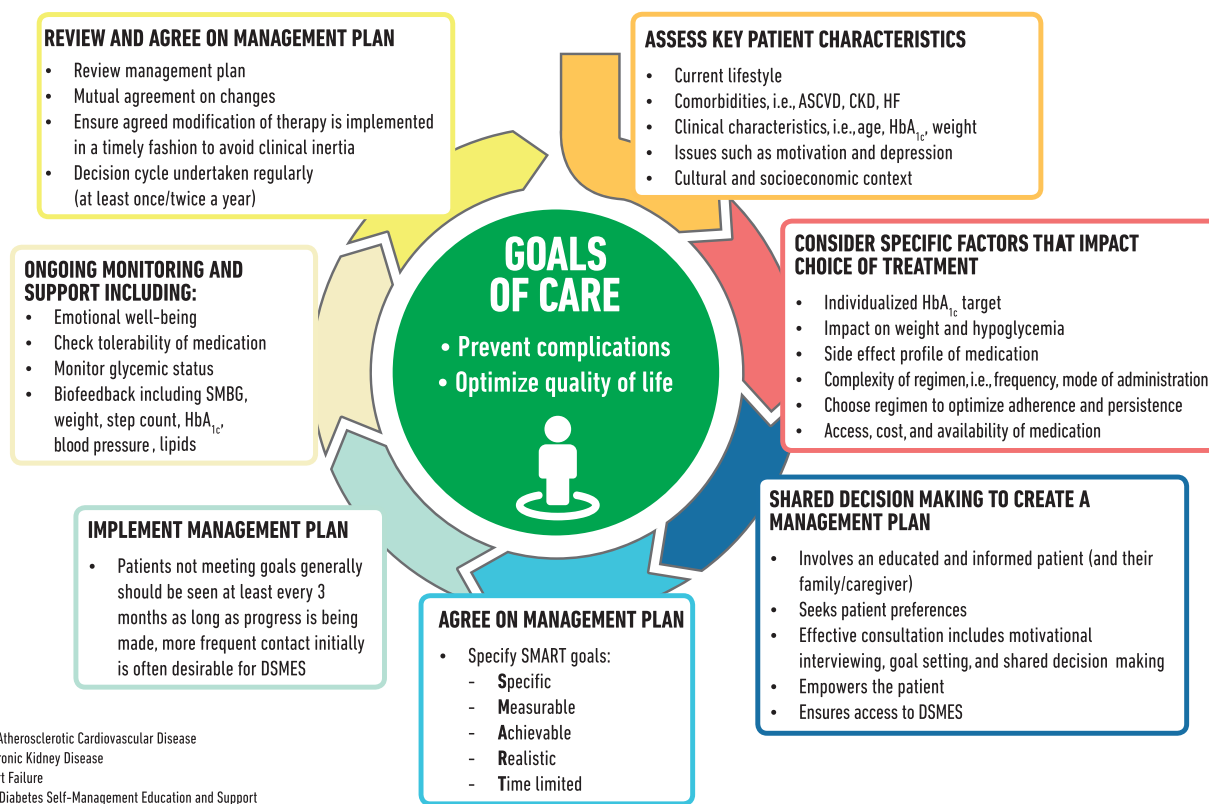


Figure 4.1—Decision cycle for patient-centered glycemic management in type 2 diabetes. Adapted from Davies et al. (119).

with the patients based on their individual preferences, values, and goals. The management plan should take into account the patient's age, cognitive abilities, school/work schedule and conditions, health beliefs, support systems, eating patterns, physical activity, social situation, financial concerns, cultural factors, literacy and numeracy (mathematical literacy), diabetes complications and duration of disease, comorbidities, health priorities, other medical conditions, preferences for care, and life expectancy. Various strategies and techniques should be used to support patients' self-management efforts, including providing education on problem-solving skills for all aspects of diabetes management.

Provider communications with patients and families should acknowledge that multiple factors impact glycemic management but also emphasize that collaboratively developed treatment plans and a healthy lifestyle can significantly improve disease outcomes and well-being (4–7). Thus, the goal of provider-patient communication is to establish a collaborative relationship and to

assess and address self-management barriers without blaming patients for “noncompliance” or “nonadherence” when the outcomes of self-management are not optimal (8). The familiar terms “noncompliance” and “nonadherence” denote a passive, obedient role for a person with diabetes in “following doctor's orders” that is at odds with the active role people with diabetes take in directing the day-to-day decision making, planning, monitoring, evaluation, and problem-solving involved in diabetes self-management. Using a nonjudgmental approach that normalizes periodic lapses in self-management may help minimize patients' resistance to reporting problems with self-management. Empathizing and using active listening techniques, such as open-ended questions, reflective statements, and summarizing what the patient said, can help facilitate communication. Patients' perceptions about their own ability, or self-efficacy, to self-manage diabetes are one important psychosocial factor related to improved diabetes self-management and treatment outcomes in diabetes (9–13) and should be a target of ongoing

assessment, patient education, and treatment planning.

Language has a strong impact on perceptions and behavior. The use of empowering language in diabetes care and education can help to inform and motivate people, yet language that shames and judges may undermine this effort. The American Diabetes Association (ADA) and American Association of Diabetes Educators consensus report, “The Use of Language in Diabetes Care and Education,” provides the authors' expert opinion regarding the use of language by health care professionals when speaking or writing about diabetes for people with diabetes or for professional audiences (14). Although further research is needed to address the impact of language on diabetes outcomes, the report includes five key consensus recommendations for language use:

- Use language that is neutral, nonjudgmental, and based on facts, actions, or physiology/biology.
- Use language that is free from stigma.
- Use language that is strength based, respectful, and inclusive and that imparts hope.

- Use language that fosters collaboration between patients and providers.
- Use language that is person centered (e.g., “person with diabetes” is preferred over “diabetic”).

COMPREHENSIVE MEDICAL EVALUATION

Recommendations

4.3 A complete medical evaluation should be performed at the initial visit to:

- Confirm the diagnosis and classify diabetes. **B**
- Evaluate for diabetes complications and potential comorbid conditions. **B**
- Review previous treatment and risk factor control in patients with established diabetes. **B**
- Begin patient engagement in the formulation of a care management plan. **B**
- Develop a plan for continuing care. **B**

4.4 A follow-up visit should include most components of the initial comprehensive medical evaluation including: interval medical history, assessment of medication-taking behavior and intolerance/side effects, physical examination, laboratory evaluation as appropriate to assess attainment of A1C and metabolic targets, and assessment of risk for complications, diabetes self-management behaviors, nutrition, psychosocial health, and the need for referrals, immunizations, or other routine health maintenance screening. **B**

4.5 Ongoing management should be guided by the assessment of diabetes complications and shared decision making to set therapeutic goals. **B**

4.6 The 10-year risk of a first atherosclerotic cardiovascular disease event should be assessed using the race- and sex-specific Pooled Cohort Equations to better stratify atherosclerotic cardiovascular disease risk. **B**

The comprehensive medical evaluation includes the initial and follow-up evaluations, assessment of complications, psychosocial assessment, management of comorbid conditions, and engagement

of the patient throughout the process. While a comprehensive list is provided in **Table 4.1**, in clinical practice, the provider may need to prioritize the components of the medical evaluation given the available resources and time. The goal is to provide the health care team information to optimally support a patient. In addition to the medical history, physical examination, and laboratory tests, providers should assess diabetes self-management behaviors, nutrition, and psychosocial health (see Section 5 “Lifestyle Management”) and give guidance on routine immunizations. The assessment of sleep pattern and duration should be considered; a recent meta-analysis found that poor sleep quality, short sleep, and long sleep were associated with higher A1C in people with type 2 diabetes (15). Interval follow-up visits should occur at least every 3–6 months, individualized to the patient, and then annually.

Lifestyle management and psychosocial care are the cornerstones of diabetes management. Patients should be referred for diabetes self-management education and support, medical nutrition therapy, and assessment of psychosocial/emotional health concerns if indicated. Patients should receive recommended preventive care services (e.g., immunizations, cancer screening, etc.), smoking cessation counseling, and ophthalmological, dental, and podiatric referrals.

The assessment of risk of acute and chronic diabetes complications and treatment planning are key components of initial and follow-up visits (**Table 4.2**). The risk of atherosclerotic cardiovascular disease and heart failure (Section 10 “Cardiovascular Disease and Risk Management”), chronic kidney disease staging (Section 11 “Microvascular Complications and Foot Care”), and risk of treatment-associated hypoglycemia (**Table 4.3**) should be used to individualize targets for glycemia (Section 6 “Glycemic Targets”), blood pressure, and lipids and to select specific glucose-lowering medication (Section 9 “Pharmacologic Approaches to Glycemic Treatment”), antihypertension medication, or statin treatment intensity.

Additional referrals should be arranged as necessary (**Table 4.4**). Clinicians should ensure that individuals with diabetes are appropriately screened

for complications and comorbidities. Discussing and implementing an approach to glycemic control with the patient is a part, not the sole goal, of the patient encounter.

Immunizations

Recommendations

4.7 Provide routinely recommended vaccinations for children and adults with diabetes by age. **C**

4.8 Annual vaccination against influenza is recommended for all people ≥ 6 months of age, especially those with diabetes. **C**

4.9 Vaccination against pneumococcal disease, including pneumococcal pneumonia, with 13-valent pneumococcal conjugate vaccine (PCV13) is recommended for children before age 2 years. People with diabetes ages 2 through 64 years should also receive 23-valent pneumococcal polysaccharide vaccine (PPSV23). At age ≥ 65 years, regardless of vaccination history, additional PPSV23 vaccination is necessary. **C**

4.10 Administer a 2- or 3-dose series of hepatitis B vaccine, depending on the vaccine, to unvaccinated adults with diabetes ages 18 through 59 years. **C**

4.11 Consider administering 3-dose series of hepatitis B vaccine to unvaccinated adults with diabetes ages ≥ 60 years. **C**

Children and adults with diabetes should receive vaccinations according to age-appropriate recommendations (16,17). The child and adolescent (≤ 18 years of age) vaccination schedule is available at www.cdc.gov/vaccines/schedules/hcp/imz/child-adolescent.html, and the adult (≥ 19 years of age) vaccination schedule is available at www.cdc.gov/vaccines/schedules/hcp/imz/adult.html. These immunization schedules include vaccination schedules specifically for children, adolescents, and adults with diabetes.

People with diabetes are at higher risk for hepatitis B infection and are more likely to develop complications from influenza and pneumococcal disease. The Centers for Disease Control and Prevention (CDC) Advisory Committee

Table 4.1 – Components of the comprehensive diabetes medical evaluation at initial, follow-up, and annual visits

		INITIAL VISIT	EVERY FOLLOW-UP VISIT	ANNUAL VISIT
PAST MEDICAL AND FAMILY HISTORY	Diabetes history			
	▪ Characteristics at onset (e.g., age, symptoms)	✓		
	▪ Review of previous treatment regimens and response	✓		
	▪ Assess frequency/cause/severity of past hospitalizations	✓		
	Family history			
	▪ Family history of diabetes in a first-degree relative	✓		
	▪ Family history of autoimmune disorder	✓		
	Personal history of complications and common comorbidities			
	▪ Macrovascular and microvascular	✓		✓
	▪ Common comorbidities (e.g., obesity, OSA)	✓		
	▪ Hypoglycemia: awareness/frequency/causes/timing of episodes	✓	✓	✓
	▪ Presence of hemoglobinopathies or anemias	✓		
	▪ High blood pressure or abnormal lipids	✓		✓
	▪ Last dental visit	✓		✓
▪ Last dilated eye exam	✓		✓	
▪ Visits to specialists	✓	✓	✓	
Interval history				
▪ Changes in medical/family history since last visit		✓	✓	
LIFESTYLE FACTORS	▪ Eating patterns and weight history	✓	✓	✓
	▪ Physical activity and sleep behaviors	✓	✓	✓
	▪ Tobacco, alcohol, and substance use	✓		✓
MEDICATIONS AND VACCINATIONS	▪ Current medication regimen	✓	✓	✓
	▪ Medication-taking behavior	✓	✓	✓
	▪ Medication intolerance or side effects	✓	✓	✓
	▪ Complementary and alternative medicine use	✓	✓	✓
	▪ Vaccination history and needs	✓		✓
TECHNOLOGY USE	▪ Assess use of health apps, online education, patient portals, etc.	✓		✓
	▪ Glucose monitoring (meter/CGM): results and data use	✓	✓	✓
	▪ Review insulin pump settings and use	✓	✓	✓
BEHAVIORAL AND DIABETES SELF-MANAGEMENT SKILLS	Psychosocial conditions			
	▪ Screen for depression, anxiety, and disordered eating; refer for further assessment or intervention if warranted	✓		✓
	▪ Identify existing social supports	✓		
	▪ Consider assessment for cognitive impairment*	✓		✓
	Diabetes self-management education and support			
	▪ History of dietician/diabetes educator visits/classes	✓	✓	✓
	▪ Assess diabetes self-management skills and barriers	✓		✓
▪ Assess familiarity with carbohydrate counting (type 1 diabetes)	✓			
Pregnancy planning				
▪ For women with childbearing capacity, review contraceptive needs and preconception planning	✓	✓	✓	

Continued on p. 538

Table 4.1 (cont.)- Components of the comprehensive diabetes medical evaluation at initial, follow-up, and annual visits

		INITIAL VISIT	EVERY FOLLOW-UP VISIT	ANNUAL VISIT
PHYSICAL EXAMINATION	▪ Height, weight, and BMI; growth/pubertal development in children and adolescents	✓	✓	✓
	▪ Blood pressure determination	✓	✓	✓
	▪ Orthostatic blood pressure measures (when indicated)	✓		
	▪ Fundoscopic examination (refer to eye specialist)	✓		✓
	▪ Thyroid palpation	✓		✓
	▪ Skin examination (e.g., acanthosis nigricans, insulin injection or insertion sites, lipodystrophy)	✓	✓	✓
	▪ Comprehensive foot examination			
	• Visual inspection (e.g., skin integrity, callous formation, foot deformity or ulcer, toenails)**	✓		✓
	• Screen for PAD (pedal pulses—refer for ABI if diminished)	✓		✓
	• Determination of temperature, vibration or pinprick sensation, and 10-g monofilament exam	✓		✓
LABORATORY EVALUATION	▪ A1C, if the results are not available within the past 3 months	✓	✓	✓
	▪ If not performed/available within the past year	✓		✓
	• Lipid profile, including total, LDL, and HDL cholesterol and triglycerides#	✓		✓^
	• Liver function tests#	✓		✓
	• Spot urinary albumin-to-creatinine ratio	✓		✓
	• Serum creatinine and estimated glomerular filtration rate*	✓		✓
	• Thyroid-stimulating hormone in patients with type 1 diabetes#	✓		✓
	• Vitamin B12 if on metformin (when indicated)	✓		✓
	• Serum potassium levels in patients on ACE inhibitors, ARBs, or diuretics*	✓		✓

ABI, ankle-brachial pressure index; ARBs, angiotensin receptor blockers; CGM, continuous glucose monitors; OSA, obstructive sleep apnea; PAD, peripheral arterial disease

*at 65 years of age or older

+may be needed more frequently in patients with known chronic kidney disease or with changes in medications that affect kidney function and serum potassium (see Table 11.2)

#may also need to be checked after initiation or dose changes of medications that affect these laboratory values (i.e., diabetes medications, blood pressure medications, cholesterol medications, or thyroid medications)

^in people without dyslipidemia and not on cholesterol lowering therapy, testing may be less frequent.

**should be performed at every visit in patients with sensory loss, previous foot ulcers, or amputations

on Immunization Practices (ACIP) recommends influenza, pneumococcal, and hepatitis B vaccinations specifically for people with diabetes. Vaccinations against tetanus-diphtheria-pertussis, measles-mumps-rubella, human papillomavirus, and shingles are also important for adults with diabetes, as they are for the general population.

Influenza

Influenza is a common, preventable infectious disease associated with high mortality and morbidity in vulnerable populations including the young and

the elderly and people with chronic diseases. Influenza vaccination in people with diabetes has been found to significantly reduce influenza and diabetes-related hospital admissions (18).

Pneumococcal Pneumonia

Like influenza, pneumococcal pneumonia is a common, preventable disease. People with diabetes are at increased risk for the bacteremic form of pneumococcal infection and have been reported to have a high risk of nosocomial bacteremia, with a mortality rate as high as 50% (19). The ADA endorses

recommendations from the CDC ACIP that adults age ≥65 years, who are at higher risk for pneumococcal disease, receive an additional 23-valent pneumococcal polysaccharide vaccine (PPSV23), regardless of prior pneumococcal vaccination history. See detailed recommendations at www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/pneumo.html.

Hepatitis B

Compared with the general population, people with type 1 or type 2 diabetes have higher rates of hepatitis B. This may be due to contact with infected blood

Table 4.2—Assessment and treatment plan*

Assess risk of diabetes complications

- ASCVD and heart failure history
- ASCVD risk factors (see **Table 10.2**) and 10-year ASCVD risk assessment
- Staging of chronic kidney disease (see **Table 11.1**)
- Hypoglycemia risk (**Table 4.3**)

Goal setting

- Set A1C/blood glucose target
- If hypertension present, establish blood pressure target
- Diabetes self-management goals (e.g., monitoring frequency)

Therapeutic treatment plan

- Lifestyle management
- Pharmacologic therapy (glucose lowering)
- Pharmacologic therapy (cardiovascular disease risk factors and renal)
- Use of glucose monitoring and insulin delivery devices
- Referral to diabetes education and medical specialists (as needed)

ASCVD, atherosclerotic cardiovascular disease. *Assessment and treatment planning is an essential component of initial and all follow-up visits.

or through improper equipment use (glucose monitoring devices or infected needles). Because of the higher likelihood of transmission, hepatitis B vaccine is recommended for adults with diabetes age <60 years. For adults age ≥60 years, hepatitis B vaccine may be administered at the discretion of the treating clinician based on the patient's likelihood of acquiring hepatitis B infection.

ASSESSMENT OF COMORBIDITIES

Besides assessing diabetes-related complications, clinicians and their patients need to be aware of common comorbidities that affect people with diabetes and may complicate management (20–24). Diabetes comorbidities are conditions that affect people with diabetes more often than age-matched people without diabetes. This section includes many of the common comorbidities observed in patients with diabetes but is not necessarily inclusive of all the conditions that have been reported.

Autoimmune Diseases

Recommendation

4.12 Consider screening patients with type 1 diabetes for autoimmune thyroid disease and celiac disease soon after diagnosis. **B**

People with type 1 diabetes are at increased risk for other autoimmune diseases including thyroid disease, primary adrenal insufficiency, celiac disease, autoimmune gastritis, autoimmune hepatitis, dermatomyositis, and myasthenia gravis (25–27). Type 1 diabetes may also occur with other autoimmune diseases in the context of specific genetic disorders or polyglandular autoimmune syndromes (28). In autoimmune diseases, the immune system fails to maintain self-tolerance to specific peptides within target organs. It is likely that many factors trigger autoimmune disease; however, common triggering factors are known for only some autoimmune conditions (i.e., gliadin peptides in celiac

disease) (see Section 13 “Children and Adolescents”).

Cancer

Diabetes is associated with increased risk of cancers of the liver, pancreas, endometrium, colon/rectum, breast, and bladder (29). The association may result from shared risk factors between type 2 diabetes and cancer (older age, obesity, and physical inactivity) but may also be due to diabetes-related factors (30), such as underlying disease physiology or diabetes treatments, although evidence for these links is scarce. Patients with diabetes should be encouraged to undergo recommended age- and sex-appropriate cancer screenings and to reduce their modifiable cancer risk factors (obesity, physical inactivity, and smoking). New onset of atypical diabetes (lean body habitus, negative family history) in a middle-aged or older patient may precede the diagnosis of pancreatic adenocarcinoma (31). However, in the absence of other symptoms (e.g., weight loss, abdominal pain), routine screening of all such patients is not currently recommended.

Cognitive Impairment/Dementia

Recommendation

4.13 In people with a history of cognitive impairment/dementia, intensive glucose control cannot be expected to remediate deficits. Treatment should be tailored to avoid significant hypoglycemia. **B**

Diabetes is associated with a significantly increased risk and rate of cognitive decline and an increased risk of dementia (32,33). A recent meta-analysis of prospective observational studies in people with diabetes showed 73% increased risk of all types of dementia, 56% increased risk of Alzheimer dementia, and 127% increased risk of vascular dementia compared with individuals without diabetes (34). The reverse is also true: people with Alzheimer dementia are more likely to develop diabetes than people without Alzheimer dementia. In a 15-year prospective study of community-dwelling people >60 years of age, the presence of diabetes at baseline significantly increased the age- and sex-adjusted

Table 4.3—Assessment of hypoglycemia risk

Factors that increase risk of treatment-associated hypoglycemia

- Use of insulin or insulin secretagogues (i.e., sulfonylureas, meglitinides)
- Impaired kidney or hepatic function
- Longer duration of diabetes
- Frailty and older age
- Cognitive impairment
- Impaired counterregulatory response, hypoglycemia unawareness
- Physical or intellectual disability that may impair behavioral response to hypoglycemia
- Alcohol use
- Polypharmacy (especially ACE inhibitors, angiotensin receptor blockers, nonselective β -blockers)

See references 114–118.

Table 4.4—Referrals for initial care management

- Eye care professional for annual dilated eye exam
- Family planning for women of reproductive age
- Registered dietitian for medical nutrition therapy
- Diabetes self-management education and support
- Dentist for comprehensive dental and periodontal examination
- Mental health professional, if indicated

incidence of all-cause dementia, Alzheimer dementia, and vascular dementia compared with rates in those with normal glucose tolerance (35).

Hyperglycemia

In those with type 2 diabetes, the degree and duration of hyperglycemia are related to dementia. More rapid cognitive decline is associated with both increased A1C and longer duration of diabetes (34). The Action to Control Cardiovascular Risk in Diabetes (ACCORD) study found that each 1% higher A1C level was associated with lower cognitive function in individuals with type 2 diabetes (36). However, the ACCORD study found no difference in cognitive outcomes in participants randomly assigned to intensive and standard glycemic control, supporting the recommendation that intensive glucose control should not be advised for the improvement of cognitive function in individuals with type 2 diabetes (37).

Hypoglycemia

In type 2 diabetes, severe hypoglycemia is associated with reduced cognitive function, and those with poor cognitive function have more severe hypoglycemia. In a long-term study of older patients with type 2 diabetes, individuals with one or more recorded episode of severe hypoglycemia had a stepwise increase in risk of dementia (38). Likewise, the ACCORD trial found that as cognitive function decreased, the risk of severe hypoglycemia increased (39). Tailoring glycemic therapy may help to prevent hypoglycemia in individuals with cognitive dysfunction.

Nutrition

In one study, adherence to the Mediterranean diet correlated with improved cognitive function (40). However, a recent Cochrane review found insufficient

evidence to recommend any dietary change for the prevention or treatment of cognitive dysfunction (41).

Statins

A systematic review has reported that data do not support an adverse effect of statins on cognition (42). The U.S. Food and Drug Administration postmarketing surveillance databases have also revealed a low reporting rate for cognitive-related adverse events, including cognitive dysfunction or dementia, with statin therapy, similar to rates seen with other commonly prescribed cardiovascular medications (42). Therefore, fear of cognitive decline should not be a barrier to statin use in individuals with diabetes and a high risk for cardiovascular disease.

Nonalcoholic Fatty Liver Disease

Recommendation

- 4.14** Patients with type 2 diabetes or prediabetes and elevated liver enzymes (alanine aminotransferase) or fatty liver on ultrasound should be evaluated for presence of nonalcoholic steatohepatitis and liver fibrosis. **C**

Diabetes is associated with the development of nonalcoholic fatty liver disease, including its more severe manifestations of nonalcoholic steatohepatitis, liver fibrosis, cirrhosis, and hepatocellular carcinoma (43). Elevations of hepatic transaminase concentrations are associated with higher BMI, waist circumference, and triglyceride levels and lower HDL cholesterol levels. Noninvasive tests, such as elastography or fibrosis biomarkers, may be used to assess risk of fibrosis, but referral to a liver specialist and liver biopsy may be required for definitive diagnosis (43a). Interventions that improve metabolic abnormalities in patients with diabetes (weight loss, glycemic control, and treatment with specific drugs for hyperglycemia or dyslipidemia) are also beneficial for fatty liver disease (44,45). Pioglitazone and vitamin E treatment of biopsy-proven nonalcoholic steatohepatitis have been shown to improve liver histology, but effects on longer-term clinical outcomes are not known (46,47). Treatment with liraglutide and with sodium–glucose cotransporter 2 inhibitors (dapagliflozin and empagliflozin)

has also shown some promise in preliminary studies, although benefits may be mediated, at least in part, by weight loss (48–50).

Pancreatitis

Recommendation

- 4.15** Islet autotransplantation should be considered for patients requiring total pancreatectomy for medically refractory chronic pancreatitis to prevent postsurgical diabetes. **C**

Diabetes is linked to diseases of the exocrine pancreas such as pancreatitis, which may disrupt the global architecture or physiology of the pancreas, often resulting in both exocrine and endocrine dysfunction. Up to half of patients with diabetes may have impaired exocrine pancreas function (51). People with diabetes are at an approximately twofold higher risk of developing acute pancreatitis (52).

Conversely, prediabetes and/or diabetes has been found to develop in approximately one-third of patients after an episode of acute pancreatitis (53), thus the relationship is likely bidirectional. Postpancreatitis diabetes may include either new-onset disease or previously unrecognized diabetes (54). Studies of patients treated with incretin-based therapies for diabetes have also reported that pancreatitis may occur more frequently with these medications, but results have been mixed (55,56).

Islet autotransplantation should be considered for patients requiring total pancreatectomy for medically refractory chronic pancreatitis to prevent postsurgical diabetes. Approximately one-third of patients undergoing total pancreatectomy with islet autotransplantation are insulin free 1 year postoperatively, and observational studies from different centers have demonstrated islet graft function up to a decade after the surgery in some patients (57–61). Both patient and disease factors should be carefully considered when deciding the indications and timing of this surgery. Surgeries should be performed in skilled facilities that have demonstrated expertise in islet autotransplantation.

Fractures

Age-specific hip fracture risk is significantly increased in people with both

type 1 (relative risk 6.3) and type 2 (relative risk 1.7) diabetes in both sexes (62). Type 1 diabetes is associated with osteoporosis, but in type 2 diabetes, an increased risk of hip fracture is seen despite higher bone mineral density (BMD) (63). In three large observational studies of older adults, femoral neck BMD T score and the World Health Organization Fracture Risk Assessment Tool (FRAX) score were associated with hip and nonspine fractures. Fracture risk was higher in participants with diabetes compared with those without diabetes for a given T score and age or for a given FRAX score (64). Providers should assess fracture history and risk factors in older patients with diabetes and recommend measurement of BMD if appropriate for the patient's age and sex. Fracture prevention strategies for people with diabetes are the same as for the general population and include vitamin D supplementation. For patients with type 2 diabetes with fracture risk factors, thiazolidinediones (65) and sodium–glucose cotransporter 2 inhibitors (66) should be used with caution.

Hearing Impairment

Hearing impairment, both in high frequency and low/midfrequency ranges, is more common in people with diabetes than in those without, perhaps due to neuropathy and/or vascular disease. In a National Health and Nutrition Examination Survey (NHANES) analysis, hearing impairment was about twice as prevalent in people with diabetes compared with those without, after adjusting for age and other risk factors for hearing impairment (67).

HIV

Recommendation

4.16 Patients with HIV should be screened for diabetes and prediabetes with a fasting glucose test before starting antiretroviral therapy, at the time of switching antiretroviral therapy, and 3–6 months after starting or switching antiretroviral therapy. If initial screening results are normal, checking fasting glucose every year is advised. **E**

Diabetes risk is increased with certain protease inhibitors (PIs) and nucleoside

reverse transcriptase inhibitors (NRTIs). New-onset diabetes is estimated to occur in more than 5% of patients infected with HIV on PIs, whereas more than 15% may have prediabetes (68). PIs are associated with insulin resistance and may also lead to apoptosis of pancreatic β -cells. NRTIs also affect fat distribution (both lipohypertrophy and lipoatrophy), which is associated with insulin resistance.

Individuals with HIV are at higher risk for developing prediabetes and diabetes on antiretroviral (ARV) therapies, so a screening protocol is recommended (69). The A1C test may underestimate glycemia in people with HIV and is not recommended for diagnosis and may present challenges for monitoring (70). In those with prediabetes, weight loss through healthy nutrition and physical activity may reduce the progression toward diabetes. Among patients with HIV and diabetes, preventive health care using an approach similar to that used in patients without HIV is critical to reduce the risks of microvascular and macrovascular complications.

For patients with HIV and ARV-associated hyperglycemia, it may be appropriate to consider discontinuing the problematic ARV agents if safe and effective alternatives are available (71). Before making ARV substitutions, carefully consider the possible effect on HIV virological control and the potential adverse effects of new ARV agents. In some cases, antihyperglycemia agents may still be necessary.

Low Testosterone in Men

Recommendation

4.17 In men with diabetes who have symptoms or signs of hypogonadism, such as decreased sexual desire (libido) or activity, or erectile dysfunction, consider screening with a morning serum testosterone level. **B**

Mean levels of testosterone are lower in men with diabetes compared with age-matched men without diabetes, but obesity is a major confounder (72,73). Treatment in asymptomatic men is controversial. Testosterone replacement in men with symptomatic hypogonadism may have benefits including improved sexual function, well-being, muscle mass and strength, and bone density (74). In

men with diabetes who have symptoms or signs of low testosterone (hypogonadism), a morning total testosterone should be measured using an accurate and reliable assay. Free or bioavailable testosterone levels should also be measured in men with diabetes who have total testosterone levels close to the lower limit, given expected decreases in sex hormone-binding globulin with diabetes. Further testing (such as luteinizing hormone and follicle-stimulating hormone levels) may be needed to distinguish between primary and secondary hypogonadism.

Obstructive Sleep Apnea

Age-adjusted rates of obstructive sleep apnea, a risk factor for cardiovascular disease, are significantly higher (4- to 10-fold) with obesity, especially with central obesity (75). The prevalence of obstructive sleep apnea in the population with type 2 diabetes may be as high as 23%, and the prevalence of any sleep-disordered breathing may be as high as 58% (76,77). In obese participants enrolled in the Action for Health in Diabetes (Look AHEAD) trial, it exceeded 80% (78). Patients with symptoms suggestive of obstructive sleep apnea (e.g., excessive daytime sleepiness, snoring, witnessed apnea) should be considered for screening (79). Sleep apnea treatment (lifestyle modification, continuous positive airway pressure, oral appliances, and surgery) significantly improves quality of life and blood pressure control. The evidence for a treatment effect on glycemic control is mixed (80).

Periodontal Disease

Periodontal disease is more severe, and may be more prevalent, in patients with diabetes than in those without (81,82). Current evidence suggests that periodontal disease adversely affects diabetes outcomes, although evidence for treatment benefits remains controversial (24).

Psychosocial/Emotional Disorders

Prevalence of clinically significant psychopathology diagnoses are considerably more common in people with diabetes than in those without the disease (83). Symptoms, both clinical and subclinical, that interfere with the person's ability to carry out daily diabetes self-management tasks must be addressed. Providers should consider an assessment of symptoms of

depression, anxiety, and disordered eating and of cognitive capacities using patient-appropriate standardized/validated tools at the initial visit, at periodic intervals, and when there is a change in disease, treatment, or life circumstance. Including caregivers and family members in this assessment is recommended. Diabetes distress is addressed in Section 5 “Lifestyle Management,” as this state is very common and distinct from the psychological disorders discussed below (84).

Anxiety Disorders

Recommendations

- 4.18** Consider screening for anxiety in people exhibiting anxiety or worries regarding diabetes complications, insulin injections or infusion, taking medications, and/or hypoglycemia that interfere with self-management behaviors and those who express fear, dread, or irrational thoughts and/or show anxiety symptoms such as avoidance behaviors, excessive repetitive behaviors, or social withdrawal. Refer for treatment if anxiety is present. **B**
- 4.19** People with hypoglycemia unawareness, which can co-occur with fear of hypoglycemia, should be treated using blood glucose awareness training (or other evidence-based intervention) to help reestablish awareness of hypoglycemia and reduce fear of hypoglycemia. **A**

Anxiety symptoms and diagnosable disorders (e.g., generalized anxiety disorder, body dysmorphic disorder, obsessive-compulsive disorder, specific phobias, and posttraumatic stress disorder) are common in people with diabetes (85).

The Behavioral Risk Factor Surveillance System (BRFSS) estimated the lifetime prevalence of generalized anxiety disorder to be 19.5% in people with either type 1 or type 2 diabetes (86). Common diabetes-specific concerns include fears related to hypoglycemia (87, 88), not meeting blood glucose targets (85), and insulin injections or infusion (89). Onset of complications presents another critical point when anxiety can

occur (90). People with diabetes who exhibit excessive diabetes self-management behaviors well beyond what is prescribed or needed to achieve glycemic targets may be experiencing symptoms of obsessive-compulsive disorder (91).

General anxiety is a predictor of injection-related anxiety and associated with fear of hypoglycemia (88,92). Fear of hypoglycemia and hypoglycemia unawareness often co-occur, and interventions aimed at treating one often benefit both (93). Fear of hypoglycemia may explain avoidance of behaviors associated with lowering glucose such as increasing insulin doses or frequency of monitoring. If fear of hypoglycemia is identified and a person does not have symptoms of hypoglycemia, a structured program of blood glucose awareness training delivered in routine clinical practice can improve A1C, reduce the rate of severe hypoglycemia, and restore hypoglycemia awareness (94,95).

Depression

Recommendations

- 4.20** Providers should consider annual screening of all patients with diabetes, especially those with a self-reported history of depression, for depressive symptoms with age-appropriate depression screening measures, recognizing that further evaluation will be necessary for individuals who have a positive screen. **B**
- 4.21** Beginning at diagnosis of complications or when there are significant changes in medical status, consider assessment for depression. **B**
- 4.22** Referrals for treatment of depression should be made to mental health providers with experience using cognitive behavioral therapy, interpersonal therapy, or other evidence-based treatment approaches in conjunction with collaborative care with the patient’s diabetes treatment team. **A**

History of depression, current depression, and antidepressant medication use are risk factors for the development of type 2 diabetes, especially if the individual has other risk factors such as obesity

and family history of type 2 diabetes (96–98). Elevated depressive symptoms and depressive disorders affect one in four patients with type 1 or type 2 diabetes (99). Thus, routine screening for depressive symptoms is indicated in this high-risk population including people with type 1 or type 2 diabetes, gestational diabetes mellitus, and postpartum diabetes. Regardless of diabetes type, women have significantly higher rates of depression than men (100).

Routine monitoring with patient-appropriate validated measures can help to identify if referral is warranted. Adult patients with a history of depressive symptoms or disorder need ongoing monitoring of depression recurrence within the context of routine care (96). Integrating mental and physical health care can improve outcomes. When a patient is in psychological therapy (talk therapy), the mental health provider should be incorporated into the diabetes treatment team (101).

Disordered Eating Behavior

Recommendations

- 4.23** Providers should consider reevaluating the treatment regimen of people with diabetes who present with symptoms of disordered eating behavior, an eating disorder, or disrupted patterns of eating. **B**
- 4.24** Consider screening for disordered or disrupted eating using validated screening measures when hyperglycemia and weight loss are unexplained based on self-reported behaviors related to medication dosing, meal plan, and physical activity. In addition, a review of the medical regimen is recommended to identify potential treatment-related effects on hunger/caloric intake. **B**

Estimated prevalence of disordered eating behaviors and diagnosable eating disorders in people with diabetes varies (102–104). For people with type 1 diabetes, insulin omission causing glycosuria in order to lose weight is the most commonly reported disordered eating behavior (105,106); in people with type 2 diabetes, bingeing (excessive food intake with an accompanying sense of

loss of control) is most commonly reported. For people with type 2 diabetes treated with insulin, intentional omission is also frequently reported (107). People with diabetes and diagnosable eating disorders have high rates of comorbid psychiatric disorders (108). People with type 1 diabetes and eating disorders have high rates of diabetes distress and fear of hypoglycemia (109).

When evaluating symptoms of disordered or disrupted eating in people with diabetes, etiology and motivation for the behavior should be considered (104,110). Adjunctive medication such as glucagon-like peptide 1 receptor agonists (111) may help individuals not only to meet glycemic targets but also to regulate hunger and food intake, thus having the potential to reduce uncontrollable hunger and bulimic symptoms.

Serious Mental Illness

Recommendations

- 4.25** Annually screen people who are prescribed atypical antipsychotic medications for prediabetes or diabetes. **B**
- 4.26** If a second-generation antipsychotic medication is prescribed for adolescents or adults with diabetes, changes in weight, glycemic control, and cholesterol levels should be carefully monitored and the treatment regimen should be reassessed. **C**
- 4.27** Incorporate monitoring of diabetes self-care activities into treatment goals in people with diabetes and serious mental illness. **B**

Studies of individuals with serious mental illness, particularly schizophrenia and other thought disorders, show significantly increased rates of type 2 diabetes (112). People with schizophrenia should be monitored for type 2 diabetes because of the known comorbidity. Disordered thinking and judgment can be expected to make it difficult to engage in behaviors that reduce risk factors for type 2 diabetes, such as restrained eating for weight management. Coordinated management of diabetes or prediabetes and serious mental illness is recommended to achieve diabetes treatment targets. In addition, those taking second-generation (atypical) antipsychotics, such as

olanzapine, require greater monitoring because of an increase in risk of type 2 diabetes associated with this medication (113).

References

1. Stelfox M, Dipnarine K, Stopka C. The Chronic Care Model and diabetes management in US primary care settings: a systematic review. *Prev Chronic Dis* 2013;10:E26
2. Coleman K, Austin BT, Brach C, Wagner EH. Evidence on the Chronic Care Model in the new millennium. *Health Aff (Millwood)* 2009;28:75–85
3. Gabbay RA, Bailit MH, Mauger DT, Wagner EH, Siminerio L. Multipayer patient-centered medical home implementation guided by the chronic care model. *Jt Comm J Qual Patient Saf* 2011;37:265–273
4. UK Prospective Diabetes Study (UKPDS) Group. Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). *Lancet* 1998;352:837–853
5. Nathan DM, Genuth S, Lachin J, et al.; Diabetes Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. *N Engl J Med* 1993;329:977–986
6. Lachin JM, Genuth S, Nathan DM, Zinman B, Rutledge BN; DCCT/EDIC Research Group. Effect of glycemic exposure on the risk of microvascular complications in the Diabetes Control and Complications Trial—revisited. *Diabetes* 2008;57:995–1001
7. White NH, Cleary PA, Dahms W, Goldstein D, Malone J, Tamborlane WV; Diabetes Control and Complications Trial (DCCT)/Epidemiology of Diabetes Interventions and Complications (EDIC) Research Group. Beneficial effects of intensive therapy of diabetes during adolescence: outcomes after the conclusion of the Diabetes Control and Complications Trial (DCCT). *J Pediatr* 2001;139:804–812
8. Anderson RM, Funnell MM. Compliance and adherence are dysfunctional concepts in diabetes care. *Diabetes Educ* 2000;26:597–604
9. Sarkar U, Fisher L, Schillinger D. Is self-efficacy associated with diabetes self-management across race/ethnicity and health literacy? *Diabetes Care* 2006;29:823–829
10. King DK, Glasgow RE, Toobert DJ, et al. Self-efficacy, problem solving, and social-environmental support are associated with diabetes self-management behaviors. *Diabetes Care* 2010;33:751–753
11. Nouwen A, Urquhart Law G, Hussain S, McGovern S, Napier H. Comparison of the role of self-efficacy and illness representations in relation to dietary self-care and diabetes distress in adolescents with type 1 diabetes. *Psychol Health* 2009;24:1071–1084
12. Beckerle CM, Lavin MA. Association of self-efficacy and self-care with glycemic control in diabetes. *Diabetes Spectr* 2013;26:172–178
13. Iannotti RJ, Schneider S, Nansel TR, et al. Self-efficacy, outcome expectations, and diabetes self-management in adolescents with type 1 diabetes. *J Dev Behav Pediatr* 2006;27:98–105
14. Dickinson JK, Guzman SJ, Maryniuk MD, et al. The use of language in diabetes care and education. *Diabetes Care* 2017;40:1790–1799
15. Lee SWH, Ng KY, Chin WK. The impact of sleep amount and sleep quality on glycemic control in type 2 diabetes: a systematic review and meta-analysis. *Sleep Med Rev* 2017;31:91–101
16. Robinson CL, Romero JR, Kempe A, Pellegrini C; Advisory Committee on Immunization Practices (ACIP) Child/Adolescent Immunization Work Group. Advisory Committee on Immunization Practices recommended immunization schedule for children and adolescents aged 18 years or younger—United States, 2017. *MMWR Morb Mortal Wkly Rep* 2017;66:134–135
17. Kim DK, Riley LE, Harriman KH, Hunter P, Bridges CB. Advisory Committee on Immunization Practices recommended immunization schedule for adults aged 19 years or older—United States, 2017. *MMWR Morb Mortal Wkly Rep* 2017;66:136–138
18. Goeijenbier M, van Sloten TT, Slobbe L, et al. Benefits of flu vaccination for persons with diabetes mellitus: a review. *Vaccine* 2017;35:5095–5101
19. Smith SA, Poland GA. Use of influenza and pneumococcal vaccines in people with diabetes. *Diabetes Care* 2000;23:95–108
20. Selvin E, Coresh J, Brancati FL. The burden and treatment of diabetes in elderly individuals in the U.S. *Diabetes Care* 2006;29:2415–2419
21. Grant RW, Ashburner JM, Hong CS, Chang Y, Barry MJ, Atlas SJ. Defining patient complexity from the primary care physician's perspective: a cohort study [published correction appears in *Ann Intern Med* 2012;157:152]. *Ann Intern Med* 2011;155:797–804
22. Tinetti ME, Fried TR, Boyd CM. Designing health care for the most common chronic condition—multimorbidity. *JAMA* 2012;307:2493–2494
23. Sudore RL, Karter AJ, Huang ES, et al. Symptom burden of adults with type 2 diabetes across the disease course: Diabetes & Aging Study. *J Gen Intern Med* 2012;27:1674–1681
24. Borgnakke WS, Ylöstalo PV, Taylor GW, Genco RJ. Effect of periodontal disease on diabetes: systematic review of epidemiologic observational evidence. *J Periodontol* 2013;84 (Suppl.):S135–S152
25. Triolo TM, Armstrong TK, McFann K, et al. Additional autoimmune disease found in 33% of patients at type 1 diabetes onset. *Diabetes Care* 2011;34:1211–1213
26. Hughes JW, Riddlesworth TD, DiMeglio LA, Miller KM, Rickels MR, McGill JB. Autoimmune diseases in children and adults with type 1 diabetes from the T1D Exchange Clinic Registry. *J Clin Endocrinol Metab* 2016;101:4931–4937
27. Kahaly GJ, Hansen MP. Type 1 diabetes associated autoimmunity. *Autoimmun Rev* 2016;15:644–648
28. Eisenbarth GS, Gottlieb PA. Autoimmune polyendocrine syndromes. *N Engl J Med* 2004;350:2068–2079
29. Suh S, Kim K-W. Diabetes and cancer: is diabetes causally related to cancer? *Diabetes Metab J* 2011;35:193–198

30. Giovannucci E, Harlan DM, Archer MC, et al. Diabetes and cancer: a consensus report. *CA Cancer J Clin* 2010;60:207–221
31. Aggarwal G, Kamada P, Chari ST. Prevalence of diabetes mellitus in pancreatic cancer compared to common cancers. *Pancreas* 2013;42:198–201
32. Cukierman T, Gerstein HC, Williamson JD. Cognitive decline and dementia in diabetes—systematic overview of prospective observational studies. *Diabetologia* 2005;48:2460–2469
33. Biessels GJ, Staekenborg S, Brunner E, Brayne C, Scheltens P. Risk of dementia in diabetes mellitus: a systematic review. *Lancet Neurol* 2006;5:64–74
34. Gudala K, Bansal D, Schifano F, Bhansali A. Diabetes mellitus and risk of dementia: a meta-analysis of prospective observational studies. *J Diabetes Investig* 2013;4:640–650
35. Ohara T, Doi Y, Ninomiya T, et al. Glucose tolerance status and risk of dementia in the community: the Hisayama study. *Neurology* 2011;77:1126–1134
36. Cukierman-Yaffe T, Gerstein HC, Williamson JD, et al.; Action to Control Cardiovascular Risk in Diabetes-Memory in Diabetes (ACCORD-MIND) Investigators. Relationship between baseline glycemic control and cognitive function in individuals with type 2 diabetes and other cardiovascular risk factors: the Action to Control Cardiovascular Risk in Diabetes-Memory in Diabetes (ACCORD-MIND) trial. *Diabetes Care* 2009;32:221–226
37. Launer LJ, Miller ME, Williamson JD, et al.; ACCORD MIND Investigators. Effects of intensive glucose lowering on brain structure and function in people with type 2 diabetes (ACCORD MIND): a randomised open-label substudy. *Lancet Neurol* 2011;10:969–977
38. Whitmer RA, Karter AJ, Yaffe K, Quesenberry CP Jr, Selby JV. Hypoglycemic episodes and risk of dementia in older patients with type 2 diabetes mellitus. *JAMA* 2009;301:1565–1572
39. Punthakee Z, Miller ME, Launer LJ, et al.; ACCORD Group of Investigators; ACCORD-MIND Investigators. Poor cognitive function and risk of severe hypoglycemia in type 2 diabetes: post hoc epidemiologic analysis of the ACCORD trial. *Diabetes Care* 2012;35:787–793
40. Scarmeas N, Stern Y, Mayeux R, Manly JJ, Schupf N, Luchsinger JA. Mediterranean diet and mild cognitive impairment. *Arch Neurol* 2009;66:216–225
41. Ooi CP, Loke SC, Yassin Z, Hamid T-A. Carbohydrates for improving the cognitive performance of independent-living older adults with normal cognition or mild cognitive impairment. *Cochrane Database Syst Rev* 2011;4:CD007220
42. Richardson K, Schoen M, French B, et al. Statins and cognitive function: a systematic review. *Ann Intern Med* 2013;159:688–697
43. El-Serag HB, Tran T, Everhart JE. Diabetes increases the risk of chronic liver disease and hepatocellular carcinoma. *Gastroenterology* 2004;126:460–468
- 43a. Chalasani N, Younossi Z, Lavine JE, et al. The diagnosis and management of nonalcoholic fatty liver disease: practice guidance from the American Association for the Study of Liver Diseases. *Hepatology* 2018;67:328–357
44. American Gastroenterological Association. American Gastroenterological Association medical position statement: nonalcoholic fatty liver disease. *Gastroenterology* 2002;123:1702–1704
45. Cusi K, Orsak B, Bril F, et al. Long-term pioglitazone treatment for patients with non-alcoholic steatohepatitis and prediabetes or type 2 diabetes mellitus: a randomized trial. *Ann Intern Med* 2016;165:305–315
46. Belfort R, Harrison SA, Brown K, et al. A placebo-controlled trial of pioglitazone in subjects with nonalcoholic steatohepatitis. *N Engl J Med* 2006;355:2297–2307
47. Sanyal AJ, Chalasani N, Kowdley KV, et al.; NASH CRN. Pioglitazone, vitamin E, or placebo for nonalcoholic steatohepatitis. *N Engl J Med* 2010;362:1675–1685
48. Armstrong MJ, Gaunt P, Aithal GP, et al.; LEAN Trial Team. Liraglutide safety and efficacy in patients with non-alcoholic steatohepatitis (LEAN): a multicentre, double-blind, randomised, placebo-controlled phase 2 study. *Lancet* 2016;387:679–690
49. Shimizu M, Suzuki K, Kato K, et al. Evaluation of the effects of dapagliflozin, a sodium-glucose co-transporter-2 inhibitor, on hepatic steatosis and fibrosis using transient elastography in patients with type 2 diabetes and non-alcoholic fatty liver disease. *Diabetes Obes Metab*. 3 September 2018 [Epub ahead of print]. DOI: 10.1111/dom.13520
50. Sattar N, Fitchett D, Hantel S, George JT, Zinman B. Empagliflozin is associated with improvements in liver enzymes potentially consistent with reductions in liver fat: results from randomised trials including the EMPA-REG OUTCOME trial. *Diabetologia* 2018;61:2155–2163
51. Hardt PD, Brendel MD, Kloer HU, Bretzel RG. Is pancreatic diabetes (type 3c diabetes) underdiagnosed and misdiagnosed? *Diabetes Care* 2008;31(Suppl. 2):S165–S169
52. Lee Y-K, Huang M-Y, Hsu C-Y, Su Y-C. Bidirectional relationship between diabetes and acute pancreatitis: a population-based cohort study in Taiwan. *Medicine (Baltimore)* 2016;95:e2448
53. Das SLM, Singh PP, Phillips ARJ, Murphy R, Windsor JA, Petrov MS. Newly diagnosed diabetes mellitus after acute pancreatitis: a systematic review and meta-analysis. *Gut* 2014;63:818–831
54. Petrov MS. Diabetes of the exocrine pancreas: American Diabetes Association-compliant lexicon. *Pancreatology* 2017;17:523–526
55. Thomsen RW, Pedersen L, Møller N, Kahlert J, Beck-Nielsen H, Sørensen HT. Incretin-based therapy and risk of acute pancreatitis: a nationwide population-based case-control study. *Diabetes Care* 2015;38:1089–1098
56. Tkáč I, Raz I. Combined analysis of three large interventional trials with gliptins indicates increased incidence of acute pancreatitis in patients with type 2 diabetes. *Diabetes Care* 2017;40:284–286
57. Bellin MD, Gelrud A, Arreaza-Rubin G, et al. Total pancreatectomy with islet autotransplantation: summary of an NIDDK workshop. *Ann Surg* 2015;261:21–29
58. Sutherland DER, Radosevich DM, Bellin MD, et al. Total pancreatectomy and islet autotransplantation for chronic pancreatitis. *J Am Coll Surg* 2012;214:409–424; discussion 424–426
59. Quartuccio M, Hall E, Singh V, et al. Glycemic predictors of insulin independence after total pancreatectomy with islet autotransplantation. *J Clin Endocrinol Metab* 2017;102:801–809
60. Webb MA, Illouz SC, Pollard CA, et al. Islet auto transplantation following total pancreatectomy: a long-term assessment of graft function. *Pancreas* 2008;37:282–287
61. Wu Q, Zhang M, Qin Y, et al. Systematic review and meta-analysis of islet autotransplantation after total pancreatectomy in chronic pancreatitis patients. *Endocr J* 2015;62:227–234
62. Janghorbani M, Van Dam RM, Willett WC, Hu FB. Systematic review of type 1 and type 2 diabetes mellitus and risk of fracture. *Am J Epidemiol* 2007;166:495–505
63. Vestergaard P. Discrepancies in bone mineral density and fracture risk in patients with type 1 and type 2 diabetes—a meta-analysis. *Osteoporos Int* 2007;18:427–444
64. Schwartz AV, Vittinghoff E, Bauer DC, et al.; Study of Osteoporotic Fractures (SOF) Research Group; Osteoporotic Fractures in Men (MrOS) Research Group; Health, Aging, and Body Composition (Health ABC) Research Group. Association of BMD and FRAX score with risk of fracture in older adults with type 2 diabetes. *JAMA* 2011;305:2184–2192
65. Kahn SE, Zinman B, Lachin JM, et al.; A Diabetes Outcome Progression Trial (ADOPT) Study Group. Rosiglitazone-associated fractures in type 2 diabetes: an analysis from A Diabetes Outcome Progression Trial (ADOPT). *Diabetes Care* 2008;31:845–851
66. Taylor SI, Blau JE, Rother KI. Possible adverse effects of SGLT2 inhibitors on bone. *Lancet Diabetes Endocrinol* 2015;3:8–10
67. Bainbridge KE, Hoffman HJ, Cowie CC. Diabetes and hearing impairment in the United States: audiometric evidence from the National Health and Nutrition Examination Survey, 1999 to 2004. *Ann Intern Med* 2008;149:1–10
68. Monroe AK, Glesby MJ, Brown TT. Diagnosing and managing diabetes in HIV-infected patients: current concepts. *Clin Infect Dis* 2015;60:453–462
69. Schambelan M, Benson CA, Carr A, et al.; International AIDS Society-USA. Management of metabolic complications associated with antiretroviral therapy for HIV-1 infection: recommendations of an International AIDS Society-USA panel. *J Acquir Immune Defic Syndr* 2002;31:257–275
70. Kim PS, Woods C, Georgoff P, et al. A1C underestimates glycemia in HIV infection. *Diabetes Care* 2009;32:1591–1593
71. Wohl DA, McComsey G, Tebas P, et al. Current concepts in the diagnosis and management of metabolic complications of HIV infection and its therapy. *Clin Infect Dis* 2006;43:645–653
72. Dhindsa S, Miller MG, McWhirter CL, et al. Testosterone concentrations in diabetic and nondiabetic obese men. *Diabetes Care* 2010;33:1186–1192
73. Grossmann M. Low testosterone in men with type 2 diabetes: significance and treatment. *J Clin Endocrinol Metab* 2011;96:2341–2353
74. Bhasin S, Cunningham GR, Hayes FJ, et al.; Endocrine Society Task Force. Testosterone therapy in men with androgen deficiency syndromes: an Endocrine Society clinical practice guideline. *J Clin Endocrinol Metab* 2010;95:2536–2559

75. Li C, Ford ES, Zhao G, Croft JB, Balluz LS, Mokdad AH. Prevalence of self-reported clinically diagnosed sleep apnea according to obesity status in men and women: National Health and Nutrition Examination Survey, 2005–2006. *Prev Med* 2010;51:18–23
76. West SD, Nicoll DJ, Stradling JR. Prevalence of obstructive sleep apnoea in men with type 2 diabetes. *Thorax* 2006;61:945–950
77. Resnick HE, Redline S, Shahar E, et al.; Sleep Heart Health Study. Diabetes and sleep disturbances: findings from the Sleep Heart Health Study. *Diabetes Care* 2003;26:702–709
78. Foster GD, Sanders MH, Millman R, et al.; Sleep AHEAD Research Group. Obstructive sleep apnea among obese patients with type 2 diabetes. *Diabetes Care* 2009;32:1017–1019
79. Bibbins-Domingo K, Grossman DC, Curry SJ, et al.; US Preventive Services Task Force. Screening for obstructive sleep apnea in adults: US Preventive Services Task Force recommendation statement. *JAMA* 2017;317:407–414
80. Shaw JE, Punjabi NM, Wilding JP, Alberti KGMM, Zimmet PZ; International Diabetes Federation Taskforce on Epidemiology and Prevention. Sleep-disordered breathing and type 2 diabetes: a report from the International Diabetes Federation Taskforce on Epidemiology and Prevention. *Diabetes Res Clin Pract* 2008;81:2–12
81. Khader YS, Dauod AS, El-Qaderi SS, Alkafajei A, Batayha WQ. Periodontal status of diabetics compared with nondiabetics: a meta-analysis. *J Diabetes Complications* 2006;20:59–68
82. Casanova L, Hughes FJ, Preshaw PM. Diabetes and periodontal disease: a two-way relationship. *Br Dent J* 2014;217:433–437
83. de Groot M, Golden SH, Wagner J. Psychological conditions in adults with diabetes. *Am Psychol* 2016;71:552–562
84. Young-Hyman D, de Groot M, Hill-Briggs F, Gonzalez JS, Hood K, Peyrot M. Psychosocial care for people with diabetes: a position statement of the American Diabetes Association. *Diabetes Care* 2016;39:2126–2140
85. Smith KJ, B eland M, Clyde M, et al. Association of diabetes with anxiety: a systematic review and meta-analysis. *J Psychosom Res* 2013;74:89–99
86. Li C, Barker L, Ford ES, Zhang X, Strine TW, Mokdad AH. Diabetes and anxiety in US adults: findings from the 2006 Behavioral Risk Factor Surveillance System. *Diabet Med* 2008;25:878–881
87. Cox DJ, Irvine A, Gonder-Frederick L, Nowacek G, Butterfield J. Fear of hypoglycemia: quantification, validation, and utilization. *Diabetes Care* 1987;10:617–621
88. Wild D, von Maltzahn R, Brohan E, Christensen T, Clauson P, Gonder-Frederick L. A critical review of the literature on fear of hypoglycemia in diabetes: implications for diabetes management and patient education. *Patient Educ Couns* 2007;68:10–15
89. Zambanini A, Newson RB, Maisey M, Feher MD. Injection related anxiety in insulin-treated diabetes. *Diabetes Res Clin Pract* 1999;46:239–246
90. Young-Hyman D, Peyrot M. *Psychosocial Care for People with Diabetes*. Alexandria, VA, American Diabetes Association, 2012
91. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*, Fifth Edition [Internet], 2013. Available from <http://psychiatryonline.org/doi/book/10.1176/appi.books.9780890425596>. Accessed 9 November 2018
92. Mitsonis C, Dimopoulos N, Psarra V. P01-138 Clinical implications of anxiety in diabetes: a critical review of the evidence base (abstract). *Eur Psychiatry* 2009;24(Suppl. 1):S526
93. Yeoh E, Choudhary P, Nwokolo M, Ayis S, Amiel SA. Interventions that restore awareness of hypoglycemia in adults with type 1 diabetes: a systematic review and meta-analysis. *Diabetes Care* 2015;38:1592–1609
94. Cox DJ, Gonder-Frederick L, Polonsky W, Schlundt D, Kovatchev B, Clarke W. Blood glucose awareness training (BGAT-2): long-term benefits. *Diabetes Care* 2001;24:637–642
95. Gonder-Frederick LA, Schmidt KM, Vajda KA, et al. Psychometric properties of the hypoglycemia fear survey-II for adults with type 1 diabetes. *Diabetes Care* 2011;34:801–806
96. Lustman PJ, Griffith LS, Clouse RE. Depression in adults with diabetes. Results of 5-yr follow-up study. *Diabetes Care* 1988;11:605–612
97. de Groot M, Crick KA, Long M, Saha C, Shubrook JH. Lifetime duration of depressive disorders in patients with type 2 diabetes. *Diabetes Care* 2016;39:2174–2181
98. Rubin RR, Ma Y, Marrero DG, et al.; Diabetes Prevention Program Research Group. Elevated depression symptoms, antidepressant medicine use, and risk of developing diabetes during the Diabetes Prevention Program. *Diabetes Care* 2008;31:420–426
99. Anderson RJ, Freedland KE, Clouse RE, Lustman PJ. The prevalence of comorbid depression in adults with diabetes: a meta-analysis. *Diabetes Care* 2001;24:1069–1078
100. Clouse RE, Lustman PJ, Freedland KE, Griffith LS, McGill JB, Carney RM. Depression and coronary heart disease in women with diabetes. *Psychosom Med* 2003;65:376–383
101. Katon WJ, Lin EHB, Von Korff M, et al. Collaborative care for patients with depression and chronic illnesses. *N Engl J Med* 2010;363:2611–2620
102. Pinhas-Hamiel O, Hamiel U, Levy-Shraga Y. Eating disorders in adolescents with type 1 diabetes: challenges in diagnosis and treatment. *World J Diabetes* 2015;6:517–526
103. Papelbaum M, Appolin ario JC, Moreira RdeO, Ellinger VCM, Kupfer R, Coutinho WF. Prevalence of eating disorders and psychiatric comorbidity in a clinical sample of type 2 diabetes mellitus patients. *Rev Bras Psiquiatr* 2005;27:135–138
104. Young-Hyman DL, Davis CL. Disordered eating behavior in individuals with diabetes: importance of context, evaluation, and classification. *Diabetes Care* 2010;33:683–689
105. Pinhas-Hamiel O, Hamiel U, Greenfield Y, et al. Detecting intentional insulin omission for weight loss in girls with type 1 diabetes mellitus. *Int J Eat Disord* 2013;46:819–825
106. Goebel-Fabbri AE, Fikkan J, Franko DL, Pearson K, Anderson BJ, Weinger K. Insulin restriction and associated morbidity and mortality in women with type 1 diabetes. *Diabetes Care* 2008;31:415–419
107. Weinger K, Beverly EA. Barriers to achieving glycemic targets: who omits insulin and why? *Diabetes Care* 2010;33:450–452
108. Hudson JI, Hiripi E, Pope HG Jr, Kessler RC. The prevalence and correlates of eating disorders in the National Comorbidity Survey Replication. *Biol Psychiatry* 2007;61:348–358
109. Martyn-Nemeth P, Quinn L, Hacker E, Park H, Kujath AS. Diabetes distress may adversely affect the eating styles of women with type 1 diabetes. *Acta Diabetol* 2014;51:683–686
110. Peterson CM, Fischer S, Young-Hyman D. Topical review: a comprehensive risk model for disordered eating in youth with type 1 diabetes. *J Pediatr Psychol* 2015;40:385–390
111. Garber AJ. Novel GLP-1 receptor agonists for diabetes. *Expert Opin Investig Drugs* 2012;21:45–57
112. Suvisaari J, Per al  J, Saarni SI, et al. Type 2 diabetes among persons with schizophrenia and other psychotic disorders in a general population survey. *Eur Arch Psychiatry Clin Neurosci* 2008;258:129–136
113. Koro CE, Fedder DO, L’Italien GJ, et al. Assessment of independent effect of olanzapine and risperidone on risk of diabetes among patients with schizophrenia: population based nested case-control study. *BMJ* 2002;325:243
114. Lipska KJ, Ross JS, Wang Y, et al. National trends in US hospital admissions for hyperglycemia and hypoglycemia among Medicare beneficiaries, 1999 to 2011. *JAMA Intern Med* 2014;174:1116–1124
115. Shorr RI, Ray WA, Daugherty JR, Griffin MR. Incidence and risk factors for serious hypoglycemia in older persons using insulin or sulfonylureas. *Arch Intern Med* 1997;157:1681–1686
116. Abdelhafiz AH, Rodr guez-Ma nas L, Morley JE, Sinclair AJ. Hypoglycemia in older people - a less well recognized risk factor for frailty. *Aging Dis* 2015;6:156–167
117. Yun J-S, Ko S-H, Ko S-H, et al. Presence of macroalbuminuria predicts severe hypoglycemia in patients with type 2 diabetes: a 10-year follow-up study. *Diabetes Care* 2013;36:1283–1289
118. Chelliah A, Burge MR. Hypoglycaemia in elderly patients with diabetes mellitus: causes and strategies for prevention. *Drugs Aging* 2004;21:511–530
119. Davies MJ, D’Alessio DA, Fradkin J, et al. Management of hyperglycemia in type 2 diabetes, 2018. A consensus report by the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD). *Diabetes Care* 2018;41:2669–2701

5. Lifestyle Management: *Standards of Medical Care in Diabetes—2019*

American Diabetes Association

Diabetes Care 2019;42(Suppl. 1):S46–S60 | <https://doi.org/10.2337/dc19-S005>

The American Diabetes Association (ADA) “Standards of Medical Care in Diabetes” includes ADA’s current clinical practice recommendations and is intended to provide the components of diabetes care, general treatment goals and guidelines, and tools to evaluate quality of care. Members of the ADA Professional Practice Committee, a multidisciplinary expert committee, are responsible for updating the Standards of Care annually, or more frequently as warranted. For a detailed description of ADA standards, statements, and reports, as well as the evidence-grading system for ADA’s clinical practice recommendations, please refer to the Standards of Care Introduction. Readers who wish to comment on the Standards of Care are invited to do so at professional.diabetes.org/SOC.

Lifestyle management is a fundamental aspect of diabetes care and includes diabetes self-management education and support (DSMES), medical nutrition therapy (MNT), physical activity, smoking cessation counseling, and psychosocial care. Patients and care providers should focus together on how to optimize lifestyle from the time of the initial comprehensive medical evaluation, throughout all subsequent evaluations and follow-up, and during the assessment of complications and management of comorbid conditions in order to enhance diabetes care.

DIABETES SELF-MANAGEMENT EDUCATION AND SUPPORT

Recommendations

- 5.1 In accordance with the national standards for diabetes self-management education and support, all people with diabetes should participate in diabetes self-management education to facilitate the knowledge, skills, and ability necessary for diabetes self-care. Diabetes self-management support is additionally recommended to assist with implementing and sustaining skills and behaviors needed for ongoing self-management. **B**
- 5.2 There are four critical times to evaluate the need for diabetes self-management education and support: at diagnosis, annually, when complicating factors arise, and when transitions in care occur. **E**
- 5.3 Clinical outcomes, health status, and quality of life are key goals of diabetes self-management education and support that should be measured as part of routine care. **C**
- 5.4 Diabetes self-management education and support should be patient centered, may be given in group or individual settings or using technology, and should be communicated with the entire diabetes care team. **A**
- 5.5 Because diabetes self-management education and support can improve outcomes and reduce costs **B**, adequate reimbursement by third-party payers is recommended. **E**

Suggested citation: American Diabetes Association. 5. Lifestyle management: Standards of Medical Care in Diabetes—2019. Diabetes Care 2019;42(Suppl. 1):S46–S60

© 2018 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. More information is available at <http://www.diabetesjournals.org/content/license>.

DSMES services facilitate the knowledge, skills, and abilities necessary for optimal diabetes self-care and incorporate the needs, goals, and life experiences of the person with diabetes. The overall objectives of DSMES are to support informed decision making, self-care behaviors, problem-solving, and active collaboration with the health care team to improve clinical outcomes, health status, and quality of life in a cost-effective manner (1). Providers are encouraged to consider the burden of treatment and the patient's level of confidence/self-efficacy for management behaviors as well as the level of social and family support when providing DSMES. Patient performance of self-management behaviors, including its effect on clinical outcomes, health status, and quality of life, as well as the psychosocial factors impacting the person's self-management should be monitored as part of routine clinical care.

In addition, in response to the growing literature that associates potentially judgmental words with increased feelings of shame and guilt, providers are encouraged to consider the impact that language has on building therapeutic relationships and to choose positive, strength-based words and phrases that put people first (2,3). Patient performance of self-management behaviors as well as psychosocial factors impacting the person's self-management should be monitored. Please see Section 4, "Comprehensive Medical Evaluation and Assessment of Comorbidities," for more on use of language.

DSMES and the current national standards guiding it (1,4) are based on evidence of benefit. Specifically, DSMES helps people with diabetes to identify and implement effective self-management strategies and cope with diabetes at the four critical time points (described below) (1). Ongoing DSMES helps people with diabetes to maintain effective self-management throughout a lifetime of diabetes as they face new challenges and as advances in treatment become available (5).

Four critical time points have been defined when the need for DSMES is to be evaluated by the medical care provider and/or multidisciplinary team, with referrals made as needed (1):

1. At diagnosis
2. Annually for assessment of education, nutrition, and emotional needs

3. When new complicating factors (health conditions, physical limitations, emotional factors, or basic living needs) arise that influence self-management
4. When transitions in care occur

DSMES focuses on supporting patient empowerment by providing people with diabetes the tools to make informed self-management decisions (6). Diabetes care has shifted to an approach that places the person with diabetes and his or her family at the center of the care model, working in collaboration with health care professionals. Patient-centered care is respectful of and responsive to individual patient preferences, needs, and values. It ensures that patient values guide all decision making (7).

Evidence for the Benefits

Studies have found that DSMES is associated with improved diabetes knowledge and self-care behaviors (8), lower A1C (7,9–11), lower self-reported weight (12,13), improved quality of life (10,14), reduced all-cause mortality risk (15), healthy coping (16,17), and reduced health care costs (18–20). Better outcomes were reported for DSMES interventions that were over 10 h in total duration (11), included ongoing support (5,21), were culturally (22,23) and age appropriate (24,25), were tailored to individual needs and preferences, and addressed psychosocial issues and incorporated behavioral strategies (6,16,26,27). Individual and group approaches are effective (13,28,29), with a slight benefit realized by those who engage in both (11). Emerging evidence demonstrates the benefit of Internet-based DSMES services for diabetes prevention and the management of type 2 diabetes (30–32). Technology-enabled diabetes self-management solutions improve A1C most effectively when there is two-way communication between the patient and the health care team, individualized feedback, use of patient-generated health data, and education (32). Current research supports nurses, dietitians, and pharmacists as providers of DSMES who may also develop curriculum (33–35). Members of the DSMES team should have specialized clinical knowledge in diabetes and behavior change principles. Certification as a certified diabetes educator (CDE) or board certified-advanced

diabetes management (BC-ADM) certification demonstrates specialized training and mastery of a specific body of knowledge (4). Additionally, there is growing evidence for the role of community health workers (36,37), as well as peer (36–40) and lay leaders (41), in providing ongoing support.

DSMES is associated with an increased use of primary care and preventive services (18,42,43) and less frequent use of acute care and inpatient hospital services (12). Patients who participate in DSMES are more likely to follow best practice treatment recommendations, particularly among the Medicare population, and have lower Medicare and insurance claim costs (19,42). Despite these benefits, reports indicate that only 5–7% of individuals eligible for DSMES through Medicare or a private insurance plan actually receive it (44,45). This low participation may be due to lack of referral or other identified barriers such as logistical issues (timing, costs) and the lack of a perceived benefit (46). Thus, in addition to educating referring providers about the benefits of DSMES and the critical times to refer (1), alternative and innovative models of DSMES delivery need to be explored and evaluated.

Reimbursement

Medicare reimburses DSMES when that service meets the national standards (1,4) and is recognized by the American Diabetes Association (ADA) or other approval bodies. DSMES is also covered by most health insurance plans. Ongoing support has been shown to be instrumental for improving outcomes when it is implemented after the completion of education services. DSMES is frequently reimbursed when performed in person. However, although DSMES can also be provided via phone calls and telehealth, these remote versions may not always be reimbursed. Changes in reimbursement policies that increase DSMES access and utilization will result in a positive impact to beneficiaries' clinical outcomes, quality of life, health care utilization, and costs (47).

NUTRITION THERAPY

For many individuals with diabetes, the most challenging part of the treatment plan is determining what to eat and following a meal plan. There is not a one-size-fits-all eating pattern for individuals

with diabetes, and meal planning should be individualized. Nutrition therapy has an integral role in overall diabetes management, and each person with diabetes should be actively engaged in education, self-management, and treatment planning with his or her health care team, including the collaborative development of an individualized eating plan (35,48). All individuals with diabetes should be offered a referral for individualized MNT provided by a registered dietitian (RD) who is knowledgeable and skilled in providing diabetes-specific MNT (49). MNT delivered by an RD is associated with A1C decreases of 1.0–1.9% for people with type 1 diabetes (50) and 0.3–2% for people with type 2 diabetes (50). See **Table 5.1** for specific nutrition recommendations. Because of the progressive nature of type 2 diabetes, lifestyle changes alone may not be adequate to maintain euglycemia over time. However, after medication is initiated, nutrition therapy continues to be an important component and should be integrated with the overall treatment plan (48).

Goals of Nutrition Therapy for Adults With Diabetes

1. To promote and support healthful eating patterns, emphasizing a variety of nutrient-dense foods in appropriate portion sizes, to improve overall health and:
 - Achieve and maintain body weight goals
 - Attain individualized glycemic, blood pressure, and lipid goals
 - Delay or prevent the complications of diabetes
2. To address individual nutrition needs based on personal and cultural preferences, health literacy and numeracy, access to healthful foods, willingness and ability to make behavioral changes, and barriers to change
3. To maintain the pleasure of eating by providing nonjudgmental messages about food choices
4. To provide an individual with diabetes the practical tools for developing healthy eating patterns rather than focusing on individual macronutrients, micronutrients, or single foods

Eating Patterns, Macronutrient Distribution, and Meal Planning

Evidence suggests that there is not an ideal percentage of calories from

carbohydrate, protein, and fat for all people with diabetes. Therefore, macronutrient distribution should be based on an individualized assessment of current eating patterns, preferences, and metabolic goals. Consider personal preferences (e.g., tradition, culture, religion, health beliefs and goals, economics) as well as metabolic goals when working with individuals to determine the best eating pattern for them (35,51,52). It is important that each member of the health care team be knowledgeable about nutrition therapy principles for people with all types of diabetes and be supportive of their implementation. Emphasis should be on healthful eating patterns containing nutrient-dense foods, with less focus on specific nutrients (53). A variety of eating patterns are acceptable for the management of diabetes (51,54), and a referral to an RD or registered dietitian nutritionist (RDN) is essential to assess the overall nutrition status of, and to work collaboratively with, the patient to create a personalized meal plan that considers the individual's health status, skills, resources, food preferences, and health goals to coordinate and align with the overall treatment plan including physical activity and medication. The Mediterranean (55,56), Dietary Approaches to Stop Hypertension (DASH) (57–59), and plant-based (60,61) diets are all examples of healthful eating patterns that have shown positive results in research, but individualized meal planning should focus on personal preferences, needs, and goals. In addition, research indicates that low-carbohydrate eating plans may result in improved glycemia and have the potential to reduce antihyperglycemic medications for individuals with type 2 diabetes (62–64). As research studies on some low-carbohydrate eating plans generally indicate challenges with long-term sustainability, it is important to reassess and individualize meal plan guidance regularly for those interested in this approach. This meal plan is not recommended at this time for women who are pregnant or lactating, people with or at risk for disordered eating, or people who have renal disease, and it should be used with caution in patients taking sodium–glucose cotransporter 2 (SGLT2) inhibitors due to the potential risk of ketoacidosis (65,66). There is inadequate research in type 1 diabetes to

support one eating plan over another at this time.

A simple and effective approach to glycemia and weight management emphasizing portion control and healthy food choices should be considered for those with type 2 diabetes who are not taking insulin, who have limited health literacy or numeracy, or who are older and prone to hypoglycemia (50). The diabetes plate method is commonly used for providing basic meal planning guidance (67) as it provides a visual guide showing how to control calories (by featuring a smaller plate) and carbohydrates (by limiting them to what fits in one-quarter of the plate) and puts an emphasis on low-carbohydrate (or non-starchy) vegetables.

Weight Management

Management and reduction of weight is important for people with type 1 diabetes, type 2 diabetes, or prediabetes who have overweight or obesity. Lifestyle intervention programs should be intensive and have frequent follow-up to achieve significant reductions in excess body weight and improve clinical indicators. There is strong and consistent evidence that modest persistent weight loss can delay the progression from prediabetes to type 2 diabetes (51,68,69) (see Section 3 “Prevention or Delay of Type 2 Diabetes”) and is beneficial to the management of type 2 diabetes (see Section 8 “Obesity Management for the Treatment of Type 2 Diabetes”).

Studies of reduced calorie interventions show reductions in A1C of 0.3% to 2.0% in adults with type 2 diabetes, as well as improvements in medication doses and quality of life (50,51). Sustaining weight loss can be challenging (70,71) but has long-term benefits; maintaining weight loss for 5 years is associated with sustained improvements in A1C and lipid levels (72). Weight loss can be attained with lifestyle programs that achieve a 500–750 kcal/day energy deficit or provide ~1,200–1,500 kcal/day for women and 1,500–1,800 kcal/day for men, adjusted for the individual's baseline body weight. For many obese individuals with type 2 diabetes, weight loss of at least 5% is needed to produce beneficial outcomes in glycemic control, lipids, and blood pressure (70). It should be noted, however, that the

Table 5.1—Medical nutrition therapy recommendations

Topic	Recommendations	Evidence rating
Effectiveness of nutrition therapy	5.6 An individualized medical nutrition therapy program as needed to achieve treatment goals, preferably provided by a registered dietitian, is recommended for all people with type 1 or type 2 diabetes, prediabetes, and gestational diabetes mellitus.	A
	5.7 A simple and effective approach to glycemia and weight management emphasizing portion control and healthy food choices may be considered for those with type 2 diabetes who are not taking insulin, who have limited health literacy or numeracy, or who are older and prone to hypoglycemia.	B
	5.8 Because diabetes nutrition therapy can result in cost savings B and improved outcomes (e.g., A1C reduction) A , medical nutrition therapy should be adequately reimbursed by insurance and other payers. E	B, A, E
Energy balance	5.9 Weight loss (>5%) achievable by the combination of reduction of calorie intake and lifestyle modification benefits overweight or obese adults with type 2 diabetes and also those with prediabetes. Intervention programs to facilitate weight loss are recommended.	A
Eating patterns and macronutrient distribution	5.10 There is no single ideal dietary distribution of calories among carbohydrates, fats, and proteins for people with diabetes; therefore, meal plans should be individualized while keeping total calorie and metabolic goals in mind.	E
	5.11 A variety of eating patterns are acceptable for the management of type 2 diabetes and prediabetes.	B
Carbohydrates	5.12 Carbohydrate intake should emphasize nutrient-dense carbohydrate sources that are high in fiber, including vegetables, fruits, legumes, whole grains, as well as dairy products.	B
	5.13 For people with type 1 diabetes and those with type 2 diabetes who are prescribed a flexible insulin therapy program, education on how to use carbohydrate counting A and in some cases how to consider fat and protein content B to determine mealtime insulin dosing is recommended to improve glycemic control.	A, B
	5.14 For individuals whose daily insulin dosing is fixed, a consistent pattern of carbohydrate intake with respect to time and amount may be recommended to improve glycemic control and reduce the risk of hypoglycemia.	B
	5.15 People with diabetes and those at risk are advised to avoid sugar-sweetened beverages (including fruit juices) in order to control glycemia and weight and reduce their risk for cardiovascular disease and fatty liver B and should minimize the consumption of foods with added sugar that have the capacity to displace healthier, more nutrient-dense food choices. A	B, A
	5.16 In individuals with type 2 diabetes, ingested protein appears to increase insulin response without increasing plasma glucose concentrations. Therefore, carbohydrate sources high in protein should be avoided when trying to treat or prevent hypoglycemia.	B
Dietary fat	5.17 Data on the ideal total dietary fat content for people with diabetes are inconclusive, so an eating plan emphasizing elements of a Mediterranean-style diet rich in monounsaturated and polyunsaturated fats may be considered to improve glucose metabolism and lower cardiovascular disease risk and can be an effective alternative to a diet low in total fat but relatively high in carbohydrates.	B
	5.18 Eating foods rich in long-chain n-3 fatty acids, such as fatty fish (EPA and DHA) and nuts and seeds (ALA), is recommended to prevent or treat cardiovascular disease B ; however, evidence does not support a beneficial role for the routine use of n-3 dietary supplements. A	B, A
Micronutrients and herbal supplements	5.19 There is no clear evidence that dietary supplementation with vitamins, minerals (such as chromium and vitamin D), herbs, or spices (such as cinnamon or aloe vera) can improve outcomes in people with diabetes who do not have underlying deficiencies and they are not generally recommended for glycemic control.	C
Alcohol	5.20 Adults with diabetes who drink alcohol should do so in moderation (no more than one drink per day for adult women and no more than two drinks per day for adult men).	C
	5.21 Alcohol consumption may place people with diabetes at increased risk for hypoglycemia, especially if taking insulin or insulin secretagogues. Education and awareness regarding the recognition and management of delayed hypoglycemia are warranted.	B
Sodium	5.22 As for the general population, people with diabetes should limit sodium consumption to <2,300 mg/day.	B
Nonnutritive sweeteners	5.23 The use of nonnutritive sweeteners may have the potential to reduce overall calorie and carbohydrate intake if substituted for caloric (sugar) sweeteners and without compensation by intake of additional calories from other food sources. For those who consume sugar-sweetened beverages regularly, a low-calorie or nonnutritive-sweetened beverage may serve as a short-term replacement strategy, but overall, people are encouraged to decrease both sweetened and nonnutritive-sweetened beverages and use other alternatives, with an emphasis on water intake.	B

clinical benefits of weight loss are progressive and more intensive weight loss goals (i.e., 15%) may be appropriate to maximize benefit depending

on need, feasibility, and safety (73). MNT guidance from an RD/RDN with expertise in diabetes and weight management, throughout the course of a

structured weight loss plan, is strongly recommended.

Studies have demonstrated that a variety of eating plans, varying in

macronutrient composition, can be used effectively and safely in the short term (1–2 years) to achieve weight loss in people with diabetes. This includes structured low-calorie meal plans that include meal replacements (72–74) and the Mediterranean eating pattern (75) as well as low-carbohydrate meal plans (62). However, no single approach has been proven to be consistently superior (76,77), and more data are needed to identify and validate those meal plans that are optimal with respect to long-term outcomes as well as patient acceptability. The importance of providing guidance on an individualized meal plan containing nutrient-dense foods, such as vegetables, fruits, legumes, dairy, lean sources of protein (including plant-based sources as well as lean meats, fish, and poultry), nuts, seeds, and whole grains, cannot be overemphasized (77), as well as guidance on achieving the desired energy deficit (78–81). Any approach to meal planning should be individualized considering the health status, personal preferences, and ability of the person with diabetes to sustain the recommendations in the plan.

Carbohydrates

Studies examining the ideal amount of carbohydrate intake for people with diabetes are inconclusive, although monitoring carbohydrate intake and considering the blood glucose response to dietary carbohydrate are key for improving postprandial glucose control (82,83). The literature concerning glycemic index and glycemic load in individuals with diabetes is complex, often yielding mixed results, though in some studies lowering the glycemic load of consumed carbohydrates has demonstrated A1C reductions of 0.2% to 0.5% (84,85). Studies longer than 12 weeks report no significant influence of glycemic index or glycemic load independent of weight loss on A1C; however, mixed results have been reported for fasting glucose levels and endogenous insulin levels.

For people with type 2 diabetes or prediabetes, low-carbohydrate eating plans show potential to improve glycemia and lipid outcomes for up to 1 year (62–64,86–89). Part of the challenge in interpreting low-carbohydrate research has been due to the wide range of definitions for a low-carbohydrate eating plan (85,86). As research studies on

low-carbohydrate eating plans generally indicate challenges with long-term sustainability, it is important to reassess and individualize meal plan guidance regularly for those interested in this approach. Providers should maintain consistent medical oversight and recognize that certain groups are not appropriate for low-carbohydrate eating plans, including women who are pregnant or lactating, children, and people who have renal disease or disordered eating behavior, and these plans should be used with caution for those taking SGLT2 inhibitors due to potential risk of ketoacidosis (65,66). There is inadequate research about dietary patterns for type 1 diabetes to support one eating plan over another at this time.

Most individuals with diabetes report a moderate intake of carbohydrate (44–46% of total calories) (51). Efforts to modify habitual eating patterns are often unsuccessful in the long term; people generally go back to their usual macronutrient distribution (51). Thus, the recommended approach is to individualize meal plans to meet caloric goals with a macronutrient distribution that is more consistent with the individual's usual intake to increase the likelihood for long-term maintenance.

As for all individuals in developed countries, both children and adults with diabetes are encouraged to minimize intake of refined carbohydrates and added sugars and instead focus on carbohydrates from vegetables, legumes, fruits, dairy (milk and yogurt), and whole grains. The consumption of sugar-sweetened beverages (including fruit juices) and processed “low-fat” or “nonfat” food products with high amounts of refined grains and added sugars is strongly discouraged (90–92).

Individuals with type 1 or type 2 diabetes taking insulin at mealtime should be offered intensive and ongoing education on the need to couple insulin administration with carbohydrate intake. For people whose meal schedule or carbohydrate consumption is variable, regular counseling to help them understand the complex relationship between carbohydrate intake and insulin needs is important. In addition, education on using the insulin-to-carbohydrate ratios for meal planning can assist them with effectively modifying insulin dosing from meal to meal and improving glycemic

control (51,82,93–96). Individuals who consume meals containing more protein and fat than usual may also need to make mealtime insulin dose adjustments to compensate for delayed postprandial glycemic excursions (97–99). For individuals on a fixed daily insulin schedule, meal planning should emphasize a relatively fixed carbohydrate consumption pattern with respect to both time and amount (35).

Protein

There is no evidence that adjusting the daily level of protein intake (typically 1–1.5 g/kg body weight/day or 15–20% total calories) will improve health in individuals without diabetic kidney disease, and research is inconclusive regarding the ideal amount of dietary protein to optimize either glycemic control or cardiovascular disease (CVD) risk (84,100). Therefore, protein intake goals should be individualized based on current eating patterns. Some research has found successful management of type 2 diabetes with meal plans including slightly higher levels of protein (20–30%), which may contribute to increased satiety (58).

Those with diabetic kidney disease (with albuminuria and/or reduced estimated glomerular filtration rate) should aim to maintain dietary protein at the recommended daily allowance of 0.8 g/kg body weight/day. Reducing the amount of dietary protein below the recommended daily allowance is not recommended because it does not alter glycemic measures, cardiovascular risk measures, or the rate at which glomerular filtration rate declines (101,102).

In individuals with type 2 diabetes, protein intake may enhance or increase the insulin response to dietary carbohydrates (103). Therefore, use of carbohydrate sources high in protein (such as milk and nuts) to treat or prevent hypoglycemia should be avoided due to the potential concurrent rise in endogenous insulin.

Fats

The ideal amount of dietary fat for individuals with diabetes is controversial. The National Academy of Medicine has defined an acceptable macronutrient distribution for total fat for all adults to be 20–35% of total calorie intake (104). The type of fats consumed is more

important than total amount of fat when looking at metabolic goals and CVD risk, and it is recommended that the percentage of total calories from saturated fats should be limited (75,90,105–107). Multiple randomized controlled trials including patients with type 2 diabetes have reported that a Mediterranean-style eating pattern (75,108–113), rich in polyunsaturated and monounsaturated fats, can improve both glycemic control and blood lipids. However, supplements do not seem to have the same effects as their whole-food counterparts. A systematic review concluded that dietary supplements with n-3 fatty acids did not improve glycemic control in individuals with type 2 diabetes (84). Randomized controlled trials also do not support recommending n-3 supplements for primary or secondary prevention of CVD (114–118). People with diabetes should be advised to follow the guidelines for the general population for the recommended intakes of saturated fat, dietary cholesterol, and *trans* fat (90). In general, *trans* fats should be avoided. In addition, as saturated fats are progressively decreased in the diet, they should be replaced with unsaturated fats and not with refined carbohydrates (112).

Sodium

As for the general population, people with diabetes are advised to limit their sodium consumption to <2,300 mg/day (35). Restriction below 1,500 mg, even for those with hypertension, is generally not recommended (119–121). Sodium intake recommendations should take into account palatability, availability, affordability, and the difficulty of achieving low-sodium recommendations in a nutritionally adequate diet (122).

Micronutrients and Supplements

There continues to be no clear evidence of benefit from herbal or nonherbal (i.e., vitamin or mineral) supplementation for people with diabetes without underlying deficiencies (35). Metformin is associated with vitamin B12 deficiency, with a recent report from the Diabetes Prevention Program Outcomes Study (DPPOS) suggesting that periodic testing of vitamin B12 levels should be considered in patients taking metformin, particularly in those with anemia

or peripheral neuropathy (123). Routine supplementation with antioxidants, such as vitamins E and C and carotene, is not advised due to lack of evidence of efficacy and concern related to long-term safety. In addition, there is insufficient evidence to support the routine use of herbals and micronutrients, such as cinnamon (124), curcumin, vitamin D (125), or chromium, to improve glycemia in people with diabetes (35,126). However, for special populations, including pregnant or lactating women, older adults, vegetarians, and people following very low-calorie or low-carbohydrate diets, a multivitamin may be necessary.

Alcohol

Moderate alcohol intake does not have major detrimental effects on long-term blood glucose control in people with diabetes. Risks associated with alcohol consumption include hypoglycemia (particularly for those using insulin or insulin secretagogue therapies), weight gain, and hyperglycemia (for those consuming excessive amounts) (35,126). People with diabetes can follow the same guidelines as those without diabetes if they choose to drink. For women, no more than one drink per day, and for men, no more than two drinks per day is recommended (one drink is equal to a 12-oz beer, a 5-oz glass of wine, or 1.5 oz of distilled spirits).

Nonnutritive Sweeteners

For some people with diabetes who are accustomed to sugar-sweetened products, nonnutritive sweeteners (containing few or no calories) may be an acceptable substitute for nutritive sweeteners (those containing calories such as sugar, honey, agave syrup) when consumed in moderation. While use of nonnutritive sweeteners does not appear to have a significant effect on glycemic control (127), they can reduce overall calorie and carbohydrate intake (51). Most systematic reviews and meta-analyses show benefits for nonnutritive sweetener use in weight loss (128,129); however, some research suggests an association with weight gain (130). Regulatory agencies set acceptable daily intake levels for each nonnutritive sweetener, defined as the amount that can be safely consumed over a person's lifetime (35,131). For those who consume sugar-sweetened beverages regularly, a low-calorie or nonnutritive-sweetened

beverage may serve as a short-term replacement strategy, but overall, people are encouraged to decrease both sweetened and nonnutritive-sweetened beverages and use other alternatives, with an emphasis on water intake (132).

PHYSICAL ACTIVITY

Recommendations

- 5.24** Children and adolescents with type 1 or type 2 diabetes or prediabetes should engage in 60 min/day or more of moderate- or vigorous-intensity aerobic activity, with vigorous muscle-strengthening and bone-strengthening activities at least 3 days/week. **C**
- 5.25** Most adults with type 1 **C** and type 2 **B** diabetes should engage in 150 min or more of moderate-to-vigorous intensity aerobic activity per week, spread over at least 3 days/week, with no more than 2 consecutive days without activity. Shorter durations (minimum 75 min/week) of vigorous-intensity or interval training may be sufficient for younger and more physically fit individuals.
- 5.26** Adults with type 1 **C** and type 2 **B** diabetes should engage in 2–3 sessions/week of resistance exercise on nonconsecutive days.
- 5.27** All adults, and particularly those with type 2 diabetes, should decrease the amount of time spent in daily sedentary behavior. **B** Prolonged sitting should be interrupted every 30 min for blood glucose benefits, particularly in adults with type 2 diabetes. **C**
- 5.28** Flexibility training and balance training are recommended 2–3 times/week for older adults with diabetes. Yoga and tai chi may be included based on individual preferences to increase flexibility, muscular strength, and balance. **C**

Physical activity is a general term that includes all movement that increases energy use and is an important part of the diabetes management plan. Exercise is a more specific form of physical activity that is structured and designed to improve physical fitness. Both physical activity and exercise are important.

Exercise has been shown to improve blood glucose control, reduce cardiovascular risk factors, contribute to weight loss, and improve well-being (133). Physical activity is as important for those with type 1 diabetes as it is for the general population, but its specific role in the prevention of diabetes complications and the management of blood glucose is not as clear as it is for those with type 2 diabetes. A recent study suggested that the percentage of people with diabetes who achieved the recommended exercise level per week (150 min) varied by race. Objective measurement by accelerometer showed that 44.2%, 42.6%, and 65.1% of whites, African Americans, and Hispanics, respectively, met the threshold (134). It is important for diabetes care management teams to understand the difficulty that many patients have reaching recommended treatment targets and to identify individualized approaches to improve goal achievement.

Moderate to high volumes of aerobic activity are associated with substantially lower cardiovascular and overall mortality risks in both type 1 and type 2 diabetes (135). A recent prospective observational study of adults with type 1 diabetes suggested that higher amounts of physical activity led to reduced cardiovascular mortality after a mean follow-up time of 11.4 years for patients with and without chronic kidney disease (136). Additionally, structured exercise interventions of at least 8 weeks' duration have been shown to lower A1C by an average of 0.66% in people with type 2 diabetes, even without a significant change in BMI (137). There are also considerable data for the health benefits (e.g., increased cardiovascular fitness, greater muscle strength, improved insulin sensitivity, etc.) of regular exercise for those with type 1 diabetes (138). A recent study suggested that exercise training in type 1 diabetes may also improve several important markers such as triglyceride level, LDL, waist circumference, and body mass (139). Higher levels of exercise intensity are associated with greater improvements in A1C and in fitness (140). Other benefits include slowing the decline in mobility among overweight patients with diabetes (141). The ADA position statement "Physical Activity/Exercise and Diabetes" reviews the evidence for the benefits of exercise in people with type

1 and type 2 diabetes and offers specific recommendation (142).

Exercise and Children

All children, including children with diabetes or prediabetes, should be encouraged to engage in regular physical activity. Children should engage in at least 60 min of moderate-to-vigorous aerobic activity every day with muscle- and bone-strengthening activities at least 3 days per week (143). In general, youth with type 1 diabetes benefit from being physically active, and an active lifestyle should be recommended to all (144). Youth with type 1 diabetes who engage in more physical activity may have better health-related quality of life (145).

Frequency and Type of Physical Activity

People with diabetes should perform aerobic and resistance exercise regularly (142). Aerobic activity bouts should ideally last at least 10 min, with the goal of ~30 min/day or more, most days of the week for adults with type 2 diabetes. Daily exercise, or at least not allowing more than 2 days to elapse between exercise sessions, is recommended to decrease insulin resistance, regardless of diabetes type (146,147). Over time, activities should progress in intensity, frequency, and/or duration to at least 150 min/week of moderate-intensity exercise. Adults able to run at 6 miles/h (9.7 km/h) for at least 25 min can benefit sufficiently from shorter-intensity activity (75 min/week) (142). Many adults, including most with type 2 diabetes, would be unable or unwilling to participate in such intense exercise and should engage in moderate exercise for the recommended duration. Adults with diabetes should engage in 2–3 sessions/week of resistance exercise on nonconsecutive days (148). Although heavier resistance training with free weights and weight machines may improve glycemic control and strength (149), resistance training of any intensity is recommended to improve strength, balance, and the ability to engage in activities of daily living throughout the life span. Providers and staff should help patients set stepwise goals toward meeting the recommended exercise targets.

Recent evidence supports that all individuals, including those with diabetes,

should be encouraged to reduce the amount of time spent being sedentary (e.g., working at a computer, watching TV) by breaking up bouts of sedentary activity (>30 min) by briefly standing, walking, or performing other light physical activities (150,151). Avoiding extended sedentary periods may help prevent type 2 diabetes for those at risk and may also aid in glycemic control for those with diabetes.

A wide range of activities, including yoga, tai chi, and other types, can have significant impacts on A1C, flexibility, muscle strength, and balance (133,152,153). Flexibility and balance exercises may be particularly important in older adults with diabetes to maintain range of motion, strength, and balance (142).

Physical Activity and Glycemic Control

Clinical trials have provided strong evidence for the A1C-lowering value of resistance training in older adults with type 2 diabetes (154) and for an additive benefit of combined aerobic and resistance exercise in adults with type 2 diabetes (155). If not contraindicated, patients with type 2 diabetes should be encouraged to do at least two weekly sessions of resistance exercise (exercise with free weights or weight machines), with each session consisting of at least one set (group of consecutive repetitive exercise motions) of five or more different resistance exercises involving the large muscle groups (154).

For type 1 diabetes, although exercise in general is associated with improvement in disease status, care needs to be taken in titrating exercise with respect to glycemic management. Each individual with type 1 diabetes has a variable glycemic response to exercise. This variability should be taken into consideration when recommending the type and duration of exercise for a given individual (138).

Women with preexisting diabetes, particularly type 2 diabetes, and those at risk for or presenting with gestational diabetes mellitus should be advised to engage in regular moderate physical activity prior to and during their pregnancies as tolerated (142).

Pre-exercise Evaluation

As discussed more fully in Section 10 "Cardiovascular Disease and Risk

Management,” the best protocol for assessing asymptomatic patients with diabetes for coronary artery disease remains unclear. The ADA consensus report “Screening for Coronary Artery Disease in Patients With Diabetes” (156) concluded that routine testing is not recommended. However, providers should perform a careful history, assess cardiovascular risk factors, and be aware of the atypical presentation of coronary artery disease in patients with diabetes. Certainly, high-risk patients should be encouraged to start with short periods of low-intensity exercise and slowly increase the intensity and duration as tolerated. Providers should assess patients for conditions that might contraindicate certain types of exercise or predispose to injury, such as uncontrolled hypertension, untreated proliferative retinopathy, autonomic neuropathy, peripheral neuropathy, and a history of foot ulcers or Charcot foot. The patient’s age and previous physical activity level should be considered. The provider should customize the exercise regimen to the individual’s needs. Those with complications may require a more thorough evaluation prior to beginning an exercise program (138).

Hypoglycemia

In individuals taking insulin and/or insulin secretagogues, physical activity may cause hypoglycemia if the medication dose or carbohydrate consumption is not altered. Individuals on these therapies may need to ingest some added carbohydrate if pre-exercise glucose levels are <90 mg/dL (5.0 mmol/L), depending on whether they are able to lower insulin doses during the workout (such as with an insulin pump or reduced pre-exercise insulin dosage), the time of day exercise is done, and the intensity and duration of the activity (138,142). In some patients, hypoglycemia after exercise may occur and last for several hours due to increased insulin sensitivity. Hypoglycemia is less common in patients with diabetes who are not treated with insulin or insulin secretagogues, and no routine preventive measures for hypoglycemia are usually advised in these cases. Intense activities may actually raise blood glucose levels instead of lowering them, especially if pre-exercise glucose levels are elevated (157).

Exercise in the Presence of Microvascular Complications

See Section 11 “Microvascular Complications and Foot Care” for more information on these long-term complications.

Retinopathy

If proliferative diabetic retinopathy or severe nonproliferative diabetic retinopathy is present, then vigorous-intensity aerobic or resistance exercise may be contraindicated because of the risk of triggering vitreous hemorrhage or retinal detachment (158). Consultation with an ophthalmologist prior to engaging in an intense exercise regimen may be appropriate.

Peripheral Neuropathy

Decreased pain sensation and a higher pain threshold in the extremities result in an increased risk of skin breakdown, infection, and Charcot joint destruction with some forms of exercise. Therefore, a thorough assessment should be done to ensure that neuropathy does not alter kinesthetic or proprioceptive sensation during physical activity, particularly in those with more severe neuropathy. Studies have shown that moderate-intensity walking may not lead to an increased risk of foot ulcers or reulceration in those with peripheral neuropathy who use proper footwear (159). In addition, 150 min/week of moderate exercise was reported to improve outcomes in patients with prediabetic neuropathy (160). All individuals with peripheral neuropathy should wear proper footwear and examine their feet daily to detect lesions early. Anyone with a foot injury or open sore should be restricted to non-weight-bearing activities.

Autonomic Neuropathy

Autonomic neuropathy can increase the risk of exercise-induced injury or adverse events through decreased cardiac responsiveness to exercise, postural hypotension, impaired thermoregulation, impaired night vision due to impaired papillary reaction, and greater susceptibility to hypoglycemia (161). Cardiovascular autonomic neuropathy is also an independent risk factor for cardiovascular death and silent myocardial ischemia (162). Therefore, individuals with diabetic autonomic neuropathy should undergo cardiac investigation before beginning physical activity more intense than that to which they are accustomed.

Diabetic Kidney Disease

Physical activity can acutely increase urinary albumin excretion. However, there is no evidence that vigorous-intensity exercise increases the rate of progression of diabetic kidney disease, and there appears to be no need for specific exercise restrictions for people with diabetic kidney disease in general (158).

SMOKING CESSATION: TOBACCO AND E-CIGARETTES

Recommendations

- 5.29** Advise all patients not to use cigarettes and other tobacco products **A** or e-cigarettes. **B**
- 5.30** Include smoking cessation counseling and other forms of treatment as a routine component of diabetes care. **A**

Results from epidemiological, case-control, and cohort studies provide convincing evidence to support the causal link between cigarette smoking and health risks (163). Recent data show tobacco use is higher among adults with chronic conditions (164) as well as in adolescents and young adults with diabetes (165). Smokers with diabetes (and people with diabetes exposed to second-hand smoke) have a heightened risk of CVD, premature death, microvascular complications, and worse glycemic control when compared with nonsmokers (166,167). Smoking may have a role in the development of type 2 diabetes (168–171).

The routine and thorough assessment of tobacco use is essential to prevent smoking or encourage cessation. Numerous large randomized clinical trials have demonstrated the efficacy and cost-effectiveness of brief counseling in smoking cessation, including the use of telephone quit lines, in reducing tobacco use. Pharmacologic therapy to assist with smoking cessation in people with diabetes has been shown to be effective (172), and for the patient motivated to quit, the addition of pharmacologic therapy to counseling is more effective than either treatment alone (173). Special considerations should include assessment of level of nicotine dependence, which is associated with difficulty in quitting and relapse (174). Although some patients may gain weight in the period shortly after smoking

cessation (175), recent research has demonstrated that this weight gain does not diminish the substantial CVD benefit realized from smoking cessation (176). One study in smokers with newly diagnosed type 2 diabetes found that smoking cessation was associated with amelioration of metabolic parameters and reduced blood pressure and albuminuria at 1 year (177).

In recent years e-cigarettes have gained public awareness and popularity because of perceptions that e-cigarette use is less harmful than regular cigarette smoking (178,179). Nonsmokers should be advised not to use e-cigarettes (180,181). There are no rigorous studies that have demonstrated that e-cigarettes are a healthier alternative to smoking or that e-cigarettes can facilitate smoking cessation (182). On the contrary, a recently published pragmatic trial found that use of e-cigarettes for smoking cessation was not more effective than “usual care,” which included access to educational information on the health benefits of smoking cessation, strategies to promote cessation, and access to a free text-messaging service that provided encouragement, advice, and tips to facilitate smoking cessation (183). Several organizations have called for more research on the short- and long-term safety and health effects of e-cigarettes (184–186).

PSYCHOSOCIAL ISSUES

Recommendations

- 5.31** Psychosocial care should be integrated with a collaborative, patient-centered approach and provided to all people with diabetes, with the goals of optimizing health outcomes and health-related quality of life. **A**
- 5.32** Psychosocial screening and follow-up may include, but are not limited to, attitudes about diabetes, expectations for medical management and outcomes, affect or mood, general and diabetes-related quality of life, available resources (financial, social, and emotional), and psychiatric history. **E**
- 5.33** Providers should consider assessment for symptoms of diabetes distress, depression, anxiety,

disordered eating, and cognitive capacities using patient-appropriate standardized and validated tools at the initial visit, at periodic intervals, and when there is a change in disease, treatment, or life circumstance. Including caregivers and family members in this assessment is recommended. **B**

- 5.34** Consider screening older adults (aged ≥ 65 years) with diabetes for cognitive impairment and depression. **B**

Please refer to the ADA position statement “Psychosocial Care for People With Diabetes” for a list of assessment tools and additional details (187).

Complex environmental, social, behavioral, and emotional factors, known as psychosocial factors, influence living with diabetes, both type 1 and type 2, and achieving satisfactory medical outcomes and psychological well-being. Thus, individuals with diabetes and their families are challenged with complex, multifaceted issues when integrating diabetes care into daily life.

Emotional well-being is an important part of diabetes care and self-management. Psychological and social problems can impair the individual’s (188–190) or family’s (191) ability to carry out diabetes care tasks and therefore potentially compromise health status. There are opportunities for the clinician to routinely assess psychosocial status in a timely and efficient manner for referral to appropriate services. A systematic review and meta-analysis showed that psychosocial interventions modestly but significantly improved A1C (standardized mean difference -0.29%) and mental health outcomes (192). However, there was a limited association between the effects on A1C and mental health, and no intervention characteristics predicted benefit on both outcomes.

Screening

Key opportunities for psychosocial screening occur at diabetes diagnosis, during regularly scheduled management visits, during hospitalizations, with new onset of complications, or when problems with glucose control, quality of life, or self-management are identified (1). Patients are likely to exhibit

psychological vulnerability at diagnosis, when their medical status changes (e.g., end of the honeymoon period), when the need for intensified treatment is evident, and when complications are discovered.

Providers can start with informal verbal inquires, for example, by asking if there have been changes in mood during the past 2 weeks or since the patient’s last visit. Providers should consider asking if there are new or different barriers to treatment and self-management, such as feeling overwhelmed or stressed by diabetes or other life stressors. Standardized and validated tools for psychosocial monitoring and assessment can also be used by providers (187), with positive findings leading to referral to a mental health provider specializing in diabetes for comprehensive evaluation, diagnosis, and treatment.

Diabetes Distress

Recommendation

- 5.35** Routinely monitor people with diabetes for diabetes distress, particularly when treatment targets are not met and/or at the onset of diabetes complications. **B**

Diabetes distress (DD) is very common and is distinct from other psychological disorders (193–195). DD refers to significant negative psychological reactions related to emotional burdens and worries specific to an individual’s experience in having to manage a severe, complicated, and demanding chronic disease such as diabetes (194–196). The constant behavioral demands (medication dosing, frequency, and titration; monitoring blood glucose, food intake, eating patterns, and physical activity) of diabetes self-management and the potential or actuality of disease progression are directly associated with reports of DD (194). The prevalence of DD is reported to be 18–45% with an incidence of 38–48% over 18 months (196). In the second Diabetes Attitudes, Wishes and Needs (DAWN2) study, significant DD was reported by 45% of the participants, but only 24% reported that their health care teams asked them how diabetes affected their lives (193). High levels of DD significantly impact medication-taking behaviors and are linked to higher

Table 5.2—Situations that warrant referral of a person with diabetes to a mental health provider for evaluation and treatment

- If self-care remains impaired in a person with diabetes distress after tailored diabetes education
- If a person has a positive screen on a validated screening tool for depressive symptoms
- In the presence of symptoms or suspicions of disordered eating behavior, an eating disorder, or disrupted patterns of eating
- If intentional omission of insulin or oral medication to cause weight loss is identified
- If a person has a positive screen for anxiety or fear of hypoglycemia
- If a serious mental illness is suspected
- In youth and families with behavioral self-care difficulties, repeated hospitalizations for diabetic ketoacidosis, or significant distress
- If a person screens positive for cognitive impairment
- Declining or impaired ability to perform diabetes self-care behaviors
- Before undergoing bariatric or metabolic surgery and after surgery if assessment reveals an ongoing need for adjustment support

A1C, lower self-efficacy, and poorer dietary and exercise behaviors (17,194, 196). DSMES has been shown to reduce DD (17). It may be helpful to provide counseling regarding expected diabetes-related versus generalized psychological distress at diagnosis and when disease state or treatment changes (197).

DD should be routinely monitored (198) using patient-appropriate validated measures (187). If DD is identified, the person should be referred for specific diabetes education to address areas of diabetes self-care that are most relevant to the patient and impact clinical management. People whose self-care remains impaired after tailored diabetes education should be referred by their care team to a behavioral health provider for evaluation and treatment.

Other psychosocial issues known to affect self-management and health outcomes include attitudes about the illness, expectations for medical management and outcomes, available resources (financial, social, and emotional) (199), and psychiatric history. For additional information on psychiatric comorbidities (depression, anxiety, disordered eating, and serious mental illness), please refer to Section 4 “Comprehensive Medical Evaluation and Assessment of Comorbidities.”

Referral to a Mental Health Specialist

Indications for referral to a mental health specialist familiar with diabetes management may include positive screening for overall stress related to work-life balance, DD, diabetes management difficulties, depression, anxiety, disordered eating, and cognitive dysfunction (see **Table 5.2** for a complete list). It is preferable to incorporate psychosocial assessment and treatment into routine care rather than waiting for a specific problem or deterioration in metabolic or

psychological status to occur (26,193). Providers should identify behavioral and mental health providers, ideally those who are knowledgeable about diabetes treatment and the psychosocial aspects of diabetes, to whom they can refer patients. The ADA provides a list of mental health providers who have received additional education in diabetes at the ADA Mental Health Provider Directory (professional.diabetes.org/ada-mental-health-provider-directory). Ideally, psychosocial care providers should be embedded in diabetes care settings. Although the clinician may not feel qualified to treat psychological problems (200), optimizing the patient-provider relationship as a foundation may increase the likelihood of the patient accepting referral for other services. Collaborative care interventions and a team approach have demonstrated efficacy in diabetes self-management, outcomes of depression, and psychosocial functioning (17,201).

References

1. Powers MA, Bardsley J, Cypress M, et al. Diabetes self-management education and support in type 2 diabetes: a joint position statement of the American Diabetes Association, the American Association of Diabetes Educators, and the Academy of Nutrition and Dietetics. *Diabetes Care* 2015;38:1372–1382
2. Dickinson JK, Guzman SJ, Maryniuk MD, et al. The use of language in diabetes care and education. *Diabetes Care* 2017;40:1790–1799
3. Dickinson JK, Maryniuk MD. Building therapeutic relationships: choosing words that put people first. *Clin Diabetes* 2017;35:51–54
4. Beck J, Greenwood DA, Blanton L, et al.; 2017 Standards Revision Task Force. 2017 national standards for diabetes self-management education and support. *Diabetes Care* 2017;40:1409–1419
5. Tang TS, Funnell MM, Brown MB, Kurlander JE. Self-management support in “real-world” settings: an empowerment-based intervention. *Patient Educ Couns* 2010;79:178–184
6. Marrero DG, Ard J, Delamater AM, et al. Twenty-first century behavioral medicine: a context for empowering clinicians and patients

with diabetes: a consensus report. *Diabetes Care* 2013;36:463–470

7. Norris SL, Lau J, Smith SJ, Schmid CH, Engelgau MM. Self-management education for adults with type 2 diabetes: a meta-analysis of the effect on glycemic control. *Diabetes Care* 2002; 25:1159–1171

8. Haas L, Maryniuk M, Beck J, et al.; 2012 Standards Revision Task Force. National standards for diabetes self-management education and support. *Diabetes Care* 2014;37(Suppl. 1): S144–S153

9. Frosch DL, Uy V, Ochoa S, Mangione CM. Evaluation of a behavior support intervention for patients with poorly controlled diabetes. *Arch Intern Med* 2011;171:2011–2017

10. Cooke D, Bond R, Lawton J, et al.; U.K. NIHR DAFNE Study Group. Structured type 1 diabetes education delivered within routine care: impact on glycemic control and diabetes-specific quality of life. *Diabetes Care* 2013;36:270–272

11. Chrvala CA, Sherr D, Lipman RD. Diabetes self-management education for adults with type 2 diabetes mellitus: a systematic review of the effect on glycemic control. *Patient Educ Couns* 2016;99:926–943

12. Steinsbakk A, Rygg LØ, Lisulo M, Rise MB, Fretheim A. Group based diabetes self-management education compared to routine treatment for people with type 2 diabetes mellitus. A systematic review with meta-analysis. *BMC Health Serv Res* 2012;12:213

13. Deakin T, McShane CE, Cade JE, Williams RD. Group based training for self-management strategies in people with type 2 diabetes mellitus. *Cochrane Database Syst Rev* 2005;2: CD003417

14. Cochran J, Conn VS. Meta-analysis of quality of life outcomes following diabetes self-management training. *Diabetes Educ* 2008;34: 815–823

15. He X, Li J, Wang B, et al. Diabetes self-management education reduces risk of all-cause mortality in type 2 diabetes patients: a systematic review and meta-analysis. *Endocrine* 2017; 55:712–731

16. Thorpe CT, Fahey LE, Johnson H, Deshpande M, Thorpe JM, Fisher EB. Facilitating healthy coping in patients with diabetes: a systematic review. *Diabetes Educ* 2013;39:33–52

17. Fisher L, Hessler D, Glasgow RE, et al. REDEEM: a pragmatic trial to reduce diabetes distress. *Diabetes Care* 2013;36:2551–2558

18. Robbins JM, Thatcher GE, Webb DA, Valdmanis VG. Nutritionist visits, diabetes classes,

- and hospitalization rates and charges: the Urban Diabetes Study. *Diabetes Care* 2008;31:655–660
19. Duncan I, Ahmed T, Li QE, et al. Assessing the value of the diabetes educator. *Diabetes Educ* 2011;37:638–657
20. Strawbridge LM, Lloyd JT, Meadow A, Riley GF, Howell BL. One-year outcomes of diabetes self-management training among Medicare beneficiaries newly diagnosed with diabetes. *Med Care* 2017;55:391–397
21. Piatt GA, Anderson RM, Brooks MM, et al. 3-year follow-up of clinical and behavioral improvements following a multifaceted diabetes care intervention: results of a randomized controlled trial. *Diabetes Educ* 2010;36:301–309
22. Glazier RH, Bajcar J, Kennie NR, Willson K. A systematic review of interventions to improve diabetes care in socially disadvantaged populations. *Diabetes Care* 2006;29:1675–1688
23. Hawthorne K, Robles Y, Cannings-John R, Edwards AG. Culturally appropriate health education for type 2 diabetes mellitus in ethnic minority groups. *Cochrane Database Syst Rev* 2008;3:CD006424
24. Chodosh J, Morton SC, Mojica W, et al. Meta-analysis: chronic disease self-management programs for older adults. *Ann Intern Med* 2005;143:427–438
25. Sarkisian CA, Brown AF, Norris KC, Wintz RL, Mangione CM. A systematic review of diabetes self-care interventions for older, African American, or Latino adults. *Diabetes Educ* 2003;29:467–479
26. Peyrot M, Rubin RR. Behavioral and psychosocial interventions in diabetes: a conceptual review. *Diabetes Care* 2007;30:2433–2440
27. Naik AD, Palmer N, Petersen NJ, et al. Comparative effectiveness of goal setting in diabetes mellitus group clinics: randomized clinical trial. *Arch Intern Med* 2011;171:453–459
28. Duke S-AS, Colagiuri S, Colagiuri R. Individual patient education for people with type 2 diabetes mellitus. *Cochrane Database Syst Rev* 2009;1:CD005268
29. Odgers-Jewell K, Ball LE, Kelly JT, Isenring EA, Reidlinger DP, Thomas R. Effectiveness of group-based self-management education for individuals with type 2 diabetes: a systematic review with meta-analyses and meta-regression. *Diabet Med* 2017;34:1027–1039
30. Pereira K, Phillips B, Johnson C, Vorderstrasse A. Internet delivered diabetes self-management education: a review. *Diabetes Technol Ther* 2015;17:55–63
31. Sepah SC, Jiang L, Peters AL. Long-term outcomes of a Web-based diabetes prevention program: 2-year results of a single-arm longitudinal study. *J Med Internet Res* 2015;17:e92
32. Greenwood DA, Gee PM, Fatkin KJ, Peeples M. A systematic review of reviews evaluating technology-enabled diabetes self-management education and support. *J Diabetes Sci Technol* 2017;11:1015–1027
33. van Eikenhorst L, Taxis K, van Dijk L, de Gier H. Pharmacist-led self-management interventions to improve diabetes outcomes. A systematic literature review and meta-analysis. *Front Pharmacol* 2017;8:891
34. Tshiananga JKT, Kocher S, Weber C, Erny-Albrecht K, Berndt K, Neeser K. The effect of nurse-led diabetes self-management education on glycosylated hemoglobin and cardiovascular risk factors: a meta-analysis. *Diabetes Educ* 2012;38:108–123
35. Evert AB, Boucher JL, Cypress M, et al. Nutrition therapy recommendations for the management of adults with diabetes. *Diabetes Care* 2014;37(Suppl. 1):S120–S143
36. Shah M, Kaselitz E, Heisler M. The role of community health workers in diabetes: update on current literature. *Curr Diab Rep* 2013;13:163–171
37. Spencer MS, Kieffer EC, Sinco B, et al. Outcomes at 18 months from a community health worker and peer leader diabetes self-management program for Latino adults. *Diabetes Care* 2018;41:1414–1422
38. Heisler M, Vijan S, Makki F, Piette JD. Diabetes control with reciprocal peer support versus nurse care management: a randomized trial. *Ann Intern Med* 2010;153:507–515
39. Long JA, Jahnle EC, Richardson DM, Loewenstein G, Volpp KG. Peer mentoring and financial incentives to improve glucose control in African American veterans: a randomized trial. *Ann Intern Med* 2012;156:416–424
40. Fisher EB, Boothroyd RI, Elstad EA, et al. Peer support of complex health behaviors in prevention and disease management with special reference to diabetes: systematic reviews. *Clin Diabetes Endocrinol* 2017;3:4
41. Foster G, Taylor SJC, Eldridge SE, Ramsay J, Griffiths CJ. Self-management education programmes by lay leaders for people with chronic conditions. *Cochrane Database Syst Rev* 2007;4:CD005108
42. Duncan I, Birkmeyer C, Coughlin S, Li QE, Sherr D, Boren S. Assessing the value of diabetes education. *Diabetes Educ* 2009;35:752–760
43. Johnson TM, Murray MR, Huang Y. Associations between self-management education and comprehensive diabetes clinical care. *Diabetes Spectr* 2010;23:41–46
44. Strawbridge LM, Lloyd JT, Meadow A, Riley GF, Howell BL. Use of Medicare's diabetes self-management training benefit. *Health Educ Behav* 2015;42:530–538
45. Li R, Shrestha SS, Lipman R, Burrows NR, Kolb LE, Rutledge S; Centers for Disease Control and Prevention (CDC). Diabetes self-management education and training among privately insured persons with newly diagnosed diabetes—United States, 2011–2012. *MMWR Morb Mortal Wkly Rep* 2014;63:1045–1049
46. Horigan G, Davies M, Findlay-White F, Chaney D, Coates V. Reasons why patients referred to diabetes education programmes choose not to attend: a systematic review. *Diabet Med* 2017;34:14–26
47. Center For Health Law and Policy Innovation. Reconsidering cost-sharing for diabetes self-management education: recommendations for policy reform [Internet]. Available from: http://www.chlpi.org/health_library/reconsidering-cost-sharing-diabetes-self-management-education-recommendations-policy-reform/. Accessed 2 November 2018
48. Davies MJ, D'Alessio DA, Fradkin J, et al. Management of hyperglycemia in type 2 diabetes, 2018. A consensus report by the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD). *Diabetes Care* 2018;41:2669–2701
49. Briggs Early K, Stanley K. Position of the Academy of Nutrition and Dietetics: the role of medical nutrition therapy and registered dietitian nutritionists in the prevention and treatment of prediabetes and type 2 diabetes. *J Acad Nutr Diet* 2018;118:343–353
50. Franz MJ, MacLeod J, Evert A, et al. Academy of Nutrition and Dietetics nutrition practice guideline for type 1 and type 2 diabetes in adults: systematic review of evidence for medical nutrition therapy effectiveness and recommendations for integration into the nutrition care process. *J Acad Nutr Diet* 2017;117:1659–1679
51. MacLeod J, Franz MJ, Handu D, et al. Academy of Nutrition and Dietetics nutrition practice guideline for type 1 and type 2 diabetes in adults: nutrition intervention evidence reviews and recommendations. *J Acad Nutr Diet* 2017;117:1637–1658
52. Schwingshackl L, Chaimani A, Hoffmann G, Schwedhelm C, Boeing H. A network meta-analysis on the comparative efficacy of different dietary approaches on glycaemic control in patients with type 2 diabetes mellitus. *Eur J Epidemiol* 2018;33:157–170
53. Maryniuk MD. From pyramids to plates to patterns: perspectives on meal planning. *Diabetes Spectr* 2017;30:67–70
54. Schwingshackl L, Schwedhelm C, Hoffmann G, et al. Food groups and risk of all-cause mortality: a systematic review and meta-analysis of prospective studies. *Am J Clin Nutr* 2017;105:1462–1473
55. Esposito K, Maiorino MI, Ciotola M, et al. Effects of a Mediterranean-style diet on the need for antihyperglycemic drug therapy in patients with newly diagnosed type 2 diabetes: a randomized trial. *Ann Intern Med* 2009;151:306–314
56. Boucher JL. Mediterranean eating pattern. *Diabetes Spectr* 2017;30:72–76
57. Cespedes EM, Hu FB, Tinker L, et al. Multiple healthful dietary patterns and type 2 diabetes in the Women's Health Initiative. *Am J Epidemiol* 2016;183:622–633
58. Ley SH, Hamdy O, Mohan V, Hu FB. Prevention and management of type 2 diabetes: dietary components and nutritional strategies. *Lancet* 2014;383:1999–2007
59. Campbell AP. DASH eating plan: an eating pattern for diabetes management. *Diabetes Spectr* 2017;30:76–81
60. Rinaldi S, Campbell EE, Fournier J, O'Connor C, Madill J. A comprehensive review of the literature supporting recommendations from the Canadian Diabetes Association for the use of a plant-based diet for management of type 2 diabetes. *Can J Diabetes* 2016;40:471–477
61. Pawlak R. vegetarian diets in the prevention and management of diabetes and its complications. *Diabetes Spectr* 2017;30:82–88
62. Saslow LR, Daubenmier JJ, Moskowitz JT, et al. Twelve-month outcomes of a randomized trial of a moderate-carbohydrate versus very low-carbohydrate diet in overweight adults with type 2 diabetes mellitus or prediabetes. *Nutr Diabetes* 2017;7:304
63. Hallberg SJ, McKenzie AL, Williams PT, et al. Effectiveness and safety of a novel care model for the management of type 2 diabetes at 1 year: an open-label, non-randomized, controlled study. *Diabetes Ther* 2018;9:583–612
64. Sainsbury E, Kizirian NV, Partridge SR, Gill T, Colagiuri S, Gibson AA. Effect of dietary

- carbohydrate restriction on glycemic control in adults with diabetes: a systematic review and meta-analysis. *Diabetes Res Clin Pract* 2018;139:239–252
65. U.S. Food and Drug Administration. FDA Drug Safety Communication: FDA revises labels of SGLT2 inhibitors for diabetes to include warnings about too much acid in the blood and serious urinary tract infections [Internet], 2015. Available from <http://www.fda.gov/Drugs/DrugSafety/ucm475463.htm>. Accessed 2 November 2018
66. Blau JE, Tella SH, Taylor SI, Rother KI. Ketoacidosis associated with SGLT2 inhibitor treatment: analysis of FAERS data. *Diabetes Metab Res Rev* 2017;33:e2924
67. Bowen ME, Cavanaugh KL, Wolff K, et al. The diabetes nutrition education study randomized controlled trial: a comparative effectiveness study of approaches to nutrition in diabetes self-management education. *Patient Educ Couns* 2016;99:1368–1376
68. Mudaliar U, Zabetian A, Goodman M, et al. Cardiometabolic risk factor changes observed in diabetes prevention programs in US settings: a systematic review and meta-analysis. *PLoS Med* 2016;13:e1002095
69. Balk EM, Earley A, Raman G, Avendano EA, Pittas AG, Remington PL. Combined diet and physical activity promotion programs to prevent type 2 diabetes among persons at increased risk: a systematic review for the Community Preventive Services Task Force. *Ann Intern Med* 2015;163:437–451
70. Franz MJ, Boucher JL, Rutten-Ramos S, VanWormer JJ. Lifestyle weight-loss intervention outcomes in overweight and obese adults with type 2 diabetes: a systematic review and meta-analysis of randomized clinical trials. *J Acad Nutr Diet* 2015;115:1447–1463
71. Sumithran P, Prendergast LA, Delbridge E, et al. Long-term persistence of hormonal adaptations to weight loss. *N Engl J Med* 2011;365:1597–1604
72. Hamdy O, Mottalib A, Morsi A, et al. Long-term effect of intensive lifestyle intervention on cardiovascular risk factors in patients with diabetes in real-world clinical practice: a 5-year longitudinal study. *BMJ Open Diabetes Res Care* 2017;5:e000259
73. Lean ME, Leslie WS, Barnes AC, et al. Primary care-led weight management for remission of type 2 diabetes (DIRECT): an open-label, cluster-randomised trial. *Lancet* 2018;391:541–551
74. Mottalib A, Salsberg V, Mohd-Yusof B-N, et al. Effects of nutrition therapy on HbA1c and cardiovascular disease risk factors in overweight and obese patients with type 2 diabetes. *Nutr J* 2018;17:42
75. Estruch R, Ros E, Salas-Salvadó J, et al.; PREDIMED Study Investigators. Primary prevention of cardiovascular disease with a Mediterranean diet supplemented with extra-virgin olive oil or nuts. *N Engl J Med* 2018;378:e34
76. Emadian A, Andrews RC, England CY, Wallace V, Thompson JL. The effect of macronutrients on glycaemic control: a systematic review of dietary randomised controlled trials in overweight and obese adults with type 2 diabetes in which there was no difference in weight loss between treatment groups. *Br J Nutr* 2015;114:1656–1666
77. Gardner CD, Trepanowski JF, Del Gobbo LC, et al. Effect of low-fat vs low-carbohydrate diet on 12-month weight loss in overweight adults and the association with genotype pattern or insulin secretion: the DIETFITS randomized clinical trial. *JAMA* 2018;319:667–679
78. Sacks FM, Bray GA, Carey VJ, et al. Comparison of weight-loss diets with different compositions of fat, protein, and carbohydrates. *N Engl J Med* 2009;360:859–873
79. de Souza RJ, Bray GA, Carey VJ, et al. Effects of 4 weight-loss diets differing in fat, protein, and carbohydrate on fat mass, lean mass, visceral adipose tissue, and hepatic fat: results from the POUNDS LOST trial. *Am J Clin Nutr* 2012;95:614–625
80. Johnston BC, Kanters S, Bandayrel K, et al. Comparison of weight loss among named diet programs in overweight and obese adults: a meta-analysis. *JAMA* 2014;312:923–933
81. Fox CS, Golden SH, Anderson C, et al.; American Heart Association Diabetes Committee of the Council on Lifestyle and Cardiometabolic Health, Council on Clinical Cardiology, Council on Cardiovascular and Stroke Nursing, Council on Cardiovascular Surgery and Anesthesia, Council on Quality of Care and Outcomes Research; American Diabetes Association. Update on prevention of cardiovascular disease in adults with type 2 diabetes mellitus in light of recent evidence: a scientific statement from the American Heart Association and the American Diabetes Association. *Diabetes Care* 2015;38:1777–1803
82. DAFNE Study Group. Training in flexible, intensive insulin management to enable dietary freedom in people with type 1 diabetes: Dose Adjustment for Normal Eating (DAFNE) randomised controlled trial. *BMJ* 2002;325:746
83. Delahanty LM, Nathan DM, Lachin JM, et al.; Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications. Association of diet with glycated hemoglobin during intensive treatment of type 1 diabetes in the Diabetes Control and Complications Trial. *Am J Clin Nutr* 2009;89:518–524
84. Wheeler ML, Dunbar SA, Jaacks LM, et al. Macronutrients, food groups, and eating patterns in the management of diabetes: a systematic review of the literature, 2010. *Diabetes Care* 2012;35:434–445
85. Thomas D, Elliott EJ. Low glycaemic index, or low glycaemic load, diets for diabetes mellitus. *Cochrane Database Syst Rev* 2009;1:CD006296
86. Snorgaard O, Poulsen GM, Andersen HK, Astrup A. Systematic review and meta-analysis of dietary carbohydrate restriction in patients with type 2 diabetes. *BMJ Open Diabetes Res Care* 2017;5:e000354
87. van Wyk HJ, Davis RE, Davies JS. A critical review of low-carbohydrate diets in people with type 2 diabetes. *Diabet Med* 2016;33:148–157
88. Meng Y, Bai H, Wang S, Li Z, Wang Q, Chen L. Efficacy of low carbohydrate diet for type 2 diabetes mellitus management: a systematic review and meta-analysis of randomized controlled trials. *Diabetes Res Clin Pract* 2017;131:124–131
89. Tay J, Luscombe-Marsh ND, Thompson CH, et al. Comparison of low- and high-carbohydrate diets for type 2 diabetes management: a randomized trial. *Am J Clin Nutr* 2015;102:780–790
90. U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary guidelines for Americans 2015–2020, Eighth Edition [Internet], 2015. Available from <https://health.gov/dietaryguidelines/2015/guidelines>. Accessed 2 November 2018
91. Nansel TR, Lipsky LM, Liu A. Greater diet quality is associated with more optimal glycemic control in a longitudinal study of youth with type 1 diabetes. *Am J Clin Nutr* 2016;104:81–87
92. Katz ML, Mehta S, Nansel T, Quinn H, Lipsky LM, Laffel LMB. Associations of nutrient intake with glycemic control in youth with type 1 diabetes: differences by insulin regimen. *Diabetes Technol Ther* 2014;16:512–518
93. Rossi MCE, Nicolucci A, Di Bartolo P, et al. Diabetes Interactive Diary: a new telemedicine system enabling flexible diet and insulin therapy while improving quality of life: an open-label, international, multicenter, randomized study. *Diabetes Care* 2010;33:109–115
94. Laurenzi A, Bolla AM, Panigoni G, et al. Effects of carbohydrate counting on glucose control and quality of life over 24 weeks in adult patients with type 1 diabetes on continuous subcutaneous insulin infusion: a randomized, prospective clinical trial (GIOCAR). *Diabetes Care* 2011;34:823–827
95. Sämman A, Mühlhauser I, Bender R, Kloos Ch, Müller UA. Glycaemic control and severe hypoglycaemia following training in flexible, intensive insulin therapy to enable dietary freedom in people with type 1 diabetes: a prospective implementation study. *Diabetologia* 2005;48:1965–1970
96. Bell KJ, Barclay AW, Petocz P, Colagiuri S, Brand-Miller JC. Efficacy of carbohydrate counting in type 1 diabetes: a systematic review and meta-analysis. *Lancet Diabetes Endocrinol* 2014;2:133–140
97. Bell KJ, Smart CE, Steil GM, Brand-Miller JC, King B, Wolpert HA. Impact of fat, protein, and glycemic index on postprandial glucose control in type 1 diabetes: implications for intensive diabetes management in the continuous glucose monitoring era. *Diabetes Care* 2015;38:1008–1015
98. Bell KJ, Toschi E, Steil GM, Wolpert HA. Optimized mealtime insulin dosing for fat and protein in type 1 diabetes: application of a model-based approach to derive insulin doses for open-loop diabetes management. *Diabetes Care* 2016;39:1631–1634
99. Paterson MA, Smart CEM, Lopez PE, et al. Influence of dietary protein on postprandial blood glucose levels in individuals with type 1 diabetes mellitus using intensive insulin therapy. *Diabet Med* 2016;33:592–598
100. Tuttle KR, Bakris GL, Bilous RW, et al. Diabetic kidney disease: a report from an ADA Consensus Conference. *Diabetes Care* 2014;37:2864–2883
101. Pan Y, Guo LL, Jin HM. Low-protein diet for diabetic nephropathy: a meta-analysis of randomized controlled trials. *Am J Clin Nutr* 2008;88:660–666
102. Robertson L, Waugh N, Robertson A. Protein restriction for diabetic renal disease. *Cochrane Database Syst Rev* 2007;4:CD002181
103. Layman DK, Clifton P, Gannon MC, Krauss RM, Nuttall FQ. Protein in optimal health: heart disease and type 2 diabetes. *Am J Clin Nutr* 2008;87:1571S–1575S

104. Institute of Medicine. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids [Internet], 2005. Washington, DC, National Academies Press. Available from <http://www.nationalacademies.org/hmd/Reports/2002/Dietary-Reference-Intakes-for-Energy-Carbohydrate-Fiber-Fat-Fatty-Acids-Cholesterol-Protein-and-Amino-Acids.aspx>. Accessed 2 November 2018
105. Ros E. Dietary cis-monounsaturated fatty acids and metabolic control in type 2 diabetes. *Am J Clin Nutr* 2003;78(Suppl.):617S–625S
106. Forouhi NG, Imamura F, Sharp SJ, et al. Association of plasma phospholipid n-3 and n-6 polyunsaturated fatty acids with type 2 diabetes: the EPIC-InterAct case-cohort study. *PLoS Med* 2016;13:e1002094
107. Wang DD, Li Y, Chiuve SE, et al. Association of specific dietary fats with total and cause-specific mortality. *JAMA Intern Med* 2016;176:1134–1145
108. Brehm BJ, Lattin BL, Summer SS, et al. One-year comparison of a high-monounsaturated fat diet with a high-carbohydrate diet in type 2 diabetes. *Diabetes Care* 2009;32:215–220
109. Shai I, Schwarzfuchs D, Henkin Y, et al.; Dietary Intervention Randomized Controlled Trial (DiRECT) Group. Weight loss with a low-carbohydrate, Mediterranean, or low-fat diet. *N Engl J Med* 2008;359:229–241
110. Brunerova L, Smejkalova V, Potockova J, Andel M. A comparison of the influence of a high-fat diet enriched in monounsaturated fatty acids and conventional diet on weight loss and metabolic parameters in obese non-diabetic and type 2 diabetic patients. *Diabet Med* 2007;24:533–540
111. Bloomfield HE, Koeller E, Greer N, MacDonald R, Kane R, Wilt TJ. Effects on health outcomes of a Mediterranean diet with no restriction on fat intake: a systematic review and meta-analysis. *Ann Intern Med* 2016;165:491–500
112. Sacks FM, Lichtenstein AH, Wu JHY, et al.; American Heart Association. Dietary fats and cardiovascular disease: a presidential advisory from the American Heart Association. *Circulation* 2017;136:e1–e23
113. Jacobson TA, Maki KC, Orringer CE, et al.; NLA Expert Panel. National Lipid Association recommendations for patient-centered management of dyslipidemia: part 2. *J Clin Lipidol* 2015;9(Suppl.):S1–S122.e1
114. Harris WS, Mozaffarian D, Rimm E, et al. Omega-6 fatty acids and risk for cardiovascular disease: a science advisory from the American Heart Association Nutrition Subcommittee of the Council on Nutrition, Physical Activity, and Metabolism; Council on Cardiovascular Nursing; and Council on Epidemiology and Prevention. *Circulation* 2009;119:902–907
115. Crochemore ICC, Souza AFP, de Souza ACF, Rosado EL. ω -3 polyunsaturated fatty acid supplementation does not influence body composition, insulin resistance, and lipemia in women with type 2 diabetes and obesity. *Nutr Clin Pract* 2012;27:553–560
116. Holman RR, Paul S, Farmer A, Tucker L, Stratton IM, Neil HA; Atorvastatin in Factorial with Omega-3 EE90 Risk Reduction in Diabetes Study Group. Atorvastatin in Factorial with Omega-3 EE90 Risk Reduction in Diabetes (AFORRD): a randomised controlled trial. *Diabetologia* 2009;52:50–59
117. Kromhout D, Geleijnse JM, de Goede J, et al. n-3 fatty acids, ventricular arrhythmia-related events, and fatal myocardial infarction in post-myocardial infarction patients with diabetes. *Diabetes Care* 2011;34:2515–2520
118. Bosch J, Gerstein HC, Dagenais GR, et al.; ORIGIN Trial Investigators. n-3 fatty acids and cardiovascular outcomes in patients with dysglycemia. *N Engl J Med* 2012;367:309–318
119. Thomas MC, Moran J, Forsblom C, et al.; FinnDiane Study Group. The association between dietary sodium intake, ESRD, and all-cause mortality in patients with type 1 diabetes. *Diabetes Care* 2011;34:861–866
120. Ekinci EI, Clarke S, Thomas MC, et al. Dietary salt intake and mortality in patients with type 2 diabetes. *Diabetes Care* 2011;34:703–709
121. Lennon SL, DellaValle DM, Rodder SG, et al. 2015 Evidence Analysis Library evidence-based nutrition practice guideline for the management of hypertension in adults. *J Acad Nutr Diet* 2017;117:1445–1458.e17
122. Maillot M, Drewnowski A. A conflict between nutritionally adequate diets and meeting the 2010 dietary guidelines for sodium. *Am J Prev Med* 2012;42:174–179
123. Aroda VR, Edelstein SL, Goldberg RB, et al.; Diabetes Prevention Program Research Group. Long-term metformin use and vitamin B12 deficiency in the Diabetes Prevention Program Outcomes Study. *J Clin Endocrinol Metab* 2016;101:1754–1761
124. Allen RW, Schwartzman E, Baker WL, Coleman CI, Phung OJ. Cinnamon use in type 2 diabetes: an updated systematic review and meta-analysis. *Ann Fam Med* 2013;11:452–459
125. Mitri J, Pittas AG. Vitamin D and diabetes. *Endocrinol Metab Clin North Am* 2014;43:205–232
126. Mozaffarian D. Dietary and policy priorities for cardiovascular disease, diabetes, and obesity: a comprehensive review. *Circulation* 2016;133:187–225
127. Grotz VL, Pi-Sunyer X, Porte D Jr, Roberts A, Richard Trout J. A 12-week randomized clinical trial investigating the potential for sucralose to affect glucose homeostasis. *Regul Toxicol Pharmacol* 2017;88:22–33
128. Miller PE, Perez V. Low-calorie sweeteners and body weight and composition: a meta-analysis of randomized controlled trials and prospective cohort studies. *Am J Clin Nutr* 2014;100:765–777
129. Rogers PJ, Hogenkamp PS, de Graaf C, et al. Does low-energy sweetener consumption affect energy intake and body weight? A systematic review, including meta-analyses, of the evidence from human and animal studies. *Int J Obes* 2016;40:381–394
130. Azad MB, Abou-Setta AM, Chauhan BF, et al. Nonnutritive sweeteners and cardiometabolic health: a systematic review and meta-analysis of randomized controlled trials and prospective cohort studies. *CMAJ* 2017;189:E929–E939
131. Eckel RH, Jakicic JM, Ard JD, et al. 2013 AHA/ACC guideline on lifestyle management to reduce cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation* 2013;129(Suppl.):S76–S99
132. Johnson RK, Lichtenstein AH, Anderson CAM, et al.; American Heart Association Nutrition Committee of the Council on Lifestyle and Cardiometabolic Health; Council on Cardiovascular and Stroke Nursing; Council on Clinical Cardiology; Council on Quality of Care and Outcomes Research; Stroke Council. Low-calorie sweetened beverages and cardiometabolic health: a science advisory from the American Heart Association. *Circulation* 2018;138:e126–e140
133. 2018 Physical Activity Guidelines Advisory Committee. 2018 Physical Activity Guidelines Advisory Committee Scientific Report. Washington, DC, U.S. Department of Health and Human Services, 2018
134. Bazargan-Hejazi S, Arroyo JS, Hsia S, Brojeni NR, Pan D. A racial comparison of differences between self-reported and objectively measured physical activity among US adults with diabetes. *Ethn Dis* 2017;27:403–410
135. Sluik D, Buijsse B, Muckelbauer R, et al. Physical activity and mortality in individuals with diabetes mellitus: a prospective study and meta-analysis. *Arch Intern Med* 2012;172:1285–1295
136. Tikkanen-Dolenc H, Wadén J, Forsblom C, et al.; FinnDiane Study Group. Physical activity reduces risk of premature mortality in patients with type 1 diabetes with and without kidney disease. *Diabetes Care* 2017;40:1727–1732
137. Boulé NG, Haddad E, Kenny GP, Wells GA, Sigal RJ. Effects of exercise on glycemic control and body mass in type 2 diabetes mellitus: a meta-analysis of controlled clinical trials. *JAMA* 2001;286:1218–1227
138. Colberg SR, Riddell MC. Physical activity: regulation of glucose metabolism, clinical management strategies, and weight control. *In American Diabetes Association/JDRF Type 1 Diabetes Sourcebook*. Peters A, Laffel L, Eds. Alexandria, VA, American Diabetes Association, 2013
139. Ostman C, Jewiss D, King N, Smart NA. Clinical outcomes to exercise training in type 1 diabetes: a systematic review and meta-analysis. *Diabetes Res Clin Pract* 2018;139:380–391
140. Boulé NG, Kenny GP, Haddad E, Wells GA, Sigal RJ. Meta-analysis of the effect of structured exercise training on cardiorespiratory fitness in type 2 diabetes mellitus. *Diabetologia* 2003;46:1071–1081
141. Rejeski WJ, Ip EH, Bertoni AG, et al.; Look AHEAD Research Group. Lifestyle change and mobility in obese adults with type 2 diabetes. *N Engl J Med* 2012;366:1209–1217
142. Colberg SR, Sigal RJ, Yardley JE, et al. Physical activity/exercise and diabetes: a position statement of the American Diabetes Association. *Diabetes Care* 2016;39:2065–2079
143. Janssen I, Leblanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int J Behav Nutr Phys Act* 2010;7:40
144. Riddell MC, Gallen IW, Smart CE, et al. Exercise management in type 1 diabetes: a consensus statement. *Lancet Diabetes Endocrinol* 2017;5:377–390
145. Anderson BJ, Laffel LM, Domenger C, et al. Factors associated with diabetes-specific health-related quality of life in youth with type 1

- diabetes: the global TEENS study. *Diabetes Care* 2017;40:1002–1009
146. Jelleyman C, Yates T, O'Donovan G, et al. The effects of high-intensity interval training on glucose regulation and insulin resistance: a meta-analysis. *Obes Rev* 2015;16:942–961
 147. Little JP, Gillen JB, Percival ME, et al. Low-volume high-intensity interval training reduces hyperglycemia and increases muscle mitochondrial capacity in patients with type 2 diabetes. *J Appl Physiol* (1985) 2011;111:1554–1560
 148. U.S. Department of Health and Human Services. 2008 physical activity guidelines for Americans [Internet], 2008. Available from <https://health.gov/paguidelines/guidelines/default.aspx>. Accessed 2 November 2018
 149. Willey KA, Singh MAF. Battling insulin resistance in elderly obese people with type 2 diabetes: bring on the heavy weights. *Diabetes Care* 2003;26:1580–1588
 150. Katzmarzyk PT, Church TS, Craig CL, Bouchard C. Sitting time and mortality from all causes, cardiovascular disease, and cancer. *Med Sci Sports Exerc* 2009;41:998–1005
 151. Dempsey PC, Larsen RN, Sethi P, et al. Benefits for type 2 diabetes of interrupting prolonged sitting with brief bouts of light walking or simple resistance activities. *Diabetes Care* 2016;39:964–972
 152. Cui J, Yan J-H, Yan L-M, Pan L, Le J-J, Guo Y-Z. Effects of yoga in adults with type 2 diabetes mellitus: a meta-analysis. *J Diabetes Investig* 2017;8:201–209
 153. Lee MS, Jun JH, Lim H-J, Lim H-S. A systematic review and meta-analysis of tai chi for treating type 2 diabetes. *Maturitas* 2015;80:14–23
 154. Colberg SR, Sigal RJ, Fernhall B, et al.; American College of Sports Medicine; American Diabetes Association. Exercise and type 2 diabetes. The American College of Sports Medicine and the American Diabetes Association: joint position statement executive summary. *Diabetes Care* 2010;33:2692–2696
 155. Church TS, Blair SN, Coreham S, et al. Effects of aerobic and resistance training on hemoglobin A_{1c} levels in patients with type 2 diabetes: a randomized controlled trial. *JAMA* 2010;304:2253–2262
 156. Bax JJ, Young LH, Frye RL, Bonow RO, Steinberg HO, Barrett EJ; ADA. Screening for coronary artery disease in patients with diabetes. *Diabetes Care* 2007;30:2729–2736
 157. Peters A, Laffel L (Eds.). *American Diabetes Association/JDRF Type 1 Diabetes Sourcebook*. Alexandria, VA, American Diabetes Association, 2013
 158. Colberg SR. *Exercise and Diabetes: A Clinician's Guide to Prescribing Physical Activity*. Alexandria, VA, American Diabetes Association, 2013
 159. Lemaster JW, Reiber GE, Smith DG, Heagerty PJ, Wallace C. Daily weight-bearing activity does not increase the risk of diabetic foot ulcers. *Med Sci Sports Exerc* 2003;35:1093–1099
 160. Smith AG, Russell J, Feldman EL, et al. Lifestyle intervention for pre-diabetic neuropathy. *Diabetes Care* 2006;29:1294–1299
 161. Spallone V, Ziegler D, Freeman R, et al.; Toronto Consensus Panel on Diabetic Neuropathy. Cardiovascular autonomic neuropathy in diabetes: clinical impact, assessment, diagnosis, and management. *Diabetes Metab Res Rev* 2011;27:639–653
 162. Pop-Busui R, Evans GW, Gerstein HC, et al.; Action to Control Cardiovascular Risk in Diabetes Study Group. Effects of cardiac autonomic dysfunction on mortality risk in the Action to Control Cardiovascular Risk in Diabetes (ACCORD) trial. *Diabetes Care* 2010;33:1578–1584
 163. Suarez L, Barrett-Connor E. Interaction between cigarette smoking and diabetes mellitus in the prediction of death attributed to cardiovascular disease. *Am J Epidemiol* 1984;120:670–675
 164. Stanton CA, Keith DR, Gaalema DE, et al. Trends in tobacco use among US adults with chronic health conditions: National Survey on Drug Use and Health 2005–2013. *Prev Med* 2016;92:160–168
 165. Bae J. Differences in cigarette use behaviors by age at the time of diagnosis with diabetes from young adulthood to adulthood: results from the National Longitudinal Study of Adolescent Health. *J Prev Med Public Health* 2013;46:249–260
 166. Śliwińska-Mossoń M, Milnerowicz H. The impact of smoking on the development of diabetes and its complications. *Diab Vasc Dis Res* 2017;14:265–276
 167. Kar D, Gillies C, Zaccardi F, et al. Relationship of cardiometabolic parameters in non-smokers, current smokers, and quitters in diabetes: a systematic review and meta-analysis. *Cardiovasc Diabetol* 2016;15:158
 168. Jankowich M, Choudhary G, Taveira TH, Wu W-C. Age-, race-, and gender-specific prevalence of diabetes among smokers. *Diabetes Res Clin Pract* 2011;93:e101–e105
 169. Akter S, Goto A, Mizoue T. Smoking and the risk of type 2 diabetes in Japan: a systematic review and meta-analysis. *J Epidemiol* 2017;27:553–561
 170. Liu X, Bragg F, Yang L, et al.; China Kadoorie Biobank Collaborative Group. Smoking and smoking cessation in relation to risk of diabetes in Chinese men and women: a 9-year prospective study of 0.5 million people. *Lancet Public Health* 2018;3:e167–e176
 171. Yeh HC, Duncan BB, Schmidt MI, Wang NY, Brancati FL. Smoking, smoking cessation, and risk for type 2 diabetes mellitus: a cohort study. *Ann Intern Med* 2010;152:10–17
 172. Tonstad S, Lawrence D. Varenicline in smokers with diabetes: a pooled analysis of 15 randomized, placebo-controlled studies of varenicline. *J Diabetes Investig* 2017;8:93–100
 173. West R. Tobacco smoking: health impact, prevalence, correlates and interventions. *Psychol Health* 2017;32:1018–1036
 174. Ranney L, Melvin C, Lux L, McClain E, Lohr KN. Systematic review: smoking cessation intervention strategies for adults and adults in special populations. *Ann Intern Med* 2006;145:845–856
 175. Tian J, Venn A, Otahal P, Gall S. The association between quitting smoking and weight gain: a systematic review and meta-analysis of prospective cohort studies. *Obes Rev* 2015;16:883–901
 176. Clair C, Rigotti NA, Porneala B, et al. Association of smoking cessation and weight change with cardiovascular disease among adults with and without diabetes. *JAMA* 2013;309:1014–1021
 177. Voulgari C, Katsilambros N, Tentolouris N. Smoking cessation predicts amelioration of microalbuminuria in newly diagnosed type 2 diabetes mellitus: a 1-year prospective study. *Metabolism* 2011;60:1456–1464
 178. Huerta TR, Walker DM, Mullen D, Johnson TJ, Ford EW. Trends in e-cigarette awareness and perceived harmfulness in the U.S. *Am J Prev Med* 2017;52:339–346
 179. Pericot-Valverde I, Gaalema DE, Priest JS, Higgins ST. E-cigarette awareness, perceived harmfulness, and ever use among U.S. adults. *Prev Med* 2017;104:92–99
 180. Leventhal AM, Strong DR, Kirkpatrick MG, et al. Association of electronic cigarette use with initiation of combustible tobacco product smoking in early adolescence. *JAMA* 2015;314:700–707
 181. Leventhal AM, Stone MD, Andrabi N, et al. Association of e-cigarette vaping and progression to heavier patterns of cigarette smoking. *JAMA* 2016;316:1918–1920
 182. Hartmann-Boyce J, McRobbie H, Bullen C, Begh R, Stead LF, Hajek P. Electronic cigarettes for smoking cessation. *Cochrane Database Syst Rev* 2016;9:CD010216
 183. Halpern SD, Harhay MO, Saulsgiver K, Brophy C, Troxel AB, Volpp KG. A pragmatic trial of e-cigarettes, incentives, and drugs for smoking cessation. *N Engl J Med* 2018;378:2302–2310
 184. Schraufnagel DE, Blasi F, Drummond MB, et al.; Forum of International Respiratory Societies. Electronic cigarettes. A position statement of the Forum of International Respiratory Societies. *Am J Respir Crit Care Med* 2014;190:611–618
 185. Bam TS, Bellew W, Berezhnova I, et al.; Tobacco Control Department International Union Against Tuberculosis and Lung Disease. Position statement on electronic cigarettes or electronic nicotine delivery systems. *Int J Tuberc Lung Dis* 2014;18:5–7
 186. Bhatnagar A, Whitsel LP, Ribisl KM, et al.; American Heart Association Advocacy Coordinating Committee, Council on Cardiovascular and Stroke Nursing, Council on Clinical Cardiology, and Council on Quality of Care and Outcomes Research. Electronic cigarettes: a policy statement from the American Heart Association. *Circulation* 2014;130:1418–1436
 187. Young-Hyman D, de Groot M, Hill-Briggs F, Gonzalez JS, Hood K, Peyrot M. Psychosocial care for people with diabetes: a position statement of the American Diabetes Association. *Diabetes Care* 2016;39:2126–2140
 188. Anderson RJ, Grigsby AB, Freedland KE, et al. Anxiety and poor glycemic control: a meta-analytic review of the literature. *Int J Psychiatry Med* 2002;32:235–247
 189. Delahanty LM, Grant RW, Wittenberg E, et al. Association of diabetes-related emotional distress with diabetes treatment in primary care patients with type 2 diabetes. *Diabet Med* 2007;24:48–54
 190. Anderson RJ, Freedland KE, Clouse RE, Lustman PJ. The prevalence of comorbid depression in adults with diabetes: a meta-analysis. *Diabetes Care* 2001;24:1069–1078
 191. Kovacs Burns K, Nicolucci A, Holt RIG, et al.; DAWN2 Study Group. Diabetes Attitudes, Wishes and Needs second study (DAWN2™): cross-national benchmarking indicators for family

- members living with people with diabetes. *Diabet Med* 2013;30:778–788
192. Harkness E, Macdonald W, Valderas J, Coventry P, Gask L, Bower P. Identifying psychosocial interventions that improve both physical and mental health in patients with diabetes: a systematic review and meta-analysis. *Diabetes Care* 2010;33:926–930
193. Nicolucci A, Kovacs Burns K, Holt RIG, et al.; DAWN2 Study Group. Diabetes Attitudes, Wishes and Needs second study (DAWN2™): cross-national benchmarking of diabetes-related psychosocial outcomes for people with diabetes. *Diabet Med* 2013;30:767–777
194. Fisher L, Hessler DM, Polonsky WH, Mullan J. When is diabetes distress clinically meaningful?: establishing cut points for the Diabetes Distress Scale. *Diabetes Care* 2012;35:259–264
195. Fisher L, Glasgow RE, Strycker LA. The relationship between diabetes distress and clinical depression with glycemic control among patients with type 2 diabetes. *Diabetes Care* 2010;33:1034–1036
196. Aikens JE. Prospective associations between emotional distress and poor outcomes in type 2 diabetes. *Diabetes Care* 2012;35:2472–2478
197. Fisher L, Skaff MM, Mullan JT, et al. Clinical depression versus distress among patients with type 2 diabetes: not just a question of semantics. *Diabetes Care* 2007;30:542–548
198. Snoek FJ, Bremmer MA, Hermanns N. Constructs of depression and distress in diabetes: time for an appraisal. *Lancet Diabetes Endocrinol* 2015;3:450–460
199. Gary TL, Safford MM, Gerzoff RB, et al. Perception of neighborhood problems, health behaviors, and diabetes outcomes among adults with diabetes in managed care: the Translating Research Into Action for Diabetes (TRIAD) study. *Diabetes Care* 2008;31:273–278
200. Beverly EA, Hultgren BA, Brooks KM, Ritholz MD, Abrahamson MJ, Weinger K. Understanding physicians' challenges when treating type 2 diabetic patients' social and emotional difficulties: a qualitative study. *Diabetes Care* 2011;34:1086–1088
201. Huang Y, Wei X, Wu T, Chen R, Guo A. Collaborative care for patients with depression and diabetes mellitus: a systematic review and meta-analysis. *BMC Psychiatry* 2013;13:260

6. Glycemic Targets: *Standards of Medical Care in Diabetes—2019* American Diabetes Association

Diabetes Care 2019;42(Suppl. 1):S61–S70 | <https://doi.org/10.2337/dc19-S006>

The American Diabetes Association (ADA) “Standards of Medical Care in Diabetes” includes ADA’s current clinical practice recommendations and is intended to provide the components of diabetes care, general treatment goals and guidelines, and tools to evaluate quality of care. Members of the ADA Professional Practice Committee, a multidisciplinary expert committee, are responsible for updating the Standards of Care annually, or more frequently as warranted. For a detailed description of ADA standards, statements, and reports, as well as the evidence-grading system for ADA’s clinical practice recommendations, please refer to the Standards of Care Introduction. Readers who wish to comment on the Standards of Care are invited to do so at professional.diabetes.org/SOC.

ASSESSMENT OF GLYCEMIC CONTROL

Glycemic management is primarily assessed with the A1C test, which was the measure studied in clinical trials demonstrating the benefits of improved glycemic control. Patient self-monitoring of blood glucose (SMBG) may help with self-management and medication adjustment, particularly in individuals taking insulin. Continuous glucose monitoring (CGM) also has an important role in assessing the effectiveness and safety of treatment in many patients with type 1 diabetes, and limited data suggest it may also be helpful in selected patients with type 2 diabetes, such as those on intensive insulin regimens (1).

A1C Testing

Recommendations

- 6.1 Perform the A1C test *at least* two times a year in patients who are meeting treatment goals (and who have stable glycemic control). **E**
- 6.2 Perform the A1C test quarterly in patients whose therapy has changed or who are not meeting glycemic goals. **E**
- 6.3 Point-of-care testing for A1C provides the opportunity for more timely treatment changes. **E**

A1C reflects average glycemia over approximately 3 months. The performance of the test is generally excellent for NGSP-certified assays (www.ngsp.org). The test is the major tool for assessing glycemic control and has strong predictive value for diabetes complications (1–3). Thus, A1C testing should be performed routinely in all patients with diabetes—at initial assessment and as part of continuing care. Measurement approximately every 3 months determines whether patients’ glycemic targets have been reached and maintained. The frequency of A1C testing should depend on the clinical situation, the treatment regimen, and the clinician’s judgment. The use of point-of-care A1C testing may provide an opportunity for more timely treatment changes during encounters between patients and providers. Patients with type 2

Suggested citation: American Diabetes Association. 6. Glycemic targets: Standards of Medical Care in Diabetes—2019. Diabetes Care 2019; 42(Suppl. 1):S61–S70

© 2018 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. More information is available at <http://www.diabetesjournals.org/content/license>.

diabetes with stable glycemia well within target may do well with A1C testing only twice per year. Unstable or intensively managed patients (e.g., pregnant women with type 1 diabetes) may require testing more frequently than every 3 months (4).

A1C Limitations

The A1C test is an indirect measure of average glycemia and, as such, is subject to limitations. As with any laboratory test, there is variability in the measurement of A1C. Although such variability is less on an intraindividual basis than that of blood glucose measurements, clinicians should exercise judgment when using A1C as the sole basis for assessing glycemic control, particularly if the result is close to the threshold that might prompt a change in medication therapy. Conditions that affect red blood cell turnover (hemolytic and other anemias, glucose-6-phosphate dehydrogenase deficiency, recent blood transfusion, use of drugs that stimulate erythropoiesis, end-stage kidney disease, and pregnancy) may result in discrepancies between the A1C result and the patient's true mean glycemia. Hemoglobin variants must be considered, particularly when the A1C result does not correlate with the patient's SMBG levels. However, most assays in use in the U.S. are accurate in individuals heterozygous for the most common variants (www.ngsp.org/interf.asp). Other measures of average glycemia such as fructosamine and 1,5-anhydroglucitol are available, but their translation into average glucose levels and their prognostic significance are not as clear as for A1C. Though some variability in the relationship between average glucose levels and A1C exists among different individuals, generally the association between mean glucose and A1C within an individual correlates over time (5).

A1C does not provide a measure of glycemic variability or hypoglycemia. For patients prone to glycemic variability, especially patients with type 1 diabetes or type 2 diabetes with severe insulin deficiency, glycemic control is best evaluated by the combination of results from SMBG or CGM and A1C. A1C may also inform the accuracy of the patient's meter (or the patient's reported SMBG results) and the adequacy of the SMBG testing schedule.

A1C and Mean Glucose

Table 6.1 shows the correlation between A1C levels and mean glucose levels based on two studies: the international A1C-Derived Average Glucose (ADAG) study, which assessed the correlation between A1C and frequent SMBG and CGM in 507 adults (83% non-Hispanic whites) with type 1, type 2, and no diabetes (6), and an empirical study of the average blood glucose levels at premeal, postmeal, and bedtime associated with specified A1C levels using data from the ADAG trial (7). The American Diabetes Association (ADA) and the American Association for Clinical Chemistry have determined that the correlation ($r = 0.92$) in the ADAG trial is strong enough to justify reporting both the A1C result and the estimated average glucose (eAG) result when a clinician orders the A1C test. Clinicians should note that the mean plasma glucose numbers in the table are based on ~2,700 readings per A1C in the ADAG trial. In a recent report, mean glucose measured with CGM versus central laboratory-measured A1C in 387 participants in three randomized trials demonstrated that A1C may underestimate or overestimate mean glucose (5). Thus, as suggested, a patient's CGM profile has considerable potential for optimizing his or her glycemic management (5).

A1C Differences in Ethnic Populations and Children

In the ADAG study, there were no significant differences among racial and ethnic groups in the regression lines between A1C and mean glucose, although the study was underpowered to detect a difference and there was a trend toward a difference between the African/African American and non-Hispanic white cohorts, with higher A1C values observed in Africans/African Americans compared with non-Hispanic whites for a given mean glucose. Other studies have also demonstrated higher A1C levels in African Americans than in whites at a given mean glucose concentration (8,9).

A1C assays are available that do not demonstrate a statistically significant difference in individuals with hemoglobin variants. Other assays have statistically significant interference, but the difference is not clinically significant. Use of an assay with such statistically

significant interference may explain a report that for any level of mean glycemia, African Americans heterozygous for the common hemoglobin variant HbS had lower A1C by about 0.3 percentage points when compared with those without the trait (10,11). Another genetic variant, X-linked glucose-6-phosphate dehydrogenase G202A, carried by 11% of African Americans, was associated with a decrease in A1C of about 0.8% in hemizygous men and 0.7% in homozygous women compared with those without the trait (12).

A small study comparing A1C to CGM data in children with type 1 diabetes found a highly statistically significant correlation between A1C and mean blood glucose, although the correlation ($r = 0.7$) was significantly lower than in the ADAG trial (13). Whether there are clinically meaningful differences in how A1C relates to average glucose in children or in different ethnicities is an area for further study (8,14,15). Until further evidence is available, it seems prudent to establish A1C goals in these populations with consideration of both individualized SMBG and A1C results.

Glucose Assessment

For many people with diabetes, glucose monitoring is key for the achievement of glycemic targets. Major clinical trials of insulin-treated patients have included SMBG as part of multifactorial interventions to demonstrate the benefit of intensive glycemic control on diabetes complications (16). SMBG is thus an integral component of effective therapy of patients taking insulin. In recent years, CGM has emerged as a complementary method for the assessment of glucose levels. Glucose monitoring allows patients to evaluate their individual response to therapy and assess whether glycemic targets are being safely achieved. Integrating results into diabetes management can be a useful tool for guiding medical nutrition therapy and physical activity, preventing hypoglycemia, and adjusting medications (particularly prandial insulin doses). The patient's specific needs and goals should dictate SMBG frequency and timing or the consideration of CGM use. Please refer to Section 7 "Diabetes Technology" for a fuller discussion of the use of SMBG and CGM.

A1C GOALS

For glycemic goals in older adults, please refer to Section 12 “Older Adults.” For glycemic goals in children, please refer to Section 13 “Children and Adolescents.” For glycemic goals in pregnant women, please refer to Section 14 “Management of Diabetes in Pregnancy.”

Recommendations

- 6.4** A reasonable A1C goal for many nonpregnant adults is <7% (53 mmol/mol). **A**
- 6.5** Providers might reasonably suggest more stringent A1C goals (such as <6.5% [48 mmol/mol]) for selected individual patients if this can be achieved without significant hypoglycemia or other adverse effects of treatment (i.e., polypharmacy). Appropriate patients might include those with short duration of diabetes, type 2 diabetes treated with lifestyle or metformin only, long life expectancy, or no significant cardiovascular disease. **C**
- 6.6** Less stringent A1C goals (such as <8% [64 mmol/mol]) may be appropriate for patients with a history of severe hypoglycemia, limited life expectancy, advanced microvascular or macrovascular complications, extensive comorbid conditions, or long-standing diabetes in whom the goal is difficult to achieve despite diabetes self-management education, appropriate glucose monitoring, and effective doses of multiple glucose-lowering agents including insulin. **B**
- 6.7** Reassess glycemic targets over time based on the criteria in **Fig. 6.1** or, in older adults, **Table 12.1. E**

A1C and Microvascular Complications

Hyperglycemia defines diabetes, and glycemic control is fundamental to diabetes management. The Diabetes Control and Complications Trial (DCCT) (16), a prospective randomized controlled trial of intensive (mean A1C about 7% [53 mmol/mol]) versus standard (mean A1C about 9% [75 mmol/mol]) glycemic control in patients with type 1 diabetes, showed definitively that better glycemic control is associated with 50–76%

Table 6.1—Mean glucose levels for specified A1C levels (6,7)

A1C (%) (mmol/mol)	Mean plasma glucose*		Mean fasting glucose		Mean premeal glucose		Mean postmeal glucose		Mean bedtime glucose	
	mg/dL	mmol/L	mg/dL	mmol/L	mg/dL	mmol/L	mg/dL	mmol/L	mg/dL	mmol/L
6 (42)	126 (100–152)	7.0 (5.5–8.5)								
5.5–6.49 (37–47)			122 (117–127)	6.8 (6.5–7.0)	118 (115–121)	6.5 (6.4–6.7)	144 (139–148)	8.0 (7.7–8.2)	136 (131–141)	7.5 (7.3–7.8)
6.5–6.99 (47–53)			142 (135–150)	7.9 (7.5–8.3)	139 (134–144)	7.7 (7.4–8.0)	164 (159–169)	9.1 (8.8–9.4)	153 (145–161)	8.5 (8.0–8.9)
7 (53)	154 (123–185)	8.6 (6.8–10.3)								
7.0–7.49 (53–58)			152 (143–162)	8.4 (7.9–9.0)	152 (147–157)	8.4 (8.2–8.7)	176 (170–183)	9.8 (9.4–10.2)	177 (166–188)	9.8 (9.2–10.4)
7.5–7.99 (58–64)			167 (157–177)	9.3 (8.7–9.8)	155 (148–161)	8.6 (8.2–8.9)	189 (180–197)	10.5 (10.0–10.9)	175 (163–188)	9.7 (9.0–10.4)
8 (64)	183 (147–217)	10.2 (8.1–12.1)								
8.0–8.5 (64–69)			178 (164–192)	9.9 (9.1–10.7)	179 (167–191)	9.9 (9.3–10.6)	206 (195–217)	11.4 (10.8–12.0)	222 (197–248)	12.3 (10.9–13.8)
9 (75)	212 (170–249)	11.8 (9.4–13.9)								
10 (86)	240 (193–282)	13.4 (10.7–15.7)								
11 (97)	269 (217–314)	14.9 (12.0–17.5)								
12 (108)	298 (240–347)	16.5 (13.3–19.3)								

Data in parentheses represent 95% CI, unless otherwise noted. A calculator for converting A1C results into eAG, in either mg/dL or mmol/L, is available at <http://professional.diabetes.org/eAG>. *These estimates are based on ADA G data of ~2,700 glucose measurements over 3 months per A1C measurement in 507 adults with type 1, type 2, and no diabetes. The correlation between A1C and average glucose was 0.92 (6).

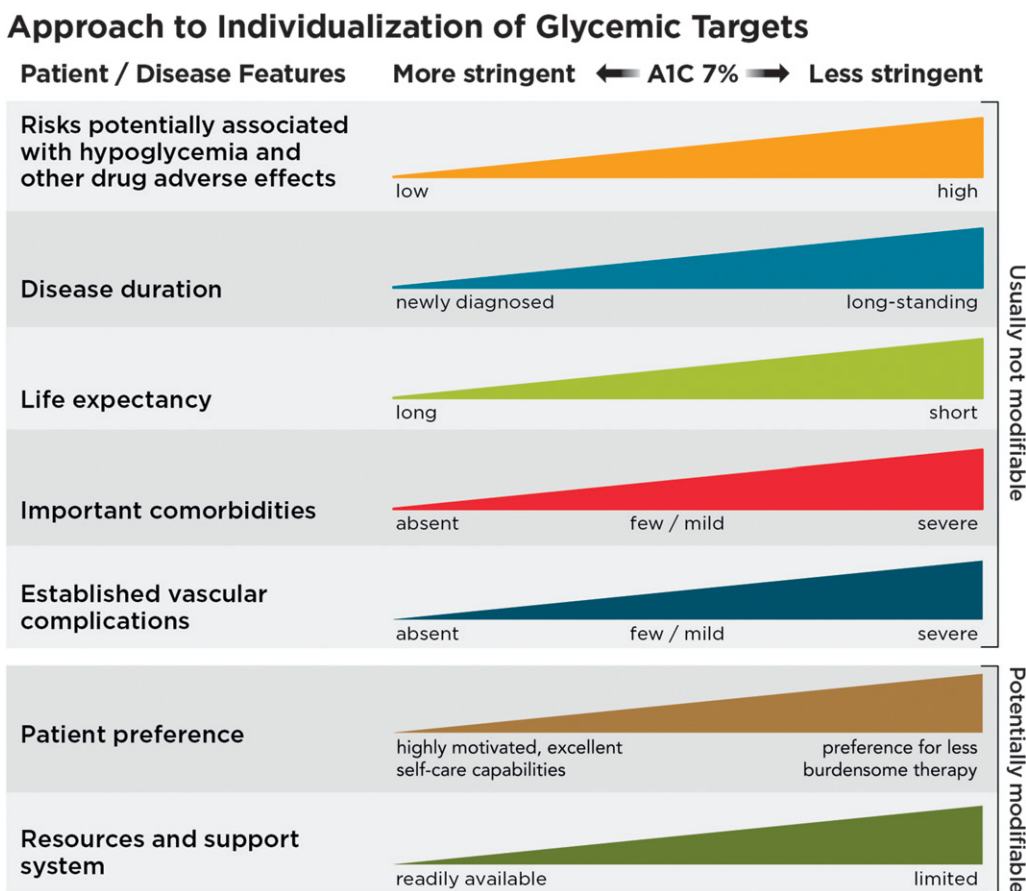


Figure 6.1—Depicted are patient and disease factors used to determine optimal A1C targets. Characteristics and predicaments toward the left justify more stringent efforts to lower A1C; those toward the right suggest less stringent efforts. A1C 7% = 53 mmol/mol. Adapted with permission from Inzucchi et al. (40).

reductions in rates of development and progression of microvascular (retinopathy, neuropathy, and diabetic kidney disease) complications. Follow-up of the DCCT cohorts in the Epidemiology of Diabetes Interventions and Complications (EDIC) study (17,18) demonstrated persistence of these microvascular benefits over two decades despite the fact that the glycemic separation between the treatment groups diminished and disappeared during follow-up.

The Kumamoto Study (19) and UK Prospective Diabetes Study (UKPDS) (20,21) confirmed that intensive glycemic control significantly decreased rates of microvascular complications in patients with short-duration type 2 diabetes. Long-term follow-up of the UKPDS cohorts showed enduring effects of early glycemic control on most microvascular complications (22).

Therefore, achieving A1C targets of <7% (53 mmol/mol) has been shown to reduce microvascular complications of type 1 and type 2 diabetes when

instituted early in the course of disease. Epidemiologic analyses of the DCCT (16) and UKPDS (23) demonstrate a curvilinear relationship between A1C and microvascular complications. Such analyses suggest that, on a population level, the greatest number of complications will be averted by taking patients from very poor control to fair/good control. These analyses also suggest that further lowering of A1C from 7% to 6% [53 mmol/mol to 42 mmol/mol] is associated with further reduction in the risk of microvascular complications, although the absolute risk reductions become much smaller. Given the substantially increased risk of hypoglycemia in type 1 diabetes trials and with polypharmacy in type 2 diabetes, the risks of lower glycemic targets may outweigh the potential benefits on microvascular complications.

Three landmark trials (Action to Control Cardiovascular Risk in Diabetes [ACCORD], Action in Diabetes and Vascular Disease: Preterax and Diamicon

MR Controlled Evaluation [ADVANCE], and Veterans Affairs Diabetes Trial [VADT]) were conducted to test the effects of near normalization of blood glucose on cardiovascular outcomes in individuals with long-standing type 2 diabetes and either known cardiovascular disease (CVD) or high cardiovascular risk. These trials showed that lower A1C levels were associated with reduced onset or progression of some microvascular complications (24–26).

The concerning mortality findings in the ACCORD trial (27), discussed below, and the relatively intense efforts required to achieve near euglycemia should also be considered when setting glycemic targets for individuals with long-standing diabetes such as those studied in ACCORD, ADVANCE, and VADT. Findings from these studies suggest caution is needed in treating diabetes aggressively to near-normal A1C goals in people with long-standing type 2 diabetes with or at significant risk of CVD. However, on the basis of physician

judgment and patient preferences, select patients, especially those with little comorbidity and long life expectancy, may benefit from adopting more intensive glycemic targets (e.g., A1C target <6.5% [48 mmol/mol]) if they can achieve it safely without hypoglycemia or significant therapeutic burden.

A1C and Cardiovascular Disease

Outcomes

Cardiovascular Disease and Type 1 Diabetes

CVD is a more common cause of death than microvascular complications in populations with diabetes. There is evidence for a cardiovascular benefit of intensive glycemic control after long-term follow-up of cohorts treated early in the course of type 1 diabetes. In the DCCT, there was a trend toward lower risk of CVD events with intensive control. In the 9-year post-DCCT follow-up of the EDIC cohort, participants previously randomized to the intensive arm had a significant 57% reduction in the risk of nonfatal myocardial infarction (MI), stroke, or cardiovascular death compared with those previously randomized to the standard arm (28). The benefit of intensive glycemic control in this cohort with type 1 diabetes has been shown to persist for several decades (29) and to be associated with a modest reduction in all-cause mortality (30).

Cardiovascular Disease and Type 2 Diabetes

In type 2 diabetes, there is evidence that more intensive treatment of glycemia in newly diagnosed patients may reduce long-term CVD rates. During the UKPDS, there was a 16% reduction in CVD events (combined fatal or nonfatal MI and sudden death) in the intensive glycemic control arm that did not reach statistical significance ($P = 0.052$), and there was no suggestion of benefit on other CVD outcomes (e.g., stroke). However, after 10 years of observational follow-up, those originally randomized to intensive glycemic control had significant long-term reductions in MI (15% with sulfonylurea or insulin as initial pharmacotherapy, 33% with metformin as initial pharmacotherapy) and in all-cause mortality (13% and 27%, respectively) (22).

ACCORD, ADVANCE, and VADT suggested no significant reduction in CVD outcomes with intensive glycemic control in participants followed for shorter durations (3.5–5.6 years) and who had

more advanced type 2 diabetes than UKPDS participants. All three trials were conducted in relatively older participants with longer known duration of diabetes (mean duration 8–11 years) and either CVD or multiple cardiovascular risk factors. The target A1C among intensive-control subjects was <6% (42 mmol/mol) in ACCORD, <6.5% (48 mmol/mol) in ADVANCE, and a 1.5% reduction in A1C compared with control subjects in VADT, with achieved A1C of 6.4% vs. 7.5% (46 mmol/mol vs. 58 mmol/mol) in ACCORD, 6.5% vs. 7.3% (48 mmol/mol vs. 56 mmol/mol) in ADVANCE, and 6.9% vs. 8.4% (52 mmol/mol vs. 68 mmol/mol) in VADT. Details of these studies are reviewed extensively in “Intensive Glycemic Control and the Prevention of Cardiovascular Events: Implications of the ACCORD, ADVANCE, and VA Diabetes Trials” (31).

The glycemic control comparison in ACCORD was halted early due to an increased mortality rate in the intensive compared with the standard treatment arm (1.41% vs. 1.14% per year; hazard ratio 1.22 [95% CI 1.01–1.46]), with a similar increase in cardiovascular deaths. Analysis of the ACCORD data did not identify a clear explanation for the excess mortality in the intensive treatment arm (27).

Longer-term follow-up has shown no evidence of cardiovascular benefit or harm in the ADVANCE trial (32). The end-stage renal disease rate was lower in the intensive treatment group over follow-up. However, 10-year follow-up of the VADT cohort (33) showed a reduction in the risk of cardiovascular events (52.7 [control group] vs. 44.1 [intervention group] events per 1,000 person-years) with no benefit in cardiovascular or overall mortality. Heterogeneity of mortality effects across studies was noted, which may reflect differences in glycemic targets, therapeutic approaches, and population characteristics (34).

Mortality findings in ACCORD (27) and subgroup analyses of VADT (35) suggest that the potential risks of intensive glycemic control may outweigh its benefits in higher-risk patients. In all three trials, severe hypoglycemia was significantly more likely in participants who were randomly assigned to the intensive glycemic control arm. Those patients with long duration of diabetes, a known history of hypoglycemia, advanced atherosclerosis,

or advanced age/frailty may benefit from less aggressive targets (36,37).

As discussed further below, severe hypoglycemia is a potent marker of high absolute risk of cardiovascular events and mortality (38). Providers should be vigilant in preventing hypoglycemia and should not aggressively attempt to achieve near-normal A1C levels in patients in whom such targets cannot be safely and reasonably achieved.

As discussed in Section 9 “Pharmacologic Approaches to Glycemic Treatment,” addition of specific sodium–glucose cotransporter 2 inhibitors (SGLT2i) or glucagon-like peptide 1 receptor agonists (GLP-1 RA) to improve cardiovascular outcomes in patients with established CVD is indicated with consideration of glycemic goals. If the patient is not at A1C target, continue metformin unless contraindicated and add SGLT2i or GLP-1 RA with proven cardiovascular benefit. If the patient is meeting A1C target, consider one of three strategies (39):

1. If already on dual therapy or multiple glucose-lowering therapies and not on an SGLT2i or GLP-1 RA, consider switching to one of these agents with proven cardiovascular benefit.
2. Reconsider/lower individualized A1C target and introduce SGLT2i or GLP-1 RA.
3. Reassess A1C at 3-month intervals and add SGLT2i or GLP-1 RA if A1C goes above target.

Setting and Modifying A1C Goals

Numerous factors must be considered when setting glycemic targets. The ADA proposes general targets appropriate for many patients but emphasizes the importance of individualization based on key patient characteristics. Glycemic targets must be individualized in the context of shared decision making to address the needs and preferences of each patient and the individual characteristics that influence risks and benefits of therapy for each patient.

The factors to consider in individualizing goals are depicted in **Fig. 6.1**. **Figure 6.1** is not designed to be applied rigidly but to be used as a broad construct to guide clinical decision making (40) in both type 1 and type 2 diabetes. More stringent control (such as an A1C of 6.5% [48 mmol/mol] or <7% [53 mmol/mol]) may be recommended if it can be achieved

safely and with acceptable burden of therapy and if life expectancy is sufficient to reap benefits of tight control. Less stringent control (A1C up to 8% [64 mmol/mol]) may be recommended if the life expectancy of the patient is such that the benefits of an intensive goal may not be realized, or if the risks and burdens outweigh the potential benefits. Severe or frequent hypoglycemia is an absolute indication for the modification of treatment regimens, including setting higher glycemic goals.

Diabetes is a chronic disease that progresses over decades. Thus, a goal that might be appropriate for an individual early in the course of the disease may change over time. Newly diagnosed patients and/or those without comorbidities that limit life expectancy may benefit from intensive control proven to prevent microvascular complications. Both DCCT/EDIC and UKPDS demonstrated metabolic memory, or a legacy effect, in which a finite period of intensive control yielded benefits that extended for decades after that control ended. Thus, a finite period of intensive control to near-normal A1C may yield enduring benefits even if control is subsequently deintensified as patient characteristics change. Over time, comorbidities may emerge, decreasing life expectancy and the potential to reap benefits from intensive control. Also, with longer duration of disease, diabetes may become more difficult to control, with increasing risks and burdens of therapy. Thus, A1C targets should be reevaluated over time to balance the risks and benefits as patient factors change.

Recommended glycemic targets for many nonpregnant adults are shown in **Table 6.2**. The recommendations include blood glucose levels that appear to correlate with achievement of an A1C of <7% (53 mmol/mol). The issue of

preprandial versus postprandial SMBG targets is complex (41). Elevated postchallenge (2-h oral glucose tolerance test) glucose values have been associated with increased cardiovascular risk independent of fasting plasma glucose in some epidemiologic studies, but intervention trials have not shown postprandial glucose to be a cardiovascular risk factor independent of A1C. In subjects with diabetes, surrogate measures of vascular pathology, such as endothelial dysfunction, are negatively affected by postprandial hyperglycemia. It is clear that postprandial hyperglycemia, like preprandial hyperglycemia, contributes to elevated A1C levels, with its relative contribution being greater at A1C levels that are closer to 7% (53 mmol/mol). However, outcome studies have clearly shown A1C to be the primary predictor of complications, and landmark trials of glycemic control such as the DCCT and UKPDS relied overwhelmingly on preprandial SMBG. Additionally, a randomized controlled trial in patients with known CVD found no CVD benefit of insulin regimens targeting postprandial glucose compared with those targeting preprandial glucose (42). Therefore, it is reasonable for postprandial testing to be recommended for individuals who have premeal glucose values within target but have A1C values above target. Measuring postprandial plasma glucose 1–2 h after the start of a meal and using treatments aimed at reducing postprandial plasma glucose values to <180 mg/dL (10.0 mmol/L) may help to lower A1C.

An analysis of data from 470 participants in the ADAG study (237 with type 1 diabetes and 147 with type 2 diabetes) found that actual average glucose levels associated with conventional A1C targets were higher than older DCCT and ADA targets (**Table 6.1**) (7,43). These findings support that premeal glucose targets

may be relaxed without undermining overall glycemic control as measured by A1C. These data prompted the revision in the ADA-recommended premeal glucose target to 80–130 mg/dL (4.4–7.2 mmol/L) but did not affect the definition of hypoglycemia.

HYPOGLYCEMIA

Recommendations

6.8 Individuals at risk for hypoglycemia should be asked about symptomatic and asymptomatic hypoglycemia at each encounter. **C**

6.9 Glucose (15–20 g) is the preferred treatment for the conscious individual with blood glucose <70 mg/dL [3.9 mmol/L]), although any form of carbohydrate that contains glucose may be used. Fifteen minutes after treatment, if SMBG shows continued hypoglycemia, the treatment should be repeated. Once SMBG returns to normal, the individual should consume a meal or snack to prevent recurrence of hypoglycemia. **E**

6.10 Glucagon should be prescribed for all individuals at increased risk of level 2 hypoglycemia, defined as blood glucose <54 mg/dL (3.0 mmol/L), so it is available should it be needed. Caregivers, school personnel, or family members of these individuals should know where it is and when and how to administer it. Glucagon administration is not limited to health care professionals. **E**

6.11 Hypoglycemia unawareness or one or more episodes of level 3 hypoglycemia should trigger reevaluation of the treatment regimen. **E**

6.12 Insulin-treated patients with hypoglycemia unawareness or an episode of level 2 hypoglycemia should be advised to raise their glycemic targets to strictly avoid hypoglycemia for at least several weeks in order to partially reverse hypoglycemia unawareness and reduce risk of future episodes. **A**

6.13 Ongoing assessment of cognitive function is suggested with

Table 6.2—Summary of glycemic recommendations for many nonpregnant adults with diabetes

A1C	<7.0% (53 mmol/mol)*
Preprandial capillary plasma glucose	80–130 mg/dL* (4.4–7.2 mmol/L)
Peak postprandial capillary plasma glucose†	<180 mg/dL* (10.0 mmol/L)

*More or less stringent glycemic goals may be appropriate for individual patients. Goals should be individualized based on duration of diabetes, age/life expectancy, comorbid conditions, known CVD or advanced microvascular complications, hypoglycemia unawareness, and individual patient considerations. †Postprandial glucose may be targeted if A1C goals are not met despite reaching preprandial glucose goals. Postprandial glucose measurements should be made 1–2 h after the beginning of the meal, generally peak levels in patients with diabetes.

Table 6.3—Classification of hypoglycemia (44)

Level	Glycemic criteria/description
Level 1	Glucose <70 mg/dL (3.9 mmol/L) and glucose \geq 54 mg/dL (3.0 mmol/L)
Level 2	Glucose <54 mg/dL (3.0 mmol/L)
Level 3	A severe event characterized by altered mental and/or physical status requiring assistance

increased vigilance for hypoglycemia by the clinician, patient, and caregivers if low cognition or declining cognition is found. **B**

Hypoglycemia is the major limiting factor in the glycemic management of type 1 and type 2 diabetes. Recommendations regarding the classification of hypoglycemia are outlined in **Table 6.3** (44). Level 1 hypoglycemia is defined as a measurable glucose concentration <70 mg/dL (3.9 mmol/L) but \geq 54 mg/dL (3.0 mmol/L). A blood glucose concentration of 70 mg/dL (3.9 mmol/L) has been recognized as a threshold for neuroendocrine responses to falling glucose in people without diabetes. Because many people with diabetes demonstrate impaired counterregulatory responses to hypoglycemia and/or experience hypoglycemia unawareness, a measured glucose level <70 mg/dL (3.9 mmol/L) is considered clinically important, independent of the severity of acute hypoglycemic symptoms. Level 2 hypoglycemia (defined as a blood glucose concentration <54 mg/dL [3.0 mmol/L]) is the threshold at which neuroglycopenic symptoms begin to occur and requires immediate action to resolve the hypoglycemic event. Lastly, level 3 hypoglycemia is defined as a severe event characterized by altered mental and/or physical functioning that requires assistance from another person for recovery.

Studies of rates of level 3 hypoglycemia that rely on claims data for hospitalization, emergency department visits, and ambulance use substantially underestimate rates of level 3 hypoglycemia (45), yet find high burden of hypoglycemia in adults over 60 years of age in the community (46). African Americans are at substantially increased risk of level 3 hypoglycemia (46,47). In addition to age and race, other important risk factors found in a community-based epidemiologic

cohort of older black and white adults with type 2 diabetes include insulin use, poor or moderate versus good glycemic control, albuminuria, and poor cognitive function (46).

Symptoms of hypoglycemia include, but are not limited to, shakiness, irritability, confusion, tachycardia, and hunger. Hypoglycemia may be inconvenient or frightening to patients with diabetes. Level 3 hypoglycemia may be recognized or unrecognized and can progress to loss of consciousness, seizure, coma, or death. It is reversed by administration of rapid-acting glucose or glucagon. Hypoglycemia can cause acute harm to the person with diabetes or others, especially if it causes falls, motor vehicle accidents, or other injury. A large cohort study suggested that among older adults with type 2 diabetes, a history of level 3 hypoglycemia was associated with greater risk of dementia (48). Conversely, in a substudy of the ACCORD trial, cognitive impairment at baseline or decline in cognitive function during the trial was significantly associated with subsequent episodes of level 3 hypoglycemia (49). Evidence from DCCT/EDIC, which involved adolescents and younger adults with type 1 diabetes, found no association between frequency of level 3 hypoglycemia and cognitive decline (50), as discussed in Section 13 “Children and Adolescents.”

Level 3 hypoglycemia was associated with mortality in participants in both the standard and the intensive glycemia arms of the ACCORD trial, but the relationships between hypoglycemia, achieved A1C, and treatment intensity were not straightforward. An association of level 3 hypoglycemia with mortality was also found in the ADVANCE trial (51). An association between self-reported level 3 hypoglycemia and 5-year mortality has also been reported in clinical practice (52)

Young children with type 1 diabetes and the elderly, including those with type 1 and type 2 diabetes (48,53),

are noted as particularly vulnerable to hypoglycemia because of their reduced ability to recognize hypoglycemic symptoms and effectively communicate their needs. Individualized glucose targets, patient education, dietary intervention (e.g., bedtime snack to prevent overnight hypoglycemia when specifically needed to treat low blood glucose), exercise management, medication adjustment, glucose monitoring, and routine clinical surveillance may improve patient outcomes (54). CGM with automated low glucose suspend has been shown to be effective in reducing hypoglycemia in type 1 diabetes (55). For patients with type 1 diabetes with level 3 hypoglycemia and hypoglycemia unawareness that persists despite medical treatment, human islet transplantation may be an option, but the approach remains experimental (56,57).

In 2015, the ADA changed its preprandial glycemic target from 70–130 mg/dL (3.9–7.2 mmol/L) to 80–130 mg/dL (4.4–7.2 mmol/L). This change reflects the results of the ADAG study, which demonstrated that higher glycemic targets corresponded to A1C goals (7). An additional goal of raising the lower range of the glycemic target was to limit overtreatment and provide a safety margin in patients titrating glucose-lowering drugs such as insulin to glycemic targets.

Hypoglycemia Treatment

Providers should continue to counsel patients to treat hypoglycemia with fast-acting carbohydrates at the hypoglycemia alert value of 70 mg/dL (3.9 mmol/L) or less. Hypoglycemia treatment requires ingestion of glucose- or carbohydrate-containing foods. The acute glycemic response correlates better with the glucose content of food than with the carbohydrate content of food. Pure glucose is the preferred treatment, but any form of carbohydrate that contains glucose will raise blood glucose. Added fat may retard and then prolong the acute glycemic response. In type 2 diabetes, ingested protein may increase insulin response without increasing plasma glucose concentrations (58). Therefore, carbohydrate sources high in protein should not be used to treat or prevent hypoglycemia. Ongoing insulin activity or insulin secretagogues may lead to recurrent hypoglycemia

unless more food is ingested after recovery. Once the glucose returns to normal, the individual should be counseled to eat a meal or snack to prevent recurrent hypoglycemia.

Glucagon

The use of glucagon is indicated for the treatment of hypoglycemia in people unable or unwilling to consume carbohydrates by mouth. Those in close contact with, or having custodial care of, people with hypoglycemia-prone diabetes (family members, roommates, school personnel, child care providers, correctional institution staff, or coworkers) should be instructed on the use of glucagon kits, including where the kit is and when and how to administer glucagon. An individual does not need to be a health care professional to safely administer glucagon. Care should be taken to ensure that glucagon kits are not expired.

Hypoglycemia Prevention

Hypoglycemia prevention is a critical component of diabetes management. SMBG and, for some patients, CGM are essential tools to assess therapy and detect incipient hypoglycemia. Patients should understand situations that increase their risk of hypoglycemia, such as when fasting for tests or procedures, when meals are delayed, during and after the consumption of alcohol, during and after intense exercise, and during sleep. Hypoglycemia may increase the risk of harm to self or others, such as with driving. Teaching people with diabetes to balance insulin use and carbohydrate intake and exercise are necessary, but these strategies are not always sufficient for prevention.

In type 1 diabetes and severely insulin-deficient type 2 diabetes, hypoglycemia unawareness (or hypoglycemia-associated autonomic failure) can severely compromise stringent diabetes control and quality of life. This syndrome is characterized by deficient counterregulatory hormone release, especially in older adults, and a diminished autonomic response, which both are risk factors for, and caused by, hypoglycemia. A corollary to this “vicious cycle” is that several weeks of avoidance of hypoglycemia has been demonstrated to improve counterregulation and hypoglycemia awareness in many patients (59). Hence, patients with one or more episodes of

clinically significant hypoglycemia may benefit from at least short-term relaxation of glycemic targets.

INTERCURRENT ILLNESS

For further information on management of patients with hyperglycemia in the hospital, please refer to Section 15 “Diabetes Care in the Hospital.”

Stressful events (e.g., illness, trauma, surgery, etc.) may worsen glycemic control and precipitate diabetic ketoacidosis or nonketotic hyperglycemic hyperosmolar state, life-threatening conditions that require immediate medical care to prevent complications and death. Any condition leading to deterioration in glycemic control necessitates more frequent monitoring of blood glucose; ketosis-prone patients also require urine or blood ketone monitoring. If accompanied by ketosis, vomiting, or alteration in the level of consciousness, marked hyperglycemia requires temporary adjustment of the treatment regimen and immediate interaction with the diabetes care team. The patient treated with noninsulin therapies or medical nutrition therapy alone may require insulin. Adequate fluid and caloric intake must be ensured. Infection or dehydration is more likely to necessitate hospitalization of the person with diabetes than the person without diabetes.

A physician with expertise in diabetes management should treat the hospitalized patient. For further information on the management of diabetic ketoacidosis and the nonketotic hyperglycemic hyperosmolar state, please refer to the ADA consensus report “Hyperglycemic Crises in Adult Patients With Diabetes” (60).

References

1. Laiteerapong N, Ham SA, Gao Y, et al. The legacy effect in type 2 diabetes: impact of early glycemic control on future complications (the Diabetes & Aging Study). *Diabetes Care*. In press
2. Stratton IM, Adler AI, Neil HAW, et al. Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study. *BMJ* 2000;321:405–412
3. Little RR, Rohlfing CL, Sacks DB; National Glycohemoglobin Standardization Program (NGSP) Steering Committee. Status of hemoglobin A_{1c} measurement and goals for improvement: from chaos to order for improving diabetes care. *Clin Chem* 2011;57:205–214
4. Jovanović L, Savas H, Mehta M, Trujillo A, Pettitt DJ. Frequent monitoring of A1C during pregnancy as a treatment tool to guide therapy. *Diabetes Care* 2011;34:53–54

5. Beck RW, Connor CG, Mullen DM, Wesley DM, Bergenstal RM. The fallacy of average: how using HbA_{1c} alone to assess glycemic control can be misleading. *Diabetes Care* 2017;40:994–999
6. Nathan DM, Kuenen J, Borg R, Zheng H, Schoenfeld D, Heine RJ; A1c-Derived Average Glucose Study Group. Translating the A1C assay into estimated average glucose values. *Diabetes Care* 2008;31:1473–1478
7. Wei N, Zheng H, Nathan DM. Empirically establishing blood glucose targets to achieve HbA_{1c} goals. *Diabetes Care* 2014;37:1048–1051
8. Selvin E. Are there clinical implications of racial differences in HbA_{1c}? A difference, to be a difference, must make a difference. *Diabetes Care* 2016;39:1462–1467
9. Bergenstal RM, Gal RL, Connor CG, et al.; T1D Exchange Racial Differences Study Group. Racial differences in the relationship of glucose concentrations and hemoglobin A_{1c} levels. *Ann Intern Med* 2017;167:95–102
10. Lacy ME, Wellenius GA, Sumner AE, et al. Association of sickle cell trait with hemoglobin A_{1c} in African Americans. *JAMA* 2017;317:507–515
11. Rohlfing C, Hanson S, Little RR. Measurement of hemoglobin A_{1c} in patients with sickle cell trait. *JAMA* 2017;317:2237
12. Wheeler E, Leong A, Liu C-T, et al.; EPIC-CVD Consortium; EPIC-InterAct Consortium; Lifelines Cohort Study. Impact of common genetic determinants of hemoglobin A1c on type 2 diabetes risk and diagnosis in ancestrally diverse populations: a transethnic genome-wide meta-analysis. *PLoS Med* 2017;14:e1002383
13. Wilson DM, Kollman; Diabetes Research in Children Network (DirecNet) Study Group. Relationship of A1C to glucose concentrations in children with type 1 diabetes: assessments by high-frequency glucose determinations by sensors. *Diabetes Care* 2008;31:381–385
14. Buse JB, Kaufman FR, Linder B, Hirst K, El Ghormli L, Willi S; HEALTHY Study Group. Diabetes screening with hemoglobin A_{1c} versus fasting plasma glucose in a multiethnic middle-school cohort. *Diabetes Care* 2013;36:429–435
15. Kamps JL, Hempe JM, Chalew SA. Racial disparity in A1C independent of mean blood glucose in children with type 1 diabetes. *Diabetes Care* 2010;33:1025–1027
16. Diabetes Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. *N Engl J Med* 1993;329:977–986
17. Diabetes Control and Complications Trial (DCCT)/Epidemiology of Diabetes Interventions and Complications (EDIC) Research Group. Effect of intensive diabetes therapy on the progression of diabetic retinopathy in patients with type 1 diabetes: 18 years of follow-up in the DCCT/EDIC. *Diabetes* 2015;64:631–642
18. Lachin JM, Genuth S, Cleary P, Davis MD, Nathan DM; Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications Research Group. Retinopathy and nephropathy in patients with type 1 diabetes four years after a trial of intensive therapy [published correction appears in *N Engl J Med* 2000;342:1376]. *N Engl J Med* 2000;342:381–389

19. Ohkubo Y, Kishikawa H, Araki E, et al. Intensive insulin therapy prevents the progression of diabetic microvascular complications in Japanese patients with non-insulin-dependent diabetes mellitus: a randomized prospective 6-year study. *Diabetes Res Clin Pract* 1995;28:103–117
20. UK Prospective Diabetes Study (UKPDS) Group. Effect of intensive blood-glucose control with metformin on complications in overweight patients with type 2 diabetes (UKPDS 34). *Lancet* 1998;352:854–865
21. UK Prospective Diabetes Study (UKPDS) Group. Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). *Lancet* 1998;352:837–853
22. Holman RR, Paul SK, Bethel MA, Matthews DR, Neil HAW. 10-year follow-up of intensive glucose control in type 2 diabetes. *N Engl J Med* 2008;359:1577–1589
23. Adler AI, Stratton IM, Neil HAW, et al. Association of systolic blood pressure with macrovascular and microvascular complications of type 2 diabetes (UKPDS 36): prospective observational study. *BMJ* 2000;321:412–419
24. Duckworth W, Abraira C, Moritz T, et al.; VADT Investigators. Glucose control and vascular complications in veterans with type 2 diabetes. *N Engl J Med* 2009;360:129–139
25. Patel A, MacMahon S, Chalmers J, et al.; ADVANCE Collaborative Group. Intensive blood glucose control and vascular outcomes in patients with type 2 diabetes. *N Engl J Med* 2008;358:2560–2572
26. Ismail-Beigi F, Craven T, Banerji MA, et al.; ACCORD trial group. Effect of intensive treatment of hyperglycaemia on microvascular outcomes in type 2 diabetes: an analysis of the ACCORD randomised trial. *Lancet* 2010;376:419–430
27. Gerstein HC, Miller ME, Byington RP, et al.; Action to Control Cardiovascular Risk in Diabetes Study Group. Effects of intensive glucose lowering in type 2 diabetes. *N Engl J Med* 2008;358:2545–2559
28. Nathan DM, Cleary PA, Backlund J-YC, et al.; Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications (DCCT/EDIC) Study Research Group. Intensive diabetes treatment and cardiovascular disease in patients with type 1 diabetes. *N Engl J Med* 2005;353:2643–2653
29. Nathan DM, Zinman B, Cleary PA, et al.; Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications (DCCT/EDIC) Research Group. Modern-day clinical course of type 1 diabetes mellitus after 30 years' duration: the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications and Pittsburgh Epidemiology of Diabetes Complications experience (1983–2005). *Arch Intern Med* 2009;169:1307–1316
30. Orchard TJ, Nathan DM, Zinman B, et al.; Writing Group for the DCCT/EDIC Research Group. Association between 7 years of intensive treatment of type 1 diabetes and long-term mortality. *JAMA* 2015;313:45–53
31. Skyler JS, Bergenstal R, Bonow RO, et al.; American Diabetes Association; American College of Cardiology Foundation; American Heart Association. Intensive glycemic control and the prevention of cardiovascular events: implications of the ACCORD, ADVANCE, and VA diabetes trials: a position statement of the American Diabetes Association and a scientific statement of the American College of Cardiology Foundation and the American Heart Association. *Diabetes Care* 2009;32:187–192
32. Zoungas S, Chalmers J, Neal B, et al.; ADVANCE-ON Collaborative Group. Follow-up of blood-pressure lowering and glucose control in type 2 diabetes. *N Engl J Med* 2014;371:1392–1406
33. Hayward RA, Reaven PD, Wiitala WL, et al.; VADT Investigators. Follow-up of glycemic control and cardiovascular outcomes in type 2 diabetes. *N Engl J Med* 2015;372:2197–2206
34. Turnbull FM, Abraira C, Anderson RJ, et al.; Control Group. Intensive glucose control and macrovascular outcomes in type 2 diabetes [published correction appears in *Diabetologia* 2009;52:2470]. *Diabetologia* 2009;52:2288–2298
35. Duckworth WC, Abraira C, Moritz TE, et al.; Investigators of the VADT. The duration of diabetes affects the response to intensive glucose control in type 2 subjects: the VA Diabetes Trial. *J Diabetes Complications* 2011;25:355–361
36. Lipska KJ, Ross JS, Miao Y, Shah ND, Lee SJ, Steinman MA. Potential overtreatment of diabetes mellitus in older adults with tight glycemic control. *JAMA Intern Med* 2015;175:356–362
37. Vijan S, Sussman JB, Yudkin JS, Hayward RA. Effect of patients' risks and preferences on health gains with plasma glucose level lowering in type 2 diabetes mellitus. *JAMA Intern Med* 2014;174:1227–1234
38. Lee AK, Warren B, Lee CJ, et al. The association of severe hypoglycemia with incident cardiovascular events and mortality in adults with type 2 diabetes. *Diabetes Care* 2018;41:104–111
39. Davies MJ, D'Alessio DA, Fradkin J, et al. Management of hyperglycemia in type 2 diabetes, 2018. A consensus report by the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD). *Diabetes Care* 2018;41:2669–2701
40. Inzucchi SE, Bergenstal RM, Buse JB, et al. Management of hyperglycemia in type 2 diabetes, 2015: a patient-centered approach: update to a position statement of the American Diabetes Association and the European Association for the Study of Diabetes. *Diabetes Care* 2015;38:140–149
41. American Diabetes Association. Postprandial blood glucose. *Diabetes Care* 2001;24:775–778
42. Raz I, Wilson PWF, Strojek K, et al. Effects of prandial versus fasting glycemia on cardiovascular outcomes in type 2 diabetes: the HEART2D trial. *Diabetes Care* 2009;32:381–386
43. Albers JW, Herman WH, Pop-Busui R, et al.; Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications Research Group. Effect of prior intensive insulin treatment during the Diabetes Control and Complications Trial (DCCT) on peripheral neuropathy in type 1 diabetes during the Epidemiology of Diabetes Interventions and Complications (EDIC) study. *Diabetes Care* 2010;33:1090–1096
44. Agiostratidou G, Anhalt H, Ball D, et al. Standardizing clinically meaningful outcome measures beyond HbA_{1c} for type 1 diabetes: a consensus report of the American Association of Clinical Endocrinologists, the American Association of Diabetes Educators, the American Diabetes Association, the Endocrine Society, JDRF International, The Leona M. and Harry B. Helmsley Charitable Trust, the Pediatric Endocrine Society, and the T1D Exchange. *Diabetes Care* 2017;40:1622–1630
45. Karter AJ, Moffet HH, Liu JY, Lipska KJ. Surveillance of hypoglycemia—limitations of emergency department and hospital utilization data. *JAMA Intern Med* 2018;178:987–988
46. Lee AK, Lee CJ, Huang ES, Sharrett AR, Coresh J, Selvin E. Risk factors for severe hypoglycemia in black and white adults with diabetes: the Atherosclerosis Risk in Communities (ARIC) study. *Diabetes Care* 2017;40:1661–1667
47. Karter AJ, Lipska KJ, O'Connor PJ, et al.; SUPREME-DM Study Group. High rates of severe hypoglycemia among African American patients with diabetes: the Surveillance, PREvention, and Management of Diabetes Mellitus (SUPREME-DM) network. *J Diabetes Complications* 2017;31:869–873
48. Whitmer RA, Karter AJ, Yaffe K, Quesenberry CP Jr, Selby JV. Hypoglycemic episodes and risk of dementia in older patients with type 2 diabetes mellitus. *JAMA* 2009;301:1565–1572
49. Punthakee Z, Miller ME, Launer LJ, et al.; ACCORD Group of Investigators; ACCORD-MIND Investigators. Poor cognitive function and risk of severe hypoglycemia in type 2 diabetes: post hoc epidemiologic analysis of the ACCORD trial. *Diabetes Care* 2012;35:787–793
50. Jacobson AM, Musen G, Ryan CM, et al.; Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications Study Research Group. Long-term effect of diabetes and its treatment on cognitive function. *N Engl J Med* 2007;356:1842–1852
51. Zoungas S, Patel A, Chalmers J, et al.; ADVANCE Collaborative Group. Severe hypoglycemia and risks of vascular events and death. *N Engl J Med* 2010;363:1410–1418
52. McCoy RG, Van Houten HK, Ziegenfuss JY, Shah ND, Wermers RA, Smith SA. Increased mortality of patients with diabetes reporting severe hypoglycemia. *Diabetes Care* 2012;35:1897–1901
53. DuBose SN, Weinstock RS, Beck RW, et al. Hypoglycemia in older adults with type 1 diabetes. *Diabetes Technol Ther* 2016;18:765–771
54. Seaquist ER, Anderson J, Childs B, et al. Hypoglycemia and diabetes: a report of a workgroup of the American Diabetes Association and the Endocrine Society. *Diabetes Care* 2013;36:1384–1395
55. Bergenstal RM, Klonoff DC, Garg SK, et al.; ASPIRE In-Home Study Group. Threshold-based insulin-pump interruption for reduction of hypoglycemia. *N Engl J Med* 2013;369:224–232
56. Hering BJ, Clarke WR, Bridges ND, et al.; Clinical Islet Transplantation Consortium.

- Phase 3 trial of transplantation of human islets in type 1 diabetes complicated by severe hypoglycemia. *Diabetes Care* 2016;39:1230–1240
57. Harlan DM. Islet transplantation for hypoglycemia unawareness/severe hypoglycemia: caveat emptor. *Diabetes Care* 2016;39:1072–1074
58. Layman DK, Clifton P, Gannon MC, Krauss RM, Nuttall FQ. Protein in optimal health: heart disease and type 2 diabetes. *Am J Clin Nutr* 2008;87:1571S–1575S
59. Cryer PE. Diverse causes of hypoglycemia-associated autonomic failure in diabetes. *N Engl J Med* 2004;350:2272–2279
60. Kitabchi AE, Umpierrez GE, Miles JM, Fisher JN. Hyperglycemic crises in adult patients with diabetes. *Diabetes Care* 2009;32:1335–1343

7. Diabetes Technology: Standards of Medical Care in Diabetes—2019

American Diabetes Association

Diabetes Care 2019;42(Suppl. 1):S71–S80 | <https://doi.org/10.2337/dc19-S007>

The American Diabetes Association (ADA) “Standards of Medical Care in Diabetes” includes ADA’s current clinical practice recommendations and is intended to provide the components of diabetes care, general treatment goals and guidelines, and tools to evaluate quality of care. Members of the ADA Professional Practice Committee, a multidisciplinary expert committee, are responsible for updating the Standards of Care annually, or more frequently as warranted. For a detailed description of ADA standards, statements, and reports, as well as the evidence-grading system for ADA’s clinical practice recommendations, please refer to the Standards of Care Introduction. Readers who wish to comment on the Standards of Care are invited to do so at professional.diabetes.org/SOC.

Diabetes technology is the term used to describe the hardware, devices, and software that people with diabetes use to help manage blood glucose levels, stave off diabetes complications, reduce the burden of living with diabetes, and improve quality of life. Historically, diabetes technology has been divided into two main categories: insulin administered by syringe, pen, or pump, and blood glucose monitoring as assessed by meter or continuous glucose monitor. More recently, diabetes technology has expanded to include hybrid devices that both monitor glucose and deliver insulin, some automatically, as well as software that serves as a medical device, providing diabetes self-management support. Diabetes technology, when applied appropriately, can improve the lives and health of people with diabetes; however, the complexity and rapid change of the diabetes technology landscape can also be a barrier to patient and provider implementation.

To provide some additional clarity in the diabetes technology space, the American Diabetes Association is, for the first time, adding a dedicated section on diabetes technology to the “Standards of Medical Care in Diabetes.” For this first writing, the section will focus on insulin delivery and glucose monitoring with the most common devices currently in use. In future years, this section will be expanded to include software as a medical device, privacy, cost, technology-enabled diabetes education and support, telemedicine, and other issues that providers and patients encounter with the use of technology in modern diabetes care.

INSULIN DELIVERY

Insulin Syringes and Pens

Recommendations

- 7.1** For people with diabetes who require insulin, insulin syringes or insulin pens may be used for insulin delivery with consideration of patient preference, insulin type and dosing regimen, cost, and self-management capabilities. **B**
- 7.2** Insulin pens or insulin injection aids may be considered for patients with dexterity issues or vision impairment to facilitate the administration of accurate insulin doses. **C**

Suggested citation: American Diabetes Association. 7. Diabetes technology: Standards of Medical Care in Diabetes—2019. Diabetes Care 2019;42 (Suppl. 1):S71–S80

© 2018 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. More information is available at <http://www.diabetesjournals.org/content/license>.

Injecting insulin with a syringe or pen is the insulin delivery method used by most people with diabetes (1,2), with the remainder using insulin pumps or automated insulin delivery devices (see sections on those topics below). For patients with diabetes who use insulin, insulin syringes and pens are both able to deliver insulin safely and effectively for the achievement of glycemic targets. When choosing between a syringe and a pen, patient preferences, cost, insulin type and dosing regimen, and self-management capabilities should be considered. It is important to note that while many insulin types are available for purchase as either pens or vials, others may only be available in one form or the other and there may be significant cost differences between pens and vials (see **Table 9.3** for a list of insulin product costs with dosage forms). Insulin pens may allow people with vision impairment or dexterity issues to dose insulin accurately (3–5), while insulin injection aids are also available to help with these issues (<http://main.diabetes.org/dforg/pdfs/2018/2018-cg-injection-aids.pdf>).

The most common syringe sizes are 1 mL, 0.5 mL, and 0.3 mL, allowing doses of up to 100 units, 50 units, and 30 units of U-100 insulin, respectively. In a few parts of the world, insulin syringes still have U-80 and U-40 markings for older insulin concentrations and veterinary insulin, and U-500 syringes are available for the use of U-500 insulin. Syringes are generally used once but may be reused by the same individual in resource-limited settings with appropriate storage and cleansing (6).

Insulin pens offer added convenience by combining the vial and syringe into a single device. Insulin pens, allowing push-button injections, come as disposable pens with prefilled cartridges or reusable insulin pens with replaceable insulin cartridges. Some reusable pens include a memory function, which can recall dose amounts and timing. “Smart” pens that can be programmed to calculate insulin doses and provide downloadable data reports are also available. Pens also vary with respect to dosing increment and minimal dose, which can range from half-unit doses to 2-unit dose increments.

Needle thickness (gauge) and length is another consideration. Needle gauges range from 22 to 33, with higher gauge indicating a thinner needle. A thicker needle can give a dose of insulin more

quickly, while a thinner needle may cause less pain. Needle length ranges from 4 to 12.7 mm, with some evidence suggesting shorter needles may lower the risk of intramuscular injection. When reused, needles may be duller and thus injection more painful. Proper insulin technique is a requisite to obtain the full benefits of insulin injection therapy, and concerns with technique and using the proper technique are outlined in Section 9 “Pharmacologic Approaches to Glycemic Treatment.”

Another insulin delivery option is a disposable patch-like device, which provides a continuous, subcutaneous infusion of rapid-acting insulin (basal), as well as 2-unit increments of bolus insulin at the press of a button (7).

Insulin Pumps

Recommendations

- 7.3** Individuals with diabetes who have been successfully using continuous subcutaneous insulin infusion should have continued access across third-party payers. **E**
- 7.4** Most adults, children, and adolescents with type 1 diabetes should be treated with intensive insulin therapy with either multiple daily injections or an insulin pump. **A**
- 7.5** Insulin pump therapy may be considered as an option for all children and adolescents, especially in children under 7 years of age. **C**

Continuous subcutaneous insulin injection (CSII) or insulin pumps have been available in the U.S. for 40 years. These devices deliver rapid-acting insulin throughout the day to help manage blood glucose levels. Most insulin pumps use tubing to deliver insulin through a cannula, while a few attach directly to the skin, without tubing.

Most studies comparing multiple daily injections (MDI) with CSII have been relatively small and of short duration. However, a recent systematic review and meta-analysis concluded that pump therapy has modest advantages for lowering A1C (−0.30% [95% CI −0.58 to −0.02]) and for reducing severe hypoglycemia rates in children and adults (8). There is no consensus to guide choosing which form of insulin administration is best for a given patient, and research to guide this decision making is needed (9). Thus, the choice of MDI or an insulin pump is often

based upon the individual characteristics of the patient and which is most likely to benefit him or her. Newer systems, such as sensor-augmented pumps and automatic insulin delivery systems, are discussed elsewhere in this section.

Adoption of pump therapy in the U.S. shows geographical variations, which may be related to provider preference or center characteristics (10,11) and socioeconomic status, as pump therapy is more common in individuals of higher socioeconomic status as reflected by race/ethnicity, private health insurance, family income, and education (11,12). Given the additional barriers to optimal diabetes care observed in disadvantaged groups (13), addressing the differences in access to insulin pumps and other diabetes technology may contribute to fewer health disparities.

Pump therapy can be successfully started at the time of diagnosis (14,15). Practical aspects of pump therapy initiation include: assessment of patient and family readiness, (although there is no consensus on which factors to consider in adults (16) or pediatrics), selection of pump type and initial pump settings, patient/family education of potential pump complications (e.g., diabetic ketoacidosis [DKA] with infusion set failure), transition from MDI, and introduction of advanced pump settings (e.g., temporary basal rates, extended/square/dual wave bolus).

Complications of the pump can be caused by issues with infusion sets (dislodgement, occlusion), which place patients at risk for ketosis and DKA and thus must be recognized and managed early (17); lipohypertrophy or, less frequently, lipodystrophy (18,19); and pump site infection (20). Discontinuation of pump therapy is relatively uncommon today; the frequency has decreased over the past decades and its causes have changed (20,21). Current reasons for attrition are problems with cost, wearability, disliking the pump, suboptimal glycemic control, or mood disorders (e.g., anxiety or depression) (22).

Insulin Pumps in Pediatrics

The safety of insulin pumps in youth has been established for over 15 years (23). Studying the effectiveness of CSII in lowering A1C has been challenging because of the potential selection bias of observational studies. Participants on CSII may have a higher socioeconomic status that

may facilitate better glycemic control (24) versus MDI. In addition, the fast pace of development of new insulins and technologies quickly renders comparisons obsolete. However, randomized controlled trials (RCTs) comparing CSII and MDI with insulin analogs demonstrate a modest improvement in A1C in participants on CSII (25,26). Observational studies, registry data, and meta-analysis have also suggested an improvement of glycemic control in participants on CSII (27–29). Although hypoglycemia was a major adverse effect of intensified insulin regimen in the Diabetes Control and Complications Trial (DCCT) (30), data suggests that CSII may reduce the rates of severe hypoglycemia compared with MDI (29,31–33). There is also evidence that CSII may reduce DKA risk (29,34) and diabetes complications, in particular, retinopathy and peripheral neuropathy in youth, compared with MDI (35). Finally, treatment satisfaction and quality-of-life measures improved on CSII compared with MDI (36,37). Therefore, CSII can be used safely and effectively in youth with type 1 diabetes to assist with achieving targeted glycemic control while reducing the risk of hypoglycemia and DKA, improving quality of life and preventing long-term complications. Based on patient-provider shared decision making, insulin pumps may be considered in all pediatric patients. In particular, pump therapy may be the preferred mode of insulin delivery for children under 7 years of age (38). Because of a paucity of data in adolescents and youths with Type 2 diabetes, there is insufficient evidence to make recommendations.

Common barriers to pump therapy adoption in children and adolescents are concerns regarding the physical interference of the device, discomfort with idea of having a device on the body therapeutic effectiveness, and financial burden (27,39).

SELF-MONITORING OF BLOOD GLUCOSE

Recommendations

7.6 Most patients using intensive insulin regimens (multiple daily injections or insulin pump therapy) should assess glucose levels using self-monitoring of blood glucose (or continuous glucose monitoring) prior to meals and snacks, at bedtime, occasionally

postprandially, prior to exercise, when they suspect low blood glucose, after treating low blood glucose until they are normoglycemic, and prior to critical tasks such as driving. **B**

7.7 When prescribed as part of a broad educational program, self-monitoring of blood glucose may help to guide treatment decisions and/or self-management for patients taking less frequent insulin injections. **B**

7.8 When prescribing self-monitoring of blood glucose, ensure that patients receive ongoing instruction and regular evaluation of technique, results, and their ability to use data from self-monitoring of blood glucose to adjust therapy. Similarly, continuous glucose monitoring use requires robust and ongoing diabetes education, training, and support. **E**

Major clinical trials of insulin-treated patients have included self-monitoring of blood glucose (SMBG) as part of multifactorial interventions to demonstrate the benefit of intensive glycemic control on diabetes complications (40). SMBG is thus an integral component of effective therapy of patients taking insulin. In recent years, continuous glucose monitoring (CGM) has emerged as a complementary method for the assessment of glucose levels (discussed below). Glucose monitoring allows patients to evaluate their individual response to therapy and assess whether glycemic targets are being safely achieved. Integrating results into diabetes management can be a useful tool for guiding medical nutrition therapy and physical activity, preventing hypoglycemia, and adjusting medications (particularly prandial insulin doses). The patient's specific needs and goals should dictate SMBG frequency and timing or the consideration of CGM use.

Optimizing Self-monitoring of Blood Glucose and Continuous Glucose Monitor Use

SMBG and CGM accuracy is dependent on the instrument and user, so it is important to evaluate each patient's monitoring technique, both initially and at regular intervals thereafter. Optimal use of SMBG and CGM requires proper review and interpretation of the data, by both the patient and the

provider, to ensure that data are used in an effective and timely manner. For patients with type 1 diabetes using CGM, the greatest predictor of A1C lowering for all age-groups was frequency of sensor use, which was highest in those aged ≥ 25 years and lower in younger age-groups (41). Similarly, for SMBG in patients with type 1 diabetes, there is a correlation between greater SMBG frequency and lower A1C (42). Among patients who check their blood glucose at least once daily, many report taking no action when results are high or low (43). Patients should be taught how to use SMBG and/or CGM data to adjust food intake, exercise, or pharmacologic therapy to achieve specific goals. The ongoing need for and frequency of SMBG should be reevaluated at each routine visit to avoid overuse, particularly if SMBG is not being used effectively for self-management (43–45).

For Patients on Intensive Insulin Regimens

SMBG or CGM is especially important for insulin-treated patients to monitor for and prevent hypoglycemia and hyperglycemia. Most patients using intensive insulin regimens (MDI or insulin pump therapy) should assess glucose levels using SMBG or a CGM prior to meals and snacks, at bedtime, occasionally postprandially, prior to exercise, when they suspect low blood glucose, after treating low blood glucose until they are normoglycemic, and prior to critical tasks such as driving. For many patients using SMBG, this will require testing up to 6–10 times daily, although individual needs may vary. A database study of almost 27,000 children and adolescents with type 1 diabetes showed that, after adjustment for multiple confounders, increased daily frequency of SMBG was significantly associated with lower A1C (–0.2% per additional test per day) and with fewer acute complications (46).

For Patients Using Basal Insulin and/or Oral Agents

The evidence is insufficient regarding when to prescribe SMBG and how often testing is needed for insulin-treated patients who do not use intensive insulin regimens, such as those with type 2 diabetes using basal insulin with or without oral agents. However, for patients using basal insulin, assessing fasting glucose with SMBG to inform dose adjustments to achieve blood glucose targets results in lower A1C (47,48).

In people with type 2 diabetes not using insulin, routine glucose monitoring may be of limited additional clinical benefit. For some individuals, glucose monitoring can provide insight into the impact of diet, physical activity, and medication management on glucose levels. Glucose monitoring may also be useful in assessing hypoglycemia, glucose levels during intercurrent illness, or discrepancies between measured A1C and glucose levels when there is concern an A1C result may not be reliable in specific individuals. However, several randomized trials have called into question the clinical utility and cost-effectiveness of routine SMBG in noninsulin-treated patients (49–52). In a year-long study of insulin-naïve patients with suboptimal initial glycemic control, a group trained in structured SMBG (a paper tool was used at least quarterly to collect and interpret seven-point SMBG profiles taken on 3 consecutive days) reduced their A1C by 0.3% more than the control group (53). A trial of once-daily SMBG that included enhanced patient feedback through messaging found no clinically or statistically significant change in A1C at 1 year (52). Meta-analyses have suggested that SMBG can reduce A1C by 0.25–0.3% at 6 months (54–56), but the effect was attenuated at 12 months in one analysis (54). Reductions in A1C were greater (–0.3%) in trials where structured SMBG data were used to adjust medications but not significant without such structured diabetes therapy adjustment (56). A key consideration is that performing SMBG alone does not lower blood glucose levels. To be useful, the information must be integrated into clinical and self-management plans.

Glucose Meter Accuracy

Recommendation

7.9 Health care providers should be aware of the medications and other factors that can interfere

with glucose meter accuracy and choose appropriate devices for their patients based on these factors. **E**

Glucose meters meeting U.S. Food and Drug Administration (FDA) guidance for meter accuracy provide the most reliable data for diabetes management. There are several current standards for accuracy of blood glucose monitors, but the two most used are those of the International Organization for Standardization (ISO 15197:2013) and the FDA. The current ISO and FDA standards are compared in **Table 7.1**. In Europe, currently marketed monitors must meet current ISO standards. In the U.S., currently marketed monitors must meet the standard under which they were approved, which may not be the current standard. Moreover, the monitoring of current accuracy is left to the manufacturer and not routinely checked by an independent source.

Patients assume their glucose monitor is accurate because it is FDA cleared, but often that is not the case. There is substantial variation in the accuracy of widely used blood glucose monitoring systems. The Diabetes Technology Society Blood Glucose Monitoring System Surveillance Program provides information on the performance of devices used for SMBG (<https://www.diabetestechology.org/surveillance.shtml>). In a recent analysis, the program found that only 6 of the top 18 glucose meters met the accuracy standard (57).

Factors Limiting Accuracy

Counterfeit Strips. Patients should be advised against purchasing or reselling preowned or second-hand test strips, as these may give incorrect results. Only unopened vials of glucose test strips should be used to ensure SMBG accuracy.

Oxygen. Currently available glucose monitors utilize an enzymatic reaction linked to an electrochemical reaction, either glucose oxidase or glucose dehydrogenase (58). Glucose oxidase monitors are sensitive to the oxygen available and should only be used with capillary blood in patients with normal oxygen saturation. Higher oxygen tensions (i.e., arterial blood or oxygen therapy) may result in false low-glucose readings, and low oxygen tensions (i.e., high altitude, hypoxia, or venous blood readings) may lead to false high-glucose readings. Glucose dehydrogenase monitors are not sensitive to oxygen.

Temperature. Because the reaction is sensitive to temperature, all monitors have an acceptable temperature range (58). Most will show an error if the temperature is unacceptable, but a few will provide a reading and a message indicating that the value may be incorrect.

Interfering Substances. There are a few physiologic and pharmacologic factors that interfere with glucose readings. Most interfere only with glucose oxidase systems (58). They are listed in **Table 7.2**.

CONTINUOUS GLUCOSE MONITORS

Recommendations

7.10 Sensor-augmented pump therapy may be considered for children, adolescents, and adults to improve glycemic control without an increase in hypoglycemia or severe hypoglycemia. Benefits correlate with adherence to ongoing use of the device. **A**

7.11 When prescribing continuous glucose monitoring, robust diabetes education, training, and support are required for optimal continuous glucose monitor implementation and ongoing use. **E**

Table 7.1—Comparison of ISO 15197 and FDA blood glucose meter accuracy standards

Setting	FDA ^{125,126}	ISO 15197-2013 ¹²⁷
Home use	95% within 15% for all BG in the usable BG range† 99% within 20% for all BG in the usable BG range†	95% within 15% for BG ≥100 mg/dL 95% within 15 mg/dL for BG <100 mg/dL 99% in A or B region of Consensus Error Grid‡
Hospital use	95% within 12% for BG ≥75 mg/dL	
	95% within 12 mg/dL for BG <75 mg/dL	
	98% within 15% for BG ≥75 mg/dL 98% within 15 mg/dL for BG <75 mg/dL	

BG, blood glucose. To convert mg/dL to mmol/L, see <http://www.endmemo.com/medical/unitconvert/Glucose.php>. †The range of BG values for which the meter has been proven accurate and will provide readings (other than low, high, or error). ‡Values outside of the “clinically acceptable” A and B regions are considered “outlier” readings and may be dangerous to use for therapeutic decisions¹²⁸.

Table 7.2—Interfering substances

Glucose oxidase monitors

Uric acid
Galactose
Xylose
Acetaminophen
L-dopa
Ascorbic acid

Glucose dehydrogenase monitors

Icodextrin (used in peritoneal dialysis)

7.12 People who have been successfully using continuous glucose monitors should have continued access across third-party payers. **E**

CGM measures interstitial glucose (which correlates well with plasma glucose). There are two types of CGM devices. Most CGM devices are real-time CGM, which continuously report glucose levels and include alarms for hypoglycemic and hyperglycemic excursions. The other type of device is intermittently scanning CGM (isCGM), which is approved for adult use only. isCGM, discussed more fully below, does not have alarms and does not communicate continuously, only on demand. It is reported to have a lower cost than systems with automatic alerts.

For some CGM systems, SMBG is required to make treatment decisions, although a randomized controlled trial of 226 adults suggested that an enhanced CGM device could be used safely and effectively without regular confirmatory SMBG in patients with well-controlled type 1 diabetes at low risk of severe hypoglycemia (59). Two CGM devices are now approved by the FDA for making treatment decisions without SMBG confirmation, sometimes called adjunctive use (60,61).

The abundance of data provided by CGM offers opportunities to analyze patient data more granularly than was previously possible, providing additional information to aid in achieving glycemic targets. A variety of metrics have been proposed (62). As recently reported, the metrics may include: 1) average glucose; 2) percentage of time in hypoglycemic ranges, i.e., <54 mg/dL (level 2), 54–70 mg/dL (level 1) (62); 3) percentage of time in target range, i.e., 70–180 mg/dL (3.9–9.9 mmol/L); 4) percentage of time in hyperglycemic range, i.e., ≥180 mg/dL

(62). To make these metrics more actionable, standardized reports with visual cues, such as an ambulatory glucose profile (62), may help the patient and the provider interpret the data and use it to guide treatment decisions.

In addition, while A1C is well established as an important risk marker for diabetes complications, with the increasing use of CGM to help facilitate safe and effective diabetes management, it is important to understand how CGM metrics, such as mean glucose and A1C correlate. Estimated A1C (eA1C) is a measure converting the mean glucose from CGM or self-monitored blood glucose readings, using a formula derived from glucose readings from a population of individuals, into an estimate of a simultaneously measured laboratory A1C. Recently, the eA1C was renamed the glucose management indicator (GMI), and a new formula was generated for converting CGM-derived mean glucose to GMI based on recent clinical trials using the most accurate CGM systems available. This provided a new way to use CGM data to estimate A1C (63).

Real-time Continuous Glucose Monitor Use in Youth

Recommendation

7.13 Real-time continuous glucose monitoring should be considered in children and adolescents with type 1 diabetes, whether using multiple daily injections or continuous subcutaneous insulin infusion, as an additional tool to help improve glucose control and reduce the risk of hypoglycemia. Benefits of continuous glucose monitoring correlate with adherence to ongoing use of the device. **B**

Data regarding use of real-time CGM in youth consist of findings from RCTs and small observational studies, as well as analysis of data collected by registries. Some of the RCTs have included both adult and pediatric participants (41,64–66), while others have only included pediatric participants (67) or limited the analysis of larger studies to just the pediatric participants (41). Given the feasibility problems of performing RCTs in very young children, small observational studies have also

provided data on real-time CGM use in the youngest age groups (68–70). Finally, while limited by the observational nature, registry data provide some evidence of real-world use of the technologies (71,72).

Impact on Glycemic Control

When data from adult and pediatric participants is analyzed together, CGM use in RCTs has been associated with reduction in A1C levels (64–66). Yet, in the JDRF CGM trial, when youth were analyzed by age-group (8- to 14-year-olds and 15- to 24-year-olds), no change in A1C was seen, likely due to poor CGM adherence (41). Indeed, in a secondary analysis of that RCT's data in both pediatric cohorts, those who utilized the sensor ≥6 days/week had an improvement in their glycemic control (73). One critical component to success with CGM is near-daily wearing of the device (64,74–76).

Though data from small observational studies demonstrate that CGM can be worn by patients <8 years old and the use of CGM provides insight to glycemic patterns (68,69), an RCT in children aged 4 to 9 years did not demonstrate improvements in glycemic control following 6 months of CGM use (67). However, observational feasibility studies of toddlers demonstrated a high degree of parental satisfaction and sustained use of the devices despite the inability to change the degree of glycemic control attained (70).

Registry data has also shown an association between CGM use and lower A1C levels (71,72), even when limiting assessment of CGM use to participants on injection therapy (72).

Impact on Hypoglycemia

Apart from the Sensing With Insulin pump Therapy to Control HbA_{1c} (SWITCH) study, which showed a significant effect of adding CGM to insulin pump therapy on time spent in hypoglycemia (64), most studies focusing on glycemic management overall failed to demonstrate a significant or relevant reduction in level 1 hypoglycemia (41,65–67,77). Notably, RCTs primarily aimed at hypoglycemia prevention did demonstrate a significant reduction in mild hypoglycemia in terms of reducing the time spent in hypoglycemia by approximately 40% and reducing the number of level 1 hypoglycemia events per day (78,79).

Real-time Continuous Glucose Monitor Use in Adults

Recommendations

- 7.14** When used properly, real-time continuous glucose monitoring in conjunction with intensive insulin regimens is a useful tool to lower A1C in adults with type 1 diabetes who are not meeting glycemic targets. **A**
- 7.15** Real-time continuous glucose monitoring may be a useful tool in those with hypoglycemia unawareness and/or frequent hypoglycemic episodes. **B**
- 7.16** Real-time continuous glucose monitoring should be used as close to daily as possible for maximal benefit. **A**
- 7.17** Real-time continuous glucose monitoring may be used effectively to improve A1C levels and neonatal outcomes in pregnant women with type 1 diabetes. **B**
- 7.18** Sensor-augmented pump therapy with automatic low-glucose suspend may be considered for adults with type 1 diabetes at high risk of hypoglycemia to prevent episodes of hypoglycemia and reduce their severity. **B**

Data exist to support the use of CGM in adults, both those on MDI and on CSII. In terms of randomized controlled trials in people with type 1 diabetes, there are four studies in adults with A1C as the primary outcome (80–84), three studies in adults with hypoglycemia as the primary outcome (85–87), four studies in adults and children with A1C as the primary outcome (41,64–66), and three studies in adults and children with hypoglycemia as a primary outcome (41,78,88). There are three studies in adults with type 1 or type 2 diabetes (89–91) and four studies with adults with type 2 diabetes (92–95). Finally, there are three studies that have been done in pregnant women with prepregnancy diabetes or gestational diabetes mellitus (96–98). Overall, excluding studies evaluating pediatric patients alone or pregnant women, 2,984 people with type 1 or type 2 diabetes have been studied to assess the benefits of CGM.

Primary Outcome: A1C Reduction

In general, A1C reduction was shown in studies where the baseline A1C was higher. In two larger studies in adults with type 1 diabetes that assessed the benefit of CGM in patients on MDI, there were significant reductions in A1C: -0.6% in one (80,81) and -0.43% in the other (82). No reduction in A1C was seen in a small study performed in underserved, less well-educated adults with type 1 diabetes (83). In the adult subset of the JDRF CGM study, there was a significant reduction in A1C of -0.53% (71) in patients who were primarily treated with insulin pump therapy. Better adherence in wearing the CGM device resulted in a greater likelihood of an improvement in glycemic control (41,84).

Studies in people with type 2 diabetes are heterogeneous in design—in two, participants were using basal insulin with oral agents or oral agents alone (65,95); in one, individuals were on MDI alone (92); and in another, participants were on CSII or MDI (79). The findings in studies with MDI alone (92) and in two studies in people using oral agents with or without insulin (93,95) showed significant reductions in A1C levels.

Primary Outcome: Hypoglycemia

In studies in adults where reduction in episodes of hypoglycemia was the primary end point, significant reductions were seen in individuals with type 1 diabetes on MDI or CSII (85–87). In one study in patients who were at higher risk for episodes of hypoglycemia (87), there was a reduction in rates of all levels of hypoglycemia (see Section 6 “Glycemic Targets” for hypoglycemia definitions). The Multiple Daily Injections and Continuous Glucose Monitoring in Diabetes (DIAMOND) study in people with type 2 diabetes on MDI did not show a reduction in hypoglycemia (92). Studies in individuals with type 2 diabetes on oral agents with or without insulin did not show reductions in rates of hypoglycemia (93,95). CGM may be particularly useful in insulin-treated patients with hypoglycemia unawareness and/or frequent hypoglycemic episodes, although studies have not shown consistent reductions in severe hypoglycemia (41,64,65).

Sensor-augmented pumps that suspend insulin when glucose is low or

predicted to go low within the next 30 min have been approved by the FDA. The Automation to Simulate Pancreatic Insulin Response (ASPIRE) trial of 247 patients with type 1 diabetes and documented nocturnal hypoglycemia showed that sensor-augmented insulin pump therapy with a low-glucose suspend function significantly reduced nocturnal hypoglycemia over 3 months without increasing A1C levels (66). In a different sensor-augmented pump, predictive low-glucose suspend reduced time spent with glucose <70 mg/dL from 3.6% at baseline to 2.6% (3.2% with sensor-augmented pump therapy without predictive low glucose suspend) without rebound hyperglycemia during a 6-week randomized crossover trial (95a). These devices may offer the opportunity to reduce hypoglycemia for those with a history of nocturnal hypoglycemia.

Real-time Continuous Glucose Monitor Use in Pregnancy

One well-designed RCT showed a reduction in A1C levels in adult women with type 1 diabetes on MDI or CSII who were pregnant (96). Neonatal outcomes were better when the mother used CGM during pregnancy (80). Two studies employing intermittent use of real-time CGM showed no difference in neonatal outcomes in women with type 1 diabetes (97) or gestational diabetes mellitus (98).

Intermittently Scanned Continuous Glucose Monitor Use

Recommendation

- 7.19** Intermittently scanned continuous glucose monitor use may be considered as a substitute for self-monitoring of blood glucose in adults with diabetes requiring frequent glucose testing. **C**

isCGM (sometimes referred to as “flash” CGM) is a CGM that measures glucose in interstitial fluid through a <0.4 mm-thick filament that is inserted under the skin. It has been available in Europe since 2014 and was approved by the FDA for use in adults in the U.S. in 2017. The personal version of isCGM has a receiver that, after scanning over the sensor by the individual, displays real-time glucose values and glucose trend arrows. The data can be uploaded and a report

created using available software. In the professional version, the patient does not carry a receiver; the data are blinded to the patient and the device is downloaded in the diabetes care provider's office using the provider's receiver and the software. The isCGM sensor is smaller than those of other systems and is water resistant. In the U.S., the FDA now requires a 1-h start-up time after activation of the system, and it can be worn up to 14 days. The isCGM does not require calibration with SMBG because it is factory calibrated. Acetaminophen does not cause interference with glucose readings. The mean absolute relative difference reported by the manufacturer is 9.4%. It measures glucose every minute, records measurements every 15 min, and displays up to 8 h of data. As opposed to real-time CGM systems, isCGM has no alarms. The direct costs of isCGM are lower than those of real-time CGM systems. In general, both the consumer and professional versions are covered by most commercial insurance carriers and eligible Medicare programs. Information on Medicaid coverage was not available at the time of this writing.

Studies in adults with diabetes indicate isCGM has acceptable accuracy when compared with SMBG (99–102), although the accuracy may be lower at high and/or low glucose levels (103,104). Studies comparing the accuracy of isCGM with real-time CGM show conflicting results (102,104,105). isCGM may decrease the risk of hypoglycemia in individuals with type 1 (85) or type 2 diabetes (94). There are a growing number of studies suggesting similar good performance and potential for benefit in special populations, including pregnant women with diabetes (106), individuals with type 1 diabetes and hypoglycemia unawareness (107), and children (108–110), although accuracy (mean absolute relative difference) could be decreased in younger children (109). Contact dermatitis has been reported and linked to the presence of isobornyl acrylate, a structural plastic of the device, which is a skin sensitizer and can cause an additional spreading allergic reaction (111–113).

There are several published reviews of data available on isCGM (114–116). The Norwegian Institute for Public Health conducted an assessment of isCGM clinical effectiveness, cost-effectiveness,

and safety for individuals with type 1 and type 2 diabetes, based on data available until January 2017 (114). The authors concluded that, although there were few quality data available at the time of the report, isCGM may increase treatment satisfaction, increase time in range, and reduce frequency of nocturnal hypoglycemia, without differences in A1C or quality of life or serious adverse events. The Canadian Agency for Drugs and Technologies in Health reviewed existing data on isCGM performance and accuracy, hypoglycemia, effect on A1C, and patient satisfaction and quality of life and concluded that the system could replace SMBG in particular in patients who require frequent testing (115). The last review published at the time of this report (116) also supported the use of isCGM as a more affordable alternative to real-time CGM systems for individuals with diabetes who are on intensive insulin therapy.

AUTOMATED INSULIN DELIVERY

Recommendation

7.20 Automated insulin delivery systems may be considered in children (>7 years) and adults with type 1 diabetes to improve glycemic control. **B**

To provide physiologic insulin delivery, insulin doses need to be adjusted based on glucose values, which is now feasible with automated insulin delivery systems consisting of three components: an insulin pump, a continuous glucose sensor, and an algorithm that determines insulin delivery. With these systems, insulin delivery cannot only be suspended but also increased or decreased based on sensor glucose values. Emerging evidence suggests such systems may lower the risk of exercise-related hypoglycemia (117) and may have psychosocial benefits (118–121).

While eventually insulin delivery in closed-loop systems may be truly automated, meals must currently be announced. A so-called hybrid approach, hybrid closed-loop (HCL), has been adopted in first-generation closed-loop systems and requires users to bolus for meals and snacks. The FDA has approved the first HCL system for use in those as young as 7 years of age. A 3-month noncontrolled trial using this device ($n =$

124) demonstrated safety (122) and improved A1C in adults (reduction from $7.3 \pm 0.9\%$ to $6.8 \pm 0.6\%$) and adolescents ($7.7 \pm 0.8\%$ to $7.1 \pm 0.6\%$) (123).

To date, the longest outpatient RCTs lasted 12 weeks and compared HCL treatment (a system that is not currently FDA approved) to sensor-augmented pumps in adults and children as young as 6 years of age ($n = 86$) with A1C levels above target at baseline. Compared with sensor-augmented pump therapy, the HCL system reduced the risk for hypoglycemia and improved glucose control in A1C levels (124).

Future Systems

A multitude of other automated insulin delivery systems are currently being investigated, including those with dual hormones (insulin and glucagon or insulin and pramlintide). Furthermore, some patients have created do-it-yourself systems through guidance from online communities, although these are not FDA approved or recommended.

References

1. Lasalvia P, Barahona-Correa JE, Romero-Alvernia DM, et al. Pen devices for insulin self-administration compared with needle and vial: systematic review of the literature and meta-analysis. *J Diabetes Sci Technol* 2016;10:959–966
2. Hanas R, de Beaufort C, Hoey H, Anderson B. Insulin delivery by injection in children and adolescents with diabetes. *Pediatr Diabetes* 2011;12:518–526
3. Pfützner A, Schipper C, Niemeier M, et al. Comparison of patient preference for two insulin injection pen devices in relation to patient dexterity skills. *J Diabetes Sci Technol* 2012;6:910–916
4. Williams AS, Schnarrenberger PA. A comparison of dosing accuracy: visually impaired and sighted people using insulin pens. *J Diabetes Sci Technol* 2010;4:514–521
5. Reinauer KM, Joksich G, Renn W, Eggstein M. Insulin pens in elderly diabetic patients. *Diabetes Care* 1990;13:1136–1137
6. Thomas DR, Fischer RG, Nicholas WC, Beghe C, Hatten KW, Thomas JN. Disposable insulin syringe reuse and aseptic practices in diabetic patients. *J Gen Intern Med* 1989;4:97–100
7. Winter A, Lintner M, Knezevich E. V-Go insulin delivery system versus multiple daily insulin injections for patients with uncontrolled type 2 diabetes mellitus. *J Diabetes Sci Technol* 2015;9:1111–1116
8. Yeh H-C, Brown TT, Maruthur N, et al. Comparative effectiveness and safety of methods of insulin delivery and glucose monitoring for diabetes mellitus: a systematic review and meta-analysis. *Ann Intern Med* 2012;157:336–347

9. Pickup JC. The evidence base for diabetes technology: appropriate and inappropriate meta-analysis. *J Diabetes Sci Technol* 2013;7:1567–1574
10. Blackman SM, Raghinaru D, Adi S, et al. Insulin pump use in young children in the T1D Exchange clinic registry is associated with lower hemoglobin A1c levels than injection therapy. *Pediatr Diabetes* 2014;15:564–572
11. Lin MH, Connor CG, Ruedy KJ, et al.; Pediatric Diabetes Consortium. Race, socioeconomic status, and treatment center are associated with insulin pump therapy in youth in the first year following diagnosis of type 1 diabetes. *Diabetes Technol Ther* 2013;15:929–934
12. Willi SM, Miller KM, DiMeglio LA, et al.; T1D Exchange Clinic Network. Racial-ethnic disparities in management and outcomes among children with type 1 diabetes. *Pediatrics* 2015;135:424–434
13. Redondo MJ, Libman I, Cheng P, et al.; Pediatric Diabetes Consortium. Racial/ethnic minority youth with recent-onset type 1 diabetes have poor prognostic factors. *Diabetes Care* 2018;41:1017–1024
14. Ramchandani N, Ten S, Anhalt H, et al. Insulin pump therapy from the time of diagnosis of type 1 diabetes. *Diabetes Technol Ther* 2006;8:663–670
15. Berghaeuser MA, Kapellen T, Heidtmann B, Haberland H, Klinkert C, Holl RW; DPV-Science-Initiative and the German working group for insulin pump treatment in paediatric patients. Continuous subcutaneous insulin infusion in toddlers starting at diagnosis of type 1 diabetes mellitus. A multicenter analysis of 104 patients from 63 centres in Germany and Austria. *Pediatr Diabetes* 2008;9:590–595
16. Peters AL, Ahmann AJ, Battelino T, et al. Diabetes technology—continuous subcutaneous insulin infusion therapy and continuous glucose monitoring in adults: an Endocrine Society clinical practice guideline. *J Clin Endocrinol Metab* 2016;101:3922–3937
17. Wheeler BJ, Heels K, Donaghue KC, Reith DM, Ambler GR. Insulin pump-associated adverse events in children and adolescents—a prospective study. *Diabetes Technol Ther* 2014;16:558–562
18. Kordonouri O, Lauterborn R, Deiss D. Lipo-hypertrophy in young patients with type 1 diabetes. *Diabetes Care* 2002;25:634
19. Kordonouri O, Biester T, Schnell K, et al. Lipoatrophy in children with type 1 diabetes: an increasing incidence? *J Diabetes Sci Technol* 2015;9:206–208
20. Guinn TS, Bailey GJ, Mecklenburg RS. Factors related to discontinuation of continuous subcutaneous insulin-infusion therapy. *Diabetes Care* 1988;11:46–51
21. Wong JC, Boyle C, DiMeglio LA, et al.; T1D Exchange Clinic Network. Evaluation of pump discontinuation and associated factors in the T1D Exchange clinic registry. *J Diabetes Sci Technol* 2017;11:224–232
22. Wong JC, Dolan LM, Yang TT, Hood KK. Insulin pump use and glycemic control in adolescents with type 1 diabetes: predictors of change in method of insulin delivery across two years. *Pediatr Diabetes* 2015;16:592–599
23. Plotnick LP, Clark LM, Brancati FL, Erlinger T. Safety and effectiveness of insulin pump therapy in children and adolescents with type 1 diabetes. *Diabetes Care* 2003;26:1142–1146
24. Redondo MJ, Connor CG, Ruedy KJ, et al.; Pediatric Diabetes Consortium. Pediatric Diabetes Consortium Type 1 Diabetes New Onset (NeOn) Study: factors associated with HbA1c levels one year after diagnosis. *Pediatr Diabetes* 2014;15:294–302
25. Doyle EA, Weinzimer SA, Steffen AT, Ahern JAH, Vincent M, Tamborlane WVA. A randomized, prospective trial comparing the efficacy of continuous subcutaneous insulin infusion with multiple daily injections using insulin glargine. *Diabetes Care* 2004;27:1554–1558
26. Alemzadeh R, Ellis JN, Holzum MK, Parton EA, Wyatt DT. Beneficial effects of continuous subcutaneous insulin infusion and flexible multiple daily insulin regimen using insulin glargine in type 1 diabetes. *Pediatrics* 2004;114:e91–e95
27. Sherr JL, Hermann JM, Campbell F, et al.; T1D Exchange Clinic Network, the DPV Initiative, and the National Paediatric Diabetes Audit and the Royal College of Paediatrics and Child Health registries. Use of insulin pump therapy in children and adolescents with type 1 diabetes and its impact on metabolic control: comparison of results from three large, transatlantic paediatric registries. *Diabetologia* 2016;59:87–91
28. Jeitler K, Horvath K, Berghold A, et al. Continuous subcutaneous insulin infusion versus multiple daily insulin injections in patients with diabetes mellitus: systematic review and meta-analysis. *Diabetologia* 2008;51:941–951
29. Karges B, Schwandt A, Heidtmann B, et al. Association of insulin pump therapy vs insulin injection therapy with severe hypoglycemia, ketoacidosis, and glycemic control among children, adolescents, and young adults with type 1 diabetes. *JAMA* 2017;318:1358–1366
30. The DCCT Research Group. Epidemiology of severe hypoglycemia in the Diabetes Control and Complications Trial. *Am J Med* 1991;90:450–459
31. Haynes A, Hermann JM, Miller KM, et al. Severe hypoglycemia rates are not associated with HbA1c: a cross-sectional analysis of 3 contemporary pediatric diabetes registry databases. *Pediatr Diabetes* 2017;18:643–650
32. Pickup JC, Sutton AJ. Severe hypoglycaemia and glycaemic control in type 1 diabetes: meta-analysis of multiple daily insulin injections compared with continuous subcutaneous insulin infusion. *Diabet Med* 2008; 25:765–774
33. Birkebaek NH, Drivovoll AK, Aakeson K, et al. Incidence of severe hypoglycemia in children with type 1 diabetes in the Nordic countries in the period 2008–2012: association with hemoglobin A_{1c} and treatment modality. *BMJ Open Diabetes Res Care* 2017;5:e000377
34. Maahs DM, Hermann JM, Holman N, et al.; National Paediatric Diabetes Audit and the Royal College of Paediatrics and Child Health, the DPV Initiative, and the T1D Exchange Clinic Network. Rates of diabetic ketoacidosis: international comparison with 49,859 pediatric patients with type 1 diabetes from England, Wales, the U.S., Austria, and Germany. *Diabetes Care* 2015; 38:1876–1882
35. Zabeen B, Craig ME, Virk SA, et al. Insulin pump therapy is associated with lower rates of retinopathy and peripheral nerve abnormality. *PLoS One* 2016;11:e0153033
36. Weintrob N, Benzaquen H, Galatzer A, et al. Comparison of continuous subcutaneous insulin infusion and multiple daily injection regimens in children with type 1 diabetes: a randomized open crossover trial. *Pediatrics* 2003;112:559–564
37. Ovipari-Arrigan L, Fredericks EM, Burkhardt N, Dale L, Hodge M, Foster C. Continuous subcutaneous insulin infusion benefits quality of life in preschool-age children with type 1 diabetes mellitus. *Pediatr Diabetes* 2007;8:377–383
38. Sundberg F, Barnard K, Cato A, et al. ISPAD Guidelines. Managing diabetes in preschool children. *Pediatr Diabetes* 2017;18:499–517
39. Commissariat PV, Boyle CT, Miller KM, et al. Insulin pump use in young children with type 1 diabetes: sociodemographic factors and parent-reported barriers. *Diabetes Technol Ther* 2017; 19:363–369
40. Nathan DM, Genuth S, Lachin J, et al.; Diabetes Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. *N Engl J Med* 1993;329:977–986
41. Tamborlane WV, Beck RW, Bode BW, et al.; Juvenile Diabetes Research Foundation Continuous Glucose Monitoring Study Group. Continuous glucose monitoring and intensive treatment of type 1 diabetes. *N Engl J Med* 2008;359:1464–1476
42. Miller KM, Beck RW, Bergenstal RM, et al.; T1D Exchange Clinic Network. Evidence of a strong association between frequency of self-monitoring of blood glucose and hemoglobin A_{1c} levels in T1D Exchange clinic registry participants. *Diabetes Care* 2013;36:2009–2014
43. Grant RW, Huang ES, Wexler DJ, et al. Patients who self-monitor blood glucose and their unused testing results. *Am J Manag Care* 2015;21:e119–e129
44. Gellad WF, Zhao X, Thorpe CT, Mor MK, Good CB, Fine MJ. Dual use of Department of Veterans Affairs and Medicare benefits and use of test strips in veterans with type 2 diabetes mellitus. *JAMA Intern Med* 2015;175:26–34
45. Endocrine Society and Choosing Wisely. Five things physicians and patients should question [Internet]. Available from <http://www.choosingwisely.org/societies/endocrine-society/>. Accessed 12 November 2018
46. Ziegler R, Heidtmann B, Hilgard D, Hofer S, Rosenbauer J, Holl R; DPV-Wiss-Initiative. Frequency of SMBG correlates with HbA1c and acute complications in children and adolescents with type 1 diabetes. *Pediatr Diabetes* 2011;12: 11–17
47. Rosenstock J, Davies M, Home PD, Larsen J, Koenen C, Scherthner G. A randomised, 52-week, treat-to-target trial comparing insulin detemir with insulin glargine when administered as addition to glucose-lowering drugs in insulin-naive people with type 2 diabetes. *Diabetologia* 2008; 51:408–416
48. Garber AJ. Treat-to-target trials: uses, interpretation and review of concepts. *Diabetes Obes Metab* 2014;16:193–205
49. Farmer A, Wade A, Goyder E, et al. Impact of self monitoring of blood glucose in the management of patients with non-insulin treated diabetes: open parallel group randomised trial. *BMJ* 2007;335:132
50. O’Kane MJ, Bunting B, Copeland M, Coates VE; ESMON study group. Efficacy of self

- monitoring of blood glucose in patients with newly diagnosed type 2 diabetes (ESMON study): randomised controlled trial. *BMJ* 2008;336:1174–1177
51. Simon J, Gray A, Clarke P, Wade A, Neil A, Farmer A; Diabetes Glycaemic Education and Monitoring Trial Group. Cost effectiveness of self monitoring of blood glucose in patients with non-insulin treated type 2 diabetes: economic evaluation of data from the DiGEM trial. *BMJ* 2008;336:1177–1180
52. Young LA, Buse JB, Weaver MA, et al.; Monitor Trial Group. Glucose self-monitoring in non-insulin-treated patients with type 2 diabetes in primary care settings: a randomized trial. *JAMA Intern Med* 2017;177:920–929
53. Polonsky WH, Fisher L, Schikman CH, et al. Structured self-monitoring of blood glucose significantly reduces A1C levels in poorly controlled, noninsulin-treated type 2 diabetes: results from the Structured Testing Program study. *Diabetes Care* 2011;34:262–267
54. Malanda UL, Welschen LMC, Riphagen II, Dekker JM, Nijpels G, Bot SDM. Self-monitoring of blood glucose in patients with type 2 diabetes mellitus who are not using insulin. *Cochrane Database Syst Rev* 2012;1:CD005060
55. Willett LR. ACP Journal Club. Meta-analysis: self-monitoring in non-insulin-treated type 2 diabetes improved HbA_{1c} by 0.25%. *Ann Intern Med* 2012;156:JC6–JC12
56. Mannucci E, Antenore A, Giorgino F, Scavini M. Effects of structured versus unstructured self-monitoring of blood glucose on glucose control in patients with non-insulin-treated type 2 diabetes: a meta-analysis of randomized controlled trials. *J Diabetes Sci Technol* 2018;12:183–189
57. Klonoff DC, Parkes JL, Kovatchev BP, et al. Investigation of the accuracy of 18 marketed blood glucose monitors. *Diabetes Care* 2018;41:1681–1688
58. Ginsberg BH. Factors affecting blood glucose monitoring: sources of errors in measurement. *J Diabetes Sci Technol* 2009;3:903–913
59. Aleppo G, Ruedy KJ, Riddlesworth TD, et al.; REPLACE-BG Study Group. REPLACE-BG: a randomized trial comparing continuous glucose monitoring with and without routine blood glucose monitoring in adults with well-controlled type 1 diabetes. *Diabetes Care* 2017;40:538–545
60. U.S. Food and Drug Administration. FDA news release: FDA expands indication for continuous glucose monitoring system, first to replace fingerstick testing for diabetes treatment decisions [Internet], 2016. Available from <https://www.fda.gov/newsevents/newsroom/pressannouncements/ucm534056.htm>. Accessed 14 September 2017
61. U.S. Food and Drug Administration. FDA news release: FDA approves first continuous glucose monitoring system for adults not requiring blood sample calibration [Internet], 2017. Available from <https://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm577890.htm>. Accessed 2 October 2017
62. Danne T, Nimri R, Battelino T, et al. International consensus on use of continuous glucose monitoring. *Diabetes Care* 2017;40:1631–1640
63. Bergenstal RM, Beck RW, Close KL, et al. Glucose management indicator (GMI): a new term for estimating A1C from continuous glucose monitoring. *Diabetes Care* 2018;41:2275–2280
64. Battelino T, Conget I, Olsen B, et al.; SWITCH Study Group. The use and efficacy of continuous glucose monitoring in type 1 diabetes treated with insulin pump therapy: a randomised controlled trial. *Diabetologia* 2012;55:3155–3162
65. Deiss D, Bolinder J, Riveline J-P, et al. Improved glycemic control in poorly controlled patients with type 1 diabetes using real-time continuous glucose monitoring. *Diabetes Care* 2006;29:2730–2732
66. O’Connell MA, Donath S, O’Neal DN, et al. Glycaemic impact of patient-led use of sensor-guided pump therapy in type 1 diabetes: a randomised controlled trial. *Diabetologia* 2009;52:1250–1257
67. Mauras N, Beck R, Xing D, et al.; Diabetes Research in Children Network (DirecNet) Study Group. A randomized clinical trial to assess the efficacy and safety of real-time continuous glucose monitoring in the management of type 1 diabetes in young children aged 4 to <10 years. *Diabetes Care* 2012;35:204–210
68. Jeha GS, Karaviti LP, Anderson B, et al. Continuous glucose monitoring and the reality of metabolic control in preschool children with type 1 diabetes. *Diabetes Care* 2004;27:2881–2886
69. Gandrud LM, Xing D, Kollman C, et al. The Medtronic Minimed Gold continuous glucose monitoring system: an effective means to discover hypo- and hyperglycemia in children under 7 years of age. *Diabetes Technol Ther* 2007;9:307–316
70. Tsalikian E, Fox L, Weinzimer S, et al.; Diabetes Research in Children Network Study Group. Feasibility of prolonged continuous glucose monitoring in toddlers with type 1 diabetes. *Pediatr Diabetes* 2012;13:301–307
71. Wong JC, Foster NC, Maahs DM, et al.; T1D Exchange Clinic Network. Real-time continuous glucose monitoring among participants in the T1D Exchange clinic registry. *Diabetes Care* 2014;37:2702–2709
72. Foster RC, Miller KM, Tamborlane WV, Bergenstal RM, Beck RW; T1D Exchange Clinic Network. Continuous glucose monitoring in patients with type 1 diabetes using insulin injections. *Diabetes Care* 2016;39:e81–e82
73. Beck RW, Buckingham B, Miller K, et al.; Juvenile Diabetes Research Foundation Continuous Glucose Monitoring Study Group. Factors predictive of use and of benefit from continuous glucose monitoring in type 1 diabetes. *Diabetes Care* 2009;32:1947–1953
74. Juvenile Diabetes Research Foundation Continuous Glucose Monitoring Study Group. Effectiveness of continuous glucose monitoring in a clinical care environment: evidence from the Juvenile Diabetes Research Foundation Continuous Glucose Monitoring (JDRF-CGM) trial. *Diabetes Care* 2010;33:17–22
75. Chase HP, Beck RW, Xing D, et al. Continuous glucose monitoring in youth with type 1 diabetes: 12-month follow-up of the Juvenile Diabetes Research Foundation continuous glucose monitoring randomized trial. *Diabetes Technol Ther* 2010;12:507–515
76. Pickup JC, Freeman SC, Sutton AJ. Glycaemic control in type 1 diabetes during real time continuous glucose monitoring compared with self monitoring of blood glucose: meta-analysis of randomised controlled trials using individual patient data. *BMJ* 2011;343:d3805
77. Riveline J-P, Schaepeelync P, Chaillous L, et al.; EVADIAC Sensor Study Group. Assessment of patient-led or physician-driven continuous glucose monitoring in patients with poorly controlled type 1 diabetes using basal-bolus insulin regimens: a 1-year multicenter study. *Diabetes Care* 2012;35:965–971
78. Battelino T, Phillip M, Bratina N, Nimri R, Oskarsson P, Bolinder J. Effect of continuous glucose monitoring on hypoglycemia in type 1 diabetes. *Diabetes Care* 2011;34:795–800
79. Beck RW, Hirsch IB, Laffel L, et al.; Juvenile Diabetes Research Foundation Continuous Glucose Monitoring Study Group. The effect of continuous glucose monitoring in well-controlled type 1 diabetes. *Diabetes Care* 2009;32:1378–1383
80. Beck RW, Riddlesworth T, Ruedy K, et al.; DIAMOND Study Group. Effect of continuous glucose monitoring on glycemic control in adults with type 1 diabetes using insulin injections: the DIAMOND randomized clinical trial. *JAMA* 2017;317:371–378
81. Riddlesworth T, Price D, Cohen N, Beck RW. Hypoglycemic event frequency and the effect of continuous glucose monitoring in adults with type 1 diabetes using multiple daily insulin injections. *Diabetes Ther* 2017;8:947–951
82. Lind M, Polonsky W, Hirsch IB, et al. Continuous glucose monitoring vs conventional therapy for glycemic control in adults with type 1 diabetes treated with multiple daily insulin injections: the GOLD randomized clinical trial [published correction appears in *JAMA* 2017;317:1912]. *JAMA* 2017;317:379–387
83. Sequeira PA, Montoya L, Ruelas V, et al. Continuous glucose monitoring pilot in low-income type 1 diabetes patients. *Diabetes Technol Ther* 2013;15:855–858
84. Tumminia A, Crimi S, Sciacca L, et al. Efficacy of real-time continuous glucose monitoring on glycaemic control and glucose variability in type 1 diabetic patients treated with either insulin pumps or multiple insulin injection therapy: a randomized controlled crossover trial. *Diabetes Metab Res Rev* 2015;31:61–68
85. Bolinder J, Antuna R, Geelhoed-Duijvestijn P, Kröger J, Weitgasser R. Novel glucose-sensing technology and hypoglycaemia in type 1 diabetes: a multicentre, non-masked, randomised controlled trial. *Lancet* 2016;388:2254–2263
86. Hermanns N, Schumann B, Kulzer B, Haak T. The impact of continuous glucose monitoring on low interstitial glucose values and low blood glucose values assessed by point-of-care blood glucose meters: results of a crossover trial. *J Diabetes Sci Technol* 2014;8:516–522
87. van Beers CAJ, DeVries JH, Kleijer SJ, et al. Continuous glucose monitoring for patients with type 1 diabetes and impaired awareness of hypoglycaemia (IN CONTROL): a randomised, open-label, crossover trial. *Lancet Diabetes Endocrinol* 2016;4:893–902
88. Heinemann L, Freckmann G, Ehrmann D, et al. Real-time continuous glucose monitoring in adults with type 1 diabetes and impaired hypoglycaemia awareness or severe hypoglycaemia

- treated with multiple daily insulin injections (HypoDE): a multicentre, randomised controlled trial. *Lancet* 2018;391:1367–1377
89. Garg S, Zisser H, Schwartz S, et al. Improvement in glycemic excursions with a transcutaneous, real-time continuous glucose sensor: a randomized controlled trial. *Diabetes Care* 2006;29:44–50
 90. New JP, Ajjan R, Pfeiffer AFH, Freckmann G. Continuous glucose monitoring in people with diabetes: the randomized controlled Glucose Level Awareness in Diabetes Study (GLADIS). *Diabet Med* 2015;32:609–617
 91. Cooke D, Hurel SJ, Casbard A, et al. Randomized controlled trial to assess the impact of continuous glucose monitoring on HbA_{1c} in insulin-treated diabetes (MITRE Study). *Diabet Med* 2009;26:540–547
 92. Beck RW, Riddlesworth TD, Ruedy K, et al.; DIAMOND Study Group. Continuous glucose monitoring versus usual care in patients with type 2 diabetes receiving multiple daily insulin injections: a randomized trial. *Ann Intern Med* 2017;167:365–374
 93. Ehrhardt NM, Chellappa M, Walker MS, Fonda SJ, Vigersky RA. The effect of real-time continuous glucose monitoring on glycemic control in patients with type 2 diabetes mellitus. *J Diabetes Sci Technol* 2011;5:668–675
 94. Haak T, Hanaire H, Ajjan R, Hermanns N, Riveline J-P, Rayman G. Flash glucose-sensing technology as a replacement for blood glucose monitoring for the management of insulin-treated type 2 diabetes: a multicenter, open-label randomized controlled trial. *Diabetes Ther* 2017;8:55–73
 95. Yoo HJ, An HG, Park SY, et al. Use of a real time continuous glucose monitoring system as a motivational device for poorly controlled type 2 diabetes. *Diabetes Res Clin Pract* 2008;82:73–79
 - 95a. Forlenza GP, Li Z, Buckingham BA, et al. Predictive low-glucose suspend reduces hypoglycemia in adults, adolescents, and children with type 1 diabetes in an at-home randomized crossover study: results of the PROLOG trial. *Diabetes Care* 2018;41:2155–2161
 96. Feig DS, Donovan LE, Corcoy R, et al.; CONCEPT Collaborative Group. Continuous glucose monitoring in pregnant women with type 1 diabetes (CONCEPT): a multicentre international randomised controlled trial. *Lancet* 2017;390:2347–2359
 97. Secher AL, Ringholm L, Andersen HU, Damm P, Mathiesen ER. The effect of real-time continuous glucose monitoring in pregnant women with diabetes: a randomized controlled trial. *Diabetes Care* 2013;36:1877–1883
 98. Wei Q, Sun Z, Yang Y, Yu H, Ding H, Wang S. Effect of a CGMS and SMBG on maternal and neonatal outcomes in gestational diabetes mellitus: a randomized controlled trial. *Sci Rep* 2016;6:19920
 99. Ólafsdóttir AF, Attvall S, Sandgren U, et al. A clinical trial of the accuracy and treatment experience of the flash glucose monitor FreeStyle Libre in adults with type 1 diabetes. *Diabetes Technol Ther* 2017;19:164–172
 100. Ji L, Guo X, Guo L, Ren Q, Yu N, Zhang J. A multicenter evaluation of the performance and usability of a novel glucose monitoring system in Chinese adults with diabetes. *J Diabetes Sci Technol* 2017;11:290–295
 101. Bailey T, Bode BW, Christiansen MP, Klaff LJ, Alva S. The performance and usability of a factory-calibrated flash glucose monitoring system. *Diabetes Technol Ther* 2015;17:787–794
 102. Aberer F, Hajnsek M, Rumpler M, et al. Evaluation of subcutaneous glucose monitoring systems under routine environmental conditions in patients with type 1 diabetes. *Diabetes Obes Metab* 2017;19:1051–1055
 103. Fokkert MJ, van Dijk PR, Edens MA, et al. Performance of the FreeStyle Libre flash glucose monitoring system in patients with type 1 and 2 diabetes mellitus. *BMJ Open Diabetes Res Care* 2017;5:e000320
 104. Bonora B, Maran A, Ciciliot S, Avogaro A, Fadini GP. Head-to-head comparison between flash and continuous glucose monitoring systems in outpatients with type 1 diabetes. *J Endocrinol Invest* 2016;39:1391–1399
 105. Boscari F, Galasso S, Acciaroli G, et al. Head-to-head comparison of the accuracy of Abbott FreeStyle Libre and Dexcom G5 Mobile. *Nutr Metab Cardiovasc Dis* 2018;28:425–427
 106. Scott EM, Bilous RW, Kautzky-Willer A. Accuracy, user acceptability, and safety evaluation for the FreeStyle Libre flash glucose monitoring system when used by pregnant women with diabetes. *Diabetes Technol Ther* 2018;20:180–188
 107. Reddy M, Jugnee N, El Laboudi A, Spanudakis E, Anantharaja S, Oliver N. A randomized controlled pilot study of continuous glucose monitoring and flash glucose monitoring in people with type 1 diabetes and impaired awareness of hypoglycaemia. *Diabet Med* 2018;35:483–490
 108. Szadkowska A, Gawrecki A, Michalak A, Zozulińska-Ziółkiewicz D, Fendler W, Młynarski W. Flash glucose measurements in children with type 1 diabetes in real-life settings: to trust or not to trust? *Diabetes Technol Ther* 2018;20:17–24
 109. Massa GG, Gys I, Op 't Eyndt A, et al. Evaluation of the FreeStyle® Libre flash glucose monitoring system in children and adolescents with type 1 diabetes. *Horm Res Paediatr* 2018;89:189–199
 110. Edge J, Acerini C, Campbell F, et al. An alternative sensor-based method for glucose monitoring in children and young people with diabetes. *Arch Dis Child* 2017;102:543–549
 111. Kamann S, Aerts O, Heinemann L. Further evidence of severe allergic contact dermatitis from isobornyl acrylate while using a continuous glucose monitoring system. *J Diabetes Sci Technol* 2018;12:630–633
 112. Aerts O, Herman A, Bruze M, Goossens A, Mowitz M. FreeStyle Libre: contact irritation versus contact allergy. *Lancet* 2017;390:1644
 113. Herman A, Aerts O, Baeck M, et al. Allergic contact dermatitis caused by isobornyl acrylate in Freestyle® Libre, a newly introduced glucose sensor. *Contact Dermat* 2017;77:367–373
 114. Norwegian Institute of Public Health. FreeStyle Libre flash glucose self-monitoring system: a single-technology assessment [Internet], 2017. Available from <http://www.fhi.no/en/publ/2017/freestyle-libre-systemet-for-egenmaling-av-blodsukker-en-hurtigmatodevurder/>. Accessed 22 October 2018
 115. Palylyk-Colwell E, Ford C. Flash glucose monitoring system for diabetes. In *CADTH Issues in Emerging Health Technologies*. Ottawa, ON, Canadian Agency for Drugs and Technologies in Health, 2016 [Internet]. Available from <http://www.ncbi.nlm.nih.gov/books/NBK476439/>. Accessed 22 October 2018
 116. Leelarathna L, Wilmut EG. Flash forward: a review of flash glucose monitoring. *Diabet Med* 2018;35:472–482
 117. Sherr JL, Cengiz E, Palerm CC, et al. Reduced hypoglycemia and increased time in target using closed-loop insulin delivery during nights with or without antecedent afternoon exercise in type 1 diabetes. *Diabetes Care* 2013;36:2909–2914
 118. Troncone A, Bonfanti R, Iafusco D, et al. Evaluating the experience of children with type 1 diabetes and their parents taking part in an artificial pancreas clinical trial over multiple days in a diabetes camp setting. *Diabetes Care* 2016;39:2158–2164
 119. Barnard KD, Wysocki T, Allen JM, et al. Closing the loop overnight at home setting: psychosocial impact for adolescents with type 1 diabetes and their parents. *BMJ Open Diabetes Res Care* 2014;2:e000025
 120. Barnard KD, Wysocki T, Thabit H, et al.; Angela Consortium. Psychosocial aspects of closed- and open-loop insulin delivery: closing the loop in adults with type 1 diabetes in the home setting. *Diabet Med* 2015;32:601–608
 121. Weissberg-Benchell J, Hessler D, Polonsky WH, Fisher L. Psychosocial impact of the bionic pancreas during summer camp. *J Diabetes Sci Technol* 2016;10:840–844
 122. Bergenstal RM, Garg S, Weinzimer SA, et al. Safety of a hybrid closed-loop insulin delivery system in patients with type 1 diabetes. *JAMA* 2016;316:1407–1408
 123. Garg SK, Weinzimer SA, Tamborlane WV, et al. Glucose outcomes with the in-home use of a hybrid closed-loop insulin delivery system in adolescents and adults with type 1 diabetes. *Diabetes Technol Ther* 2017;19:155–163
 124. Tauschmann M, Thabit H, Bally L, et al. Closed-loop insulin delivery in suboptimally controlled type 1 diabetes: a multicentre, 12-week randomised trial. *Lancet* 2018;392:1321–1329
 125. U.S. Food and Drug Administration. Self-monitoring blood glucose test systems for over-the-counter use: guidance for industry and Food and Drug Administration staff [Internet]. Available from <https://www.fda.gov/downloads/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/UCM380327.pdf>. Accessed 14 November 2018
 126. U.S. Food and Drug Administration. Blood glucose monitoring test systems for prescription point-of-care use: guidance for industry and Food and Drug Administration staff [Internet]. Available from <https://www.fda.gov/downloads/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/UCM380325.pdf>. Accessed 14 November 2018
 127. International Standards Organization. ISO 15197:2013 [Internet]. Available from <https://www.iso.org/standard/54976.html>. Accessed 14 November 2018
 128. Parkes JL, Slatin SL, Pardo S, Ginsberg BH. A new consensus error grid to evaluate the clinical significance of inaccuracies in the measurement of blood glucose. *Diabetes Care* 2000;23:1143–1148

8. Obesity Management for the Treatment of Type 2 Diabetes: *Standards of Medical Care in Diabetes—2019*

American Diabetes Association

Diabetes Care 2019;42(Suppl. 1):S81–S89 | <https://doi.org/10.2337/dc19-S008>

The American Diabetes Association (ADA) “Standards of Medical Care in Diabetes” includes ADA’s current clinical practice recommendations and is intended to provide the components of diabetes care, general treatment goals and guidelines, and tools to evaluate quality of care. Members of the ADA Professional Practice Committee, a multidisciplinary expert committee, are responsible for updating the Standards of Care annually, or more frequently as warranted. For a detailed description of ADA standards, statements, and reports, as well as the evidence-grading system for ADA’s clinical practice recommendations, please refer to the Standards of Care Introduction. Readers who wish to comment on the Standards of Care are invited to do so at professional.diabetes.org/SOC.

There is strong and consistent evidence that obesity management can delay the progression from prediabetes to type 2 diabetes (1–5) and is beneficial in the treatment of type 2 diabetes (6–17). In patients with type 2 diabetes who are overweight or obese, modest and sustained weight loss has been shown to improve glycemic control and to reduce the need for glucose-lowering medications (6–8). Small studies have demonstrated that in patients with type 2 diabetes and obesity, more extreme dietary energy restriction with very low-calorie diets can reduce A1C to <6.5% (48 mmol/mol) and fasting glucose to <126 mg/dL (7.0 mmol/L) in the absence of pharmacologic therapy or ongoing procedures (10,18,19). Weight loss–induced improvements in glycemia are most likely to occur early in the natural history of type 2 diabetes when obesity-associated insulin resistance has caused reversible β -cell dysfunction but insulin secretory capacity remains relatively preserved (8,11,19,20). The goal of this section is to provide evidence-based recommendations for weight-loss therapy, including diet, behavioral, pharmacologic, and surgical interventions, for obesity management as treatment for hyperglycemia in type 2 diabetes.

ASSESSMENT

Recommendation

8.1 At each patient encounter, BMI should be calculated and documented in the medical record. **B**

At each routine patient encounter, BMI should be calculated as weight divided by height squared (kg/m^2) (21). BMI should be classified to determine the presence of overweight or obesity, discussed with the patient, and documented in the patient

Suggested citation: American Diabetes Association. 8. Obesity management for the treatment of type 2 diabetes: Standards of Medical Care in Diabetes—2019. Diabetes Care 2019;42(Suppl. 1): S81–S89

© 2018 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. More information is available at <http://www.diabetesjournals.org/content/license>.

record. In Asian Americans, the BMI cutoff points to define overweight and obesity are lower than in other populations (Table 8.1) (22,23). Providers should advise patients who are overweight or obese that, in general, higher BMIs increase the risk of cardiovascular disease and all-cause mortality. Providers should assess each patient’s readiness to achieve weight loss and jointly determine weight-loss goals and intervention strategies. Strategies may include diet, physical activity, behavioral therapy, pharmacologic therapy, and metabolic surgery (Table 8.1). The latter two strategies may be prescribed for carefully selected patients as adjuncts to diet, physical activity, and behavioral therapy.

DIET, PHYSICAL ACTIVITY, AND BEHAVIORAL THERAPY

Recommendations

- 8.2** Diet, physical activity, and behavioral therapy designed to achieve and maintain >5% weight loss should be prescribed for patients with type 2 diabetes who are overweight or obese and ready to achieve weight loss. **A**
- 8.3** Such interventions should be high intensity (≥16 sessions in 6 months) and focus on diet, physical activity, and behavioral strategies to achieve a 500–750 kcal/day energy deficit. **A**
- 8.4** Diets should be individualized, as those that provide the same caloric restriction but differ in protein, carbohydrate, and fat content are equally effective in achieving weight loss. **A**
- 8.5** For patients who achieve short-term weight-loss goals, long-term (≥1 year) comprehensive weight-maintenance programs should be prescribed. Such programs

should provide at least monthly contact and encourage ongoing monitoring of body weight (weekly or more frequently) and/or other self-monitoring strategies, such as tracking intake, steps, etc.; continued consumption of a reduced-calorie diet; and participation in high levels of physical activity (200–300 min/week). **A**

8.6 To achieve weight loss of >5%, short-term (3-month) interventions that use very low-calorie diets (≤800 kcal/day) and total meal replacements may be prescribed for carefully selected patients by trained practitioners in medical care settings with close medical monitoring. To maintain weight loss, such programs must incorporate long-term comprehensive weight-maintenance counseling. **B**

Among patients with type 2 diabetes who are overweight or obese and have inadequate glycemic, blood pressure, and lipid control and/or other obesity-related medical conditions, lifestyle changes that result in modest and sustained weight loss produce clinically meaningful reductions in blood glucose, A1C, and triglycerides (6–8). Greater weight loss produces even greater benefits, including reductions in blood pressure, improvements in LDL and HDL cholesterol, and reductions in the need for medications to control blood glucose, blood pressure, and lipids (6–8,24), and may result in achievement of glycemic goals in the absence of antihyperglycemia agent use in some patients (25).

Look AHEAD Trial

Although the Action for Health in Diabetes (Look AHEAD) trial did not show that an intensive lifestyle intervention

reduced cardiovascular events in adults with type 2 diabetes who were overweight or obese (26), it did show the feasibility of achieving and maintaining long-term weight loss in patients with type 2 diabetes. In the Look AHEAD intensive lifestyle intervention group, mean weight loss was 4.7% at 8 years (27). Approximately 50% of intensive lifestyle intervention participants lost and maintained ≥5% and 27% lost and maintained ≥10% of their initial body weight at 8 years (27). Participants randomly assigned to the intensive lifestyle group achieved equivalent risk factor control but required fewer glucose-, blood pressure-, and lipid-lowering medications than those randomly assigned to standard care. Secondary analyses of the Look AHEAD trial and other large cardiovascular outcome studies document other benefits of weight loss in patients with type 2 diabetes, including improvements in mobility, physical and sexual function, and health-related quality of life (28). A post hoc analysis of the Look AHEAD study suggests that heterogeneous treatment effects may have been present. Participants who had moderately or poorly controlled diabetes (A1C ≥6.8% [51 mmol/mol]) as well as both those with well-controlled diabetes (A1C <6.8% [51 mmol/mol]) and good self-reported health were found to have significantly reduced cardiovascular events with intensive lifestyle intervention during follow-up (29).

Lifestyle Interventions

Significant weight loss can be attained with lifestyle programs that achieve a 500–750 kcal/day energy deficit, which in most cases is approximately 1,200–1,500 kcal/day for women and 1,500–1,800 kcal/day for men, adjusted for the individual’s baseline body weight. Weight loss of 3–5% is the minimum

Table 8.1—Treatment options for overweight and obesity in type 2 diabetes

Treatment	BMI category (kg/m ²)			
	25.0–26.9 (or 23.0–26.9*)	27.0–29.9	30.0–34.9 (or 27.5–32.4*)	35.0–39.9 (or 32.5–37.4*)
Diet, physical activity, and behavioral therapy	†	†	†	†
Pharmacotherapy		†	†	†
Metabolic surgery			†	†

*Cutoff points for Asian American individuals. †Treatment may be indicated for selected motivated patients.

necessary for any clinical benefit (21,30). However, weight-loss benefits are progressive; more intensive weight-loss goals (>5%, >7%, >15%, etc.) may be pursued if needed to achieve a healthy weight and if they can be feasibly and safely attained.

These diets may differ in the types of foods they restrict (such as high-fat or high-carbohydrate foods) but are effective if they create the necessary energy deficit (21,31–33). Use of meal replacement plans prescribed by trained practitioners, with close patient monitoring, can be beneficial. Within the intensive lifestyle intervention group of the Look AHEAD trial, for example, use of a partial meal replacement plan was associated with improvements in diet quality (34). The diet choice should be based on the patient's health status and preferences.

Intensive behavioral lifestyle interventions should include ≥ 16 sessions in 6 months and focus on diet, physical activity, and behavioral strategies to achieve an ~ 500 – 750 kcal/day energy deficit. Interventions should be provided by trained interventionists in either individual or group sessions (30).

Patients with type 2 diabetes who are overweight or obese and have lost weight during the 6-month intensive behavioral lifestyle intervention should be enrolled in long-term (≥ 1 year) comprehensive weight-loss maintenance programs that provide at least monthly contact with a trained interventionist and focus on ongoing monitoring of body weight (weekly or more frequently) and/or other self-monitoring strategies such as tracking intake, steps, etc.; continued consumption of a reduced-calorie diet; and participation in high levels of physical activity (200–300 min/week (35)). Some commercial and proprietary weight-loss programs have shown promising weight-loss results (36).

When provided by trained practitioners in medical care settings with close medical monitoring, short-term (3-month) interventions that use very low-calorie diets (defined as ≤ 800 kcal/day) and total meal replacements may achieve greater short-term weight loss (10%–15%) than intensive behavioral lifestyle interventions that typically achieve 5% weight loss. However, weight regain following the cessation of very low-calorie diets is greater than following

intensive behavioral lifestyle interventions unless a long-term comprehensive weight-loss maintenance program is provided (37,38).

PHARMACOTHERAPY

Recommendations

- 8.7** When choosing glucose-lowering medications for overweight or obese patients with type 2 diabetes, consider their effect on weight. **E**
- 8.8** Whenever possible, minimize medications for comorbid conditions that are associated with weight gain. **E**
- 8.9** Weight-loss medications are effective as adjuncts to diet, physical activity, and behavioral counseling for selected patients with type 2 diabetes and BMI ≥ 27 kg/m². Potential benefits must be weighed against the potential risks of the medications. **A**
- 8.10** If a patient's response to weight-loss medications is $< 5\%$ weight loss after 3 months or if there are significant safety or tolerability issues at any time, the medication should be discontinued and alternative medications or treatment approaches should be considered. **A**

Antihyperglycemia Therapy

Agents associated with varying degrees of weight loss include metformin, α -glucosidase inhibitors, sodium–glucose cotransporter 2 inhibitors, glucagon-like peptide 1 receptor agonists, and amylin mimetics. Dipeptidyl peptidase 4 inhibitors are weight neutral. Unlike these agents, insulin secretagogues, thiazolidinediones, and insulin often cause weight gain (see Section 9 “Pharmacologic Approaches to Glycemic Treatment”).

A recent meta-analysis of 227 randomized controlled trials of antihyperglycemia treatments in type 2 diabetes found that A1C changes were not associated with baseline BMI, indicating that patients with obesity can benefit from the same types of treatments for diabetes as normal-weight patients (39).

Concomitant Medications

Providers should carefully review the patient's concomitant medications and, whenever possible, minimize or provide

alternatives for medications that promote weight gain. Medications associated with weight gain include antipsychotics (e.g., clozapine, olanzapine, risperidone, etc.) and antidepressants (e.g., tricyclic antidepressants, selective serotonin reuptake inhibitors), glucocorticoids, injectable progestins, anticonvulsants including gabapentin, and possibly sedating antihistamines and anticholinergics (40).

Approved Weight-Loss Medications

The U.S. Food and Drug Administration (FDA) has approved medications for both short-term and long-term weight management as adjuncts to diet, exercise, and behavioral therapy. Nearly all FDA-approved medications for weight loss have been shown to improve glycemic control in patients with type 2 diabetes and delay progression to type 2 diabetes in patients at risk (41). Phentermine is indicated as short-term (≤ 12 weeks) treatment (42). Five weight-loss medications (or combination medications) are FDA-approved for long-term use (more than a few weeks) by patients with BMI ≥ 27 kg/m² with one or more obesity-associated comorbid conditions (e.g., type 2 diabetes, hypertension, and dyslipidemia) who are motivated to lose weight (41). Medications approved by the FDA for the treatment of obesity and their advantages and disadvantages are summarized in **Table 8.2**. The rationale for weight-loss medications is to help patients to more consistently adhere to low-calorie diets and to reinforce lifestyle changes. Providers should be knowledgeable about the product label and should balance the potential benefits of successful weight loss against the potential risks of the medication for each patient. These medications are contraindicated in women who are pregnant or actively trying to conceive. Women of reproductive potential must be counseled regarding the use of reliable methods of contraception.

Assessing Efficacy and Safety

Efficacy and safety should be assessed at least monthly for the first 3 months of treatment. If a patient's response is deemed insufficient (weight loss $< 5\%$) after 3 months or if there are significant safety or tolerability issues at any time, the medication should be discontinued and alternative medications or treatment approaches should be considered.

Table 8.2—Medications approved by the FDA for the treatment of obesity

Medication name	Typical adult maintenance dose	Average wholesale price (30-day supply) (100)	National Average Drug Acquisition Cost (30-day supply) (101)	1-Year (52- or 56-week) mean weight loss (% loss from baseline)		Common side effects (102–107)	Possible safety concerns/considerations (102–107)
				Treatment arm	Weight loss (% loss from baseline)		
Short-term treatment (≤12 weeks)							
Phentermine (108)							
	8–37.5 mg q.d.*	\$5–\$56 (37.5 mg dose)	\$4 (37.5 mg dose)	15 mg q.d.† 7.5 mg q.d.† PBO	6.1 5.5 1.7	Dry mouth, insomnia, dizziness, irritability	<ul style="list-style-type: none"> • Risk of severe hypertension • Contraindicated for use in combination with monoamine oxidase inhibitors
Long-term treatment (>12 weeks)							
Lipase inhibitor							
Orlistat (3)							
	60 mg t.i.d. (OTC) 120 mg t.i.d. (Rx)	\$41–\$82 \$748	\$42 \$556	120 mg t.i.d.‡ PBO	9.6 5.6	Abdominal pain, flatulence, fecal urgency, back pain, headache	<ul style="list-style-type: none"> • Potential malabsorption of fat-soluble vitamins (A, D, E, K) and of certain medications (e.g., cyclosporine, thyroid hormone, anticonvulsants, etc.) • Rare cases of severe liver injury reported • Cholelithiasis • Nephrolithiasis
Selective serotonin (5-HT) 5-HT _{2C} receptor agonist							
Lorcaserin (14)							
	10 mg b.i.d.	\$318	\$255	10 mg b.i.d. PBO	4.5 1.5	Headache, nausea, dizziness, fatigue, nasopharyngitis	<ul style="list-style-type: none"> • Serotonin syndrome— and neuroleptic malignant syndrome—like reactions theoretically possible when coadministered with other serotonergic or antidopaminergic agents • Monitor for depression or suicidal thoughts • Worsening hypertension • Avoid in liver and renal failure
Lorcaserin XR							
	20 mg q.d.	\$318	\$254				
Sympathomimetic amine anorectic/antiepileptic combination							
Phentermine/topiramate ER (109)							
	7.5 mg/46 mg q.d.§	\$223 (7.5 mg/46 mg dose)	\$178 (7.5 mg/46 mg dose)	15 mg/92 mg q.d. 7.5 mg/46 mg q.d. PBO	9.8 7.8 1.2	Constipation, paresthesia, insomnia, nasopharyngitis, xerostomia	<ul style="list-style-type: none"> • Birth defects • Cognitive impairment • Acute angle-closure glaucoma
Opioid antagonist/antidepressant combination							
Naltrexone/bupropion ER (15)							
	8 mg/90 mg, 2 tablets b.i.d.	\$334	\$267	16 mg/ 180 mg b.i.d. PBO	5.0 1.8	Constipation, nausea, headache, xerostomia, insomnia	<ul style="list-style-type: none"> • Contraindicated in patients with uncontrolled hypertension and/or seizure disorders • Contraindicated for use with chronic opioid therapy • Acute angle-closure glaucoma • Black box warning: <ul style="list-style-type: none"> • Risk of suicidal behavior/ideation

Continued on p. S85

Table 8.2—Continued

Medication name	Typical adult maintenance dose	Average wholesale price (30-day supply) (100)	National Average Drug Acquisition Cost (30-day supply) (101)	1-Year (52- or 56-week) mean weight loss (% loss from baseline)		Common side effects (102–107)	Possible safety concerns/considerations (102–107)
				Treatment arm	Weight loss (% loss from baseline)		
Glucagon-like peptide 1 receptor agonist Liraglutide (16)	3 mg q.d.	\$1,441	\$1,154	3.0 mg q.d. 1.8 mg q.d. PBO	6.0 4.7 2.0	Hypoglycemia, constipation, nausea, headache, indigestion	<ul style="list-style-type: none"> • ?Acute pancreatitis • Black box warning: <ul style="list-style-type: none"> • Risk of thyroid C-cell tumors • Contraindicated with personal or family history of MTC or MEN 2

All medications are contraindicated in women who are or may become pregnant. Women of reproductive potential must be counseled regarding the use of reliable methods of contraception. Select safety and side effect information is provided; for a comprehensive discussion of safety considerations, please refer to the prescribing information for each agent. b.i.d., twice daily; ER, extended release; MEN 2, multiple endocrine neoplasia syndrome type 2; MTC, medullary thyroid carcinoma; OTC, over the counter; PBO, placebo; q.d., daily; Rx, prescription; t.i.d., three times daily; XR, extended release. *Use lowest effective dose; maximum appropriate dose is 37.5 mg. †Duration of treatment was 28 weeks in a general obese adult population. ‡Enrolled participants had normal (79%) or impaired (21%) glucose tolerance. §Maximum dose, depending on response, is 15 mg/92 mg q.d. ||Approximately 68% of enrolled participants had type 2 diabetes or impaired glucose tolerance.

MEDICAL DEVICES FOR WEIGHT LOSS

Several minimally invasive medical devices have been recently approved by the FDA for short-term weight loss (43). It remains to be seen how these are used for obesity treatment. Given the high cost, extremely limited insurance coverage, and paucity of data in people with diabetes at this time, these are not considered to be the standard of care for obesity management in people with type 2 diabetes.

METABOLIC SURGERY

Recommendations

- 8.11** Metabolic surgery should be recommended as an option to treat type 2 diabetes in appropriate surgical candidates with BMI ≥ 40 kg/m² (BMI ≥ 37.5 kg/m² in Asian Americans) and in adults with BMI 35.0–39.9 kg/m² (32.5–37.4 kg/m² in Asian Americans) who do not achieve durable weight loss and improvement in comorbidities (including hyperglycemia) with reasonable nonsurgical methods. **A**
- 8.12** Metabolic surgery may be considered as an option for adults with type 2 diabetes and BMI 30.0–34.9 kg/m² (27.5–32.4 kg/m² in Asian Americans) who do not achieve durable weight loss and improvement in comorbidities (including hyperglycemia) with reasonable nonsurgical methods. **A**
- 8.13** Metabolic surgery should be performed in high-volume centers with multidisciplinary teams that understand and are experienced in the management of diabetes and gastrointestinal surgery. **C**
- 8.14** Long-term lifestyle support and routine monitoring of micronutrient and nutritional status must be provided to patients after surgery, according to guidelines for postoperative management of metabolic surgery by national and international professional societies. **C**
- 8.15** People presenting for metabolic surgery should receive a comprehensive readiness and mental health assessment. **B**

8.16 People who undergo metabolic surgery should be evaluated to assess the need for ongoing mental health services to help them adjust to medical and psychosocial changes after surgery. **C**

Several gastrointestinal (GI) operations including partial gastrectomies and bariatric procedures (35) promote dramatic and durable weight loss and improvement of type 2 diabetes in many patients. Given the magnitude and rapidity of the effect of GI surgery on hyperglycemia and experimental evidence that rearrangements of GI anatomy similar to those in some metabolic procedures directly affect glucose homeostasis (36), GI interventions have been suggested as treatments for type 2 diabetes, and in that context they are termed “metabolic surgery.”

A substantial body of evidence has now been accumulated, including data from numerous randomized controlled (nonblinded) clinical trials, demonstrating that metabolic surgery achieves superior glycemic control and reduction of cardiovascular risk factors in patients with type 2 diabetes and obesity compared with various lifestyle/medical interventions (17). Improvements in microvascular complications of diabetes, cardiovascular disease, and cancer have been observed only in nonrandomized observational studies (44–53). Cohort studies attempting to match surgical and nonsurgical subjects suggest that the procedure may reduce longer-term mortality (45).

On the basis of this mounting evidence, several organizations and government agencies have recommended expanding the indications for metabolic surgery to include patients with type 2 diabetes who do not achieve durable weight loss and improvement in comorbidities (including hyperglycemia) with reasonable nonsurgical methods at BMIs as low as 30 kg/m² (27.5 kg/m² for Asian Americans) (54–61). Please refer to “Metabolic Surgery in the Treatment Algorithm for Type 2 Diabetes: A Joint Statement by International Diabetes Organizations” for a thorough review (17).

Randomized controlled trials have documented diabetes remission during postoperative follow-up ranging from

1 to 5 years in 30%–63% of patients with Roux-en-Y gastric bypass (RYGB), which generally leads to greater degrees and lengths of remission compared with other bariatric surgeries (17,62). Available data suggest an erosion of diabetes remission over time (63): 35%–50% or more of patients who initially achieve remission of diabetes eventually experience recurrence. However, the median disease-free period among such individuals following RYGB is 8.3 years (64,65). With or without diabetes relapse, the majority of patients who undergo surgery maintain substantial improvement of glycemic control from baseline for at least 5 (66,67) to 15 (45,46,65,68–70) years.

Exceedingly few presurgical predictors of success have been identified, but younger age, shorter duration of diabetes (e.g., <8 years) (71), nonuse of insulin, maintenance of weight loss, and better glycemic control are consistently associated with higher rates of diabetes remission and/or lower risk of weight regain (45,69,71,72). Greater baseline visceral fat area may also help to predict better postoperative outcomes, especially among Asian American patients with type 2 diabetes, who typically have more visceral fat compared with Caucasians with diabetes of the same BMI (73).

Beyond improving glycemia, metabolic surgery has been shown to confer additional health benefits in randomized controlled trials, including substantial reductions in cardiovascular disease risk factors (17), reductions in incidence of microvascular disease (74), and enhancements in quality of life (66,71,75).

Although metabolic surgery has been shown to improve the metabolic profiles of patients with type 1 diabetes and morbid obesity, establishing the role of metabolic surgery in such patients will require larger and longer studies (76).

Metabolic surgery is more expensive than nonsurgical management strategies, but retrospective analyses and modeling studies suggest that metabolic surgery may be cost-effective or even cost-saving for patients with type 2 diabetes. However, results are largely dependent on assumptions about the long-term effectiveness and safety of the procedures (77,78).

Adverse Effects

The safety of metabolic surgery has improved significantly over the past

two decades, with continued refinement of minimally invasive approaches (laparoscopic surgery), enhanced training and credentialing, and involvement of multidisciplinary teams. Mortality rates with metabolic operations are typically 0.1%–0.5%, similar to cholecystectomy or hysterectomy (79–83). Morbidity has also dramatically declined with laparoscopic approaches. Major complications rates (e.g., venous thromboembolism, need for operative reintervention) are 2%–6%, with other minor complications in up to 15% (79–88), which compare favorably with rates for other commonly performed elective operations (83). Empirical data suggest that proficiency of the operating surgeon is an important factor for determining mortality, complications, reoperations, and readmissions (89).

Longer-term concerns include dumping syndrome (nausea, colic, and diarrhea), vitamin and mineral deficiencies, anemia, osteoporosis, and, rarely (90), severe hypoglycemia. Long-term nutritional and micronutrient deficiencies and related complications occur with variable frequency depending on the type of procedure and require lifelong vitamin/nutritional supplementation (91,92). Postprandial hypoglycemia is most likely to occur with RYGB (92,93). The exact prevalence of symptomatic hypoglycemia is unknown. In one study, it affected 11% of 450 patients who had undergone RYGB or vertical sleeve gastrectomy (90). Patients who undergo metabolic surgery may be at increased risk for substance use, including drug and alcohol use and cigarette smoking. Additional potential risks of metabolic surgery that have been described include worsening or new-onset depression and/or anxiety, need for additional GI surgery, and suicidal ideation (94–97).

People with diabetes presenting for metabolic surgery also have increased rates of depression and other major psychiatric disorders (98). Candidates for metabolic surgery with histories of alcohol, tobacco, or substance abuse; significant depression; suicidal ideation; or other mental health conditions should therefore first be assessed by a mental health professional with expertise in obesity management prior to consideration for surgery (99). Surgery should be postponed in patients with alcohol or

substance abuse disorders, significant depression, suicidal ideation, or other mental health conditions until these conditions have been fully addressed. Individuals with preoperative psychopathology should be assessed regularly following metabolic surgery to optimize mental health management and to ensure psychiatric symptoms do not interfere with weight loss and lifestyle changes.

References

- Knowler WC, Barrett-Connor E, Fowler SE, et al.; Diabetes Prevention Program Research Group. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med* 2002;346:393–403
- Garvey WT, Ryan DH, Henry R, et al. Prevention of type 2 diabetes in subjects with prediabetes and metabolic syndrome treated with phentermine and topiramate extended release. *Diabetes Care* 2014;37:912–921
- Torgerson JS, Hauptman J, Boldrin MN, Sjörström L. XENical in the prevention of Diabetes in Obese Subjects (XENDOS) study: a randomized study of orlistat as an adjunct to lifestyle changes for the prevention of type 2 diabetes in obese patients. *Diabetes Care* 2004;27:155–161
- le Roux CW, Astrup A, Fujioka K, et al.; SCALE Obesity Prediabetes NN8022-1839 Study Group. 3 years of liraglutide versus placebo for type 2 diabetes risk reduction and weight management in individuals with prediabetes: a randomised, double-blind trial. *Lancet* 2017;389:1399–1409
- Booth H, Khan O, Prevost T, et al. Incidence of type 2 diabetes after bariatric surgery: population-based matched cohort study. *Lancet Diabetes Endocrinol* 2014;2:963–968
- UKPDS Group. UK Prospective Diabetes Study 7: response of fasting plasma glucose to diet therapy in newly presenting type II diabetic patients. *Metabolism* 1990;39:905–912
- Goldstein DJ. Beneficial health effects of modest weight loss. *Int J Obes Relat Metab Disord* 1992;16:397–415
- Pastors JG, Warshaw H, Daly A, Franz M, Kulkarni K. The evidence for the effectiveness of medical nutrition therapy in diabetes management. *Diabetes Care* 2002;25:608–613
- Lim EL, Hollingsworth KG, Aribisala BS, Chen MJ, Mathers JC, Taylor R. Reversal of type 2 diabetes: normalisation of beta cell function in association with decreased pancreas and liver triacylglycerol. *Diabetologia* 2011;54:2506–2514
- Jackness C, Karmally W, Febres G, et al. Very low-calorie diet mimics the early beneficial effect of Roux-en-Y gastric bypass on insulin sensitivity and β -cell function in type 2 diabetic patients. *Diabetes* 2013;62:3027–3032
- Rothberg AE, McEwen LN, Kraftson AT, Fowler CE, Herman WH. Very-low-energy diet for type 2 diabetes: an underutilized therapy? *J Diabetes Complications* 2014;28:506–510
- Hollander PA, Elbein SC, Hirsch IB, et al. Role of orlistat in the treatment of obese patients with type 2 diabetes: a 1-year randomized double-blind study. *Diabetes Care* 1998;21:1288–1294
- Garvey WT, Ryan DH, Bohannon NJV, et al. Weight-loss therapy in type 2 diabetes: effects of phentermine and topiramate extended release. *Diabetes Care* 2014;37:3309–3316
- O'Neil PM, Smith SR, Weissman NJ, et al. Randomized placebo-controlled clinical trial of lorcaserin for weight loss in type 2 diabetes mellitus: the BLOOM-DM study. *Obesity (Silver Spring)* 2012;20:1426–1436
- Hollander P, Gupta AK, Plodkowski R, et al.; COR-Diabetes Study Group. Effects of naltrexone sustained-release/bupropion sustained-release combination therapy on body weight and glycemic parameters in overweight and obese patients with type 2 diabetes. *Diabetes Care* 2013;36:4022–4029
- Davies MJ, Bergenstal R, Bode B, et al.; NN8022-1922 Study Group. Efficacy of liraglutide for weight loss among patients with type 2 diabetes: the SCALE diabetes randomized clinical trial. *JAMA* 2015;314:687–699
- Rubino F, Nathan DM, Eckel RH, et al.; Delegates of the 2nd Diabetes Surgery Summit. Metabolic surgery in the treatment algorithm for type 2 diabetes: a joint statement by international diabetes organizations. *Diabetes Care* 2016;39:861–877
- Day JW, Ottaway N, Patterson JT, et al. A new glucagon and GLP-1 co-agonist eliminates obesity in rodents. *Nat Chem Biol* 2009;5:749–757
- Steven S, Hollingsworth KG, Al-Mrabeh A, et al. Very low-calorie diet and 6 months of weight stability in type 2 diabetes: pathophysiological changes in responders and nonresponders. *Diabetes Care* 2016;39:808–815
- Schauer PR, Mingrone G, Ikramuddin S, Wolfe B. Clinical outcomes of metabolic surgery: efficacy of glycemic control, weight loss, and remission of diabetes. *Diabetes Care* 2016;39:902–911
- Jensen MD, Ryan DH, Apovian CM, et al.; American College of Cardiology/American Heart Association Task Force on Practice Guidelines; Obesity Society. 2013 AHA/ACC/TOS guideline for the management of overweight and obesity in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and The Obesity Society. *J Am Coll Cardiol* 2014;63(Suppl. 2):2985–3023
- WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* 2004;363:157–163
- Araneta MR, Grandinetti A, Chang HK. Optimum BMI cut points to screen Asian Americans for type 2 diabetes: the UCSF Filipino Health Study and the North Kohala Study (Abstract). *Diabetes* 2014;63(Suppl. 1):A20
- Rothberg AE, McEwen LN, Kraftson AT, et al. Impact of weight loss on waist circumference and the components of the metabolic syndrome. *BMJ Open Diabetes Res Care* 2017;5:e000341
- Lean ME, Leslie WS, Barnes AC, et al. Primary care-led weight management for remission of type 2 diabetes (DIRECT): an open-label, cluster-randomised trial. *Lancet* 2018;391:541–551
- Wing RR, Bolin P, Brancati FL, et al.; Look AHEAD Research Group. Cardiovascular effects of intensive lifestyle intervention in type 2 diabetes. *N Engl J Med* 2013;369:145–154
- Look AHEAD Research Group. Eight-year weight losses with an intensive lifestyle intervention: the Look AHEAD study. *Obesity (Silver Spring)* 2014;22:5–13
- Wilding JPH. The importance of weight management in type 2 diabetes mellitus. *Int J Clin Pract* 2014;68:682–691
- Baum A, Scarpa J, Bruzelius E, Tamler R, Basu S, Faghmous J. Targeting weight loss interventions to reduce cardiovascular complications of type 2 diabetes: a machine learning-based post-hoc analysis of heterogeneous treatment effects in the Look AHEAD trial. *Lancet Diabetes Endocrinol* 2017;5:808–815
- Franz MJ, Boucher JL, Rutten-Ramos S, VanWormer JJ. Lifestyle weight-loss intervention outcomes in overweight and obese adults with type 2 diabetes: a systematic review and meta-analysis of randomized clinical trials. *J Acad Nutr Diet* 2015;115:1447–1463
- Sacks FM, Bray GA, Carey VJ, et al. Comparison of weight-loss diets with different compositions of fat, protein, and carbohydrates. *N Engl J Med* 2009;360:859–873
- de Souza RJ, Bray GA, Carey VJ, et al. Effects of 4 weight-loss diets differing in fat, protein, and carbohydrate on fat mass, lean mass, visceral adipose tissue, and hepatic fat: results from the POUNDS LOST trial. *Am J Clin Nutr* 2012;95:614–625
- Johnston BC, Kanters S, Bandayrel K, et al. Comparison of weight loss among named diet programs in overweight and obese adults: a meta-analysis. *JAMA* 2014;312:923–933
- Raynor HA, Anderson AM, Miller GD, et al.; Look AHEAD Research Group. Partial meal replacement plan and quality of the diet at 1 year: Action for Health in Diabetes (Look AHEAD) Trial. *J Acad Nutr Diet* 2015;115:731–742
- Donnelly JE, Blair SN, Jakicic JM, Manore MM, Rankin JW, Smith BK; American College of Sports Medicine. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. *Med Sci Sports Exerc* 2009;41:459–471
- Gudzune KA, Doshi RS, Mehta AK, et al. Efficacy of commercial weight-loss programs: an updated systematic review. *Ann Intern Med* 2015;162:501–512
- Tsai AG, Wadden TA. The evolution of very-low-calorie diets: an update and meta-analysis. *Obesity (Silver Spring)* 2006;14:1283–1293
- Johansson K, Neovius M, Hemmingsson E. Effects of anti-obesity drugs, diet, and exercise on weight-loss maintenance after a very-low-calorie diet or low-calorie diet: a systematic review and meta-analysis of randomized controlled trials. *Am J Clin Nutr* 2014;99:14–23
- Cai X, Yang W, Gao X, Zhou L, Han X, Ji L. Baseline body mass index and the efficacy of hypoglycemic treatment in type 2 diabetes: a meta-analysis. *PLoS One* 2016;11:e0166625
- Domecq JP, Prutsky G, Leppin A, et al. Clinical review: Drugs commonly associated with weight change: a systematic review and meta-analysis. *J Clin Endocrinol Metab* 2015;100:363–370
- Kahan S, Fujioka K. Obesity pharmacotherapy in patients with type 2 diabetes. *Diabetes Spectr* 2017;30:250–257
- Drugs.com. Phentermine [FDA prescribing information] [Internet]. 2017. Available from: <https://www.drugs.com/pro/phentermine.html>. Accessed 22 September 2017

43. Sullivan S. Endoscopic medical devices for primary obesity treatment in patients with diabetes. *Diabetes Spectr* 2017;30:258–264
44. Sjöström L, Lindroos A-K, Peltonen M, et al.; Swedish Obese Subjects Study Scientific Group. Lifestyle, diabetes, and cardiovascular risk factors 10 years after bariatric surgery. *N Engl J Med* 2004;351:2683–2693
45. Sjöström L, Peltonen M, Jacobson P, et al. Association of bariatric surgery with long-term remission of type 2 diabetes and with microvascular and macrovascular complications. *JAMA* 2014;311:2297–2304
46. Adams TD, Davidson LE, Litwin SE, et al. Health benefits of gastric bypass surgery after 6 years. *JAMA* 2012;308:1122–1131
47. Sjöström L, Narbro K, Sjöström CD, et al.; Swedish Obese Subjects Study. Effects of bariatric surgery on mortality in Swedish obese subjects. *N Engl J Med* 2007;357:741–752
48. Sjöström L, Gummesson A, Sjöström CD, et al.; Swedish Obese Subjects Study. Effects of bariatric surgery on cancer incidence in obese patients in Sweden (Swedish Obese Subjects Study): a prospective, controlled intervention trial. *Lancet Oncol* 2009;10:653–662
49. Sjöström L, Peltonen M, Jacobson P, et al. Bariatric surgery and long-term cardiovascular events. *JAMA* 2012;307:56–65
50. Adams TD, Gress RE, Smith SC, et al. Long-term mortality after gastric bypass surgery. *N Engl J Med* 2007;357:753–761
51. Arterburn DE, Olsen MK, Smith VA, et al. Association between bariatric surgery and long-term survival. *JAMA* 2015;313:62–70
52. Adams TD, Arterburn DE, Nathan DM, Eckel RH. Clinical outcomes of metabolic surgery: microvascular and macrovascular complications. *Diabetes Care* 2016;39:912–923
53. Sheng B, Truong K, Spitler H, Zhang L, Tong X, Chen L. The long-term effects of bariatric surgery on type 2 diabetes remission, microvascular and macrovascular complications, and mortality: a systematic review and meta-analysis. *Obes Surg* 2017;27:2724–2732
54. Rubino F, Kaplan LM, Schauer PR, Cummings DE; Diabetes Surgery Summit Delegates. The Diabetes Surgery Summit consensus conference: recommendations for the evaluation and use of gastrointestinal surgery to treat type 2 diabetes mellitus. *Ann Surg* 2010;251:399–405
55. Cummings DE, Cohen RV. Beyond BMI: the need for new guidelines governing the use of bariatric and metabolic surgery. *Lancet Diabetes Endocrinol* 2014;2:175–181
56. Zimmet P, Alberti KGMM, Rubino F, Dixon JB. IDF's view of bariatric surgery in type 2 diabetes. *Lancet* 2011;378:108–110
57. Kasama K, Mui W, Lee WJ, et al. IFSO-APC consensus statements 2011. *Obes Surg* 2012;22:677–684
58. Wentworth JM, Burton P, Laurie C, Brown WA, O'Brien PE. Five-year outcomes of a randomized trial of gastric band surgery in overweight but not obese people with type 2 diabetes. *Diabetes Care* 2017;40:e44–e45
59. Cummings DE, Arterburn DE, Westbrook EO, et al. Gastric bypass surgery vs intensive lifestyle and medical intervention for type 2 diabetes: the CROSSROADS randomised controlled trial. *Diabetologia* 2016;59:945–953
60. Liang Z, Wu Q, Chen B, Yu P, Zhao H, Ouyang X. Effect of laparoscopic Roux-en-Y gastric bypass surgery on type 2 diabetes mellitus with hypertension: a randomized controlled trial. *Diabetes Res Clin Pract* 2013;101:50–56
61. Aminian A, Chang J, Brethauer SA, Kim JJ; American Society for Metabolic and Bariatric Surgery Clinical Issues Committee. ASMBS updated position statement on bariatric surgery in class I obesity (BMI 30–35 kg/m²). *Surg Obes Relat Dis* 2018;14:1071–1087
62. Isaman DJM, Rothberg AE, Herman WH. Reconciliation of type 2 diabetes remission rates in studies of Roux-en-Y gastric bypass. *Diabetes Care* 2016;39:2247–2253
63. Ikramuddin S, Korner J, Lee W-J, et al. Durability of addition of Roux-en-Y gastric bypass to lifestyle intervention and medical management in achieving primary treatment goals for uncontrolled type 2 diabetes in mild to moderate obesity: a randomized control trial. *Diabetes Care* 2016;39:1510–1518
64. Sjöholm K, Pajunen P, Jacobson P, et al. Incidence and remission of type 2 diabetes in relation to degree of obesity at baseline and 2 year weight change: the Swedish Obese Subjects (SOS) study. *Diabetologia* 2015;58:1448–1453
65. Arterburn DE, Bogart A, Sherwood NE, et al. A multisite study of long-term remission and relapse of type 2 diabetes mellitus following gastric bypass. *Obes Surg* 2013;23:93–102
66. Mingrone G, Panunzi S, De Gaetano A, et al. Bariatric-metabolic surgery versus conventional medical treatment in obese patients with type 2 diabetes: 5 year follow-up of an open-label, single-centre, randomised controlled trial. *Lancet* 2015;386:964–973
67. Schauer PR, Bhatt DL, Kirwan JP, et al.; STAMPEDE Investigators. Bariatric surgery versus intensive medical therapy for diabetes—5-year outcomes. *N Engl J Med* 2017;376:641–651
68. Cohen RV, Pinheiro JC, Schiavon CA, Salles JE, Wajchenberg BL, Cummings DE. Effects of gastric bypass surgery in patients with type 2 diabetes and only mild obesity. *Diabetes Care* 2012;35:1420–1428
69. Brethauer SA, Aminian A, Romero-Talamás H, et al. Can diabetes be surgically cured? Long-term metabolic effects of bariatric surgery in obese patients with type 2 diabetes mellitus. *Ann Surg* 2013;258:628–636; discussion 636–637
70. Hsu C-C, Almulaifi A, Chen J-C, et al. Effect of bariatric surgery vs medical treatment on type 2 diabetes in patients with body mass index lower than 35: five-year outcomes. *JAMA Surg* 2015;150:1117–1124
71. Schauer PR, Bhatt DL, Kirwan JP, et al.; STAMPEDE Investigators. Bariatric surgery versus intensive medical therapy for diabetes—3-year outcomes. *N Engl J Med* 2014;370:2002–2013
72. Hariri K, Guevara D, Jayaram A, Kini SU, Herron DM, Fernandez-Ranvier G. Preoperative insulin therapy as a marker for type 2 diabetes remission in obese patients after bariatric surgery. *Surg Obes Relat Dis* 2018;14:332–337
73. Yu H, Di J, Bao Y, et al. Visceral fat area as a new predictor of short-term diabetes remission after Roux-en-Y gastric bypass surgery in Chinese patients with a body mass index less than 35 kg/m². *Surg Obes Relat Dis* 2015;11:6–11
74. O'Brien R, Johnson E, Haneuse S, et al. Microvascular outcomes in patients with diabetes after bariatric surgery versus usual care: a matched cohort study. *Ann Intern Med* 2018;169:300–310
75. Halperin F, Ding S-A, Simonson DC, et al. Roux-en-Y gastric bypass surgery or lifestyle with intensive medical management in patients with type 2 diabetes: feasibility and 1-year results of a randomized clinical trial. *JAMA Surg* 2014;149:716–726
76. Kirwan JP, Aminian A, Kashyap SR, Burguera B, Brethauer SA, Schauer PR. Bariatric surgery in obese patients with type 1 diabetes. *Diabetes Care* 2016;39:941–948
77. Rubin JK, Hinrichs-Krapels S, Hesketh R, Martin A, Herman WH, Rubino F. Identifying barriers to appropriate use of metabolic/bariatric surgery for type 2 diabetes treatment: Policy Lab results. *Diabetes Care* 2016;39:954–963
78. Fouse T, Schauer P. The socioeconomic impact of morbid obesity and factors affecting access to obesity surgery. *Surg Clin North Am* 2016;96:669–679
79. Flum DR, Belle SH, King WC, et al.; Longitudinal Assessment of Bariatric Surgery (LABS) Consortium. Perioperative safety in the longitudinal assessment of bariatric surgery. *N Engl J Med* 2009;361:445–454
80. Courcoulas AP, Christian NJ, Belle SH, et al.; Longitudinal Assessment of Bariatric Surgery (LABS) Consortium. Weight change and health outcomes at 3 years after bariatric surgery among individuals with severe obesity. *JAMA* 2013;310:2416–2425
81. Arterburn DE, Courcoulas AP. Bariatric surgery for obesity and metabolic conditions in adults. *BMJ* 2014;349:g3961
82. Young MT, Gebhart A, Phelan MJ, Nguyen NT. Use and outcomes of laparoscopic sleeve gastrectomy vs laparoscopic gastric bypass: analysis of the American College of Surgeons NSQIP. *J Am Coll Surg* 2015;220:880–885
83. Aminian A, Brethauer SA, Kirwan JP, Kashyap SR, Burguera B, Schauer PR. How safe is metabolic/diabetes surgery? *Diabetes Obes Metab* 2015;17:198–201
84. Birkmeyer NJO, Dimick JB, Share D, et al.; Michigan Bariatric Surgery Collaborative. Hospital complication rates with bariatric surgery in Michigan. *JAMA* 2010;304:435–442
85. Altieri MS, Yang J, Telem DA, et al. Lap band outcomes from 19,221 patients across centers and over a decade within the state of New York. *Surg Endosc* 2016;30:1725–1732
86. Hutter MM, Schirmer BD, Jones DB, et al. First report from the American College of Surgeons Bariatric Surgery Center Network: laparoscopic sleeve gastrectomy has morbidity and effectiveness positioned between the band and the bypass. *Ann Surg* 2011;254:410–420; discussion 420–422
87. Nguyen NT, Slone JA, Nguyen X-MT, Hartman JS, Hoyt DB. A prospective randomized trial of laparoscopic gastric bypass versus laparoscopic adjustable gastric banding for the treatment of morbid obesity: outcomes, quality of life, and costs. *Ann Surg* 2009;250:631–641

88. Courcoulas AP, King WC, Belle SH, et al. Seven-year weight trajectories and health outcomes in the Longitudinal Assessment of Bariatric Surgery (LABS) Study. *JAMA Surg* 2018;153:427–434
89. Birkmeyer JD, Finks JF, O'Reilly A, et al.; Michigan Bariatric Surgery Collaborative. Surgical skill and complication rates after bariatric surgery. *N Engl J Med* 2013;369:1434–1442
90. Service FJ, Thompson GB, Service FJ, Andrews JC, Collazo-Clavell ML, Lloyd RV. Hyperinsulinemic hypoglycemia with nesidioblastosis after gastric-bypass surgery. *N Engl J Med* 2005;353:249–254
91. Mechanick JL, Kushner RF, Sugerman HJ, et al.; American Association of Clinical Endocrinologists; Obesity Society; American Society for Metabolic & Bariatric Surgery. American Association of Clinical Endocrinologists, The Obesity Society, and American Society for Metabolic & Bariatric Surgery medical guidelines for clinical practice for the perioperative nutritional, metabolic, and nonsurgical support of the bariatric surgery patient. *Obesity (Silver Spring)* 2009;17 (Suppl. 1):S1–S70
92. Mechanick JL, Youdim A, Jones DB, et al.; American Association of Clinical Endocrinologists; Obesity Society; American Society for Metabolic & Bariatric Surgery. Clinical practice guidelines for the perioperative nutritional, metabolic, and nonsurgical support of the bariatric surgery patient—2013 update: cosponsored by American Association of Clinical Endocrinologists, The Obesity Society, and American Society for Metabolic & Bariatric Surgery. *Obesity (Silver Spring)* 2013;21(Suppl. 1):S1–S27
93. Lee CJ, Clark JM, Schweitzer M, et al. Prevalence of and risk factors for hypoglycemic symptoms after gastric bypass and sleeve gastrectomy. *Obesity (Silver Spring)* 2015;23:1079–1084
94. Conason A, Teixeira J, Hsu C-H, Puma L, Knafo D, Geliebter A. Substance use following bariatric weight loss surgery. *JAMA Surg* 2013;148:145–150
95. Bhatti JA, Nathens AB, Thiruchelvam D, Grantcharov T, Goldstein BI, Redelmeier DA. Self-harm emergencies after bariatric surgery: a population-based cohort study. *JAMA Surg* 2016;151:226–232
96. Peterhänzel C, Petroff D, Klinitzke G, Kersting A, Wagner B. Risk of completed suicide after bariatric surgery: a systematic review. *Obes Rev* 2013;14:369–382
97. Jakobsen GS, Småstuen MC, Sandbu R, Nordstrand N, Hofsø D, Lindberg M, et al. Association of bariatric surgery vs medical obesity treatment with long-term medical complications and obesity-related comorbidities. *JAMA* 2018;319:291–301
98. Young-Hyman D, Peyrot M. *Psychosocial Care for People with Diabetes*. Alexandria, VA, American Diabetes Association, 2012
99. Greenberg I, Sogg S, M Perna F. Behavioral and psychological care in weight loss surgery: best practice update. *Obesity (Silver Spring)* 2009;17:880–884
100. Truven Health Analytics. Introduction to RED BOOK Online [Internet], 2013. Available from http://www.micromedexsolutions.com/micromedex2/4.34.0/WebHelp/RED_BOOK/Introduction_to_REDB_BOOK_Online.htm. Accessed 5 September 2018
101. Data.Medicaid.gov. NADAC (National Average Drug Acquisition Cost) [Internet], 2018. Available from <https://data.medicaid.gov/Drug-Pricing-and-Payment/NADAC-National-Average-Drug-Acquisition-Cost-/a4y5-998d>. Accessed 5 September 2018
102. U.S. National Library of Medicine. Phentermine - phentermine hydrochloride capsule [Internet], 2017. Available from <https://dailymed.nlm.nih.gov/dailymed/drugInfo.cfm?setid=737eef3b-9a6b-4ab3-a25c-49d84d2a0197>. Accessed 12 September 2018
103. Nalpropion Pharmaceuticals. Contrave (naltrexone HCl/bupropion HCl) extended-release tablets [prescribing information] [Internet], 2018. Available from <https://contrave.com>. Accessed 12 September 2018
104. CHEPLAPHARM, H2-Pharma. Xenical (orlistat) capsules [prescribing information] [Internet]. Available from <https://xenical.com>. Accessed 12 September 2018
105. Eisai Inc. Belviq (lorcaserin HCl) tablets [prescribing information] [Internet], 2016. Available from <https://www.belviq.com>. Accessed 12 September 2018
106. VIVUS, Inc. Qsymia (phentermine and topiramate extended-release) capsules [prescribing information] [Internet], 2018. Available from <https://qsymia.com>. Accessed 12 September 2018
107. Novo Nordisk Inc. Saxenda (liraglutide) injection [prescribing information] [Internet], 2018. Available from <https://www.saxenda.com>. Accessed 12 September 2018
108. Aronne LJ, Wadden TA, Peterson C, Winslow D, Odeh S, Gadde KM. Evaluation of phentermine and topiramate versus phentermine/topiramate extended-release in obese adults. *Obesity (Silver Spring)* 2013;21:2163–2171
109. Gadde KM, Allison DB, Ryan DH, et al. Effects of low-dose, controlled-release, phentermine plus topiramate combination on weight and associated comorbidities in overweight and obese adults (CONQUER): a randomised, placebo-controlled, phase 3 trial. *Lancet* 2011;377:1341–1352



9. Pharmacologic Approaches to Glycemic Treatment: Standards of Medical Care in Diabetes—2019

American Diabetes Association

Diabetes Care 2019;42(Suppl. 1):S90–S102 | <https://doi.org/10.2337/dc19-S009>

The American Diabetes Association (ADA) “Standards of Medical Care in Diabetes” includes ADA’s current clinical practice recommendations and is intended to provide the components of diabetes care, general treatment goals and guidelines, and tools to evaluate quality of care. Members of the ADA Professional Practice Committee, a multidisciplinary expert committee, are responsible for updating the Standards of Care annually, or more frequently as warranted. For a detailed description of ADA standards, statements, and reports, as well as the evidence-grading system for ADA’s clinical practice recommendations, please refer to the Standards of Care Introduction. Readers who wish to comment on the Standards of Care are invited to do so at professional.diabetes.org/SOC.

PHARMACOLOGIC THERAPY FOR TYPE 1 DIABETES

Recommendations

- 9.1 Most people with type 1 diabetes should be treated with multiple daily injections of prandial and basal insulin, or continuous subcutaneous insulin infusion. **A**
- 9.2 Most individuals with type 1 diabetes should use rapid-acting insulin analogs to reduce hypoglycemia risk. **A**
- 9.3 Consider educating individuals with type 1 diabetes on matching prandial insulin doses to carbohydrate intake, premeal blood glucose levels, and anticipated physical activity. **E**
- 9.4 Individuals with type 1 diabetes who have been successfully using continuous subcutaneous insulin infusion should have continued access to this therapy after they turn 65 years of age. **E**

Insulin Therapy

Because the hallmark of type 1 diabetes is absent or near-absent β -cell function, insulin treatment is essential for individuals with type 1 diabetes. Insufficient provision of insulin causes not only hyperglycemia but also systematic metabolic disturbances like hypertriglyceridemia and ketoacidosis, as well as tissue catabolism. Over the past three decades, evidence has accumulated supporting multiple daily injections of insulin or continuous subcutaneous administration through an insulin pump as providing the best combination of effectiveness and safety for people with type 1 diabetes.

Generally, insulin requirements can be estimated based on weight, with typical doses ranging from 0.4 to 1.0 units/kg/day. Higher amounts are required during puberty, pregnancy, and medical illness. The American Diabetes Association/JDRF

Suggested citation: American Diabetes Association. 9. Pharmacologic approaches to glycemic treatment: Standards of Medical Care in Diabetes—2019. Diabetes Care 2019;42(Suppl. 1):S90–S102

© 2018 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. More information is available at <http://www.diabetesjournals.org/content/license>.

Type 1 Diabetes Sourcebook notes 0.5 units/kg/day as a typical starting dose in patients with type 1 diabetes who are metabolically stable, with half administered as prandial insulin given to control blood glucose after meals and the other half as basal insulin to control glycemia in the periods between meal absorption (1); this guideline provides detailed information on intensification of therapy to meet individualized needs. In addition, the American Diabetes Association position statement “Type 1 Diabetes Management Through the Life Span” provides a thorough overview of type 1 diabetes treatment (2).

Physiologic insulin secretion varies with glycemia, meal size, and tissue demands for glucose. To approach this variability in people using insulin treatment, strategies have evolved to adjust prandial doses based on predicted needs. Thus, education of patients on how to adjust prandial insulin to account for carbohydrate intake, premeal glucose levels, and anticipated activity can be effective and should be considered. Newly available information suggests that individuals in whom carbohydrate counting is effective can incorporate estimates of meal fat and protein content into their prandial dosing for added benefit (3–5).

Most studies comparing multiple daily injections with continuous subcutaneous insulin infusion (CSII) have been relatively small and of short duration. However, a recent systematic review and meta-analysis concluded that pump therapy has modest advantages for lowering A1C (–0.30% [95% CI –0.58 to –0.02]) and for reducing severe hypoglycemia rates in children and adults (6). There is no consensus to guide choosing which form of insulin administration is best for a given patient, and research to guide this decision making is needed (7). The arrival of continuous glucose monitors to clinical practice has proven beneficial in specific circumstances. Reduction of nocturnal hypoglycemia in people with type 1 diabetes using insulin pumps with glucose sensors is improved by automatic suspension of insulin delivery at a preset glucose level (7–9). The U.S. Food and Drug Administration (FDA) has also approved the first hybrid closed-loop pump system. The safety and efficacy of hybrid closed-loop systems has been supported in

the literature in adolescents and adults with type 1 diabetes (10,11). Intensive diabetes management using CSII and continuous glucose monitoring should be considered in selected patients. See Section 7 “Diabetes Technology” for a full discussion of insulin delivery devices.

The Diabetes Control and Complications Trial (DCCT) demonstrated that intensive therapy with multiple daily injections or CSII reduced A1C and was associated with improved long-term outcomes (12–14). The study was carried out with short-acting and intermediate-acting human insulins. Despite better microvascular, macrovascular, and all-cause mortality outcomes, intensive therapy was associated with a higher rate of severe hypoglycemia (61 episodes per 100 patient-years of therapy). Since the DCCT, rapid-acting and long-acting insulin analogs have been developed. These analogs are associated with less hypoglycemia, less weight gain, and lower A1C than human insulins in people with type 1 diabetes (15–17). Longer-acting basal analogs (U-300 glargine or degludec) may convey a lower hypoglycemia risk compared with U-100 glargine in patients with type 1 diabetes (18,19). Rapid-acting inhaled insulin to be used before meals is now available and may reduce rates of hypoglycemia in patients with type 1 diabetes (20).

Postprandial glucose excursions may be better controlled by adjusting the timing of prandial insulin dose administration. The optimal time to administer prandial insulin varies, based on the type of insulin used (regular, rapid-acting analog, inhaled, etc.), measured blood glucose level, timing of meals, and carbohydrate consumption. Recommendations for prandial insulin dose administration should therefore be individualized.

Insulin Injection Technique

Ensuring that patients and/or caregivers understand correct insulin injection technique is important to optimize glucose control and insulin use safety. Thus, it is important that insulin be delivered into the proper tissue in the right way. Recommendations have been published elsewhere outlining best practices for insulin injection (21). Proper insulin injection technique includes injecting into appropriate body areas, injection site rotation, appropriate care of injection sites to avoid infection or other

complications, and avoidance of intramuscular (IM) insulin delivery.

Exogenous-delivered insulin should be injected into subcutaneous tissue, not intramuscularly. Recommended sites for insulin injection include the abdomen, thigh, buttock, and upper arm (21). Because insulin absorption from IM sites differs according to the activity of the muscle, inadvertent IM injection can lead to unpredictable insulin absorption and variable effects on glucose, with IM injection being associated with frequent and unexplained hypoglycemia in several reports (21–23). Risk for IM insulin delivery is increased in younger and lean patients when injecting into the limbs rather than truncal sites (abdomen and buttocks) and when using longer needles (24). Recent evidence supports the use of short needles (e.g., 4-mm pen needles) as effective and well tolerated when compared to longer needles (25,26), including a study performed in obese adults (27). Injection site rotation is additionally necessary to avoid lipohypertrophy and lipoatrophy (21). Lipohypertrophy can contribute to erratic insulin absorption, increased glycemic variability, and unexplained hypoglycemic episodes (28). Patients and/or caregivers should receive education about proper injection site rotation and to recognize and avoid areas of lipohypertrophy (21). As noted in **Table 4.1**, examination of insulin injection sites for the presence of lipohypertrophy, as well as assessment of injection device use and injection technique, are key components of a comprehensive diabetes medical evaluation and treatment plan. As referenced above, there are now numerous evidence-based insulin delivery recommendations that have been published. Proper insulin injection technique may lead to more effective use of this therapy and, as such, holds the potential for improved clinical outcomes.

Noninsulin Treatments for Type 1 Diabetes

Injectable and oral glucose-lowering drugs have been studied for their efficacy as adjuncts to insulin treatment of type 1 diabetes. Pramlintide is based on the naturally occurring β -cell peptide amylin and is approved for use in adults with type 1 diabetes. Results from randomized controlled studies show variable reductions of A1C (0–0.3%) and body weight

(1–2 kg) with addition of pramlintide to insulin (29,30). Similarly, results have been reported for several agents currently approved only for the treatment of type 2 diabetes. The addition of metformin to adults with type 1 diabetes caused small reductions in body weight and lipid levels but did not improve A1C (31,32). The addition of the glucagon-like peptide 1 (GLP-1) receptor agonists liraglutide and exenatide to insulin therapy caused small (0.2%) reductions in A1C compared with insulin alone in people with type 1 diabetes and also reduced body weight by ~3 kg (33). Similarly, the addition of a sodium–glucose cotransporter 2 (SGLT2) inhibitor to insulin therapy has been associated with improvements in A1C and body weight when compared with insulin alone (34–36); however, SGLT2 inhibitor use is also associated with more adverse events including ketoacidosis. The dual SGLT1/2 inhibitor sotagliflozin is currently under consideration by the FDA and, if approved, would be the first adjunctive oral therapy in type 1 diabetes.

The risks and benefits of adjunctive agents beyond pramlintide in type 1 diabetes continue to be evaluated through the regulatory process; however, at this time, these adjunctive agents are not approved in the context of type 1 diabetes (37).

SURGICAL TREATMENT FOR TYPE 1 DIABETES

Pancreas and Islet Transplantation

Pancreas and islet transplantation normalizes glucose levels but requires lifelong immunosuppression to prevent graft rejection and recurrence of autoimmune islet destruction. Given the potential adverse effects of immunosuppressive therapy, pancreas transplantation should be reserved for patients with type 1 diabetes undergoing simultaneous renal transplantation, following renal transplantation, or for those with recurrent ketoacidosis or severe hypoglycemia despite intensive glycemic management (38).

PHARMACOLOGIC THERAPY FOR TYPE 2 DIABETES

Recommendations

9.5 Metformin is the preferred initial pharmacologic agent for the treatment of type 2 diabetes. **A**

9.6 Once initiated, metformin should be continued as long as it is tolerated and not contraindicated; other agents, including insulin, should be added to metformin. **A**

9.7 Long-term use of metformin may be associated with biochemical vitamin B12 deficiency, and periodic measurement of vitamin B12 levels should be considered in metformin-treated patients, especially in those with anemia or peripheral neuropathy. **B**

9.8 The early introduction of insulin should be considered if there is evidence of ongoing catabolism (weight loss), if symptoms of hyperglycemia are present, or when A1C levels (>10% [86 mmol/mol]) or blood glucose levels (≥ 300 mg/dL [16.7 mmol/L]) are very high. **E**

9.9 Consider initiating dual therapy in patients with newly diagnosed type 2 diabetes who have A1C $\geq 1.5\%$ (12.5 mmol/mol) above their glycemic target. **E**

9.10 A patient-centered approach should be used to guide the choice of pharmacologic agents. Considerations include comorbidities (atherosclerotic cardiovascular disease, heart failure, chronic kidney disease), hypoglycemia risk, impact on weight, cost, risk for side effects, and patient preferences. **E**

9.11 Among patients with type 2 diabetes who have established atherosclerotic cardiovascular disease, sodium–glucose cotransporter 2 inhibitors, or glucagon-like peptide 1 receptor agonists with demonstrated cardiovascular disease benefit (**Table 9.1**) are recommended as part of the antihyperglycemic regimen. **A**

9.12 Among patients with atherosclerotic cardiovascular disease at high risk of heart failure or in whom heart failure coexists, sodium–glucose cotransporter 2 inhibitors are preferred. **C**

9.13 For patients with type 2 diabetes and chronic kidney disease,

consider use of a sodium–glucose cotransporter 2 inhibitor or glucagon-like peptide 1 receptor agonist shown to reduce risk of chronic kidney disease progression, cardiovascular events, or both. **C**

9.14 In most patients who need the greater glucose-lowering effect of an injectable medication, glucagon-like peptide 1 receptor agonists are preferred to insulin. **B**

9.15 Intensification of treatment for patients with type 2 diabetes not meeting treatment goals should not be delayed. **B**



9.16 The medication regimen should be reevaluated at regular intervals (every 3–6 months) and adjusted as needed to incorporate new patient factors (**Table 9.1**). **E**

The American Diabetes Association/European Association for the Study of Diabetes consensus report “Management of Hyperglycemia in Type 2 Diabetes, 2018” (39) recommends a patient-centered approach to choosing appropriate pharmacologic treatment of blood glucose (**Fig. 9.1**). This includes consideration of efficacy and key patient factors: 1) important comorbidities such as atherosclerotic cardiovascular disease (ASCVD), chronic kidney disease (CKD), and heart failure (HF), 2) hypoglycemia risk, 3) effects on body weight, 4) side effects, 5) cost, and 6) patient preferences. Lifestyle modifications that improve health (see Section 5 “Lifestyle Management”) should be emphasized along with any pharmacologic therapy. See Sections 12 and 13 for recommendations specific for older adults and for children and adolescents with type 2 diabetes, respectively.

Initial Therapy

Metformin should be started at the time type 2 diabetes is diagnosed unless there are contraindications; for most patients this will be monotherapy in combination with lifestyle modifications. Metformin is effective and safe, is inexpensive, and may reduce risk of cardiovascular events and death (40). Metformin is available in an immediate-release form for twice-daily dosing or as an extended-release

Table 9.1—Drug-specific and patient factors to consider when selecting antihyperglycemic treatment in adults with type 2 diabetes

Drug Class	Efficacy	Hypoglycemia	Weight change	CV effects		Cost	Oral/SQ	Renal effects		Additional considerations
				ASCVD	CHF			Progression of CKD	Dosing/use considerations*	
Metformin	High	No	Neutral (potential for modest loss)	Potential benefit	Neutral	Low	Oral	Neutral	Dosing/use considerations* <ul style="list-style-type: none"> • Contaminated with eCFR <30 	<ul style="list-style-type: none"> • Gastrointestinal side effects common • Potential for B12 deficiency
SGLT2 inhibitors	Intermediate	No	Loss	Benefit: empagliflozin†, canagliflozin	 Benefit: ertugliflozin, dapagliflozin, ertugliflozin	High	Oral	 Benefit: ertugliflozin, dapagliflozin, ertugliflozin	<ul style="list-style-type: none"> • Renal dose adjustment required (canagliflozin, dapagliflozin, ertugliflozin) 	<ul style="list-style-type: none"> • FDA Black Box: Risk of amputation (canagliflozin) • Risk of bone fractures (canagliflozin) • DKA risk (all agents; rare in T2DM) • Genitourinary infections • Risk of volume depletion, hypotension • ↓LDL cholesterol • Risk of Fournier’s gangrene
GLP-1 RAs	High	No	Loss	Neutral: lixisenatide	Neutral	High	SQ	Benefit: liraglutide	<ul style="list-style-type: none"> • Renal dose adjustment required (exenatide, lixisenatide) 	<ul style="list-style-type: none"> • FDA Black Box: Risk of thyroid C-cell tumors (liraglutide, albiglutide, dulaglutide, exenatide extended release) • Gastrointestinal side effects common (nausea, vomiting, diarrhea) • Injection site reactions • Acute pancreatitis risk
DPP-4 inhibitors	Intermediate	No	Neutral	Neutral	Potential risk: saxagliptin, alogliptin	High	Oral	Neutral	<ul style="list-style-type: none"> • Renal dose adjustment required (saxagliptin, alogliptin); can be used in renal impairment • No dose adjustment required for liraglutin 	<ul style="list-style-type: none"> • Potential risk of acute pancreatitis • Joint pain
Thiazolidinediones	High	No	Gain	Potential benefit: pioglitazone	Increased risk	Low	Oral	Neutral	<ul style="list-style-type: none"> • No dose adjustment required • Generally not recommended in renal impairment due to fluid retention 	<ul style="list-style-type: none"> • FDA Black Box: Congestive heart failure (pioglitazone, rosiglitazone) • Fluid retention (edema; heart failure) • Benefit in NASH • Risk of bone fractures • Bladder cancer (pioglitazone) • ↑LDL cholesterol (rosiglitazone)
Sulfonylureas (2nd generation)	High	Yes	Gain	Neutral	Neutral	Low	Oral	Neutral	<ul style="list-style-type: none"> • Gliburide: not recommended • Glipizide and glimepiride: initiate conservatively to avoid hypoglycemia 	<ul style="list-style-type: none"> • FDA Special Warning on increased risk of cardiovascular mortality based on studies of an older sulfonylurea (tolbutamide)
Insulin	Highest	Yes	Gain	Neutral	Neutral	Low	SQ	Neutral	<ul style="list-style-type: none"> • Lower insulin doses required with a decrease in eCFR; titrate per clinical response 	<ul style="list-style-type: none"> • Injection site reactions • Higher risk of hypoglycemia with human insulin (PHI or premixed formulations) vs. analogs
Human Insulin Analogs						High	SQ			

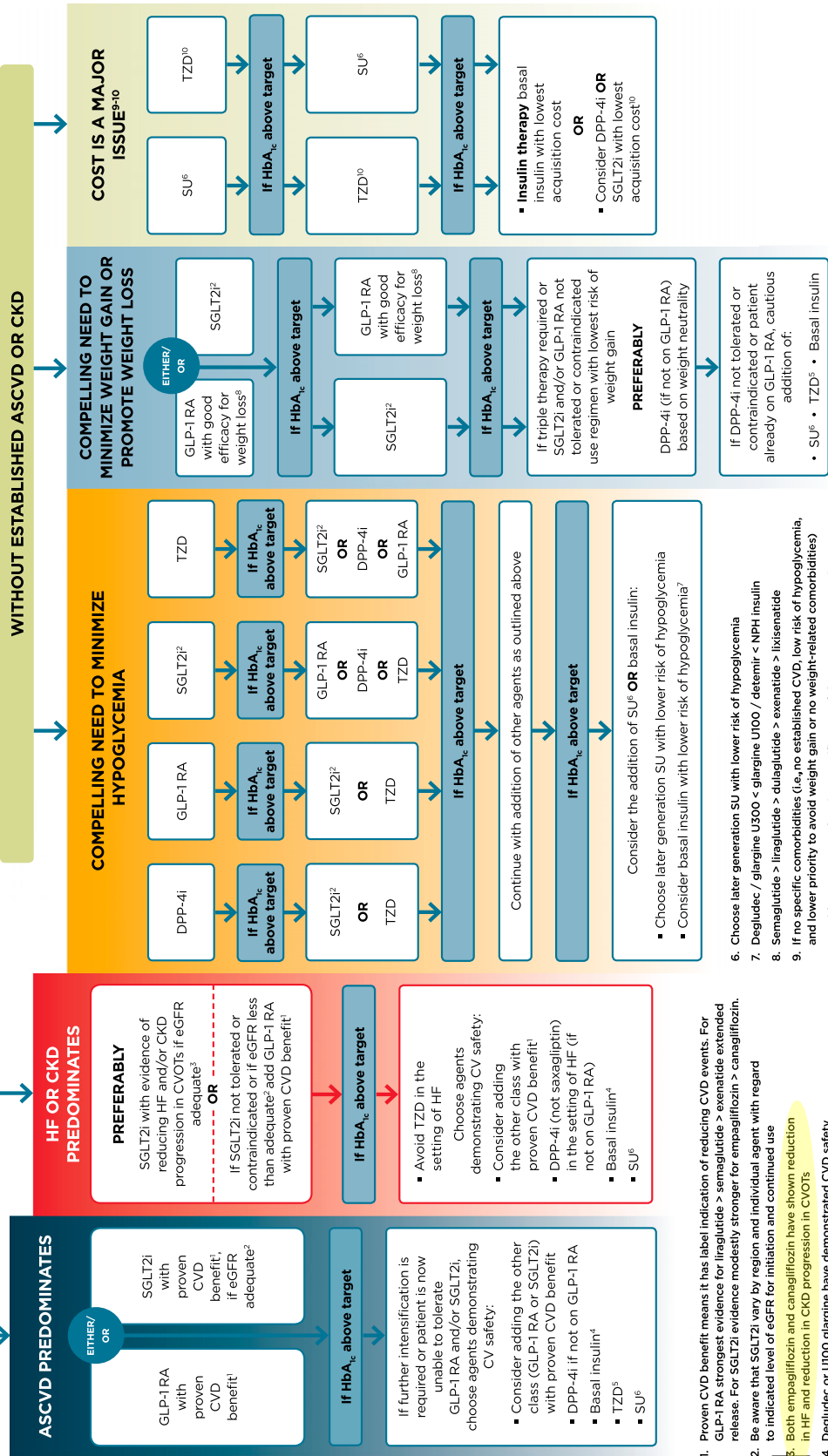
*For agent-specific dosing recommendations, please refer to the manufacturers’ prescribing information. †FDA approved for CVD benefit. CHF, congestive heart failure; CV, cardiovascular; DPP-4, dipeptidyl peptidase 4; DKA, diabetic ketoacidosis; DKD, diabetic kidney disease; GLP-1 RAs, glucagon-like peptide 1 receptor agonists; NASH, nonalcoholic steatohepatitis; SGLT2, sodium–glucose cotransporter 2; SQ, subcutaneous; T2DM, type 2 diabetes.



FIRST-LINE therapy is metformin and comprehensive lifestyle (including weight management and physical activity) if HbA_{1c} above target proceed as below

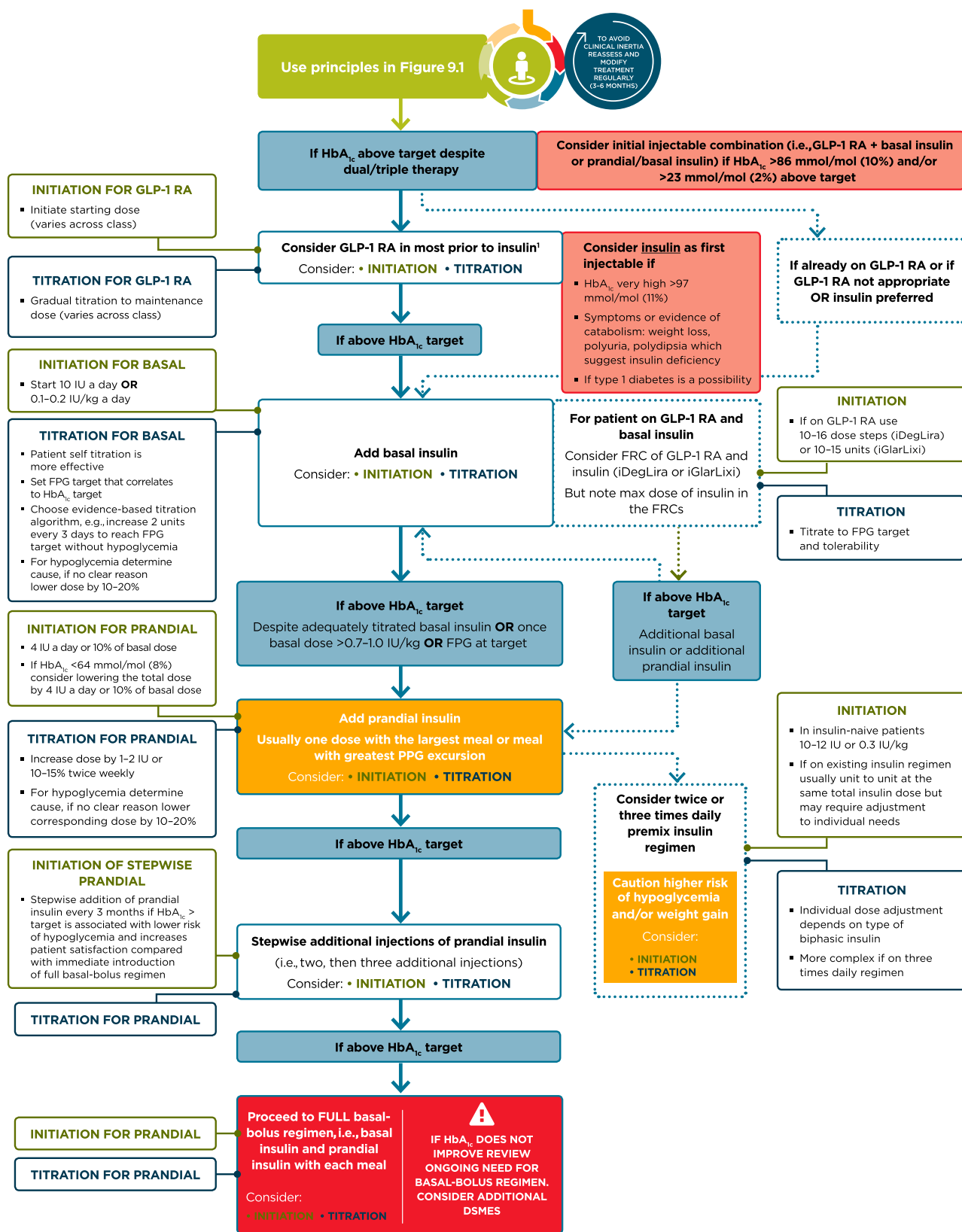
NO

ESTABLISHED ASCVD OR CKD



1. Proven CVD benefit means it has label indication of reducing CVD events. For GLP-1 RA strongest evidence for liraglutide > semaglutide > exenatide extended release. For SGLT2i evidence modestly stronger for empagliflozin > canagliflozin.
2. Be aware that SGLT2i vary by region and individual agent with regard to indicated level of eGFR for initiation and continued use
3. Both empagliflozin and canagliflozin have shown reduction in HF and reduction in CKD progression in CVOTs
4. Degludec or U100 glargine have demonstrated CVD safety
5. Low dose may be better tolerated though less well studied for CVD effects

Figure 9.1—Glucose-lowering medication in type 2 diabetes: overall approach. For appropriate context, see Fig. 4.1. ASCVD, atherosclerotic cardiovascular disease; CKD, chronic kidney disease; CV, cardiovascular; CVD, cardiovascular disease; CVOTs, cardiovascular outcomes trials; DPP-4i, dipeptidyl peptidase 4 inhibitor; eGFR, estimated glomerular filtration rate; GLP-1 RA, glucagon-like peptide 1 receptor agonist; HF, heart failure; SGLT2i, sodium-glucose cotransporter 2 inhibitor; SU, sulfonylurea; TZD, thiazolidinedione. Adapted from Davies et al. (39).



1. When selecting GLP-1 RA, consider: patient preference, HbA_{1c} lowering, weight-lowering effect, or frequency of injection. If CVD, consider GLP-1 RA with proven CVD benefit

Figure 9.2—Intensifying to injectable therapies. For appropriate context, see Fig. 4.1. DSMES, diabetes self-management education and support; FPG, fasting plasma glucose; FRC, fixed-ratio combination; GLP-1 RA, glucagon-like peptide 1 receptor agonist; max, maximum; PPG, postprandial glucose. Adapted from Davies et al. (39).

Table 9.2—Median monthly cost of maximum approved daily dose of noninsulin glucose-lowering agents in the U.S.

Class	Compound(s)	Dosage strength/product (if applicable)	Median AWP (min, max) [†]	Median NADAC (min, max) [†]	Maximum approved daily dose*	
Biguanides	• Metformin	500 mg (IR)	\$84 (\$4, \$93)	\$2	2,000 mg	
		850 mg (IR)	\$108 (\$6, \$109)	\$3	2,550 mg	
		1,000 mg (IR)	\$87 (\$4, \$88)	\$2	2,000 mg	
		500 mg (ER)	\$89 (\$82, \$6,671)	\$4 (\$4, \$1,267)	2,000 mg	
		750 mg (ER)	\$72 (\$65, \$92)	\$4	1,500 mg	
		1,000 mg (ER)	\$1,028 (\$1,028, \$7,214)	\$311 (\$311, \$1,321)	2,000 mg	
Sulfonylureas (2nd generation)	• Glimepiride	4 mg	\$71 (\$71, \$198)	\$4	8 mg	
		10 mg (IR)	\$75 (\$67, \$97)	\$5	40 mg (IR)	
	• Glipizide	10 mg (XL)	\$48	\$15	20 mg (XL)	
		• Glyburide	6 mg (micronized)	\$50 (\$48, \$71)	\$10	12 mg (micronized)
	5 mg		\$93 (\$63, \$103)	\$13	20 mg	
Thiazolidinediones	• Pioglitazone	45 mg	\$348 (\$283, \$349)	\$4	45 mg	
		4 mg	\$407	\$329	8 mg	
α-Glucosidase inhibitors	• Acarbose	100 mg	\$106 (\$104, \$106)	\$23	300 mg	
		100 mg	\$241	\$311	300 mg	
Meglitinides (glinides)	• Nateglinide	120 mg	\$155	\$46	360 mg	
		• Repaglinide	2 mg	\$878 (\$162, \$898)	\$48	16 mg
DPP-4 inhibitors	• Alogliptin	25 mg	\$234	\$170	25 mg	
		• Saxagliptin	5 mg	\$490 (\$462, \$490)	\$392	5 mg
		• Linagliptin	5 mg	\$494	\$395	5 mg
		• Sitagliptin	100 mg	\$516	\$413	100 mg
SGLT2 inhibitors	• Ertugliflozin	15 mg	\$322	\$257	15 mg	
		• Dapagliflozin	10 mg	\$557	\$446	10 mg
		• Canagliflozin	300 mg	\$558	\$446	300 mg
		• Empagliflozin	25 mg	\$558	\$448	25 mg
GLP-1 receptor agonists	• Exenatide (extended release)	2 mg powder for suspension or pen	\$792	\$634	2 mg**	
		• Exenatide	10 μg pen	\$850	\$680	20 μg
		• Dulaglutide	1.5/0.5 mL pen	\$876	\$702	1.5 mg**
		• Semaglutide	1 mg pen	\$875	\$704	1 mg**
		• Liraglutide	18 mg/3 mL pen	\$1,044	\$835	1.8 mg
Bile acid sequestrants	• Colesevelam	625 mg tabs	\$712 (\$674, \$712)	\$354	3.75 g	
		3.75 g suspension	\$674	\$598	3.75 g	
Dopamine-2 agonists	• Bromocriptine	0.8 mg	\$855	\$685	4.8 mg	
Amylin mimetics	• Pramlintide	120 μg pen	\$2,547	\$2,036	120 μg/injection+++	

AWP, average wholesale price; DPP-4, dipeptidyl peptidase 4; ER and XL, extended release; GLP-1, glucagon-like peptide 1; IR, immediate release; NADAC, National Average Drug Acquisition Cost; SGLT2, sodium-glucose cotransporter 2. [†]Calculated for 30-day supply (AWP [44] or NADAC [45] unit price × number of doses required to provide maximum approved daily dose × 30 days); median AWP or NADAC listed alone when only one product and/or price. *Utilized to calculate median AWP and NADAC (min, max); generic prices used, if available commercially. **Administered once weekly. +++AWP and NADAC calculated based on 120 μg three times daily.

form that can be given once daily. Compared with sulfonylureas, metformin as first-line therapy has beneficial effects on A1C, weight, and cardiovascular mortality (41); there is little systematic data available for other oral agents as initial therapy of type 2 diabetes. The principal side effects of metformin are gastrointestinal intolerance due to bloating, abdominal discomfort, and diarrhea. The drug is cleared by renal filtration, and very high circulating levels (e.g., as a result of overdose or acute renal failure) have been associated with lactic acidosis. However, the occurrence of this complication is now known to be very rare, and metformin may be safely

used in patients with reduced estimated glomerular filtration rates (eGFR); the FDA has revised the label for metformin to reflect its safety in patients with eGFR ≥30 mL/min/1.73 m² (42). A recent randomized trial confirmed previous observations that metformin use is associated with vitamin B12 deficiency and worsening of symptoms of neuropathy (43). This is compatible with a recent report from the Diabetes Prevention Program Outcomes Study (DPPOS) suggesting periodic testing of vitamin B12 (44).

In patients with contraindications or intolerance of metformin, initial therapy should be based on patient factors;

consider a drug from another class depicted in **Fig. 9.1**. When A1C is ≥1.5% (12.5 mmol/mol) above glycemic target (see Section 6 “Glycemic Targets” for more information on selecting appropriate targets), many patients will require dual combination therapy to achieve their target A1C level (45). Insulin has the advantage of being effective where other agents are not and should be considered as part of any combination regimen when hyperglycemia is severe, especially if catabolic features (weight loss, hypertriglyceridemia, ketosis) are present. Consider initiating insulin therapy when blood glucose is ≥300 mg/dL (16.7 mmol/L) or A1C is ≥10% (86 mmol/

Table 9.3—Median cost of insulin products in the U.S. calculated as AWP (44) and NADAC (45) per 1,000 units of specified dosage form/product

Insulins	Compounds	Dosage form/product	Median AWP (min, max)*	Median NADAC (min, max)*	
Rapid-acting analogs	• Lispro biosimilar	U-100 vial	\$280	\$226	
		U-100 prefilled pen	\$361	\$289	
	• Glulisine	U-100 vial	\$324	\$260	
		U-100 prefilled pen	\$417	\$334	
	• Lispro	U-100 vial	\$330	\$264	
		U-100 3 mL cartridges	\$408	\$326	
		U-100 prefilled pen; U-200 prefilled pen	\$424	\$340	
	• Aspart	U-100 vial	\$347	\$278	
		U-100 3 mL cartridges	\$430	\$343	
		U-100 prefilled pen	\$447	\$358	
• Inhaled insulin	Inhalation cartridges	\$993	\$606		
Short-acting	• Human Regular	U-100 vial	\$165 (\$165, \$178)	\$135 (\$135, \$146)	
Intermediate-acting	• Human NPH	U-100 vial	\$165 (\$165, \$178)	\$135 (\$135, \$144)	
		U-100 prefilled pen	\$377	\$304	
Concentrated Human Regular insulin	• U-500 Human Regular insulin	U-500 vial	\$178	\$142	
		U-500 prefilled pen	\$230	\$184	
Basal analogs	• Glargine biosimilar	U-100 prefilled pen	\$261	\$209	
		• Glargine	U-100 vial; U-100 prefilled pen	\$323	\$259
			U-300 prefilled pen	\$331	\$266
	• Detemir	U-100 vial; U-100 prefilled pen	\$353	\$281	
		• Degludec	U-100 prefilled pen; U-200 prefilled pen	\$388	\$310
	Premixed insulin products	• NPH/Regular 70/30	U-100 vial	\$165 (\$165, \$178)	\$135 (\$135, \$144)
U-100 prefilled pen			\$377	\$306	
• Lispro 50/50		U-100 vial	\$342	\$274	
		U-100 prefilled pen	\$424	\$340	
• Lispro 75/25		U-100 vial	\$342	\$273	
		U-100 prefilled pen	\$424	\$340	
• Aspart 70/30		U-100 vial	\$360	\$288	
		U-100 prefilled pen	\$447	\$358	
Premixed insulin/GLP-1 receptor agonist products	• Degludec/Liraglutide	100/3.6 prefilled pen	\$793	\$638	
	• Glargine/Lixisenatide	100/33 prefilled pen	\$537	\$431	

AWP, average wholesale price; GLP-1, glucagon-like peptide 1; NADAC, National Average Drug Acquisition Cost. *AWP or NADAC calculated as in Table 9.2; median listed alone when only one product and/or price.

mol) or if the patient has symptoms of hyperglycemia (i.e., polyuria or polydipsia), even at diagnosis or early in the course of treatment (Fig. 9.2). As glucose toxicity resolves, simplifying the regimen and/or changing to oral agents is often possible.

Combination Therapy

Although there are numerous trials comparing dual therapy with metformin alone, few directly compare drugs as add-on therapy. A comparative effectiveness meta-analysis suggests that each new class of noninsulin agents added to initial therapy generally lowers A1C approximately 0.7–1.0% (46). If the A1C target is not achieved after approximately 3 months and the patient *does not* have ASCVD or CKD, consider a combination of metformin and any one of the

preferred six treatment options: sulfonylurea, thiazolidinedione, dipeptidyl peptidase 4 (DPP-4) inhibitor, SGLT2 inhibitor, GLP-1 receptor agonist, or basal insulin; the choice of which agent to add is based on drug-specific effects and patient factors (Fig. 9.1 and Table 9.1). For patients in whom ASCVD, HF, or CKD predominates, the best choice for a second agent is a GLP-1 receptor agonist or SGLT2 inhibitor with demonstrated cardiovascular risk reduction, after consideration of drug-specific and patient factors (Table 9.1). For patients without established ASCVD or CKD, the choice of a second agent to add to metformin is not yet guided by empiric evidence. Rather, drug choice is based on avoidance of side effects, particularly hypoglycemia and weight gain, cost, and patient preferences (47). Similar

considerations are applied in patients who require a third agent to achieve glycemic goals; there is also very little trial-based evidence to guide this choice. In all cases, treatment regimens need to be continuously reviewed for efficacy, side effects, and patient burden (Table 9.1). In some instances, patients will require medication reduction or discontinuation. Common reasons for this include ineffectiveness, intolerable side effects, expense, or a change in glycemic goals (e.g., in response to development of comorbidities or changes in treatment goals). See Section 12 “Older Adults” for a full discussion of treatment considerations in older adults.

Even though most patients prefer oral medications to drugs that need to be injected, the eventual need for the greater potency of injectable medications

is common, particularly in people with a longer duration of diabetes. The addition of basal insulin, either human NPH or one of the long-acting insulin analogs, to oral agent regimens is a well-established approach that is effective for many patients. In addition, recent evidence supports the utility of GLP-1 receptor agonists in patients not reaching glycemic targets with oral agent regimens. In trials comparing the addition of GLP-1 receptor agonists or insulin in patients needing further glucose lowering, the efficacy of the two treatments was similar (48–50). However, GLP-1 receptor agonists had a lower risk of hypoglycemia and beneficial effects on body weight compared with insulin, albeit with greater gastrointestinal side effects. Thus, trial results support a GLP-1 receptor agonist as the preferred option for patients requiring the potency of an injectable therapy for glucose control (Fig. 9.2). However, high costs and tolerability issues are important barriers to the use of GLP-1 receptor agonists.

Cost-effectiveness models of the newer agents based on clinical utility and glycemic effect have been reported (51). Table 9.2 provides cost information for currently approved noninsulin therapies. Of note, prices listed are average wholesale prices (AWP) (52) and National Average Drug Acquisition Costs (NADAC) (53) and do not account for discounts, rebates, or other price adjustments often involved in prescription sales that affect the actual cost incurred by the patient. While there are alternative means to estimate medication prices, AWP and NADAC were utilized to provide two separate measures to allow for a comparison of drug prices with the primary goal of highlighting the importance of cost considerations when prescribing antihyperglycemic treatments.



Cardiovascular Outcomes Trials

There are now multiple large randomized controlled trials reporting statistically significant reductions in cardiovascular events in patients with type 2 diabetes treated with an SGLT2 inhibitor (empagliflozin, canagliflozin) or GLP-1 receptor agonist (liraglutide, semaglutide). In people with diabetes with established ASCVD, empagliflozin decreased a composite three-point major cardiovascular event (MACE) outcome and mortality compared with placebo (54). Similarly, canagliflozin reduced the occurrence

of MACE in a group of subjects with, or at high risk for, ASCVD (55). In both of these trials, SGLT2 inhibitors reduced hospitalization for HF (54,55); this was a secondary outcome of these studies and will require confirmation in more defined populations. In people with type 2 diabetes with ASCVD or increased risk for ASCVD, the addition of liraglutide decreased MACE and mortality (56), and the closely related GLP-1 receptor agonist semaglutide also had favorable effects on cardiovascular end points in high-risk subjects (57). In these cardiovascular outcomes trials, empagliflozin, canagliflozin, liraglutide, and semaglutide all had beneficial effects on composite indices of CKD (54–57). See ANTIHYPERGLYCEMIC THERAPIES AND CARDIOVASCULAR OUTCOMES in Section 10 “Cardiovascular Disease and Risk Management” and Table 10.4 for a detailed description of these cardiovascular outcomes trials, as well as a discussion of how HF may impact treatment choices. See Section 11 “Microvascular Complications and Foot Care” for a detailed discussion on how CKD may impact treatment choices. Additional large randomized trials of other agents in these classes are ongoing.

The subjects enrolled in the cardiovascular outcomes trials using empagliflozin, canagliflozin, liraglutide, and semaglutide had A1C $\geq 7\%$, and more than 70% were taking metformin at baseline. Moreover, the benefit of treatment was less evident in subjects with lower risk for ASCVD. Thus, extension of these results to practice is most appropriate for people with type 2 diabetes and established ASCVD who require additional glucose-lowering treatment beyond metformin and lifestyle management. For these patients, incorporating one of the SGLT2 inhibitors or GLP-1 receptor agonists that have been demonstrated to reduce cardiovascular events is recommended (Table 9.1).

Insulin Therapy

Many patients with type 2 diabetes eventually require and benefit from insulin therapy (Fig. 9.2). See the section above, INSULIN INJECTION TECHNIQUE, for important guidance on how to administer insulin safely and effectively. The progressive nature of type 2 diabetes should be regularly and objectively explained to patients, and providers

should avoid using insulin as a threat or describing it as a sign of personal failure or punishment. Rather, the utility and importance of insulin to maintain glycemic control once progression of the disease overcomes the effect of oral agents should be emphasized. Educating and involving patients in insulin management is beneficial. Instruction of patients in self-titration of insulin doses based on self-monitoring of blood glucose improves glycemic control in patients with type 2 diabetes initiating insulin (58). Comprehensive education regarding self-monitoring of blood glucose, diet, and the avoidance and appropriate treatment of hypoglycemia are critically important in any patient using insulin.

Basal Insulin

Basal insulin alone is the most convenient initial insulin regimen and can be added to metformin and other oral agents. Starting doses can be estimated based on body weight (e.g., 10 units a day or 0.1–0.2 units/kg/day) and the degree of hyperglycemia, with individualized titration over days to weeks as needed. The principal action of basal insulin is to restrain hepatic glucose production, with a goal of maintaining euglycemia overnight and between meals (59,60). Control of fasting glucose can be achieved with human NPH insulin or with the use of a long-acting insulin analog. In clinical trials, long-acting basal analogs (U-100 glargine or detemir) have been demonstrated to reduce the risk of symptomatic and nocturnal hypoglycemia compared with NPH insulin (61–66), although these advantages are generally modest and may not persist (67). Longer-acting basal analogs (U-300 glargine or degludec) may convey a lower hypoglycemia risk compared with U-100 glargine when used in combination with oral agents (68–74). Despite evidence for reduced hypoglycemia with newer, longer-acting basal insulin analogs in clinical trial settings, in practice they may not affect the development of hypoglycemia compared with NPH insulin (75).

The cost of insulin has been rising steadily, and at a pace several fold that of other medical expenditures, over the past decade (76). This expense contributes significant burden to the patient as insulin has become a growing “out-of-pocket” cost for people with diabetes, and direct patient costs

contribute to treatment nonadherence (76). Therefore, consideration of cost is an important component of effective management. For many patients with type 2 diabetes (e.g., individuals with relaxed A1C goals, low rates of hypoglycemia, and prominent insulin resistance, as well as those with cost concerns), human insulin (NPH and Regular) may be the appropriate choice of therapy, and clinicians should be familiar with its use (77). **Table 9.3** provides AWP (52) and NADAC (53) information (cost per 1,000 units) for currently available insulin and insulin combination products in the U.S. As stated for **Table 9.2**, AWP and NADAC prices listed do not account for discounts, rebates, or other price adjustments that may affect the actual cost to the patient. For example, human regular insulin, NPH, and 70/30 NPH/Regular products can be purchased for considerably less than the AWP and NADAC prices listed in **Table 9.3** at select pharmacies.

Prandial Insulin

Individuals with type 2 diabetes may require doses of insulin before meals in addition to basal insulin. The recommended starting dose of mealtime insulin is either 4 units or 10% of the basal dose at each meal. Titration is done based on home glucose monitoring or A1C. With significant additions to the prandial insulin dose, particularly with the evening meal, consideration should be given to decreasing the basal insulin dose. Meta-analyses of trials comparing rapid-acting insulin analogs with human regular insulin in patients with type 2 diabetes have not reported important differences in A1C or hypoglycemia (78,79).

Premixed Insulin

Premixed insulin products contain both a basal and prandial component, allowing coverage of both basal and prandial needs with a single injection. The NPH/Regular premix is composed of 70% NPH insulin and 30% regular insulin. The use of premixed insulin products has its advantages and disadvantages, as discussed below in COMBINATION INJECTABLE THERAPY.

Concentrated Insulin Products

Several concentrated insulin preparations are currently available. U-500 regular insulin is, by definition, five times more concentrated than U-100 regular insulin. Regular U-500 has distinct

pharmacokinetics with delayed onset and longer duration of action, characteristics more like an intermediate-acting insulin. U-300 glargine and U-200 degludec are three and two times as concentrated, respectively, as their U-100 formulations and allow higher doses of basal insulin administration per volume used. U-300 glargine has a longer duration of action than U-100 glargine but modestly lower efficacy per unit administered (80,81). The FDA has also approved a concentrated formulation of rapid-acting insulin lispro, U-200 (200 units/mL). These concentrated preparations may be more convenient and comfortable for patients to inject and may improve adherence in those with insulin resistance who require large doses of insulin. While U-500 regular insulin is available in both prefilled pens and vials (a dedicated syringe was FDA approved in July 2016), other concentrated insulins are available only in prefilled pens to minimize the risk of dosing errors.

Inhaled Insulin

Inhaled insulin is available for prandial use with a limited dosing range; studies in people with type 1 diabetes suggest rapid pharmacokinetics (20). A pilot study found evidence that compared with injectable rapid-acting insulin, supplemental doses of inhaled insulin taken based on postprandial glucose levels may improve blood glucose management without additional hypoglycemia or weight gain, although results from a larger study are needed for confirmation (82).

Inhaled insulin is contraindicated in patients with chronic lung disease, such as asthma and chronic obstructive pulmonary disease, and is not recommended in patients who smoke or who recently stopped smoking. All patients require spirometry (FEV₁) testing to identify potential lung disease prior to and after starting inhaled insulin therapy.

Combination Injectable Therapy

If basal insulin has been titrated to an acceptable fasting blood glucose level (or if the dose is >0.5 units/kg/day) and A1C remains above target, consider advancing to combination injectable therapy (**Fig. 9.2**). This approach can use a GLP-1 receptor agonist added to basal insulin or multiple doses of insulin. The combination of basal insulin and GLP-1 receptor agonist has potent glucose-

lowering actions and less weight gain and hypoglycemia compared with intensified insulin regimens (83–85). Two different once-daily fixed-dual combination products containing basal insulin plus a GLP-1 receptor agonist are available: insulin glargine plus lixisenatide and insulin degludec plus liraglutide.

Intensification of insulin treatment can be done by adding doses of prandial to basal insulin. Starting with a single prandial dose with the largest meal of the day is simple and effective, and it can be advanced to a regimen with multiple prandial doses if necessary (86). Alternatively, in a patient on basal insulin in whom additional prandial coverage is desired, the regimen can be converted to two or three doses of a premixed insulin. Each approach has advantages and disadvantages. For example, basal/prandial regimens offer greater flexibility for patients who eat on irregular schedules. On the other hand, two doses of premixed insulin is a simple, convenient means of spreading insulin across the day. Moreover, human insulins, separately or as premixed NPH/Regular (70/30) formulations, are less costly alternatives to insulin analogs. **Figure 9.2** outlines these options, as well as recommendations for further intensification, if needed, to achieve glycemic goals.

When initiating combination injectable therapy, metformin therapy should be maintained while sulfonylureas and DPP-4 inhibitors are typically discontinued. In patients with suboptimal blood glucose control, especially those requiring large insulin doses, adjunctive use of a thiazolidinedione or an SGLT2 inhibitor may help to improve control and reduce the amount of insulin needed, though potential side effects should be considered. Once a basal/bolus insulin regimen is initiated, dose titration is important, with adjustments made in both mealtime and basal insulins based on the blood glucose levels and an understanding of the pharmacodynamic profile of each formulation (pattern control). As people with type 2 diabetes get older, it may become necessary to simplify complex insulin regimens because of a decline in self-management ability (see Section 12 “Older Adults”).

References

1. Peters A, Laffel L (Eds.). *American Diabetes Association/JDRF Type 1 Diabetes Sourcebook*. Alexandria, VA, American Diabetes Association, 2013

2. Chiang JL, Kirkman MS, Laffel LMB, Peters AL; *Type 1 Diabetes Sourcebook* Authors. Type 1 diabetes through the life span: a position statement of the American Diabetes Association. *Diabetes Care* 2014;37:2034–2054
3. Wolpert HA, Atakov-Castillo A, Smith SA, Steil GM. Dietary fat acutely increases glucose concentrations and insulin requirements in patients with type 1 diabetes: implications for carbohydrate-based bolus dose calculation and intensive diabetes management. *Diabetes Care* 2013;36:810–816
4. Bell KJ, Toschi E, Steil GM, Wolpert HA. Optimized mealtime insulin dosing for fat and protein in type 1 diabetes: application of a model-based approach to derive insulin doses for open-loop diabetes management. *Diabetes Care* 2016;39:1631–1634
5. Bell KJ, Smart CE, Steil GM, Brand-Miller JC, King B, Wolpert HA. Impact of fat, protein, and glycemic index on postprandial glucose control in type 1 diabetes: implications for intensive diabetes management in the continuous glucose monitoring era. *Diabetes Care* 2015;38:1008–1015
6. Yeh H-C, Brown TT, Maruthur N, et al. Comparative effectiveness and safety of methods of insulin delivery and glucose monitoring for diabetes mellitus: a systematic review and meta-analysis. *Ann Intern Med* 2012;157:336–347
7. Pickup JC. The evidence base for diabetes technology: appropriate and inappropriate meta-analysis. *J Diabetes Sci Technol* 2013;7:1567–1574
8. Bergenstal RM, Klonoff DC, Garg SK, et al.; ASPIRE In-Home Study Group. Threshold-based insulin-pump interruption for reduction of hypoglycemia. *N Engl J Med* 2013;369:224–232
9. Buckingham BA, Raghinaru D, Cameron F, et al.; In Home Closed Loop Study Group. Predictive low-glucose insulin suspension reduces duration of nocturnal hypoglycemia in children without increasing ketosis. *Diabetes Care* 2015;38:1197–1204
10. Bergenstal RM, Garg S, Weinzimer SA, et al. Safety of a hybrid closed-loop insulin delivery system in patients with type 1 diabetes. *JAMA* 2016;316:1407–1408
11. Garg SK, Weinzimer SA, Tamborlane WV, et al. Glucose outcomes with the in-home use of a hybrid closed-loop insulin delivery system in adolescents and adults with type 1 diabetes. *Diabetes Technol Ther* 2017;19:155–163
12. Cleary PA, Orchard TJ, Genuth S, et al.; DCCT/EDIC Research Group. The effect of intensive glycemic treatment on coronary artery calcification in type 1 diabetic participants of the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications (DCCT/EDIC) Study. *Diabetes* 2006;55:3556–3565
13. Nathan DM, Cleary PA, Backlund J-YC, et al.; Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications (DCCT/EDIC) Study Research Group. Intensive diabetes treatment and cardiovascular disease in patients with type 1 diabetes. *N Engl J Med* 2005;353:2643–2653
14. Diabetes Control and Complications Trial (DCCT)/Epidemiology of Diabetes Interventions and Complications (EDIC) Study Research Group. Mortality in type 1 diabetes in the DCCT/EDIC versus the general population. *Diabetes Care* 2016;39:1378–1383
15. Tricco AC, Ashoor HM, Antony J, et al. Safety, effectiveness, and cost effectiveness of long acting versus intermediate acting insulin for patients with type 1 diabetes: systematic review and network meta-analysis. *BMJ* 2014;349:g5459
16. Bartley PC, Bogoev M, Larsen J, Philotheou A. Long-term efficacy and safety of insulin detemir compared to Neutral Protamine Hagedorn insulin in patients with type 1 diabetes using a treat-to-target basal-bolus regimen with insulin aspart at meals: a 2-year, randomized, controlled trial. *Diabet Med* 2008;25:442–449
17. DeWitt DE, Hirsch IB. Outpatient insulin therapy in type 1 and type 2 diabetes mellitus: scientific review. *JAMA* 2003;289:2254–2264
18. Lane W, Bailey TS, Gerety G, et al.; Group Information; SWITCH 1. Effect of insulin degludec vs insulin glargine U100 on hypoglycemia in patients with type 1 diabetes: the SWITCH 1 randomized clinical trial. *JAMA* 2017;318:33–44
19. Home PD, Bergenstal RM, Bolli GB, et al. New insulin glargine 300 units/mL versus glargine 100 units/mL in people with type 1 diabetes: a randomized, phase 3a, open-label clinical trial (EDITION 4). *Diabetes Care* 2015;38:2217–2225
20. Bode BW, McGill JB, Lorber DL, Gross JL, Chang PC, Bregman DB; Affinity 1 Study Group. Inhaled technosphere insulin compared with injected prandial insulin in type 1 diabetes: a randomized 24-week trial. *Diabetes Care* 2015;38:2266–2273
21. Frid AH, Kreugel G, Grassi G, et al. New insulin delivery recommendations. *Mayo Clin Proc* 2016;91:1231–1255
22. Karges B, Boehm BO, Karges W. Early hypoglycaemia after accidental intramuscular injection of insulin glargine. *Diabet Med* 2005;22:1444–1445
23. Frid A, Gunnarsson R, Güntner P, Linde B. Effects of accidental intramuscular injection on insulin absorption in IDDM. *Diabetes Care* 1988;11:41–45
24. Gibney MA, Arce CH, Byron KJ, Hirsch LJ. Skin and subcutaneous adipose layer thickness in adults with diabetes at sites used for insulin injections: implications for needle length recommendations. *Curr Med Res Opin* 2010;26:1519–1530
25. Hirsch LJ, Gibney MA, Albanese J, et al. Comparative glycemic control, safety and patient ratings for a new 4 mm × 32G insulin pen needle in adults with diabetes. *Curr Med Res Opin* 2010;26:1531–1541
26. Miwa T, Itoh R, Kobayashi T, et al. Comparison of the effects of a new 32-gauge × 4-mm pen needle and a 32-gauge × 6-mm pen needle on glycemic control, safety, and patient ratings in Japanese adults with diabetes. *Diabetes Technol Ther* 2012;14:1084–1090
27. Bergenstal RM, Strack ES, Peremislav D, Gibney MA, Parvu V, Hirsch LJ. Safety and efficacy of insulin therapy delivered via a 4mm pen needle in obese patients with diabetes. *Mayo Clin Proc* 2015;90:329–338
28. Famulla S, Hövelmann U, Fischer A, et al. Insulin injection into lipohypertrophic tissue: blunted and more variable insulin absorption and action and impaired postprandial glucose control. *Diabetes Care* 2016;39:1486–1492
29. Ratner RE, Dickey R, Fineman M, et al. Amylin replacement with pramlintide as an adjunct to insulin therapy improves long-term glycaemic and weight control in type 1 diabetes mellitus: a 1-year, randomized controlled trial. *Diabet Med* 2004;21:1204–1212
30. Edelman S, Garg S, Frias J, et al. A double-blind, placebo-controlled trial assessing pramlintide treatment in the setting of intensive insulin therapy in type 1 diabetes. *Diabetes Care* 2006;29:2189–2195
31. Meng H, Zhang A, Liang Y, Hao J, Zhang X, Lu J. Effect of metformin on glycaemic control in patients with type 1 diabetes: a meta-analysis of randomized controlled trials. *Diabetes Metab Res Rev* 2018;34:e2983
32. Petrie JR, Chaturvedi N, Ford I, et al.; REMOVAL Study Group. Cardiovascular and metabolic effects of metformin in patients with type 1 diabetes (REMOVAL): a double-blind, randomised, placebo-controlled trial. *Lancet Diabetes Endocrinol* 2017;5:597–609
33. Wang W, Liu H, Xiao S, Liu S, Li X, Yu P. Effects of insulin plus glucagon-like peptide-1 receptor agonists (GLP-1RAs) in treating type 1 diabetes mellitus: a systematic review and meta-analysis. *Diabetes Ther* 2017;8:727–738
34. Henry RR, Thakkar P, Tong C, Polidori D, Alba M. Efficacy and safety of canagliflozin, a sodium-glucose cotransporter 2 inhibitor, as add-on to insulin in patients with type 1 diabetes. *Diabetes Care* 2015;38:2258–2265
35. Dandona P, Mathieu C, Phillip M, et al.; DEPICT-1 Investigators. Efficacy and safety of dapagliflozin in patients with inadequately controlled type 1 diabetes (DEPICT-1): 24 week results from a multicentre, double-blind, phase 3, randomised controlled trial. *Lancet Diabetes Endocrinol* 2017;5:864–876
36. Patoulias D, Imprialos K, Stavropoulos K, Athyros V, Doumas M. SGLT-2 inhibitors in type 1 diabetes mellitus: a comprehensive review of the literature. *Curr Clin Pharmacol*. 7 August 2018 [Epub ahead of print]. DOI: 10.2174/1574884713666180807150509
37. Lexicon Pharmaceuticals. FDA to review Zynquista™ (sotagliflozin) as potential treatment for type 1 diabetes [Internet], 2018. Available from <http://www.lexpharma.com/media-center/news/673-fda-to-review-zynquista-sotagliflozin-as-potential-treatment-for-type-1-diabetes>. Accessed 30 September 2018
38. Robertson RP, Davis C, Larsen J, Stratta R, Sutherland DER; American Diabetes Association. Pancreas and islet transplantation in type 1 diabetes. *Diabetes Care* 2006;29:935
39. Davies MJ, D'Alessio DA, Fradkin J, et al. Management of hyperglycemia in type 2 diabetes, 2018. A consensus report by the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD). *Diabetes Care* 2018;41:2669–2701
40. Holman RR, Paul SK, Bethel MA, Matthews DR, Neil HAW. 10-year follow-up of intensive glucose control in type 2 diabetes. *N Engl J Med* 2008;359:1577–1589
41. Maruthur NM, Tseng E, Hutfless S, et al. Diabetes medications as monotherapy or metformin-based combination therapy for type 2 diabetes: a systematic review and meta-analysis. *Ann Intern Med* 2016;164:740–751

42. U.S. Food and Drug Administration. FDA Drug Safety Communication: FDA revises warnings regarding use of the diabetes medicine metformin in certain patients with reduced kidney function [Internet]. Available from <http://www.fda.gov/Drugs/DrugSafety/ucm493244.htm>. Accessed 14 October 2016
43. Out M, Kooy A, Leher P, Schalkwijk CA, Stehouwer CDA. Long-term treatment with metformin in type 2 diabetes and methylmalonic acid: post hoc analysis of a randomized controlled 4.3 year trial. *J Diabetes Complications* 2018;32:171–178
44. Aroda VR, Edelstein SL, Goldberg RB, et al.; Diabetes Prevention Program Research Group. Long-term metformin use and vitamin B12 deficiency in the Diabetes Prevention Program Outcomes Study. *J Clin Endocrinol Metab* 2016; 101:1754–1761
45. Henry RR, Murray AV, Marmolejo MH, Hennicken D, Ptaszynska A, List JF. Dapagliflozin, metformin XR, or both: initial pharmacotherapy for type 2 diabetes, a randomised controlled trial. *Int J Clin Pract* 2012;66:446–456
46. Bennett WL, Maruthur NM, Singh S, et al. Comparative effectiveness and safety of medications for type 2 diabetes: an update including new drugs and 2-drug combinations. *Ann Intern Med* 2011;154:602–613
47. Vijan S, Sussman JB, Yudkin JS, Hayward RA. Effect of patients' risks and preferences on health gains with plasma glucose level lowering in type 2 diabetes mellitus. *JAMA Intern Med* 2014;174:1227–1234
48. Singh S, Wright EE Jr, Kwan AYM, et al. Glucagon-like peptide-1 receptor agonists compared with basal insulins for the treatment of type 2 diabetes mellitus: a systematic review and meta-analysis. *Diabetes Obes Metab* 2017; 19:228–238
49. Levin PA, Nguyen H, Wittbrodt ET, Kim SC. Glucagon-like peptide-1 receptor agonists: a systematic review of comparative effectiveness research. *Diabetes Metab Syndr Obes* 2017; 10:123–139
50. Abd El Aziz MS, Kahle M, Meier JJ, Nauck MA. A meta-analysis comparing clinical effects of short- or long-acting GLP-1 receptor agonists versus insulin treatment from head-to-head studies in type 2 diabetic patients. *Diabetes Obes Metab* 2017;19:216–227
51. Institute for Clinical and Economic Review. Controversies in the management of patients with type 2 diabetes [Internet], December 2014. Available from <https://icer-review.org/wp-content/uploads/2015/03/CEPAC-T2D-Final-Report-December-22.pdf>. Accessed 9 November 2018
52. Truven Health Analytics. Micromedex 2.0 Introduction to RED BOOK Online [Internet], 2018. Available from http://www.micromedexsolutions.com/micromedex2/4.34.0/WebHelp/RED_BOOK/Introduction_to_REDB_BOOK_Online.htm. Accessed 5 September 2018
53. Centers for Medicare & Medicaid Services. NADAC (national average drug acquisition cost), drug pricing and payment [Internet], 2018. Available from <https://data.medicare.gov/Drug-Pricing-and-Payment/NADAC-National-Average-Drug-Acquisition-Cost-/a4y5-998d>. Accessed 5 September 2018
54. Zinman B, Wanner C, Lachin JM, et al.; EMPA-REG OUTCOME Investigators. Empagliflozin, cardiovascular outcomes, and mortality in type 2 diabetes. *N Engl J Med* 2015;373: 2117–2128
55. Neal B, Perkovic V, Mahaffey KW, et al.; CANVAS Program Collaborative Group. Canagliflozin and cardiovascular and renal events in type 2 diabetes. *N Engl J Med* 2017;377:644–657
56. Marso SP, Daniels GH, Brown-Frandsen K, et al.; LEADER Steering Committee; LEADER Trial Investigators. Liraglutide and cardiovascular outcomes in type 2 diabetes. *N Engl J Med* 2016;375:311–322
57. Marso SP, Bain SC, Consoi A, et al.; SUSTAIN-6 Investigators. Semaglutide and cardiovascular outcomes in patients with type 2 diabetes. *N Engl J Med* 2016;375:1834–1844
58. Blonde L, Merilainen M, Karwe V, Raskin P; TITRATE Study Group. Patient-directed titration for achieving glycaemic goals using a once-daily basal insulin analogue: an assessment of two different fasting plasma glucose targets – the TITRATE study. *Diabetes Obes Metab* 2009;11:623–631
59. Porcellati F, Lucidi P, Cioli P, et al. Pharmacokinetics and pharmacodynamics of insulin glargine given in the evening as compared with in the morning in type 2 diabetes. *Diabetes Care* 2015;38:503–512
60. Wang Z, Hedrington MS, Gogitidze Joy N, et al. Dose-response effects of insulin glargine in type 2 diabetes. *Diabetes Care* 2010;33:1555–1560
61. Singh SR, Ahmad F, Lal A, Yu C, Bai Z, Bennett H. Efficacy and safety of insulin analogues for the management of diabetes mellitus: a meta-analysis. *CMAJ* 2009;180:385–397
62. Horvath K, Jeitler K, Berghold A, et al. Long-acting insulin analogues versus NPH insulin (human isophane insulin) for type 2 diabetes mellitus. *Cochrane Database Syst Rev* 2007;2: CD005613
63. Monami M, Marchionni N, Mannucci E. Long-acting insulin analogues versus NPH human insulin in type 2 diabetes: a meta-analysis. *Diabetes Res Clin Pract* 2008;81:184–189
64. Owens DR, Traylor L, Mullins P, Landgraf W. Patient-level meta-analysis of efficacy and hypoglycaemia in people with type 2 diabetes initiating insulin glargine 100 U/mL or neutral protamine Hagedorn insulin analysed according to concomitant oral antidiabetes therapy. *Diabetes Res Clin Pract* 2017;124(Suppl. C):57–65
65. Riddle MC, Rosenstock J, Gerich J; Insulin Glargine 4002 Study Investigators. The treat-to-target trial: randomized addition of glargine or human NPH insulin to oral therapy of type 2 diabetic patients. *Diabetes Care* 2003;26:3080–3086
66. Hermansen K, Davies M, Dereziński T, Martínez Ravn G, Clauson P, Home P. A 26-week, randomized, parallel, treat-to-target trial comparing insulin detemir with NPH insulin as add-on therapy to oral glucose-lowering drugs in insulin-naïve people with type 2 diabetes. *Diabetes Care* 2006;29:1269–1274
67. Yki-Järvinen H, Kauppinen-Mäkelin R, Tiikkainen M, et al. Insulin glargine or NPH combined with metformin in type 2 diabetes: the LANMET study. *Diabetologia* 2006;49:442–451
68. Bolli GB, Riddle MC, Bergenstal RM, et al.; EDITION 3 study investigators. New insulin glargine 300 U/ml compared with glargine 100 U/ml in insulin-naïve people with type 2 diabetes on oral glucose-lowering drugs: a randomized controlled trial (EDITION 3). *Diabetes Obes Metab* 2015;17:386–394
69. Terauchi Y, Koyama M, Cheng X, et al. New insulin glargine 300 U/ml versus glargine 100 U/ml in Japanese people with type 2 diabetes using basal insulin and oral antihyperglycaemic drugs: glucose control and hypoglycaemia in a randomized controlled trial (EDITION JP 2). *Diabetes Obes Metab* 2016;18:366–374
70. Yki-Järvinen H, Bergenstal RM, Bolli GB, et al. Glycaemic control and hypoglycaemia with new insulin glargine 300 U/ml versus insulin glargine 100 U/ml in people with type 2 diabetes using basal insulin and oral antihyperglycaemic drugs: the EDITION 2 randomized 12-month trial including 6-month extension. *Diabetes Obes Metab* 2015;17:1142–1149
71. Marso SP, McGuire DK, Zinman B, et al.; DEVOTE Study Group. Efficacy and safety of degludec versus glargine in type 2 diabetes. *N Engl J Med* 2017;377:723–732
72. Rodbard HW, Cariou B, Zinman B, et al.; BEGIN Once Long trial investigators. Comparison of insulin degludec with insulin glargine in insulin-naïve subjects with type 2 diabetes: a 2-year randomized, treat-to-target trial. *Diabet Med* 2013;30:1298–1304
73. Wysham C, Bhargava A, Chaykin L, et al. Effect of insulin degludec vs insulin glargine U100 on hypoglycemia in patients with type 2 diabetes: the SWITCH 2 randomized clinical trial. *JAMA* 2017;318:45–56
74. Zinman B, Philis-Tsimikas A, Cariou B, et al.; NN1250-3579 (BEGIN Once Long) Trial Investigators. Insulin degludec versus insulin glargine in insulin-naïve patients with type 2 diabetes: a 1-year, randomized, treat-to-target trial (BEGIN Once Long). *Diabetes Care* 2012;35:2464–2471
75. Lipska KJ, Parker MM, Moffet HH, Huang ES, Karter AJ. Association of initiation of basal insulin analogs vs neutral protamine Hagedorn insulin with hypoglycemia-related emergency department visits or hospital admissions and with glycemic control in patients with type 2 diabetes. *JAMA* 2018;320:53–62
76. Cefalu WT, Dawes DE, Gavlak G, et al.; Insulin Access and Affordability Working Group. Insulin Access and Affordability Working Group: conclusions and recommendations. *Diabetes Care* 2018;41:1299–1311
77. Lipska KJ, Hirsch IB, Riddle MC. Human insulin for type 2 diabetes: an effective, less-expensive option. *JAMA* 2017;318:23–24
78. Mannucci E, Monami M, Marchionni N. Short-acting insulin analogues vs. regular human insulin in type 2 diabetes: a meta-analysis. *Diabetes Obes Metab* 2009;11:53–59
79. Heller S, Bode B, Kozlovski P, Svendsen AL. Meta-analysis of insulin aspart versus regular human insulin used in a basal-bolus regimen for the treatment of diabetes mellitus. *J Diabetes* 2013;5:482–491
80. Riddle MC, Yki-Järvinen H, Bolli GB, et al. One-year sustained glycaemic control and less hypoglycaemia with new insulin glargine 300 U/ml compared with 100 U/ml in people with type 2 diabetes using basal plus meal-time insulin: the EDITION 1 12-month randomized trial, including 6-month extension. *Diabetes Obes Metab* 2015;17:835–842

81. Yki-Järvinen H, Bergenstal R, Ziemer M, et al.; EDITION 2 Study Investigators. New insulin glargine 300 units/mL versus glargine 100 units/mL in people with type 2 diabetes using oral agents and basal insulin: glucose control and hypoglycemia in a 6-month randomized controlled trial (EDITION 2). *Diabetes Care* 2014;37:3235–3243
82. Akturk HK, Snell-Bergeon JK, Rewers A, et al. Improved postprandial glucose with inhaled technosphere insulin compared with insulin aspart in patients with type 1 diabetes on multiple daily injections: the STAT study. *Diabetes Technol Ther* 2018;20:639–647
83. Diamant M, Nauck MA, Shaginian R, et al.; 4B Study Group. Glucagon-like peptide 1 receptor agonist or bolus insulin with optimized basal insulin in type 2 diabetes. *Diabetes Care* 2014;37:2763–2773
84. Eng C, Kramer CK, Zinman B, Retnakaran R. Glucagon-like peptide-1 receptor agonist and basal insulin combination treatment for the management of type 2 diabetes: a systematic review and meta-analysis. *Lancet* 2014;384:2228–2234
85. Maiorino MI, Chiodini P, Bellastella G, Capuano A, Esposito K, Giugliano D. Insulin and glucagon-like peptide 1 receptor agonist combination therapy in type 2 diabetes: a systematic review and meta-analysis of randomized controlled trials. *Diabetes Care* 2017;40:614–624
86. Rodbard HW, Visco VE, Andersen H, Hiort LC, Shu DHW. Treatment intensification with stepwise addition of prandial insulin aspart boluses compared with full basal-bolus therapy (FullSTEP Study): a randomised, treat-to-target clinical trial. *Lancet Diabetes Endocrinol* 2014;2:30–37



American Diabetes Association

10. Cardiovascular Disease and Risk Management: *Standards of Medical Care in Diabetes—2019*

Diabetes Care 2019;42(Suppl. 1):S103–S123 | <https://doi.org/10.2337/dc19S010>

The American Diabetes Association (ADA) “Standards of Medical Care in Diabetes” includes ADA’s current clinical practice recommendations and is intended to provide the components of diabetes care, general treatment goals and guidelines, and tools to evaluate quality of care. Members of the ADA Professional Practice Committee, a multidisciplinary expert committee, are responsible for updating the Standards of Care annually, or more frequently as warranted. For a detailed description of ADA standards, statements, and reports, as well as the evidence-grading system for ADA’s clinical practice recommendations, please refer to the Standards of Care Introduction. Readers who wish to comment on the Standards of Care are invited to do so at professional.diabetes.org/SOC.

For prevention and management of diabetes complications in children and adolescents, please refer to Section 13 “Children and Adolescents.”

Atherosclerotic cardiovascular disease (ASCVD)—defined as coronary heart disease, cerebrovascular disease, or peripheral arterial disease presumed to be of atherosclerotic origin—is the leading cause of morbidity and mortality for individuals with diabetes and results in an estimated \$37.3 billion in cardiovascular-related spending per year associated with diabetes (1). Common conditions coexisting with type 2 diabetes (e.g., hypertension and dyslipidemia) are clear risk factors for ASCVD, and diabetes itself confers independent risk. Numerous studies have shown the efficacy of controlling individual cardiovascular risk factors in preventing or slowing ASCVD in people with diabetes. Furthermore, large benefits are seen when multiple cardiovascular risk factors are addressed simultaneously. Under the current paradigm of aggressive risk factor modification in patients with diabetes, there is evidence that measures of 10-year coronary heart disease (CHD) risk among U.S. adults with diabetes have improved significantly over the past decade (2) and that ASCVD morbidity and mortality have decreased (3,4).

Heart failure is another major cause of morbidity and mortality from cardiovascular disease. Recent studies have found that rates of incident heart failure hospitalization (adjusted for age and sex) were twofold higher in patients with diabetes compared with those without (5,6). People with diabetes may have heart failure with preserved ejection fraction (HFpEF) or with reduced ejection fraction (HFrEF). Hypertension is often a precursor of heart failure of either type, and ASCVD can coexist with either type (7), whereas prior myocardial infarction (MI) is often a major factor in HFrEF. Rates of heart failure hospitalization have been improved in recent trials including patients with type 2 diabetes, most of whom also had ASCVD, with sodium–glucose cotransporter 2 (SGLT2) inhibitors (8–10).

For prevention and management of both ASCVD and heart failure, cardiovascular risk factors should be systematically assessed at least annually in all patients with diabetes. These risk factors include obesity/overweight, hypertension, dyslipidemia, smoking, a

This section has received endorsement from the American College of Cardiology.

Suggested citation: American Diabetes Association. 10. Cardiovascular disease and risk management: Standards of Medical Care in Diabetes—2019. Diabetes Care 2019;42(Suppl. 1): S103–S123

© 2018 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. More information is available at <http://www.diabetesjournals.org/content/license>.

family history of premature coronary disease, chronic kidney disease, and the presence of albuminuria. Modifiable abnormal risk factors should be treated as described in these guidelines.

The Risk Calculator

The American College of Cardiology/American Heart Association ASCVD risk calculator (Risk Estimator Plus) is generally a useful tool to estimate 10-year ASCVD risk (<http://tools.acc.org/ASCVD-Risk-Estimator-Plus>). These calculators have diabetes as a risk factor, since diabetes itself confers increased risk for ASCVD, although it should be acknowledged that these risk calculators do not account for the duration of diabetes or the presence of diabetes complications, such as albuminuria. Although some variability in calibration exists in various subgroups, including by sex, race, and diabetes, the overall risk prediction does not differ in those with or without diabetes (11–14), validating the use of risk calculators in people with diabetes. The 10-year risk of a first ASCVD event should be assessed to better stratify ASCVD risk and help guide therapy, as described below.

Recently, risk scores and other cardiovascular biomarkers have been developed for risk stratification of secondary prevention patients (i.e., those who are already high risk because they have ASCVD) but are not yet in widespread use (15,16). With newer, more expensive lipid-lowering therapies now available, use of these risk assessments may help target these new therapies to “higher risk” ASCVD patients in the future.

HYPERTENSION/BLOOD PRESSURE CONTROL

Hypertension, defined as a sustained blood pressure $\geq 140/90$ mmHg, is common among patients with either type 1 or type 2 diabetes. Hypertension is a major risk factor for both ASCVD and microvascular complications. Moreover, numerous studies have shown that antihypertensive therapy reduces ASCVD events, heart failure, and microvascular complications. Please refer to the American Diabetes Association (ADA) position statement “Diabetes and Hypertension” for a detailed review of the epidemiology, diagnosis, and treatment of hypertension (17). The recommendations presented here reflect ADA’s updated stance on blood pressure.

Screening and Diagnosis

Recommendations

- 10.1** Blood pressure should be measured at every routine clinical visit. Patients found to have elevated blood pressure ($\geq 140/90$ mmHg) should have blood pressure confirmed using multiple readings, including measurements on a separate day, to diagnose hypertension. **B**
- 10.2** All hypertensive patients with diabetes should monitor their blood pressure at home. **B**

Blood pressure should be measured by a trained individual and should follow the guidelines established for the general population: measurement in the seated position, with feet on the floor and arm supported at heart level, after 5 min of rest. Cuff size should be appropriate for the upper-arm circumference. Elevated values should be confirmed on a separate day. Postural changes in blood pressure and pulse may be evidence of autonomic neuropathy and therefore require adjustment of blood pressure targets. Orthostatic blood pressure measurements should be checked on initial visit and as indicated.

Home blood pressure self-monitoring and 24-h ambulatory blood pressure monitoring may provide evidence of white coat hypertension, masked hypertension, or other discrepancies between office and “true” blood pressure (17). In addition to confirming or refuting a diagnosis of hypertension, home blood pressure assessment may be useful to monitor antihypertensive treatment. Studies of individuals without diabetes found that home measurements may better correlate with ASCVD risk than office measurements (18,19). Moreover, home blood pressure monitoring may improve patient medication adherence and thus help reduce cardiovascular risk (20).

Treatment Goals

Recommendations

- 10.3** For patients with diabetes and hypertension, blood pressure targets should be individualized through a shared decision-making process that addresses cardiovascular risk, potential

adverse effects of antihypertensive medications, and patient preferences. **C**

- 10.4** For individuals with diabetes and hypertension at higher cardiovascular risk (existing atherosclerotic cardiovascular disease or 10-year atherosclerotic cardiovascular disease risk $>15\%$), a blood pressure target of $<130/80$ mmHg may be appropriate, if it can be safely attained. **C**
- 10.5** For individuals with diabetes and hypertension at lower risk for cardiovascular disease (10-year atherosclerotic cardiovascular disease risk $<15\%$), treat to a blood pressure target of $<140/90$ mmHg. **A**
- 10.6** In pregnant patients with diabetes and preexisting hypertension who are treated with antihypertensive therapy, blood pressure targets of $120\text{--}160/80\text{--}105$ mmHg are suggested in the interest of optimizing long-term maternal health and minimizing impaired fetal growth. **E**

Randomized clinical trials have demonstrated unequivocally that treatment of hypertension to blood pressure $<140/90$ mmHg reduces cardiovascular events as well as microvascular complications (21–27). Therefore, patients with type 1 or type 2 diabetes who have hypertension should, at a minimum, be treated to blood pressure targets of $<140/90$ mmHg. The benefits and risks of intensifying antihypertensive therapy to target blood pressures lower than $<140/90$ mmHg (e.g., $<130/80$ or $<120/80$ mmHg) have been evaluated in large randomized clinical trials and meta-analyses of clinical trials. Notably, there is an absence of high-quality data available to guide blood pressure targets in type 1 diabetes.

Randomized Controlled Trials of Intensive Versus Standard Blood Pressure Control

The Action to Control Cardiovascular Risk in Diabetes blood pressure (ACCORD BP) trial provides the strongest direct assessment of the benefits and risks of intensive blood pressure control among people with type 2 diabetes (28). In ACCORD BP, compared with standard blood pressure control (target systolic blood pressure <140 mmHg), intensive blood

Table 10.1—Randomized controlled trials of intensive versus standard hypertension treatment strategies

Clinical trial	Population	Intensive	Standard	Outcomes
ACCORD BP (28)	4,733 participants with T2D aged 40–79 years with prior evidence of CVD or multiple cardiovascular risk factors	Systolic blood pressure target: <120 mmHg Achieved (mean) systolic/diastolic: 119.3/64.4 mmHg	Systolic blood pressure target: 130–140 mmHg Achieved (mean) systolic/diastolic: 133.5/70.5 mmHg	<ul style="list-style-type: none"> • No benefit in primary end point: composite of nonfatal MI, nonfatal stroke, and CVD death • Stroke risk reduced 41% with intensive control, not sustained through follow-up beyond the period of active treatment • Adverse events more common in intensive group, particularly elevated serum creatinine and electrolyte abnormalities
ADVANCE BP (29)	11,140 participants with T2D aged 55 years and older with prior evidence of CVD or multiple cardiovascular risk factors	Intervention: a single-pill, fixed-dose combination of perindopril and indapamide Achieved (mean) systolic/diastolic: 136/73 mmHg	Control: placebo Achieved (mean) systolic/diastolic: 141.6/75.2 mmHg	<ul style="list-style-type: none"> • Intervention reduced risk of primary composite end point of major macrovascular and microvascular events (9%), death from any cause (14%), and death from CVD (18%) • 6-year observational follow-up found reduction in risk of death in intervention group attenuated but still significant (174)
HOT (173)	18,790 participants, including 1,501 with diabetes	Diastolic blood pressure target: ≤80 mmHg	Diastolic blood pressure target: ≤90 mmHg	<ul style="list-style-type: none"> • In the overall trial, there was no cardiovascular benefit with more intensive targets • In the subpopulation with diabetes, an intensive diastolic target was associated with a significantly reduced risk (51%) of CVD events
SPRINT (39)	9,361 participants without diabetes	Systolic blood pressure target: <120 mmHg Achieved (mean): 121.4 mmHg	Systolic blood pressure target: <140 mmHg Achieved (mean): 136.2 mmHg	<ul style="list-style-type: none"> • Intensive systolic blood pressure target lowered risk of the primary composite outcome 25% (MI, ACS, stroke, HF, and death due to CVD) • Intensive target reduced risk of death 27% • Intensive therapy increased risks of electrolyte abnormalities and AKI

ACS, acute coronary syndrome; AKI, acute kidney injury; CVD, cardiovascular disease; HF, heart failure; MI, myocardial infarction; T2D, type 2 diabetes. Data from this table can also be found in the ADA position statement “Diabetes and Hypertension” (17).

pressure control (target systolic blood pressure <120 mmHg) did not reduce total major atherosclerotic cardiovascular events but did reduce the risk of stroke, at the expense of increased adverse events (**Table 10.1**). The ACCORD BP results suggest that blood pressure targets more intensive than <140/90 mmHg are not likely to improve cardiovascular outcomes among most people with type 2 diabetes but may be reasonable for patients who may derive the most

benefit and have been educated about added treatment burden, side effects, and costs, as discussed below.

Additional studies, such as the Systolic Blood Pressure Intervention Trial (SPRINT) and the Hypertension Optimal Treatment (HOT) trial, also examined effects of intensive versus standard control (**Table 10.1**), though the relevance of their results to people with diabetes is less clear. The Action in Diabetes and Vascular Disease: Preterax and

Diamicon MR Controlled Evaluation—Blood Pressure (ADVANCE BP) trial did not explicitly test blood pressure targets (29); the achieved blood pressure in the intervention group was higher than that achieved in the ACCORD BP intensive arm and would be consistent with a target blood pressure of <140/90 mmHg. Notably, ACCORD BP and SPRINT measured blood pressure using automated office blood pressure measurement, which yields values that are generally

lower than typical office blood pressure readings by approximately 5–10 mmHg (30), suggesting that implementing the ACCORD BP or SPRINT protocols in an outpatient clinic might require a systolic blood pressure target higher than <120 mmHg, such as <130 mmHg.

A number of post hoc analyses have attempted to explain the apparently divergent results of ACCORD BP and SPRINT. Some investigators have argued that the divergent results are not due to differences between people with and without diabetes but rather are due to differences in study design or to characteristics other than diabetes (31–33). Others have opined that the divergent results are most readily explained by the lack of benefit of intensive blood pressure control on cardiovascular mortality in ACCORD BP, which may be due to differential mechanisms underlying cardiovascular disease in type 2 diabetes, to chance, or both (34).

Meta-analyses of Trials

To clarify optimal blood pressure targets in patients with diabetes, meta-analyses have stratified clinical trials by mean baseline blood pressure or mean blood pressure attained in the intervention (or intensive treatment) arm. Based on these analyses, antihypertensive treatment appears to be beneficial when mean baseline blood pressure is $\geq 140/90$ mmHg or mean attained intensive blood pressure is $\geq 130/80$ mmHg (17,21,22,24–26). Among trials with lower baseline or attained blood pressure, antihypertensive treatment reduced the risk of stroke, retinopathy, and albuminuria, but effects on other ASCVD outcomes and heart failure were not evident. Taken together, these meta-analyses consistently show that treating patients with baseline blood pressure ≥ 140 mmHg to targets <140 mmHg is beneficial, while more intensive targets may offer additional (though probably less robust) benefits.

Individualization of Treatment Targets

Patients and clinicians should engage in a shared decision-making process to determine individual blood pressure targets (17). This approach acknowledges that the benefits and risks of intensive blood pressure targets are uncertain and may vary across patients and is consistent with a patient-focused approach to care that values patient priorities and

provider judgment (35). Secondary analyses of ACCORD BP and SPRINT suggest that clinical factors can help determine individuals more likely to benefit and less likely to be harmed by intensive blood pressure control (36).

Absolute benefit from blood pressure reduction correlated with absolute baseline cardiovascular risk in SPRINT and in earlier clinical trials conducted at higher baseline blood pressure levels (11,37). Extrapolation of these studies suggests that patients with diabetes may also be more likely to benefit from intensive blood pressure control when they have high absolute cardiovascular risk. Therefore, it may be reasonable to target blood pressure <130/80 mmHg among patients with diabetes and either clinically diagnosed cardiovascular disease (particularly stroke, which was significantly reduced in ACCORD BP) or 10-year ASCVD risk $\geq 15\%$, if it can be attained safely. This approach is consistent with guidelines from the American College of Cardiology/American Heart Association, which advocate a blood pressure target <130/80 mmHg for all patients, with or without diabetes (38).

Potential adverse effects of antihypertensive therapy (e.g., hypotension, syncope, falls, acute kidney injury, and electrolyte abnormalities) should also be taken into account (28,39–41). Patients with older age, chronic kidney disease, and frailty have been shown to be at higher risk of adverse effects of intensive blood pressure control (41). In addition, patients with orthostatic hypotension, substantial comorbidity, functional limitations, or polypharmacy may be at high risk of adverse effects, and some patients may prefer higher blood pressure targets to enhance quality of life. Patients with low absolute cardiovascular risk (10-year ASCVD risk <15%) or with a history of adverse effects of intensive blood pressure control or at high risk of such adverse effects should have a higher blood pressure target. In such patients, a blood pressure target of <140/90 mmHg is recommended, if it can be safely attained.

Pregnancy and Antihypertensive Medications

Since there is a lack of randomized controlled trials of antihypertensive therapy in pregnant women with diabetes, recommendations for the management of hypertension in pregnant women with diabetes should be similar to those for

all pregnant women. The American College of Obstetricians and Gynecologists (ACOG) has recommended that women with mild to moderate gestational hypertension (systolic blood pressure <160 mmHg or diastolic blood pressure <110 mmHg) do not need to be treated with antihypertensive medications as there is no benefit identified that clearly outweighs potential risks of therapy (42). A 2014 Cochrane systematic review of antihypertensive therapy for mild to moderate chronic hypertension that included 49 trials and over 4,700 women did not find any conclusive evidence for or against blood pressure treatment to reduce the risk of preeclampsia for the mother or effects on perinatal outcomes such as preterm birth, small-for-gestational-age infants, or fetal death (43). For pregnant women who require antihypertensive therapy, systolic blood pressure levels of 120–160 mmHg and diastolic blood pressure levels of 80–105 mmHg are suggested to optimize maternal health without risking fetal harm. Lower targets (systolic blood pressure 110–119 mmHg and diastolic blood pressure 65–79 mmHg) may contribute to improved long-term maternal health; however, they may be associated with impaired fetal growth. Pregnant women with hypertension and evidence of end-organ damage from cardiovascular and/or renal disease may be considered for lower blood pressure targets to avoid progression of these conditions during pregnancy.

During pregnancy, treatment with ACE inhibitors, angiotensin receptor blockers (ARBs), and spironolactone are contraindicated as they may cause fetal damage. Antihypertensive drugs known to be effective and safe in pregnancy include methyldopa, labetalol, and long-acting nifedipine, while hydralazine may be considered in the acute management of hypertension in pregnancy or severe preeclampsia (42). Diuretics are not recommended for blood pressure control in pregnancy but may be used during late-stage pregnancy if needed for volume control (42,44). ACOG also recommends that postpartum patients with gestational hypertension, preeclampsia, and superimposed preeclampsia have their blood pressures observed for 72 h in the hospital and for 7–10 days postpartum. Long-term follow-up is recommended for these women as they have increased lifetime cardiovascular risk (45). See Section

14 “Management of Diabetes in Pregnancy” for additional information.

Treatment Strategies

Lifestyle Intervention

Recommendations

10.7 For patients with blood pressure >120/80 mmHg, lifestyle intervention consists of weight loss if overweight or obese, a Dietary Approaches to Stop Hypertension (DASH)-style dietary pattern including reducing sodium and increasing potassium intake, moderation of alcohol intake, and increased physical activity. **B**

Lifestyle management is an important component of hypertension treatment because it lowers blood pressure, enhances the effectiveness of some antihypertensive medications, promotes other aspects of metabolic and vascular health, and generally leads to few adverse effects. Lifestyle therapy consists of reducing excess body weight through caloric restriction, restricting sodium intake (<2,300 mg/day), increasing consumption of fruits and vegetables (8–10 servings per day) and low-fat dairy products (2–3 servings per day), avoiding excessive alcohol consumption (no more than 2 servings per day in men and no more than 1 serving per day in women) (46), and increasing activity levels (47).

These lifestyle interventions are reasonable for individuals with diabetes and mildly elevated blood pressure (systolic >120 mmHg or diastolic >80 mmHg) and should be initiated along with pharmacologic therapy when hypertension is diagnosed (Fig. 10.1) (47). A lifestyle therapy plan should be developed in collaboration with the patient and discussed as part of diabetes management.

Pharmacologic Interventions

Recommendations

- 10.8** Patients with confirmed office-based blood pressure \geq 140/90 mmHg should, in addition to lifestyle therapy, have prompt initiation and timely titration of pharmacologic therapy to achieve blood pressure goals. **A**
- 10.9** Patients with confirmed office-based blood pressure \geq 160/100 mmHg should, in addition

to lifestyle therapy, have prompt initiation and timely titration of two drugs or a single-pill combination of drugs demonstrated to reduce cardiovascular events in patients with diabetes. **A**

- 10.10** Treatment for hypertension should include drug classes demonstrated to reduce cardiovascular events in patients with diabetes (ACE inhibitors, angiotensin receptor blockers, thiazide-like diuretics, or dihydropyridine calcium channel blockers). **A**
- 10.11** Multiple-drug therapy is generally required to achieve blood pressure targets. However, combinations of ACE inhibitors and angiotensin receptor blockers and combinations of ACE inhibitors or angiotensin receptor blockers with direct renin inhibitors should not be used. **A**
- 10.12** An ACE inhibitor or angiotensin receptor blocker, at the maximum tolerated dose indicated for blood pressure treatment, is the recommended first-line treatment for hypertension in patients with diabetes and urinary albumin-to-creatinine ratio \geq 300 mg/g creatinine **A** or 30–299 mg/g creatinine. **B** If one class is not tolerated, the other should be substituted. **B**
- 10.13** For patients treated with an ACE inhibitor, angiotensin receptor blocker, or diuretic, serum creatinine/estimated glomerular filtration rate and serum potassium levels should be monitored at least annually. **B**

Initial Number of Antihypertensive Medications.

Initial treatment for people with diabetes depends on the severity of hypertension (Fig. 10.1). Those with blood pressure between 140/90 mmHg and 159/99 mmHg may begin with a single drug. For patients with blood pressure \geq 160/100 mmHg, initial pharmacologic treatment with two antihypertensive medications is recommended in order to more effectively achieve adequate blood pressure control

(48–50). Single-pill antihypertensive combinations may improve medication adherence in some patients (51).

Classes of Antihypertensive Medications. Initial treatment for hypertension should include any of the drug classes demonstrated to reduce cardiovascular events in patients with diabetes: ACE inhibitors (52,53), ARBs (52,53), thiazide-like diuretics (54), or dihydropyridine calcium channel blockers (55). For patients with albuminuria (urine albumin-to-creatinine ratio \geq 30 mg/g), initial treatment should include an ACE inhibitor or ARB in order to reduce the risk of progressive kidney disease (17) (Fig. 10.1). In the absence of albuminuria, risk of progressive kidney disease is low, and ACE inhibitors and ARBs have not been found to afford superior cardioprotection when compared with thiazide-like diuretics or dihydropyridine calcium channel blockers (56). β -Blockers may be used for the treatment of prior MI, active angina, or heart failure but have not been shown to reduce mortality as blood pressure-lowering agents in the absence of these conditions (23,57).

Multiple-Drug Therapy. Multiple-drug therapy is often required to achieve blood pressure targets (Fig. 10.1), particularly in the setting of diabetic kidney disease. However, the use of both ACE inhibitors and ARBs in combination, or the combination of an ACE inhibitor or ARB and a direct renin inhibitor, is not recommended given the lack of added ASCVD benefit and increased rate of adverse events—namely, hyperkalemia, syncope, and acute kidney injury (AKI) (58–60). Titration of and/or addition of further blood pressure medications should be made in a timely fashion to overcome clinical inertia in achieving blood pressure targets.

Bedtime Dosing. Growing evidence suggests that there is an association between the absence of nocturnal blood pressure dipping and the incidence of ASCVD. A meta-analysis of randomized clinical trials found a small benefit of evening versus morning dosing of antihypertensive medications with regard to blood pressure control but had no data on clinical effects (61). In two subgroup analyses of a single subsequent randomized controlled trial, moving at least one antihypertensive medication to bedtime significantly reduced cardiovascular events, but results

Recommendations for the Treatment of Confirmed Hypertension in People With Diabetes

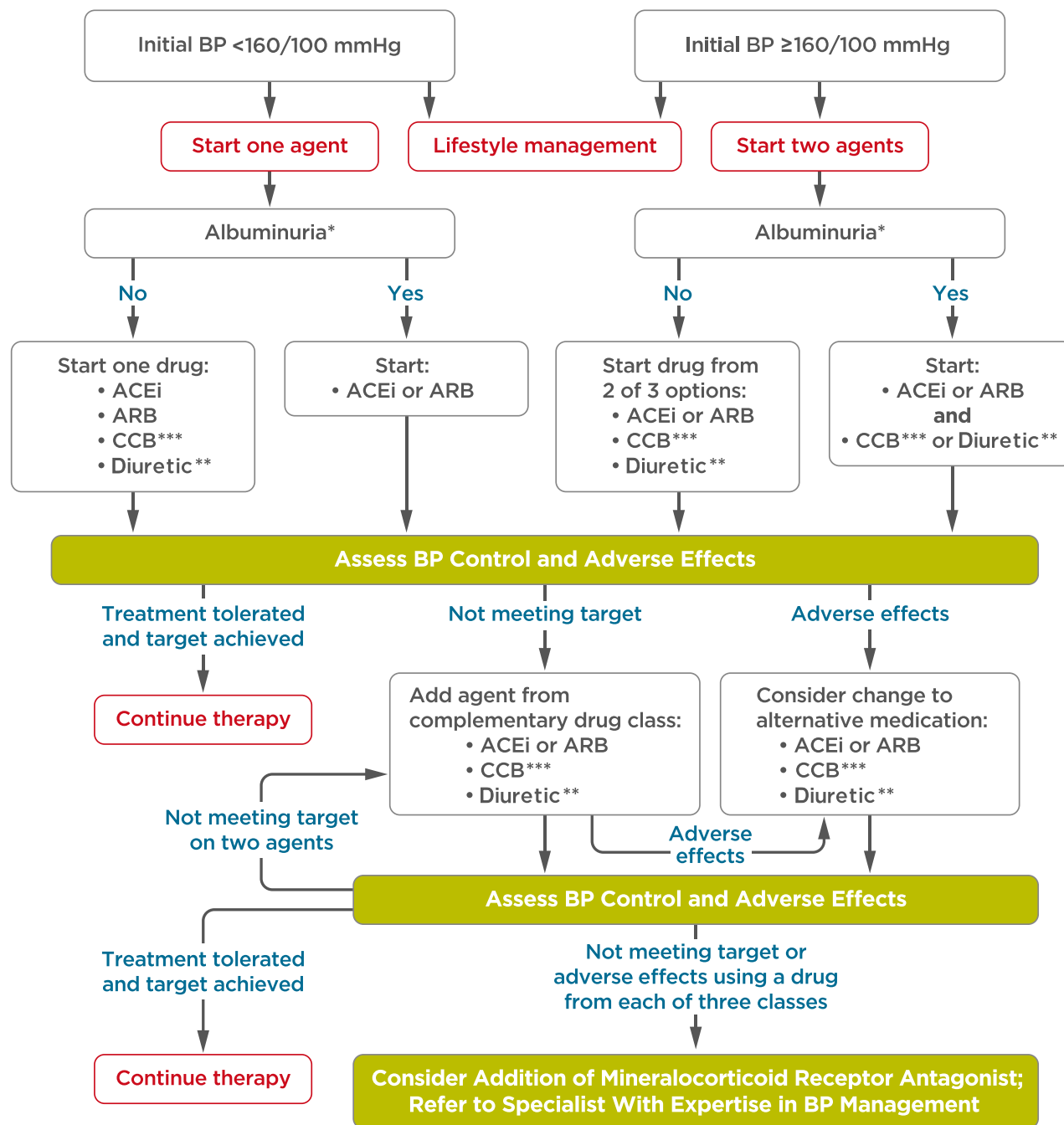


Figure 10.1—Recommendations for the treatment of confirmed hypertension in people with diabetes. *An ACE inhibitor (ACEi) or angiotensin receptor blocker (ARB) is suggested to treat hypertension for patients with urine albumin-to-creatinine ratio 30–299 mg/g creatinine and strongly recommended for patients with urine albumin-to-creatinine ratio ≥300 mg/g creatinine. **Thiazide-like diuretic; long-acting agents shown to reduce cardiovascular events, such as chlorthalidone and indapamide, are preferred. ***Dihydropyridine calcium channel blocker (CCB). BP, blood pressure. Adapted from de Boer et al. (17).

were based on a small number of events (62).

Hyperkalemia and Acute Kidney Injury. Treatment with ACE inhibitors or ARBs can cause AKI and hyperkalemia, while

diuretics can cause AKI and either hypokalemia or hyperkalemia (depending on mechanism of action) (63,64). Detection and management of these abnormalities is important because AKI and hyperkalemia each increase the risks of

cardiovascular events and death (65). Therefore, serum creatinine and potassium should be monitored during treatment with an ACE inhibitor, ARB, or diuretic, particularly among patients with reduced glomerular filtration who

are at increased risk of hyperkalemia and AKI (63,64,66).

Resistant Hypertension

Recommendation

10.14 Patients with hypertension who are not meeting blood pressure targets on three classes of antihypertensive medications (including a diuretic) should be considered for mineralocorticoid receptor antagonist therapy. **B**

Resistant hypertension is defined as blood pressure $\geq 140/90$ mmHg despite a therapeutic strategy that includes appropriate lifestyle management plus a diuretic and two other antihypertensive drugs belonging to different classes at adequate doses. Prior to diagnosing resistant hypertension, a number of other conditions should be excluded, including medication nonadherence, white coat hypertension, and secondary hypertension. In general, barriers to medication adherence (such as cost and side effects) should be identified and addressed (**Fig. 10.1**). Mineralocorticoid receptor antagonists are effective for management of resistant hypertension in patients with type 2 diabetes when added to existing treatment with an ACE inhibitor or ARB, thiazide-like diuretic, and dihydropyridine calcium channel blocker (67). Mineralocorticoid receptor antagonists also reduce albuminuria and have additional cardiovascular benefits (68–71). However, adding a mineralocorticoid receptor antagonist to a regimen including an ACE inhibitor or ARB may increase the risk for hyperkalemia, emphasizing the importance of regular monitoring for serum creatinine and potassium in these patients, and long-term outcome studies are needed to better evaluate the role of mineralocorticoid receptor antagonists in blood pressure management.

LIPID MANAGEMENT

Lifestyle Intervention

Recommendations

10.15 Lifestyle modification focusing on weight loss (if indicated); application of a Mediterranean diet or Dietary Approaches to Stop Hypertension (DASH) dietary pattern; reduction of

saturated fat and *trans* fat; increase of dietary n-3 fatty acids, viscous fiber, and plant stanols/sterols intake; and increased physical activity should be recommended to improve the lipid profile and reduce the risk of developing atherosclerotic cardiovascular disease in patients with diabetes. **A**

10.16 Intensify lifestyle therapy and optimize glycemic control for patients with elevated triglyceride levels (≥ 150 mg/dL [1.7 mmol/L]) and/or low HDL cholesterol (< 40 mg/dL [1.0 mmol/L] for men, < 50 mg/dL [1.3 mmol/L] for women). **C**

Lifestyle intervention, including weight loss (72), increased physical activity, and medical nutrition therapy, allows some patients to reduce ASCVD risk factors. Nutrition intervention should be tailored according to each patient's age, diabetes type, pharmacologic treatment, lipid levels, and medical conditions.

Recommendations should focus on application of a Mediterranean diet (73) or Dietary Approaches to Stop Hypertension (DASH) dietary pattern, reducing saturated and *trans* fat intake and increasing plant stanols/sterols, n-3 fatty acids, and viscous fiber (such as in oats, legumes, and citrus) intake (74). Glycemic control may also beneficially modify plasma lipid levels, particularly in patients with very high triglycerides and poor glycemic control. See Section 5 "Lifestyle Management" for additional nutrition information.

Ongoing Therapy and Monitoring With Lipid Panel

Recommendations

10.17 In adults not taking statins or other lipid-lowering therapy, it is reasonable to obtain a lipid profile at the time of diabetes diagnosis, at an initial medical evaluation, and every 5 years thereafter if under the age of 40 years, or more frequently if indicated. **E**

10.18 Obtain a lipid profile at initiation of statins or other lipid-lowering therapy, 4–12 weeks

after initiation or a change in dose, and annually thereafter as it may help to monitor the response to therapy and inform medication adherence. **E**

In adults with diabetes, it is reasonable to obtain a lipid profile (total cholesterol, LDL cholesterol, HDL cholesterol, and triglycerides) at the time of diagnosis, at the initial medical evaluation, and at least every 5 years thereafter in patients under the age of 40 years. In younger patients with longer duration of disease (such as those with youth-onset type 1 diabetes), more frequent lipid profiles may be reasonable. A lipid panel should also be obtained immediately before initiating statin therapy. Once a patient is taking a statin, LDL cholesterol levels should be assessed 4–12 weeks after initiation of statin therapy, after any change in dose, and on an individual basis (e.g., to monitor for medication adherence and efficacy). If LDL cholesterol levels are not responding in spite of medication adherence, clinical judgment is recommended to determine the need for and timing of lipid panels. In individual patients, the highly variable LDL cholesterol-lowering response seen with statins is poorly understood (75). Clinicians should attempt to find a dose or alternative statin that is tolerable if side effects occur. There is evidence for benefit from even extremely low, less than daily statin doses (76).

Statin Treatment

Recommendations

10.19 For patients of all ages with diabetes and atherosclerotic cardiovascular disease or 10-year atherosclerotic cardiovascular disease risk $> 20\%$, high-intensity statin therapy should be added to lifestyle therapy. **A**

10.20 For patients with diabetes aged < 40 years with additional atherosclerotic cardiovascular disease risk factors, the patient and provider should consider using moderate-intensity statin in addition to lifestyle therapy. **C**

10.21 For patients with diabetes aged 40–75 years **A** and

>75 years **B** without atherosclerotic cardiovascular disease, use moderate-intensity statin in addition to lifestyle therapy.

10.22 In patients with diabetes who have multiple atherosclerotic cardiovascular disease risk factors, it is reasonable to consider high-intensity statin therapy. **C**

10.23 For patients who do not tolerate the intended intensity, the maximally tolerated statin dose should be used. **E**

10.24 For patients with diabetes and atherosclerotic cardiovascular disease, if LDL cholesterol is ≥ 70 mg/dL on maximally tolerated statin dose, consider adding additional LDL-lowering therapy (such as ezetimibe or PCSK9 inhibitor). **A** Ezetimibe may be preferred due to lower cost.

10.25 Statin therapy is contraindicated in pregnancy. **B**

demonstrated the beneficial effects of statin therapy on ASCVD outcomes in subjects with and without CHD (77,78). Subgroup analyses of patients with diabetes in larger trials (79–83) and trials in patients with diabetes (84,85) showed significant primary and secondary prevention of ASCVD events and CHD death in patients with diabetes. Meta-analyses, including data from over 18,000 patients with diabetes from 14 randomized trials of statin therapy (mean follow-up 4.3 years), demonstrate a 9% proportional reduction in all-cause mortality and 13% reduction in vascular mortality for each mmol/L (39 mg/dL) reduction in LDL cholesterol (86).

Accordingly, statins are the drugs of choice for LDL cholesterol lowering and cardioprotection. **Table 10.2** shows recommended lipid-lowering strategies, and **Table 10.3** shows the two statin dosing intensities that are recommended for use in clinical practice: high-intensity statin therapy will achieve approximately a 50% reduction in LDL cholesterol, and moderate-intensity statin regimens achieve 30–50% reductions in LDL cholesterol. Low-dose statin therapy is generally not recommended in patients with diabetes but is sometimes the only dose of statin that a patient can tolerate. For patients who do not tolerate the intended intensity of statin, the maximally tolerated statin dose should be used.

As in those without diabetes, absolute reductions in ASCVD outcomes (CHD death and nonfatal MI) are greatest in people with high baseline ASCVD risk (known ASCVD and/or very high LDL cholesterol levels), but the overall benefits of statin therapy in people with diabetes at moderate or even low risk for ASCVD are convincing (87,88). The *relative* benefit of lipid-lowering therapy has been uniform across most subgroups tested (78,86), including subgroups that varied with respect to age and other risk factors.

Primary Prevention (Patients Without ASCVD)

For primary prevention, moderate-dose statin therapy is recommended for those 40 years and older (80,87,88), though high-intensity therapy may be considered on an individual basis in the context of additional ASCVD risk factors. The evidence is strong for patients with diabetes aged 40–75 years, an age-group well represented in statin trials showing benefit. Since risk is enhanced in patients with diabetes, as noted above, patients who also have multiple other coronary risk factors have increased risk, equivalent to that of those with ASCVD. As such, recent guidelines recommend that in patients with diabetes who have multiple ASCVD risk factors, it is reasonable to prescribe high-intensity statin therapy (12,89). Furthermore, for patients with diabetes whose ASCVD risk is $>20\%$, i.e., an ASCVD risk equivalent, the same high-intensity statin therapy is recommended as for those with documented ASCVD (12).

The evidence is lower for patients aged >75 years; relatively few older patients with diabetes have been enrolled in primary prevention trials. However, heterogeneity by age has not been seen in the relative benefit of lipid-lowering therapy in trials that included older participants (78,85,86), and because older age confers higher risk, the absolute benefits are actually greater (78,90). Moderate-intensity statin therapy is recommended in patients with diabetes that are 75 years or older. However, the risk-benefit profile should be routinely evaluated in this population, with downward titration of dose performed as needed. See Section 12 “Older Adults” for more details on clinical considerations for this population.

Age < 40 Years and/or Type 1 Diabetes. Very little clinical trial evidence exists for

Initiating Statin Therapy Based on Risk

Patients with type 2 diabetes have an increased prevalence of lipid abnormalities, contributing to their high risk of ASCVD. Multiple clinical trials have

Table 10.2—Recommendations for statin and combination treatment in adults with diabetes

Age	ASCVD or 10-year ASCVD risk $>20\%$	Recommended statin intensity ^a and combination treatment*
<40 years	No	None [†]
	Yes	High <ul style="list-style-type: none"> • In patients with ASCVD, if LDL cholesterol ≥ 70 mg/dL despite maximally tolerated statin dose, consider adding additional LDL-lowering therapy (such as ezetimibe or PCSK9 inhibitor)[#]
≥ 40 years	No	Moderate [‡]
	Yes	High <ul style="list-style-type: none"> • In patients with ASCVD, if LDL cholesterol ≥ 70 mg/dL despite maximally tolerated statin dose, consider adding additional LDL-lowering therapy (such as ezetimibe or PCSK9 inhibitor)

ASCVD, atherosclerotic cardiovascular disease; PCSK9, proprotein convertase subtilisin/kexin type 9. *In addition to lifestyle therapy. ^aFor patients who do not tolerate the intended intensity of statin, the maximally tolerated statin dose should be used. [†]Moderate-intensity statin may be considered based on risk-benefit profile and presence of ASCVD risk factors. ASCVD risk factors include LDL cholesterol ≥ 100 mg/dL (2.6 mmol/L), high blood pressure, smoking, chronic kidney disease, albuminuria, and family history of premature ASCVD. [‡]High-intensity statin may be considered based on risk-benefit profile and presence of ASCVD risk factors. [#]Adults aged <40 years with prevalent ASCVD were not well represented in clinical trials of non-statin-based LDL reduction. Before initiating combination lipid-lowering therapy, consider the potential for further ASCVD risk reduction, drug-specific adverse effects, and patient preferences.

Table 10.3—High-intensity and moderate-intensity statin therapy*

High-intensity statin therapy (lowers LDL cholesterol by $\geq 50\%$)	Moderate-intensity statin therapy (lowers LDL cholesterol by 30–50%)
Atorvastatin 40–80 mg	Atorvastatin 10–20 mg
Rosuvastatin 20–40 mg	Rosuvastatin 5–10 mg
	Simvastatin 20–40 mg
	Pravastatin 40–80 mg
	Lovastatin 40 mg
	Fluvastatin XL 80 mg
	Pitavastatin 2–4 mg

*Once-daily dosing. XL, extended release.

patients with type 2 diabetes under the age of 40 years or for patients with type 1 diabetes of any age. For pediatric recommendations, see Section 13 “Children and Adolescents.” In the Heart Protection Study (lower age limit 40 years), the subgroup of ~600 patients with type 1 diabetes had a proportionately similar, although not statistically significant, reduction in risk as patients with type 2 diabetes (80). Even though the data are not definitive, similar statin treatment approaches should be considered for patients with type 1 or type 2 diabetes, particularly in the presence of other cardiovascular risk factors. Patients below the age of 40 have lower risk of developing a cardiovascular event over a 10-year horizon; however, their lifetime risk of developing cardiovascular disease and suffering an MI, stroke, or cardiovascular death is high. For patients under the age of 40 years and/or who have type 1 diabetes with other ASCVD risk factors, we recommend that the patient and health care provider discuss the relative benefits and risks and consider the use of moderate-intensity statin therapy. Please refer to “Type 1 Diabetes Mellitus and Cardiovascular Disease: A Scientific Statement From the American Heart Association and American Diabetes Association” (91) for additional discussion.

Secondary Prevention (Patients With ASCVD)

Because risk is high in patients with ASCVD, intensive therapy is indicated and has been shown to be of benefit in multiple large randomized cardiovascular outcomes trials (86,90,92,93). High-intensity statin therapy is recommended for all patients with diabetes and ASCVD. This recommendation is based on the Cholesterol Treatment Trialists’ Collaboration involving 26 statin trials, of which 5 compared high-intensity versus moderate-intensity statins. Together, they found reductions in nonfatal cardiovascular

events with more intensive therapy, in patients with and without diabetes (78,82,92).

Over the past few years, there have been multiple large randomized trials investigating the benefits of adding non-statin agents to statin therapy, including those that evaluated further lowering of LDL cholesterol with ezetimibe (90,94) and proprotein convertase subtilisin/kexin type 9 (PCSK9) inhibitors (93). Each trial found a significant benefit in the reduction of ASCVD events that was directly related to the degree of further LDL cholesterol lowering. These large trials included a significant number of participants with diabetes. For patients with ASCVD who are on high-intensity (and maximally tolerated) statin therapy and have an LDL cholesterol ≥ 70 mg/dL, the addition of nonstatin LDL-lowering therapy is recommended following a clinician-patient discussion about the net benefit, safety, and cost (Table 10.2).

Combination Therapy for LDL Cholesterol Lowering

Statins and Ezetimibe

The IMPROVED Reduction of Outcomes: Vytorin Efficacy International Trial (IMPROVE-IT) was a randomized controlled trial in 18,144 patients comparing the addition of ezetimibe to simvastatin therapy versus simvastatin alone. Individuals were ≥ 50 years of age, had experienced a recent acute coronary syndrome (ACS), and were treated for an average of 6 years. Overall, the addition of ezetimibe led to a 6.4% relative benefit and a 2% absolute reduction in major adverse cardiovascular events, with the degree of benefit being directly proportional to the change in LDL cholesterol, which was 70 mg/dL in the statin group on average and 54 mg/dL in the combination group (90). In those with

diabetes (27% of participants), the combination of moderate-intensity simvastatin (40 mg) and ezetimibe (10 mg) showed a significant reduction of major adverse cardiovascular events with an absolute risk reduction of 5% (40% vs. 45% cumulative incidence at 7 years) and relative risk reduction of 14% (hazard ratio [HR] 0.86 [95% CI 0.78–0.94]) over moderate-intensity simvastatin (40 mg) alone (94).

Statins and PCSK9 Inhibitors

Placebo-controlled trials evaluating the addition of the PCSK9 inhibitors evolocumab and alirocumab to maximally tolerated doses of statin therapy in participants who were at high risk for ASCVD demonstrated an average reduction in LDL cholesterol ranging from 36% to 59%. These agents have been approved as adjunctive therapy for patients with ASCVD or familial hypercholesterolemia who are receiving maximally tolerated statin therapy but require additional lowering of LDL cholesterol (95,96).

The effects of PCSK9 inhibition on ASCVD outcomes was investigated in the Further Cardiovascular Outcomes Research With PCSK9 Inhibition in Subjects With Elevated Risk (FOURIER) trial, which enrolled 27,564 patients with prior ASCVD and an additional high-risk feature who were receiving their maximally tolerated statin therapy (two-thirds were on high-intensity statin) but who still had an LDL cholesterol ≥ 70 mg/dL or a non-HDL cholesterol ≥ 100 mg/dL (93). Patients were randomized to receive subcutaneous injections of evolocumab (either 140 mg every 2 weeks or 420 mg every month based on patient preference) versus placebo. Evolocumab reduced LDL cholesterol by 59% from a median of 92 to 30 mg/dL in the treatment arm.

During the median follow-up of 2.2 years, the composite outcome of cardiovascular death, MI, stroke, hospitalization for angina, or revascularization occurred in 11.3% vs. 9.8% of the placebo and evolocumab groups, respectively, representing a 15% relative risk reduction ($P < 0.001$). The combined end point of cardiovascular death, MI, or stroke was reduced by 20%, from 7.4% to 5.9% ($P < 0.001$). Importantly, similar benefits were seen in prespecified subgroup of patients with diabetes, comprising 11,031 patients (40% of the trial) (97).

Treatment of Other Lipoprotein Fractions or Targets



Recommendations

- 10.26** For patients with fasting triglyceride levels ≥ 500 mg/dL (5.7 mmol/L), evaluate for secondary causes of hypertriglyceridemia and consider medical therapy to reduce the risk of pancreatitis. **C**
- 10.27** In adults with moderate hypertriglyceridemia (fasting or nonfasting triglycerides 175–499 mg/dL), clinicians should address and treat lifestyle factors (obesity and metabolic syndrome), secondary factors (diabetes, chronic liver or kidney disease and/or nephrotic syndrome, hypothyroidism), and medications that raise triglycerides. **C**



Hypertriglyceridemia should be addressed with dietary and lifestyle changes including weight loss and abstinence from alcohol (98). Severe hypertriglyceridemia (fasting triglycerides ≥ 500 mg/dL and especially $>1,000$ mg/dL) may warrant pharmacologic therapy (fibric acid derivatives and/or fish oil) to reduce the risk of acute pancreatitis. In addition, if 10-year ASCVD risk is $\geq 7.5\%$, it is reasonable to initiate moderate-intensity statin therapy or increase statin intensity from moderate to high. In patients with moderate hypertriglyceridemia, lifestyle interventions, treatment of secondary factors, and avoidance of medications that might raise triglycerides are recommended.

Low levels of HDL cholesterol, often associated with elevated triglyceride levels, are the most prevalent pattern of dyslipidemia in individuals with type 2 diabetes. However, the evidence for the use of drugs that target these lipid fractions is substantially less robust than that for statin therapy (99). In a large trial in patients with diabetes, fenofibrate failed to reduce overall cardiovascular outcomes (100).

Other Combination Therapy

Recommendations

- 10.28** Combination therapy (statin/fibrate) has not been shown to improve atherosclerotic cardio-

vascular disease outcomes and is generally not recommended. **A**

- 10.29** Combination therapy (statin/niacin) has not been shown to provide additional cardiovascular benefit above statin therapy alone, may increase the risk of stroke with additional side effects, and is generally not recommended. **A**

Statin and Fibrate

Combination therapy (statin and fibrate) is associated with an increased risk for abnormal transaminase levels, myositis, and rhabdomyolysis. The risk of rhabdomyolysis is more common with higher doses of statins and renal insufficiency and appears to be higher when statins are combined with gemfibrozil (compared with fenofibrate) (101).

In the ACCORD study, in patients with type 2 diabetes who were at high risk for ASCVD, the combination of fenofibrate and simvastatin did not reduce the rate of fatal cardiovascular events, nonfatal MI, or nonfatal stroke as compared with simvastatin alone. Prespecified subgroup analyses suggested heterogeneity in treatment effects with possible benefit for men with both a triglyceride level ≥ 204 mg/dL (2.3 mmol/L) and an HDL cholesterol level ≤ 34 mg/dL (0.9 mmol/L) (102). A prospective trial of a newer fibrate in this specific population of patients is ongoing (103).

Statin and Niacin

The Atherothrombosis Intervention in Metabolic Syndrome With Low HDL/High Triglycerides: Impact on Global Health Outcomes (AIM-HIGH) trial randomized over 3,000 patients (about one-third with diabetes) with established ASCVD, low LDL cholesterol levels (<180 mg/dL [4.7 mmol/L]), low HDL cholesterol levels (men <40 mg/dL [1.0 mmol/L] and women <50 mg/dL [1.3 mmol/L]), and triglyceride levels of 150–400 mg/dL (1.7–4.5 mmol/L) to statin therapy plus extended-release niacin or placebo. The trial was halted early due to lack of efficacy on the primary ASCVD outcome (first event of the composite of death from CHD, nonfatal MI, ischemic stroke, hospitalization for an ACS, or symptom-driven coronary or cerebral revascularization) and a possible

increase in ischemic stroke in those on combination therapy (104).

The much larger Heart Protection Study 2—Treatment of HDL to Reduce the Incidence of Vascular Events (HPS2-THRIVE) trial also failed to show a benefit of adding niacin to background statin therapy (105). A total of 25,673 patients with prior vascular disease were randomized to receive 2 g of extended-release niacin and 40 mg of laropiprant (an antagonist of the prostaglandin D2 receptor DP₁ that has been shown to improve adherence to niacin therapy) versus a matching placebo daily and followed for a median follow-up period of 3.9 years. There was no significant difference in the rate of coronary death, MI, stroke, or coronary revascularization with the addition of niacin-laropiprant versus placebo (13.2% vs. 13.7%; rate ratio 0.96; $P = 0.29$). Niacin-laropiprant was associated with an increased incidence of new-onset diabetes (absolute excess, 1.3 percentage points; $P < 0.001$) and disturbances in diabetes control among those with diabetes. In addition, there was an increase in serious adverse events associated with the gastrointestinal system, musculoskeletal system, skin, and, unexpectedly, infection and bleeding.

Therefore, combination therapy with a statin and niacin is not recommended given the lack of efficacy on major ASCVD outcomes and increased side effects.

Diabetes With Statin Use

Several studies have reported a modestly increased risk of incident diabetes with statin use (106,107), which may be limited to those with diabetes risk factors. An analysis of one of the initial studies suggested that although statin use was associated with diabetes risk, the cardiovascular event rate reduction with statins far outweighed the risk of incident diabetes even for patients at highest risk for diabetes (108). The absolute risk increase was small (over 5 years of follow-up, 1.2% of participants on placebo developed diabetes and 1.5% on rosuvastatin developed diabetes) (108). A meta-analysis of 13 randomized statin trials with 91,140 participants showed an odds ratio of 1.09 for a new diagnosis of diabetes, so that (on average) treatment of 255 patients with statins for 4 years resulted in one additional case of diabetes while simultaneously preventing 5.4

vascular events among those 255 patients (107).

Lipid-Lowering Agents and Cognitive Function

Although this issue has been raised, several lines of evidence point against this association, as detailed in a 2018 European Atherosclerosis Society Consensus Panel statement (109). First, there are three large randomized trials of statin versus placebo where specific cognitive tests were performed, and no differences were seen between statin and placebo (110–113). In addition, no change in cognitive function has been reported in studies with the addition of ezetimibe (90) or PCSK9 inhibitors (93,114) to statin therapy, including among patients treated to very low LDL cholesterol levels. In addition, the most recent systematic review of the U.S. Food and Drug Administration's (FDA's) postmarketing surveillance databases, randomized controlled trials, and cohort, case-control, and cross-sectional studies evaluating cognition in patients receiving statins found that published data do not reveal an adverse effect of statins on cognition (115). Therefore, a concern that statins or other lipid-lowering agents might cause cognitive dysfunction or dementia is not currently supported by evidence and should not deter their use in individuals with diabetes at high risk for ASCVD (115).

ANTIPLATELET AGENTS

Recommendations

- 10.30** Use aspirin therapy (75–162 mg/day) as a secondary prevention strategy in those with diabetes and a history of atherosclerotic cardiovascular disease. **A**
- 10.31** For patients with atherosclerotic cardiovascular disease and documented aspirin allergy, clopidogrel (75 mg/day) should be used. **B**
- 10.32** Dual antiplatelet therapy (with low-dose aspirin and a P2Y12 inhibitor) is reasonable for a year after an acute coronary syndrome **A** and may have benefits beyond this period. **B**
- 10.33** Aspirin therapy (75–162 mg/day) may be considered as a

primary prevention strategy in those with diabetes who are at increased cardiovascular risk, after a discussion with the patient on the benefits versus increased risk of bleeding. **C**

Risk Reduction

Aspirin has been shown to be effective in reducing cardiovascular morbidity and mortality in high-risk patients with previous MI or stroke (secondary prevention) and is strongly recommended. In primary prevention, however, among patients with no previous cardiovascular events, its net benefit is more controversial (116,117).

Previous randomized controlled trials of aspirin specifically in patients with diabetes failed to consistently show a significant reduction in overall ASCVD end points, raising questions about the efficacy of aspirin for primary prevention in people with diabetes, although some sex differences were suggested (118–120).

The Antithrombotic Trialists' Collaboration published an individual patient-level meta-analysis (116) of the six large trials of aspirin for primary prevention in the general population. These trials collectively enrolled over 95,000 participants, including almost 4,000 with diabetes. Overall, they found that aspirin reduced the risk of serious vascular events by 12% (RR 0.88 [95% CI 0.82–0.94]). The largest reduction was for nonfatal MI, with little effect on CHD death (RR 0.95 [95% CI 0.78–1.15]) or total stroke.

Most recently, the ASCEND (A Study of Cardiovascular Events in Diabetes) trial randomized 15,480 patients with diabetes but no evident cardiovascular disease to aspirin 100 mg daily or placebo (121). The primary efficacy end point was vascular death, MI, or stroke or transient ischemic attack. The primary safety outcome was major bleeding (i.e., intracranial hemorrhage, sight-threatening bleeding in the eye, gastrointestinal bleeding, or other serious bleeding). During a mean follow-up of 7.4 years, there was a significant 12% reduction in the primary efficacy end point (8.5% vs. 9.6%; $P = 0.01$). In contrast, major bleeding was significantly increased from 3.2% to 4.1% in the aspirin group (rate ratio 1.29; $P = 0.003$), with most of the excess being

gastrointestinal bleeding and other extracranial bleeding. There were no significant differences by sex, weight, or duration of diabetes or other baseline factors including ASCVD risk score.

Two other large randomized trials of aspirin for primary prevention, in patients without diabetes (ARRIVE [Aspirin to Reduce Risk of Initial Vascular Events]) (122) and in the elderly (ASPREE [Aspirin in Reducing Events in the Elderly]) (123), including 11% with diabetes, found no benefit of aspirin on the primary efficacy end point and an increased risk of bleeding. In ARRIVE, with 12,546 patients over a period of 60 months follow-up, the primary end point occurred in 4.29% vs. 4.48% of patients in the aspirin versus placebo groups (HR 0.96; 95% CI 0.81–1.13; $P = 0.60$). Gastrointestinal bleeding events (characterized as mild) occurred in 0.97% of patients in the aspirin group vs. 0.46% in the placebo group (HR 2.11; 95% CI 1.36–3.28; $P = 0.0007$). In ASPREE, including 19,114 persons, for the rate of cardiovascular disease (fatal CHD, MI, stroke, or hospitalization for heart failure) after a median of 4.7 years of follow-up, the rates per 1,000 person-years were 10.7 vs. 11.3 events in aspirin vs. placebo groups (HR 0.95; 95% CI 0.83–1.08). The rate of major hemorrhage per 1,000 person-years was 8.6 events vs. 6.2 events, respectively (HR 1.38; 95% CI 1.18–1.62; $P < 0.001$).

Thus, aspirin appears to have a modest effect on ischemic vascular events, with the absolute decrease in events depending on the underlying ASCVD risk. The main adverse effect is an increased risk of gastrointestinal bleeding. The excess risk may be as high as 5 per 1,000 per year in real-world settings. However, for adults with ASCVD risk $>1\%$ per year, the number of ASCVD events prevented will be similar to the number of episodes of bleeding induced, although these complications do not have equal effects on long-term health (124).

Treatment Considerations

In 2010, a position statement of the ADA, the American Heart Association, and the American College of Cardiology Foundation recommended that low-dose (75–162 mg/day) aspirin for primary prevention is reasonable for adults with diabetes and no previous history of vascular disease who are at increased ASCVD risk

and who are not at increased risk for bleeding (125). These recommendations for using aspirin as primary prevention include both men and women aged ≥ 50 years with diabetes and at least one additional major risk factor (family history of premature ASCVD, hypertension, dyslipidemia, smoking, or chronic kidney disease/albuminuria) who are not at increased risk of bleeding (e.g., older age, anemia, renal disease) (126–129). Non-invasive imaging techniques such as coronary computed tomography angiography may potentially help further tailor aspirin therapy, particularly in those at low risk (130), but are not generally recommended. For patients over the age of 70 years (with or without diabetes), the balance appears to have greater risk than benefit (121,123). Thus, for primary prevention, the use of aspirin needs to be carefully considered and may generally not be recommended. Aspirin may be considered in the context of high cardiovascular risk with low bleeding risk, but generally not in older adults. For patients with documented ASCVD, use of aspirin for secondary prevention has far greater benefit than risk; for this indication, aspirin is still recommended (116).

Aspirin Use in People <50 Years of Age

Aspirin is not recommended for those at low risk of ASCVD (such as men and women aged <50 years with diabetes with no other major ASCVD risk factors) as the low benefit is likely to be outweighed by the risks of bleeding. Clinical judgment should be used for those at intermediate risk (younger patients with one or more risk factors or older patients with no risk factors) until further research is available. Patients' willingness to undergo long-term aspirin therapy should also be considered (131). Aspirin use in patients aged <21 years is generally contraindicated due to the associated risk of Reye syndrome.

Aspirin Dosing

Average daily dosages used in most clinical trials involving patients with diabetes ranged from 50 mg to 650 mg but were mostly in the range of 100–325 mg/day. There is little evidence to support any specific dose, but using the lowest possible dose may help to reduce side effects (132). In the U.S., the most common low-dose tablet is 81 mg. Although platelets from patients with diabetes

have altered function, it is unclear what, if any, effect that finding has on the required dose of aspirin for cardioprotective effects in the patient with diabetes. Many alternate pathways for platelet activation exist that are independent of thromboxane A_2 and thus are not sensitive to the effects of aspirin (133). "Aspirin resistance" has been described in patients with diabetes when measured by a variety of ex vivo and in vitro methods (platelet aggregometry, measurement of thromboxane B_2) (134), but other studies suggest no impairment in aspirin response among patients with diabetes (135). A recent trial suggested that more frequent dosing regimens of aspirin may reduce platelet reactivity in individuals with diabetes (136); however, these observations alone are insufficient to empirically recommend that higher doses of aspirin be used in this group at this time. Another recent meta-analysis raised the hypothesis that low-dose aspirin efficacy is reduced in those weighing more than 70 kg (137); however, the ASCEND trial found benefit of low dose aspirin in those in this weight range, which would thus not validate this suggested hypothesis (121). It appears that 75–162 mg/day is optimal.

Indications for P2Y12 Receptor Antagonist Use

A P2Y12 receptor antagonist in combination with aspirin should be used for at least 1 year in patients following an ACS and may have benefits beyond this period. Evidence supports use of either ticagrelor or clopidogrel if no percutaneous coronary intervention was performed and clopidogrel, ticagrelor, or prasugrel if a percutaneous coronary intervention was performed (138). In patients with diabetes and prior MI (1–3 years before), adding ticagrelor to aspirin significantly reduces the risk of recurrent ischemic events including cardiovascular and CHD death (139).

CARDIOVASCULAR DISEASE

Recommendations

Screening

10.34 In asymptomatic patients, routine screening for coronary artery disease is not recommended as it does not improve outcomes as long as atherosclerotic

cardiovascular disease risk factors are treated. **A**

10.35 Consider investigations for coronary artery disease in the presence of any of the following: atypical cardiac symptoms (e.g., unexplained dyspnea, chest discomfort); signs or symptoms of associated vascular disease including carotid bruits, transient ischemic attack, stroke, claudication, or peripheral arterial disease; or electrocardiogram abnormalities (e.g., Q waves). **E**

Treatment

10.36 In patients with known atherosclerotic cardiovascular disease, consider ACE inhibitor or angiotensin receptor blocker therapy to reduce the risk of cardiovascular events. **B**

10.37 In patients with prior myocardial infarction, β -blockers should be continued for at least 2 years after the event. **B**

10.38 In patients with type 2 diabetes with stable congestive heart failure, metformin may be used if estimated glomerular filtration rate remains >30 mL/min but should be avoided in unstable or hospitalized patients with congestive heart failure. **B**

10.39 Among patients with type 2 diabetes who have established atherosclerotic cardiovascular disease, sodium–glucose cotransporter 2 inhibitors or glucagon-like peptide 1 receptor agonists with demonstrated cardiovascular disease benefit (Table 9.1) are recommended as part of the antihyperglycemic regimen. **A**

10.40 Among patients with atherosclerotic cardiovascular disease at high risk of heart failure or in whom heart failure coexists, sodium–glucose cotransporter 2 inhibitors are preferred. **C**

Cardiac Testing

Candidates for advanced or invasive cardiac testing include those with 1) typical or atypical cardiac symptoms and

2) an abnormal resting electrocardiogram (ECG). Exercise ECG testing without or with echocardiography may be used as the initial test. In adults with diabetes ≥ 40 years of age, measurement of coronary artery calcium is also reasonable for cardiovascular risk assessment. Pharmacologic stress echocardiography or nuclear imaging should be considered in individuals with diabetes in whom resting ECG abnormalities preclude exercise stress testing (e.g., left bundle branch block or ST-T abnormalities). In addition, individuals who require stress testing and are unable to exercise should undergo pharmacologic stress echocardiography or nuclear imaging.

Screening Asymptomatic Patients

The screening of asymptomatic patients with high ASCVD risk is not recommended (140), in part because these high-risk patients should already be receiving intensive medical therapy—an approach that provides similar benefit as invasive revascularization (141,142). There is also some evidence that silent ischemia may reverse over time, adding to the controversy concerning aggressive screening strategies (143). In prospective studies, coronary artery calcium has been established as an independent predictor of future ASCVD events in patients with diabetes and is consistently superior to both the UK Prospective Diabetes Study (UKPDS) risk engine and the Framingham Risk Score in predicting risk in this population (144–146). However, a randomized observational trial demonstrated no clinical benefit to routine screening of asymptomatic patients with type 2 diabetes and normal ECGs (147). Despite abnormal myocardial perfusion imaging in more than one in five patients, cardiac outcomes were essentially equal (and very low) in screened versus unscreened patients. Accordingly, indiscriminate screening is not considered cost-effective. Studies have found that a risk factor–based approach to the initial diagnostic evaluation and subsequent follow-up for coronary artery disease fails to identify which patients with type 2 diabetes will have silent ischemia on screening tests (148,149).

Any benefit of newer noninvasive coronary artery disease screening methods, such as computed tomography calcium scoring and computed tomography angiography, to identify patient subgroups

for different treatment strategies remains unproven in asymptomatic patients with diabetes, though research is ongoing. Although asymptomatic patients with diabetes with higher coronary disease burden have more future cardiac events (144,150,151), the role of these tests beyond risk stratification is not clear.

While coronary artery screening methods, such as calcium scoring, may improve cardiovascular risk assessment in people with type 2 diabetes (152), their routine use leads to radiation exposure and may result in unnecessary invasive testing such as coronary angiography and revascularization procedures. The ultimate balance of benefit, cost, and risks of such an approach in asymptomatic patients remains controversial, particularly in the modern setting of aggressive ASCVD risk factor control.

Lifestyle and Pharmacologic Interventions

Intensive lifestyle intervention focusing on weight loss through decreased caloric intake and increased physical activity as performed in the Action for Health in Diabetes (Look AHEAD) trial may be considered for improving glucose control, fitness, and some ASCVD risk factors (153). Patients at increased ASCVD risk should receive aspirin and a statin and ACE inhibitor or ARB therapy if the patient has hypertension, unless there are contraindications to a particular drug class. While clear benefit exists for ACE inhibitor or ARB therapy in patients with diabetic kidney disease or hypertension, the benefits in patients with ASCVD in the absence of these conditions are less clear, especially when LDL cholesterol is concomitantly controlled (154,155). In patients with prior MI, active angina, or HF/rEF, β -blockers should be used (156).

Antihyperglycemic Therapies and Cardiovascular Outcomes

In 2008, the FDA issued a guidance for industry to perform cardiovascular outcomes trials for all new medications for the treatment for type 2 diabetes amid concerns of increased cardiovascular risk (157). Previously approved diabetes medications were not subject to the guidance. Recently published cardiovascular outcomes trials have provided additional data on cardiovascular outcomes in patients with type 2 diabetes with cardiovascular disease or at high risk for

cardiovascular disease (see **Table 10.4**). Cardiovascular outcomes trials of dipeptidyl peptidase 4 (DPP-4) inhibitors have all, so far, not shown cardiovascular benefits relative to placebo. However, results from other new agents have provided a mix of results.

The BI 10773 (Empagliflozin) Cardiovascular Outcome Event Trial in Type 2 Diabetes Mellitus Patients (EMPA-REG OUTCOME) trial was a randomized, double-blind trial that assessed the effect of empagliflozin, an SGLT2 inhibitor, versus placebo on cardiovascular outcomes in 7,020 patients with type 2 diabetes and existing cardiovascular disease. Study participants had a mean age of 63 years, 57% had diabetes for more than 10 years, and 99% had established cardiovascular disease. EMPA-REG OUTCOME showed that over a median follow-up of 3.1 years, treatment reduced the composite outcome of MI, stroke, and cardiovascular death by 14% (absolute rate 10.5% vs. 12.1% in the placebo group, HR in the empagliflozin group 0.86; 95% CI 0.74–0.99; $P = 0.04$ for superiority) and cardiovascular death by 38% (absolute rate 3.7% vs. 5.9%, HR 0.62; 95% CI 0.49–0.77; $P < 0.001$) (8). The FDA added an indication for empagliflozin to reduce the risk of major adverse cardiovascular death in adults with type 2 diabetes and cardiovascular disease.

A second large cardiovascular outcomes trial program of an SGLT2 inhibitor, canagliflozin, has been reported (9). The Canagliflozin Cardiovascular Assessment Study (CANVAS) integrated data from two trials, including the CANVAS trial that started in 2009 before the approval of canagliflozin and the CANVAS-Renal (CANVAS-R) trial that started in 2014 after the approval of canagliflozin. Combining both these trials, 10,142 participants with type 2 diabetes (two-thirds with established CVD) were randomized to canagliflozin or placebo and were followed for an average 3.6 years. The mean age of patients was 63 years and 66% had a history of cardiovascular disease. The combined analysis of the two trials found that canagliflozin significantly reduced the composite outcome of cardiovascular death, MI, or stroke versus placebo (occurring in 26.9 vs. 31.5 participants per 1,000 patient-years; HR 0.86 [95% CI 0.75–0.97]; $P < 0.001$ for noninferiority; $P = 0.02$ for superiority). The specific

estimates for canagliflozin versus placebo on the primary composite cardiovascular outcome were HR 0.88 (0.75–1.03) for the CANVAS trial and 0.82 (0.66–1.01) for CANVAS-R, with no heterogeneity found between trials. In the combined analysis, there was not a statistically significant difference in cardiovascular death (HR 0.87 [95% CI 0.72–1.06]). The initial CANVAS trial was partially unblinded prior to completion because of the need to file interim cardiovascular outcomes data for regulatory approval of the drug (158). Of note, there was an increased risk of lower-limb amputation with canagliflozin (6.3 vs. 3.4 participants per 1,000 patient-years; HR 1.97 [95% CI 1.41–2.75]) (9).

The Liraglutide Effect and Action in Diabetes: Evaluation of Cardiovascular Outcome Results (LEADER) trial was a randomized, double-blind trial that assessed the effect of liraglutide, a glucagon-like peptide 1 (GLP-1) receptor agonist, versus placebo on cardiovascular outcomes in 9,340 patients with type 2 diabetes at high risk for cardiovascular disease or with cardiovascular disease. Study participants had a mean age of 64 years and a mean duration of diabetes of nearly 13 years. Over 80% of study participants had established cardiovascular disease. After a median follow-up of 3.8 years, LEADER showed that the primary composite outcome (MI, stroke, or cardiovascular death) occurred in fewer participants in the treatment group (13.0%) when compared with the placebo group (14.9%) (HR 0.87; 95% CI 0.78–0.97; $P < 0.001$ for noninferiority; $P = 0.01$ for superiority). Deaths from cardiovascular causes were significantly reduced in the liraglutide group (4.7%) compared with the placebo group (6.0%) (HR 0.78; 95% CI 0.66–0.93; $P = 0.007$) (159). The FDA approved the use of liraglutide to reduce the risk of major adverse cardiovascular events, including heart attack, stroke, and cardiovascular death, in adults with type 2 diabetes and established cardiovascular disease.

Results from a moderate-sized trial of another GLP-1 receptor agonist, semaglutide, were consistent with the LEADER trial (160). Semaglutide is a once-weekly GLP-1 receptor agonist approved by the FDA for the treatment of type 2 diabetes. The Trial to Evaluate Cardiovascular and Other Long-term Outcomes With

Semaglutide in Subjects With Type 2 Diabetes (SUSTAIN-6) was the initial randomized trial powered to test noninferiority of semaglutide for the purpose of initial regulatory approval. In this study, 3,297 patients with type 2 diabetes were randomized to receive once-weekly semaglutide (0.5 mg or 1.0 mg) or placebo for 2 years. The primary outcome (the first occurrence of cardiovascular death, nonfatal MI, or nonfatal stroke) occurred in 108 patients (6.6%) in the semaglutide group vs. 146 patients (8.9%) in the placebo group (HR 0.74 [95% CI 0.58–0.95]; $P < 0.001$). More patients discontinued treatment in the semaglutide group because of adverse events, mainly gastrointestinal.

The Evaluation of Lixisenatide in Acute Coronary Syndrome (ELIXA) trial studied the once-daily GLP-1 receptor agonist lixisenatide on cardiovascular outcomes in patients with type 2 diabetes who had had a recent acute coronary event (161). A total of 6,068 patients with type 2 diabetes with a recent hospitalization for MI or unstable angina within the previous 180 days were randomized to receive lixisenatide or placebo in addition to standard care and were followed for a median of approximately 2.1 years. The primary outcome of cardiovascular death, MI, stroke, or hospitalization for unstable angina occurred in 406 patients (13.4%) in the lixisenatide group vs. 399 (13.2%) in the placebo group (HR 1.2 [95% CI 0.89–1.17]), which demonstrated the noninferiority of lixisenatide to placebo ($P < 0.001$) but did not show superiority ($P = 0.81$).

The Exenatide Study of Cardiovascular Event Lowering (EXSCEL) trial also reported results with the once-weekly GLP-1 receptor agonist extended-release exenatide and found that major adverse cardiovascular events were numerically lower with use of extended-release exenatide compared with placebo, although this difference was not statistically significant (162). A total of 14,752 patients with type 2 diabetes (of whom 10,782 [73.1%] had previous cardiovascular disease) were randomized to receive extended-release exenatide 2 mg or placebo and followed for a median of 3.2 years. The primary end point of cardiovascular death, MI, or stroke occurred in 839 patients (11.4%; 3.7 events per 100 person-years) in the exenatide group and in 905 patients (12.2%; 4.0

events per 100 person-years) in the placebo group (HR 0.91 [95% CI 0.83–1.00]; $P < 0.001$ for noninferiority) but was not superior to placebo with respect to the primary end point ($P = 0.06$ for superiority). However, all-cause mortality was lower in the exenatide group (HR 0.86 [95% CI 0.77–0.97]). The incidence of acute pancreatitis, pancreatic cancer, medullary thyroid carcinoma, and serious adverse events did not differ significantly between the two groups.

The Harmony Outcomes trial randomized 9,463 patients with type 2 diabetes and cardiovascular disease to once-weekly subcutaneous albiglutide or matching placebo, in addition to their standard care. Over a median duration of 1.6 years, the GLP-1 receptor agonist reduced the risk of cardiovascular death, MI, or stroke to an incidence rate of 4.6 events per 100 person-years in the albiglutide group vs. 5.9 events in the placebo group (HR ratio 0.78, $P = 0.0006$ for superiority) (163). This agent is not currently available for clinical use.

In summary, there are now several large randomized controlled trials reporting statistically significant reductions in cardiovascular events for two of the FDA-approved SGLT2 inhibitors (empagliflozin and canagliflozin) and three FDA-approved GLP-1 receptor agonists (liraglutide, albiglutide [although that agent was removed from the market for business reasons], and semaglutide [lower risk of cardiovascular events in a moderate-sized clinical trial but one not powered as a cardiovascular outcomes trial]). In these trials, the majority, if not all, patients in the trial had ASCVD. The empagliflozin and liraglutide trials further demonstrated significant reductions in cardiovascular death. Once-weekly exenatide did not have statistically significant reductions in major adverse cardiovascular events or cardiovascular mortality but did have a significant reduction in all-cause mortality. In contrast, other GLP-1 receptor agonists have not shown similar reductions in cardiovascular events (Table 10.4). Additional large randomized trials of other agents in these classes are ongoing.

Of note, these studies examined the drugs in combination with metformin (Table 10.4) in the great majority of patients for whom metformin was not contraindicated or was tolerated. For patients with type 2 diabetes who have ASCVD, on lifestyle and metformin

Table 10.4—Cardiovascular outcomes trials of available antihyperglycemic medications completed after the issuance of the FDA 2008 guidelines

Intervention	DPP-4 inhibitors			GLP-1 receptor agonists			SGLT2 inhibitors			
	SAVOR-TIMI 53 (168) (n = 16,492)	EXAMINE (175) (n = 5,380)	TECOS (171) (n = 14,671)	ELIXA (161) (n = 6,068)	LEADER (159) (n = 9,340)	SUSTAIN-6 (160)* (n = 3,297)	EXSCAL (162) (n = 14,752)	EMPA-REG OUTCOME (8) (n = 7,020)	CANVAS (9) (n = 4,330)	CANVAS-R (9) (n = 5,812)
Main inclusion criteria	Type 2 diabetes and history of or multiple risk factors for CVD	Type 2 diabetes and ACS within 15–90 days before randomization	Type 2 diabetes and preexisting CVD	Type 2 diabetes history of ACS (<180 days)	Type 2 diabetes and preexisting CVD, kidney disease, or HF at ≥50 years of age or cardiovascular risk at ≥60 years of age	Type 2 diabetes and preexisting CVD, HF, or CKD at ≥50 years of age or cardiovascular risk at ≥60 years of age	Type 2 diabetes with or without preexisting CVD	Type 2 diabetes and preexisting CVD	Type 2 diabetes at ≥30 years of age or >2 cardiovascular risk factors at ≥50 years of age	Type 2 diabetes and preexisting CVD
A1C inclusion criteria (%)	≥6.5	6.5–11.0	6.5–8.0	5.5–11.0	≥7.0	≥7.0	6.5–10.0	7.0–10.0	7.0–10.5	7.0–10.5
Age (years)††	65.1	61.0	65.4	60.3	64.3	64.6	62	63.1	63.3	63.3
Diabetes duration (years)††	10.3	7.1	11.6	9.3	12.8	13.9	12	57% >10	13.5	13.5
Median follow-up (years)	2.1	1.5	3.0	2.1	3.8	2.1	3.2	3.1	5.7	2.1
Statin use (%)	78	91	80	93	72	73	74	77	75	75
Metformin use (%)	70	66	82	66	76	73	77	74	77	77
Prior CVD/CHF (%)	78/13	100/28	74/18	100/22	81/18	60/24	73.1/16.2	99/10	65.6/14.4	65.6/14.4
Mean baseline A1C (%)	8.0	8.0	7.2	7.7	8.7	8.7	8.0	8.1	8.2	8.2
Mean difference in A1C between groups at end of treatment (%)	−0.3 ^Δ	−0.3 ^Δ	−0.3 ^Δ	−0.3 ^Δ	−0.4 ^Δ	−0.7 or −1.0 ^{Δ†}	−0.53 ^Δ	−0.3 ^{Δ†}	−0.58 ^Δ	−0.58 ^Δ
Year started/reported	2010/2013	2009/2013	2008/2015	2010/2015	2010/2016	2013/2016	2010/2017	2010/2015	2009/2017	2009/2017
Primary outcome§	3-point MACE	3-point MACE	4-point MACE	4-point MACE	3-point MACE	3-point MACE	3-point MACE	3-point MACE	3-point MACE	3-point MACE
	1.00 (0.89–1.12)	0.96 (95% UL ≤1.16)	0.98 (0.89–1.08)	1.02 (0.89–1.17)	0.87 (0.78–0.97)	0.74 (0.58–0.95)	0.91 (0.83–1.00)	0.86 (0.74–0.99)	0.86 (0.75–0.97)§	0.73 (0.47–0.77)
Key secondary outcomes¶	Expanded MACE	4-point MACE	3-point MACE	Expanded MACE	Expanded MACE	Expanded MACE	Individual components of MACE (see below)	4-point MACE	All-cause and cardiovascular mortality (see below)	40% reduction in composite eGFR, renal replacement, renal death
	1.02 (0.94–1.11)	0.95 (95% UL ≤1.14)	0.99 (0.89–1.10)	1.00 (0.90–1.11)	0.88 (0.81–0.96)	0.74 (0.62–0.89)	0.89 (0.78–1.01)	0.89 (0.78–1.01)	0.60 (0.47–0.77)	0.60 (0.47–0.77)
Cardiovascular death§	1.03 (0.87–1.22)	0.85 (0.66–1.10)	1.03 (0.89–1.19)	0.98 (0.78–1.22)	0.78 (0.66–0.93)	0.98 (0.65–1.48)	0.88 (0.76–1.02)	0.62 (0.49–0.77)	0.96 (0.77–1.18)¶	0.87 (0.72–1.06)¶
MI§	0.95 (0.80–1.12)	1.08 (0.88–1.33)	0.95 (0.81–1.11)	1.03 (0.87–1.22)	0.86 (0.73–1.00)	0.74 (0.51–1.08)	0.97 (0.85–1.10)	0.87 (0.70–1.09)	0.85 (0.65–1.11)	0.85 (0.61–1.19)
Stroke§	1.11 (0.88–1.39)	0.91 (0.55–1.50)	0.97 (0.79–1.19)	1.12 (0.79–1.58)	0.86 (0.71–1.06)	0.61 (0.38–0.99)	0.85 (0.70–1.03)	1.18 (0.89–1.56)	0.97 (0.70–1.35)	0.82 (0.57–1.18)
HF hospitalizations§	1.27 (1.07–1.51)	1.19 (0.90–1.58)	1.00 (0.83–1.20)	0.96 (0.75–1.23)	0.87 (0.73–1.05)	1.11 (0.77–1.61)	0.94 (0.78–1.13)	0.65 (0.50–0.85)	0.77 (0.55–1.08)	0.56 (0.38–0.83)

Continued on p. S118

Table 10.4—Continued

	DPP-4 inhibitors			GLP-1 receptor agonists			SGLT2 inhibitors			
	SAVOR-TIMI 53 (168) (n = 16,492)	EXAMINE (175) (n = 5,380)	TECOS (171) (n = 14,671)	ELIXA (161) (n = 6,068)	LEADER (159) (n = 9,340)	SUSTAIN-6 (160)* (n = 3,297)	EXSCEL (162) (n = 14,752)	EMPA-REG OUTCOME (8) (n = 7,020)	CANVAS (9) (n = 4,330)	CANVAS-R (9) (n = 5,812)
Unstable angina hospitalizations§	1.19 (0.89–1.60)	0.90 (0.60–1.37)	0.90 (0.70–1.16)	1.11 (0.47–2.62)	0.98 (0.76–1.26)	0.82 (0.47–1.44)	1.05 (0.94–1.18)	0.99 (0.74–1.34)	—	—
All-cause mortality§	1.11 (0.96–1.27)	0.88 (0.71–1.09)	1.01 (0.90–1.14)	0.94 (0.78–1.13)	0.85 (0.74–0.97)	1.05 (0.74–1.50)	0.86 (0.77–0.97)	0.68 (0.57–0.82)	0.87 (0.74–1.01)††	0.90 (0.76–1.07)##
Worsening nephropathy§	1.08 (0.88–1.32)	—	—	—	0.78 (0.67–0.92)	0.64 (0.46–0.88)	—	0.61 (0.53–0.70)	0.60 (0.47–0.77)	—

—, not assessed/reported; ACS, acute coronary syndrome; CHF, congestive heart failure; CKD, chronic kidney disease; DPP-4, dipeptidyl peptidase 4; eGFR, estimated glomerular filtration rate; GLP-1, glucagon-like peptide 1; HF, heart failure; MACE, major adverse cardiac event; MI, myocardial infarction; SGLT2, sodium–glucose cotransporter 2; UL, upper limit. Data from this table was adapted from Cefalu et al. (176) in the January 2018 issue of *Diabetes Care*. *Powered to rule out a hazard ratio of 1.8; superiority hypothesis not prespecified. **On the basis of prespecified outcomes, the renal outcomes are not viewed as statistically significant. †Age was reported as means in all trials except EXAMINE, which reported medians; diabetes duration was reported as means in all but four trials, with SAVOR-TIMI 58, EXAMINE, and EXSCEL reporting medians and EMPA-REG OUTCOME reporting as percentage of population with diabetes duration >10 years. †A1C change of 0.66% with 0.5 mg and 1.05% with 1 mg dose of semaglutide. ‡AIC change of 0.30 in EMPA-REG OUTCOME is based on pooled results for both doses (i.e., 0.24% for >10 mg and 0.36% for 25 mg of empagliflozin). §Outcomes reported as hazard ratio (95% CI). ||Worsening nephropathy is defined as the new onset of urine albumin-to-creatinine ratio >300 mg/g creatinine or a doubling of the serum creatinine level and an estimated glomerular filtration rate of <45 mL/min/1.73 m², the need for continuous renal-replacement therapy, or death from renal disease in EMPA-REG OUTCOME, LEADER, and SUSTAIN-6 and as doubling of creatinine level, initiation of dialysis, renal transplantation, or creatinine >6.0 mg/dL (530 μmol/L) in SAVOR-TIMI 53. Worsening nephropathy was a prespecified exploratory adjudicated outcome in SAVOR-TIMI 53, LEADER, and SUSTAIN-6 but not in EMPA-REG OUTCOME. ¶Truncated data set (prespecified in treating hierarchy as the principal data set for analysis of all-cause mortality and cardiovascular death in the CANVAS Program). †Significant difference in A1C between groups (P < 0.05). #Nontruncated data set. ††Truncated integrated data set (refers to pooled data from CANVAS after 20 November 2012 plus CANVAS-R; prespecified in treating hierarchy as the principal data set for analysis of all-cause mortality and cardiovascular death in the CANVAS Program). ##Nontruncated integrated data (refers to pooled data from CANVAS, including before 20 November 2012 plus CANVAS-R).

therapy, it is recommended to incorporate an agent with strong evidence for cardiovascular risk reduction, especially those with proven reduction of cardiovascular death, after consideration of drug-specific patient factors (Table 9.1). See Fig. 9.1 for additional recommendations on antihyperglycemic treatment in adults with type 2 diabetes.

Antihyperglycemic Therapies and Heart Failure

As many as 50% of patients with type 2 diabetes may develop heart failure (164). Data on the effects of glucose-lowering agents on heart failure outcomes have demonstrated that thiazolidinediones have a strong and consistent relationship with increased risk of heart failure (165–167). Therefore, thiazolidinedione use should be avoided in patients with symptomatic heart failure.

Recent studies have also examined the relationship between DPP-4 inhibitors and heart failure and have had mixed results. The Saxagliptin Assessment of Vascular Outcomes Recorded in Patients with Diabetes Mellitus—Thrombolysis in Myocardial Infarction 53 (SAVOR-TIMI 53) study showed that patients treated with saxagliptin (a DPP-4 inhibitor) were more likely to be hospitalized for heart failure than those given placebo (3.5% vs. 2.8%, respectively) (168). Two other recent multicenter, randomized, double-blind, noninferiority trials, Examination of Cardiovascular Outcomes with Alogliptin versus Standard of Care (EXAMINE) and Trial Evaluating Cardiovascular Outcomes with Sitagliptin (TECOS), did not show associations between DPP-4 inhibitor use and heart failure. The FDA reported that the hospital admission rate for heart failure in EXAMINE was 3.9% for patients randomly assigned to alogliptin compared with 3.3% for those randomly assigned to placebo (169). Alogliptin had no effect on the composite end point of cardiovascular death and hospital admission for heart failure in the post hoc analysis (HR 1.0 [95% CI 0.82–1.21]) (170). TECOS showed no difference in the rate of heart failure hospitalization for the sitagliptin group (3.1%; 1.07 per 100 person-years) compared with the placebo group (3.1%; 1.09 per 100 person-years) (171).

In four cardiovascular outcome trials of GLP-1 receptor agonists, no evidence for an increased risk of heart failure was

found and the agents had a neutral effect on hospitalization for heart failure (159–162).

A benefit on the incidence of heart failure has been observed with the use of some SGLT2 inhibitors. In EMPA-REG OUTCOME, the addition of empagliflozin to standard care led to a significant 35% reduction in hospitalization for heart failure compared with placebo (8). Although the majority of patients in the study did not have heart failure at baseline, this benefit was consistent in patients with and without a prior history of heart failure (172). Similarly, in CANVAS, there was a 33% reduction in hospitalization for heart failure with canagliflozin versus placebo (9). Although heart failure hospitalizations were prospectively adjudicated in both trials, the type(s) of heart failure events prevented were not characterized. These preliminary findings, which strongly suggest heart failure–related benefits of SGLT2 inhibitors (particularly the prevention of heart failure), are being followed up with new outcomes trials in patients with established heart failure, both with and without diabetes, to determine their efficacy in treatment of heart failure.

References

- American Diabetes Association. Economic costs of diabetes in the U.S. in 2017. *Diabetes Care* 2018;41:917–928
- Ali MK, Bullard KM, Saaddine JB, Cowie CC, Imperatore G, Gregg EW. Achievement of goals in U.S. diabetes care, 1999–2010. *N Engl J Med* 2013;368:1613–1624
- Buse JB, Ginsberg HN, Bakris GL, et al.; American Heart Association; American Diabetes Association. Primary prevention of cardiovascular diseases in people with diabetes mellitus: a scientific statement from the American Heart Association and the American Diabetes Association. *Diabetes Care* 2007;30:162–172
- Gaede P, Lund-Andersen H, Parving H-H, Pedersen O. Effect of a multifactorial intervention on mortality in type 2 diabetes. *N Engl J Med* 2008;358:580–591
- Cavender MA, Steg PG, Smith SC Jr, et al.; REACH Registry Investigators. Impact of diabetes mellitus on hospitalization for heart failure, cardiovascular events, and death: outcomes at 4 years from the Reduction of Atherothrombosis for Continued Health (REACH) registry. *Circulation* 2015;132:923–931
- McAllister DA, Read S, Kerssens J, et al. Incidence of hospitalisation for heart failure and case-fatality among 3.25 million people with and without diabetes. *Circulation*. 27 June 2018 [Epub ahead of print]. DOI: 10.1161/CIRCULATIONAHA.118.034986
- Lam CSP, Voors AA, de Boer RA, Solomon SD, van Veldhuisen DJ. Heart failure with preserved ejection fraction: from mechanisms to therapies. *Eur Heart J* 2018;39:2780–2792
- Zinman B, Wanner C, Lachin JM, et al.; EMPA-REG OUTCOME Investigators. Empagliflozin, cardiovascular outcomes, and mortality in type 2 diabetes. *N Engl J Med* 2015;373:2117–2128
- Neal B, Perkovic V, Mahaffey KW, et al.; CANVAS Program Collaborative Group. Canagliflozin and cardiovascular and renal events in type 2 diabetes. *N Engl J Med* 2017;377:644–657
- Fitchett D, Butler J, van de Borne P, et al.; EMPA-REG OUTCOME® trial investigators. Effects of empagliflozin on risk for cardiovascular death and heart failure hospitalization across the spectrum of heart failure risk in the EMPA-REG OUTCOME® trial. *Eur Heart J* 2018;39:363–370
- Blood Pressure Lowering Treatment Trialists' Collaboration. Blood pressure-lowering treatment based on cardiovascular risk: a meta-analysis of individual patient data. *Lancet* 2014;384:591–598
- Grundy SM, Stone NJ, Bailey AL, et al. 2018 AHA/ACC/AACVPR/AAPA/ABC/ACPM/ADA/AGS/APHA/ASPC/NLA/PCNA guideline on the management of blood cholesterol: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *J Am Coll Cardiol*. November 2018 [Epub ahead of print]. DOI: 10.1016/j.jacc.2018.11.003
- Muntner P, Colantonio LD, Cushman M, et al. Validation of the atherosclerotic cardiovascular disease Pooled Cohort risk equations. *JAMA* 2014;311:1406–1415
- DeFilippis AP, Young R, McEvoy JW, et al. Risk score overestimation: the impact of individual cardiovascular risk factors and preventive therapies on the performance of the American Heart Association-American College of Cardiology-Atherosclerotic Cardiovascular Disease risk score in a modern multi-ethnic cohort. *Eur Heart J* 2017;38:598–608
- Bohula EA, Morrow DA, Giugliano RP, et al. Atherothrombotic risk stratification and ezetimibe for secondary prevention. *J Am Coll Cardiol* 2017;69:911–921
- Bohula EA, Bonaca MP, Braunwald E, et al. Atherothrombotic risk stratification and the efficacy and safety of vorapaxar in patients with stable ischemic heart disease and previous myocardial infarction. *Circulation* 2016;134:304–313
- de Boer IH, Bangalore S, Benetos A, et al. Diabetes and hypertension: a position statement by the American Diabetes Association. *Diabetes Care* 2017;40:1273–1284
- Bobrie G, Genès N, Vaur L, et al. Is “isolated home” hypertension as opposed to “isolated office” hypertension a sign of greater cardiovascular risk? *Arch Intern Med* 2001;161:2205–2211
- Sega R, Facchetti R, Bombelli M, et al. Prognostic value of ambulatory and home blood pressures compared with office blood pressure in the general population: follow-up results from the Pressioni Arteriose Monitorate e Loro Associazioni (PAMELA) study. *Circulation* 2005;111:1777–1783
- Omboni S, Gazzola T, Carabelli G, Parati G. Clinical usefulness and cost effectiveness of home blood pressure telemonitoring: meta-analysis of randomized controlled studies. *J Hypertens* 2013;31:455–467; discussion 467–468
- Emdin CA, Rahimi K, Neal B, Callender T, Perkovic V, Patel A. Blood pressure lowering in type 2 diabetes: a systematic review and meta-analysis. *JAMA* 2015;313:603–615
- Arguedas JA, Leiva V, Wright JM. Blood pressure targets for hypertension in people with diabetes mellitus. *Cochrane Database Syst Rev* 2013;10:CD008277
- Ettehad D, Emdin CA, Kiran A, et al. Blood pressure lowering for prevention of cardiovascular disease and death: a systematic review and meta-analysis. *Lancet* 2016;387:957–967
- Brunström M, Carlberg B. Effect of antihypertensive treatment at different blood pressure levels in patients with diabetes mellitus: systematic review and meta-analyses. *BMJ* 2016;352:i717
- Bangalore S, Kumar S, Lobach I, Messerli FH. Blood pressure targets in subjects with type 2 diabetes mellitus/impaired fasting glucose: observations from traditional and Bayesian random-effects meta-analyses of randomized trials. *Circulation* 2011;123:2799–2810
- Thomopoulos C, Parati G, Zanchetti A. Effects of blood-pressure-lowering treatment on outcome incidence in hypertension: 10 - should blood pressure management differ in hypertensive patients with and without diabetes mellitus? Overview and meta-analyses of randomized trials. *J Hypertens* 2017;35:922–944
- Xie X, Atkins E, Lv J, et al. Effects of intensive blood pressure lowering on cardiovascular and renal outcomes: updated systematic review and meta-analysis. *Lancet* 2016;387:435–443
- Cushman WC, Evans GW, Byington RP, et al.; ACCORD Study Group. Effects of intensive blood-pressure control in type 2 diabetes mellitus. *N Engl J Med* 2010;362:1575–1585
- Patel A, MacMahon S, Chalmers J, et al.; ADVANCE Collaborative Group. Effects of a fixed combination of perindopril and indapamide on macrovascular and microvascular outcomes in patients with type 2 diabetes mellitus (the ADVANCE trial): a randomised controlled trial. *Lancet* 2007;370:829–840
- Bakris GL. The implications of blood pressure measurement methods on treatment targets for blood pressure. *Circulation* 2016;134:904–905
- Margolis KL, O'Connor PJ, Morgan TM, et al. Outcomes of combined cardiovascular risk factor management strategies in type 2 diabetes: the ACCORD randomized trial. *Diabetes Care* 2014;37:1721–1728
- Buckley LF, Dixon DL, Wohlford GF IV, Wijesinghe DS, Baker WL, Van Tassel BW. Intensive versus standard blood pressure control in SPRINT-eligible participants of ACCORD-BP [published correction appears in *Diabetes Care* 2018;41:2048]. *Diabetes Care* 2017;40:1733–1738
- Brouwer TF, Vehmeijer JT, Kalkman DN, et al. Intensive blood pressure lowering in patients with and patients without type 2 diabetes: a pooled analysis from two randomized trials. *Diabetes Care* 2018;41:1142–1148
- Lamprea-Montealegre JA, de Boer IH. Re-evaluating the evidence for blood pressure targets in type 2 Diabetes. *Diabetes Care* 2018;41:1132–1133
- de Boer IH, Bakris G, Cannon CP. Individualizing blood pressure targets for people with

- diabetes and hypertension: comparing the ADA and the ACC/AHA recommendations. *JAMA* 2018; 319:1319–1320
36. Basu S, Sussman JB, Rigdon J, Steimle L, Denton BT, Hayward RA. Benefit and harm of intensive blood pressure treatment: derivation and validation of risk models using data from the SPRINT and ACCORD trials. *PLoS Med* 2017; 14:e1002410
37. Phillips RA, Xu J, Peterson LE, Arnold RM, Diamond JA, Schussheim AE. Impact of cardiovascular risk on the relative benefit and harm of intensive treatment of hypertension. *J Am Coll Cardiol* 2018;71:1601–1610
38. Whelton PK, Carey RM, Aronow WS, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *J Am Coll Cardiol* 2018;71:e127–e248
39. Wright JT Jr, Williamson JD, Whelton PK, et al.; SPRINT Research Group. A randomized trial of intensive versus standard blood-pressure control. *N Engl J Med* 2015;373:2103–2116
40. Beddhu S, Greene T, Boucher R, et al. Intensive systolic blood pressure control and incident chronic kidney disease in people with and without diabetes mellitus: secondary analyses of two randomised controlled trials. *Lancet Diabetes Endocrinol* 2018;6:555–563
41. Sink KM, Evans GW, Shorr RI, et al. Syncope, hypotension, and falls in the treatment of hypertension: results from the randomized clinical Systolic Blood Pressure Intervention Trial. *J Am Geriatr Soc* 2018;66:679–686
42. American College of Obstetricians and Gynecologists' Task Force on Hypertension in Pregnancy. Hypertension in pregnancy. Report of the American College of Obstetricians and Gynecologists' Task Force on Hypertension in Pregnancy. *Obstet Gynecol* 2013;122:1122–1131
43. Abalos E, Duley L, Steyn DW. Antihypertensive drug therapy for mild to moderate hypertension during pregnancy. *Cochrane Database Syst Rev* 2014;2:CD002252
44. Al-Balas M, Bozzo P, Einarson A. Use of diuretics during pregnancy. *Can Fam Physician* 2009;55:44–45
45. Irgens HU, Reisaeter L, Irgens LM, Lie RT. Long term mortality of mothers and fathers after pre-eclampsia: population based cohort study. *BMJ* 2001;323:1213–1217
46. Sacks FM, Svetkey LP, Vollmer WM, et al.; DASH-Sodium Collaborative Research Group. Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) diet. *N Engl J Med* 2001; 344:3–10
47. James PA, Oparil S, Carter BL, et al. 2014 evidence-based guideline for the management of high blood pressure in adults: report from the panel members appointed to the Eighth Joint National Committee (JNC 8). *JAMA* 2014;311: 507–520
48. Bakris GL, Weir MR; Study of Hypertension and the Efficacy of Lotrel in Diabetes (SHIELD) Investigators. Achieving goal blood pressure in patients with type 2 diabetes: conventional versus fixed-dose combination approaches. *J Clin Hypertens (Greenwich)* 2003;5:202–209
49. Feldman RD, Zou GY, Vandervoort MK, Wong CJ, Nelson SAE, Feagan BG. A simplified approach to the treatment of uncomplicated hypertension: a cluster randomized, controlled trial. *Hypertension* 2009;53:646–653
50. Webster R, Salam A, de Silva HA, Selak V, Stepien S, Rajapakse S, et al. Fixed low-dose triple combination antihypertensive medication vs usual care for blood pressure control in patients with mild to moderate hypertension in Sri Lanka: a randomized clinical trial. *JAMA* 2018;320: 566–579
51. Bangalore S, Kamalakkannan G, Parkar S, Messerli FH. Fixed-dose combinations improve medication compliance: a meta-analysis. *Am J Med* 2007;120:713–719
52. Catalá-López F, Macías Saint-Gerons D, González-Bermejo D, et al. Cardiovascular and renal outcomes of renin-angiotensin system blockade in adult patients with diabetes mellitus: a systematic review with network meta-analyses. *PLoS Med* 2016;13:e1001971
53. Palmer SC, Mavridis D, Navarese E, et al. Comparative efficacy and safety of blood pressure-lowering agents in adults with diabetes and kidney disease: a network meta-analysis. *Lancet* 2015; 385:2047–2056
54. Barzilay JI, Davis BR, Bettencourt J, et al.; ALLHAT Collaborative Research Group. Cardiovascular outcomes using doxazosin vs. chlorthalidone for the treatment of hypertension in older adults with and without glucose disorders: a report from the ALLHAT study. *J Clin Hypertens (Greenwich)* 2004;6:116–125
55. Weber MA, Bakris GL, Jamerson K, et al.; ACCOMPLISH Investigators. Cardiovascular events during differing hypertension therapies in patients with diabetes. *J Am Coll Cardiol* 2010;56: 77–85
56. Bangalore S, Fakheri R, Toklu B, Messerli FH. Diabetes mellitus as a compelling indication for use of renin angiotensin system blockers: systematic review and meta-analysis of randomized trials. *BMJ* 2016;352:i438
57. Carlberg B, Samuelsson O, Lindholm LH. Atenolol in hypertension: is it a wise choice? *Lancet* 2004;364:1684–1689
58. Yusuf S, Teo KK, Pogue J, et al.; ONTARGET Investigators. Telmisartan, ramipril, or both in patients at high risk for vascular events. *N Engl J Med* 2008;358:1547–1559
59. Fried LF, Emanuele N, Zhang JH, et al.; VA NEPHRON-D Investigators. Combined angiotensin inhibition for the treatment of diabetic nephropathy. *N Engl J Med* 2013;369:1892–1903
60. Makani H, Bangalore S, Desouza KA, Shah A, Messerli FH. Efficacy and safety of dual blockade of the renin-angiotensin system: meta-analysis of randomised trials. *BMJ* 2013;346:f360
61. Zhao P, Xu P, Wan C, Wang Z. Evening versus morning dosing regimen drug therapy for hypertension. *Cochrane Database Syst Rev* 2011; 10:CD004184
62. Hermida RC, Ayala DE, Mojón A, Fernández JR. Influence of time of day of blood pressure-lowering treatment on cardiovascular risk in hypertensive patients with type 2 diabetes. *Diabetes Care* 2011;34:1270–1276
63. Nilsson E, Gasparini A, Ärnlöv J, et al. Incidence and determinants of hyperkalemia and hypokalemia in a large healthcare system. *Int J Cardiol* 2017;245:277–284
64. Bandak G, Sang Y, Gasparini A, et al. Hyperkalemia after initiating renin-angiotensin system blockade: the Stockholm Creatinine Measurements (SCREAM) project. *J Am Heart Assoc* 2017; 6:e005428
65. Hughes-Austin JM, Rifkin DE, Beben T, et al. The relation of serum potassium concentration with cardiovascular events and mortality in community-living individuals. *Clin J Am Soc Nephrol* 2017;12:245–252
66. James MT, Grams ME, Woodward M, et al.; CKD Prognosis Consortium. A meta-analysis of the association of estimated GFR, albuminuria, diabetes mellitus, and hypertension with acute kidney injury. *Am J Kidney Dis* 2015;66: 602–612
67. Iliescu R, Lohmeier TE, Tudorancea I, Laffin L, Bakris GL. Renal denervation for the treatment of resistant hypertension: review and clinical perspective. *Am J Physiol Renal Physiol* 2015;309: F583–F594
68. Bakris GL, Agarwal R, Chan JC, et al.; Mineralocorticoid Receptor Antagonist Tolerability Study—Diabetic Nephropathy (ARTS-DN) Study Group. Effect of finerenone on albuminuria in patients with diabetic nephropathy: a randomized clinical trial. *JAMA* 2015;314: 884–894
69. Williams B, MacDonald TM, Morant S, et al.; British Hypertension Society's PATHWAY Studies Group. Spironolactone versus placebo, bisoprolol, and doxazosin to determine the optimal treatment for drug-resistant hypertension (PATHWAY-2): a randomised, double-blind, crossover trial. *Lancet* 2015;386:2059–2068
70. Filippatos G, Anker SD, Böhm M, et al. A randomized controlled study of finerenone vs. eplerenone in patients with worsening chronic heart failure and diabetes mellitus and/or chronic kidney disease. *Eur Heart J* 2016; 37:2105–2114
71. Bombak AS, Klemmer PJ. Mineralocorticoid receptor blockade in chronic kidney disease. *Blood Purif* 2012;33:119–124
72. Jensen MD, Ryan DH, Apovian CM, et al.; American College of Cardiology/American Heart Association Task Force on Practice Guidelines; Obesity Society. 2013 AHA/ACC/TOS guideline for the management of overweight and obesity in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and The Obesity Society. *J Am Coll Cardiol* 2014;129(25 Suppl. 2): S102–S138
73. Estruch R, Ros E, Salas-Salvadó J, et al.; PREDIMED Study Investigators. Primary prevention of cardiovascular disease with a Mediterranean diet supplemented with extra-virgin olive oil or nuts. *N Engl J Med* 2018;378:e34
74. Eckel RH, Jakicic JM, Ard JD, et al. 2013 AHA/ACC guideline on lifestyle management to reduce cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation* 2013;129:S76–S99
75. Chasman DI, Posada D, Subrahmanyam L, Cook NR, Stanton VP Jr, Ridker PM. Pharmacogenetic study of statin therapy and cholesterol reduction. *JAMA* 2004;291:2821–2827
76. Meeck C, Wierzbicki AS, Jewkes C, et al. Daily and intermittent rosuvastatin 5 mg therapy in

- statin intolerant patients: an observational study. *Curr Med Res Opin* 2012;28:371–378
77. Mihaylova B, Emberson J, Blackwell L, et al.; Cholesterol Treatment Trialists' (CTT) Collaborators. The effects of lowering LDL cholesterol with statin therapy in people at low risk of vascular disease: meta-analysis of individual data from 27 randomised trials. *Lancet* 2012;380:581–590
78. Baigent C, Keech A, Kearney PM, et al.; Cholesterol Treatment Trialists' (CTT) Collaborators. Efficacy and safety of cholesterol-lowering treatment: prospective meta-analysis of data from 90,056 participants in 14 randomised trials of statins. *Lancet* 2005;366:1267–1278
79. Pyörälä K, Pedersen TR, Kjekshus J, Faergeman O, Olsson AG, Thorgeirsson G. Cholesterol lowering with simvastatin improves prognosis of diabetic patients with coronary heart disease. A subgroup analysis of the Scandinavian Simvastatin Survival Study (4S). *Diabetes Care* 1997;20:614–620
80. Collins R, Armitage J, Parish S, Sleight P, Peto R; Heart Protection Study Collaborative Group. MRC/BHF Heart Protection Study of cholesterol-lowering with simvastatin in 5963 people with diabetes: a randomised placebo-controlled trial. *Lancet* 2003;361:2005–2016
81. Goldberg RB, Mellies MJ, Sacks FM, et al.; The Care Investigators. Cardiovascular events and their reduction with pravastatin in diabetic and glucose-intolerant myocardial infarction survivors with average cholesterol levels: subgroup analyses in the Cholesterol and Recurrent Events (CARE) trial. *Circulation* 1998;98:2513–2519
82. Shepherd J, Barter P, Carmena R, et al. Effect of lowering LDL cholesterol substantially below currently recommended levels in patients with coronary heart disease and diabetes: the Treating to New Targets (TNT) study. *Diabetes Care* 2006;29:1220–1226
83. Sever PS, Poulter NR, Dahlöf B, et al. Reduction in cardiovascular events with atorvastatin in 2,532 patients with type 2 diabetes: Anglo-Scandinavian Cardiac Outcomes Trial–lipid-lowering arm (ASCOT-LLA). *Diabetes Care* 2005;28:1151–1157
84. Knopp RH, d'Emden M, Smilde JG, Pocock SJ. Efficacy and safety of atorvastatin in the prevention of cardiovascular end points in subjects with type 2 diabetes: the Atorvastatin Study for Prevention of Coronary Heart Disease Endpoints in Non-Insulin-Dependent Diabetes Mellitus (ASPEN). *Diabetes Care* 2006;29:1478–1485
85. Colhoun HM, Betteridge DJ, Durrington PN, et al.; CARDS investigators. Primary prevention of cardiovascular disease with atorvastatin in type 2 diabetes in the Collaborative Atorvastatin Diabetes Study (CARDS): multicentre randomised placebo-controlled trial. *Lancet* 2004;364:685–696
86. Kearney PM, Blackwell L, Collins R, et al.; Cholesterol Treatment Trialists' (CTT) Collaborators. Efficacy of cholesterol-lowering therapy in 18,686 people with diabetes in 14 randomised trials of statins: a meta-analysis. *Lancet* 2008;371:117–125
87. Taylor F, Huffman MD, Macedo AF, et al. Statins for the primary prevention of cardiovascular disease. *Cochrane Database Syst Rev* 2013;1:CD004816
88. Carter AA, Gomes T, Camacho X, Juurlink DN, Shah BR, Mamdani MM. Risk of incident diabetes among patients treated with statins: population based study [published correction appears in *BMJ* 2013;347:f4356]. *BMJ* 2013;346:f2610
89. Baigent C, Blackwell L, Emberson J, et al.; Cholesterol Treatment Trialists' (CTT) Collaborators. Efficacy and safety of more intensive lowering of LDL cholesterol: a meta-analysis of data from 170,000 participants in 26 randomised trials. *Lancet* 2010;376:1670–1681
90. Cannon CP, Blazing MA, Giugliano RP, et al.; IMPROVE-IT Investigators. Ezetimibe added to statin therapy after acute coronary syndromes. *N Engl J Med* 2015;372:2387–2397
91. de Ferranti SD, de Boer IH, Fonseca V, et al. Type 1 diabetes mellitus and cardiovascular disease: a scientific statement from the American Heart Association and American Diabetes Association. *Circulation* 2014;130:1110–1130
92. Cannon CP, Braunwald E, McCabe CH, et al.; Pravastatin or Atorvastatin Evaluation and Infection Therapy-Thrombolysis in Myocardial Infarction 22 Investigators. Intensive versus moderate lipid lowering with statins after acute coronary syndromes. *N Engl J Med* 2004;350:1495–1504
93. Sabatine MS, Giugliano RP, Keech AC, et al.; FOURIER Steering Committee and Investigators. Evolocumab and clinical outcomes in patients with cardiovascular disease. *N Engl J Med* 2017;376:1713–1722
94. Giugliano RP, Cannon CP, Blazing MA, et al.; IMPROVE-IT (Improved Reduction of Outcomes: Vytorin Efficacy International Trial) Investigators. Benefit of adding ezetimibe to statin therapy on cardiovascular outcomes and safety in patients with versus without diabetes mellitus: results from IMPROVE-IT (Improved Reduction of Outcomes: Vytorin Efficacy International Trial). *Circulation* 2018;137:1571–1582
95. Moriarty PM, Jacobson TA, Bruckert E, et al. Efficacy and safety of alirocumab, a monoclonal antibody to PCSK9, in statin-intolerant patients: design and rationale of ODYSSEY ALTERNATIVE, a randomized phase 3 trial. *J Clin Lipidol* 2014;8:554–561
96. Zhang X-L, Zhu Q-Q, Zhu L, et al. Safety and efficacy of anti-PCSK9 antibodies: a meta-analysis of 25 randomized, controlled trials. *BMC Med* 2015;13:123
97. Sabatine MS, Leiter LA, Wiviott SD, et al. Cardiovascular safety and efficacy of the PCSK9 inhibitor evolocumab in patients with and without diabetes and the effect of evolocumab on glycaemia and risk of new-onset diabetes: a pre-specified analysis of the FOURIER randomised controlled trial. *Lancet Diabetes Endocrinol* 2017;5:941–950
98. Berglund L, Brunzell JD, Goldberg AC, et al.; Endocrine Society. Evaluation and treatment of hypertriglyceridemia: an Endocrine Society clinical practice guideline. *J Clin Endocrinol Metab* 2012;97:2969–2989
99. Singh IM, Shishehbor MH, Ansell BJ. High-density lipoprotein as a therapeutic target: a systematic review. *JAMA* 2007;298:786–798
100. Keech A, Simes RJ, Barter P, et al.; FIELD study investigators. Effects of long-term fenofibrate therapy on cardiovascular events in 9795 people with type 2 diabetes mellitus (the FIELD study): randomised controlled trial. *Lancet* 2005;366:1849–1861
101. Jones PH, Davidson MH. Reporting rate of rhabdomyolysis with fenofibrate + statin versus gemfibrozil + any statin. *Am J Cardiol* 2005;95:120–122
102. Ginsberg HN, Elam MB, Lovato LC, et al.; ACCORD Study Group. Effects of combination lipid therapy in type 2 diabetes mellitus. *N Engl J Med* 2010;362:1563–1574
103. Kowa Research Institute, Inc. Pemafibrate to Reduce Cardiovascular Outcomes by Reducing Triglycerides in Patients With diabetes (PROMINENT) In: *ClinicalTrials.gov* [Internet]. Bethesda, MD, National Library of Medicine. Available from <https://clinicaltrials.gov/ct2/show/NCT03071692>. NLM Identifier: NCT03071692. Accessed 8 October 2018
104. Boden WE, Probstfield JL, Anderson T, et al.; AIM-HIGH Investigators. Niacin in patients with low HDL cholesterol levels receiving intensive statin therapy. *N Engl J Med* 2011;365:2255–2267
105. Landray MJ, Haynes R, Hopewell JC, et al.; HPS2-THRIVE Collaborative Group. Effects of extended-release niacin with laropiprant in high-risk patients. *N Engl J Med* 2014;371:203–212
106. Rajpathak SN, Kumbhani DJ, Crandall J, Barzilai N, Alderman M, Ridker PM. Statin therapy and risk of developing type 2 diabetes: a meta-analysis. *Diabetes Care* 2009;32:1924–1929
107. Sattar N, Preiss D, Murray HM, et al. Statins and risk of incident diabetes: a collaborative meta-analysis of randomised statin trials. *Lancet* 2010;375:735–742
108. Ridker PM, Pradhan A, MacFadyen JG, Libby P, Glynn RJ. Cardiovascular benefits and diabetes risks of statin therapy in primary prevention: an analysis from the JUPITER trial. *Lancet* 2012;380:565–571
109. Mach F, Ray KK, Wiklund O, et al.; European Atherosclerosis Society Consensus Panel. Adverse effects of statin therapy: perception vs. the evidence – focus on glucose homeostasis, cognitive, renal and hepatic function, haemorrhagic stroke and cataract. *Eur Heart J* 2018;39:2526–2539
110. Heart Protection Study Collaborative Group. MRC/BHF Heart Protection Study of cholesterol lowering with simvastatin in 20,536 high-risk individuals: a randomised placebo-controlled trial. *Lancet* 2002;360:7–22
111. Shepherd J, Blauw GJ, Murphy MB, et al.; PROSPER study group. PROspective Study of Pravastatin in the Elderly at Risk. Pravastatin in elderly individuals at risk of vascular disease (PROSPER): a randomised controlled trial. *Lancet* 2002;360:1623–1630
112. Trompet S, van Vliet P, de Craen AJM, et al. Pravastatin and cognitive function in the elderly. Results of the PROSPER study. *J Neurol* 2010;257:85–90
113. Yusuf S, Bosch J, Dagenais G, et al.; HOPE-3 Investigators. Cholesterol lowering in intermediate-risk persons without cardiovascular disease. *N Engl J Med* 2016;374:2021–2031
114. Giugliano RP, Mach F, Zavitz K, et al.; EBBINGHAUS Investigators. Cognitive function in a randomized trial of evolocumab. *N Engl J Med* 2017;377:633–643

115. Richardson K, Schoen M, French B, et al. Statins and cognitive function: a systematic review. *Ann Intern Med* 2013;159:688–697
116. Baigent C, Blackwell L, Collins R, et al.; Antithrombotic Trialists' (ATT) Collaboration. Aspirin in the primary and secondary prevention of vascular disease: collaborative meta-analysis of individual participant data from randomised trials. *Lancet* 2009;373:1849–1860
117. Perk J, De Backer G, Gohlke H, et al.; European Association for Cardiovascular Prevention & Rehabilitation (EACPR); ESC Committee for Practice Guidelines (CPG). European Guidelines on cardiovascular disease prevention in clinical practice (version 2012): The Fifth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of nine societies and by invited experts). *Eur Heart J* 2012;33:1635–1701
118. Belch J, MacCuish A, Campbell I, et al. The prevention of progression of arterial disease and diabetes (POPAD) trial: factorial randomised placebo controlled trial of aspirin and antioxidants in patients with diabetes and asymptomatic peripheral arterial disease. *BMJ* 2008;337:a1840
119. Zhang C, Sun A, Zhang P, et al. Aspirin for primary prevention of cardiovascular events in patients with diabetes: a meta-analysis. *Diabetes Res Clin Pract* 2010;87:211–218
120. De Berardis G, Sacco M, Strippoli GFM, et al. Aspirin for primary prevention of cardiovascular events in people with diabetes: meta-analysis of randomised controlled trials. *BMJ* 2009;339:b4531
121. ASCEND Study Collaborative Group. Effects of aspirin for primary prevention in persons with diabetes mellitus. *N Engl J Med* 2018;379:1529–1539
122. Gaziano JM, Brotons C, Coppolecchia R, et al.; ARRIVE Executive Committee. Use of aspirin to reduce risk of initial vascular events in patients at moderate risk of cardiovascular disease (ARRIVE): a randomised, double-blind, placebo-controlled trial. *Lancet* 2018;392:1036–1046
123. McNeil JJ, Wolfe R, Woods RL, et al.; ASPREE Investigator Group. Effect of aspirin on cardiovascular events and bleeding in the healthy elderly. *N Engl J Med* 2018;379:1509–1518
124. Pignone M, Earnshaw S, Tice JA, Pletcher MJ. Aspirin, statins, or both drugs for the primary prevention of coronary heart disease events in men: a cost-utility analysis. *Ann Intern Med* 2006;144:326–336
125. Pignone M, Alberts MJ, Colwell JA, et al.; American Diabetes Association; American Heart Association; American College of Cardiology Foundation. Aspirin for primary prevention of cardiovascular events in people with diabetes: a position statement of the American Diabetes Association, a scientific statement of the American Heart Association, and an expert consensus document of the American College of Cardiology Foundation. *Diabetes Care* 2010;33:1395–1402
126. Huxley RR, Peters SAE, Mishra GD, Woodward M. Risk of all-cause mortality and vascular events in women versus men with type 1 diabetes: a systematic review and meta-analysis. *Lancet Diabetes Endocrinol* 2015;3:198–206
127. Peters SAE, Huxley RR, Woodward M. Diabetes as risk factor for incident coronary heart disease in women compared with men: a systematic review and meta-analysis of 64 cohorts including 858,507 individuals and 28,203 coronary events. *Diabetologia* 2014;57:1542–1551
128. Kalyani RR, Lazo M, Ouyang P, et al. Sex differences in diabetes and risk of incident coronary artery disease in healthy young and middle-aged adults. *Diabetes Care* 2014;37:830–838
129. Peters SAE, Huxley RR, Woodward M. Diabetes as a risk factor for stroke in women compared with men: a systematic review and meta-analysis of 64 cohorts, including 775,385 individuals and 12,539 strokes. *Lancet* 2014;383:1973–1980
130. Dimitriu-Leen AC, Scholte AJHA, van Rosendaal AR, et al. Value of coronary computed tomography angiography in tailoring aspirin therapy for primary prevention of atherosclerotic events in patients at high risk with diabetes mellitus. *Am J Cardiol* 2016;117:887–893
131. Mora S, Ames JM, Manson JE. Low-dose aspirin in the primary prevention of cardiovascular disease: shared decision making in clinical practice. *JAMA* 2016;316:709–710
132. Campbell CL, Smyth S, Montalescot G, Steinhubl SR. Aspirin dose for the prevention of cardiovascular disease: a systematic review. *JAMA* 2007;297:2018–2024
133. Davi G, Patrono C. Platelet activation and atherothrombosis. *N Engl J Med* 2007;357:2482–2494
134. Larsen SB, Grove EL, Neergaard-Petersen S, Würtz M, Hvas A-M, Kristensen SD. Determinants of reduced antiplatelet effect of aspirin in patients with stable coronary artery disease. *PLoS One* 2015;10:e0126767
135. Zaccardi F, Rizzi A, Petrucci G, et al. In vivo platelet activation and aspirin responsiveness in type 1 diabetes. *Diabetes* 2016;65:503–509
136. Bethel MA, Harrison P, Sourij H, et al. Randomized controlled trial comparing impact on platelet reactivity of twice-daily with once-daily aspirin in people with type 2 diabetes. *Diabet Med* 2016;33:224–230
137. Rothwell PM, Cook NR, Gaziano JM, et al. Effects of aspirin on risks of vascular events and cancer according to bodyweight and dose: analysis of individual patient data from randomised trials. *Lancet* 2018;392:387–399
138. Vandvik PO, Lincoff AM, Gore JM, et al. Primary and secondary prevention of cardiovascular disease: Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines [published correction appears in *Chest* 2012;141:1129]. *Chest* 2012;141(Suppl.):e637S–e668S
139. Bhatt DL, Bonaca MP, Bansilal S, et al. Reduction in ischemic events with ticagrelor in diabetic patients with prior myocardial infarction in PEGASUS-TIMI 54. *J Am Coll Cardiol* 2016;67:2732–2740
140. Bax JJ, Young LH, Frye RL, Bonow RO, Steinberg HO, Barrett EJ. Screening for coronary artery disease in patients with diabetes. *Diabetes Care* 2007;30:2729–2736
141. Boden WE, O'Rourke RA, Teo KK, et al.; COURAGE Trial Research Group. Optimal medical therapy with or without PCI for stable coronary disease. *N Engl J Med* 2007;356:1503–1516
142. BARI 2D Study Group, Frye RL, August P, et al. A randomized trial of therapies for type 2 diabetes and coronary artery disease. *N Engl J Med* 2009;360:2503–2015
143. Wackers FJT, Chyun DA, Young LH, et al.; Detection of Ischemia in Asymptomatic Diabetics (DIAD) Investigators. Resolution of asymptomatic myocardial ischemia in patients with type 2 diabetes in the Detection of Ischemia in Asymptomatic Diabetics (DIAD) study. *Diabetes Care* 2007;30:2892–2898
144. Elkeles RS, Godsland IF, Feher MD, et al.; PREDICT Study Group. Coronary calcium measurement improves prediction of cardiovascular events in asymptomatic patients with type 2 diabetes: the PREDICT study. *Eur Heart J* 2008;29:2244–2251
145. Raggi P, Shaw LJ, Berman DS, Callister TQ. Prognostic value of coronary artery calcium screening in subjects with and without diabetes. *J Am Coll Cardiol* 2004;43:1663–1669
146. Anand DV, Lim E, Hopkins D, et al. Risk stratification in uncomplicated type 2 diabetes: prospective evaluation of the combined use of coronary artery calcium imaging and selective myocardial perfusion scintigraphy. *Eur Heart J* 2006;27:713–721
147. Young LH, Wackers FJT, Chyun DA, et al.; DIAD Investigators. Cardiac outcomes after screening for asymptomatic coronary artery disease in patients with type 2 diabetes: the DIAD study: a randomized controlled trial. *JAMA* 2009;301:1547–1555
148. Wackers FJT, Young LH, Inzucchi SE, et al.; Detection of Ischemia in Asymptomatic Diabetics Investigators. Detection of silent myocardial ischemia in asymptomatic diabetic subjects: the DIAD study. *Diabetes Care* 2004;27:1954–1961
149. Scognamiglio R, Negut C, Ramondo A, Tiengo A, Avogaro A. Detection of coronary artery disease in asymptomatic patients with type 2 diabetes mellitus. *J Am Coll Cardiol* 2006;47:65–71
150. Hadamitzky M, Hein F, Meyer T, et al. Prognostic value of coronary computed tomographic angiography in diabetic patients without known coronary artery disease. *Diabetes Care* 2010;33:1358–1363
151. Choi E-K, Chun EJ, Choi S-I, et al. Assessment of subclinical coronary atherosclerosis in asymptomatic patients with type 2 diabetes mellitus with single photon emission computed tomography and coronary computed tomography angiography. *Am J Cardiol* 2009;104:890–896
152. Malik S, Zhao Y, Budoff M, et al. Coronary artery calcium score for long-term risk classification in individuals with type 2 diabetes and metabolic syndrome from the Multi-Ethnic Study of Atherosclerosis. *JAMA Cardiol* 2017;2:1332–1340
153. Wing RR, Bolin P, Brancati FL, et al.; Look AHEAD Research Group. Cardiovascular effects of intensive lifestyle intervention in type 2 diabetes. *N Engl J Med* 2013;369:145–154
154. Braunwald E, Domanski MJ, Fowler SE, et al.; PEACE Trial Investigators. Angiotensin-converting-enzyme inhibition in stable coronary artery disease. *N Engl J Med* 2004;351:2058–2068
155. Telmisartan Randomised Assessment Study in ACE intolerant subjects with cardiovascular

- Disease (TRANSCEND) Investigators, Yusuf S, Teo K, et al. Effects of the angiotensin-receptor blocker telmisartan on cardiovascular events in high-risk patients intolerant to angiotensin-converting enzyme inhibitors: a randomised controlled trial. *Lancet* 2008;372:1174–1183
156. Kezerashvili A, Marzo K, De Leon J. Beta blocker use after acute myocardial infarction in the patient with normal systolic function: when is it “ok” to discontinue? *Curr Cardiol Rev* 2012;8:77–84
157. U.S. Food and Drug Administration. Guidance for industry. Diabetes mellitus—evaluating cardiovascular risk in new antidiabetic therapies to treat type 2 diabetes [Internet]. Silver Spring, MD, 2008. Available from <http://www.fda.gov/downloads/Drugs/GuidanceComplianceRegulatoryInformation/Guidances/ucm071627.pdf>. Accessed 3 November 2017
158. Neal B, Perkovic V, Matthews DR, et al.; CANVAS-R Trial Collaborative Group. Rationale, design and baseline characteristics of the CANagliflozin cardioVascular Assessment Study-Renal (CANVAS-R): a randomized, placebo-controlled trial. *Diabetes Obes Metab* 2017; 19:387–393
159. Marso SP, Daniels GH, Brown-Frandsen K, et al.; LEADER Steering Committee; LEADER Trial Investigators. Liraglutide and cardiovascular outcomes in type 2 diabetes. *N Engl J Med* 2016;375: 311–322
160. Marso SP, Bain SC, Consoli A, et al.; SUSTAIN-6 Investigators. Semaglutide and cardiovascular outcomes in patients with type 2 diabetes. *N Engl J Med* 2016;375:1834–1844
161. Pfeffer MA, Claggett B, Diaz R, et al.; ELIXA Investigators. Lixisenatide in patients with type 2 diabetes and acute coronary syndrome. *N Engl J Med* 2015;373:2247–2257
162. Holman RR, Bethel MA, Mentz RJ, et al.; EXSCEL Study Group. Effects of once-weekly exenatide on cardiovascular outcomes in type 2 diabetes. *N Engl J Med* 2017;377:1228–1239
163. Hernandez AF, Green JB, Janmohamed S, et al.; Harmony Outcomes committees and investigators. Albiglutide and cardiovascular outcomes in patients with type 2 diabetes and cardiovascular disease (Harmony Outcomes): a double-blind, randomised placebo-controlled trial. *Lancet* 2018;392:1519–1529
164. Kannel WB, Hjortland M, Castelli WP. Role of diabetes in congestive heart failure: the Framingham study. *Am J Cardiol* 1974;34: 29–34
165. Dormandy JA, Charbonnel B, Eckland DJA, et al.; PROactive Investigators. Secondary prevention of macrovascular events in patients with type 2 diabetes in the PROactive Study (PROspective pioglitAzone Clinical Trial In macroVascular Events): a randomised controlled trial. *Lancet* 2005;366:1279–1289
166. Singh S, Loke YK, Furberg CD. Long-term risk of cardiovascular events with rosiglitazone: a meta-analysis. *JAMA* 2007;298:1189–1195
167. Lincoff AM, Wolski K, Nicholls SJ, Nissen SE. Pioglitazone and risk of cardiovascular events in patients with type 2 diabetes mellitus: a meta-analysis of randomized trials. *JAMA* 2007;298: 1180–1188
168. Scirica BM, Bhatt DL, Braunwald E, et al.; SAVOR-TIMI 53 Steering Committee and Investigators. Saxagliptin and cardiovascular outcomes in patients with type 2 diabetes mellitus. *N Engl J Med* 2013;369:1317–1326
169. U.S. Food and Drug Administration. FDA Drug Safety Communication: FDA adds warnings about heart failure risk to labels of type 2 diabetes medicines containing saxagliptin and alogliptin [Internet], 2016. Available from <http://www.fda.gov/Drugs/DrugSafety/ucm486096.htm>. Accessed 24 September 2018
170. Zannad F, Cannon CP, Cushman WC, et al.; EXAMINE Investigators. Heart failure and mortality outcomes in patients with type 2 diabetes taking alogliptin versus placebo in EXAMINE: a multicentre, randomised, double-blind trial. *Lancet* 2015;385:2067–2076
171. Green JB, Bethel MA, Armstrong PW, et al.; TECOS Study Group. Effect of sitagliptin on cardiovascular outcomes in type 2 diabetes. *N Engl J Med* 2015;373:232–242
172. Fitchett D, Butler J, van de Borne P, et al. Effects of empagliflozin on risk for cardiovascular death and heart failure hospitalization across the spectrum of heart failure risk in the EMPA-REG OUTCOME trial. *Eur Heart J* 2017;39:363–370
173. Hansson L, Zanchetti A, Carruthers SG, et al.; HOT Study Group. Effects of intensive blood-pressure lowering and low-dose aspirin in patients with hypertension: principal results of the Hypertension Optimal Treatment (HOT) randomised trial. *Lancet* 1998;351:1755–1762
174. Zoungas S, Chalmers J, Neal B, et al.; ADVANCE-ON Collaborative Group. Follow-up of blood-pressure lowering and glucose control in type 2 diabetes. *N Engl J Med* 2014;371:1392–1406
175. White WB, Cannon CP, Heller SR, et al.; EXAMINE Investigators. Alogliptin after acute coronary syndrome in patients with type 2 diabetes. *N Engl J Med* 2013;369:1327–1335
176. Cefalu WT, Kaul S, Gerstein HC, et al. Cardiovascular outcomes trials in type 2 diabetes: where do we go from here? Reflections from a *Diabetes Care* Editors’ Expert Forum. *Diabetes Care* 2018;41:14–31



11. Microvascular Complications and Foot Care: *Standards of Medical Care in Diabetes—2019*

American Diabetes Association

Diabetes Care 2019;42(Suppl. 1):S124–S138 | <https://doi.org/10.2337/dc19-S011>

The American Diabetes Association (ADA) “Standards of Medical Care in Diabetes” includes ADA’s current clinical practice recommendations and is intended to provide the components of diabetes care, general treatment goals and guidelines, and tools to evaluate quality of care. Members of the ADA Professional Practice Committee, a multidisciplinary expert committee, are responsible for updating the Standards of Care annually, or more frequently as warranted. For a detailed description of ADA standards, statements, and reports, as well as the evidence-grading system for ADA’s clinical practice recommendations, please refer to the Standards of Care Introduction. Readers who wish to comment on the Standards of Care are invited to do so at professional.diabetes.org/SOC.

For prevention and management of diabetes complications in children and adolescents, please refer to Section 13 “Children and Adolescents.”

CHRONIC KIDNEY DISEASE

Recommendations

Screening

11.1 At least once a year, assess urinary albumin (e.g., spot urinary albumin-to-creatinine ratio) and estimated glomerular filtration rate in patients with type 1 diabetes with duration of ≥ 5 years, in all patients with type 2 diabetes, and in all patients with comorbid hypertension. **B**

Treatment

11.2 Optimize glucose control to reduce the risk or slow the progression of chronic kidney disease. **A**

11.3 For patients with type 2 diabetes and chronic kidney disease, consider use of a sodium–glucose cotransporter 2 inhibitor or glucagon-like peptide 1 receptor agonist shown to reduce risk of chronic kidney disease progression, cardiovascular events, or both (**Table 9.1**). **C**

11.4 Optimize blood pressure control to reduce the risk or slow the progression of chronic kidney disease. **A**

11.5 For people with nondialysis-dependent chronic kidney disease, dietary protein intake should be approximately 0.8 g/kg body weight per day (the recommended daily allowance). For patients on dialysis, higher levels of dietary protein intake should be considered. **B**

11.6 In nonpregnant patients with diabetes and hypertension, either an ACE inhibitor or an angiotensin receptor blocker is recommended for those with modestly elevated urinary albumin-to-creatinine ratio (30–299 mg/g creatinine) **B** and is strongly recommended for those with urinary albumin-to-creatinine

Suggested citation: American Diabetes Association. 11. Microvascular complications and foot care: Standards of Medical Care in Diabetes—2019. Diabetes Care 2019;42(Suppl. 1):S124–S138

© 2018 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. More information is available at <http://www.diabetesjournals.org/content/license>.

ratio ≥ 300 mg/g creatinine and/or estimated glomerular filtration rate < 60 mL/min/ 1.73 m². **A**

- 11.7** Periodically monitor serum creatinine and potassium levels for the development of increased creatinine or changes in potassium when ACE inhibitors, angiotensin receptor blockers, or diuretics are used. **B**
- 11.8** Continued monitoring of urinary albumin-to-creatinine ratio in patients with albuminuria treated with an ACE inhibitor or an angiotensin receptor blocker is reasonable to assess the response to treatment and progression of chronic kidney disease. **E**
- 11.9** An ACE inhibitor or an angiotensin receptor blocker is not recommended for the primary prevention of chronic kidney disease in patients with diabetes who have normal blood pressure, normal urinary albumin-to-creatinine ratio (< 30 mg/g creatinine), and normal estimated glomerular filtration rate. **B**
- 11.10** When estimated glomerular filtration rate is < 60 mL/min/ 1.73 m², evaluate and manage potential complications of chronic kidney disease. **E**
- 11.11** Patients should be referred for evaluation for renal replacement treatment if they have an estimated glomerular filtration rate < 30 mL/min/ 1.73 m². **A**
- 11.12** Promptly refer to a physician experienced in the care of kidney disease for uncertainty about the etiology of kidney disease, difficult management issues, and rapidly progressing kidney disease. **B**

Epidemiology of Diabetes and Chronic Kidney Disease

Chronic kidney disease (CKD) is diagnosed by the persistent presence of elevated urinary albumin excretion (albuminuria), low estimated glomerular filtration rate (eGFR), or other manifestations of kidney damage (1,2). In this section, the focus will be on CKD attributed to diabetes (diabetic kidney disease), which occurs in 20–40% of patients with diabetes (1,3–5). CKD typically

develops after diabetes duration of 10 years in type 1 diabetes but may be present at diagnosis of type 2 diabetes. CKD can progress to end-stage renal disease (ESRD) requiring dialysis or kidney transplantation and is the leading cause of ESRD in the U.S. (6). In addition, among people with type 1 or 2 diabetes, the presence of CKD markedly increases cardiovascular risk and health care costs (7).

Assessment of Albuminuria and Estimated Glomerular Filtration Rate

Screening for albuminuria can be most easily performed by urinary albumin-to-creatinine ratio (UACR) in a random spot urine collection (1,2). Timed or 24-h collections are more burdensome and add little to prediction or accuracy. Measurement of a spot urine sample for albumin alone (whether by immunoassay or by using a sensitive dipstick test specific for albuminuria) without simultaneously measuring urine creatinine (Cr) is less expensive but susceptible to false-negative and false-positive determinations as a result of variation in urine concentration due to hydration.

Normal UACR is generally defined as < 30 mg/g Cr, and increased urinary albumin excretion is defined as ≥ 30 mg/g Cr. However, UACR is a continuous measurement, and differences within the normal and abnormal ranges are associated with renal and cardiovascular outcomes (7–9). Furthermore, because of biological variability in urinary albumin excretion, two of three specimens of UACR collected within a 3- to 6-month period should be abnormal before considering a patient to have albuminuria. Exercise within 24 h, infection, fever, congestive heart failure, marked hyperglycemia, menstruation, and marked hypertension may elevate UACR independently of kidney damage.

eGFR should be calculated from serum Cr using a validated formula. The Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation is generally preferred (2). eGFR is routinely reported by laboratories with serum Cr, and eGFR calculators are available from www.nkdep.nih.gov. An eGFR < 60 mL/min/ 1.73 m² is generally considered abnormal, though optimal thresholds for clinical diagnosis are debated (10).

Urinary albumin excretion and eGFR each vary within people over time, and abnormal results should be confirmed to stage CKD (1,2).

Diagnosis of Diabetic Kidney Disease

Diabetic kidney disease is usually a clinical diagnosis made based on the presence of albuminuria and/or reduced eGFR in the absence of signs or symptoms of other primary causes of kidney damage. The typical presentation of diabetic kidney disease is considered to include a long-standing duration of diabetes, retinopathy, albuminuria without hematuria, and gradually progressive loss of eGFR. However, signs of CKD may be present at diagnosis or without retinopathy in type 2 diabetes, and reduced eGFR without albuminuria has been frequently reported in type 1 and type 2 diabetes and is becoming more common over time as the prevalence of diabetes increases in the U.S. (3,4,11,12).

An active urinary sediment (containing red or white blood cells or cellular casts), rapidly increasing albuminuria or nephrotic syndrome, rapidly decreasing eGFR, or the absence of retinopathy (in type 1 diabetes) may suggest alternative or additional causes of kidney disease. For patients with these features, referral to a nephrologist for further diagnosis, including the possibility of kidney biopsy, should be considered. It is rare for patients with type 1 diabetes to develop kidney disease without retinopathy. In type 2 diabetes, retinopathy is only moderately sensitive and specific for CKD caused by diabetes, as confirmed by kidney biopsy (13).

Staging of Chronic Kidney Disease

Stages 1–2 CKD have been defined by evidence of kidney damage (usually albuminuria) with eGFR ≥ 60 mL/min/ 1.73 m², while stages 3–5 CKD have been defined by progressively lower ranges of eGFR (14) (Table 11.1). At any eGFR, the degree of albuminuria is associated with risk of CKD progression, cardiovascular disease (CVD), and mortality (7). Therefore, Kidney Disease: Improving Global Outcomes (KDIGO) recommends a more comprehensive CKD staging that incorporates albuminuria at all stages of eGFR; this system is more closely associated with risk but is also more complex and does not translate directly to treatment decisions (2). Regardless of classification scheme, both eGFR and albuminuria should be quantified to guide treatment decisions: CKD complications (Table 11.2) correlate with eGFR, many drugs are limited to

Table 11.1—CKD stages and corresponding focus of kidney-related care

Stage	CKD stage†		Focus of kidney-related care			
	eGFR (mL/min/1.73 m ²)	Evidence of kidney damage*	Diagnose cause of kidney injury	Evaluate and treat risk factors for CKD progression**	Evaluate and treat CKD complications***	Prepare for renal replacement therapy
No clinical evidence of CKD	≥60	—				
1	≥90	+	✓	✓		
2	60–89	+	✓	✓		
3	30–59	+/-	✓	✓	✓	
4	15–29	+/-		✓	✓	✓
5	<15	+/-			✓	✓

CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate. †CKD stages 1 and 2 are defined by evidence of kidney damage (+), while CKD stages 3–5 are defined by reduced eGFR with or without evidence of kidney damage (+/-). At any stage of CKD, the degree of albuminuria, observed history of eGFR loss, and cause of kidney damage (including possible causes other than diabetes) may also be used to characterize CKD, gauge prognosis, and guide treatment decisions. *Kidney damage is most often manifest as albuminuria (UACR ≥30 mg/g Cr) but can also include glomerular hematuria, other abnormalities of the urinary sediment, radiographic abnormalities, and other presentations. **Risk factors for CKD progression include elevated blood pressure, hyperglycemia, and albuminuria. ***See **Table 11.2**.

acceptable eGFR ranges, and the degree of albuminuria may influence choice of antihypertensive (see Section 10 “Cardiovascular Disease and Risk Management”) or glucose-lowering medications (see below). Observed history of eGFR loss (which is also associated with risk of CKD progression and other adverse health outcomes) and cause of kidney damage (including possible causes other than diabetes) may also affect these decisions (15).

Acute Kidney Injury

Acute kidney injury (AKI) is usually diagnosed by a rapid increase in serum Cr, which is also reflected as a rapid decrease in eGFR, over a relatively short period of time. People with diabetes are at higher risk of AKI than those without diabetes (16). Other risk factors for AKI include preexisting CKD, the use of medications that cause kidney injury (e.g.,

nonsteroidal anti-inflammatory drugs), and the use of medications that alter renal blood flow and intrarenal hemodynamics. In particular, many antihypertensive medications (e.g., diuretics, ACE inhibitors, and angiotensin receptor blockers [ARBs]) can reduce intravascular volume, renal blood flow, and/or glomerular filtration. There is a concern that sodium–glucose cotransporter 2 (SGLT2) inhibitors may promote AKI through volume depletion, particularly when combined with diuretics or other medications that reduce glomerular filtration. However, existing evidence from clinical trials and observational studies suggests that SGLT2 inhibitors do not significantly increase AKI (17–19). Timely identification and treatment of AKI are important because AKI is associated with increased risks of progressive CKD and other poor health outcomes (20).

Surveillance

Albuminuria and eGFR should be monitored regularly to enable timely diagnosis of CKD, monitor progression of CKD, detect superimposed kidney diseases including AKI, assess risk of CKD complications, dose drugs appropriately, and determine whether nephrology referral is needed. Among people with existing kidney disease, albuminuria and eGFR may change due to progression of CKD, development of a separate superimposed cause of kidney disease, AKI, or other effects of medications, as noted above. Serum potassium should also be monitored for patients treated with ACE inhibitors, ARBs, and diuretics because these medications can cause hyperkalemia or hypokalemia, which are associated with cardiovascular risk and mortality (21–23). For patients with eGFR <60 mL/min/1.73 m², appropriate medication dosing should be verified, exposure to nephrotoxins (e.g., nonsteroidal anti-inflammatory drugs and iodinated contrast) should be minimized, and potential CKD complications should be evaluated (**Table 11.2**).

The need for annual quantitative assessment of albumin excretion after diagnosis of albuminuria, institution of ACE inhibitors or ARB therapy, and achieving blood pressure control is a subject of debate. Continued surveillance can assess both response to therapy and disease progression and may aid in assessing adherence to ACE inhibitor or ARB therapy. In addition, in clinical trials of ACE inhibitors or ARB therapy in type 2 diabetes, reducing albuminuria from

Table 11.2—Selected complications of CKD

Complication	Medical and laboratory evaluation
Elevated blood pressure	Blood pressure, weight
Volume overload	History, physical examination, weight
Electrolyte abnormalities	Serum electrolytes
Metabolic acidosis	Serum electrolytes
Anemia	Hemoglobin; iron testing if indicated
Metabolic bone disease	Serum calcium, phosphate, PTH, vitamin 25(OH)D

Complications of chronic kidney disease (CKD) generally become prevalent when estimated glomerular filtration rate falls below 60 mL/min/1.73 m² (stage 3 CKD or greater) and become more common and severe as CKD progresses. Evaluation of elevated blood pressure and volume overload should occur at every clinical contact possible; laboratory evaluations are generally indicated every 6–12 months for stage 3 CKD, every 3–5 months for stage 4 CKD, and every 1–3 months for stage 5 CKD, or as indicated to evaluate symptoms or changes in therapy. PTH, parathyroid hormone; 25(OH)D, 25-hydroxyvitamin D.

levels ≥ 300 mg/g Cr has been associated with improved renal and cardiovascular outcomes, leading some to suggest that medications should be titrated to minimize UACR. However, this approach has not been formally evaluated in prospective trials. In type 1 diabetes, remission of albuminuria may occur spontaneously and cohort studies evaluating associations of change in albuminuria with clinical outcomes have reported inconsistent results (24,25).

The prevalence of CKD complications correlates with eGFR (25a). When eGFR is < 60 mL/min/1.73 m², screening for complications of CKD is indicated (**Table 11.2**). Early vaccination against hepatitis B virus is indicated in patients likely to progress to ESRD (see Section 4 “Comprehensive Medical Evaluation and Assessment of Comorbidities” for further information on immunization).

Interventions

Nutrition

For people with nondialysis-dependent CKD, dietary protein intake should be approximately 0.8 g/kg body weight per day (the recommended daily allowance) (1). Compared with higher levels of dietary protein intake, this level slowed GFR decline with evidence of a greater effect over time. Higher levels of dietary protein intake ($> 20\%$ of daily calories from protein or > 1.3 g/kg/day) have been associated with increased albuminuria, more rapid kidney function loss, and CVD mortality and therefore should be avoided. Reducing the amount of dietary protein below the recommended daily allowance of 0.8 g/kg/day is not recommended because it does not alter glycemic measures, cardiovascular risk measures, or the course of GFR decline.

Restriction of dietary sodium (to $< 2,300$ mg/day) may be useful to control blood pressure and reduce cardiovascular risk (26), and restriction of dietary potassium may be necessary to control serum potassium concentration (16,21–23). These interventions may be most important for patients with reduced eGFR, for whom urinary excretion of sodium and potassium may be impaired. Recommendations for dietary sodium and potassium intake should be individualized on the basis of comorbid conditions, medication use, blood pressure, and laboratory data.

Glycemic Targets

Intensive glycemic control with the goal of achieving near-normoglycemia has been shown in large prospective randomized studies to delay the onset and progression of albuminuria and reduced eGFR in patients with type 1 diabetes (27,28) and type 2 diabetes (1,29–34). Insulin alone was used to lower blood glucose in the Diabetes Control and Complications Trial (DCCT)/Epidemiology of Diabetes Interventions and Complications (EDIC) study of type 1 diabetes, while a variety of agents were used in clinical trials of type 2 diabetes, supporting the conclusion that glycemic control itself helps prevent CKD and its progression. The effects of glucose-lowering therapies on CKD have helped define A1C targets (see **Table 6.2**).

The presence of CKD affects the risks and benefits of intensive glycemic control and a number of specific glucose-lowering medications. In the Action to Control Cardiovascular Risk in Diabetes (ACCORD) trial of type 2 diabetes, adverse effects of intensive glycemic control (hypoglycemia and mortality) were increased among patients with kidney disease at baseline (35,36). Moreover, there is a lag time of at least 2 years in type 2 diabetes to over 10 years in type 1 diabetes for the effects of intensive glucose control to manifest as improved eGFR outcomes (33,37,38). Therefore, in some patients with prevalent CKD and substantial comorbidity, target A1C levels may be less intensive (1,39).

Direct Renal Effects of Glucose-Lowering Medications

Some glucose-lowering medications also have effects on the kidney that are direct, i.e., not mediated through glycemia. For example, SGLT2 inhibitors reduce renal tubular glucose reabsorption, weight, systemic blood pressure, intraglomerular pressure, and albuminuria and slow GFR loss through mechanisms that appear independent of glycemia (18,40–43). Glucagon-like peptide 1 receptor agonists (GLP-1 RA) also have direct effects on the kidney and have been reported to improve renal outcomes compared with placebo (44–47). Renal effects should be considered when selecting antihyperglycemia agents (see Section 9 “Pharmacologic Approaches to Glycemic Treatment”).

Selection of Glucose-Lowering Medications for Patients With Chronic Kidney Disease

For patients with type 2 diabetes and established CKD, special considerations for the selection of glucose-lowering medications include limitations to available medications when eGFR is diminished and a desire to mitigate high risks of CKD progression, CVD, and hypoglycemia (48,49). Drug dosing may require modification with eGFR < 60 mL/min/1.73 m² (1).

The U.S. Food and Drug Administration (FDA) revised its guidance for the use of metformin in CKD in 2016 (50), recommending use of eGFR instead of serum Cr to guide treatment and expanding the pool of patients with kidney disease for whom metformin treatment should be considered. The revised FDA guidance states that metformin is contraindicated in patients with an eGFR < 30 mL/min/1.73 m², eGFR should be monitored while taking metformin, the benefits and risks of continuing treatment should be reassessed when eGFR falls < 45 mL/min/1.73 m², metformin should not be initiated for patients with an eGFR < 45 mL/min/1.73 m², and metformin should be temporarily discontinued at the time of or before iodinated contrast imaging procedures in patients with eGFR 30–60 mL/min/1.73 m². Within these constraints, metformin should be considered the first-line treatment for all patients with type 2 diabetes, including those with CKD.

SGLT2 inhibitors and GLP-1 RA should be considered for patients with type 2 diabetes and CKD who require another drug added to metformin to attain target A1C or cannot use or tolerate metformin. SGLT2 inhibitors and GLP-1 RA are suggested because they appear to reduce risks of CKD progression, CVD events, and hypoglycemia.

A number of large cardiovascular outcomes trials in patients with type 2 diabetes at high risk for CVD or with existing CVD examined kidney effects as secondary outcomes. These trials include EMPA-REG OUTCOME [BI 10773 (Empagliflozin) Cardiovascular Outcome Event Trial in Type 2 Diabetes Mellitus Patients], CANVAS (Canagliflozin Cardiovascular Assessment Study), LEADER (Liraglutide Effect and Action in Diabetes: Evaluation of Cardiovascular Outcome Results), and SUSTAIN-6 (Trial to Evaluate Cardiovascular and Other Long-term Outcomes With Semaglutide in Subjects With Type 2 Diabetes) (42,44,47,51).

Specifically, compared with placebo, empagliflozin reduced the risk of incident or worsening nephropathy (a composite of progression to UACR >300 mg/g Cr, doubling of serum Cr, ESRD, or death from ESRD) by 39% and the risk of doubling of serum Cr accompanied by $eGFR \leq 45$ mL/min/1.73 m² by 44%; canagliflozin reduced the risk of progression of albuminuria by 27% and the risk of reduction in $eGFR$, ESRD, or death from ESRD by 40%; liraglutide reduced the risk of new or worsening nephropathy (a composite of persistent macroalbuminuria, doubling of serum Cr, ESRD, or death from ESRD) by 22%; and semaglutide reduced the risk of new or worsening nephropathy (a composite of persistent UACR >300 mg/g Cr, doubling of serum Cr, or ESRD) by 36% (each $P < 0.01$).


These analyses were limited by evaluation of study populations not selected primarily for CKD and examination of renal effects as secondary outcomes. However, all of these trials included large numbers of people with kidney disease (for example, the baseline prevalence of albuminuria in EMPA-REG OUTCOME was 53%), and some of the cardiovascular outcomes trials (CANVAS and LEADER) were enriched with patients with kidney disease through eligibility criteria based on albuminuria or reduced $eGFR$. In addition, subgroup analyses of CANVAS and LEADER suggested that the renal benefits of canagliflozin and liraglutide were as great or greater for participants with CKD at baseline (19,46) and in CANVAS were similar for participants with or without atherosclerotic cardiovascular disease (ASCVD) at baseline (52). Smaller, shorter-term trials also demonstrate favorable renal effects of medications in these classes (53, 53a). Together, these consistent results suggest likely renal benefits of both drug classes.

Several large clinical trials of SGLT2 inhibitors focused on patients with CKD, and assessment of primary renal outcomes are completed or ongoing. Canagliflozin and Renal Endpoints in Diabetes with Established Nephropathy Clinical Evaluation (CRENCE), a placebo-controlled trial of canagliflozin among 4,401 adults with type 2 diabetes, UACR ≥ 300 mg/g, and $eGFR$ 30–90 mL/min/1.73 m², has a primary composite end point of ESRD, doubling of serum Cr, or renal or cardiovascular death (54). It

was stopped early due to positive efficacy, with detailed results expected in 2019.

In addition to renal effects, some SGLT2 inhibitors and GLP-1 RA have demonstrated cardiovascular benefits. Namely, in EMPA-REG OUTCOME, CANVAS, and LEADER, empagliflozin, canagliflozin, and liraglutide, respectively, each reduced cardiovascular events, evaluated as primary outcomes, compared with placebo (see Section 10 “Cardiovascular Disease and Risk Management” for further discussion). The glucose-lowering effects of SGLT2 inhibitors are blunted with $eGFR$ (18,51). However, the cardiovascular benefits of empagliflozin, canagliflozin, and liraglutide were similar among participants with and without kidney disease at baseline (42,44,51,55). Most participants with CKD in these trials also had diagnosed ASCVD at baseline, though approximately 28% of CANVAS participants with CKD did not have diagnosed ASCVD (19).

Important caveats limit the strength of evidence supporting the recommendation of SGLT2 inhibitors and GLP-1 RA in patients with type 2 diabetes and CKD. As noted above, published data address a limited group of CKD patients, mostly with coexisting ASCVD. Renal events have been examined primarily as secondary outcomes in published large trials. Also, adverse event profiles of these agents must be considered. Please refer to **Table 9.1** for drug-specific factors, including adverse event information, for these agents. Therefore, additional clinical trials are needed to more rigorously assess the benefits and risks of these classes of drugs among people with CKD.

 For patients with type 2 diabetes and CKD, the selection of specific agents may depend on comorbidity and CKD stage. SGLT2 inhibitors may be more useful for patients at high risk of CKD progression (i.e., with albuminuria or a history of documented $eGFR$ loss) (Fig. 9.1) because they appear to have large beneficial effects on CKD incidence. Empagliflozin and canagliflozin are only approved by the FDA for use with $eGFR \geq 45$ mL/min/1.73 m² (though pivotal trials for each included participants with $eGFR \geq 30$ mL/min/1.73 m² and demonstrated benefit in subgroups with low $eGFR$) (18,19), and dapagliflozin is only approved for $eGFR \geq 60$ mL/min/1.73 m². Some GLP-1 RA may be used with lower $eGFR$ and may have greater benefits for

reduction of ASCVD than for CKD progression or heart failure.

Cardiovascular Disease and Blood Pressure

Hypertension is a strong risk factor for the development and progression of CKD (56). Antihypertensive therapy reduces the risk of albuminuria (57–60), and among patients with type 1 or 2 diabetes with established CKD ($eGFR < 60$ mL/min/1.73 m² and UACR ≥ 300 mg/g Cr), ACE inhibitor or ARB therapy reduces the risk of progression to ESRD (61–63). Moreover, antihypertensive therapy reduces risks of cardiovascular events (57).

Blood pressure levels $<140/90$ mmHg are generally recommended to reduce CVD mortality and slow CKD progression among people with diabetes (60). Lower blood pressure targets (e.g., $<130/80$ mmHg) may be considered for patients based on individual anticipated benefits and risks. Patients with CKD are at increased risk of CKD progression (particularly those with albuminuria) and CVD and therefore may be suitable in some cases for lower blood pressure targets.

ACE inhibitors or ARBs are the preferred first-line agent for blood pressure treatment among patients with diabetes, hypertension, $eGFR < 60$ mL/min/1.73 m², and UACR ≥ 300 mg/g Cr because of their proven benefits for prevention of CKD progression (61–64). In general, ACE inhibitors and ARBs are considered to have similar benefits (65,66) and risks. In the setting of lower levels of albuminuria (30–299 mg/g Cr), ACE inhibitor or ARB therapy has been demonstrated to reduce progression to more advanced albuminuria (≥ 300 mg/g Cr) and cardiovascular events but not progression to ESRD (64,67). While ACE inhibitors or ARBs are often prescribed for albuminuria without hypertension, clinical trials have not been performed in this setting to determine whether this improves renal outcomes.

Absent kidney disease, ACE inhibitors or ARBs are useful to control blood pressure but may not be superior to alternative proven classes of antihypertensive therapy, including thiazide-like diuretics and dihydropyridine calcium channel blockers (68). In a trial of people with type 2 diabetes and normal urine albumin excretion, an ARB reduced or suppressed the development of albuminuria but increased the rate of

cardiovascular events (69). In a trial of people with type 1 diabetes exhibiting neither albuminuria nor hypertension, ACE inhibitors or ARBs did not prevent the development of diabetic glomerulopathy assessed by kidney biopsy (70). *Therefore, ACE inhibitors or ARBs are not recommended for patients without hypertension to prevent the development of CKD.*

Two clinical trials studied the combinations of ACE inhibitors and ARBs and found no benefits on CVD or CKD, and the drug combination had higher adverse event rates (hyperkalemia and/or AKI) (71,72). *Therefore, the combined use of ACE inhibitors and ARBs should be avoided.*

Mineralocorticoid receptor antagonists (spironolactone, eplerenone, and finerenone) in combination with ACE inhibitors or ARBs remain an area of great interest. Mineralocorticoid receptor antagonists are effective for management of resistant hypertension, have been shown to reduce albuminuria in short-term studies of CKD, and may have additional cardiovascular benefits (73–75). There has been, however, an increase in hyperkalemic episodes in those on dual therapy, and larger, longer trials with clinical outcomes are needed before recommending such therapy.

Referral to a Nephrologist

Consider referral to a physician experienced in the care of kidney disease when there is uncertainty about the etiology of kidney disease, difficult management issues (anemia, secondary hyperparathyroidism, metabolic bone disease, resistant hypertension, or electrolyte disturbances), or advanced kidney disease (eGFR <30 mL/min/1.73 m²) requiring discussion of renal replacement therapy for ESRD. The threshold for referral may vary depending on the frequency with which a provider encounters patients with diabetes and kidney disease. Consultation with a nephrologist when stage 4 CKD develops (eGFR <30 mL/min/1.73 m²) has been found to reduce cost, improve quality of care, and delay dialysis (76). However, other specialists and providers should also educate their patients about the progressive nature of CKD, the kidney preservation benefits of proactive treatment of blood pressure and blood glucose, and the

potential need for renal replacement therapy.

DIABETIC RETINOPATHY

Recommendations

- 11.13** Optimize glycemic control to reduce the risk or slow the progression of diabetic retinopathy. **A**
- 11.14** Optimize blood pressure and serum lipid control to reduce the risk or slow the progression of diabetic retinopathy. **A**

Screening

- 11.15** Adults with type 1 diabetes should have an initial dilated and comprehensive eye examination by an ophthalmologist or optometrist within 5 years after the onset of diabetes. **B**
- 11.16** Patients with type 2 diabetes should have an initial dilated and comprehensive eye examination by an ophthalmologist or optometrist at the time of the diabetes diagnosis. **B**
- 11.17** If there is no evidence of retinopathy for one or more annual eye exam and glycemia is well controlled, then exams every 1–2 years may be considered. If any level of diabetic retinopathy is present, subsequent dilated retinal examinations should be repeated at least annually by an ophthalmologist or optometrist. If retinopathy is progressing or sight-threatening, then examinations will be required more frequently. **B**
- 11.18** Telemedicine programs that use validated retinal photography with remote reading by an ophthalmologist or optometrist and timely referral for a comprehensive eye examination when indicated can be an appropriate screening strategy for diabetic retinopathy. **B**
- 11.19** Women with preexisting type 1 or type 2 diabetes who are planning pregnancy or who are pregnant should be counseled on the risk of development and/or progression of diabetic retinopathy. **B**
- 11.20** Eye examinations should occur before pregnancy or in the first

trimester in patients with preexisting type 1 or type 2 diabetes, and then patients should be monitored every trimester and for 1-year postpartum as indicated by the degree of retinopathy. **B**

Treatment

- 11.21** Promptly refer patients with any level of macular edema, severe nonproliferative diabetic retinopathy (a precursor of proliferative diabetic retinopathy), or any proliferative diabetic retinopathy to an ophthalmologist who is knowledgeable and experienced in the management of diabetic retinopathy. **A**
- 11.22** The traditional standard treatment, panretinal laser photocoagulation therapy, is indicated to reduce the risk of vision loss in patients with high-risk proliferative diabetic retinopathy and, in some cases, severe nonproliferative diabetic retinopathy. **A**
- 11.23** Intravitreal injections of anti-vascular endothelial growth factor ranibizumab are not inferior to traditional panretinal laser photocoagulation and are also indicated to reduce the risk of vision loss in patients with proliferative diabetic retinopathy. **A**
- 11.24** Intravitreal injections of anti-vascular endothelial growth factor are indicated for central-involved diabetic macular edema, which occurs beneath the foveal center and may threaten reading vision. **A**
- 11.25** The presence of retinopathy is not a contraindication to aspirin therapy for cardioprotection, as aspirin does not increase the risk of retinal hemorrhage. **A**

Diabetic retinopathy is a highly specific vascular complication of both type 1 and type 2 diabetes, with prevalence strongly related to both the duration of diabetes and the level of glycemic control (77). Diabetic retinopathy is the most frequent cause of new cases of blindness among adults aged 20–74 years in developed countries. Glaucoma, cataracts, and other disorders of the eye occur earlier and more frequently in people with diabetes.

In addition to diabetes duration, factors that increase the risk of, or are associated with, retinopathy include chronic hyperglycemia (78), nephropathy (79), hypertension (80), and dyslipidemia (81). Intensive diabetes management with the goal of achieving near-normoglycemia has been shown in large prospective randomized studies to prevent and/or delay the onset and progression of diabetic retinopathy and potentially improve patient-reported visual function (30,82–84).

Several case series and a controlled prospective study suggest that pregnancy in patients with type 1 diabetes may aggravate retinopathy and threaten vision, especially when glycemic control is poor at the time of conception (85,86). Laser photocoagulation surgery can minimize the risk of vision loss (86).

Screening

The preventive effects of therapy and the fact that patients with proliferative diabetic retinopathy (PDR) or macular edema may be asymptomatic provide strong support for screening to detect diabetic retinopathy.

An ophthalmologist or optometrist who is knowledgeable and experienced in diagnosing diabetic retinopathy should perform the examinations. Youth with type 1 or type 2 diabetes are also at risk for complications and need to be screened for diabetic retinopathy (87). If diabetic retinopathy is present, prompt referral to an ophthalmologist is recommended. Subsequent examinations for patients with type 1 or type 2 diabetes are generally repeated annually for patients with minimal to no retinopathy. Exams every 1–2 years may be cost-effective after one or more normal eye exams, and in a population with well-controlled type 2 diabetes, there was essentially no risk of development of significant retinopathy with a 3-year interval after a normal examination (88). Less frequent intervals have been found in simulated modeling to be potentially effective in screening for diabetic retinopathy in patients without diabetic retinopathy (89). More frequent examinations by the ophthalmologist will be required if retinopathy is progressing.

Retinal photography with remote reading by experts has great potential to provide screening services in areas where qualified eye care professionals

are not readily available (82,83). High-quality fundus photographs can detect most clinically significant diabetic retinopathy. Interpretation of the images should be performed by a trained eye care provider. Retinal photography may also enhance efficiency and reduce costs when the expertise of ophthalmologists can be used for more complex examinations and for therapy (90,91). In-person exams are still necessary when the retinal photos are of unacceptable quality and for follow-up if abnormalities are detected. Retinal photos are not a substitute for comprehensive eye exams, which should be performed at least initially and at intervals thereafter as recommended by an eye care professional. Results of eye examinations should be documented and transmitted to the referring health care professional.

Type 1 Diabetes

Because retinopathy is estimated to take at least 5 years to develop after the onset of hyperglycemia, patients with type 1 diabetes should have an initial dilated and comprehensive eye examination within 5 years after the diagnosis of diabetes (92).

Type 2 Diabetes

Patients with type 2 diabetes who may have had years of undiagnosed diabetes and have a significant risk of prevalent diabetic retinopathy at the time of diagnosis should have an initial dilated and comprehensive eye examination at the time of diagnosis.

Pregnancy

Pregnancy is associated with a rapid progression of diabetic retinopathy (93,94). Women with preexisting type 1 or type 2 diabetes who are planning pregnancy or who have become pregnant should be counseled on the risk of development and/or progression of diabetic retinopathy. In addition, rapid implementation of intensive glycemic management in the setting of retinopathy is associated with early worsening of retinopathy (86). Women who develop gestational diabetes mellitus do not require eye examinations during pregnancy and do not appear to be at increased risk of developing diabetic retinopathy during pregnancy (95).

Treatment

Two of the main motivations for screening for diabetic retinopathy are to

prevent loss of vision and to intervene with treatment when vision loss can be prevented or reversed.

Photocoagulation Surgery

Two large trials, the Diabetic Retinopathy Study (DRS) in patients with PDR and the Early Treatment Diabetic Retinopathy Study (ETDRS) in patients with macular edema, provide the strongest support for the therapeutic benefits of photocoagulation surgery. The DRS (96) showed in 1978 that panretinal photocoagulation surgery reduced the risk of severe vision loss from PDR from 15.9% in untreated eyes to 6.4% in treated eyes with the greatest benefit ratio in those with more advanced baseline disease (disc neovascularization or vitreous hemorrhage). In 1985, the ETDRS also verified the benefits of panretinal photocoagulation for high-risk PDR and in older-onset patients with severe nonproliferative diabetic retinopathy or less-than-high-risk PDR. Panretinal laser photocoagulation is still commonly used to manage complications of diabetic retinopathy that involve retinal neovascularization and its complications.

Anti-Vascular Endothelial Growth Factor Treatment

Recent data from the Diabetic Retinopathy Clinical Research Network and others demonstrate that intravitreal injections of anti-vascular endothelial growth factor (anti-VEGF) agent, specifically ranibizumab, resulted in visual acuity outcomes that were not inferior to those observed in patients treated with panretinal laser at 2 years of follow-up (97). In addition, it was observed that patients treated with ranibizumab tended to have less peripheral visual field loss, fewer vitrectomy surgeries for secondary complications from their proliferative disease, and a lower risk of developing diabetic macular edema. However, a potential drawback in using anti-VEGF therapy to manage proliferative disease is that patients were required to have a greater number of visits and received a greater number of treatments than is typically required for management with panretinal laser, which may not be optimal for some patients. Other emerging therapies for retinopathy that may use sustained intravitreal delivery of pharmacologic agents are currently under investigation. The FDA approved ranibizumab for the treatment of diabetic retinopathy in 2017.

While the ETDRS (98) established the benefit of focal laser photocoagulation surgery in eyes with clinically significant macular edema (defined as retinal edema located at or within 500 μm of the center of the macula), current data from well-designed clinical trials demonstrate that intravitreal anti-VEGF agents provide a more effective treatment regimen for central-involved diabetic macular edema than monotherapy or even combination therapy with laser (99–101). There are currently three anti-VEGF agents commonly used to treat eyes with central-involved diabetic macular edema—bevacizumab, ranibizumab, and aflibercept (77).

In both the DRS and the ETDRS, laser photocoagulation surgery was beneficial in reducing the risk of further visual loss in affected patients but generally not beneficial in reversing already diminished acuity. Anti-VEGF therapy improves vision and has replaced the need for laser photocoagulation in the vast majority of patients with diabetic macular edema (102). Most patients require near-monthly administration of intravitreal therapy with anti-VEGF agents during the first 12 months of treatment, with fewer injections needed in subsequent years to maintain remission from central-involved diabetic macular edema.

Adjunctive Therapy

Lowering blood pressure has been shown to decrease retinopathy progression, although tight targets (systolic blood pressure <120 mmHg) do not impart additional benefit (83). ACE inhibitors and ARBs are both effective treatments in diabetic retinopathy (103). In patients with dyslipidemia, retinopathy progression may be slowed by the addition of fenofibrate, particularly with very mild nonproliferative diabetic retinopathy at baseline (81,104).

NEUROPATHY

Recommendations

Screening

11.26 All patients should be assessed for diabetic peripheral neuropathy starting at diagnosis of type 2 diabetes and 5 years after the diagnosis of type 1 diabetes and at least annually thereafter. **B**

11.27 Assessment for distal symmetric polyneuropathy should include a careful history and assessment of either temperature or pinprick sensation (small-fiber function) and vibration sensation using a 128-Hz tuning fork (for large-fiber function). All patients should have annual 10-g monofilament testing to identify feet at risk for ulceration and amputation. **B**

11.28 Symptoms and signs of autonomic neuropathy should be assessed in patients with microvascular complications. **E**

Treatment

11.29 Optimize glucose control to prevent or delay the development of neuropathy in patients with type 1 diabetes **A** and to slow the progression of neuropathy in patients with type 2 diabetes. **B**

11.30 Assess and treat patients to reduce pain related to diabetic peripheral neuropathy **B** and symptoms of autonomic neuropathy and to improve quality of life. **E**

11.31 Pregabalin, duloxetine, or gabapentin are recommended as initial pharmacologic treatments for neuropathic pain in diabetes. **A**

The diabetic neuropathies are a heterogeneous group of disorders with diverse clinical manifestations. The early recognition and appropriate management of neuropathy in the patient with diabetes is important.

1. Diabetic neuropathy is a diagnosis of exclusion. Nondiabetic neuropathies may be present in patients with diabetes and may be treatable.
2. Numerous treatment options exist for symptomatic diabetic neuropathy.
3. Up to 50% of diabetic peripheral neuropathy (DPN) may be asymptomatic. If not recognized and if preventive foot care is not implemented, patients are at risk for injuries to their insensate feet.
4. Recognition and treatment of autonomic neuropathy may improve symptoms, reduce sequelae, and improve quality of life.

Specific treatment for the underlying nerve damage, other than improved glycemic control, is currently not available. Glycemic control can effectively prevent DPN and cardiac autonomic neuropathy (CAN) in type 1 diabetes (105,106) and may modestly slow their progression in type 2 diabetes (32), but does not reverse neuronal loss. Therapeutic strategies (pharmacologic and nonpharmacologic) for the relief of painful DPN and symptoms of autonomic neuropathy can potentially reduce pain (107) and improve quality of life.

Diagnosis

Diabetic Peripheral Neuropathy

Patients with type 1 diabetes for 5 or more years and all patients with type 2 diabetes should be assessed annually for DPN using the medical history and simple clinical tests. Symptoms vary according to the class of sensory fibers involved. The most common early symptoms are induced by the involvement of small fibers and include pain and dysesthesia (unpleasant sensations of burning and tingling). The involvement of large fibers may cause numbness and loss of protective sensation (LOPS). LOPS indicates the presence of distal sensorimotor polyneuropathy and is a risk factor for diabetic foot ulceration. The following clinical tests may be used to assess small- and large-fiber function and protective sensation:

1. Small-fiber function: pinprick and temperature sensation
2. Large-fiber function: vibration perception and 10-g monofilament
3. Protective sensation: 10-g monofilament

These tests not only screen for the presence of dysfunction but also predict future risk of complications. Electrophysiological testing or referral to a neurologist is rarely needed, except in situations where the clinical features are atypical or the diagnosis is unclear.

In all patients with diabetes and DPN, causes of neuropathy other than diabetes should be considered, including toxins (e.g., alcohol), neurotoxic medications (e.g., chemotherapy), vitamin B12 deficiency, hypothyroidism, renal disease, malignancies (e.g., multiple myeloma, bronchogenic carcinoma), infections (e.g., HIV), chronic inflammatory demyelinating neuropathy, inherited

neuropathies, and vasculitis (108). See the American Diabetes Association (ADA) position statement “Diabetic Neuropathy” for more details (107).

Diabetic Autonomic Neuropathy

The symptoms and signs of autonomic neuropathy should be elicited carefully during the history and physical examination. Major clinical manifestations of diabetic autonomic neuropathy include hypoglycemia unawareness, resting tachycardia, orthostatic hypotension, gastroparesis, constipation, diarrhea, fecal incontinence, erectile dysfunction, neurogenic bladder, and sudomotor dysfunction with either increased or decreased sweating.

Cardiac Autonomic Neuropathy. CAN is associated with mortality independently of other cardiovascular risk factors (109,110). In its early stages, CAN may be completely asymptomatic and detected only by decreased heart rate variability with deep breathing. Advanced disease may be associated with resting tachycardia (>100 bpm) and orthostatic hypotension (a fall in systolic or diastolic blood pressure by >20 mmHg or >10 mmHg, respectively, upon standing without an appropriate increase in heart rate). CAN treatment is generally focused on alleviating symptoms.

Gastrointestinal Neuropathies. Gastrointestinal neuropathies may involve any portion of the gastrointestinal tract with manifestations including esophageal dysmotility, gastroparesis, constipation, diarrhea, and fecal incontinence. Gastroparesis should be suspected in individuals with erratic glycemic control or with upper gastrointestinal symptoms without another identified cause. Exclusion of organic causes of gastric outlet obstruction or peptic ulcer disease (with esophagogastroduodenoscopy or a barium study of the stomach) is needed before considering a diagnosis of or specialized testing for gastroparesis. The diagnostic gold standard for gastroparesis is the measurement of gastric emptying with scintigraphy of digestible solids at 15-min intervals for 4 h after food intake. The use of ^{13}C octanoic acid breath test is emerging as a viable alternative.

Genitourinary Disturbances. Diabetic autonomic neuropathy may also cause

genitourinary disturbances, including sexual dysfunction and bladder dysfunction. In men, diabetic autonomic neuropathy may cause erectile dysfunction and/or retrograde ejaculation (107). Female sexual dysfunction occurs more frequently in those with diabetes and presents as decreased sexual desire, increased pain during intercourse, decreased sexual arousal, and inadequate lubrication (111). Lower urinary tract symptoms manifest as urinary incontinence and bladder dysfunction (nocturia, frequent urination, urination urgency, and weak urinary stream). Evaluation of bladder function should be performed for individuals with diabetes who have recurrent urinary tract infections, pyelonephritis, incontinence, or a palpable bladder.

Treatment

Glycemic Control

Near-normal glycemic control, implemented early in the course of diabetes, has been shown to effectively delay or prevent the development of DPN and CAN in patients with type 1 diabetes (112–115). Although the evidence for the benefit of near-normal glycemic control is not as strong for type 2 diabetes, some studies have demonstrated a modest slowing of progression without reversal of neuronal loss (32,116). Specific glucose-lowering strategies may have different effects. In a post hoc analysis, participants, particularly men, in the Bypass Angioplasty Revascularization Investigation in Type 2 Diabetes (BARI 2D) trial treated with insulin sensitizers had a lower incidence of distal symmetric polyneuropathy over 4 years than those treated with insulin/sulfonylurea (117).

Neuropathic Pain

Neuropathic pain can be severe and can impact quality of life, limit mobility, and contribute to depression and social dysfunction (118). No compelling evidence exists in support of glycemic control or lifestyle management as therapies for neuropathic pain in diabetes or prediabetes, which leaves only pharmaceutical interventions (119).

Pregabalin and duloxetine have received regulatory approval by the FDA, Health Canada, and the European Medicines Agency for the treatment of neuropathic pain in diabetes. The opioid tapentadol has regulatory approval in

the U.S. and Canada, but the evidence of its use is weaker (120). Comparative effectiveness studies and trials that include quality-of-life outcomes are rare, so treatment decisions must consider each patient’s presentation and comorbidities and often follow a trial-and-error approach. Given the range of partially effective treatment options, a tailored and stepwise pharmacologic strategy with careful attention to relative symptom improvement, medication adherence, and medication side effects is recommended to achieve pain reduction and improve quality of life (121–123).

Pregabalin, a calcium channel $\alpha 2\text{-}\delta$ subunit ligand, is the most extensively studied drug for DPN. The majority of studies testing pregabalin have reported favorable effects on the proportion of participants with at least 30–50% improvement in pain (120,122,124–127). However, not all trials with pregabalin have been positive (120,122,128,129), especially when treating patients with advanced refractory DPN (126). Adverse effects may be more severe in older patients (130) and may be attenuated by lower starting doses and more gradual titration. The related drug, *gabapentin*, has also shown efficacy for pain control in diabetic neuropathy and may be less expensive, although it is not FDA approved for this indication (131).

Duloxetine is a selective norepinephrine and serotonin reuptake inhibitor. Doses of 60 and 120 mg/day showed efficacy in the treatment of pain associated with DPN in multicenter randomized trials, although some of these had high drop-out rates (120,122,127,129). Duloxetine also appeared to improve neuropathy-related quality of life (132). In longer-term studies, a small increase in A1C was reported in people with diabetes treated with duloxetine compared with placebo (133). Adverse events may be more severe in older people but may be attenuated with lower doses and slower titrations of duloxetine.

Tapentadol is a centrally acting opioid analgesic that exerts its analgesic effects through both μ -opioid receptor agonism and noradrenaline reuptake inhibition. Extended-release tapentadol was approved by the FDA for the treatment of neuropathic pain associated with diabetes based on data from two multicenter clinical trials in which participants titrated to an optimal dose of tapentadol

were randomly assigned to continue that dose or switch to placebo (134,135). However, both used a design enriched for patients who responded to tapentadol and therefore their results are not generalizable. A recent systematic review and meta-analysis by the Special Interest Group on Neuropathic Pain of the International Association for the Study of Pain found the evidence supporting the effectiveness of tapentadol in reducing neuropathic pain to be inconclusive (120). Therefore, given the high risk for addiction and safety concerns compared with the relatively modest pain reduction, the use of extended-release tapentadol is not generally recommended as a first- or second-line therapy. The use of any opioids for management of chronic neuropathic pain carries the risk of addiction and should be avoided.

Tricyclic antidepressants, venlafaxine, carbamazepine, and topical capsaicin, although not approved for the treatment of painful DPN, may be effective and considered for the treatment of painful DPN (107,120,122).

Orthostatic Hypotension

Treating orthostatic hypotension is challenging. The therapeutic goal is to minimize postural symptoms rather than to restore normotension. Most patients require both nonpharmacologic measures (e.g., ensuring adequate salt intake, avoiding medications that aggravate hypotension, or using compressive garments over the legs and abdomen) and pharmacologic measures. Physical activity and exercise should be encouraged to avoid deconditioning, which is known to exacerbate orthostatic intolerance, and volume repletion with fluids and salt is critical. Midodrine and droxidopa are approved by the FDA for the treatment of orthostatic hypotension.

Gastroparesis

Treatment for diabetic gastroparesis may be very challenging. A low-fiber, low-fat eating plan provided in small frequent meals with a greater proportion of liquid calories may be useful (136–138). In addition, foods with small particle size may improve key symptoms (139). Withdrawing drugs with adverse effects on gastrointestinal motility including opioids, anticholinergics, tricyclic antidepressants, GLP-1 RA, pramlintide, and possibly dipeptidyl peptidase 4 inhibitors

may also improve intestinal motility (136,140). In cases of severe gastroparesis, pharmacologic interventions are needed. Only metoclopramide, a prokinetic agent, is approved by the FDA for the treatment of gastroparesis. However, the level of evidence regarding the benefits of metoclopramide for the management of gastroparesis is weak, and given the risk for serious adverse effects (extrapyramidal signs such as acute dystonic reactions, drug-induced parkinsonism, akathisia, and tardive dyskinesia), its use in the treatment of gastroparesis beyond 12 weeks is no longer recommended by the FDA or the European Medicines Agency. It should be reserved for severe cases that are unresponsive to other therapies (140). Other treatment options include domperidone (available outside of the U.S.) and erythromycin, which is only effective for short-term use due to tachyphylaxis (141,142). Gastric electrical stimulation using a surgically implantable device has received approval from the FDA, although its efficacy is variable and use is limited to patients with severe symptoms that are refractory to other treatments (143).

Erectile Dysfunction

In addition to treatment of hypogonadism if present, treatments for erectile dysfunction may include phosphodiesterase type 5 inhibitors, intracorporeal or intraurethral prostaglandins, vacuum devices, or penile prostheses. As with DPN treatments, these interventions do not change the underlying pathology and natural history of the disease process but may improve the patient's quality of life.

FOOT CARE

Recommendations

- 11.32** Perform a comprehensive foot evaluation at least annually to identify risk factors for ulcers and amputations. **B**
- 11.33** Patients with evidence of sensory loss or prior ulceration or amputation should have their feet inspected at every visit. **C**
- 11.34** Obtain a prior history of ulceration, amputation, Charcot foot, angioplasty or vascular surgery, cigarette smoking, retinopathy,

and renal disease and assess current symptoms of neuropathy (pain, burning, numbness) and vascular disease (leg fatigue, claudication). **B**

- 11.35** The examination should include inspection of the skin, assessment of foot deformities, neurological assessment (10-g monofilament testing with at least one other assessment: pinprick, temperature, vibration), and vascular assessment including pulses in the legs and feet. **B**
- 11.36** Patients with symptoms of claudication or decreased or absent pedal pulses should be referred for ankle-brachial index and for further vascular assessment as appropriate. **C**
- 11.37** A multidisciplinary approach is recommended for individuals with foot ulcers and high-risk feet (e.g., dialysis patients and those with Charcot foot or prior ulcers or amputation). **B**
- 11.38** Refer patients who smoke or who have histories of prior lower-extremity complications, loss of protective sensation, structural abnormalities, or peripheral arterial disease to foot care specialists for ongoing preventive care and lifelong surveillance. **C**
- 11.39** Provide general preventive foot self-care education to all patients with diabetes. **B**
- 11.40** The use of specialized therapeutic footwear is recommended for high-risk patients with diabetes including those with severe neuropathy, foot deformities, or history of amputation. **B**

Foot ulcers and amputation, which are consequences of diabetic neuropathy and/or peripheral arterial disease (PAD), are common and represent major causes of morbidity and mortality in people with diabetes. Early recognition and treatment of patients with diabetes and feet at risk for ulcers and amputations can delay or prevent adverse outcomes.

The risk of ulcers or amputations is increased in people who have the following risk factors:

- Poor glycemic control
- Peripheral neuropathy with LOPS
- Cigarette smoking
- Foot deformities
- Preulcerative callus or corn
- PAD
- History of foot ulcer
- Amputation
- Visual impairment
- CKD (especially patients on dialysis)

Clinicians are encouraged to review ADA screening recommendations for further details and practical descriptions of how to perform components of the comprehensive foot examination (144).

Evaluation for Loss of Protective Sensation

All adults with diabetes should undergo a comprehensive foot evaluation at least annually. Detailed foot assessments may occur more frequently in patients with histories of ulcers or amputations, foot deformities, insensate feet, and PAD (145). To assess risk, clinicians should ask about history of foot ulcers or amputation, neuropathic and peripheral vascular symptoms, impaired vision, renal disease, tobacco use, and foot care practices. A general inspection of skin integrity and musculoskeletal deformities should be performed. Vascular assessment should include inspection and palpation of pedal pulses.

The neurological exam performed as part of the foot examination is designed to identify LOPS rather than early neuropathy. The 10-g monofilament is the most useful test to diagnose LOPS. Ideally, the 10-g monofilament test should be performed with at least one other assessment (pinprick, temperature or vibration sensation using a 128-Hz tuning fork, or ankle reflexes). Absent monofilament sensation suggests LOPS, while at least two normal tests (and no abnormal test) rules out LOPS.

Evaluation for Peripheral Arterial Disease

Initial screening for PAD should include a history of decreased walking speed, leg fatigue, claudication, and an assessment of the pedal pulses. Ankle-brachial index testing should be performed in patients with symptoms or signs of PAD.

Patient Education

All patients with diabetes and particularly those with high-risk foot conditions

(history of ulcer or amputation, deformity, LOPS, or PAD) and their families should be provided general education about risk factors and appropriate management (146). Patients at risk should understand the implications of foot deformities, LOPS, and PAD; the proper care of the foot, including nail and skin care; and the importance of foot monitoring on a daily basis. Patients with LOPS should be educated on ways to substitute other sensory modalities (palpation or visual inspection using an unbreakable mirror) for surveillance of early foot problems.

The selection of appropriate footwear and footwear behaviors at home should also be discussed. Patients' understanding of these issues and their physical ability to conduct proper foot surveillance and care should be assessed. Patients with visual difficulties, physical constraints preventing movement, or cognitive problems that impair their ability to assess the condition of the foot and to institute appropriate responses will need other people, such as family members, to assist with their care.

Treatment

People with neuropathy or evidence of increased plantar pressures (e.g., erythema, warmth, or calluses) may be adequately managed with well-fitted walking shoes or athletic shoes that cushion the feet and redistribute pressure. People with bony deformities (e.g., hammertoes, prominent metatarsal heads, bunions) may need extra wide or deep shoes. People with bony deformities, including Charcot foot, who cannot be accommodated with commercial therapeutic footwear, will require custom-molded shoes. Special consideration and a thorough workup should be performed when patients with neuropathy present with the acute onset of a red, hot, swollen foot or ankle, and Charcot neuroarthropathy should be excluded. Early diagnosis and treatment of Charcot neuroarthropathy is the best way to prevent deformities that increase the risk of ulceration and amputation. The routine prescription of therapeutic footwear is not generally recommended. However, patients should be provided adequate information to aid in selection of appropriate footwear. General footwear recommendations include a broad and square toe box, laces with three or

four eyes per side, padded tongue, quality lightweight materials, and sufficient size to accommodate a cushioned insole. Use of custom therapeutic footwear can help reduce the risk of future foot ulcers in high-risk patients (145,147).

Most diabetic foot infections are polymicrobial, with aerobic gram-positive cocci. Staphylococci and streptococci are the most common causative organisms. Wounds without evidence of soft tissue or bone infection do not require antibiotic therapy. Empiric antibiotic therapy can be narrowly targeted at gram-positive cocci in many patients with acute infections, but those at risk for infection with antibiotic-resistant organisms or with chronic, previously treated, or severe infections require broader-spectrum regimens and should be referred to specialized care centers (148). Foot ulcers and wound care may require care by a podiatrist, orthopedic or vascular surgeon, or rehabilitation specialist experienced in the management of individuals with diabetes (148).

Hyperbaric oxygen therapy (HBOT) in patients with diabetic foot ulcers has mixed evidence supporting its use as an adjunctive treatment to enhance wound healing and prevent amputation (149–151). In a relatively high-quality double-blind study of patients with chronic diabetic foot ulcers, hyperbaric oxygen as an adjunctive therapy resulted in significantly more complete healing of the index ulcer in patients treated with HBOT compared with placebo at 1 year of follow-up (152). However, multiple subsequently published studies have either failed to demonstrate a benefit of HBOT or have been relatively small with potential flaws in study design (150). A well-conducted randomized controlled study performed in 103 patients found that HBOT did not reduce the indication for amputation or facilitate wound healing compared with comprehensive wound care in patients with chronic diabetic foot ulcers (153). A systematic review by the International Working Group on the Diabetic Foot of interventions to improve the healing of chronic diabetic foot ulcers concluded that analysis of the evidence continues to present methodological challenges as randomized controlled studies remain few, with a majority being of poor quality (150). HBOT also does not seem to have a significant effect on health-related quality

of life in patients with diabetic foot ulcers (154,155). A recent review concluded that the evidence to date remains inconclusive regarding the clinical and cost-effectiveness of HBOT as an adjunctive treatment to standard wound care for diabetic foot ulcers (156). Results from the recently published Dutch DAMOCLES (Does Applying More Oxygen Cure Lower Extremity Sores?) trial demonstrated that HBOT in patients with diabetes and ischemic wounds did not significantly improve complete wound healing and limb salvage (157). The Centers for Medicare & Medicaid Services currently covers HBOT for diabetic foot ulcers that have failed a standard course of wound therapy when there are no measurable signs of healing for at least 30 consecutive days (158). HBOT should be a topic of shared decision making before treatment is considered for selected patients with diabetic foot ulcers (158).

References

- Tuttle KR, Bakris GL, Bilous RW, et al. Diabetic kidney disease: a report from an ADA Consensus Conference. *Diabetes Care* 2014;37:2864–2883
- National Kidney Foundation. KDIGO 2012 clinical practice guideline for the evaluation and management of chronic kidney disease. *Kidney Int Suppl* 2013;3:1–150
- Afkarian M, Zelnick LR, Hall YN, et al. Clinical manifestations of kidney disease among US adults with diabetes, 1988–2014. *JAMA* 2016;316:602–610
- de Boer IH, Rue TC, Hall YN, Heagerty PJ, Weiss NS, Himmelfarb J. Temporal trends in the prevalence of diabetic kidney disease in the United States. *JAMA* 2011;305:2532–2539
- de Boer IH; DCCT/EDIC Research Group. Kidney disease and related findings in the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications study. *Diabetes Care* 2014;37:24–30
- United States Renal Data System. *Annual Data Report: Epidemiology of Kidney Disease in the United States*. Bethesda, MD, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, 2016
- Fox CS, Matsushita K, Woodward M, et al.; Chronic Kidney Disease Prognosis Consortium. Associations of kidney disease measures with mortality and end-stage renal disease in individuals with and without diabetes: a meta-analysis. *Lancet* 2012;380:1662–1673
- Afkarian M, Sachs MC, Kestenbaum B, et al. Kidney disease and increased mortality risk in type 2 diabetes. *J Am Soc Nephrol* 2013;24:302–308
- Groop P-H, Thomas MC, Moran JL, et al.; FinnDiane Study Group. The presence and severity of chronic kidney disease predicts all-cause mortality in type 1 diabetes. *Diabetes* 2009;58:1651–1658
- Delanaye P, Glasscock RJ, Pottel H, Rule AD. An age-calibrated definition of chronic kidney disease: rationale and benefits. *Clin Biochem Rev* 2016;37:17–26
- Kramer HJ, Nguyen QD, Curhan G, Hsu C-Y. Renal insufficiency in the absence of albuminuria and retinopathy among adults with type 2 diabetes mellitus. *JAMA* 2003;289:3273–3277
- Molitch ME, Steffes M, Sun W, et al.; Epidemiology of Diabetes Interventions and Complications Study Group. Development and progression of renal insufficiency with and without albuminuria in adults with type 1 diabetes in the Diabetes Control and Complications Trial and the Epidemiology of Diabetes Interventions and Complications study. *Diabetes Care* 2010;33:1536–1543
- He F, Xia X, Wu XF, Yu XQ, Huang FX. Diabetic retinopathy in predicting diabetic nephropathy in patients with type 2 diabetes and renal disease: a meta-analysis. *Diabetologia* 2013;56:457–466
- Levey AS, Coresh J, Balk E, et al.; National Kidney Foundation. National Kidney Foundation practice guidelines for chronic kidney disease: evaluation, classification, and stratification. *Ann Intern Med* 2003;139:137–147
- Coresh J, Turin TC, Matsushita K, et al. Decline in estimated glomerular filtration rate and subsequent risk of end-stage renal disease and mortality. *JAMA* 2014;311:2518–2531
- James MT, Grams ME, Woodward M, et al.; CKD Prognosis Consortium. A meta-analysis of the association of estimated GFR, albuminuria, diabetes mellitus, and hypertension with acute kidney injury. *Am J Kidney Dis* 2015;66:602–612
- Nadkarni GN, Ferrandino R, Chang A, et al. Acute kidney injury in patients on SGLT2 inhibitors: a propensity-matched analysis. *Diabetes Care* 2017;40:1479–1485
- Wanner C, Inzucchi SE, Lachin JM, et al.; EMPA-REG OUTCOME Investigators. Empagliflozin and progression of kidney disease in type 2 diabetes. *N Engl J Med* 2016;375:323–334
- Neuen BL, Ohkuma T, Neal B, et al. Cardiovascular and renal outcomes with canagliflozin according to baseline kidney function: data from the CANVAS Program. *Circulation* 2018;138:1537–1550
- Thakar CV, Christianson A, Himmelfarb J, Leonard AC. Acute kidney injury episodes and chronic kidney disease risk in diabetes mellitus. *Clin J Am Soc Nephrol* 2011;6:2567–2572
- Hughes-Austin JM, Rifkin DE, Beben T, et al. The relation of serum potassium concentration with cardiovascular events and mortality in community-living individuals. *Clin J Am Soc Nephrol* 2017;12:245–252
- Bandak G, Sang Y, Gasparini A, et al. Hyperkalemia after initiating renin-angiotensin system blockade: the Stockholm Creatinine Measurements (SCREAM) Project. *J Am Heart Assoc* 2017;6:e005428
- Nilsson E, Gasparini A, Ärnlöv J, et al. Incidence and determinants of hyperkalemia and hypokalemia in a large healthcare system. *Int J Cardiol* 2017;245:277–284
- de Boer IH, Gao X, Cleary PA, et al.; Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications (DCCT/EDIC) Research Group. Albuminuria changes and cardiovascular and renal outcomes in type 1 diabetes: the DCCT/EDIC study. *Clin J Am Soc Nephrol* 2016;11:1969–1977
- Sumida K, Molnar MZ, Potukuchi PK, et al. Changes in albuminuria and subsequent risk of incident kidney disease. *Clin J Am Soc Nephrol* 2017;12:1941–1949
- Inker LA, Grams ME, Levey AS, et al.; CKD Prognosis Consortium. Relationship of estimated GFR and albuminuria to concurrent laboratory abnormalities: an individual participant data meta-analysis in a global consortium. *Am J Kidney Dis*. 19 October 2018 [Epub ahead of print]. DOI: 10.1053/j.ajkd.2018.08.013
- Mills KT, Chen J, Yang W, et al.; Chronic Renal Insufficiency Cohort (CRIC) Study Investigators. Sodium excretion and the risk of cardiovascular disease in patients with chronic kidney disease. *JAMA* 2016;315:2200–2210
- DCCT/EDIC Research Group. Effect of intensive diabetes treatment on albuminuria in type 1 diabetes: long-term follow-up of the Diabetes Control and Complications Trial and Epidemiology of Diabetes Interventions and Complications study. *Lancet Diabetes Endocrinol* 2014;2:793–800
- de Boer IH, Sun W, Cleary PA, et al.; DCCT/EDIC Research Group. Intensive diabetes therapy and glomerular filtration rate in type 1 diabetes. *N Engl J Med* 2011;365:2366–2376
- UK Prospective Diabetes Study (UKPDS) Group. Effect of intensive blood-glucose control with metformin on complications in overweight patients with type 2 diabetes (UKPDS 34). *Lancet* 1998;352:854–865
- UK Prospective Diabetes Study (UKPDS) Group. Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). *Lancet* 1998;352:837–853
- Patel A, MacMahon S, Chalmers J, et al.; ADVANCE Collaborative Group. Intensive blood glucose control and vascular outcomes in patients with type 2 diabetes. *N Engl J Med* 2008;358:2560–2572
- Ismail-Beigi F, Craven T, Banerji MA, et al.; ACCORD trial group. Effect of intensive treatment of hyperglycaemia on microvascular outcomes in type 2 diabetes: an analysis of the ACCORD randomised trial. *Lancet* 2010;376:419–430
- Zoungas S, Chalmers J, Neal B, et al.; ADVANCE-ON Collaborative Group. Follow-up of blood-pressure lowering and glucose control in type 2 diabetes. *N Engl J Med* 2014;371:1392–1406
- Zoungas S, Arima H, Gerstein HC, et al.; Collaborators on Trials of Lowering Glucose (CONTROL) group. Effects of intensive glucose control on microvascular outcomes in patients with type 2 diabetes: a meta-analysis of individual participant data from randomised controlled trials. *Lancet Diabetes Endocrinol* 2017;5:431–437
- Miller ME, Bonds DE, Gerstein HC, et al.; ACCORD Investigators. The effects of baseline characteristics, glycaemia treatment approach, and glycated haemoglobin concentration on the risk of severe hypoglycaemia: post hoc epidemiological analysis of the ACCORD study. *BMJ* 2010;340:b5444
- Papademetriou V, Lovato L, Doumas M, et al.; ACCORD Study Group. Chronic kidney

- disease and intensive glycemic control increase cardiovascular risk in patients with type 2 diabetes. *Kidney Int* 2015;87:649–659
37. Perkovic V, Heerspink HL, Chalmers J, et al.; ADVANCE Collaborative Group. Intensive glucose control improves kidney outcomes in patients with type 2 diabetes. *Kidney Int* 2013;83:517–523
38. Wong MG, Perkovic V, Chalmers J, et al.; ADVANCE-ON Collaborative Group. Long-term benefits of intensive glucose control for preventing end-stage kidney disease: ADVANCE-ON. *Diabetes Care* 2016;39:694–700
39. National Kidney Foundation. KDOQI clinical practice guideline for diabetes and CKD: 2012 update. *Am J Kidney Dis* 2012;60:850–886
40. Cherney DZI, Perkins BA, Soleymanlou N, et al. Renal hemodynamic effect of sodium-glucose cotransporter 2 inhibition in patients with type 1 diabetes mellitus. *Circulation* 2014;129:587–597
41. Heerspink HJL, Desai M, Jardine M, Balis D, Meininger G, Perkovic V. Canagliflozin slows progression of renal function decline independently of glycemic effects. *J Am Soc Nephrol* 2017;28:368–375 PubMed
42. Neal B, Perkovic V, Mahaffey KW, et al.; CANVAS Program Collaborative Group. Canagliflozin and cardiovascular and renal events in type 2 diabetes. *N Engl J Med* 2017;377:644–657
43. Zelniker TA, Braunwald E. Cardiac and renal effects of sodium-glucose co-transporter 2 inhibitors in diabetes: JACC state-of-the-art review. *J Am Coll Cardiol* 2018;72:1845–1855
44. Marso SP, Daniels GH, Brown-Frandsen K, et al.; LEADER Steering Committee; LEADER Trial Investigators. Liraglutide and cardiovascular outcomes in type 2 diabetes. *N Engl J Med* 2016;375:311–322
45. Cooper ME, Perkovic V, McGill JB, et al. Kidney disease end points in a pooled analysis of individual patient-level data from a large clinical trials program of the dipeptidyl peptidase 4 inhibitor linagliptin in type 2 diabetes. *Am J Kidney Dis* 2015;66:441–449
46. Mann JFE, Ørsted DD, Brown-Frandsen K, et al.; LEADER Steering Committee and Investigators. Liraglutide and renal outcomes in type 2 diabetes. *N Engl J Med* 2017;377:839–848
47. Marso SP, Bain SC, Consoli A, et al.; SUSTAIN-6 Investigators. Semaglutide and cardiovascular outcomes in patients with type 2 diabetes. *N Engl J Med* 2016;375:1834–1844
48. Karter AJ, Warton EM, Lipska KJ, et al. Development and validation of a tool to identify patients with type 2 diabetes at high risk of hypoglycemia-related emergency department or hospital use. *JAMA Intern Med* 2017;177:1461–1470
49. Moen MF, Zhan M, Hsu VD, et al. Frequency of hypoglycemia and its significance in chronic kidney disease. *Clin J Am Soc Nephrol* 2009;4:1121–1127
50. U.S. Food and Drug Administration. FDA drug safety communication: FDA revises warnings regarding use of the diabetes medicine metformin in certain patients with reduced kidney function [Internet], 2016. Available from <http://www.fda.gov/Drugs/DrugSafety/ucm493244.htm>. Accessed 14 October 2016
51. Zinman B, Wanner C, Lachin JM, et al.; EMPA-REG OUTCOME Investigators. Empagliflozin, cardiovascular outcomes, and mortality in type 2 diabetes. *N Engl J Med* 2015;373:2117–2128
52. Mahaffey KW, Neal B, Perkovic V, et al.; CANVAS Program Collaborative Group. Canagliflozin for primary and secondary prevention of cardiovascular events: results from the CANVAS Program (Canagliflozin Cardiovascular Assessment Study). *Circulation* 2018;137:323–334
53. Tuttle KR, Lakshmanan MC, Rayner B, et al. Dulaglutide versus insulin glargine in patients with type 2 diabetes and moderate-to-severe chronic kidney disease (AWARD-7): a multicentre, open-label, randomised trial. *Lancet Diabetes Endocrinol* 2018;6:605–617
- 53a. Lambers-Heerspink HJ, Desai M, Jardine M, et al. Canagliflozin slows progression of renal function decline independent of glycemic effects. *J Am Soc Nephrol* 2017;28:368–375
54. Jardine MJ, Mahaffey KW, Neal B, et al.; CREDENCE study investigators. The Canagliflozin and Renal Endpoints in Diabetes with Established Nephropathy Clinical Evaluation (CREDENCE) study rationale, design, and baseline characteristics. *Am J Nephrol* 2017;46:462–472
55. Wanner C, Lachin JM, Inzucchi SE, et al.; EMPA-REG OUTCOME Investigators. Empagliflozin and clinical outcomes in patients with type 2 diabetes, established cardiovascular disease and chronic kidney disease. *Circulation* 2018;137:119–129
56. Leehey DJ, Zhang JH, Emanuele NV, et al.; VA NEPHRON-D Study Group. BP and renal outcomes in diabetic kidney disease: the Veterans Affairs Nephropathy in Diabetes Trial. *Clin J Am Soc Nephrol* 2015;10:2159–2169
57. Emdin CA, Rahimi K, Neal B, Callender T, Perkovic V, Patel A. Blood pressure lowering in type 2 diabetes: a systematic review and meta-analysis. *JAMA* 2015;313:603–615
58. Cushman WC, Evans GW, Byington RP, et al.; ACCORD Study Group. Effects of intensive blood-pressure control in type 2 diabetes mellitus. *N Engl J Med* 2010;362:1575–1585
59. UK Prospective Diabetes Study Group. Tight blood pressure control and risk of macrovascular and microvascular complications in type 2 diabetes: UKPDS 38. *BMJ* 1998;317:703–713
60. de Boer IH, Bangalore S, Benetos A, et al. Diabetes and hypertension: a position statement by the American Diabetes Association. *Diabetes Care* 2017;40:1273–1284
61. Brenner BM, Cooper ME, de Zeeuw D, et al.; RENAAL Study Investigators. Effects of losartan on renal and cardiovascular outcomes in patients with type 2 diabetes and nephropathy. *N Engl J Med* 2001;345:861–869
62. Lewis EJ, Hunsicker LG, Bain RP, Rohde RD; The Collaborative Study Group. The effect of angiotensin-converting-enzyme inhibition on diabetic nephropathy. *N Engl J Med* 1993;329:1456–1462
63. Lewis EJ, Hunsicker LG, Clarke WR, et al.; Collaborative Study Group. Renoprotective effect of the angiotensin-receptor antagonist irbesartan in patients with nephropathy due to type 2 diabetes. *N Engl J Med* 2001;345:851–860
64. Heart Outcomes Prevention Evaluation Study Investigators. Effects of ramipril on cardiovascular and microvascular outcomes in people with diabetes mellitus: results of the HOPE study and MICRO-HOPE substudy. *Lancet* 2000;355:253–259
65. Barnett AH, Bain SC, Bouter P, et al.; Diabetics Exposed to Telmisartan and Enalapril Study Group. Angiotensin-receptor blockade versus converting-enzyme inhibition in type 2 diabetes and nephropathy. *N Engl J Med* 2004;351:1952–1961
66. Wu H-Y, Peng C-L, Chen P-C, et al. Comparative effectiveness of angiotensin-converting enzyme inhibitors versus angiotensin II receptor blockers for major renal outcomes in patients with diabetes: a 15-year cohort study. *PLoS One* 2017;12:e0177654
67. Parving HH, Lehnert H, Bröchner-Mortensen J, Gomis R, Andersen S, Arner P; Irbesartan in Patients with Type 2 Diabetes and Microalbuminuria Study Group. The effect of irbesartan on the development of diabetic nephropathy in patients with type 2 diabetes. *N Engl J Med* 2001;345:870–878
68. Bangalore S, Fakheri R, Toklu B, Messerli FH. Diabetes mellitus as a compelling indication for use of renin angiotensin system blockers: systematic review and meta-analysis of randomized trials. *BMJ* 2016;352:i438
69. Haller H, Ito S, Izzo JL Jr, et al.; ROADMAP Trial Investigators. Olmesartan for the delay or prevention of microalbuminuria in type 2 diabetes. *N Engl J Med* 2011;364:907–917
70. Mauer M, Zinman B, Gardiner R, et al. Renal and retinal effects of enalapril and losartan in type 1 diabetes. *N Engl J Med* 2009;361:40–51
71. Yusuf S, Teo KK, Pogue J, et al.; ONTARGET Investigators. Telmisartan, ramipril, or both in patients at high risk for vascular events. *N Engl J Med* 2008;358:1547–1559
72. Fried LF, Emanuele N, Zhang JH, et al.; VA NEPHRON-D Investigators. Combined angiotensin inhibition for the treatment of diabetic nephropathy. *N Engl J Med* 2013;369:1892–1903
73. Bakris GL, Agarwal R, Chan JC, et al.; Mineralocorticoid Receptor Antagonist Tolerability Study–Diabetic Nephropathy (ARTS-DN) Study Group. Effect of finerenone on albuminuria in patients with diabetic nephropathy: a randomized clinical trial. *JAMA* 2015;314:884–894
74. Williams B, MacDonald TM, Morant S, et al.; British Hypertension Society’s PATHWAY Studies Group. Spironolactone versus placebo, bisoprolol, and doxazosin to determine the optimal treatment for drug-resistant hypertension (PATHWAY-2): a randomised, double-blind, crossover trial. *Lancet* 2015;386:2059–2068
75. Filippatos G, Anker SD, Böhm M, et al. A randomized controlled study of finerenone vs. eplerenone in patients with worsening chronic heart failure and diabetes mellitus and/or chronic kidney disease. *Eur Heart J* 2016;37:2105–2114
76. Smart NA, Dieberg G, Ladhani M, Titus T. Early referral to specialist nephrology services for preventing the progression to end-stage kidney disease. *Cochrane Database Syst Rev* 2014;6:CD007333
77. Solomon SD, Chew E, Duh EJ, et al. Diabetic retinopathy: a position statement by the American Diabetes Association. *Diabetes Care* 2017;40:412–418
78. Klein R. Hyperglycemia and microvascular and macrovascular disease in diabetes. *Diabetes Care* 1995;18:258–268

79. Estacio RO, McFarling E, Biggerstaff S, Jeffers BW, Johnson D, Schrier RW. Overt albuminuria predicts diabetic retinopathy in Hispanics with NIDDM. *Am J Kidney Dis* 1998;31:947–953
80. Leske MC, Wu S-Y, Hennis A, et al.; Barbados Eye Study Group. Hyperglycemia, blood pressure, and the 9-year incidence of diabetic retinopathy: the Barbados Eye Studies. *Ophthalmology* 2005;112:799–805
81. Chew EY, Davis MD, Danis RP, et al.; Action to Control Cardiovascular Risk in Diabetes Eye Study Research Group. The effects of medical management on the progression of diabetic retinopathy in persons with type 2 diabetes: the Action to Control Cardiovascular Risk in Diabetes (ACCORD) Eye Study. *Ophthalmology* 2014;121:2443–2451
82. Nathan DM, Genuth S, Lachin J, et al.; Diabetes Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. *N Engl J Med* 1993;329:977–986
83. Chew EY, Ambrosius WT, Davis MD, et al.; ACCORD Study Group; ACCORD Eye Study Group. Effects of medical therapies on retinopathy progression in type 2 diabetes. *N Engl J Med* 2010;363:233–244
84. Gubitosi-Klug RA, Sun W, Cleary PA, et al.; Writing Team for the DCCT/EDIC Research Group. Effects of prior intensive insulin therapy and risk factors on patient-reported visual function outcomes in the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications (DCCT/EDIC) cohort. *JAMA Ophthalmol* 2016;134:137–145
85. Fong DS, Aiello LP, Ferris FL 3rd, Klein R. Diabetic retinopathy. *Diabetes Care* 2004;27:2540–2553
86. Diabetes Control and Complications Trial Research Group. Effect of pregnancy on microvascular complications in the diabetes control and complications trial. *Diabetes Care* 2000;23:1084–1091
87. Dabelea D, Stafford JM, Mayer-Davis EJ, et al.; SEARCH for Diabetes in Youth Research Group. Association of type 1 diabetes vs type 2 diabetes diagnosed during childhood and adolescence with complications during teenage years and young adulthood. *JAMA* 2017;317:825–835
88. Agardh E, Tababat-Khani P. Adopting 3-year screening intervals for sight-threatening retinal vascular lesions in type 2 diabetic subjects without retinopathy. *Diabetes Care* 2011;34:1318–1319
89. Nathan DM, Bebu I, Hainsworth D, et al.; DCCT/EDIC Research Group. Frequency of evidence-based screening for retinopathy in type 1 diabetes. *N Engl J Med* 2017;376:1507–1516
90. Daskivich LP, Vasquez C, Martinez CJr, Tseng C-H, Mangione CM. Implementation and evaluation of a large-scale teleretinal diabetic retinopathy screening program in the Los Angeles County Department of Health Services. *JAMA Intern Med* 2017;177:642–649
91. Sim DA, Mitry D, Alexander P, et al. The evolution of teleophthalmology programs in the United Kingdom: beyond diabetic retinopathy screening. *J Diabetes Sci Technol* 2016;10:308–317
92. Hooper P, Boucher MC, Cruess A, et al. Canadian Ophthalmological Society evidence-based clinical practice guidelines for the management of diabetic retinopathy. *Can J Ophthalmol* 2012;47(Suppl. 1):S1–S30
93. Axer-Siegel R, Hod M, Fink-Cohen S, et al. Diabetic retinopathy during pregnancy. *Ophthalmology* 1996;103:1815–1819
94. Best RM, Chakravarthy U. Diabetic retinopathy in pregnancy. *Br J Ophthalmol* 1997;81:249–251
95. Gunderson EP, Lewis CE, Tsai A-L, et al. A 20-year prospective study of childbearing and incidence of diabetes in young women, controlling for glycemia before conception: the Coronary Artery Risk Development in Young Adults (CARDIA) Study. *Diabetes* 2007;56:2990–2996
96. The Diabetic Retinopathy Study Research Group. Preliminary report on effects of photocoagulation therapy. *Am J Ophthalmol* 1976;81:383–396
97. Gross JG, Glassman AR, Jampol LM, et al.; Writing Committee for the Diabetic Retinopathy Clinical Research Network. Panretinal photocoagulation vs intravitreal ranibizumab for proliferative diabetic retinopathy: a randomized clinical trial. *JAMA* 2015;314:2137–2146
98. Early Treatment Diabetic Retinopathy Study Research Group. Photocoagulation for diabetic macular edema. Early Treatment Diabetic Retinopathy Study report number 1. *Arch Ophthalmol* 1985;103:1796–1806
99. Elman MJ, Aiello LP, Beck RW, et al.; Diabetic Retinopathy Clinical Research Network. Randomized trial evaluating ranibizumab plus prompt or deferred laser or triamcinolone plus prompt laser for diabetic macular edema. *Ophthalmology* 2010;117:1064–1077.e35
100. Mitchell P, Bandello F, Schmidt-Erfurth U, et al.; RESTORE study group. The RESTORE study: ranibizumab monotherapy or combined with laser versus laser monotherapy for diabetic macular edema. *Ophthalmology* 2011;118:615–625
101. Elman MJ, Bressler NM, Qin H, et al.; Diabetic Retinopathy Clinical Research Network. Expanded 2-year follow-up of ranibizumab plus prompt or deferred laser or triamcinolone plus prompt laser for diabetic macular edema. *Ophthalmology* 2011;118:609–614
102. Nguyen QD, Brown DM, Marcus DM, et al.; RISE and RIDE Research Group. Ranibizumab for diabetic macular edema: results from 2 phase III randomized trials: RISE and RIDE. *Ophthalmology* 2012;119:789–801
103. Shih C-J, Chen H-T, Kuo S-C, et al. Comparative effectiveness of angiotensin-converting enzyme inhibitors and angiotensin II receptor blockers in patients with type 2 diabetes and retinopathy. *CMAJ* 2016;188:E148–E157
104. Shi R, Zhao L, Wang F, et al. Effects of lipid-lowering agents on diabetic retinopathy: a meta-analysis and systematic review. *Int J Ophthalmol* 2018;11:287–295
105. Ang L, Jaiswal M, Martin C, Pop-Busui R. Glucose control and diabetic neuropathy: lessons from recent large clinical trials. *Curr Diab Rep* 2014;14:528
106. Martin CL, Albers JW, Pop-Busui R; DCCT/EDIC Research Group. Neuropathy and related findings in the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications study. *Diabetes Care* 2014;37:31–38
107. Pop-Busui R, Boulton AJM, Feldman EL, et al. Diabetic neuropathy: a position statement by the American Diabetes Association. *Diabetes Care* 2017;40:136–154
108. Freeman R. Not all neuropathy in diabetes is of diabetic etiology: differential diagnosis of diabetic neuropathy. *Curr Diab Rep* 2009;9:423–431
109. Pop-Busui R, Evans GW, Gerstein HC, et al.; Action to Control Cardiovascular Risk in Diabetes Study Group. Effects of cardiac autonomic dysfunction on mortality risk in the Action to Control Cardiovascular Risk in Diabetes (ACCORD) trial. *Diabetes Care* 2010;33:1578–1584
110. Pop-Busui R, Cleary PA, Braffett BH, et al.; DCCT/EDIC Research Group. Association between cardiovascular autonomic neuropathy and left ventricular dysfunction: DCCT/EDIC study (Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications). *J Am Coll Cardiol* 2013;61:447–454
111. Smith AG, Lessard M, Reyna S, Doudova M, Singleton JR. The diagnostic utility of Sudoscan for distal symmetric peripheral neuropathy. *J Diabetes Complications* 2014;28:511–516
112. Diabetes Control and Complications Trial (DCCT) Research Group. Effect of intensive diabetes treatment on nerve conduction in the Diabetes Control and Complications Trial. *Ann Neurol* 1995;38:869–880
113. CDC Study Group. The effect of intensive diabetes therapy on measures of autonomic nervous system function in the Diabetes Control and Complications Trial (DCCT). *Diabetologia* 1998;41:416–423
114. Albers JW, Herman WH, Pop-Busui R, et al.; Diabetes Control and Complications Trial /Epidemiology of Diabetes Interventions and Complications Research Group. Effect of prior intensive insulin treatment during the Diabetes Control and Complications Trial (DCCT) on peripheral neuropathy in type 1 diabetes during the Epidemiology of Diabetes Interventions and Complications (EDIC) study. *Diabetes Care* 2010;33:1090–1096
115. Pop-Busui R, Low PA, Waberski BH, et al.; DCCT/EDIC Research Group. Effects of prior intensive insulin therapy on cardiac autonomic nervous system function in type 1 diabetes mellitus: the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications study (DCCT/EDIC). *Circulation* 2009;119:2886–2893
116. Callaghan BC, Little AA, Feldman EL, Hughes RAC. Enhanced glucose control for preventing and treating diabetic neuropathy. *Cochrane Database Syst Rev* 2012;6:CD007543
117. Pop-Busui R, Lu J, Brooks MM, et al.; BARI 2D Study Group. Impact of glycemic control strategies on the progression of diabetic peripheral neuropathy in the Bypass Angioplasty Revascularization Investigation 2 Diabetes (BARI 2D) cohort. *Diabetes Care* 2013;36:3208–3215
118. Sadosky A, Schaefer C, Mann R, et al. Burden of illness associated with painful diabetic peripheral neuropathy among adults seeking treatment in the US: results from a retrospective chart review and cross-sectional survey. *Diabetes Metab Syndr Obes* 2013;6:79–92
119. Waldfoegel JM, Nesbit SA, Dy SM, et al. Pharmacotherapy for diabetic peripheral neuropathy pain and quality of life: a systematic review. *Neurology* 2017;88:1958–1967
120. Finnerup NB, Attal N, Haroutounian S, et al. Pharmacotherapy for neuropathic pain in adults:

- a systematic review and meta-analysis. *Lancet Neurol* 2015;14:162–173
121. Brill V, England J, Franklin GM, et al.; American Academy of Neurology; American Association of Neuromuscular and Electrodiagnostic Medicine; American Academy of Physical Medicine and Rehabilitation. Evidence-based guideline: treatment of painful diabetic neuropathy: report of the American Academy of Neurology, the American Association of Neuromuscular and Electrodiagnostic Medicine, and the American Academy of Physical Medicine and Rehabilitation [published correction appears in *Neurology* 2011;77:603]. *Neurology* 2011;76:1758–1765
122. Griebeler ML, Morey-Vargas OL, Brito JP, et al. Pharmacologic interventions for painful diabetic neuropathy: an umbrella systematic review and comparative effectiveness network meta-analysis. *Ann Intern Med* 2014;161:639–649
123. Ziegler D, Fonseca V. From guideline to patient: a review of recent recommendations for pharmacotherapy of painful diabetic neuropathy. *J Diabetes Complications* 2015;29:146–156
124. Freeman R, Durso-Decruz E, Emir B. Efficacy, safety, and tolerability of pregabalin treatment for painful diabetic peripheral neuropathy: findings from seven randomized, controlled trials across a range of doses. *Diabetes Care* 2008;31:1448–1454
125. Moore RA, Straube S, Wiffen PJ, Derry S, McQuay HJ. Pregabalin for acute and chronic pain in adults. *Cochrane Database Syst Rev* 2009;3:CD007076
126. Raskin P, Huffman C, Toth C, et al. Pregabalin in patients with inadequately treated painful diabetic peripheral neuropathy: a randomized withdrawal trial. *Clin J Pain* 2014;30:379–390
127. Tesfaye S, Wilhelm S, Lledo A, et al. Duloxetine and pregabalin: high-dose monotherapy or their combination? The “COMBO-DN study”—a multinational, randomized, double-blind, parallel-group study in patients with diabetic peripheral neuropathic pain. *Pain* 2013;154:2616–2625
128. Ziegler D, Duan WR, An G, Thomas JW, Nothaft W. A randomized double-blind, placebo-, and active-controlled study of T-type calcium channel blocker ABT-639 in patients with diabetic peripheral neuropathic pain. *Pain* 2015;156:2013–2020
129. Quilici S, Chancellor J, Löthgren M, et al. Meta-analysis of duloxetine vs. pregabalin and gabapentin in the treatment of diabetic peripheral neuropathic pain. *BMC Neurol* 2009;9:6
130. Dworkin RH, Jensen MP, Gammaitoni AR, Olaleye DO, Galer BS. Symptom profiles differ in patients with neuropathic versus non-neuropathic pain. *J Pain* 2007;8:118–126
131. Wiffen PJ, Derry S, Bell RF, et al. Gabapentin for chronic neuropathic pain in adults. *Cochrane Database Syst Rev* 2017;6:CD007938
132. Wernicke JF, Pritchett YL, D’Souza DN, et al. A randomized controlled trial of duloxetine in diabetic peripheral neuropathic pain. *Neurology* 2006;67:1411–1420
133. Hardy T, Sachson R, Shen S, Armbruster M, Boulton AJM. Does treatment with duloxetine for neuropathic pain impact glycemic control? *Diabetes Care* 2007;30:21–26
134. Schwartz S, Etropolski M, Shapiro DY, et al. Safety and efficacy of tapentadol ER in patients with painful diabetic peripheral neuropathy: results of a randomized-withdrawal, placebo-controlled trial. *Curr Med Res Opin* 2011;27:151–162
135. Vinik AI, Shapiro DY, Rauschkolb C, et al. A randomized withdrawal, placebo-controlled study evaluating the efficacy and tolerability of tapentadol extended release in patients with chronic painful diabetic peripheral neuropathy. *Diabetes Care* 2014;37:2302–2309
136. Camilleri M, Parkman HP, Shafi MA, Abell TL, Gerson L; American College of Gastroenterology. Clinical guideline: management of gastroparesis. *Am J Gastroenterol* 2013;108:18–37; quiz 38
137. Parrish CR, Pastors JG. Nutritional management of gastroparesis in people with diabetes. *Diabetes Spectr* 2007;20:231–234
138. Parkman HP, Yates KP, Hasler WL, et al.; NIDDK Gastroparesis Clinical Research Consortium. Dietary intake and nutritional deficiencies in patients with diabetic or idiopathic gastroparesis. *Gastroenterology* 2011;141:486–498, 498.e1–7
139. Olausson EA, Störsrud S, Grundin H, Isaksson M, Attvall S, Simrén M. A small particle size diet reduces upper gastrointestinal symptoms in patients with diabetic gastroparesis: a randomized controlled trial. *Am J Gastroenterol* 2014;109:375–385
140. Umptierre GE, Ed. *Therapy for Diabetes Mellitus and Related Disorders*. 6th ed. Alexandria, VA, American Diabetes Association, 2014
141. Sugumar A, Singh A, Pasricha PJ. A systematic review of the efficacy of domperidone for the treatment of diabetic gastroparesis. *Clin Gastroenterol Hepatol* 2008;6:726–733
142. Maganti K, Onyemere K, Jones MP. Oral erythromycin and symptomatic relief of gastroparesis: a systematic review. *Am J Gastroenterol* 2003;98:259–263
143. McCallum RW, Snape W, Brody F, Wo J, Parkman HP, Nowak T. Gastric electrical stimulation with Enterra therapy improves symptoms from diabetic gastroparesis in a prospective study. *Clin Gastroenterol Hepatol* 2010;8:947–954; quiz e116
144. Boulton AJM, Armstrong DG, Albert SF, et al.; American Diabetes Association; American Association of Clinical Endocrinologists. Comprehensive foot examination and risk assessment: a report of the Task Force of the Foot Care Interest Group of the American Diabetes Association, with endorsement by the American Association of Clinical Endocrinologists. *Diabetes Care* 2008;31:1679–1685
145. Hingorani A, LaMuraglia GM, Henke P, et al. The management of diabetic foot: a clinical practice guideline by the Society for Vascular Surgery in collaboration with the American Podiatric Medical Association and the Society for Vascular Medicine. *J Vasc Surg* 2016;63(Suppl.):3S–21S
146. Bonner T, Foster M, Spears-Lanoix E. Type 2 diabetes-related foot care knowledge and foot self-care practice interventions in the United States: a systematic review of the literature. *Diabet Foot Ankle* 2016;7:29758
147. Rizzo L, Tedeschi A, Fallani E, et al. Custom-made orthosis and shoes in a structured follow-up program reduces the incidence of neuropathic ulcers in high-risk diabetic foot patients. *Int J Low Extrem Wounds* 2012;11:59–64
148. Lipsky BA, Berendt AR, Cornia PB, et al.; Infectious Diseases Society of America. 2012 Infectious Diseases Society of America clinical practice guideline for the diagnosis and treatment of diabetic foot infections. *Clin Infect Dis* 2012;54:e132–e173
149. Elraiyah T, Tsapas A, Prutsky G, et al. A systematic review and meta-analysis of adjunctive therapies in diabetic foot ulcers. *J Vasc Surg* 2016;63(2 Suppl.):46S–58S.e1–2
150. Game FL, Apelqvist J, Attinger C, et al.; International Working Group on the Diabetic Foot. Effectiveness of interventions to enhance healing of chronic ulcers of the foot in diabetes: a systematic review. *Diabetes Metab Res Rev* 2016;32(Suppl. 1):154–168
151. Kranke P, Bennett MH, Martyn-St James M, Schnabel A, Debus SE, Weibel S. Hyperbaric oxygen therapy for chronic wounds. *Cochrane Database Syst Rev* 2015;6:CD004123
152. Löndahl M, Katzman P, Nilsson A, Hammarlund C. Hyperbaric oxygen therapy facilitates healing of chronic foot ulcers in patients with diabetes. *Diabetes Care* 2010;33:998–1003
153. Fedorko L, Bowen JM, Jones W, et al. Hyperbaric oxygen therapy does not reduce indications for amputation in patients with diabetes with nonhealing ulcers of the lower limb: a prospective, double-blind, randomized controlled clinical trial. *Diabetes Care* 2016;39:392–399
154. Li G, Hopkins RB, Levine MAH, et al. Relationship between hyperbaric oxygen therapy and quality of life in participants with chronic diabetic foot ulcers: data from a randomized controlled trial. *Acta Diabetol* 2017;54:823–831
155. Boulton AJM. The Diabetic Foot [Internet], 2000. South Dartmouth, MA, MDText.com, Inc. Available from <http://www.ncbi.nlm.nih.gov/books/NBK409609/>. Accessed 5 October 2017
156. Health Quality Ontario. Hyperbaric oxygen therapy for the treatment of diabetic foot ulcers: a health technology assessment. *Ont Health Technol Assess Ser* 2017;17:1–142
157. Stoeckenbroek RM, Santema TB, Koelemay MJ, et al. Is additional hyperbaric oxygen therapy cost-effective for treating ischemic diabetic ulcers? Study protocol for the Dutch DAMOCLES multicenter randomized clinical trial? *J Diabetes* 2015;7:125–132
158. Huang ET, Mansouri J, Murad MH, et al.; UHMS CPG Oversight Committee. A clinical practice guideline for the use of hyperbaric oxygen therapy in the treatment of diabetic foot ulcers. *Undersea Hyperb Med* 2015;42:205–247

12. Older Adults: *Standards of Medical Care in Diabetes—2019*

American Diabetes Association

Diabetes Care 2019;42(Suppl. 1):S139–S147 | <https://doi.org/10.2337/dc19s012>

The American Diabetes Association (ADA) “Standards of Medical Care in Diabetes” includes ADA’s current clinical practice recommendations and is intended to provide the components of diabetes care, general treatment goals and guidelines, and tools to evaluate quality of care. Members of the ADA Professional Practice Committee, a multidisciplinary expert committee, are responsible for updating the Standards of Care annually, or more frequently as warranted. For a detailed description of ADA standards, statements, and reports, as well as the evidence-grading system for ADA’s clinical practice recommendations, please refer to the Standards of Care Introduction. Readers who wish to comment on the Standards of Care are invited to do so at professional.diabetes.org/SOC.

Recommendations

- 12.1** Consider the assessment of medical, psychological, functional (self-management abilities), and social geriatric domains in older adults to provide a framework to determine targets and therapeutic approaches for diabetes management. **C**
- 12.2** Screening for geriatric syndromes may be appropriate in older adults experiencing limitations in their basic and instrumental activities of daily living as they may affect diabetes self-management and be related to health-related quality of life. **C**

Diabetes is an important health condition for the aging population; approximately one-quarter of people over the age of 65 years have diabetes and one-half of older adults have prediabetes (1), and this proportion is expected to increase rapidly in the coming decades. Older individuals with diabetes have higher rates of premature death, functional disability, accelerated muscle loss, and coexisting illnesses, such as hypertension, coronary heart disease, and stroke, than those without diabetes. Older adults with diabetes also are at greater risk than other older adults for several common geriatric syndromes, such as polypharmacy, cognitive impairment, urinary incontinence, injurious falls, and persistent pain. These conditions may impact older adults’ diabetes self-management abilities (2). See Section 4 “Comprehensive Medical Evaluation and Assessment of Comorbidities” for comorbidities to consider when caring for older adult patients with diabetes.

Screening for diabetes complications in older adults should be individualized and periodically revisited, as the results of screening tests may impact therapeutic approaches and targets (2–4). Older adults are at increased risk for depression and should therefore be screened and treated accordingly (5). Diabetes management may require assessment of medical, psychological, functional, and social domains. This may provide a framework to determine targets and therapeutic approaches, including whether referral for diabetes self-management education is appropriate (when complicating factors arise or when transitions in care occur) or whether the current

Suggested citation: American Diabetes Association. 12. Older adults: Standards of Medical Care in Diabetes—2019. Diabetes Care 2019;42 (Suppl. 1):S139–S147

© 2018 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. More information is available at <http://www.diabetesjournals.org/content/license>.

regimen is too complex for the patient's self-management ability. Particular attention should be paid to complications that can develop over short periods of time and/or would significantly impair functional status, such as visual and lower-extremity complications. Please refer to the American Diabetes Association (ADA) consensus report "Diabetes in Older Adults" for details (2).

NEUROCOGNITIVE FUNCTION

Recommendation

12.3 Screening for early detection of mild cognitive impairment or dementia and depression is indicated for adults 65 years of age or older at the initial visit and annually as appropriate. **B**

Older adults with diabetes are at higher risk of cognitive decline and institutionalization (6,7). The presentation of cognitive impairment ranges from subtle executive dysfunction to memory loss and overt dementia. People with diabetes have higher incidences of all-cause dementia, Alzheimer disease, and vascular dementia than people with normal glucose tolerance (8). The effects of hyperglycemia and hyperinsulinemia on the brain are areas of intense research. Clinical trials of specific interventions—including cholinesterase inhibitors and glutamatergic antagonists—have not shown positive therapeutic benefit in maintaining or significantly improving cognitive function or in preventing cognitive decline (9). Pilot studies in patients with mild cognitive impairment evaluating the potential benefits of intranasal insulin therapy and metformin therapy provide insights for future clinical trials and mechanistic studies (10–12).

The presence of cognitive impairment can make it challenging for clinicians to help their patients reach individualized glycemic, blood pressure, and lipid targets. Cognitive dysfunction makes it difficult for patients to perform complex self-care tasks, such as glucose monitoring and adjusting insulin doses. It also hinders their ability to appropriately maintain the timing and content of diet. When clinicians are managing patients with cognitive dysfunction, it is critical to simplify drug regimens and to involve caregivers in all aspects of care.

Poor glycemic control is associated with a decline in cognitive function (13), and longer duration of diabetes is associated with worsening cognitive function. There are ongoing studies evaluating whether preventing or delaying diabetes onset may help to maintain cognitive function in older adults. However, studies examining the effects of intensive glycemic and blood pressure control to achieve specific targets have not demonstrated a reduction in brain function decline (14,15).

Older adults with diabetes should be carefully screened and monitored for cognitive impairment (2) (see **Table 4.1** for depression and cognitive screening recommendations). Several organizations have released simple assessment tools, such as the Mini-Mental State Examination (16) and the Montreal Cognitive Assessment (17), which may help to identify patients requiring neuropsychological evaluation, particularly those in whom dementia is suspected (i.e., experiencing memory loss and decline in their basic and instrumental activities of daily living). Annual screening for cognitive impairment is indicated for adults 65 years of age or older for early detection of mild cognitive impairment or dementia (4,18). Screening for cognitive impairment should additionally be considered in the presence of a significant decline in clinical status, inclusive of increased difficulty with self-care activities, such as errors in calculating insulin dose, difficulty counting carbohydrates, skipping meals, skipping insulin doses, and difficulty recognizing, preventing, or treating hypoglycemia. People who screen positive for cognitive impairment should receive diagnostic assessment as appropriate, including referral to a behavioral health provider for formal cognitive/neuropsychological evaluation (19).

HYPOGLYCEMIA

Recommendation

12.4 Hypoglycemia should be avoided in older adults with diabetes. It should be assessed and managed by adjusting glycemic targets and pharmacologic interventions. **B**

Older adults are at higher risk of hypoglycemia for many reasons, including

insulin deficiency necessitating insulin therapy and progressive renal insufficiency. In addition, older adults tend to have higher rates of unidentified cognitive deficits, causing difficulty in complex self-care activities (e.g., glucose monitoring, adjusting insulin doses, etc.). These cognitive deficits have been associated with increased risk of hypoglycemia, and, conversely, severe hypoglycemia has been linked to increased risk of dementia (20). Therefore, it is important to routinely screen older adults for cognitive dysfunction and discuss findings with the patients and their caregivers.

Hypoglycemic events should be diligently monitored and avoided, whereas glycemic targets and pharmacologic interventions may need to be adjusted to accommodate for the changing needs of the older adult (2). Of note, it is important to prevent hypoglycemia to reduce the risk of cognitive decline (20) and other major adverse outcomes. Intensive glucose control in the Action to Control Cardiovascular Risk in Diabetes-Memory in Diabetes study (ACCORD MIND) was not found to benefit brain structure or cognitive function during follow-up (14). In the Diabetes Control and Complications Trial (DCCT), no significant long-term declines in cognitive function were observed, despite participants' relatively high rates of recurrent severe hypoglycemia (21). To achieve the appropriate balance between glycemic control and risk for hypoglycemia, it is important to carefully assess and reassess patients' risk for worsening of glycemic control and functional decline.

TREATMENT GOALS

Recommendations

12.5 Older adults who are otherwise healthy with few coexisting chronic illnesses and intact cognitive function and functional status should have lower glycemic goals (such as A1C <7.5% [58 mmol/mol]), while those with multiple coexisting chronic illnesses, cognitive impairment, or functional dependence should have less stringent glycemic goals (such as A1C <8.0–8.5% [64–69 mmol/mol]). **C**

12.6 Glycemic goals for some older adults might reasonably be

relaxed as part of individualized care, but hyperglycemia leading to symptoms or risk of acute hyperglycemia complications should be avoided in all patients. **C**

12.7 Screening for diabetes complications should be individualized in older adults. Particular attention should be paid to complications that would lead to functional impairment. **C**

12.8 Treatment of hypertension to individualized target levels is indicated in most older adults. **C**

12.9 Treatment of other cardiovascular risk factors should be individualized in older adults considering the time frame of benefit. Lipid-lowering therapy and aspirin therapy may benefit those with life expectancies at least equal to the time frame of primary prevention or secondary intervention trials. **E**

The care of older adults with diabetes is complicated by their clinical, cognitive, and functional heterogeneity. Some older individuals may have developed diabetes years earlier and have significant complications, others are newly diagnosed and may have had years of undiagnosed diabetes with resultant complications, and still other older adults may have truly recent-onset disease with few or no complications (22). Some older adults with diabetes have other underlying chronic conditions, substantial diabetes-related comorbidity, limited cognitive or physical functioning, or frailty (23,24). Other older individuals with diabetes have little comorbidity and are active. Life expectancies are highly variable but are often longer than clinicians realize. Providers caring for older adults with diabetes must take this heterogeneity into consideration when setting and prioritizing treatment goals (25) (**Table 12.1**). In addition, older adults with diabetes should be assessed for disease treatment and self-management knowledge, health literacy, and mathematical literacy (numeracy) at the onset of treatment. See **Fig. 6.1** for patient- and disease-related factors to consider when determining individualized glycemic targets.

A1C is used as the standard biomarker for glycemic control in all patients with

diabetes but may have limitations in patients who have medical conditions that impact red blood cell turnover (see Section 2 “Classification and Diagnosis of Diabetes” for additional details on the limitations of A1C) (26). Many conditions associated with increased red blood cell turnover, such as hemodialysis, recent blood loss or transfusion, or erythropoietin therapy, are commonly seen in older adults with functional limitations, which can falsely increase or decrease A1C. In these instances, plasma blood glucose and fingerstick readings should be used for goal setting (**Table 12.1**).

Healthy Patients With Good Functional Status

There are few long-term studies in older adults demonstrating the benefits of intensive glycemic, blood pressure, and lipid control. Patients who can be expected to live long enough to reap the benefits of long-term intensive diabetes management, who have good cognitive and physical function, and who choose to do so via shared decision making may be treated using therapeutic interventions and goals similar to those for younger adults with diabetes (**Table 12.1**).

As with all patients with diabetes, diabetes self-management education and ongoing diabetes self-management support are vital components of diabetes care for older adults and their caregivers. Self-management knowledge and skills should be reassessed when regimen changes are made or an individual's functional abilities diminish. In addition, declining or impaired ability to perform diabetes self-care behaviors may be an indication for referral of older adults with diabetes for cognitive and physical functional assessment using age-normalized evaluation tools (3,19).

Patients With Complications and Reduced Functionality

For patients with advanced diabetes complications, life-limiting comorbid illnesses, or substantial cognitive or functional impairments, it is reasonable to set less intensive glycemic goals (**Table 12.1**). Factors to consider in individualizing glycemic goals are outlined in **Fig. 6.1**. These patients are less likely to benefit from reducing the risk of microvascular complications and more likely to suffer serious adverse effects from hypoglycemia. However, patients

with poorly controlled diabetes may be subject to acute complications of diabetes, including dehydration, poor wound healing, and hyperglycemic hyperosmolar coma. Glycemic goals at a minimum should avoid these consequences.

Vulnerable Patients at the End of Life

For patients receiving palliative care and end-of-life care, the focus should be to avoid symptoms and complications from glycemic management. Thus, when organ failure develops, several agents will have to be downtitrated or discontinued. For the dying patient, most agents for type 2 diabetes may be removed (27). There is, however, no consensus for the management of type 1 diabetes in this scenario (28). See **END-OF-LIFE CARE** below, for additional information.

Beyond Glycemic Control

Although hyperglycemia control may be important in older individuals with diabetes, greater reductions in morbidity and mortality are likely to result from control of other cardiovascular risk factors rather than from tight glycemic control alone. There is strong evidence from clinical trials of the value of treating hypertension in older adults (29,30). There is less evidence for lipid-lowering therapy and aspirin therapy, although the benefits of these interventions for primary prevention and secondary intervention are likely to apply to older adults whose life expectancies equal or exceed the time frames of the clinical trials.

LIFESTYLE MANAGEMENT

Recommendation

12.10 Optimal nutrition and protein intake is recommended for older adults; regular exercise, including aerobic activity and resistance training, should be encouraged in all older adults who can safely engage in such activities. **B**

Diabetes in the aging population is associated with reduced muscle strength, poor muscle quality, and accelerated loss of muscle mass, resulting in sarcopenia. Diabetes is also recognized as an independent risk factor for frailty. Frailty is characterized by decline in physical performance and an increased risk of poor

Table 12.1—Framework for considering treatment goals for glycemia, blood pressure, and dyslipidemia in older adults with diabetes (2)

Patient characteristics/ health status	Rationale	Reasonable A1C goal†	Fasting or preprandial glucose	Bedtime glucose	Blood pressure	Lipids
Healthy (few coexisting chronic illnesses, intact cognitive and functional status)	Longer remaining life expectancy	<7.5% (58 mmol/mol)	90–130 mg/dL (5.0–7.2 mmol/L)	90–150 mg/dL (5.0–8.3 mmol/L)	<140/90 mmHg	Statin unless contraindicated or not tolerated
Complex/intermediate (multiple coexisting chronic illnesses* or 2+ instrumental ADL impairments or mild-to-moderate cognitive impairment)	Intermediate remaining life expectancy, high treatment burden, hypoglycemia vulnerability, fall risk	<8.0% (64 mmol/mol)	90–150 mg/dL (5.0–8.3 mmol/L)	100–180 mg/dL (5.6–10.0 mmol/L)	<140/90 mmHg	Statin unless contraindicated or not tolerated
Very complex/poor health (LTC or end-stage chronic illnesses** or moderate-to-severe cognitive impairment or 2+ ADL dependencies)	Limited remaining life expectancy makes benefit uncertain	<8.5%† (69 mmol/mol)	100–180 mg/dL (5.6–10.0 mmol/L)	110–200 mg/dL (6.1–11.1 mmol/L)	<150/90 mmHg	Consider likelihood of benefit with statin (secondary prevention more so than primary)

This represents a consensus framework for considering treatment goals for glycemia, blood pressure, and dyslipidemia in older adults with diabetes. The patient characteristic categories are general concepts. Not every patient will clearly fall into a particular category. Consideration of patient and caregiver preferences is an important aspect of treatment individualization. Additionally, a patient's health status and preferences may change over time. †A lower A1C goal may be set for an individual if achievable without recurrent or severe hypoglycemia or undue treatment burden. *Coexisting chronic illnesses are conditions serious enough to require medications or lifestyle management and may include arthritis, cancer, congestive heart failure, depression, emphysema, falls, hypertension, incontinence, stage 3 or worse chronic kidney disease, myocardial infarction, and stroke. "Multiple" means at least three, but many patients may have five or more (54). **The presence of a single end-stage chronic illness, such as stage 3–4 congestive heart failure or oxygen-dependent lung disease, chronic kidney disease requiring dialysis, or uncontrolled metastatic cancer, may cause significant symptoms or impairment of functional status and significantly reduce life expectancy. †A1C of 8.5% (69 mmol/mol) equates to an unmet average glucose of ~200 mg/dL (11.1 mmol/L). Looser A1C targets above 8.5% (69 mmol/mol) are not recommended as they may expose patients to more frequent higher glucose values and the acute risks from glycosuria, dehydration, hyperglycemic hyperosmolar syndrome, and poor wound healing. ADL, activities of daily living.

health outcomes due to physiologic vulnerability to clinical, functional, or psychosocial stressors. Inadequate nutritional intake, particularly inadequate protein intake, can increase the risk of sarcopenia and frailty in older adults. Management of frailty in diabetes includes optimal nutrition with adequate protein intake combined with an exercise program that includes aerobic and resistance training (31,32).

PHARMACOLOGIC THERAPY

Recommendations

- 12.11** In older adults at increased risk of hypoglycemia, medication classes with low risk of hypoglycemia are preferred. **B**
- 12.12** Overtreatment of diabetes is common in older adults and should be avoided. **B**
- 12.13** Deintensification (or simplification) of complex regimens is recommended to reduce the risk of hypoglycemia, if it can be achieved within the individualized A1C target. **B**

Special care is required in prescribing and monitoring pharmacologic therapies in older adults (33). See Fig. 9.1 for general recommendations regarding antihyperglycemia treatment for adults with type 2 diabetes and Table 9.1 for patient- and drug-specific factors to consider when selecting antihyperglycemia agents. Cost may be an important consideration, especially as older adults tend to be on many medications. See Tables 9.2 and 9.3 for median monthly cost of noninsulin glucose-lowering agents and insulin in the U.S., respectively. It is important to match complexity of the treatment regimen to the self-management ability of an older patient. Many older adults with diabetes struggle to maintain the frequent blood glucose testing and insulin injection regimens they previously followed, perhaps for many decades, as they develop medical conditions that may impair their ability to follow their regimen safely. Individualized glycemic goals should be established (Fig. 6.1) and periodically adjusted based on coexisting chronic illnesses, cognitive function, and functional status (2). Tight glycemic control in older adults with multiple medical conditions is considered overtreatment

Simplification of Complex Insulin Therapy

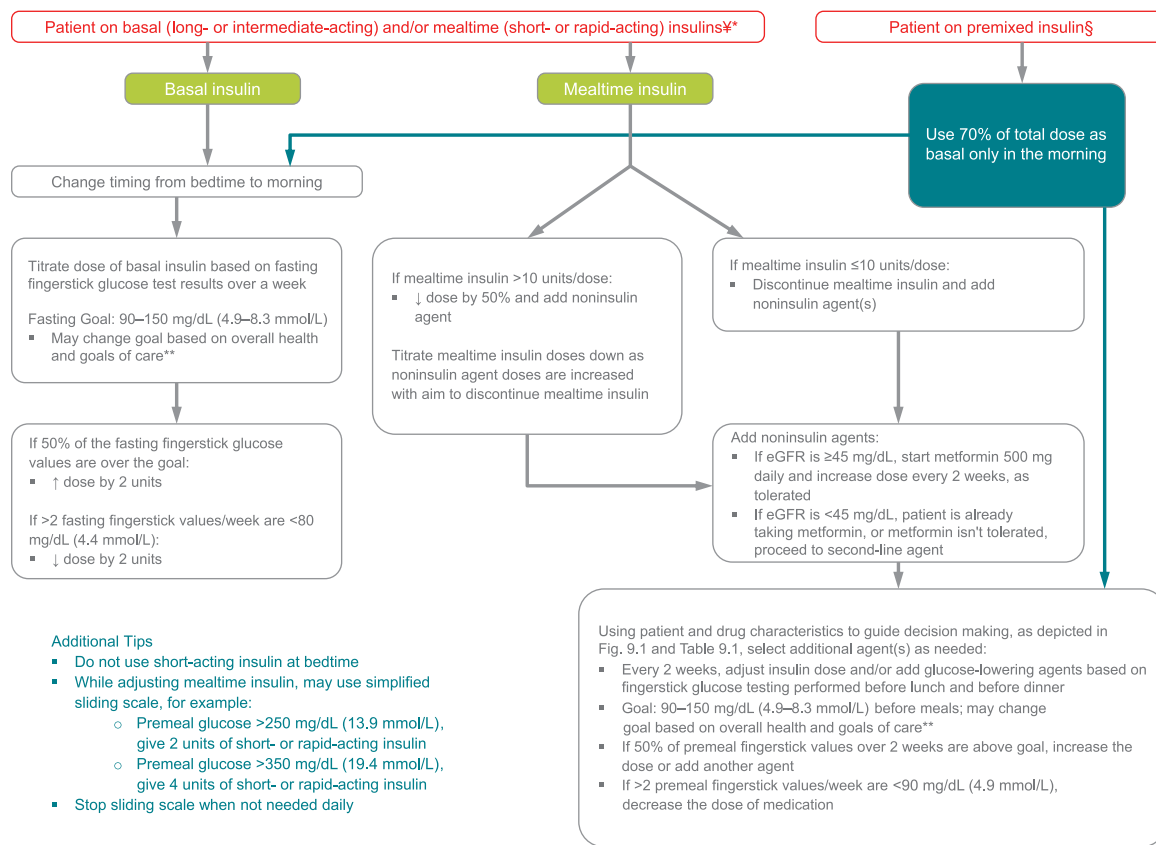


Fig. 12.1—Algorithm to simplify insulin regimen for older patients with type 2 diabetes. eGFR, estimated glomerular filtration rate. *Basal insulins: glargine U-100 and U-300, detemir, degludec, and human NPH. **See Table 12.1. †Mealtime insulins: short-acting (regular human insulin) or rapid-acting (lispro, aspart, and glulisine). ‡Premixed insulins: 70/30, 75/25, and 50/50 products. Adapted with permission from Munshi and colleagues (39,55,56).

and is associated with an increased risk of hypoglycemia; unfortunately, overtreatment is common in clinical practice (34–38). Deintensification of regimens in patients taking noninsulin glucose-lowering medications can be achieved by either lowering the dose or discontinuing some medications, so long as the individualized A1C target is maintained. When patients are found to have an insulin regimen with complexity beyond their self-management abilities, lowering the dose of insulin may not be adequate. Simplification of the insulin regimen to match an individual’s self-management abilities in these situations has been shown to reduce hypoglycemia and disease-related distress without worsening glycemic control (39–41). **Figure 12.1** depicts an algorithm that can be used to simplify the insulin regimen (39). **Table 12.2** provides examples of and rationale for situations where deintensification and/or insulin regimen

simplification may be appropriate in older adults.

Metformin

Metformin is the first-line agent for older adults with type 2 diabetes. Recent studies have indicated that it may be used safely in patients with estimated glomerular filtration rate ≥ 30 mL/min/1.73 m² (42). However, it is contraindicated in patients with advanced renal insufficiency and should be used with caution in patients with impaired hepatic function or congestive heart failure due to the increased risk of lactic acidosis. Metformin may be temporarily discontinued before procedures, during hospitalizations, and when acute illness may compromise renal or liver function.

Thiazolidinediones

Thiazolidinediones, if used at all, should be used very cautiously in those with, or at risk for, congestive heart failure and those at risk for falls or fractures.

Insulin Secretagogues

Sulfonylureas and other insulin secretagogues are associated with hypoglycemia and should be used with caution. If used, shorter-duration sulfonylureas, such as glipizide, are preferred. Glyburide is a longer-duration sulfonylurea and contraindicated in older adults (43).

Incretin-Based Therapies

Oral dipeptidyl peptidase 4 (DPP-4) inhibitors have few side effects and minimal hypoglycemia, but their costs may be a barrier to some older patients. DPP-4 inhibitors do not increase major adverse cardiovascular outcomes (44).

Glucagon-like peptide 1 (GLP-1) receptor agonists are injectable agents, which require visual, motor, and cognitive skills for appropriate administration. They may be associated with nausea, vomiting, and diarrhea. Also, weight loss with GLP-1 receptor agonists may not be desirable in some older

Table 12.2—Considerations for treatment regimen simplification and deintensification/deprescribing in older adults with diabetes (39,55)

Patient characteristics/ health status	Reasonable A1C/ treatment goal	Rationale/considerations	When may regimen simplification be required?	When may treatment deintensification/ deprescribing be required?
Healthy (few coexisting chronic illnesses, intact cognitive and functional status)	A1C <7.5% (58 mmol/mol)	<ul style="list-style-type: none"> • Patients can generally perform complex tasks to maintain good glycemic control when health is stable • During acute illness, patients may be more at risk for administration or dosing errors that can result in hypoglycemia, falls, fractures, etc. 	<ul style="list-style-type: none"> • If severe or recurrent hypoglycemia occurs in patients on insulin therapy (even if A1C is appropriate) • If wide glucose excursions are observed • If cognitive or functional decline occurs following acute illness 	<ul style="list-style-type: none"> • If severe or recurrent hypoglycemia occurs in patients on noninsulin therapies with high risk of hypoglycemia (even if A1C is appropriate) • If wide glucose excursions are observed • In the presence of polypharmacy
Complex/intermediate (multiple coexisting chronic illnesses or 2+ instrumental ADL impairments or mild-to-moderate cognitive impairment)	A1C <8.0% (64 mmol/mol)	<ul style="list-style-type: none"> • Comorbidities may affect self-management abilities and capacity to avoid hypoglycemia • Long-acting medication formulations may decrease pill burden and complexity of medication regimen 	<ul style="list-style-type: none"> • If severe or recurrent hypoglycemia occurs in patients on insulin therapy (even if A1C is appropriate) • If unable to manage complexity of an insulin regimen • If there is a significant change in social circumstances, such as loss of caregiver, change in living situation, or financial difficulties 	<ul style="list-style-type: none"> • If severe or recurrent hypoglycemia occurs in patients on noninsulin therapies with high risk of hypoglycemia (even if A1C is appropriate) • If wide glucose excursions are observed • In the presence of polypharmacy
Community-dwelling patients receiving care in a skilled nursing facility for short-term rehabilitation	Avoid reliance on A1C Glucose target: 100–200 mg/dL (5.55–11.1 mmol/L)	<ul style="list-style-type: none"> • Glycemic control is important for recovery, wound healing, hydration, and avoidance of infections • Patients recovering from illness may not have returned to baseline cognitive function at the time of discharge • Consider the type of support the patient will receive at home 	<ul style="list-style-type: none"> • If treatment regimen increased in complexity during hospitalization, it is reasonable, in many cases, to reinstate the prehospitalization medication regimen during the rehabilitation 	<ul style="list-style-type: none"> • If the hospitalization for acute illness resulted in weight loss, anorexia, short-term cognitive decline, and/or loss of physical functioning
Very complex/poor health (long-term care or end-stage chronic illnesses or moderate-to-severe cognitive impairment or 2+ ADL dependencies)	A1C <8.5% (69 mmol/L) [†]	<ul style="list-style-type: none"> • No benefits of tight glycemic control in this population • Hypoglycemia should be avoided • Most important outcomes are maintenance of cognitive and functional status 	<ul style="list-style-type: none"> • If on an insulin regimen and the patient would like to decrease the number of injections and fingerstick blood glucose monitoring events each day • If the patient has an inconsistent eating pattern 	<ul style="list-style-type: none"> • If on noninsulin agents with a high hypoglycemia risk in the context of cognitive dysfunction, depression, anorexia, or inconsistent eating pattern • If taking any medications without clear benefits
Patients at end of life	Avoid hypoglycemia and symptomatic hyperglycemia	<ul style="list-style-type: none"> • Goal is to provide comfort and avoid tasks or interventions that cause pain or discomfort • Caregivers are important in providing medical care and maintaining quality of life 	<ul style="list-style-type: none"> • If there is pain or discomfort caused by treatment (e.g., injections or fingersticks) • If there is excessive caregiver stress due to treatment complexity 	<ul style="list-style-type: none"> • If taking any medications without clear benefits in improving symptoms and/or comfort

Treatment regimen simplification refers to changing strategy to decrease the complexity of a medication regimen, e.g., fewer administration times, fewer fingerstick readings, decreasing the need for calculations (such as sliding scale insulin calculations or insulin-carbohydrate ratio calculations). Deintensification/deprescribing refers to decreasing the dose or frequency of administration of a treatment or discontinuing a treatment altogether. ADL, activities of daily living. [†]Consider adjustment of A1C goal if the patient has a condition that may interfere with erythrocyte life span/turnover.

patients, particularly those with cachexia. In patients with established atherosclerotic cardiovascular disease, GLP-1 receptor agonists have shown cardiovascular benefits (44).

Sodium–Glucose Cotransporter 2 Inhibitors

Sodium–glucose cotransporter 2 inhibitors are administered orally, which may be convenient for older adults with diabetes; however, long-term experience in this population is limited despite the initial efficacy and safety data reported with these agents. In patients with established atherosclerotic cardiovascular disease, these agents have shown cardiovascular benefits (44).

Insulin Therapy

The use of insulin therapy requires that patients or their caregivers have good visual and motor skills and cognitive ability. Insulin therapy relies on the ability of the older patient to administer insulin on their own or with the assistance of a caregiver. Insulin doses should be titrated to meet individualized glycemic targets and to avoid hypoglycemia.

Once-daily basal insulin injection therapy is associated with minimal side effects and may be a reasonable option in many older patients. Multiple daily injections of insulin may be too complex for the older patient with advanced diabetes complications, life-limiting coexisting chronic illnesses, or limited functional status. **Figure 12.1** provides a potential approach to insulin regimen simplification.

Other Factors to Consider

The needs of older adults with diabetes and their caregivers should be evaluated to construct a tailored care plan. Impaired social functioning may reduce their quality of life and increase the risk of functional dependency (45). The patient's living situation must be considered as it may affect diabetes management and support needs. Social and instrumental support networks (e.g., adult children, caretakers) that provide instrumental or emotional support for older adults with diabetes should be included in diabetes management discussions and shared decision making.

Older adults in assisted living facilities may not have support to administer their own medications, whereas those living in a nursing home (community living

centers) may rely completely on the care plan and nursing support. Those receiving palliative care (with or without hospice) may require an approach that emphasizes comfort and symptom management, while de-emphasizing strict metabolic and blood pressure control.

TREATMENT IN SKILLED NURSING FACILITIES AND NURSING HOMES

Recommendations

12.14 Consider diabetes education for the staff of long-term care facilities to improve the management of older adults with diabetes. **E**

12.15 Patients with diabetes residing in long-term care facilities need careful assessment to establish glycemic goals and to make appropriate choices of glucose-lowering agents based on their clinical and functional status. **E**

Management of diabetes in the long-term care (LTC) setting (i.e., nursing homes and skilled nursing facilities) is unique. Individualization of health care is important in all patients; however, practical guidance is needed for medical providers as well as the LTC staff and caregivers (46). Training should include diabetes detection and institutional quality assessment. LTC facilities should develop their own policies and procedures for prevention and management of hypoglycemia.

Resources

Staff of LTC facilities should receive appropriate diabetes education to improve the management of older adults with diabetes. Treatments for each patient should be individualized. Special management considerations include the need to avoid both hypoglycemia and the complications of hyperglycemia (2,47). For more information, see the ADA position statement “Management of Diabetes in Long-term Care and Skilled Nursing Facilities” (46).

Nutritional Considerations

An older adult residing in an LTC facility may have irregular and unpredictable meal consumption, undernutrition, anorexia, and impaired swallowing. Furthermore, therapeutic diets may inadvertently

lead to decreased food intake and contribute to unintentional weight loss and undernutrition. Diets tailored to a patient's culture, preferences, and personal goals may increase quality of life, satisfaction with meals, and nutrition status (48).

Hypoglycemia

Older adults with diabetes in LTC are especially vulnerable to hypoglycemia. They have a disproportionately high number of clinical complications and comorbidities that can increase hypoglycemia risk: impaired cognitive and renal function, slowed hormonal regulation and counterregulation, suboptimal hydration, variable appetite and nutritional intake, polypharmacy, and slowed intestinal absorption (49). Oral agents may achieve similar glycemic outcomes in LTC populations as basal insulin (34,50).

Another consideration for the LTC setting is that, unlike the hospital setting, medical providers are not required to evaluate the patients daily. According to federal guidelines, assessments should be done at least every 30 days for the first 90 days after admission and then at least once every 60 days. Although in practice the patients may actually be seen more frequently, the concern is that patients may have uncontrolled glucose levels or wide excursions without the practitioner being notified. Providers may make adjustments to treatment regimens by telephone, fax, or in person directly at the LTC facilities provided they are given timely notification of blood glucose management issues from a standardized alert system.

The following alert strategy could be considered:

- 1. Call provider immediately:** in case of low blood glucose levels (≤ 70 mg/dL [3.9 mmol/L]).
- 2. Call as soon as possible:** a) glucose values between 70 and 100 mg/dL (3.9 and 5.6 mmol/L) (regimen may need to be adjusted), b) glucose values greater than 250 mg/dL (13.9 mmol/L) within a 24-h period, c) glucose values greater than 300 mg/dL (16.7 mmol/L) over 2 consecutive days, d) when any reading is too high for the glucometer, or e) the patient is sick, with vomiting, symptomatic hyperglycemia, or poor oral intake.

END-OF-LIFE CARE

Recommendations

12.16 When palliative care is needed in older adults with diabetes, strict blood pressure control may not be necessary, and withdrawal of therapy may be appropriate. Similarly, the intensity of lipid management can be relaxed, and withdrawal of lipid-lowering therapy may be appropriate. **E**

12.17 Overall comfort, prevention of distressing symptoms, and preservation of quality of life and dignity are primary goals for diabetes management at the end of life. **E**

The management of the older adult at the end of life receiving palliative medicine or hospice care is a unique situation. Overall, palliative medicine promotes comfort, symptom control and prevention (pain, hypoglycemia, hyperglycemia, and dehydration), and preservation of dignity and quality of life in patients with limited life expectancy (47,51). A patient has the right to refuse testing and treatment, whereas providers may consider withdrawing treatment and limiting diagnostic testing, including a reduction in the frequency of fingerstick testing (52). Glucose targets should aim to prevent hypoglycemia and hyperglycemia. Treatment interventions need to be mindful of quality of life. Careful monitoring of oral intake is warranted. The decision process may need to involve the patient, family, and caregivers, leading to a care plan that is both convenient and effective for the goals of care (53). The pharmacologic therapy may include oral agents as first line, followed by a simplified insulin regimen. If needed, basal insulin can be implemented, accompanied by oral agents and without rapid-acting insulin. Agents that can cause gastrointestinal symptoms such as nausea or excess weight loss may not be good choices in this setting. As symptoms progress, some agents may be slowly tapered and discontinued.

Different patient categories have been proposed for diabetes management in those with advanced disease (28).

1. A stable patient: continue with the patient's previous regimen, with a

focus on the prevention of hypoglycemia and the management of hyperglycemia using blood glucose testing, keeping levels below the renal threshold of glucose. There is very little role for A1C monitoring and lowering.

- 2. A patient with organ failure:** preventing hypoglycemia is of greater significance. Dehydration must be prevented and treated. In people with type 1 diabetes, insulin administration may be reduced as the oral intake of food decreases but should not be stopped. For those with type 2 diabetes, agents that may cause hypoglycemia should be downtitrated. The main goal is to avoid hypoglycemia, allowing for glucose values in the upper level of the desired target range.
- 3. A dying patient:** for patients with type 2 diabetes, the discontinuation of all medications may be a reasonable approach, as patients are unlikely to have any oral intake. In patients with type 1 diabetes, there is no consensus, but a small amount of basal insulin may maintain glucose levels and prevent acute hyperglycemic complications.

References

- Centers for Disease Control and Prevention. National Diabetes Statistics Report [Internet], 2017. Available from <https://www.cdc.gov/diabetes/data/statistics/statistics-report.html>. Accessed 20 September 2018
- Kirkman MS, Briscoe VJ, Clark N, et al. Diabetes in older adults. *Diabetes Care* 2012;35:2650–2664
- Young-Hyman D, de Groot M, Hill-Briggs F, Gonzalez JS, Hood K, Peyrot M. Psychosocial care for people with diabetes: a position statement of the American Diabetes Association. *Diabetes Care* 2016;39:2126–2140
- Institute of Medicine of the National Academies. Cognitive Aging: Progress in Understanding and Opportunities for Action [Internet], 2015. Available from <http://nationalacademies.org/hmd/Reports/2015/Cognitive-Aging.aspx>. Accessed 20 September 2018
- Kimbro LB, Mangione CM, Steers WN, et al. Depression and all-cause mortality in persons with diabetes mellitus: are older adults at higher risk? Results from the Translating Research Into Action for Diabetes Study. *J Am Geriatr Soc* 2014; 62:1017–1022
- Cukierman T, Gerstein HC, Williamson JD. Cognitive decline and dementia in diabetes—systematic overview of prospective observational studies. *Diabetologia* 2005;48:2460–2469
- Roberts RO, Knopman DS, Przybelski SA, et al. Association of type 2 diabetes with brain atrophy

and cognitive impairment. *Neurology* 2014;82:1132–1141

- Xu WL, von Strauss E, Qiu CX, Winblad B, Fratiglioni L. Uncontrolled diabetes increases the risk of Alzheimer's disease: a population-based cohort study. *Diabetologia* 2009;52:1031–1039
- Ghezzi L, Scarpini E, Galimberti D. Disease-modifying drugs in Alzheimer's disease. *Drug Des Devel Ther* 2013;7:1471–1478
- Craft S, Baker LD, Montine TJ, et al. Intranasal insulin therapy for Alzheimer disease and amnesic mild cognitive impairment: a pilot clinical trial. *Arch Neurol* 2012;69:29–38
- Freiherr J, Hallschmid M, Frey WH 2nd, et al. Intranasal insulin as a treatment for Alzheimer's disease: a review of basic research and clinical evidence. *CNS Drugs* 2013;27:505–514
- Alagiakrishnan K, Sankaralingam S, Ghosh M, Mereu L, Senior P. Antidiabetic drugs and their potential role in treating mild cognitive impairment and Alzheimer's disease. *Discov Med* 2013; 16:277–286
- Yaffe K, Falvey C, Hamilton N, et al. Diabetes, glucose control, and 9-year cognitive decline among older adults without dementia. *Arch Neurol* 2012;69:1170–1175
- Launer LJ, Miller ME, Williamson JD, et al.; ACCORD MIND investigators. Effects of intensive glucose lowering on brain structure and function in people with type 2 diabetes (ACCORD MIND): a randomized open-label substudy. *Lancet Neurol* 2011;10:969–977
- Murray AM, Hsu F-C, Williamson JD, et al.; Action to Control Cardiovascular Risk in Diabetes Follow-On Memory in Diabetes (ACCORDION MIND) Investigators. ACCORDION MIND: results of the observational extension of the ACCORD MIND randomised trial. *Diabetologia* 2017;60: 69–80
- Cummings JL, Frank JC, Cherry D, et al. Guidelines for managing Alzheimer's disease: part I. Assessment. *Am Fam Physician* 2002; 65:2263–2272
- Nasreddine ZS, Phillips NA, Bédirian V, et al. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. *J Am Geriatr Soc* 2005;53:695–699
- Moreno G, Mangione CM, Kimbro L, Vaisberg E; American Geriatrics Society Expert Panel on Care of Older Adults with Diabetes Mellitus. Guidelines abstracted from the American Geriatrics Society guidelines for improving the care of older adults with diabetes mellitus: 2013 update. *J Am Geriatr Soc* 2013;61:2020–2026
- American Psychological Association. Guidelines for the Evaluation of Dementia and Age-Related Cognitive Change [Internet], 2011. Available from <http://www.apa.org/practice/guidelines/dementia.aspx>. Accessed 20 September 2018
- Feinkohl I, Aung PP, Keller M, et al.; Edinburgh Type 2 Diabetes Study (ET2DS) Investigators. Severe hypoglycemia and cognitive decline in older people with type 2 diabetes: the Edinburgh Type 2 Diabetes Study. *Diabetes Care* 2014;37:507–515
- Jacobson AM, Musen G, Ryan CM, et al.; Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications Study Research Group. Long-

term effect of diabetes and its treatment on cognitive function. *N Engl J Med* 2007;356:1842–1852

22. Selvin E, Coresh J, Brancati FL. The burden and treatment of diabetes in elderly individuals in the U.S. *Diabetes Care* 2006;29:2415–2419
23. Bandeen-Roche K, Seplaki CL, Huang J, et al. Frailty in older adults: a nationally representative profile in the United States. *J Gerontol A Biol Sci Med Sci* 2015;70:1427–1434
24. Kalyani RR, Tian J, Xue Q-L, et al. Hyperglycemia and incidence of frailty and lower extremity mobility limitations in older women. *J Am Geriatr Soc* 2012;60:1701–1707
25. Blaum C, Cigolle CT, Boyd C, et al. Clinical complexity in middle-aged and older adults with diabetes: the Health and Retirement Study. *Med Care* 2010;48:327–334
26. NGSP. Factors that Interfere with HbA1c Test Results [Internet], 2018. Available from <http://www.ngsp.org/factors.asp>. Accessed 20 September 2018
27. Sinclair A, Dunning T, Colagiuri S. *IDF Global Guideline For Managing Older People With Type 2 Diabetes*. International Diabetes Federation, Brussels, Belgium, 2013
28. Angelo M, Ruchalski C, Sproge BJ. An approach to diabetes mellitus in hospice and palliative medicine. *J Palliat Med* 2011;14:83–87
29. Beckett NS, Peters R, Fletcher AE, et al.; HYVET Study Group. Treatment of hypertension in patients 80 years of age or older. *N Engl J Med* 2008;358:1887–1898
30. de Boer IH, Bangalore S, Benetos A, et al. Diabetes and hypertension: a position statement by the American Diabetes Association. *Diabetes Care* 2017;40:1273–1284
31. Sinclair AJ, Abdelhafiz A, Dunning T, et al. An international position statement on the management of frailty in diabetes mellitus: summary of recommendations 2017. *J Frailty Aging* 2018;7:10–20
32. Castro-Rodríguez M, Carnicero JA, Garcia-Garcia FJ, et al. Frailty as a major factor in the increased risk of death and disability in older people with diabetes. *J Am Med Dir Assoc* 2016;17:949–955
33. Valencia WM, Florez H. Pharmacological treatment of diabetes in older people. *Diabetes Obes Metab* 2014;16:1192–1203
34. Andreassen LM, Sandberg S, Kristensen GBB, Sølvik UØ, Kjome RLS. Nursing home patients with diabetes: prevalence, drug treatment and glycemic control. *Diabetes Res Clin Pract* 2014;105:102–109
35. Lipska KJ, Ross JS, Miao Y, Shah ND, Lee SJ, Steinman MA. Potential overtreatment of diabetes mellitus in older adults with tight glycemic control. *JAMA Intern Med* 2015;175:356–362
36. Thorpe CT, Gellad WF, Good CB, et al. Tight glycemic control and use of hypoglycemic medications in older veterans with type 2 diabetes and comorbid dementia. *Diabetes Care* 2015;38:588–595
37. McAlister FA, Youngson E, Eurich DT. Treatment deintensification is uncommon in adults with type 2 diabetes mellitus: a retrospective cohort study. *Circ Cardiovasc Qual Outcomes* 2017;10:e003514
38. Arnold SV, Lipska KJ, Wang J, Seman L, Mehta SN, Kosiborod M. Use of intensive glycemic management in older adults with diabetes mellitus. *J Am Geriatr Soc* 2018;66:1190–1194
39. Munshi MN, Slyne C, Segal AR, Saul N, Lyons C, Weinger K. Simplification of insulin regimen in older adults and risk of hypoglycemia. *JAMA Intern Med* 2016;176:1023–1025
40. Sussman JB, Kerr EA, Saini SD, et al. Rates of deintensification of blood pressure and glycemic medication treatment based on levels of control and life expectancy in older patients with diabetes mellitus. *JAMA Intern Med* 2015;175:1942–1949
41. Abdelhafiz AH, Sinclair AJ. Deintensification of hypoglycaemic medications—use of a systematic review approach to highlight safety concerns in older people with type 2 diabetes. *J Diabetes Complications* 2018;32:444–450
42. Inzucchi SE, Lipska KJ, Mayo H, Bailey CJ, McGuire DK. Metformin in patients with type 2 diabetes and kidney disease: a systematic review. *JAMA* 2014;312:2668–2675
43. American Geriatrics Society 2015 Beers Criteria Update Expert Panel. American Geriatrics Society 2015 updated Beers criteria for potentially inappropriate medication use in older adults. *J Am Geriatr Soc* 2015;63:2227–2246
44. Davies MJ, D’Alessio DA, Fradkin J. Management of hyperglycemia in type 2 diabetes, 2018. A consensus report by the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD). *Diabetes Care* 2018;41:2669–2701
45. Laiteerapong N, Karter AJ, Liu JY, et al. Correlates of quality of life in older adults with diabetes: the Diabetes & Aging Study. *Diabetes Care* 2011;34:1749–1753
46. Munshi MN, Florez H, Huang ES, et al. Management of diabetes in long-term care and skilled nursing facilities: a position statement of the American Diabetes Association. *Diabetes Care* 2016;39:308–318
47. Sinclair A, Morley JE, Rodríguez-Mañas L, et al. Diabetes mellitus in older people: position statement on behalf of the International Association of Gerontology and Geriatrics (IAGG), the European Diabetes Working Party for Older People (EDWPOP), and the International Task Force of Experts in Diabetes. *J Am Med Dir Assoc* 2012;13:497–502
48. Dornier B, Friedrich EK, Posthauer ME. Practice paper of the American Dietetic Association: individualized nutrition approaches for older adults in health care communities. *J Am Diet Assoc* 2010;110:1554–1563
49. Migdal A, Yarandi SS, Smiley D, Umpierrez GE. Update on diabetes in the elderly and in nursing home residents. *J Am Med Dir Assoc* 2011;12:627–632.e2
50. Pasquel FJ, Powell W, Peng L, et al. A randomized controlled trial comparing treatment with oral agents and basal insulin in elderly patients with type 2 diabetes in long-term care facilities. *BMJ Open Diabetes Res Care* 2015;3:e000104
51. Quinn K, Hudson P, Dunning T. Diabetes management in patients receiving palliative care. *J Pain Symptom Manage* 2006;32:275–286
52. Ford-Dunn S, Smith A, Quin J. Management of diabetes during the last days of life: attitudes of consultant diabetologists and consultant palliative care physicians in the UK. *Palliat Med* 2006;20:197–203
53. Mallery LH, Ransom T, Steeves B, Cook B, Dunbar P, Moorhouse P. Evidence-informed guidelines for treating frail older adults with type 2 diabetes: from the Diabetes Care Program of Nova Scotia (DCPNS) and the Palliative and Therapeutic Harmonization (PATH) program. *J Am Med Dir Assoc* 2013;14:801–808
54. Laiteerapong N, Iveniuk J, John PM, Laumann EO, Huang ES. Classification of older adults who have diabetes by comorbid conditions, United States, 2005–2006. *Prev Chronic Dis* 2012;9:E100
55. Munshi MN, Slyne C, Segal AR, Saul N, Lyons C, Weinger K. Liberating A1C goals in older adults may not protect against the risk of hypoglycemia. *J Diabetes Complications* 2017;31:1197–1199
56. Leung E, Wongrakpanich S, Munshi MN. Diabetes management in the elderly. *Diabetes Spectr* 2018;31:245–253

13. Children and Adolescents: *Standards of Medical Care in Diabetes—2019*

American Diabetes Association

Diabetes Care 2019;42(Suppl. 1):S148–S164 | <https://doi.org/10.2337/dc19-S013>

The American Diabetes Association (ADA) “Standards of Medical Care in Diabetes” includes ADA’s current clinical practice recommendations and is intended to provide the components of diabetes care, general treatment goals and guidelines, and tools to evaluate quality of care. Members of the ADA Professional Practice Committee, a multidisciplinary expert committee, are responsible for updating the Standards of Care annually, or more frequently as warranted. For a detailed description of ADA standards, statements, and reports, as well as the evidence-grading system for ADA’s clinical practice recommendations, please refer to the Standards of Care Introduction. Readers who wish to comment on the Standards of Care are invited to do so at professional.diabetes.org/SOC.

The management of diabetes in children and adolescents cannot simply be derived from care routinely provided to adults with diabetes. The epidemiology, pathophysiology, developmental considerations, and response to therapy in pediatric-onset diabetes are different from adult diabetes. There are also differences in recommended care for children and adolescents with type 1 as opposed to type 2 diabetes. This section first addresses care for children and adolescents with type 1 diabetes and next addresses care for children and adolescents with type 2 diabetes. **Figure 13.1** provides guidance on managing new-onset diabetes in overweight youth before type 1 or type 2 diabetes is diagnosed and so applies to all overweight youth. Lastly, guidance is provided in this section on transition of care from pediatric to adult providers to ensure that the continuum of care is appropriate as the child with diabetes develops into adulthood. Due to the nature of clinical research in children, the recommendations for children and adolescents with diabetes are less likely to be based on clinical trial evidence. However, expert opinion and a review of available and relevant experimental data are summarized in the American Diabetes Association (ADA) position statements “Type 1 Diabetes in Children and Adolescents” (1) and “Evaluation and Management of Youth-Onset Type 2 Diabetes” (2). The ADA consensus report “Youth-Onset Type 2 Diabetes Consensus Report: Current Status, Challenges, and Priorities” (3) characterizes type 2 diabetes in children and evaluates treatment options as well, but also discusses knowledge gaps and recruitment challenges in clinical and translational research in youth-onset type 2 diabetes.

TYPE 1 DIABETES

Type 1 diabetes is the most common form of diabetes in youth (4), although recent data suggest that it may account for a large proportion of cases diagnosed in adult life (5). The provider must consider the unique aspects of care and management of children and adolescents with type 1 diabetes, such as changes in insulin sensitivity related to physical growth and sexual maturation, ability to provide self-care, supervision in the child care

Suggested citation: American Diabetes Association. 13. Children and adolescents: Standards of Medical Care in Diabetes—2019. Diabetes Care 2019;42(Suppl. 1):S148–S164

© 2018 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. More information is available at <http://www.diabetesjournals.org/content/license>.

and school environment, neurological vulnerability to hypoglycemia and hyperglycemia in young children, as well as possible adverse neurocognitive effects of diabetic ketoacidosis (DKA) (6,7). Attention to family dynamics, developmental stages, and physiologic differences related to sexual maturity is essential in developing and implementing an optimal diabetes treatment plan (8).

A multidisciplinary team of specialists trained in pediatric diabetes management and sensitive to the challenges of children and adolescents with type 1 diabetes and their families should provide care for this population. It is essential that diabetes self-management education and support, medical nutrition therapy, and psychosocial support be provided at diagnosis and regularly thereafter in a developmentally appropriate format that builds on prior knowledge by individuals experienced with the educational, nutritional, behavioral, and emotional needs of the growing child and family. The appropriate balance between adult supervision and independent self-care should be defined at the first interaction and reevaluated at subsequent visits, with the expectation that it will evolve as the adolescent gradually becomes an emerging young adult.

Diabetes Self-management Education and Support

Recommendation

13.1 Youth with type 1 diabetes and parents/caregivers (for patients aged <18 years) should receive culturally sensitive and developmentally appropriate individualized diabetes self-management education and support according to national standards at diagnosis and routinely thereafter. **B**

No matter how sound the medical regimen, it can only be effective if the family and/or affected individuals are able to implement it. Family involvement is a vital component of optimal diabetes management throughout childhood and adolescence. Health care providers in the diabetes care team who care for children and adolescents must be capable of evaluating the educational, behavioral, emotional, and psychosocial factors that impact implementation of a treatment plan and must work with the individual

and family to overcome barriers or re-define goals as appropriate. Diabetes self-management education and support requires periodic reassessment, especially as the youth grows, develops, and acquires the need for greater independent self-care skills. In addition, it is necessary to assess the educational needs and skills of day care providers, school nurses, or other school personnel who participate in the care of the young child with diabetes (9).

Nutrition Therapy

Recommendations

13.2 Individualized medical nutrition therapy is recommended for children and adolescents with type 1 diabetes as an essential component of the overall treatment plan. **A**

13.3 Monitoring carbohydrate intake, whether by carbohydrate counting or experience-based estimation, is key to achieving optimal glycemic control. **B**

13.4 Comprehensive nutrition education at diagnosis, with annual updates, by an experienced registered dietitian is recommended to assess caloric and nutrition intake in relation to weight status and cardiovascular disease risk factors and to inform macronutrient choices. **E**

Dietary management should be individualized: family habits, food preferences, religious or cultural needs, schedules, physical activity, and the patient's and family's abilities in numeracy, literacy, and self-management should be considered. Dietitian visits should include assessment for changes in food preferences over time, access to food, growth and development, weight status, cardiovascular risk, and potential for eating disorders. Dietary adherence is associated with better glycemic control in youth with type 1 diabetes (10).

Physical Activity and Exercise

Recommendations

13.5 Exercise is recommended for all youth with type 1 diabetes with the goal of 60 min of moderate- to vigorous-intensity aerobic

activity daily, with vigorous muscle-strengthening and bone-strengthening activities at least 3 days per week. **C**

13.6 Education about frequent patterns of glycemia during and after exercise, which may include initial transient hyperglycemia followed by hypoglycemia, is essential. Families should also receive education on prevention and management of hypoglycemia during and after exercise, including ensuring patients have a pre-exercise glucose level of 90–250 mg/dL (5–13 mmol/L) and accessible carbohydrates before engaging in activity, individualized according to the type/intensity of the planned physical activity. **E**

13.7 Patients should be educated on strategies to prevent hypoglycemia during exercise, after exercise, and overnight following exercise, which may include reducing prandial insulin dosing for the meal/snack preceding (and, if needed, following) exercise, increasing carbohydrate intake, eating bedtime snacks, using continuous glucose monitoring, and/or reducing basal insulin doses. **C**

13.8 Frequent glucose monitoring before, during, and after exercise, with or without use of continuous glucose monitoring, is important to prevent, detect, and treat hypoglycemia and hyperglycemia with exercise. **C**

Exercise positively affects insulin sensitivity, physical fitness, strength building, weight management, social interaction, mood, self-esteem building, and creation of healthful habits for adulthood, but it also has the potential to cause both hypoglycemia and hyperglycemia.

See below for strategies to mitigate hypoglycemia risk and minimize hyperglycemia with exercise. For an in-depth discussion, see recently published reviews and guidelines (11–13).

Overall, it is recommended that youth with type 1 diabetes participate in 60 min of moderate- (e.g., brisk walking, dancing) to vigorous- (e.g., running, jumping rope)

intensity aerobic activity daily, including resistance and flexibility training (14). Although uncommon in the pediatric population, patients should be medically evaluated for comorbid conditions or diabetes complications that may restrict participation in an exercise program. As hyperglycemia can occur before, during, and after physical activity, it is important to ensure that the elevated glucose level is not related to insulin deficiency that would lead to worsening hyperglycemia with exercise and ketosis risk. Intense activity should be postponed with marked hyperglycemia (glucose ≥ 350 mg/dL [19.4 mmol/L]), moderate to large urine ketones, and/or β -hydroxybutyrate (B-OHB) >1.5 mmol/L. Caution may be needed when B-OHB levels are ≥ 0.6 mmol/L (10,11).

The prevention and treatment of hypoglycemia associated with physical activity include decreasing the prandial insulin for the meal/snack before exercise and/or increasing food intake. Patients on insulin pumps can lower basal rates by ~ 10 – 50% or more or suspend for 1–2 h during exercise (15). Decreasing basal rates or long acting insulin doses by $\sim 20\%$ after exercise may reduce delayed exercise-induced hypoglycemia (16). Accessible rapid-acting carbohydrates and frequent blood glucose monitoring before, during, and after exercise, with or without continuous glucose monitoring, maximize safety with exercise.

Blood glucose targets prior to exercise should be 90–250 mg/dL (5.0–13.9 mmol/L). Consider additional carbohydrate intake during and/or after exercise, depending on the duration and intensity of physical activity, to prevent hypoglycemia. For low- to moderate-intensity aerobic activities (30–60 min), and if the patient is fasting, 10–15 g of carbohydrate may prevent hypoglycemia (17). After insulin boluses (relative hyperinsulinemia), consider 0.5–1.0 g of carbohydrates/kg per hour of exercise (~ 30 – 60 g), which is similar to carbohydrate requirements to optimize performance in athletes without type 1 diabetes (18–20).

In addition, obesity is as common in children and adolescents with type 1 diabetes as in those without diabetes. It is associated with higher frequency of cardiovascular risk factors, and it disproportionately affects racial/ethnic minorities in the U.S. (21–25). Therefore, diabetes care providers should monitor weight

status and encourage a healthy diet, exercise, and healthy weight as key components of pediatric type 1 diabetes care.

School and Child Care

As a large portion of a child's day is spent in school, close communication with and the cooperation of school or day care personnel are essential for optimal diabetes management, safety, and maximal academic opportunities. Refer to the ADA position statements "Diabetes Care in the School Setting" (26) and "Care of Young Children With Diabetes in the Child Care Setting" (27) for additional details.

Psychosocial Issues

Recommendations

- 13.9** At diagnosis and during routine follow-up care, assess psychosocial issues and family stresses that could impact diabetes management and provide appropriate referrals to trained mental health professionals, preferably experienced in childhood diabetes. **E**
- 13.10** Mental health professionals should be considered integral members of the pediatric diabetes multidisciplinary team. **E**
- 13.11** Encourage developmentally appropriate family involvement in diabetes management tasks for children and adolescents, recognizing that premature transfer of diabetes care to the child can result in diabetes burn-out nonadherence and deterioration in glycemic control. **A**
- 13.12** Providers should consider asking youth and their parents about social adjustment (peer relationships) and school performance to determine whether further intervention is needed. **B**
- 13.13** Assess youth with diabetes for psychosocial and diabetes-related distress, generally starting at 7–8 years of age. **B**
- 13.14** Offer adolescents time by themselves with their care provider(s) starting at age 12 years, or when developmentally appropriate. **E**
- 13.15** Starting at puberty, preconception counseling should be incorporated into routine diabetes

care for all girls of childbearing potential. **A**

- 13.16** Begin screening youth with type 1 diabetes for eating disorders between 10 and 12 years of age. The Diabetes Eating Problems Survey-Revised (DEPS-R) is a reliable, valid, and brief screening tool for identifying disturbed eating behavior. **B**

Rapid and dynamic cognitive, developmental, and emotional changes occur during childhood, adolescence, and emerging adulthood. Diabetes management during childhood and adolescence places substantial burdens on the youth and family, necessitating ongoing assessment of psychosocial status and diabetes distress in the patient and the caregiver during routine diabetes visits (28–34). Early detection of depression, anxiety, eating disorders, and learning disabilities can facilitate effective treatment options and help minimize adverse effects on diabetes management and disease outcomes (33,35). There are validated tools, such as the Problem Areas in Diabetes-Teen (PAID-T) and Parent (P-PAID-Teen) (34), that can be used in assessing diabetes-specific distress in youth starting at age 12 years and in their parent caregivers. Furthermore, the complexities of diabetes management require ongoing parental involvement in care throughout childhood with developmentally appropriate family teamwork between the growing child/teen and parent in order to maintain adherence and to prevent deterioration in glycemic control (36,37). As diabetes-specific family conflict is related to poorer adherence and glycemic control, it is appropriate to inquire about such conflict during visits and to either help to negotiate a plan for resolution or refer to an appropriate mental health specialist (38). Monitoring of social adjustment (peer relationships) and school performance can facilitate both well-being and academic achievement (39). Suboptimal glycemic control is a risk factor for underperformance at school and increased absenteeism (40).

Shared decision making with youth regarding the adoption of regimen components and self-management behaviors can improve diabetes self-efficacy, adherence, and metabolic outcomes (22,41).

Although cognitive abilities vary, the ethical position often adopted is the “mature minor rule,” whereby children after age 12 or 13 years who appear to be “mature” have the right to consent or withhold consent to general medical treatment, except in cases in which refusal would significantly endanger health (42).

Beginning at the onset of puberty or at diagnosis of diabetes, all adolescent girls and women with childbearing potential should receive education about the risks of malformations associated with poor metabolic control and the use of effective contraception to prevent unplanned pregnancy. Preconception counseling using developmentally appropriate educational tools enables adolescent girls to make well-informed decisions (43). Preconception counseling resources tailored for adolescents are available at no cost through the ADA (44). Refer to the ADA position statement “Psychosocial Care for People With Diabetes” for further details (35).

Youth with type 1 diabetes have an increased risk of disordered eating behavior as well as clinical eating disorders with serious short-term and long-term negative effects on diabetes outcomes and health in general. Therefore, it is important to screen for eating disorders in youth with type 1 diabetes using tools such as the Diabetes Eating Problems Survey-Revised (DEPS-R) to allow for early diagnosis and intervention (45–48).

Screening

Screening for psychosocial distress and mental health problems is an important component of ongoing care. It is important to consider the impact of diabetes on quality of life as well as the development of mental health problems related to diabetes distress, fear of hypoglycemia (and hyperglycemia), symptoms of anxiety, disordered eating behaviors as well as eating disorders, and symptoms of depression (49). Consider assessing youth for diabetes distress, generally starting at 7 or 8 years of age (35). Consider screening for depression and disordered

eating behaviors using available screening tools (28,45). With respect to disordered eating, it is important to recognize the unique and dangerous disordered eating behavior of insulin omission for weight control in type 1 diabetes (50). The presence of a mental health professional on pediatric multidisciplinary teams highlights the importance of attending to the psychosocial issues of diabetes. These psychosocial factors are significantly related to self-management difficulties, suboptimal glycemic control, reduced quality of life, and higher rates of acute and chronic diabetes complications.

Glycemic Control

Recommendations

- 13.17** The majority of children and adolescents with type 1 diabetes should be treated with intensive insulin regimens, either via multiple daily injections or continuous subcutaneous insulin infusion. **A**
- 13.18** All children and adolescents with type 1 diabetes should self-monitor glucose levels multiple times daily (up to 6–10 times/day), including premeal, prebedtime, and as needed for safety in specific situations such as exercise, driving, or the presence of symptoms of hypoglycemia. **B**
- 13.19** Continuous glucose monitoring should be considered in all children and adolescents with type 1 diabetes, whether using injections or continuous subcutaneous insulin infusion, as an additional tool to help improve glucose control. Benefits of continuous glucose monitoring correlate with adherence to ongoing use of the device. **B**
- 13.20** Automated insulin delivery systems appear to improve glycemic control and reduce hypoglycemia in children and

should be considered in children with type 1 diabetes. **B**
13.21 An A1C target of <7.5% (58 mmol/mol) should be considered in children and adolescents with type 1 diabetes but should be individualized based on the needs and situation of the patient and family. **E**

Please refer to Section 7 “Diabetes Technology” for more information on the use of blood glucose meters, continuous glucose monitors, and insulin pumps. More information on insulin injection technique can be found in Section 9 “Pharmacologic Approaches to Glycemic Treatment,” p. S90.

Current standards for diabetes management reflect the need to lower glucose as safely as possible. This should be done with stepwise goals. When establishing individualized glycemic targets, special consideration should be given to the risk of hypoglycemia in young children (aged <6 years) who are often unable to recognize, articulate, and/or manage hypoglycemia. However, registry data indicate that lower A1C can be achieved in children, including those <6 years, without increased risk of severe hypoglycemia (51,52).

Type 1 diabetes can be associated with adverse effects on cognition during childhood and adolescence. Factors that contribute to adverse effects on brain development and function include young age or DKA at onset of type 1 diabetes, severe hypoglycemia at <6 years of age, and chronic hyperglycemia (53,54). However, meticulous use of new therapeutic modalities such as rapid- and long-acting insulin analogs, technological advances (e.g., continuous glucose monitors, low-glucose suspend insulin pumps, and automated insulin delivery systems), and intensive self-management education now make it more feasible to achieve excellent glycemic control while reducing the incidence of severe hypoglycemia (55–64). Intermittently scanned continuous glucose monitors (sometimes referred to as “flash” continuous glucose monitors) are

Table 13.1—Blood glucose and A1C targets for children and adolescents with type 1 diabetes

Blood glucose goal range		A1C	Rationale
Before meals	Bedtime/overnight		
90–130 mg/dL (5.0–7.2 mmol/L)	90–150 mg/dL (5.0–8.3 mmol/L)	<7.5% (58 mmol/mol)	A lower goal (<7.0% [53 mmol/mol]) is reasonable if it can be achieved without excessive hypoglycemia

not currently approved for use in children and adolescents. A strong relationship exists between frequency of blood glucose monitoring and glycemic control (57–66).

The Diabetes Control and Complications Trial (DCCT), which did not enroll children <13 years of age, demonstrated that near normalization of blood glucose levels was more difficult to achieve in adolescents than in adults. Nevertheless, the increased use of basal-bolus regimens, insulin pumps, frequent blood glucose monitoring, goal setting, and improved patient education in youth from infancy through adolescence has been associated with more children reaching the blood glucose targets recommended by ADA (67–70), particularly in those families in which both the parents and the child with diabetes participate jointly to perform the required diabetes-related tasks. Furthermore, studies documenting neurocognitive imaging differences related to hyperglycemia in children provide another motivation for lowering glycemic targets (6).

In selecting glycemic targets, the long-term health benefits of achieving a lower A1C should be balanced against the risks of hypoglycemia and the developmental burdens of intensive regimens in children and youth. In addition, achieving lower A1C levels is likely facilitated by setting lower A1C targets (51,71). A1C and blood glucose targets are presented in **Table 13.1**. Lower goals may be possible during the “honeymoon” phase of type 1 diabetes.

Key Concepts in Setting Glycemic Targets

- Targets should be *individualized*, and lower targets may be reasonable based on a benefit-risk assessment.
- Blood glucose targets should be modified in children with frequent hypoglycemia or hypoglycemia unawareness.
- Postprandial blood glucose values should be measured when there is a discrepancy between preprandial blood glucose values and A1C levels and to assess preprandial insulin doses in those on basal-bolus or pump regimens.

Autoimmune Conditions

Recommendation

13.22 Assess for additional autoimmune conditions soon after the diagnosis of type 1 diabetes and if symptoms develop. **E**

Because of the increased frequency of other autoimmune diseases in type 1

diabetes, screening for thyroid dysfunction and celiac disease should be considered (72,73). Periodic screening in asymptomatic individuals has been recommended, but the optimal frequency of screening is unclear.

Although much less common than thyroid dysfunction and celiac disease, other autoimmune conditions, such as Addison disease (primary adrenal insufficiency), autoimmune hepatitis, autoimmune gastritis, dermatomyositis, and myasthenia gravis, occur more commonly in the population with type 1 diabetes than in the general pediatric population and should be assessed and monitored as clinically indicated. In addition, relatives of patients should be offered testing for islet autoantibodies through research studies (e.g., TrialNet) for early diagnosis of preclinical type 1 diabetes (stages 1 and 2).

Thyroid Disease

Recommendations

- 13.23** Consider testing children with type 1 diabetes for antithyroid peroxidase and antithyroglobulin antibodies soon after the diagnosis. **B**
- 13.24** Measure thyroid-stimulating hormone concentrations at diagnosis when clinically stable or soon after glycemic control has been established. If normal, suggest rechecking every 1–2 years or sooner if the patient develops symptoms or signs suggestive of thyroid dysfunction, thyromegaly, an abnormal growth rate, or unexplained glycemic variability. **E**

Autoimmune thyroid disease is the most common autoimmune disorder associated with diabetes, occurring in 17–30% of patients with type 1 diabetes (74). At the time of diagnosis, about 25% of children with type 1 diabetes have thyroid autoantibodies (75); their presence is predictive of thyroid dysfunction—most commonly hypothyroidism, although hyperthyroidism occurs in ~0.5% of patients with type 1 diabetes (76,77). For thyroid autoantibodies, a recent study from Sweden indicated antithyroid peroxidase antibodies were more predictive than antithyroglobulin antibodies in multivariate analysis (78). Thyroid function tests may be

misleading (euthyroid sick syndrome) if performed at the time of diagnosis owing to the effect of previous hyperglycemia, ketosis or ketoacidosis, weight loss, etc. Therefore, if performed at diagnosis and slightly abnormal, thyroid function tests should be repeated soon after a period of metabolic stability and good glycemic control. Subclinical hypothyroidism may be associated with increased risk of symptomatic hypoglycemia (79) and reduced linear growth rate. Hyperthyroidism alters glucose metabolism and usually causes deterioration of glycemic control.

Celiac Disease

Recommendations

- 13.25** Screen children with type 1 diabetes for celiac disease by measuring IgA tissue transglutaminase (tTG) antibodies, with documentation of normal total serum IgA levels, soon after the diagnosis of diabetes, or IgG to tTG and deamidated gliadin antibodies if IgA deficient. **E**
- 13.26** Repeat screening within 2 years of diabetes diagnosis and then again after 5 years and consider more frequent screening in children who have symptoms or a first-degree relative with celiac disease. **B**
- 13.27** Individuals with biopsy-confirmed celiac disease should be placed on a gluten-free diet and have a consultation with a dietitian experienced in managing both diabetes and celiac disease. **B**

Celiac disease is an immune-mediated disorder that occurs with increased frequency in patients with type 1 diabetes (1.6–16.4% of individuals compared with 0.3–1% in the general population) (72,73,80–83).

Screening for celiac disease includes measuring serum levels of IgA and tissue transglutaminase antibodies, or, with IgA deficiency, screening can include measuring IgG tissue transglutaminase antibodies or IgG deamidated gliadin peptide antibodies. Because most cases of celiac disease are diagnosed within the first 5 years after the diagnosis of type 1 diabetes, screening should be considered

at the time of diagnosis and repeated at 2 and then 5 years (82) or if clinical symptoms indicate, such as poor growth or increased hypoglycemia (83,84).

Although celiac disease can be diagnosed more than 10 years after diabetes diagnosis, there are insufficient data after 5 years to determine the optimal screening frequency. Measurement of tissue transglutaminase antibody should be considered at other times in patients with symptoms suggestive of celiac disease (82). Monitoring for symptoms should include assessment of linear growth and weight gain (83,84). A small-bowel biopsy in antibody-positive children is recommended to confirm the diagnosis (85). European guidelines on screening for celiac disease in children (not specific to children with type 1 diabetes) suggest that biopsy may not be necessary in symptomatic children with high antibody titers (i.e., greater than 10 times the upper limit of normal) provided that further testing is performed (verification of endomysial antibody positivity on a separate blood sample). Whether this approach may be appropriate for asymptomatic children in high-risk groups remains an open question, though evidence is emerging (86). It is also advisable to check for celiac disease–associated HLA types in patients who are diagnosed without a small intestinal biopsy. In symptomatic children with type 1 diabetes and confirmed celiac disease, gluten-free diets reduce symptoms and rates of hypoglycemia (87). The challenging dietary restrictions associated with having both type 1 diabetes and celiac disease place a significant burden on individuals. Therefore, a biopsy to confirm the diagnosis of celiac disease is recommended, especially in asymptomatic children, before establishing a diagnosis of celiac disease (88) and endorsing significant dietary changes. A gluten-free diet was beneficial in asymptomatic adults with positive antibodies confirmed by biopsy (89).

Management of Cardiovascular Risk Factors

Hypertension

Recommendations

Screening

13.28 Blood pressure should be measured at each routine visit.

Children found to have high-normal blood pressure (systolic blood pressure or diastolic blood pressure \geq 90th percentile for age, sex, and height) or hypertension (systolic blood pressure or diastolic blood pressure \geq 95th percentile for age, sex, and height) should have elevated blood pressure confirmed on 3 separate days. **B**

Treatment

13.29 Initial treatment of high-normal blood pressure (systolic blood pressure or diastolic blood pressure consistently \geq 90th percentile for age, sex, and height) includes dietary modification and increased exercise, if appropriate, aimed at weight control. If target blood pressure is not reached within 3–6 months of initiating lifestyle intervention, pharmacologic treatment should be considered. **E**

13.30 In addition to lifestyle modification, pharmacologic treatment of hypertension (systolic blood pressure or diastolic blood pressure consistently \geq 95th percentile for age, sex, and height) should be considered as soon as hypertension is confirmed. **E**

13.31 ACE inhibitors or angiotensin receptor blockers should be considered for the initial pharmacologic treatment of hypertension **E** in children and adolescents, following reproductive counseling due to the potential teratogenic effects of both drug classes. **E**

13.32 The goal of treatment is blood pressure consistently $<$ 90th percentile for age, sex, and height. **E**

Blood pressure measurements should be performed using the appropriate size cuff with the child seated and relaxed. Hypertension should be confirmed on at least 3 separate days. Evaluation should proceed as clinically indicated (90). Treatment is generally initiated with an ACE inhibitor, but an angiotensin receptor blocker can be used if the ACE inhibitor is not tolerated (e.g., due to cough) (91).

Normal blood pressure levels for age, sex, and height and appropriate methods for measurement are available online at nhlbi.nih.gov/files/docs/resources/heart/hbp_ped.pdf.

Dyslipidemia

Recommendations

Testing

13.33 Obtain a fasting lipid profile in children \geq 10 years of age soon after the diagnosis of diabetes (after glucose control has been established). **E**

13.34 If LDL cholesterol values are within the accepted risk level ($<$ 100 mg/dL [2.6 mmol/L]), a lipid profile repeated every 3–5 years is reasonable. **E**

Treatment

13.35 If lipids are abnormal, initial therapy should consist of optimizing glucose control and medical nutrition therapy using a Step 2 American Heart Association diet to decrease the amount of saturated fat to 7% of total calories and dietary cholesterol to 200 mg/day, which is safe and does not interfere with normal growth and development. **B**

13.36 After the age of 10 years, addition of a statin is suggested in patients who, despite medical nutrition therapy and lifestyle changes, continue to have LDL cholesterol $>$ 160 mg/dL (4.1 mmol/L) or LDL cholesterol $>$ 130 mg/dL (3.4 mmol/L) and one or more cardiovascular disease risk factor, following reproductive counseling because of the potential teratogenic effects of statins. **E**

13.37 The goal of therapy is an LDL cholesterol value $<$ 100 mg/dL (2.6 mmol/L). **E**

Population-based studies estimate that 14–45% of children with type 1 diabetes have two or more atherosclerotic cardiovascular disease (ASCVD) risk factors (92–94), and the prevalence of cardiovascular disease (CVD) risk factors increases with age (94) and among racial/ethnic minorities (21), with girls having a higher risk burden than boys (93).

Pathophysiology. The atherosclerotic process begins in childhood, and although ASCVD events are not expected to occur during childhood, observations using a variety of methodologies show that youth with type 1 diabetes may have subclinical CVD within the first decade of diagnosis (95–97). Studies of carotid intima-media thickness have yielded inconsistent results (90,91).

Treatment. Pediatric lipid guidelines provide some guidance relevant to children with type 1 diabetes (90,98–100); however, there are few studies on modifying lipid levels in children with type 1 diabetes. A 6-month trial of dietary counseling produced a significant improvement in lipid levels (101); likewise, a lifestyle intervention trial with 6 months of exercise in adolescents demonstrated improvement in lipid levels (102).

Although intervention data are sparse, the American Heart Association categorizes children with type 1 diabetes in the highest tier for cardiovascular risk and recommends both lifestyle and pharmacologic treatment for those with elevated LDL cholesterol levels (100,103). Initial therapy should be with a nutrition plan that restricts saturated fat to 7% of total calories and dietary cholesterol to 200 mg/day. Data from randomized clinical trials in children as young as 7 months of age indicate that this diet is safe and does not interfere with normal growth and development (104).

For children with a significant family history of CVD, the National Heart, Lung, and Blood Institute recommends obtaining a fasting lipid panel beginning at 2 years of age (98). Abnormal results from a random lipid panel should be confirmed with a fasting lipid panel. Data from the SEARCH for Diabetes in Youth (SEARCH) study show that improved glucose control over a 2-year period is associated with a more favorable lipid profile; however, improved glycemic control alone will not normalize lipids in youth with type 1 diabetes and dyslipidemia (105).

Neither long-term safety nor cardiovascular outcome efficacy of statin therapy has been established for children; however, studies have shown short-term safety equivalent to that seen in adults and efficacy in lowering LDL cholesterol levels in familial hypercholesterolemia or severe hyperlipidemia, improving endothelial

function and causing regression of carotid intimal thickening (106,107). Statins are not approved for patients aged <10 years, and statin treatment should generally not be used in children with type 1 diabetes before this age. Statins are contraindicated in pregnancy; therefore, prevention of unplanned pregnancies is of paramount importance for postpubertal girls (see Section 14 “Management of Diabetes in Pregnancy” for more information). The multicenter, randomized, placebo-controlled Adolescent Type 1 Diabetes Cardio-Renal Intervention Trial (AddIT) provides safety data on pharmacologic treatment with an ACE inhibitor and statin in adolescents with type 1 diabetes.

Smoking

Recommendations

13.38 Elicit a smoking history at initial and follow-up diabetes visits; discourage smoking in youth who do not smoke, and encourage smoking cessation in those who do smoke. **A**

13.39 e-Cigarette use should be discouraged. **B**

The adverse health effects of smoking are well recognized with respect to future cancer and CVD risk. Despite this, smoking rates are significantly higher among youth with diabetes than among youth without diabetes (108,109). In youth with diabetes, it is important to avoid additional CVD risk factors. Smoking increases the risk of onset of albuminuria; therefore, smoking avoidance is important to prevent both microvascular and macrovascular complications (98, 110). Discouraging cigarette smoking, including e-cigarettes (111,112), is an important part of routine diabetes care. In younger children, it is important to assess exposure to cigarette smoke in the home because of the adverse effects of secondhand smoke and to discourage youth from ever smoking if exposed to smokers in childhood.

Microvascular Complications

Nephropathy

Recommendations

Screening

13.40 Annual screening for albuminuria with a random (morning

sample preferred to avoid effects of exercise) spot urine sample for albumin-to-creatinine ratio should be considered at puberty or at age >10 years, whichever is earlier, once the child has had diabetes for 5 years. **B**

Treatment

13.41 An ACE inhibitor or an angiotensin receptor blocker, titrated to normalization of albumin excretion, may be considered when elevated urinary albumin-to-creatinine ratio (>30 mg/g) is documented (two of three urine samples obtained over a 6-month interval following efforts to improve glycemic control and normalize blood pressure). **E**

Data from 7,549 participants <20 years of age in the T1D Exchange clinic registry emphasize the importance of good glycemic and blood pressure control, particularly as diabetes duration increases, in order to reduce the risk of diabetic kidney disease. The data also underscore the importance of routine screening to ensure early diagnosis and timely treatment of albuminuria (113). An estimation of glomerular filtration rate (GFR), calculated using GFR estimating equations from the serum creatinine, height, age, and sex (114), should be considered at baseline and repeated as indicated based on clinical status, age, diabetes duration, and therapies. Improved methods are needed to screen for early GFR loss, since estimated GFR is inaccurate at GFR >60 mL/min/1.73 m² (114,115). The AddIT study in adolescents with type 1 diabetes demonstrated safety of ACE inhibitor treatment, but the treatment did not change the albumin-to-creatinine ratio over the course of the study (90).

Retinopathy

Recommendations

13.42 An initial dilated and comprehensive eye examination is recommended once youth have had type 1 diabetes for 3–5 years, provided they are age ≥10 years or puberty has started, whichever is earlier. **B**

13.43 After the initial examination, annual routine follow-up is generally recommended. Less-frequent examinations, every 2 years, may be acceptable on the advice of an eye care professional and based on risk factor assessment. **E**

Retinopathy (like albuminuria) most commonly occurs after the onset of puberty and after 5–10 years of diabetes duration (116). Referrals should be made to eye care professionals with expertise in diabetic retinopathy and experience in counseling the pediatric patient and family on the importance of prevention, early detection, and intervention.

Neuropathy

Recommendation

13.44 Consider an annual comprehensive foot exam at the start of puberty or at age ≥ 10 years, whichever is earlier, once the youth has had type 1 diabetes for 5 years. **B**

Diabetic neuropathy rarely occurs in prepubertal children or after only 1–2 years of diabetes (116), although data suggest a prevalence of distal peripheral neuropathy of 7% in 1,734 youth with type 1 diabetes and associated with the presence of CVD risk factors (117,118). A comprehensive foot exam, including inspection, palpation of dorsalis pedis and posterior tibial pulses, and determination of proprioception, vibration, and monofilament sensation, should be performed annually along with an assessment of symptoms of neuropathic pain (118). Foot inspection can be performed at each visit to educate youth regarding the importance of foot care (see Section 11 “Microvascular Complications and Foot Care”).

TYPE 2 DIABETES

For information on testing for type 2 diabetes and prediabetes in children and adolescents, please refer to Section 2 “Classification and Diagnosis of Diabetes.” For additional support for these recommendations, see the ADA position statement “Evaluation and Management of Youth-Onset Type 2 Diabetes” (2).

Type 2 diabetes in youth has increased over the past 20 years, and recent estimates suggest an incidence of $\sim 5,000$ new cases per year in the U.S. (119). The Centers for Disease Control and Prevention published projections for type 2 diabetes prevalence using the SEARCH database; assuming a 2.3% annual increase, the prevalence in those under 20 years of age will quadruple in 40 years (120,121).

Evidence suggests that type 2 diabetes in youth is different not only from type 1 diabetes but also from type 2 diabetes in adults and has unique features, such as a more rapidly progressive decline in β -cell function and accelerated development of diabetes complications (2,122). Type 2 diabetes disproportionately impacts youth of ethnic and racial minorities and can occur in complex psychosocial and cultural environments, which may make it difficult to sustain healthy lifestyle changes and self-management behaviors (22,123–126). Additional risk factors associated with type 2 diabetes in youth include adiposity, family history of diabetes, female sex, and low socioeconomic status (122).

As with type 1 diabetes, youth with type 2 diabetes spend much of the day in school. Therefore, close communication with and the cooperation of school personnel are essential for optimal diabetes management, safety, and maximal academic opportunities.

Screening and Diagnosis

Recommendations

13.45 Risk-based screening for prediabetes and/or type 2 diabetes should be considered in children and adolescents after the onset of puberty or ≥ 10 years of age, whichever occurs earlier, who are overweight (BMI ≥ 85 th percentile) or obese (BMI ≥ 95 th percentile) and who have one or more additional risk factors for diabetes (see **Table 2.4** for evidence grading of other risk factors).

13.46 If tests are normal, repeat testing at a minimum of 3-year intervals **E**, or more frequently if BMI is increasing. **C**

13.47 Fasting plasma glucose, 2-h plasma glucose during a 75-g

oral glucose tolerance test, and A1C can be used to test for prediabetes or diabetes in children and adolescents. **B**

13.48 Children and adolescents with overweight/obesity in whom the diagnosis of type 2 diabetes is being considered should have a panel of pancreatic autoantibodies tested to exclude the possibility of autoimmune type 1 diabetes. **B**

In the last decade, the incidence and prevalence of type 2 diabetes in adolescents has increased dramatically, especially in racial and ethnic minority populations (98,127). A few recent studies suggest oral glucose tolerance tests or fasting plasma glucose values as more suitable diagnostic tests than A1C in the pediatric population, especially among certain ethnicities (128), although fasting glucose alone may overdiagnose diabetes in children (129,130). In addition, many of these studies do not recognize that diabetes diagnostic criteria are based on long-term health outcomes, and validations are not currently available in the pediatric population (131). ADA acknowledges the limited data supporting A1C for diagnosing type 2 diabetes in children and adolescents. Although A1C is not recommended for diagnosis of diabetes in children with cystic fibrosis or symptoms suggestive of acute onset of type 1 diabetes, and only A1C assays without interference are appropriate for children with hemoglobinopathies, ADA continues to recommend A1C for diagnosis of type 2 diabetes in this population (132,133).

Diagnostic Challenges

Given the current obesity epidemic, distinguishing between type 1 and type 2 diabetes in children can be difficult. Overweight and obesity are common in children with type 1 diabetes (23), and diabetes-associated autoantibodies and ketosis may be present in pediatric patients with features of type 2 diabetes (including obesity and acanthosis nigricans) (129). The presence of islet autoantibodies has been associated with faster progression to insulin deficiency (129). At onset, DKA occurs in $\sim 6\%$ of

youth aged 10–19 years with type 2 diabetes (134). Although uncommon, type 2 diabetes has been observed in prepubertal children under the age of 10, and thus it should be part of the differential in children with suggestive symptoms (135). Finally, obesity (136) and type 2 diabetes–associated genetic factors may (137) contribute to the development of type 1 diabetes in some individuals, which further blurs the lines between diabetes types. However, accurate diagnosis is critical, as treatment regimens, educational approaches, dietary advice, and outcomes differ markedly between patients with the two diagnoses.

Management

Recommendations

Lifestyle Management

- 13.49** All youth with type 2 diabetes and their families should receive comprehensive diabetes self-management education and support that is specific to youth with type 2 diabetes and is culturally competent. **B**
- 13.50** Youth with overweight/obesity and type 2 diabetes and their families should be provided with developmentally and culturally appropriate comprehensive lifestyle programs that are integrated with diabetes management to achieve 7–10% decrease in excess weight. **C**
- 13.51** Given the necessity of long-term weight management for children and adolescents with type 2 diabetes, lifestyle intervention should be based on a chronic care model and offered in the context of diabetes care. **E**
- 13.52** Youth with diabetes, like all children, should be encouraged to participate in at least 30–60 min of moderate to vigorous physical activity at least 5 days per week (and strength training on at least 3 days/week) **B** and to decrease sedentary behavior. **C**
- 13.53** Nutrition for youth with type 2 diabetes, like all children, should focus on healthy eating patterns that emphasize consumption of nutrient-

dense, high-quality foods and decreased consumption of calorie-dense, nutrient-poor foods, particularly sugar-added beverages. **B**

Glycemic Targets

- 13.54** Home self-monitoring of blood glucose regimens should be individualized, taking into consideration the pharmacologic treatment of the patient. **E**
- 13.55** A1C should be measured every 3 months. **E**
- 13.56** A reasonable A1C target for most children and adolescents with type 2 diabetes treated with oral agents alone is <7% (53 mmol/mol). More stringent A1C targets (such as <6.5% [48 mmol/mol]) may be appropriate for selected individual patients if this can be achieved without significant hypoglycemia or other adverse effects of treatment. Appropriate patients might include those with short duration of diabetes and lesser degrees of β -cell dysfunction and patients treated with lifestyle or metformin only who achieve significant weight improvement. **E**
- 13.57** A1C targets for patients on insulin should be individualized, taking into account the relatively low rates of hypoglycemia in youth-onset type 2 diabetes. **E**

Pharmacologic Management

- 13.58** Initiate pharmacologic therapy, in addition to lifestyle therapy, at diagnosis of type 2 diabetes. **A**
- 13.59** In incidentally diagnosed or metabolically stable patients (A1C <8.5% [69 mmol/mol] and asymptomatic), metformin is the initial pharmacologic treatment of choice if renal function is normal. **A**
- 13.60** Youth with marked hyperglycemia (blood glucose \geq 250 mg/dL [13.9 mmol/L], A1C \geq 8.5% [69 mmol/mol]) without acidosis at diagnosis who are symptomatic with polyuria, polydipsia, nocturia, and/or weight loss should

be treated initially with basal insulin while metformin is initiated and titrated. **B**

- 13.61** In patients with ketosis/ketoacidosis, treatment with subcutaneous or intravenous insulin should be initiated to rapidly correct the hyperglycemia and the metabolic derangement. Once acidosis is resolved, metformin should be initiated while subcutaneous insulin therapy is continued. **A**
- 13.62** In individuals presenting with severe hyperglycemia (blood glucose \geq 600 mg/dL [33.3 mmol/L]), consider assessment for hyperglycemic hyperosmolar nonketotic syndrome. **A**
- 13.63** If the A1C target is no longer met with metformin monotherapy, or if contraindications or intolerable side effects of metformin develop, basal insulin therapy should be initiated. **B**
- 13.64** Patients treated with basal insulin up to 1.5 units/kg/day who do not meet A1C target should be moved to multiple daily injections with basal and premeal bolus insulins. **E**
- 13.65** In patients initially treated with insulin and metformin who are meeting glucose targets based on home blood glucose monitoring, insulin can be tapered over 2–6 weeks by decreasing the insulin dose 10–30% every few days. **B**
- 13.66** Use of medications not approved by the U.S. Food and Drug Administration for youth with type 2 diabetes is not recommended outside of research trials. **B**

Treatment of youth-onset type 2 diabetes should include lifestyle management, diabetes self-management education, and pharmacologic treatment. Initial treatment of youth with obesity and diabetes must take into account that diabetes type is often uncertain in the first few weeks of treatment, due to overlap in presentation, and that a substantial percentage of youth with type 2 diabetes will present with clinically significant ketoacidosis (138). Therefore, initial therapy should address

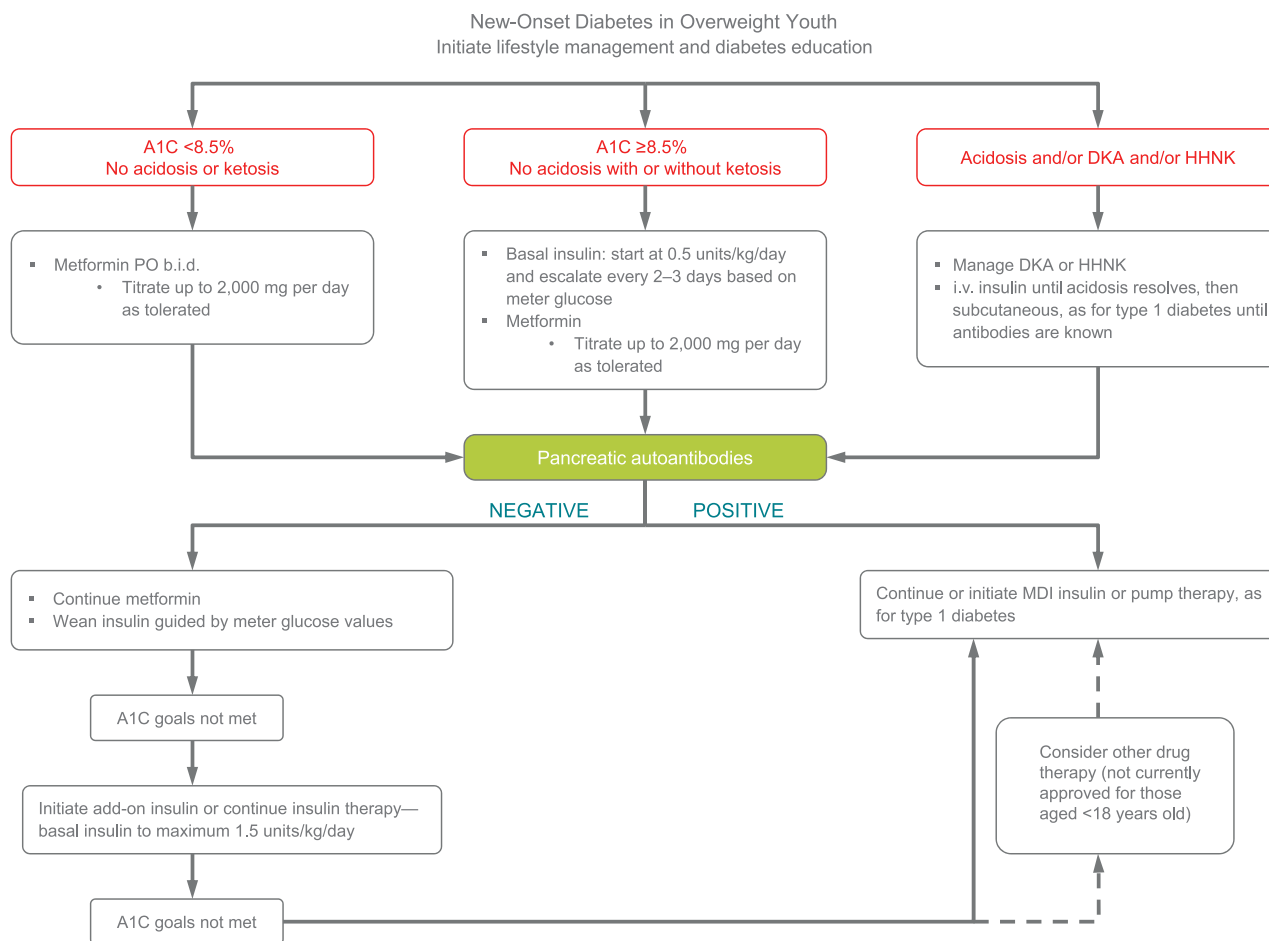


Figure 13.1—Management of new-onset diabetes in overweight youth (2). A1C 8.5% = 69 mmol/mol. DKA, diabetic ketoacidosis; HHNK, hyperosmolar hyperglycemic nonketotic syndrome; MDI, multiple daily injections.

the hyperglycemia and associated metabolic derangements irrespective of ultimate diabetes type, with adjustment of therapy once metabolic compensation has been established and subsequent information, such as islet autoantibody results, becomes available. **Figure 13.1** provides an approach to initial treatment of new-onset diabetes in overweight youth.

Glycemic targets should be individualized, taking into consideration long-term health benefits of more stringent targets as well as risk for adverse effects, such as hypoglycemia. A lower target A1C in youth with type 2 diabetes when compared with those recommended in type 1 diabetes is justified by lower risk of hypoglycemia and higher risk of complications (139–142).

Patients and their families must prioritize lifestyle modifications such as eating a balanced diet, achieving and maintaining a healthy weight, and exercising regularly. A family-centered

approach to nutrition and lifestyle modification is essential in children with type 2 diabetes, and nutrition recommendations should be culturally appropriate and sensitive to family resources (see Section 5 “Lifestyle Management”). Given the complex social and environmental context surrounding youth with type 2 diabetes, individual-level lifestyle interventions may not be sufficient to target the complex interplay of family dynamics, mental health, community readiness, and the broader environmental system (2).

A multidisciplinary diabetes team, including a physician, diabetes nurse educator, registered dietitian, and psychologist or social worker, is essential. In addition to blood glucose control and self-management education (143–145), initial treatment must include management of comorbidities such as obesity, dyslipidemia, hypertension, and microvascular complications.

Current pharmacologic treatment options for youth-onset type 2 diabetes are

limited to two approved drugs—insulin and metformin (2). Presentation with ketoacidosis or marked ketosis requires a period of insulin therapy until fasting and postprandial glycemia have been restored to normal or near-normal levels. Metformin therapy may be used as an adjunct after resolution of ketosis/ketoacidosis. Initial treatment should also be with insulin when the distinction between type 1 diabetes and type 2 diabetes is unclear and in patients who have random blood glucose concentrations ≥ 250 mg/dL (13.9 mmol/L) and/or A1C $\geq 8.5\%$ (69 mmol/mol) (146). Insulin is needed when the glycemic target is not met on metformin alone, or if there is metformin intolerance or renal or hepatic insufficiency (147).

When insulin treatment is not required, initiation of metformin is recommended. The Treatment Options for Type 2 Diabetes in Adolescents and Youth (TODAY) study found that metformin alone provided durable glycemic

control (A1C \leq 8% [64 mmol/mol] for 6 months) in approximately half of the subjects (148). To date, the TODAY study is the only trial combining lifestyle and metformin therapy in youth with type 2 diabetes; the combination did not perform better than metformin alone in achieving durable glycemic control (148).

Metabolic Surgery

Recommendations

- 13.67** Metabolic surgery may be considered for the treatment of adolescents with type 2 diabetes who are markedly obese (BMI $>$ 35 kg/m²) and who have uncontrolled glycemia and/or serious comorbidities despite lifestyle and pharmacologic intervention. **A**
- 13.68** Metabolic surgery should be performed only by an experienced surgeon working as part of a well-organized and engaged multidisciplinary team including surgeon, endocrinologist, nutritionist, behavioral health specialist, and nurse. **A**

The results of weight-loss and lifestyle interventions for obesity in children and adolescents have been disappointing, and no effective and safe pharmacologic intervention is available or approved by the U.S. Food and Drug Administration in youth. Over the last decade, weight-loss surgery has been increasingly performed in adolescents with obesity. Small retrospective analyses and a recent prospective multicenter nonrandomized study suggest that bariatric or metabolic surgery may have benefits in obese adolescents with type 2 diabetes similar to those observed in adults. Teenagers experience similar degrees of weight loss, diabetes remission, and improvement of cardiometabolic risk factors for at least 3 years after surgery (149). No randomized trials, however, have yet compared the effectiveness and safety of surgery to those of conventional treatment options in adolescents (150). The guidelines used as an indication for metabolic surgery in adolescents generally include BMI $>$ 35 kg/m² with comorbidities or BMI $>$ 40 kg/m² with or without comorbidities (151–162). A number of groups,

including the Pediatric Bariatric Study Group and the Teen Longitudinal Assessment of Bariatric Surgery (Teen-LABS) Study have demonstrated the effectiveness of metabolic surgery in adolescents (155–161).

Prevention and Management of Diabetes Complications

Recommendations

Nephropathy

- 13.69** Blood pressure should be measured at every visit. **A**
- 13.70** Blood pressure should be optimized to reduce risk and/or slow the progression of diabetic kidney disease. **A**
- 13.71** If blood pressure is $>$ 95th percentile for age, sex, and height, increased emphasis should be placed on lifestyle management to promote weight loss. If blood pressure remains above the 95th percentile after 6 months, antihypertensive therapy should be initiated. **C**
- 13.72** Initial therapeutic options include ACE inhibitors or angiotensin receptor blockers. Other blood pressure-lowering agents may be added as needed. **C**
- 13.73** Protein intake should be at the recommended daily allowance of 0.8 g/kg/day. **E**
- 13.74** Urine albumin-to-creatinine ratio should be obtained at the time of diagnosis and annually thereafter. An elevated urine albumin-to-creatinine ratio ($>$ 30 mg/g creatinine) should be confirmed on two of three samples. **B**
- 13.75** Estimated glomerular filtration rate should be determined at the time of diagnosis and annually thereafter. **E**
- 13.76** In nonpregnant patients with diabetes and hypertension, either an ACE inhibitor or an angiotensin receptor blocker is recommended for those with modestly elevated urinary albumin-to-creatinine ratio (30–299 mg/g creatinine) **D** and is strongly recommended

for those with urinary albumin-to-creatinine ratio $>$ 300 mg/g creatinine and/or estimated glomerular filtration rate $<$ 60 mL/min/1.73 m². **E**

- 13.77** For those with nephropathy, continued monitoring (yearly urinary albumin-to-creatinine ratio, estimated glomerular filtration rate, and serum potassium) may aid in assessing adherence and detecting progression of disease. **E**
- 13.78** Referral to nephrology is recommended in case of uncertainty of etiology, worsening urinary albumin-to-creatinine ratio, or decrease in estimated glomerular filtration rate. **E**

Neuropathy

- 13.79** Youth with type 2 diabetes should be screened for the presence of neuropathy by foot examination at diagnosis and annually. The examination should include inspection, assessment of foot pulses, pinprick and 10-g monofilament sensation tests, testing of vibration sensation using 128-Hz tuning fork, and ankle reflexes. **C**
- 13.80** Prevention should focus on achieving glycemic targets. **C**

Retinopathy

- 13.81** Screening for retinopathy should be performed by dilated funduscopy or retinal photography at or soon after diagnosis and annually thereafter. **C**
- 13.82** Optimizing glycemia is recommended to decrease the risk or slow the progression of retinopathy. **B**
- 13.83** Less frequent examination (every 2 years) may be considered if there is adequate glycemic control and a normal eye exam. **C**

Nonalcoholic Fatty Liver Disease

- 13.84** Evaluation for nonalcoholic fatty liver disease (by measuring aspartate aminotransferase and alanine aminotransferase) should be done at diagnosis and annually thereafter. **B**

13.85 Referral to gastroenterology should be considered for persistently elevated or worsening transaminases. **B**

Obstructive Sleep Apnea

13.86 Screening for symptoms of sleep apnea should be done at each visit, and referral to a pediatric sleep specialist for evaluation and a polysomnogram, if indicated, is recommended. Obstructive sleep apnea should be treated when documented. **B**

Polycystic Ovary Syndrome

13.87 Evaluate for polycystic ovary syndrome in female adolescents with type 2 diabetes, including laboratory studies when indicated. **B**

13.88 Oral contraceptive pills for treatment of polycystic ovary syndrome are not contraindicated for girls with type 2 diabetes. **C**

13.89 Metformin in addition to lifestyle modification is likely to improve the menstrual cyclicity and hyperandrogenism in girls with type 2 diabetes. **E**

Cardiovascular Disease

13.90 Intensive lifestyle interventions focusing on weight loss, dyslipidemia, hypertension, and dysglycemia are important to prevent overt cardiovascular disease in early adulthood. **E**

Dyslipidemia

13.91 Lipid testing should be performed when initial glycemic control has been achieved and annually thereafter. **B**

13.92 Optimal goals are LDL cholesterol <100 mg/dL (2.6 mmol/L), HDL cholesterol >35 mg/dL (0.905 mmol/L), and triglycerides <150 mg/dL (1.7 mmol/L). **E**

13.93 If LDL cholesterol is >130 mg/dL, blood glucose control should be maximized and dietary counseling should be provided using the American Heart Association Step 2 diet. **E**

13.94 If LDL cholesterol remains above goal after 6 months of

dietary intervention, initiate therapy with statin, with goal of LDL <100 mg/dL. **B**

13.95 If triglycerides are >400 mg/dL (4.7 mmol/L) fasting or >1,000 mg/dL (11.6 mmol/L) nonfasting, optimize glycemia and begin fibrates, with a goal of <400 mg/dL (4.7 mmol/L) fasting (to reduce risk for pancreatitis). **C**

Cardiac Function Testing

13.96 Routine screening for heart disease with electrocardiogram, echocardiogram, or stress testing is not recommended in asymptomatic youth with type 2 diabetes. **B**

Comorbidities may already be present at the time of diagnosis of type 2 diabetes in youth (122,163). Therefore, blood pressure measurement, a fasting lipid panel, assessment of random urine albumin-to-creatinine ratio, and a dilated eye examination should be performed at diagnosis. Thereafter, screening guidelines and treatment recommendations for hypertension, dyslipidemia, urine albumin excretion, and retinopathy are similar to those for youth with type 1 diabetes. Additional problems that may need to be addressed include polycystic ovary disease and other comorbidities associated with pediatric obesity, such as sleep apnea, hepatic steatosis, orthopedic complications, and psychosocial concerns. The ADA position statement "Evaluation and Management of Youth-Onset Type 2 Diabetes" (2) provides guidance on the prevention, screening, and treatment of type 2 diabetes and its comorbidities in children and adolescents.

Youth-onset type 2 diabetes is associated with significant microvascular and macrovascular risk burden and a substantial increase in the risk of cardiovascular morbidity and mortality at an earlier age than those diagnosed later in life (164). The higher complication risk in earlier-onset type 2 diabetes is likely related to prolonged lifetime exposure to hyperglycemia and other atherogenic risk factors, including insulin resistance, dyslipidemia, hypertension, and chronic inflammation. There is low risk of hypoglycemia in

youth with type 2 diabetes, even if they are being treated with insulin (165), and there are high rates of complications (139–142). These diabetes comorbidities also appear to be higher than in youth with type 1 diabetes despite shorter diabetes duration and lower A1C (163). In addition, the progression of vascular abnormalities appears to be more pronounced in youth-onset type 2 diabetes compared with type 1 diabetes of similar duration, including ischemic heart disease and stroke (166).

Psychosocial Factors

Recommendations

13.97 Providers should assess social context, including potential food insecurity, housing stability, and financial barriers, and apply that information to treatment decisions. **E**

13.98 Use patient-appropriate standardized and validated tools to assess for diabetes distress and mental/behavioral health in youth with type 2 diabetes, with attention to symptoms of depression and eating disorders, and refer to specialty care when indicated. **B**

13.99 When choosing glucose-lowering or other medications for youth with overweight/obesity and type 2 diabetes, consider medication-taking behavior and their effect on weight. **E**

13.100 Starting at puberty, preconception counseling should be incorporated into routine diabetes clinic visits for all females of childbearing potential because of the adverse pregnancy outcomes in this population. **A**

13.101 Patients should be screened for smoking and alcohol use at diagnosis and regularly thereafter. **C**

Most youth with type 2 diabetes come from racial/ethnic minority groups, have low socioeconomic status, and often experience multiple psychosocial

stressors (22,35,123–126). Consideration of the sociocultural context and efforts to personalize diabetes management are of critical importance to minimize barriers to care, enhance adherence, and maximize response to treatment.

Evidence about psychiatric disorders and symptoms in youth with type 2 diabetes is limited (167–171), but given the sociocultural context for many youth and the medical burden and obesity associated with type 2 diabetes, ongoing surveillance of mental health/behavioral health is indicated. Symptoms of depression and disordered eating are common and associated with poorer glycemic control (168,172,173).

Many of the drugs prescribed for diabetes and psychiatric disorders are associated with weight gain and can increase patients' concerns about eating, body shape, and weight (174,175).

The TODAY study documented (176) that despite disease- and age-specific counseling, 10.2% of the females in the cohort became pregnant over an average of 3.8 years of study participation. Of note, 26.4% of pregnancies ended in a miscarriage, stillbirth, or intrauterine death, and 20.5% of the live-born infants had a major congenital anomaly.

TRANSITION FROM PEDIATRIC TO ADULT CARE

Recommendations

- 13.102** Pediatric diabetes providers should begin to prepare youth for transition to adult health care in early adolescence and, at the latest, at least 1 year before the transition. **E**
- 13.103** Both pediatric and adult diabetes care providers should provide support and resources for transitioning young adults. **E**
- 13.104** Youth with type 2 diabetes should be transferred to an adult-oriented diabetes specialist when deemed appropriate by the patient and provider. **E**

Care and close supervision of diabetes management are increasingly shifted from parents and other adults to the

youth with type 1 or type 2 diabetes throughout childhood and adolescence. The shift from pediatric to adult health care providers, however, often occurs abruptly as the older teen enters the next developmental stage, referred to as emerging adulthood (177), which is a critical period for young people who have diabetes. During this period of major life transitions, youth begin to move out of their parents' homes and must become fully responsible for their diabetes care. Their new responsibilities include self-management of their diabetes, making medical appointments, and financing health care, once they are no longer covered by their parents' health insurance plans (ongoing coverage until age 26 years is currently available under provisions of the U.S. Affordable Care Act). In addition to lapses in health care, this is also a period associated with deterioration in glycemic control; increased occurrence of acute complications; psychosocial, emotional, and behavioral challenges; and the emergence of chronic complications (178–181). The transition period from pediatric to adult care is prone to fragmentation in health care delivery, which may adversely impact health care quality, cost, and outcomes (182).

Although scientific evidence is limited, it is clear that comprehensive and coordinated planning that begins in early adolescence is necessary to facilitate a seamless transition from pediatric to adult health care (178,179,183,184). A comprehensive discussion regarding the challenges faced during this period, including specific recommendations, is found in the ADA position statement "Diabetes Care for Emerging Adults: Recommendations for Transition From Pediatric to Adult Diabetes Care Systems" (179).

The Endocrine Society in collaboration with the ADA and other organizations has developed transition tools for clinicians and youth and families (184).

References

- Chiang JL, Maahs DM, Garvey KC, et al. Type 1 diabetes in children and adolescents: a position statement by the American Diabetes Association. *Diabetes Care* 2018;41:2026–2044
- Arslanian S, Bacha F, Grey M, Marcus MD, White NH, Zeitler P. Evaluation and management of youth-onset type 2 diabetes: a position

statement by the American Diabetes Association. *Diabetes Care* 2018;41:2648–2668

- Nadeau KJ, Anderson BJ, Berg EG, et al. Youth-onset type 2 diabetes consensus report: current status, challenges, and priorities. *Diabetes Care* 2016;39:1635–1642
- Mayer-Davis EJ, Lawrence JM, Dabelea D, et al.; SEARCH for Diabetes in Youth Study. Incidence trends of type 1 and type 2 diabetes among youths, 2002–2012. *N Engl J Med* 2017;376:1419–1429
- Thomas NJ, Jones SE, Weedon MN, Shields BM, Oram RA, Hattersley AT. Frequency and phenotype of type 1 diabetes in the first six decades of life: a cross-sectional, genetically stratified survival analysis from UK Biobank. *Lancet Diabetes Endocrinol* 2018;6:122–129
- Barnea-Goraly N, Raman M, Mazaika P, et al.; Diabetes Research in Children Network (DirecNet). Alterations in white matter structure in young children with type 1 diabetes. *Diabetes Care* 2014;37:332–340
- Cameron FJ, Scratch SE, Nadebaum C, et al.; DKA Brain Injury Study Group. Neurological consequences of diabetic ketoacidosis at initial presentation of type 1 diabetes in a prospective cohort study of children. *Diabetes Care* 2014;37:1554–1562
- Markowitz JT, Garvey KC, Laffel LMB. Developmental changes in the roles of patients and families in type 1 diabetes management. *Curr Diabetes Rev* 2015;11:231–238
- Driscoll KA, Volkening LK, Haro H, et al. Are children with type 1 diabetes safe at school? Examining parent perceptions. *Pediatr Diabetes* 2015;16:613–620
- Mehta SN, Volkening LK, Anderson BJ, et al.; Family Management of Childhood Diabetes Study Steering Committee. Dietary behaviors predict glycemic control in youth with type 1 diabetes. *Diabetes Care* 2008;31:1318–1320
- Riddell MC, Gallen IW, Smart CE, et al. Exercise management in type 1 diabetes: a consensus statement. *Lancet Diabetes Endocrinol* 2017;5:377–390
- Colberg SR, Sigal RJ, Yardley JE, et al. Physical activity/exercise and diabetes: a position statement of the American Diabetes Association. *Diabetes Care* 2016;39:2065–2079
- Robertson K, Adolfsson P, Scheiner G, Hanas R, Riddell MC. Exercise in children and adolescents with diabetes. *Pediatr Diabetes* 2009;10 (Suppl. 12):154–168
- U.S. Department of Health and Human Services. 2008 physical activity guidelines for Americans: index [Internet]. Available from <https://health.gov/paguidelines/guidelines/default.aspx>. Accessed 16 October 2018
- Tsalikian E, Kollman C, Tamborlane WB, et al.; Diabetes Research in Children Network (DirecNet) Study Group. Prevention of hypoglycemia during exercise in children with type 1 diabetes by suspending basal insulin. *Diabetes Care* 2006;29:2200–2204
- Taplin CE, Cobry E, Messer L, McFann K, Chase HP, Fiallo-Scharer R. Preventing post-exercise nocturnal hypoglycemia in children with type 1 diabetes. *J Pediatr* 2010;157:784–788.e1
- Riddell MC, Milliken J. Preventing exercise-induced hypoglycemia in type 1 diabetes using real-time continuous glucose monitoring and a

- new carbohydrate intake algorithm: an observational field study. *Diabetes Technol Ther* 2011;13:819–825
18. Francescato MP, Stel G, Stenner E, Geat M. Prolonged exercise in type 1 diabetes: performance of a customizable algorithm to estimate the carbohydrate supplements to minimize glycemic imbalances. *PLoS One* 2015;10:e0125220
 19. Adolfsson P, Mattsson S, Jendle J. Evaluation of glucose control when a new strategy of increased carbohydrate supply is implemented during prolonged physical exercise in type 1 diabetes. *Eur J Appl Physiol* 2015;115:2599–2607
 20. Baker LB, Rollo I, Stein KW, Jeukendrup AE. Acute effects of carbohydrate supplementation on intermittent sports performance. *Nutrients* 2015;7:5733–5763
 21. Redondo MJ, Libman I, Cheng P, et al.; Pediatric Diabetes Consortium. Racial/ethnic minority youth with recent-onset type 1 diabetes have poor prognostic factors. *Diabetes Care* 2018;41:1017–1024
 22. Liu LL, Lawrence JM, Davis C, et al.; SEARCH for Diabetes in Youth Study Group. Prevalence of overweight and obesity in youth with diabetes in USA: the SEARCH for Diabetes in Youth study. *Pediatr Diabetes* 2010;11:4–11
 23. DuBose SN, Hermann JM, Tamborlane WV, et al.; Type 1 Diabetes Exchange Clinic Network and Diabetes Prospective Follow-up Registry. Obesity in youth with type 1 diabetes in Germany, Austria, and the United States. *J Pediatr* 2015;167:627–632.e4
 24. Corbin KD, Driscoll KA, Pratley RE, Smith SR, Maahs DM, Mayer-Davis EJ; Advancing Care for Type 1 Diabetes and Obesity Network (ACT1ON). Obesity in type 1 diabetes: pathophysiology, clinical impact, and mechanisms. *Endocr Rev* 2018;39:629–663
 25. Redondo MJ, Foster NC, Libman IM, et al. Prevalence of cardiovascular risk factors in youth with type 1 diabetes and elevated body mass index. *Acta Diabetol* 2016;53:271–277
 26. Jackson CC, Albanese-O'Neill A, Butler KL, et al. Diabetes care in the school setting: a position statement of the American Diabetes Association. *Diabetes Care* 2015;38:1958–1963
 27. Siminerio LM, Albanese-O'Neill A, Chiang JL, et al.; American Diabetes Association. Care of young children with diabetes in the child care setting: a position statement of the American Diabetes Association. *Diabetes Care* 2014;37:2834–2842
 28. Corathers SD, Kichler J, Jones N-HY, et al. Improving depression screening for adolescents with type 1 diabetes. *Pediatrics*. 2013;132:e1395–e1402
 29. Hood KK, Beavers DP, Yi-Frazier J, et al. Psychosocial burden and glycemic control during the first 6 years of diabetes: results from the SEARCH for Diabetes in Youth study. *J Adolesc Health* 2014;55:498–504
 30. Ducat L, Philipson LH, Anderson BJ. The mental health comorbidities of diabetes. *JAMA* 2014;312:691–692
 31. Hagger V, Hendrieckx C, Sturt J, Skinner TC, Speight J. Diabetes distress among adolescents with type 1 diabetes: a systematic review. *Curr Diab Rep* 2016;16:9
 32. Anderson BJ, Laffel LM, Domenger C, et al. Factors associated with diabetes-specific health-related quality of life in youth with type 1 diabetes: the global TEENS study [published correction appears in *Diabetes Care* 2018;41:640]. *Diabetes Care* 2017;40:1002–1009
 33. Hilliard ME, De Wit M, Wasserman RM, et al. Screening and support for emotional burdens of youth with type 1 diabetes: strategies for diabetes care providers. *Pediatr Diabetes* 2018;19:534–543
 34. Shapiro JB, Vesco AT, Weil LEG, Evans MA, Hood KK, Weissberg-Benchell J. Psychometric properties of the Problem Areas in Diabetes: Teen and Parent of Teen versions. *J Pediatr Psychol* 2018;43:561–571
 35. Young-Hyman D, de Groot M, Hill-Briggs F, Gonzalez JS, Hood K, Peyrot M. Psychosocial care for people with diabetes: a position statement of the American Diabetes Association. *Diabetes Care* 2016;39:2126–2140
 36. Katz ML, Volkening LK, Butler DA, Anderson BJ, Laffel LM. Family-based psychoeducation and Care Ambassador intervention to improve glycemic control in youth with type 1 diabetes: a randomized trial. *Pediatr Diabetes* 2014;15:142–150
 37. Laffel LMB, Vangsness L, Connell A, Goebel-Fabbri A, Butler D, Anderson BJ. Impact of ambulatory, family-focused teamwork intervention on glycemic control in youth with type 1 diabetes. *J Pediatr* 2003;142:409–416
 38. Anderson BJ, Vangsness L, Connell A, Butler D, Goebel-Fabbri A, Laffel LMB. Family conflict, adherence, and glycaemic control in youth with short duration type 1 diabetes. *Diabet Med* 2002;19:635–642
 39. Helgeson VS, Palladino DK. Implications of psychosocial factors for diabetes outcomes among children with type 1 diabetes: a review. *Soc Personal Psychol Compass* 2012;6:228–242
 40. McCarthy AM, Lindgren S, Mengeling MA, Tsalikian E, Engvall J. Factors associated with academic achievement in children with type 1 diabetes. *Diabetes Care* 2003;26:112–117
 41. Kuther TL. Medical decision-making and minors: issues of consent and assent. *Adolescence* 2003;38:343–358
 42. Coleman DL, Rosoff PM. The legal authority of mature minors to consent to general medical treatment. *Pediatrics* 2013;131:786–793
 43. Charron-Prochownik D, Sereika SM, Becker D, et al. Long-term effects of the booster-enhanced READY-Girls preconception counseling program on intentions and behaviors for family planning in teens with diabetes. *Diabetes Care* 2013;36:3870–3874
 44. Charron-Prochownik D, Downs J. *Diabetes and Reproductive Health for Girls*. Alexandria, VA, American Diabetes Association, 2016
 45. Markowitz JT, Butler DA, Volkening LK, Antisdell JE, Anderson BJ, Laffel LMB. Brief screening tool for disordered eating in diabetes: internal consistency and external validity in a contemporary sample of pediatric patients with type 1 diabetes. *Diabetes Care* 2010;33:495–500
 46. Goebel-Fabbri AE. Disturbed eating behaviors and eating disorders in type 1 diabetes: clinical significance and treatment recommendations. *Curr Diab Rep* 2009;9:133–139
 47. Atik Altınok Y, Özgür S, Meseri R, Özen S, Darcın Ş, Gökşen D. Reliability and validity of the diabetes eating problem survey in Turkish children and adolescents with type 1 diabetes mellitus. *J Clin Res Pediatr Endocrinol* 2017;9:323–328
 48. Saßmann H, Albrecht C, Busse-Widmann P, et al. Psychometric properties of the German version of the Diabetes Eating Problem Survey-Revised: additional benefit of disease-specific screening in adolescents with type 1 diabetes. *Diabet Med* 2015;32:1641–1647
 49. Lawrence JM, Yi-Frazier JP, Black MH, et al.; SEARCH for Diabetes in Youth Study Group. Demographic and clinical correlates of diabetes-related quality of life among youth with type 1 diabetes. *J Pediatr* 2012;161:201–207.e2
 50. Wisting L, Frøisland DH, Skriverhaug T, Dahl-Jørgensen K, Rø O. Disturbed eating behavior and omission of insulin in adolescents receiving intensified insulin treatment: a nationwide population-based study. *Diabetes Care* 2013;36:3382–3387
 51. Maahs DM, Hermann JM, DuBose SN, et al.; DPV Initiative; T1D Exchange Clinic Network. Contrasting the clinical care and outcomes of 2,622 children with type 1 diabetes less than 6 years of age in the United States T1D Exchange and German/Austrian DPV registries. *Diabetologia* 2014;57:1578–1585
 52. Haynes A, Hermann JM, Miller KM, et al.; T1D Exchange, WACDD and DPV registries. Severe hypoglycemia rates are not associated with HbA1c: a cross-sectional analysis of 3 contemporary pediatric diabetes registry databases. *Pediatr Diabetes* 2017;18:643–650
 53. Ryan CM. Why is cognitive dysfunction associated with the development of diabetes early in life? The diathesis hypothesis. *Pediatr Diabetes* 2006;7:289–297
 54. Cameron FJ. The impact of diabetes on brain function in childhood and adolescence. *Pediatr Clin North Am* 2015;62:911–927
 55. Campbell MS, Schatz DA, Chen V, et al.; T1D Exchange Clinic Network. A contrast between children and adolescents with excellent and poor control: the T1D Exchange clinic registry experience. *Pediatr Diabetes* 2014;15:110–117
 56. Cooper MN, O'Connell SM, Davis EA, Jones TW. A population-based study of risk factors for severe hypoglycaemia in a contemporary cohort of childhood-onset type 1 diabetes. *Diabetologia* 2013;56:2164–2170
 57. Bergenstal RM, Klonoff DC, Garg SK, et al.; ASPIRE In-Home Study Group. Threshold-based insulin-pump interruption for reduction of hypoglycemia. *N Engl J Med* 2013;369:224–232
 58. Abraham MB, Davey R, O'Grady MJ, et al. Effectiveness of a predictive algorithm in the prevention of exercise-induced hypoglycemia in type 1 diabetes. *Diabetes Technol Ther* 2016;18:543–550
 59. Buckingham BA, Bailey TS, Christiansen M, et al. Evaluation of a predictive low-glucose management system in-clinic. *Diabetes Technol Ther* 2017;19:288–292
 60. Nimri R, Muller I, Atlas E, et al. MD-Logic overnight control for 6 weeks of home use in patients with type 1 diabetes: randomized crossover trial. *Diabetes Care* 2014;37:3025–3032
 61. Thabit H, Tauschmann M, Allen JM, et al. Home use of an artificial beta cell in type 1 diabetes. *N Engl J Med* 2015;373:2129–2140
 62. Bergenstal RM, Garg S, Weinzimer SA, et al. Safety of a hybrid closed-loop insulin delivery system in patients with type 1 diabetes. *JAMA* 2016;316:1407–1408

63. Kovatchev B, Cheng P, Anderson SM, et al. Feasibility of long-term closed-loop control: a multicenter 6-month trial of 24/7 automated insulin delivery. *Diabetes Technol Ther* 2017;19:18–24
64. El-Khatib FH, Balliro C, Hillard MA, et al. Home use of a bihormonal bionic pancreas versus insulin pump therapy in adults with type 1 diabetes: a multicentre randomised crossover trial. *Lancet* 2017;389:369–380
65. Levine BS, Anderson BJ, Butler DA, Antisdel JE, Brackett J, Laffel LM. Predictors of glycemic control and short-term adverse outcomes in youth with type 1 diabetes. *J Pediatr* 2001;139:197–203
66. Miller KM, Beck RW, Bergenstal RM, et al.; T1D Exchange Clinic Network. Evidence of a strong association between frequency of self-monitoring of blood glucose and hemoglobin A_{1c} levels in T1D Exchange clinic registry participants. *Diabetes Care* 2013;36:2009–2014
67. Rosenbauer J, Dost A, Karges B, et al.; DPV Initiative and the German BMBF Competence Network Diabetes Mellitus. Improved metabolic control in children and adolescents with type 1 diabetes: a trend analysis using prospective multicenter data from Germany and Austria. *Diabetes Care* 2012;35:80–86
68. Cameron FJ, de Beaufort C, Aanstoot HJ, et al.; Hvidoere International Study Group. Lessons from the Hvidoere International Study Group on childhood diabetes: be dogmatic about outcome and flexible in approach. *Pediatr Diabetes* 2013;14:473–480
69. Nimri R, Weintrob N, Benzaquen H, Ofan R, Fayman G, Phillip M. Insulin pump therapy in youth with type 1 diabetes: a retrospective paired study. *Pediatrics* 2006;117:2126–2131
70. Doyle EA, Weinzimer SA, Steffen AT, Ahern JAH, Vincent M, Tamborlane WVA. A randomized, prospective trial comparing the efficacy of continuous subcutaneous insulin infusion with multiple daily injections using insulin glargine. *Diabetes Care* 2004;27:1554–1558
71. Swift PGF, Skinner TC, de Beaufort CE, et al.; Hvidoere Study Group on Childhood Diabetes. Target setting in intensive insulin management is associated with metabolic control: the Hvidoere childhood diabetes study group centre differences study 2005. *Pediatr Diabetes* 2010;11:271–278
72. Hughes JW, Riddlesworth TD, DiMeglio LA, Miller KM, Rickels MR, McGill JB. Autoimmune diseases in children and adults with type 1 diabetes from the T1D Exchange Clinic Registry. *J Clin Endocrinol Metab* 2016;101:4931–4937
73. Kahaly GJ, Hansen MP. Type 1 diabetes associated autoimmunity. *Autoimmun Rev* 2016;15:644–648
74. Roldán MB, Alonso M, Barrio R. Thyroid autoimmunity in children and adolescents with type 1 diabetes mellitus. *Diabetes Nutr Metab* 1999;12:27–31
75. Triolo TM, Armstrong TK, McFann K, et al. Additional autoimmune disease found in 33% of patients at type 1 diabetes onset. *Diabetes Care* 2011;34:1211–1213
76. Kordonouri O, Deiss D, Danne T, Dorow A, Bassir C, Grüters-Kieslich A. Predictivity of thyroid autoantibodies for the development of thyroid disorders in children and adolescents with type 1 diabetes. *Diabet Med* 2002;19:518–521
77. Dost A, Rohrer TR, Fröhlich-Reiterer E, et al.; DPV Initiative and the German Competence Network Diabetes Mellitus. Hyperthyroidism in 276 children and adolescents with type 1 diabetes from Germany and Austria. *Horm Res Paediatr* 2015;84:190–198
78. Jonsdottir B, Larsson C, Carlsson A, et al.; Better Diabetes Diagnosis Study Group. Thyroid and islet autoantibodies predict autoimmune thyroid disease at type 1 diabetes diagnosis. *J Clin Endocrinol Metab* 2017;102:1277–1285
79. Mohn A, Di Michele S, Di Luzio R, Tumini S, Chiarelli F. The effect of subclinical hypothyroidism on metabolic control in children and adolescents with type 1 diabetes mellitus. *Diabet Med* 2002;19:70–73
80. Holmes GKT. Screening for coeliac disease in type 1 diabetes. *Arch Dis Child* 2002;87:495–498
81. Rewers M, Liu E, Simmons J, Redondo MJ, Hoffenberg EJ. Celiac disease associated with type 1 diabetes mellitus. *Endocrinol Metab Clin North Am* 2004;33:197–214
82. Pham-Short A, Donaghue KC, Ambler G, Phelan H, Twigg S, Craig ME. Screening for celiac disease in type 1 diabetes: a systematic review. *Pediatrics* 2015;136:e170–e176
83. Craig ME, Prinz N, Boyle CT, et al.; Australasian Diabetes Data Network (ADDN); T1D Exchange Clinic Network (T1DX); National Paediatric Diabetes Audit (NPDA) and the Royal College of Paediatrics and Child Health; Prospective Diabetes Follow-up Registry (DPV) initiative. Prevalence of celiac disease in 52,721 youth with type 1 diabetes: international comparison across three continents. *Diabetes Care* 2017;40:1034–1040
84. Simmons JH, Foster NC, Riddlesworth TD, et al.; T1D Exchange Clinic Network. Sex- and age-dependent effects of celiac disease on growth and weight gain in children with type 1 diabetes: analysis of the Type 1 Diabetes Exchange Clinic Registry. *Pediatr Diabetes* 2018;19:741–748
85. Rubio-Tapia A, Hill ID, Kelly CP, Calderwood AH, Murray JA; American College of Gastroenterology. ACG clinical guidelines: diagnosis and management of celiac disease. *Am J Gastroenterol* 2013;108:656–676
86. Paul SP, Sandhu BK, Spray CH, Basude D, Ramani P. Evidence supporting serology-based pathway for diagnosing celiac disease in asymptomatic children from high-risk groups. *J Pediatr Gastroenterol Nutr* 2018;66:641–644
87. Abid N, McGlone O, Cardwell C, McCallion W, Carson D. Clinical and metabolic effects of gluten free diet in children with type 1 diabetes and coeliac disease. *Pediatr Diabetes* 2011;12:322–325
88. Husby S, Koletzko S, Korponay-Szabó IR, et al.; ESPGHAN Working Group on Coeliac Disease Diagnosis; ESPGHAN Gastroenterology Committee; European Society for Pediatric Gastroenterology, Hepatology, and Nutrition. European Society for Pediatric Gastroenterology, Hepatology, and Nutrition guidelines for the diagnosis of coeliac disease. *J Pediatr Gastroenterol Nutr* 2012;54:136–160
89. Kurppa K, Paavola A, Collin P, et al. Benefits of a gluten-free diet for asymptomatic patients with serologic markers of celiac disease. *Gastroenterology* 2014;147:610–617.e1
90. Marcovecchio ML, Chiesa ST, Bond S, et al.; AddIT Study Group. ACE inhibitors and statins in adolescents with type 1 diabetes. *N Engl J Med* 2017;377:1733–1745
91. de Ferranti SD, de Boer IH, Fonseca V, et al. Type 1 diabetes mellitus and cardiovascular disease: a scientific statement from the American Heart Association and American Diabetes Association. *Circulation* 2014;130:1110–1130
92. Rodriguez BL, Fujimoto WY, Mayer-Davis EJ, et al. Prevalence of cardiovascular disease risk factors in U.S. children and adolescents with diabetes: the SEARCH for Diabetes in Youth study. *Diabetes Care* 2006;29:1891–1896
93. Margeisdottir HD, Larsen JR, Brunborg C, Overby NC, Dahl-Jørgensen K; Norwegian Study Group for Childhood Diabetes. High prevalence of cardiovascular risk factors in children and adolescents with type 1 diabetes: a population-based study. *Diabetologia* 2008;51:554–561
94. Schwab KO, Doerfer J, Hecker W, et al.; DPV Initiative of the German Working Group for Pediatric Diabetology. Spectrum and prevalence of atherogenic risk factors in 27,358 children, adolescents, and young adults with type 1 diabetes: cross-sectional data from the German diabetes documentation and quality management system (DPV). *Diabetes Care* 2006;29:218–225
95. Singh TP, Groehn H, Kazmers A. Vascular function and carotid intimal-medial thickness in children with insulin-dependent diabetes mellitus. *J Am Coll Cardiol* 2003;41:661–665
96. Haller MJ, Stein J, Shuster J, et al. Peripheral artery tonometry demonstrates altered endothelial function in children with type 1 diabetes. *Pediatr Diabetes* 2007;8:193–198
97. Urbina EM, Wadwa RP, Davis C, et al. Prevalence of increased arterial stiffness in children with type 1 diabetes mellitus differs by measurement site and sex: the SEARCH for Diabetes in Youth Study. *J Pediatr* 2010;156:731–737.e1
98. Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents; National Heart, Lung, and Blood Institute. Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents: summary report. *Pediatrics* 2011;128(Suppl. 5):S213–S256
99. Daniels SR, Greer FR; Committee on Nutrition. Lipid screening and cardiovascular health in childhood. *Pediatrics* 2008;122:198–208
100. Kavey R-EW, Allada V, Daniels SR, et al.; American Heart Association Expert Panel on Population and Prevention Science; American Heart Association Council on Cardiovascular Disease in the Young; American Heart Association Council on Epidemiology and Prevention; American Heart Association Council on Nutrition, Physical Activity and Metabolism; American Heart Association Council on High Blood Pressure Research; American Heart Association Council on Cardiovascular Nursing; American Heart Association Council on the Kidney in Heart Disease; Interdisciplinary Working Group on Quality of Care and Outcomes Research. Cardiovascular risk reduction in high-risk pediatric patients: a scientific statement from the American Heart Association Expert Panel on Population and Prevention Science; the Councils on Cardiovascular Disease in the Young, Epidemiology and Prevention, Nutrition, Physical Activity

- and Metabolism, High Blood Pressure Research, Cardiovascular Nursing, and the Kidney in Heart Disease; and the Interdisciplinary Working Group on Quality of Care and Outcomes Research: endorsed by the American Academy of Pediatrics. *Circulation* 2006;114:2710–2738
101. Cadario F, Prodam F, Pasqualicchio S, et al. Lipid profile and nutritional intake in children and adolescents with type 1 diabetes improve after a structured dietician training to a Mediterranean-style diet. *J Endocrinol Invest* 2012;35:160–168
102. Salem MA, AboElAsrar MA, Elbarbary NS, ElHilaly RA, Refaat YM. Is exercise a therapeutic tool for improvement of cardiovascular risk factors in adolescents with type 1 diabetes mellitus? A randomised controlled trial. *Diabetol Metab Syndr* 2010;2:47
103. McCrindle BW, Urbina EM, Dennison BA, et al.; American Heart Association Atherosclerosis, Hypertension, and Obesity in Youth Committee; American Heart Association Council of Cardiovascular Disease in the Young; American Heart Association Council on Cardiovascular Nursing. Drug therapy of high-risk lipid abnormalities in children and adolescents: a scientific statement from the American Heart Association Atherosclerosis, Hypertension, and Obesity in Youth Committee, Council of Cardiovascular Disease in the Young, with the Council on Cardiovascular Nursing. *Circulation* 2007;115:1948–1967
104. Salo P, Viikari J, Hämäläinen M, et al. Serum cholesterol ester fatty acids in 7- and 13-month-old children in a prospective randomized trial of a low-saturated fat, low-cholesterol diet: the STRIP baby project: Special Turku coronary Risk factor Intervention Project for children. *Acta Paediatr* 1999;88:505–512
105. Maahs DM, Dabelea D, D'Agostino RB Jr, et al.; SEARCH for Diabetes in Youth Study. Glucose control predicts 2-year change in lipid profile in youth with type 1 diabetes. *J Pediatr* 2013;162:101–107.e1
106. McCrindle BW, Ose L, Marais AD. Efficacy and safety of atorvastatin in children and adolescents with familial hypercholesterolemia or severe hyperlipidemia: a multicenter, randomized, placebo-controlled trial. *J Pediatr* 2003;143:74–80
107. Wiegman A, Hutten BA, de Groot E, et al. Efficacy and safety of statin therapy in children with familial hypercholesterolemia: a randomized controlled trial. *JAMA* 2004;292:331–337
108. Karter AJ, Stevens MR, Gregg EW, et al. Educational disparities in rates of smoking among diabetic adults: the Translating Research Into Action for Diabetes study. *Am J Public Health* 2008;98:365–370
109. Reynolds K, Liese AD, Anderson AM, et al. Prevalence of tobacco use and association between cardiometabolic risk factors and cigarette smoking in youth with type 1 or type 2 diabetes mellitus. *J Pediatr* 2011;158:594–601.e1
110. Scott LJ, Warram JH, Hanna LS, Laffel LM, Ryan L, Krolewski AS. A nonlinear effect of hyperglycemia and current cigarette smoking are major determinants of the onset of microalbuminuria in type 1 diabetes. *Diabetes* 2001;50:2842–2849
111. Chaffee BW, Watkins SL, Glantz SA. Electronic cigarette use and progression from experimentation to established smoking. *Pediatrics* 2018;141:e20173594
112. Audrain-McGovern J, Stone MD, Barrington-Trimis J, Unger JB, Leventhal AM. Adolescent e-cigarette, hookah, and conventional cigarette use and subsequent marijuana use. *Pediatrics* 2018;142:e20173616
113. Daniels M, DuBose SN, Maahs DM, et al.; T1D Exchange Clinic Network. Factors associated with microalbuminuria in 7,549 children and adolescents with type 1 diabetes in the T1D Exchange clinic registry. *Diabetes Care* 2013;36:2639–2645
114. Schwartz GJ, Work DF. Measurement and estimation of GFR in children and adolescents. *Clin J Am Soc Nephrol* 2009;4:1832–1843
115. Inker LA, Schmid CH, Tighiouart H, et al.; CKD-EPI Investigators. Estimating glomerular filtration rate from serum creatinine and cystatin C. *N Engl J Med* 2012;367:20–29
116. Cho YH, Craig ME, Hing S, et al. Microvascular complications assessment in adolescents with 2- to 5-yr duration of type 1 diabetes from 1990 to 2006. *Pediatr Diabetes* 2011;12:682–689
117. Jaiswal M, Divers J, Dabelea D, et al. Prevalence of and risk factors for diabetic peripheral neuropathy in youth with type 1 and type 2 diabetes: SEARCH for Diabetes in Youth Study. *Diabetes Care* 2017;40:1226–1232
118. Pop-Busui R, Boulton AJM, Feldman EL, et al. Diabetic neuropathy: a position statement by the American Diabetes Association. *Diabetes Care* 2017;40:136–154
119. Lawrence JM, Imperatore G, Pettitt DJ, et al. Incidence of diabetes in United States youth by diabetes type, race/ethnicity, and age, 2008–2009 (Abstract). *Diabetes* 2014;63(Suppl. 1):A407
120. Imperatore G, Boyle JP, Thompson TJ, et al.; SEARCH for Diabetes in Youth Study Group. Projections of type 1 and type 2 diabetes burden in the U.S. population aged <20 years through 2050: dynamic modeling of incidence, mortality, and population growth. *Diabetes Care* 2012;35:2515–2520
121. Pettitt DJ, Talton J, Dabelea D, et al.; SEARCH for Diabetes in Youth Study Group. Prevalence of diabetes in U.S. youth in 2009: the SEARCH for Diabetes in Youth Study. *Diabetes Care* 2014;37:402–408
122. Copeland KC, Zeitler P, Geffner M, et al.; TODAY Study Group. Characteristics of adolescents and youth with recent-onset type 2 diabetes: the TODAY cohort at baseline. *J Clin Endocrinol Metab* 2011;96:159–167
123. Arslanian SA. Metabolic differences between Caucasian and African-American children and the relationship to type 2 diabetes mellitus. *J Pediatr Endocrinol Metab* 2002;15(Suppl. 1):509–517
124. Naughton MJ, Ruggiero AM, Lawrence JM, et al.; SEARCH for Diabetes in Youth Study Group. Health-related quality of life of children and adolescents with type 1 or type 2 diabetes mellitus: SEARCH for Diabetes in Youth Study. *Arch Pediatr Adolesc Med* 2008;162:649–657
125. Wadden TA, Webb VL, Moran CH, Bailer BA. Lifestyle modification for obesity: new developments in diet, physical activity, and behavior therapy. *Circulation* 2012;125:1157–1170
126. Whalen DJ, Belden AC, Tillman R, Barch DM, Luby JL. Early adversity, psychopathology, and latent class profiles of global physical health from preschool through early adolescence. *Psychosom Med* 2016;78:1008–1018
127. Dabelea D, Mayer-Davis EJ, Saydah S, et al.; SEARCH for Diabetes in Youth Study. Prevalence of type 1 and type 2 diabetes among children and adolescents from 2001 to 2009. *JAMA* 2014;311:1778–1786
128. Buse JB, Kaufman FR, Linder B, Hirst K, El Ghormli L, Willi S; HEALTHY Study Group. Diabetes screening with hemoglobin A_{1c} versus fasting plasma glucose in a multiethnic middle-school cohort. *Diabetes Care* 2013;36:429–435
129. Klingensmith GJ, Pyle L, Arslanian S, et al.; TODAY Study Group. The presence of GAD and IA-2 antibodies in youth with a type 2 diabetes phenotype: results from the TODAY study. *Diabetes Care* 2010;33:1970–1975
130. Hannon TS, Arslanian SA. The changing face of diabetes in youth: lessons learned from studies of type 2 diabetes. *Ann N Y Acad Sci* 2015;1353:113–137
131. Kapadia C, Zeitler P; Drugs and Therapeutics Committee of the Pediatric Endocrine Society. Hemoglobin A_{1c} measurement for the diagnosis of type 2 diabetes in children. *Int J Pediatr Endocrinol* 2012;2012:31
132. Kester LM, Hey H, Hannon TS. Using hemoglobin A_{1c} for prediabetes and diabetes diagnosis in adolescents: can adult recommendations be upheld for pediatric use? *J Adolesc Health* 2012;50:321–323
133. Wu E-L, Kazzi NG, Lee JM. Cost-effectiveness of screening strategies for identifying pediatric diabetes mellitus and dysglycemia. *JAMA Pediatr* 2013;167:32–39
134. Dabelea D, Rewers A, Stafford JM, et al.; SEARCH for Diabetes in Youth Study Group. Trends in the prevalence of ketoacidosis at diabetes diagnosis: the SEARCH for Diabetes in Youth Study. *Pediatrics* 2014;133:e938–e945
135. Hutchins J, Barajas RA, Hale D, Escaname E, Lynch J. Type 2 diabetes in a 5-year-old and single center experience of type 2 diabetes in youth under 10. *Pediatr Diabetes* 2017;18:674–677
136. Ferrara CT, Geyer SM, Liu Y-F, et al.; Type 1 Diabetes TrialNet Study Group. Excess BMI in childhood: a modifiable risk factor for type 1 diabetes development? *Diabetes Care* 2017;40:698–701
137. Redondo MJ, Geyer S, Steck AK, et al.; Type 1 Diabetes TrialNet Study Group. *TCF7L2* genetic variants contribute to phenotypic heterogeneity of type 1 diabetes. *Diabetes Care* 2018;41:311–317
138. Pinhas-Hamiel O, Dolan LM, Zeitler PS. Diabetic ketoacidosis among obese African-American adolescents with NIDDM. *Diabetes Care* 1997;20:484–486
139. TODAY Study Group. Safety and tolerability of the treatment of youth-onset type 2 diabetes: the TODAY experience. *Diabetes Care* 2013;36:1765–1771
140. TODAY Study Group. Retinopathy in youth with type 2 diabetes participating in the TODAY clinical trial. *Diabetes Care* 2013;36:1772–1774
141. TODAY Study Group. Lipid and inflammatory cardiovascular risk worsens over 3 years in youth with type 2 diabetes: the TODAY clinical trial. *Diabetes Care* 2013;36:1758–1764
142. TODAY Study Group. Rapid rise in hypertension and nephropathy in youth with type 2

- diabetes: the TODAY clinical trial. *Diabetes Care* 2013;36:1735–1741
143. Grey M, Schreiner B, Pyle L. Development of a diabetes education program for youth with type 2 diabetes. *Diabetes Educ* 2009;35:108–116
144. American Diabetes Association. Be Healthy Today; Be Healthy For Life [Internet]. Available from <http://main.diabetes.org/dorg/PDFs/Type-2-Diabetes-in-Youth/Type-2-Diabetes-in-Youth.pdf>. Accessed 16 October 2018
145. Atkinson A, Radjenovic D. Meeting quality standards for self-management education in pediatric type 2 diabetes. *Diabetes Spectr* 2007;20:40–46
146. Copeland KC, Silverstein J, Moore KR, et al. Management of newly diagnosed type 2 diabetes mellitus (T2DM) in children and adolescents. *Pediatrics* 2013;131:364–382
147. Levitt Katz LE, Bacha F, Gidding SS, et al.; TODAY Study Group. Lipid profiles, inflammatory markers, and insulin therapy in youth with type 2 Diabetes. *J Pediatr* 2018;196:208–216.e2
148. Zeitler P, Hirst K, Pyle L, et al.; TODAY Study Group. A clinical trial to maintain glycemic control in youth with type 2 diabetes. *N Engl J Med* 2012;366:2247–2256
149. Inge TH, Courcoulas AP, Jenkins TM, et al.; Teen-LABS Consortium. Weight loss and health status 3 years after bariatric surgery in adolescents. *N Engl J Med* 2016;374:113–123
150. Rubino F, Nathan DM, Eckel RH, et al.; Delegates of the 2nd Diabetes Surgery Summit. Metabolic surgery in the treatment algorithm for type 2 diabetes: a joint statement by international diabetes organizations. *Diabetes Care* 2016;39:861–877
151. Pratt JSA, Lenders CM, Dionne EA, et al. Best practice updates for pediatric/adolescent weight loss surgery. *Obesity (Silver Spring)* 2009; 17:901–910
152. Dolan K, Creighton L, Hopkins G, Fielding G. Laparoscopic gastric banding in morbidly obese adolescents. *Obes Surg* 2003;13:101–104
153. Sugerman HJ, Sugerman EL, DeMaria EJ, et al. Bariatric surgery for severely obese adolescents. *J Gastrointest Surg* 2003;7:102–108
154. Inge TH, Garcia V, Daniels S, et al. A multidisciplinary approach to the adolescent bariatric surgical patient. *J Pediatr Surg* 2004; 39:442–447; discussion 446–447
155. Lawson ML, Kirk S, Mitchell T, et al.; Pediatric Bariatric Study Group. One-year outcomes of Roux-en-Y gastric bypass for morbidly obese adolescents: a multicenter study from the Pediatric Bariatric Study Group. *J Pediatr Surg* 2006;41:137–143
156. Inge TH, Zeller M, Harmon C, et al. Teen-Longitudinal Assessment of Bariatric Surgery: methodological features of the first prospective multicenter study of adolescent bariatric surgery. *J Pediatr Surg* 2007;42:1969–1971
157. Ellis LJ, Mead E, Atkinson G, et al. Surgery for the treatment of obesity in children and adolescents. *Cochrane Database Syst Rev* 2015;6: CD011740
158. Michalsky MP, Inge TH, Simmons M, et al.; Teen-LABS Consortium. Cardiovascular risk factors in severely obese adolescents: the Teen Longitudinal Assessment of Bariatric Surgery (Teen-LABS) study. *JAMA Pediatr* 2015;169: 438–444
159. Zeinoddini A, Heidari R, Talebpour M. Laparoscopic gastric plication in morbidly obese adolescents: a prospective study. *Surg Obes Relat Dis* 2014;10:1135–1139
160. Göthberg G, Gronowitz E, Flodmark C-E, et al. Laparoscopic Roux-en-Y gastric bypass in adolescents with morbid obesity—surgical aspects and clinical outcome. *Semin Pediatr Surg* 2014;23:11–16
161. Inge TH, Prigeon RL, Elder DA, et al. Insulin sensitivity and β -cell function improve after gastric bypass in severely obese adolescents. *J Pediatr* 2015;167:1042–1048.e1
162. Styne DM, Arslanian SA, Connor EL, et al. Pediatric obesity—assessment, treatment, and prevention: an Endocrine Society clinical practice guideline. *J Clin Endocrinol Metab* 2017;102: 709–757
163. Eppens MC, Craig ME, Cusumano J, et al. Prevalence of diabetes complications in adolescents with type 2 compared with type 1 diabetes. *Diabetes Care* 2006;29:1300–1306
164. Song SH, Hardisty CA. Early onset type 2 diabetes mellitus: a harbinger for complications in later years—clinical observation from a secondary care cohort. *QJM* 2009;102:799–806
165. Zeitler P, Fu J, Tandon N, et al.; International Society for Pediatric and Adolescent Diabetes. ISPAD Clinical Practice Consensus Guidelines 2014. Type 2 diabetes in the child and adolescent. *Pediatr Diabetes* 2014;15(Suppl. 20):26–46
166. Song SH. Complication characteristics between young-onset type 2 versus type 1 diabetes in a UK population. *BMJ Open Diabetes Res Care* 2015;3:e000044
167. Cefalu WT. “TODAY” reflects on the changing “faces” of type 2 diabetes. *Diabetes Care* 2013;36:1732–1734
168. Lawrence JM, Standiford DA, Loots B, et al.; SEARCH for Diabetes in Youth Study. Prevalence and correlates of depressed mood among youth with diabetes: the SEARCH for Diabetes in Youth study. *Pediatrics* 2006;117:1348–1358
169. Levitt Katz LE, Swami S, Abraham M, et al. Neuropsychiatric disorders at the presentation of type 2 diabetes mellitus in children. *Pediatr Diabetes* 2005;6:84–89
170. Lewis-Fernández R, Rotheram-Borus MJ, Betts VT, et al. Rethinking funding priorities in mental health research. *Br J Psychiatry* 2016;208: 507–509
171. Reinehr T. Type 2 diabetes mellitus in children and adolescents. *World J Diabetes* 2013;4:270–281
172. Pinhas-Hamiel O, Hamiel U, Levy-Shraga Y. Eating disorders in adolescents with type 1 diabetes: challenges in diagnosis and treatment. *World J Diabetes* 2015;6:517–526
173. TODAY Study Group. Binge eating, mood, and quality of life in youth with type 2 diabetes: baseline data from the TODAY study. *Diabetes Care* 2011;34:858–860
174. Shelton RC. Depression, antidepressants, and weight gain in children. *Obesity (Silver Spring)* 2016;24:2450
175. Baeza I, Vigo L, de la Serna E, et al. The effects of antipsychotics on weight gain, weight-related hormones and homocysteine in children and adolescents: a 1-year follow-up study. *Eur Child Adolesc Psychiatry* 2017;26:35–46
176. Klingensmith GJ, Pyle L, Nadeau KJ, et al. Pregnancy outcomes in youth with type 2 diabetes: the TODAY study experience. *Diabetes Care* 2016;39:122–129
177. Arnett JJ. Emerging adulthood: a theory of development from the late teens through the twenties. *Am Psychol* 2000;55:469–480
178. Weissberg-Benchell J, Wolpert H, Anderson BJ. Transitioning from pediatric to adult care: a new approach to the post-adolescent young person with type 1 diabetes. *Diabetes Care* 2007; 30:2441–2446
179. Peters A, Laffel L; American Diabetes Association Transitions Working Group. Diabetes care for emerging adults: recommendations for transition from pediatric to adult diabetes care systems: a position statement of the American Diabetes Association, with representation by the American College of Osteopathic Family Physicians, the American Academy of Pediatrics, the American Association of Clinical Endocrinologists, the American Osteopathic Association, the Centers for Disease Control and Prevention, Children with Diabetes, The Endocrine Society, the International Society for Pediatric and Adolescent Diabetes, Juvenile Diabetes Research Foundation International, the National Diabetes Education Program, and the Pediatric Endocrine Society (formerly Lawson Wilkins Pediatric Endocrine Society). *Diabetes Care* 2011;34:2477–2485
180. Bryden KS, Peveler RC, Stein A, Neil A, Mayou RA, Dunger DB. Clinical and psychological course of diabetes from adolescence to young adulthood: a longitudinal cohort study. *Diabetes Care* 2001;24:1536–1540
181. Laing SP, Jones ME, Swerdlow AJ, Burden AC, Gatling W. Psychosocial and socioeconomic risk factors for premature death in young people with type 1 diabetes. *Diabetes Care* 2005;28: 1618–1623
182. Mays JA, Jackson KL, Derby TA, et al. An evaluation of recurrent diabetic ketoacidosis, fragmentation of care, and mortality across Chicago, Illinois. *Diabetes Care* 2016;39:1671–1676
183. Garvey KC, Foster NC, Agarwal S, et al. Health care transition preparation and experiences in a U.S. national sample of young adults with type 1 diabetes. *Diabetes Care* 2017;40:317–324
184. The Endocrine Society. Managing the transition of care for patients with type 1 diabetes [Internet]. Available from <https://www.endocrine.org/guidelines-and-clinical-practice-quality-improvement-resources/clinical-practice-resources/transition-of-care>. Accessed 16 October 2018

14. Management of Diabetes in Pregnancy: *Standards of Medical Care in Diabetes—2019*

American Diabetes Association

Diabetes Care 2019;42(Suppl. 1):S165–S172 | <https://doi.org/10.2337/dc19-S014>

The American Diabetes Association (ADA) “Standards of Medical Care in Diabetes” includes ADA’s current clinical practice recommendations and is intended to provide the components of diabetes care, general treatment goals and guidelines, and tools to evaluate quality of care. Members of the ADA Professional Practice Committee, a multidisciplinary expert committee, are responsible for updating the Standards of Care annually, or more frequently as warranted. For a detailed description of ADA standards, statements, and reports, as well as the evidence-grading system for ADA’s clinical practice recommendations, please refer to the Standards of Care Introduction. Readers who wish to comment on the Standards of Care are invited to do so at professional.diabetes.org/SOC.

DIABETES IN PREGNANCY

The prevalence of diabetes in pregnancy has been increasing in the U.S. The majority is gestational diabetes mellitus (GDM) with the remainder primarily preexisting type 1 diabetes and type 2 diabetes. The rise in GDM and type 2 diabetes in parallel with obesity both in the U.S. and worldwide is of particular concern. Both type 1 diabetes and type 2 diabetes in pregnancy confer significantly greater maternal and fetal risk than GDM, with some differences according to type of diabetes. In general, specific risks of uncontrolled diabetes in pregnancy include spontaneous abortion, fetal anomalies, preeclampsia, fetal demise, macrosomia, neonatal hypoglycemia, and neonatal hyperbilirubinemia, among others. In addition, diabetes in pregnancy may increase the risk of obesity and type 2 diabetes in offspring later in life (1,2).

PRECONCEPTION COUNSELING

Recommendations

- 14.1** Starting at puberty and continuing in all women with reproductive potential, preconception counseling should be incorporated into routine diabetes care. **A**
- 14.2** Family planning should be discussed and effective contraception should be prescribed and used until a woman is prepared and ready to become pregnant. **A**
- 14.3** Preconception counseling should address the importance of glycemic management as close to normal as is safely possible, ideally A1C <6.5% (48 mmol/mol), to reduce the risk of congenital anomalies, preeclampsia, macrosomia, and other complications. **B**

All women of childbearing age with diabetes should be counseled about the importance of tight glycemic control prior to conception. Observational studies show an increased risk of diabetic embryopathy, especially anencephaly, microcephaly, congenital heart disease, and caudal regression, directly proportional to elevations in

Suggested citation: American Diabetes Association. 14. Management of diabetes in pregnancy: Standards of Medical Care in Diabetes—2019. Diabetes Care 2019;42(Suppl. 1):S165–S172

© 2018 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. More information is available at <http://www.diabetesjournals.org/content/license>.

A1C during the first 10 weeks of pregnancy (3). Although observational studies are confounded by the association between elevated periconceptional A1C and other poor self-care behaviors, the quantity and consistency of data are convincing and support the recommendation to optimize glycemic control prior to conception, with A1C <6.5% (48 mmol/mol) associated with the lowest risk of congenital anomalies (3–6).

There are opportunities to educate all women and adolescents of reproductive age with diabetes about the risks of unplanned pregnancies and improved maternal and fetal outcomes with pregnancy planning (7). Effective preconception counseling could avert substantial health and associated cost burdens in offspring (8). Family planning should be discussed, and effective contraception should be prescribed and used until a woman is prepared and ready to become pregnant.

To minimize the occurrence of complications, beginning at the onset of puberty or at diagnosis, all girls and women with diabetes of childbearing potential should receive education about 1) the risks of malformations associated with unplanned pregnancies and poor metabolic control and 2) the use of effective contraception at all times when preventing a pregnancy. Preconception counseling using developmentally appropriate educational tools enables adolescent girls to make well-informed decisions (7). Preconception counseling resources tailored for adolescents are available at no cost through the American Diabetes Association (ADA) (9).

Preconception Care

Recommendations

14.4 Women with preexisting type 1 or type 2 diabetes who are planning pregnancy or who have become pregnant should be counseled on the risk of development and/or progression of diabetic retinopathy. Dilated eye examinations should occur ideally before pregnancy or in the first trimester, and then patients should be monitored every trimester and for 1-year postpartum as indicated by the degree of retinopathy and as recommended by the eye care provider. **B**

14.5 Women with preexisting diabetes should ideally be managed in a multidisciplinary clinic including an endocrinologist, maternal-fetal medicine specialist, dietitian, and diabetes educator, when available. **B**

Preconception visits should include rubella, syphilis, hepatitis B virus, and HIV testing, as well as Pap test, cervical cultures, blood typing, prescription of prenatal vitamins (with at least 400 mg of folic acid), and smoking cessation counseling if indicated. Diabetes-specific testing should include A1C, thyroid-stimulating hormone, creatinine, and urinary albumin-to-creatinine ratio; review of the medication list for potentially teratogenic drugs, i.e., ACE inhibitors (10), angiotensin receptor blockers (10), and statins (11,12); and referral for a comprehensive eye exam. Women with preexisting diabetic retinopathy will need close monitoring during pregnancy to ensure that retinopathy does not progress (13). Preconception counseling should include an explanation of the risks to mother and fetus related to pregnancy and the ways to reduce risk and include glycemic goal setting, lifestyle management, and medical nutrition therapy.

Several studies have shown improved diabetes and pregnancy outcomes when care has been delivered from preconception through pregnancy by a multidisciplinary group focused on improved glycemic control (14–16). One study showed that care of preexisting diabetes in clinics that included diabetes and obstetric specialists improved care (17). However, there is no consensus on the structure of multidisciplinary team care for diabetes and pregnancy, and there is a lack of evidence on the impact on outcomes of various methods of health care delivery (18).

GLYCEMIC TARGETS IN PREGNANCY

Recommendations

14.6 Fasting and postprandial self-monitoring of blood glucose are recommended in both gestational diabetes mellitus and preexisting diabetes in pregnancy to achieve glycemic control. Some women with preexisting

diabetes should also test blood glucose preprandially. **B**

14.7 Due to increased red blood cell turnover, A1C is slightly lower in normal pregnancy than in normal nonpregnant women. Ideally, the A1C target in pregnancy is <6% (42 mmol/mol) if this can be achieved without significant hypoglycemia, but the target may be relaxed to <7% (53 mmol/mol) if necessary to prevent hypoglycemia. **B**

Pregnancy in women with normal glucose metabolism is characterized by fasting levels of blood glucose that are lower than in the nonpregnant state due to insulin-independent glucose uptake by the fetus and placenta and by postprandial hyperglycemia and carbohydrate intolerance as a result of diabetogenic placental hormones. In patients with preexisting diabetes, glycemic targets are usually achieved through a combination of insulin administration and medical nutrition therapy. Because glycemic targets in pregnancy are stricter than in nonpregnant individuals, it is important that women with diabetes eat consistent amounts of carbohydrates to match with insulin dosage and to avoid hyperglycemia or hypoglycemia. Referral to a registered dietitian is important in order to establish a food plan and insulin-to-carbohydrate ratio and to determine weight gain goals.

Insulin Physiology

Early pregnancy is a time of enhanced insulin sensitivity, lower glucose levels, and lower insulin requirements in women with type 1 diabetes. The situation rapidly reverses as insulin resistance increases exponentially during the second and early third trimesters and levels off toward the end of the third trimester. In women with normal pancreatic function, insulin production is sufficient to meet the challenge of this physiological insulin resistance and to maintain normal glucose levels. However, in women with GDM or preexisting diabetes, hyperglycemia occurs if treatment is not adjusted appropriately.

Glucose Monitoring

Reflecting this physiology, fasting and postprandial monitoring of blood glucose

is recommended to achieve metabolic control in pregnant women with diabetes. Preprandial testing is also recommended for women with preexisting diabetes using insulin pumps or basal-bolus therapy, so that premeal rapid-acting insulin dosage can be adjusted. Postprandial monitoring is associated with better glycemic control and lower risk of preeclampsia (19–21). There are no adequately powered randomized trials comparing different fasting and postmeal glycemic targets in diabetes in pregnancy.

Similar to the targets recommended by the American College of Obstetricians and Gynecologists (the same as for GDM; described below) (22), the ADA-recommended targets for women with type 1 or type 2 diabetes are as follows:

- Fasting <95 mg/dL (5.3 mmol/L) and either
- One-hour postprandial <140 mg/dL (7.8 mmol/L) or
- Two-hour postprandial <120 mg/dL (6.7 mmol/L)

These values represent optimal control if they can be achieved safely. In practice, it may be challenging for women with type 1 diabetes to achieve these targets without hypoglycemia, particularly women with a history of recurrent hypoglycemia or hypoglycemia unawareness.

If women cannot achieve these targets without significant hypoglycemia, the ADA suggests less stringent targets based on clinical experience and individualization of care.

A1C in Pregnancy

In studies of women without preexisting diabetes, increasing A1C levels within the normal range is associated with adverse outcomes (23). In the Hyperglycemia and Adverse Pregnancy Outcome (HAPO) study, increasing levels of glycemia were associated with worsening outcomes (24). Observational studies in preexisting diabetes and pregnancy show the lowest rates of adverse fetal outcomes in association with A1C <6–6.5% (42–48 mmol/mol) early in gestation (4–6,25). Clinical trials have not evaluated the risks and benefits of achieving these targets, and treatment goals should account for the risk of

maternal hypoglycemia in setting an individualized target of <6% (42 mmol/mol) to <7% (53 mmol/mol). Due to physiological increases in red blood cell turnover, A1C levels fall during normal pregnancy (26,27). Additionally, as A1C represents an integrated measure of glucose, it may not fully capture postprandial hyperglycemia, which drives macrosomia. Thus, although A1C may be useful, it should be used as a secondary measure of glycemic control in pregnancy, after self-monitoring of blood glucose.

In the second and third trimesters, A1C <6% (42 mmol/mol) has the lowest risk of large-for-gestational-age infants (25,28,29), preterm delivery (30), and preeclampsia (1,31). Taking all of this into account, a target of <6% (42 mmol/mol) is optimal during pregnancy if it can be achieved without significant hypoglycemia. The A1C target in a given patient should be achieved without hypoglycemia, which, in addition to the usual adverse sequelae, may increase the risk of low birth weight (32). Given the alteration in red blood cell kinetics during pregnancy and physiological changes in glycemic parameters, A1C levels may need to be monitored more frequently than usual (e.g., monthly).

MANAGEMENT OF GESTATIONAL DIABETES MELLITUS

Recommendations

- 14.8** Lifestyle change is an essential component of management of gestational diabetes mellitus and may suffice for the treatment of many women. Medications should be added if needed to achieve glycemic targets. **A**
- 14.9** Insulin is the preferred medication for treating hyperglycemia in gestational diabetes mellitus as it does not cross the placenta to a measurable extent. Metformin and glyburide should not be used as first-line agents, as both cross the placenta to the fetus. All oral agents lack long-term safety data. **A**
- 14.10** Metformin, when used to treat polycystic ovary syndrome and induce ovulation, should be discontinued once pregnancy has been confirmed. **A**

GDM is characterized by increased risk of macrosomia and birth complications and an increased risk of maternal type 2 diabetes after pregnancy. The association of macrosomia and birth complications with oral glucose tolerance test (OGTT) results is continuous with no clear inflection points (24). In other words, risks increase with progressive hyperglycemia. Therefore, all women should be tested as outlined in Section 2 “Classification and Diagnosis of Diabetes.” Although there is some heterogeneity, many randomized controlled trials (RCTs) suggest that the risk of GDM may be reduced by diet, exercise, and lifestyle counseling, particularly when interventions are started during the first or early in the second trimester (33–35).

Lifestyle Management

After diagnosis, treatment starts with medical nutrition therapy, physical activity, and weight management depending on pregestational weight, as outlined in the section below on preexisting type 2 diabetes, and glucose monitoring aiming for the targets recommended by the Fifth International Workshop-Conference on Gestational Diabetes Mellitus (36):

- Fasting <95 mg/dL (5.3 mmol/L) and either
- One-hour postprandial <140 mg/dL (7.8 mmol/L) or
- Two-hour postprandial <120 mg/dL (6.7 mmol/L)

Depending on the population, studies suggest that 70–85% of women diagnosed with GDM under Carpenter-Coustan or National Diabetes Data Group (NDDG) criteria can control GDM with lifestyle modification alone; it is anticipated that this proportion will be even higher if the lower International Association of Diabetes and Pregnancy Study Groups (IADPSG) (37) diagnostic thresholds are used.

Medical Nutrition Therapy

Medical nutrition therapy for GDM is an individualized nutrition plan developed between the woman and a registered dietitian familiar with the management of GDM (38,39). The food plan should provide adequate calorie intake to promote fetal/neonatal and maternal health, achieve glycemic goals, and promote appropriate gestational weight

gain. There is no definitive research that identifies a specific optimal calorie intake for women with GDM or suggests that their calorie needs are different from those of pregnant women without GDM. The food plan should be based on a nutrition assessment with guidance from the Dietary Reference Intakes (DRI). The DRI for all pregnant women recommends a minimum of 175 g of carbohydrate, a minimum of 71 g of protein, and 28 g of fiber. As is true for all nutrition therapy in patients with diabetes, the amount and type of carbohydrate will impact glucose levels, especially postmeal excursions.

Pharmacologic Therapy

Treatment of GDM with lifestyle and insulin has been demonstrated to improve perinatal outcomes in two large randomized studies as summarized in a U.S. Preventive Services Task Force review (40). Insulin is the first-line agent recommended for treatment of GDM in the U.S. While individual RCTs support limited efficacy of metformin (41,42) and glyburide (43) in reducing glucose levels for the treatment of GDM, these agents are not recommended as first-line treatment for GDM because they are known to cross the placenta and data on safety for offspring is lacking (22). Furthermore, in two RCTs, glyburide and metformin failed to provide adequate glycemic control in 23% and 25–28%, respectively (44,45), of women with GDM.

Sulfonylureas

Sulfonylureas are known to cross the placenta and have been associated with increased neonatal hypoglycemia. Concentrations of glyburide in umbilical cord plasma are approximately 70% of maternal levels (44,45). Glyburide was associated with a higher rate of neonatal hypoglycemia and macrosomia than insulin or metformin in a 2015 meta-analysis and systematic review (46). More recently, glyburide failed to be found noninferior to insulin based on a composite outcome of neonatal hypoglycemia, macrosomia, and hyperbilirubinemia. Long-term safety data for offspring are not available (47,48).

Metformin

Metformin was associated with a lower risk of neonatal hypoglycemia and less maternal weight gain than insulin in

systematic reviews (46,49,50); however, metformin may slightly increase the risk of prematurity. Like glyburide, metformin crosses the placenta, and umbilical cord blood levels of metformin are higher than simultaneous maternal levels (51,52). In the Metformin in Gestational Diabetes: The Offspring Follow-Up (MiG TOFU) study's analyses of 7- to 9-year-old offspring, 9-year-old offspring exposed to metformin for the treatment of GDM were larger (based on a number of measurements) than those exposed to insulin (53). In two RCTs of metformin use in pregnancy for polycystic ovary syndrome, follow-up of 4-year-old offspring demonstrated higher BMI and increased obesity in the offspring exposed to metformin (53,54). Further study of long-term outcomes in the offspring is needed (53,54).

Randomized, double-blind, controlled trials comparing metformin with other therapies for ovulation induction in women with polycystic ovary syndrome have not demonstrated benefit in preventing spontaneous abortion or GDM (55), and there is no evidence-based need to continue metformin in such patients once pregnancy has been confirmed (56–58).

Insulin

Insulin use should follow the guidelines below. Both multiple daily insulin injections and continuous subcutaneous insulin infusion are reasonable delivery strategies, and neither has been shown to be superior during pregnancy (59).

MANAGEMENT OF PREEXISTING TYPE 1 DIABETES AND TYPE 2 DIABETES IN PREGNANCY

Insulin Use

Recommendation

14.11 Insulin is the preferred agent for management of both type 1 diabetes and type 2 diabetes in pregnancy because it does not cross the placenta and because oral agents are generally insufficient to overcome the insulin resistance in type 2 diabetes and are ineffective in type 1 diabetes. **E**

The physiology of pregnancy necessitates frequent titration of insulin to match changing requirements and underscores the importance of daily

and frequent self-monitoring of blood glucose. Early in the first trimester, there is an increase in insulin requirements, followed by a decrease in weeks 9 through 16 (60). Women, particularly those with type 1 diabetes, may experience increased hypoglycemia. After 16 weeks, rapidly increasing insulin resistance requires weekly increases in insulin dose of about 5% per week to achieve glycemic targets. There is roughly a doubling of insulin requirements by the late third trimester. In general, a smaller proportion of the total daily dose should be given as basal insulin (<50%) and a greater proportion (>50%) as prandial insulin. Late in the third trimester, there is often a leveling off or small decrease in insulin requirements. Due to the complexity of insulin management in pregnancy, referral to a specialized center offering team-based care (with team members including maternal-fetal medicine specialist, endocrinologist, or other provider experienced in managing pregnancy in women with preexisting diabetes, dietitian, nurse, and social worker, as needed) is recommended if this resource is available.

None of the currently available human insulin preparations have been demonstrated to cross the placenta (61–66).

A recent Cochrane systematic review was not able to recommend any specific insulin regimen over another for the treatment of diabetes in pregnancy (67).

Preeclampsia and Aspirin

Recommendation

14.12 Women with type 1 or type 2 diabetes should be prescribed low-dose aspirin 60–150 mg/day (usual dose 81 mg/day) from the end of the first trimester until the baby is born in order to lower the risk of preeclampsia. **A**

Diabetes in pregnancy is associated with an increased risk of preeclampsia (68). Based upon the results of clinical trials, the U.S. Preventive Services Task Force recommends the use of low-dose aspirin (81 mg/day) as a preventive medication after 12 weeks of gestation in women who are at high risk for preeclampsia (69). A cost-benefit analysis

has concluded that this approach would reduce morbidity, save lives, and lower health care costs (70).

Type 1 Diabetes

Women with type 1 diabetes have an increased risk of hypoglycemia in the first trimester and, like all women, have altered counterregulatory response in pregnancy that may decrease hypoglycemia awareness. Education for patients and family members about the prevention, recognition, and treatment of hypoglycemia is important before, during, and after pregnancy to help to prevent and manage the risks of hypoglycemia. Insulin resistance drops rapidly with delivery of the placenta. Women become very insulin sensitive immediately following delivery and may initially require much less insulin than in the prepartum period.

Pregnancy is a ketogenic state, and women with type 1 diabetes, and to a lesser extent those with type 2 diabetes, are at risk for diabetic ketoacidosis at lower blood glucose levels than in the nonpregnant state. Women with pre-existing diabetes, especially type 1 diabetes, need ketone strips at home and education on diabetic ketoacidosis prevention and detection. In addition, rapid implementation of tight glycemic control in the setting of retinopathy is associated with worsening of retinopathy (13).

The role of continuous glucose monitoring in pregnancies impacted by diabetes is still being studied. In one RCT, continuous glucose monitoring use in pregnancies complicated by type 1 diabetes showed improved neonatal outcomes and a slight reduction in A1C, but interestingly no difference in severe hypoglycemic events compared with control subjects (71).

Type 2 Diabetes

Type 2 diabetes is often associated with obesity. Recommended weight gain during pregnancy for overweight women is 15–25 lb and for obese women is 10–20 lb (72). Glycemic control is often easier to achieve in women with type 2 diabetes than in those with type 1 diabetes but can require much higher doses of insulin, sometimes necessitating concentrated insulin formulations. As in type 1 diabetes, insulin requirements drop dramatically after delivery. The risk for associated hypertension and other comorbidities

may be as high or higher with type 2 diabetes as with type 1 diabetes, even if diabetes is better controlled and of shorter apparent duration, with pregnancy loss appearing to be more prevalent in the third trimester in women with type 2 diabetes compared with the first trimester in women with type 1 diabetes (73,74).

PREGNANCY AND DRUG CONSIDERATIONS

Recommendations

14.13 In pregnant patients with diabetes and chronic hypertension, blood pressure targets of 120–160/80–105 mmHg are suggested in the interest of optimizing long-term maternal health and minimizing impaired fetal growth. **E**

14.14 Potentially teratogenic medications (i.e., ACE inhibitors, angiotensin receptor blockers, statins) should be avoided in sexually active women of child-bearing age who are not using reliable contraception. **B**

In normal pregnancy, blood pressure is lower than in the nonpregnant state. In a pregnancy complicated by diabetes and chronic hypertension, target goals for systolic blood pressure 120–160 mmHg and diastolic blood pressure 80–105 mmHg are reasonable (75). Lower blood pressure levels may be associated with impaired fetal growth. In a 2015 study targeting diastolic blood pressure of 100 mmHg versus 85 mmHg in pregnant women, only 6% of whom had GDM at enrollment, there was no difference in pregnancy loss, neonatal care, or other neonatal outcomes, although women in the less intensive treatment group had a higher rate of uncontrolled hypertension (76).

During pregnancy, treatment with ACE inhibitors and angiotensin receptor blockers is contraindicated because they may cause fetal renal dysplasia, oligohydramnios, and intrauterine growth restriction (10). Antihypertensive drugs known to be effective and safe in pregnancy include methyldopa, nifedipine, labetalol, diltiazem, clonidine, and prazosin. Atenolol is not recommended. Chronic diuretic use during pregnancy

is not recommended as it has been associated with restricted maternal plasma volume, which may reduce uteroplacental perfusion (77). On the basis of available evidence, statins should also be avoided in pregnancy (78).

Please see PREGNANCY AND ANTIHYPERTENSIVE MEDICATIONS in Section 10 “Cardiovascular Disease and Risk Management” for more information on managing blood pressure in pregnancy.

POSTPARTUM CARE

Postpartum care should include psychosocial assessment and support for self-care.

Lactation

In light of the immediate nutritional and immunological benefits of breastfeeding for the baby, all women including those with diabetes should be supported in attempts to breastfeed. Breastfeeding may also confer longer-term metabolic benefits to both mother (79) and offspring (80).

Gestational Diabetes Mellitus

Initial Testing

Because GDM may represent preexisting undiagnosed type 2 or even type 1 diabetes, women with GDM should be tested for persistent diabetes or prediabetes at 4–12 weeks postpartum with a 75-g OGTT using nonpregnancy criteria as outlined in Section 2 “Classification and Diagnosis of Diabetes.”

Postpartum Follow-up

The OGTT is recommended over A1C at the time of the 4- to 12-week postpartum visit because A1C may be persistently impacted (lowered) by the increased red blood cell turnover related to pregnancy or blood loss at delivery and because the OGTT is more sensitive at detecting glucose intolerance, including both prediabetes and diabetes. Reproductive-aged women with prediabetes may develop type 2 diabetes by the time of their next pregnancy and will need preconception evaluation. Because GDM is associated with an increased lifetime maternal risk for diabetes estimated at 50–70% after 15–25 years (81,82), women should also be tested every 1–3 years thereafter if the 4- to 12-week postpartum 75-g OGTT is normal, with frequency of testing depending on other risk factors including family history,

prepregnancy BMI, and need for insulin or oral glucose-lowering medication during pregnancy. Ongoing evaluation may be performed with any recommended glycemic test (e.g., A1C, fasting plasma glucose, or 75-g OGTT using nonpregnant thresholds).

Gestational Diabetes Mellitus and Type 2 Diabetes

Women with a history of GDM have a greatly increased risk of conversion to type 2 diabetes over time (81). In the prospective Nurses' Health Study II (NHS II), subsequent diabetes risk after a history of GDM was significantly lower in women who followed healthy eating patterns (83). Adjusting for BMI moderately, but not completely, attenuated this association. Interpregnancy or postpartum weight gain is associated with increased risk of adverse pregnancy outcomes in subsequent pregnancies (84) and earlier progression to type 2 diabetes.

Both metformin and intensive lifestyle intervention prevent or delay progression to diabetes in women with prediabetes and a history of GDM. Of women with a history of GDM and prediabetes, only 5–6 women need to be treated with either intervention to prevent one case of diabetes over 3 years (85). In these women, lifestyle intervention and metformin reduced progression to diabetes by 35% and 40%, respectively, over 10 years compared with placebo (86). If the pregnancy has motivated the adoption of a healthier diet, building on these gains to support weight loss is recommended in the postpartum period.

Preexisting Type 1 and Type 2 Diabetes

Insulin sensitivity increases dramatically with delivery of the placenta. Thus, insulin requirements in the immediate postpartum period are roughly 34% lower than prepregnancy insulin requirements (87). Insulin sensitivity then returns to prepregnancy levels over the following 1–2 weeks. In women taking insulin, particular attention should be directed to hypoglycemia prevention in the setting of breastfeeding and erratic sleep and eating schedules (88).

Contraception

A major barrier to effective preconception care is the fact that the majority of pregnancies are unplanned. Planning

pregnancy is critical in women with preexisting diabetes due to the need for preconception glycemic control to prevent congenital malformations and reduce the risk of other complications. Therefore, all women with diabetes of childbearing potential should have family planning options reviewed at regular intervals. This applies to women in the immediate postpartum period. Women with diabetes have the same contraception options and recommendations as those without diabetes. The risk of an unplanned pregnancy outweighs the risk of any given contraception option.

References

- Holmes VA, Young IS, Patterson CC, et al.; Diabetes and Pre-eclampsia Intervention Trial Study Group. Optimal glycemic control, pre-eclampsia, and gestational hypertension in women with type 1 diabetes in the Diabetes and Pre-eclampsia Intervention Trial. *Diabetes Care* 2011;34:1683–1688
- Dabelea D, Hanson RL, Lindsay RS, et al. Intrauterine exposure to diabetes conveys risks for type 2 diabetes and obesity: a study of discordant sibships. *Diabetes* 2000;49:2208–2211
- Guerin A, Nisenbaum R, Ray JG. Use of maternal GbH concentration to estimate the risk of congenital anomalies in the offspring of women with prepregnancy diabetes. *Diabetes Care* 2007;30:1920–1925
- Jensen DM, Korsholm L, Ovesen P, et al. Peri-conceptual A1C and risk of serious adverse pregnancy outcome in 933 women with type 1 diabetes. *Diabetes Care* 2009;32:1046–1048
- Nielsen GL, Møller M, Sørensen HT. HbA1c in early diabetic pregnancy and pregnancy outcomes: a Danish population-based cohort study of 573 pregnancies in women with type 1 diabetes. *Diabetes Care* 2006;29:2612–2616
- Suhonen L, Hiilesmaa V, Teramo K. Glycaemic control during early pregnancy and fetal malformations in women with type 1 diabetes mellitus. *Diabetologia* 2000;43:79–82
- Charron-Prochownik D, Sereika SM, Becker D, et al. Long-term effects of the booster-enhanced READY-Girls preconception counseling program on intentions and behaviors for family planning in teens with diabetes. *Diabetes Care* 2013;36:3870–3874
- Peterson C, Grosse SD, Li R, et al. Preventable health and cost burden of adverse birth outcomes associated with pregestational diabetes in the United States. *Am J Obstet Gynecol* 2015; 212:74.e1–74.e9
- Charron-Prochownik D, Downs J. *Diabetes and Reproductive Health for Girls*. Alexandria, VA, American Diabetes Association, 2016
- Bullo M, Tschumi S, Bucher BS, Bianchetti MG, Simonetti GD. Pregnancy outcome following exposure to angiotensin-converting enzyme inhibitors or angiotensin receptor antagonists: a systematic review. *Hypertension* 2012;60:444–450
- Taguchi N, Rubin ET, Hosokawa A, et al. Prenatal exposure to HMG-CoA reductase inhibitors: effects on fetal and neonatal outcomes. *Reprod Toxicol* 2008;26:175–177
- Bateman BT, Hernandez-Diaz S, Fischer MA, et al. Statins and congenital malformations: cohort study. *BMJ* 2015;350:h1035
- Chew EY, Mills JL, Metzger BE, et al.; National Institute of Child Health and Human Development Diabetes in Early Pregnancy Study. Metabolic control and progression of retinopathy: the Diabetes in Early Pregnancy Study. *Diabetes Care* 1995;18:631–637
- McElvy SS, Miodovnik M, Rosenn B, et al. A focused preconceptional and early pregnancy program in women with type 1 diabetes reduces perinatal mortality and malformation rates to general population levels. *J Matern Fetal Med* 2000;9:14–20
- Murphy HR, Roland JM, Skinner TC, et al. Effectiveness of a regional pregnancy care program in women with type 1 and type 2 diabetes: benefits beyond glycemic control. *Diabetes Care* 2010;33:2514–2520
- Elixhauser A, Weschler JM, Kitzmiller JL, et al. Cost-benefit analysis of preconception care for women with established diabetes mellitus. *Diabetes Care* 1993;16:1146–1157
- Owens LA, Avalos G, Kirwan B, Carmody L, Dunne F. ATLANTIC DIP: closing the loop: a change in clinical practice can improve outcomes for women with pregestational diabetes. *Diabetes Care* 2012;35:1669–1671
- Taylor C, McCance DR, Chappell L, Nelson-Piercy C, Thorne SA, Ismail KMK, et al. Implementation of guidelines for multidisciplinary team management of pregnancy in women with pre-existing diabetes or cardiac conditions: results from a UK national survey. *BMC Pregnancy Childbirth* 2017;17:434
- Manderson JG, Patterson CC, Hadden DR, Traub AI, Ennis C, McCance DR. Preprandial versus postprandial blood glucose monitoring in type 1 diabetic pregnancy: a randomized controlled clinical trial. *Am J Obstet Gynecol* 2003;189:507–512
- de Veciana M, Major CA, Morgan MA, et al. Postprandial versus preprandial blood glucose monitoring in women with gestational diabetes mellitus requiring insulin therapy. *N Engl J Med* 1995;333:1237–1241
- Jovanovic-Peterson L, Peterson CM, Reed GF, et al. Maternal postprandial glucose levels and infant birth weight: the Diabetes in Early Pregnancy Study. The National Institute of Child Health and Human Development—Diabetes in Early Pregnancy Study. *Am J Obstet Gynecol* 1991;164:103–111
- Committee on Practice Bulletins—Obstetrics. ACOG Practice Bulletin No. 190: Gestational Diabetes Mellitus. *Obstet Gynecol* 2018;131: e49–e64
- Ho Y-R, Wang P, Lu M-C, Tseng S-T, Yang C-P, Yan Y-H. Associations of mid-pregnancy HbA1c with gestational diabetes and risk of adverse pregnancy outcomes in high-risk Taiwanese women. *PLoS One* 2017;12:e0177563
- Metzger BE, Lowe LP, Dyer AR, et al.; HAPO Study Cooperative Research Group. Hyperglycemia and adverse pregnancy outcomes. *N Engl J Med* 2008;358:1991–2002
- Maresh MJA, Holmes VA, Patterson CC, et al.; Diabetes and Pre-eclampsia Intervention Trial Study Group. Glycemic targets in the second and

- third trimester of pregnancy for women with type 1 diabetes. *Diabetes Care* 2015;38:34–42
26. Nielsen LR, Ekblom P, Damm P, et al. HbA1c levels are significantly lower in early and late pregnancy. *Diabetes Care* 2004;27:1200–1201
27. Mosca A, Paleari R, Dalfrà MG, et al. Reference intervals for hemoglobin A1c in pregnant women: data from an Italian multicenter study. *Clin Chem* 2006;52:1138–1143
28. Hummel M, Marienfeld S, Huppmann M, et al. Fetal growth is increased by maternal type 1 diabetes and HLA DR4-related gene interactions. *Diabetologia* 2007;50:850–858
29. Cyganek K, Skupien J, Katra B, et al. Risk of macrosomia remains glucose-dependent in a cohort of women with pregestational type 1 diabetes and good glycemic control. *Endocrine* 2017;55:447–455
30. Abell SK, Boyle JA, de Courten B, et al. Impact of type 2 diabetes, obesity and glycaemic control on pregnancy outcomes. *Aust N Z J Obstet Gynaecol* 2017;57:308–314
31. Temple RC, Aldridge V, Stanley K, Murphy HR. Glycaemic control throughout pregnancy and risk of pre-eclampsia in women with type 1 diabetes. *BJOG* 2006;113:1329–1332
32. Combs CA, Gunderson E, Kitzmiller JL, Gavin LA, Main EK. Relationship of fetal macrosomia to maternal postprandial glucose control during pregnancy. *Diabetes Care* 1992;15:1251–1257
33. Bain E, Crane M, Tieu J, Han S, Crowther CA, Middleton P. Diet and exercise interventions for preventing gestational diabetes mellitus. *Cochrane Database Syst Rev* 2015;4:CD010443
34. Koivusalo SB, Rönö K, Klemetti MM, et al. Gestational diabetes mellitus can be prevented by lifestyle intervention: the Finnish Gestational Diabetes Prevention Study (RADIEL): a randomized controlled trial. *Diabetes Care* 2016;39:24–30
35. Wang C, Wei Y, Zhang X, et al. A randomized clinical trial of exercise during pregnancy to prevent gestational diabetes mellitus and improve pregnancy outcome in overweight and obese pregnant women. *Am J Obstet Gynecol* 2017;216:340–351
36. Metzger BE, Buchanan TA, Coustan DR, et al. Summary and recommendations of the Fifth International Workshop-Conference on Gestational Diabetes Mellitus. *Diabetes Care* 2007;30 (Suppl. 2):S251–S260
37. Mayo K, Melamed N, Vandenberghe H, Berger H. The impact of adoption of the International Association of Diabetes in Pregnancy Study Group criteria for the screening and diagnosis of gestational diabetes. *Am J Obstet Gynecol* 2015;212:224.e1–224.e9
38. Han S, Crowther CA, Middleton P, Heatley E. Different types of dietary advice for women with gestational diabetes mellitus. *Cochrane Database Syst Rev* 2013;3:CD009275
39. Viana LV, Gross JL, Azevedo MJ. Dietary intervention in patients with gestational diabetes mellitus: a systematic review and meta-analysis of randomized clinical trials on maternal and newborn outcomes. *Diabetes Care* 2014;37:3345–3355
40. Hartling L, Dryden DM, Guthrie A, Muise M, Vandermeer B, Donovan L. Benefits and harms of treating gestational diabetes mellitus: a systematic review and meta-analysis for the U.S. Preventive Services Task Force and the National Institutes of Health Office of Medical Applications of Research. *Ann Intern Med* 2013;159:123–129
41. Rowan JA, Hague WM, Gao W, Battin MR, Moore MP; MiG Trial Investigators. Metformin versus insulin for the treatment of gestational diabetes. *N Engl J Med* 2008;358:2003–2015
42. Gui J, Liu Q, Feng L. Metformin vs insulin in the management of gestational diabetes: a meta-analysis. *PLoS One* 2013;8:e64585
43. Langer O, Conway DL, Berkus MD, Xenakis EM-J, Gonzales O. A comparison of glyburide and insulin in women with gestational diabetes mellitus. *N Engl J Med* 2000;343:1134–1138
44. Hebert MF, Ma X, Narahariseti SB, et al.; Obstetric-Fetal Pharmacology Research Unit Network. Are we optimizing gestational diabetes treatment with glyburide? The pharmacologic basis for better clinical practice. *Clin Pharmacol Ther* 2009;85:607–614
45. Malek R, Davis SN. Pharmacokinetics, efficacy and safety of glyburide for treatment of gestational diabetes mellitus. *Expert Opin Drug Metab Toxicol* 2016;12:691–699
46. Balsells M, García-Patterson A, Solà I, Roqué M, Gich I, Corcoy R. Glibenclamide, metformin, and insulin for the treatment of gestational diabetes: a systematic review and meta-analysis. *BMJ* 2015;350:h102
47. Coustan DR. Pharmacological management of gestational diabetes: an overview. *Diabetes Care* 2007;30(Suppl. 2):S206–S208
48. Sénat M-V, Affres H, Letourneau A, et al.; Groupe de Recherche en Obstétrique et Gynécologie (GROG). Effect of glyburide vs subcutaneous insulin on perinatal complications among women with gestational diabetes: a randomized clinical trial. *JAMA* 2018;319:1773–1780
49. Jiang Y-F, Chen X-Y, Ding T, Wang X-F, Zhu Z-N, Su S-W. Comparative efficacy and safety of OADs in management of GDM: network meta-analysis of randomized controlled trials. *J Clin Endocrinol Metab* 2015;100:2071–2080
50. Camelo Castillo W, Boggess K, Stürmer T, Brookhart MA, Benjamin DK Jr, Jonsson Funk M. Association of adverse pregnancy outcomes with glyburide vs insulin in women with gestational diabetes. *JAMA Pediatr* 2015;169:452–458
51. Vanky E, Zahlsen K, Spigset O, Carlsen SM. Placental passage of metformin in women with polycystic ovary syndrome. *Fertil Steril* 2005;83:1575–1578
52. Charles B, Norris R, Xiao X, Hague W. Population pharmacokinetics of metformin in late pregnancy. *Ther Drug Monit* 2006;28:67–72
53. Rowan JA, Rush EC, Plank LD, et al. Metformin in Gestational Diabetes: The Offspring Follow-Up (MiG TOFU): body composition and metabolic outcomes at 7–9 years of age. *BMJ Open Diabetes Res Care* 2018;6:e000456
54. Hanem LGE, Stridsklev S, Júliússon PB, et al. Metformin use in PCOS pregnancies increases the risk of offspring overweight at 4 years of age: follow-up of two RCTs. *J Clin Endocrinol Metab* 2018;103:1612–1621
55. Vanky E, Stridsklev S, Heimstad R, et al. Metformin versus placebo from first trimester to delivery in polycystic ovary syndrome: a randomized, controlled multicenter study. *J Clin Endocrinol Metab* 2010;95:E448–E455
56. Legro RS, Barnhart HX, Schlaff WD, et al.; Cooperative Multicenter Reproductive Medicine Network. Clomiphene, metformin, or both for infertility in the polycystic ovary syndrome. *N Engl J Med* 2007;356:551–566
57. Palomba S, Orio F Jr, Falbo A, et al. Prospective parallel randomized, double-blind, double-dummy controlled clinical trial comparing clomiphene citrate and metformin as the first-line treatment for ovulation induction in non-obese anovulatory women with polycystic ovary syndrome. *J Clin Endocrinol Metab* 2005;90:4068–4074
58. Palomba S, Orio F Jr, Nardo LG, et al. Metformin administration versus laparoscopic ovarian diathermy in clomiphene citrate-resistant women with polycystic ovary syndrome: a prospective parallel randomized double-blind placebo-controlled trial. *J Clin Endocrinol Metab* 2004;89:4801–4809
59. Farrar D, Tuffnell DJ, West J, West HM. Continuous subcutaneous insulin infusion versus multiple daily injections of insulin for pregnant women with diabetes. *Cochrane Database Syst Rev* 2016;6:CD005542
60. García-Patterson A, Gich I, Amini SB, Catalano PM, de Leiva A, Corcoy R. Insulin requirements throughout pregnancy in women with type 1 diabetes mellitus: three changes of direction. *Diabetologia* 2010;53:446–451
61. Menon RK, Cohen RM, Sperling MA, Cutfield WS, Mimouni F, Khoury JC. Transplacental passage of insulin in pregnant women with insulin-dependent diabetes mellitus. Its role in fetal macrosomia. *N Engl J Med* 1990;323:309–315
62. Pollex EK, Feig DS, Lubetsky A, Yip PM, Koren G. Insulin glargine safety in pregnancy: a transplacental transfer study. *Diabetes Care* 2010;33:29–33
63. Holcberg G, Tsadkin-Tamir M, Sapir O, et al. Transfer of insulin lispro across the human placenta. *Eur J Obstet Gynecol Reprod Biol* 2004;115:117–118
64. Boskovic R, Feig DS, Derewlany L, Knie B, Portnoi G, Koren G. Transfer of insulin lispro across the human placenta: in vitro perfusion studies. *Diabetes Care* 2003;26:1390–1394
65. McCance DR, Damm P, Mathiesen ER, et al. Evaluation of insulin antibodies and placental transfer of insulin aspart in pregnant women with type 1 diabetes mellitus. *Diabetologia* 2008;51:2141–2143
66. Suffecool K, Rosenn B, Niederkofler EE, et al. Insulin detemir does not cross the human placenta. *Diabetes Care* 2015;38:e20–e21
67. O'Neill SM, Kenny LC, Khashan AS, West HM, Smyth RM, Kearney PM. Different insulin types and regimens for pregnant women with pre-existing diabetes. *Cochrane Database Syst Rev* 2017;2:CD011880
68. Duckitt K, Harrington D. Risk factors for pre-eclampsia at antenatal booking: systematic review of controlled studies. *BMJ* 2005;330:565
69. Henderson JT, Whitlock EP, O'Conner E, Senger CA, Thompson JH, Rowland MG. Low-dose aspirin for the prevention of morbidity and mortality from preeclampsia: a systematic evidence review for the U.S. Preventive Services Task Force, 2014. Rockville, MD, Agency for Healthcare Research and Quality (Report No. 14-05207-EF-1)

70. Werner EF, Hauspurg AK, Rouse DJ. A cost-benefit analysis of low-dose aspirin prophylaxis for the prevention of preeclampsia in the United States. *Obstet Gynecol* 2015;126:1242–1250
71. Feig DS, Donovan LE, Corcoy R, et al.; CONCEPTT Collaborative Group. Continuous glucose monitoring in pregnant women with type 1 diabetes (CONCEPTT): a multicentre international randomised controlled trial. *Lancet* 2017;390:2347–2359
72. Institute of Medicine and National Research Council. *Weight Gain During Pregnancy: Re-examining the Guidelines*. Washington, DC, National Academies Press, 2009
73. Clausen TD, Mathiesen E, Ekbohm P, Hellmuth E, Mandrup-Poulsen T, Damm P. Poor pregnancy outcome in women with type 2 diabetes. *Diabetes Care* 2005;28:323–328
74. Cundy T, Gamble G, Neale L, et al. Differing causes of pregnancy loss in type 1 and type 2 diabetes. *Diabetes Care* 2007;30:2603–2607
75. American College of Obstetricians and Gynecologists; Task Force on Hypertension in Pregnancy. Hypertension in pregnancy. Report of the American College of Obstetricians and Gynecologists' Task Force on Hypertension in Pregnancy. *Obstet Gynecol* 2013;122:1122–1131
76. Magee LA, von Dadelszen P, Rey E, et al. Less-tight versus tight control of hypertension in pregnancy. *N Engl J Med* 2015;372:407–417
77. Sibai BM. Treatment of hypertension in pregnant women. *N Engl J Med* 1996;335:257–265
78. Kazmin A, Garcia-Bournissen F, Koren G. Risks of statin use during pregnancy: a systematic review. *J Obstet Gynaecol Can* 2007;29:906–908
79. Stuebe AM, Rich-Edwards JW, Willett WC, Manson JE, Michels KB. Duration of lactation and incidence of type 2 diabetes. *JAMA* 2005;294:2601–2610
80. Pereira PF, Alfenas Rde CG, Araújo RMA. Does breastfeeding influence the risk of developing diabetes mellitus in children? A review of current evidence. *J Pediatr (Rio J)* 2014;90:7–15
81. Kim C, Newton KM, Knopp RH. Gestational diabetes and the incidence of type 2 diabetes: a systematic review. *Diabetes Care* 2002;25:1862–1868
82. Drury MI. Carbohydrate metabolism in pregnancy and the newborn. Sutherland HW, Stowers JM, Eds. Edinburgh, Churchill Livingstone, 1984
83. Tobias DK, Hu FB, Chavarro J, Rosner B, Mozaffarian D, Zhang C. Healthful dietary patterns and type 2 diabetes mellitus risk among women with a history of gestational diabetes mellitus. *Arch Intern Med* 2012;172:1566–1572
84. Villamor E, Cnattingius S. Interpregnancy weight change and risk of adverse pregnancy outcomes: a population-based study. *Lancet* 2006;368:1164–1170
85. Ratner RE, Christophi CA, Metzger BE, et al.; Diabetes Prevention Program Research Group. Prevention of diabetes in women with a history of gestational diabetes: effects of metformin and lifestyle interventions. *J Clin Endocrinol Metab* 2008;93:4774–4779
86. Aroda VR, Christophi CA, Edelstein SL, et al.; Diabetes Prevention Program Research Group. The effect of lifestyle intervention and metformin on preventing or delaying diabetes among women with and without gestational diabetes: the Diabetes Prevention Program Outcomes Study 10-year follow-up. *J Clin Endocrinol Metab* 2015;100:1646–1653
87. Roeder HA, Moore TR, Ramos GA. Changes in postpartum insulin requirements for patients with well-controlled type 1 diabetes. *Am J Perinatol* 2016;33:683–687
88. Riviello C, Mello G, Jovanovic LG. Breastfeeding and the basal insulin requirement in type 1 diabetic women. *Endocr Pract* 2009;15:187–193

15. Diabetes Care in the Hospital: *Standards of Medical Care in Diabetes—2019*

American Diabetes Association

Diabetes Care 2019;42(Suppl. 1):S173–S181 | <https://doi.org/10.2337/dc19-S015>

The American Diabetes Association (ADA) “Standards of Medical Care in Diabetes” includes ADA’s current clinical practice recommendations and is intended to provide the components of diabetes care, general treatment goals and guidelines, and tools to evaluate quality of care. Members of the ADA Professional Practice Committee, a multidisciplinary expert committee, are responsible for updating the Standards of Care annually, or more frequently as warranted. For a detailed description of ADA standards, statements, and reports, as well as the evidence-grading system for ADA’s clinical practice recommendations, please refer to the Standards of Care Introduction. Readers who wish to comment on the Standards of Care are invited to do so at professional.diabetes.org/SOC.

In the hospital, both hyperglycemia and hypoglycemia are associated with adverse outcomes, including death (1,2). Therefore, inpatient goals should include the prevention of both hyperglycemia and hypoglycemia. Hospitals should promote the shortest safe hospital stay and provide an effective transition out of the hospital that prevents acute complications and readmission.

For in-depth review of inpatient hospital practice, consult recent reviews that focus on hospital care for diabetes (3,4).

HOSPITAL CARE DELIVERY STANDARDS

Recommendation

15.1 Perform an A1C on all patients with diabetes or hyperglycemia (blood glucose >140 mg/dL [7.8 mmol/L]) admitted to the hospital if not performed in the prior 3 months. **B**

High-quality hospital care for diabetes requires both hospital care delivery standards, often assured by structured order sets, and quality assurance standards for process improvement. “Best practice” protocols, reviews, and guidelines (2) are inconsistently implemented within hospitals. To correct this, hospitals have established protocols for structured patient care and structured order sets, which include computerized physician order entry (CPOE).

Considerations on Admission

Initial orders should state the type of diabetes (i.e., type 1 or type 2 diabetes) or no previous history of diabetes. Because inpatient insulin use (5) and discharge orders (6) can be more effective if based on an A1C level on admission (7), perform an A1C test on all patients with diabetes or hyperglycemia admitted to the hospital if the test has not been performed in the prior 3 months (8). In addition, diabetes self-management knowledge and behaviors should be assessed on admission and

Suggested citation: American Diabetes Association. 15. Diabetes care in the hospital: Standards of Medical Care in Diabetes—2019. Diabetes Care 2019;42(Suppl. 1):S173–S181

© 2018 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. More information is available at <http://www.diabetesjournals.org/content/license>.

diabetes self-management education should be provided, if appropriate. Diabetes self-management education should include appropriate skills needed after discharge, such as taking antihyperglycemic medications, monitoring glucose, and recognizing and treating hypoglycemia (2).

Physician Order Entry

Recommendation

15.2 Insulin should be administered using validated written or computerized protocols that allow for predefined adjustments in the insulin dosage based on glycemic fluctuations. **E**

The National Academy of Medicine recommends CPOE to prevent medication-related errors and to increase efficiency in medication administration (9). A Cochrane review of randomized controlled trials using computerized advice to improve glucose control in the hospital found significant improvement in the percentage of time patients spent in the target glucose range, lower mean blood glucose levels, and no increase in hypoglycemia (10). Thus, where feasible, there should be structured order sets that provide computerized advice for glucose control. Electronic insulin order templates also improve mean glucose levels without increasing hypoglycemia in patients with type 2 diabetes, so structured insulin order sets should be incorporated into the CPOE (11).

Diabetes Care Providers in the Hospital

Recommendation

15.3 When caring for hospitalized patients with diabetes, consider consulting with a specialized diabetes or glucose management team where possible. **E**

Appropriately trained specialists or specialty teams may reduce length of stay, improve glycemic control, and improve outcomes, but studies are few (12,13). A call to action outlined the studies needed to evaluate these outcomes (14). People with diabetes are known to have a higher risk of 30-day readmission following hospitalization. Specialized diabetes teams caring for patients with diabetes during their hospital stay can improve readmission rates and lower cost of care (15,16).

Early evidence suggests that virtual glucose management services may be used to improve glycemic outcomes in hospitalized patients and facilitate transition of care after discharge (17). Details of team formation are available from the Joint Commission standards for programs and the Society of Hospital Medicine (18,19).

Quality Assurance Standards

Even the best orders may not be carried out in a way that improves quality, nor are they automatically updated when new evidence arises. To this end, the Joint Commission has an accreditation program for the hospital care of diabetes (18), and the Society of Hospital Medicine has a workbook for program development (19).

GLYCEMIC TARGETS IN HOSPITALIZED PATIENTS

Recommendations

15.4 Insulin therapy should be initiated for treatment of persistent hyperglycemia starting at a threshold ≥ 180 mg/dL (10.0 mmol/L). Once insulin therapy is started, a target glucose range of 140–180 mg/dL (7.8–10.0 mmol/L) is recommended for the majority of critically ill patients and noncritically ill patients. **A**

15.5 More stringent goals, such as 110–140 mg/dL (6.1–7.8 mmol/L), may be appropriate for selected patients, if this can be achieved without significant hypoglycemia. **C**

Standard Definition of Glucose Abnormalities

Hyperglycemia in hospitalized patients is defined as blood glucose levels >140 mg/dL (7.8 mmol/L) (2,20). Blood glucose levels that are persistently above this level may require alterations in diet or a change in medications that cause hyperglycemia. An admission A1C value $\geq 6.5\%$ (48 mmol/mol) suggests that diabetes preceded hospitalization (see Section 2 “Classification and Diagnosis of Diabetes”) (2,20). Level 1 hypoglycemia in hospitalized patients is defined as a measurable glucose concentration <70 mg/dL (3.9 mmol/L) but ≥ 54 mg/dL (3.0 mmol/L). Level 2 hypoglycemia (defined as a blood glucose concentration <54 mg/dL [3.0 mmol/L]) is the threshold

at which neuroglycopenic symptoms begin to occur and requires immediate action to resolve the hypoglycemic event. Lastly, level 3 hypoglycemia is defined as a severe event characterized by altered mental and/or physical functioning that requires assistance from another person for recovery. See **Table 15.1** for levels of hypoglycemia (21). Hypoglycemia is discussed more fully below.

Moderate Versus Tight Glycemic Control

A meta-analysis of over 26 studies, including the Normoglycemia in Intensive Care Evaluation–Survival Using Glucose Algorithm Regulation (NICE-SUGAR) study, showed increased rates of “severe hypoglycemia” (defined in the analysis as blood glucose <40 mg/dL [2.2 mmol/L]) and mortality in cohorts with tight versus moderate glycemic control (22). Recent randomized controlled studies and meta-analyses in surgical patients have also reported that targeting perioperative blood glucose levels to <180 mg/dL (10-mmol/L) is associated with lower rates of mortality and stroke compared with a target glucose <200 mg/dL (11.1 mmol/L), whereas no significant additional benefit was found with more strict glycemic control (<140 mg/dL [7.8 mmol/L]) (23,24). Insulin therapy should be initiated for treatment of persistent hyperglycemia starting at a threshold ≥ 180 mg/dL (10.0 mmol/L). Once insulin therapy is started, a target glucose range of 140–180 mg/dL (7.8–10.0 mmol/L) is recommended for the majority of critically ill and noncritically ill patients (2). More stringent goals, such as <140 mg/dL (7.8 mmol/L), may be appropriate for selected patients, as long as this can be achieved without significant hypoglycemia. Conversely, higher glucose ranges may be acceptable in terminally ill patients,

Table 15.1—Levels of hypoglycemia (21)

Level	Glycemic criteria/description
Level 1	Glucose <70 mg/dL (3.9 mmol/L) and glucose ≥ 54 mg/dL (3.0 mmol/L)
Level 2	Glucose <54 mg/dL (3.0 mmol/L)
Level 3	A severe event characterized by altered mental and/or physical status requiring assistance

in patients with severe comorbidities, and in inpatient care settings where frequent glucose monitoring or close nursing supervision is not feasible.

Clinical judgment combined with ongoing assessment of the patient's clinical status, including changes in the trajectory of glucose measures, illness severity, nutritional status, or concomitant medications that might affect glucose levels (e.g., glucocorticoids), should be incorporated into the day-to-day decisions regarding insulin dosing (2).

BEDSIDE BLOOD GLUCOSE MONITORING

Indications

In the patient who is eating meals, glucose monitoring should be performed before meals. In the patient who is not eating, glucose monitoring is advised every 4–6 h (2). More frequent blood glucose testing ranging from every 30 min to every 2 h is required for patients receiving intravenous insulin. Observational studies have shown that safety standards should be established for blood glucose monitoring that prohibit the sharing of fingerstick lancing devices, lancets, and needles (25).

Point-of-Care Meters

Point-of-care (POC) meters have limitations for measuring blood glucose. Although the U.S. Food and Drug Administration (FDA) has standards for blood glucose meters used by lay persons, there have been questions about the appropriateness of these criteria, especially in the hospital and for lower blood glucose readings (26). Significant discrepancies between capillary, venous, and arterial plasma samples have been observed in patients with low or high hemoglobin concentrations and with hypoperfusion. Any glucose result that does not correlate with the patient's clinical status should be confirmed through conventional laboratory glucose tests. The FDA established a separate category for POC glucose meters for use in health care settings and has released guidance on in-hospital use with stricter standards (27). Before choosing a device for in-hospital use, consider the device's approval status and accuracy.

Continuous Glucose Monitoring

Real-time continuous glucose monitoring (CGM) provides frequent measurements of interstitial glucose levels, as

well as direction and magnitude of glucose trends, which may have an advantage over POC glucose testing in detecting and reducing the incidence of hypoglycemia in the hospital setting (28,29). Several inpatient studies have shown that CGM use did not improve glucose control but detected a greater number of hypoglycemic events than POC testing (30,31). However, a recent review has recommended against using CGM in adults in a hospital setting until more safety and efficacy data become available (30). For more information on CGM, see Section 7 "Diabetes Technology."

ANTIHYPERGLYCEMIC AGENTS IN HOSPITALIZED PATIENTS

Recommendations

- 15.6** Basal insulin or a basal plus bolus correction insulin regimen is the preferred treatment for noncritically ill hospitalized patients with poor oral intake or those who are taking nothing by mouth. An insulin regimen with basal, prandial, and correction components is the preferred treatment for noncritically ill hospitalized patients with good nutritional intake. **A**
- 15.7** Sole use of sliding scale insulin in the inpatient hospital setting is strongly discouraged. **A**

In most instances in the hospital setting, insulin is the preferred treatment for hyperglycemia (2). However, in certain circumstances, it may be appropriate to continue home regimens including oral antihyperglycemic medications (32). If oral medications are held in the hospital, there should be a protocol for resuming them 1–2 days before discharge. Insulin pens are the subject of an FDA warning because of potential blood-borne diseases, and care should be taken to follow the label insert "For single patient use only" (33). Recent reports, however, have indicated that the inpatient use of insulin pens appears to be safe and may be associated with improved nurse satisfaction compared with the use of insulin vials and syringes (34–36).

Insulin Therapy

Critical Care Setting

In the critical care setting, continuous intravenous insulin infusion has been

shown to be the best method for achieving glycemic targets. Intravenous insulin infusions should be administered based on validated written or computerized protocols that allow for predefined adjustments in the infusion rate, accounting for glycemic fluctuations and insulin dose (2).

Noncritical Care Setting

Outside of critical care units, scheduled insulin regimens are recommended to manage hyperglycemia in patients with diabetes. Regimens using insulin analogs and human insulin result in similar glycemic control in the hospital setting (37).

The use of subcutaneous rapid- or short-acting insulin before meals or every 4–6 h if no meals are given or if the patient is receiving continuous enteral/parenteral nutrition is indicated to correct hyperglycemia (2). Basal insulin or a basal plus bolus correction insulin regimen is the preferred treatment for noncritically ill hospitalized patients with poor oral intake or those who are taking nothing by mouth (NPO). An insulin regimen with basal, prandial, and correction components is the preferred treatment for noncritically ill hospitalized patients with good nutritional intake.

If the patient is eating, insulin injections should align with meals. In such instances, POC glucose testing should be performed immediately before meals. If oral intake is poor, a safer procedure is to administer the rapid-acting insulin immediately after the patient eats or to count the carbohydrates and cover the amount ingested (37).

A randomized controlled trial has shown that basal-bolus treatment improved glycemic control and reduced hospital complications compared with sliding scale insulin in general surgery patients with type 2 diabetes (38). Prolonged sole use of sliding scale insulin in the inpatient hospital setting is strongly discouraged (2,14).

While there is evidence for using premixed insulin formulations in the outpatient setting (39), a recent inpatient study of 70/30 NPH/regular insulin versus basal-bolus therapy showed comparable glycemic control but significantly increased hypoglycemia in the group receiving premixed insulin (40). Therefore, premixed insulin regimens are not routinely recommended for in-hospital use.

Type 1 Diabetes

For patients with type 1 diabetes, dosing insulin based solely on premeal glucose levels does not account for basal insulin requirements or caloric intake, increasing both hypoglycemia and hyperglycemia risks. Typically, basal insulin dosing schemes are based on body weight, with some evidence that patients with renal insufficiency should be treated with lower doses (41). An insulin regimen with basal and correction components is necessary for all hospitalized patients with type 1 diabetes, with the addition of prandial insulin if the patient is eating.

Transitioning Intravenous to Subcutaneous Insulin

When discontinuing intravenous insulin, a transition protocol is associated with less morbidity and lower costs of care (42) and is therefore recommended. A patient with type 1 or type 2 diabetes being transitioned to outpatient subcutaneous insulin should receive subcutaneous basal insulin 2–4 h before the intravenous insulin is discontinued. Converting to basal insulin at 60–80% of the daily infusion dose has been shown to be effective (2,42,43). For patients continuing regimens with concentrated insulin (U-200, U-300, or U-500) in the inpatient setting, it is important to ensure the correct dosing by utilizing an individual pen and cartridge for each patient, meticulous pharmacist supervision of the dose administered, or other means (44,45).

Noninsulin Therapies

The safety and efficacy of noninsulin antihyperglycemic therapies in the hospital setting is an area of active research. A few recent randomized pilot trials in general medicine and surgery patients reported that a dipeptidyl peptidase 4 inhibitor alone or in combination with basal insulin was well tolerated and resulted in similar glucose control and frequency of hypoglycemia compared with a basal-bolus regimen (46–48). However, an FDA bulletin states that providers should consider discontinuing saxagliptin and alogliptin in people who develop heart failure (49). A review of antihyperglycemic medications concluded that glucagon-like peptide 1 receptor agonists show promise in the inpatient setting (50); however, proof of safety and efficacy awaits the results of randomized controlled trials (51).

Moreover, the gastrointestinal symptoms associated with the glucagon-like peptide 1 receptor agonists may be problematic in the inpatient setting.

Regarding the sodium–glucose transporter 2 (SGLT2) inhibitors, the FDA includes warnings about diabetic ketoacidosis (DKA) and urosepsis (52), urinary tract infections, and kidney injury (53) on the drug labels. A recent review suggested SGLT2 inhibitors be avoided in severe illness, when ketone bodies are present, and during prolonged fasting and surgical procedures (3). Until safety and effectiveness are established, SGLT2 inhibitors cannot be recommended for routine in-hospital use.

HYPOGLYCEMIA

Recommendations

- 15.8** A hypoglycemia management protocol should be adopted and implemented by each hospital or hospital system. A plan for preventing and treating hypoglycemia should be established for each patient. Episodes of hypoglycemia in the hospital should be documented in the medical record and tracked. **E**
- 15.9** The treatment regimen should be reviewed and changed as necessary to prevent further hypoglycemia when a blood glucose value of <70 mg/dL (3.9 mmol/L) is documented. **C**

Patients with or without diabetes may experience hypoglycemia in the hospital setting. While hypoglycemia is associated with increased mortality (54), hypoglycemia may be a marker of underlying disease rather than the cause of increased mortality. However, until it is proven not to be causal, it is prudent to avoid hypoglycemia. Despite the preventable nature of many inpatient episodes of hypoglycemia, institutions are more likely to have nursing protocols for hypoglycemia treatment than for its prevention when both are needed.

A hypoglycemia prevention and management protocol should be adopted and implemented by each hospital or hospital system. There should be a standardized hospital-wide, nurse-initiated hypoglycemia treatment protocol to immediately address blood glucose levels of <70 mg/dL (3.9 mmol/L), as well as individualized plans for preventing

and treating hypoglycemia for each patient. An American Diabetes Association (ADA) consensus report suggested that a patient's overall treatment regimen be reviewed when a blood glucose value of <70 mg/dL (3.9 mmol/L) is identified because such readings often predict imminent level 3 hypoglycemia (2).

Episodes of hypoglycemia in the hospital should be documented in the medical record and tracked (2).

Triggering Events

Iatrogenic hypoglycemia triggers may include sudden reduction of corticosteroid dose, reduced oral intake, emesis, new NPO status, inappropriate timing of short- or rapid-acting insulin in relation to meals, reduced infusion rate of intravenous dextrose, unexpected interruption of oral, enteral, or parenteral feedings, and altered ability of the patient to report symptoms (3).

Predictors of Hypoglycemia

In one study, 84% of patients with an episode of "severe hypoglycemia" (defined as <40 mg/dL [2.2 mmol/L]) had a prior episode of hypoglycemia (<70 mg/dL [3.9 mmol/L]) during the same admission (55). In another study of hypoglycemic episodes (defined as <50 mg/dL [2.8 mmol/L]), 78% of patients were using basal insulin, with the incidence of hypoglycemia peaking between midnight and 6 A.M. Despite recognition of hypoglycemia, 75% of patients did not have their dose of basal insulin changed before the next insulin administration (56).

Prevention

Common preventable sources of iatrogenic hypoglycemia are improper prescribing of hypoglycemic medications, inappropriate management of the first episode of hypoglycemia, and nutrition–insulin mismatch, often related to an unexpected interruption of nutrition. Studies of "bundled" preventative therapies including proactive surveillance of glycemic outliers and an interdisciplinary data-driven approach to glycemic management showed that hypoglycemic episodes in the hospital could be prevented. Compared with baseline, two such studies found that hypoglycemic events fell by 56% to 80% (57,58). The Joint Commission recommends that all hypoglycemic episodes be evaluated for a root

cause and the episodes be aggregated and reviewed to address systemic issues.

MEDICAL NUTRITION THERAPY IN THE HOSPITAL

The goals of medical nutrition therapy in the hospital are to provide adequate calories to meet metabolic demands, optimize glycemic control, address personal food preferences, and facilitate creation of a discharge plan. The ADA does not endorse any single meal plan or specified percentages of macronutrients. Current nutrition recommendations advise individualization based on treatment goals, physiological parameters, and medication use. Consistent carbohydrate meal plans are preferred by many hospitals as they facilitate matching the prandial insulin dose to the amount of carbohydrate consumed (59). Regarding enteral nutritional therapy, diabetes-specific formulas appear to be superior to standard formulas in controlling postprandial glucose, A1C, and the insulin response (60).

When the nutritional issues in the hospital are complex, a registered dietitian, knowledgeable and skilled in medical nutrition therapy, can serve as an individual inpatient team member. That person should be responsible for integrating information about the patient's clinical condition, meal planning, and lifestyle habits and for establishing realistic treatment goals after discharge. Orders should also indicate that the meal delivery and nutritional insulin coverage should be coordinated, as their variability often creates the possibility of hyperglycemic and hypoglycemic events.

SELF-MANAGEMENT IN THE HOSPITAL

Diabetes self-management in the hospital may be appropriate for select youth and adult patients (61,62). Candidates include patients who successfully conduct self-management of diabetes at home, have the cognitive and physical skills needed to successfully self-administer insulin, and perform self-monitoring of blood glucose. In addition, they should have adequate oral intake, be proficient in carbohydrate estimation, use multiple daily insulin injections or continuous subcutaneous insulin infusion (CSII), have stable insulin requirements, and understand sick-day management. If self-management is to be used, a protocol should include a requirement that the

patient, nursing staff, and physician agree that patient self-management is appropriate. If CSII is to be used, hospital policy and procedures delineating guidelines for CSII therapy, including the changing of infusion sites, are advised (63).

STANDARDS FOR SPECIAL SITUATIONS

Enteral/Parenteral Feedings

For patients receiving enteral or parenteral feedings who require insulin, insulin should be divided into basal, prandial, and correctional components. This is particularly important for people with type 1 diabetes to ensure that they continue to receive basal insulin even if the feedings are discontinued. One may use the patient's preadmission basal insulin dose or a percentage of the total daily dose of insulin when the patient is being fed (usually 30–50% of the total daily dose of insulin) to estimate basal insulin requirements. However, if no basal insulin was used, consider using 5 units of NPH/detemir insulin subcutaneously every 12 h or 10 units of insulin glargine every 24 h (64). For patients receiving continuous tube feedings, the total daily nutritional component may be calculated as 1 unit of insulin for every 10–15 g carbohydrate per day or as a percentage of the total daily dose of insulin when the patient is being fed (usually 50–70% of the total daily dose of insulin). Correctional insulin should also be administered subcutaneously every 6 h using human regular insulin or every 4 h using a rapid-acting insulin such as lispro, aspart, or glulisine. For patients receiving enteral bolus feedings, approximately 1 unit of regular human insulin or rapid-acting insulin per 10–15 g carbohydrate should be given subcutaneously before each feeding.

Correctional insulin coverage should be added as needed before each feeding. For patients receiving continuous peripheral or central parenteral nutrition, human regular insulin may be added to the solution, particularly if >20 units of correctional insulin have been required in the past 24 h. A starting dose of 1 unit of human regular insulin for every 10 g dextrose has been recommended (65), to be adjusted daily in the solution. Correctional insulin should be administered subcutaneously. For full enteral/parenteral feeding guidance, the reader

is encouraged to consult review articles detailing this topic (2,66).

Glucocorticoid Therapy

Glucocorticoid type and duration of action must be considered in determining insulin treatment regimens. Once-a-day, short-acting glucocorticoids such as prednisone peak in about 4–8 h (67), so coverage with intermediate-acting (NPH) insulin may be sufficient. For long-acting glucocorticoids such as dexamethasone or multidose or continuous glucocorticoid use, long-acting insulin may be used (32,66). For higher doses of glucocorticoids, increasing doses of prandial and correctional insulin may be needed in addition to basal insulin (68). Whatever orders are started, adjustments based on anticipated changes in glucocorticoid dosing and POC glucose test results are critical.

Perioperative Care

Many standards for perioperative care lack a robust evidence base. However, the following approach (69) may be considered:

1. Target glucose range for the perioperative period should be 80–180 mg/dL (4.4–10.0 mmol/L).
2. Perform a preoperative risk assessment for patients at high risk for ischemic heart disease and those with autonomic neuropathy or renal failure.
3. Withhold metformin the day of surgery.
4. Withhold any other oral hypoglycemic agents the morning of surgery or procedure and give half of NPH dose or 60–80% doses of long-acting analog or pump basal insulin.
5. Monitor blood glucose at least every 4–6 h while NPO and dose with short- or rapid-acting insulin as needed.

A review found that perioperative glycemic control tighter than 80–180 mg/dL (4.4–10.0 mmol/L) did not improve outcomes and was associated with more hypoglycemia (70); therefore, in general, tighter glycemic targets are not advised. A recent study reported that, compared with the usual insulin dose, on average an approximate 25% reduction in the insulin dose given the evening before surgery was more likely to achieve perioperative blood glucose

levels in the target range with decreased risk for hypoglycemia (71).

In noncardiac general surgery patients, basal insulin plus premeal short- or rapid-acting insulin (basal-bolus) coverage has been associated with improved glycemic control and lower rates of perioperative complications compared with the traditional sliding scale regimen (short- or rapid-acting insulin coverage only with no basal insulin dosing) (38,72).

Diabetic Ketoacidosis and Hyperosmolar Hyperglycemic State

There is considerable variability in the presentation of DKA and hyperosmolar hyperglycemic state, ranging from euglycemia or mild hyperglycemia and acidosis to severe hyperglycemia, dehydration, and coma; therefore, treatment individualization based on a careful clinical and laboratory assessment is needed (73–76).

Management goals include restoration of circulatory volume and tissue perfusion, resolution of hyperglycemia, and correction of electrolyte imbalance and ketosis. It is also important to treat any correctable underlying cause of DKA such as sepsis.

In critically ill and mentally obtunded patients with DKA or hyperosmolar hyperglycemic state, continuous intravenous insulin is the standard of care. Successful transition of patients from intravenous to subcutaneous insulin requires administration of basal insulin 2–4 h prior to the intravenous insulin being stopped to prevent recurrence of ketoacidosis and rebound hyperglycemia (76). There is no significant difference in outcomes for intravenous human regular insulin versus subcutaneous rapid-acting analogs when combined with aggressive fluid management for treating mild or moderate DKA (77). Patients with uncomplicated DKA may sometimes be treated with subcutaneous insulin in the emergency department or step-down units (78), an approach that may be safer and more cost-effective than treatment with intravenous insulin (79). If subcutaneous administration is used, it is important to provide adequate fluid replacement, nurse training, frequent bedside testing, infection treatment if warranted, and appropriate follow-up to avoid recurrent DKA. Several studies have shown that the use of bicarbonate in patients with DKA made no difference in resolution of acidosis or time to

discharge, and its use is generally not recommended (80). For further information regarding treatment, refer to recent in-depth reviews (3).

TRANSITION FROM THE ACUTE CARE SETTING

Recommendation

15.10 There should be a structured discharge plan tailored to the individual patient with diabetes. **B**

A structured discharge plan tailored to the individual patient may reduce length of hospital stay and readmission rates and increase patient satisfaction (81). Therefore, there should be a structured discharge plan tailored to each patient. Discharge planning should begin at admission and be updated as patient needs change.

Transition from the acute care setting is a risky time for all patients. Inpatients may be discharged to varied settings, including home (with or without visiting nurse services), assisted living, rehabilitation, or skilled nursing facilities. For the patient who is discharged to home or to assisted living, the optimal program will need to consider diabetes type and severity, effects of the patient's illness on blood glucose levels, and the patient's capacities and preferences. See Section 12 "Older Adults" for more information.

An outpatient follow-up visit with the primary care provider, endocrinologist, or diabetes educator within 1 month of discharge is advised for all patients having hyperglycemia in the hospital. If glycemic medications are changed or glucose control is not optimal at discharge, an earlier appointment (in 1–2 weeks) is preferred, and frequent contact may be needed to avoid hyperglycemia and hypoglycemia. A recently described discharge algorithm for glycemic medication adjustment based on admission A1C found that use of the algorithm to guide treatment decisions resulted in significant improvements in the average A1C after discharge (6). Therefore, if an A1C from the prior 3 months is unavailable, measuring the A1C in all patients with diabetes or hyperglycemia admitted to the hospital is recommended.

Clear communication with outpatient providers either directly or via hospital discharge summaries facilitates safe

transitions to outpatient care. Providing information regarding the cause of hyperglycemia (or the plan for determining the cause), related complications and comorbidities, and recommended treatments can assist outpatient providers as they assume ongoing care.

The Agency for Healthcare Research and Quality (AHRQ) recommends that, at a minimum, discharge plans include the following (82):

Medication Reconciliation

- The patient's medications must be cross-checked to ensure that no chronic medications were stopped and to ensure the safety of new prescriptions.
- Prescriptions for new or changed medication should be filled and reviewed with the patient and family at or before discharge.

Structured Discharge Communication

- Information on medication changes, pending tests and studies, and follow-up needs must be accurately and promptly communicated to outpatient physicians.
- Discharge summaries should be transmitted to the primary care provider as soon as possible after discharge.
- Appointment-keeping behavior is enhanced when the inpatient team schedules outpatient medical follow-up prior to discharge.

It is recommended that the following areas of knowledge be reviewed and addressed prior to hospital discharge:

- Identification of the health care provider who will provide diabetes care after discharge.
- Level of understanding related to the diabetes diagnosis, self-monitoring of blood glucose, home blood glucose goals, and when to call the provider.
- Definition, recognition, treatment, and prevention of hyperglycemia and hypoglycemia.
- Information on making healthy food choices at home and referral to an outpatient registered dietitian nutritionist to guide individualization of meal plan, if needed.
- If relevant, when and how to take blood glucose-lowering medications, including insulin administration.

- Sick-day management.
- Proper use and disposal of needles and syringes.

It is important that patients be provided with appropriate durable medical equipment, medications, supplies (e.g., blood glucose test strips), and prescriptions along with appropriate education at the time of discharge in order to avoid a potentially dangerous hiatus in care.

PREVENTING ADMISSIONS AND READMISSIONS

Preventing Hypoglycemic Admissions in Older Adults

Insulin-treated patients 80 years of age or older are more than twice as likely to visit the emergency department and nearly five times as likely to be admitted for insulin-related hypoglycemia than those 45–64 years of age (83). However, older adults with type 2 diabetes in long-term care facilities taking either oral antihyperglycemic agents or basal insulin have similar glycemic control (84), suggesting that oral therapy may be used in place of insulin to lower the risk of hypoglycemia for some patients. In addition, many older adults with diabetes are overtreated (85), with half of those maintaining an A1C <7% (53 mmol/mol) being treated with insulin or a sulfonylurea, which are associated with hypoglycemia. To further lower the risk of hypoglycemia-related admissions in older adults, providers may, on an individual basis, relax A1C targets to 8% (64 mmol/mol) or 8.5% (69 mmol/mol) in patients with shortened life expectancies and significant comorbidities (refer to Section 12 “Older Adults” for detailed criteria).

Preventing Readmissions

In patients with diabetes, the hospital readmission rate is between 14 and 20% (86). Risk factors for readmission include lower socioeconomic status, certain racial/ethnic minority groups, comorbidities, urgent admission, and recent prior hospitalization (86). Of interest, 30% of patients with two or more hospital stays account for over 50% of hospitalizations and their accompanying hospital costs (87). While there is no standard to prevent readmissions, several successful strategies have been reported, including an intervention program targeting ketosis-prone patients with type 1 diabetes (88), initiating insulin treatment in patients

with admission A1C >9% (75 mmol/mol) (89), and a transitional care model (90). For people with diabetic kidney disease, patient-centered medical home collaboratives may decrease risk-adjusted readmission rates (91).

References

1. Clement S, Braithwaite SS, Magee MF, et al.; Diabetes in Hospitals Writing Committee. Management of diabetes and hyperglycemia in hospitals [published corrections appear in *Diabetes Care* 2004;27:856 and *Diabetes Care* 2004;27:1255]. *Diabetes Care* 2004;27:553–591
2. Moghissi ES, Korytkowski MT, DiNardo M, et al.; American Association of Clinical Endocrinologists; American Diabetes Association. American Association of Clinical Endocrinologists and American Diabetes Association consensus statement on inpatient glycemic control. *Diabetes Care* 2009;32:1119–1131
3. Umpierrez G, Korytkowski M. Diabetic emergencies—ketoacidosis, hyperglycaemic hyperosmolar state and hypoglycaemia. *Nat Rev Endocrinol* 2016;12:222–232
4. Bogun M, Inzucchi SE. Inpatient management of diabetes and hyperglycemia. *Clin Ther* 2013;35:724–733
5. Pasquel FJ, Gomez-Huelgas R, Anzola I, et al. Predictive value of admission hemoglobin A_{1c} on inpatient glycemic control and response to insulin therapy in medicine and surgery patients with type 2 diabetes. *Diabetes Care* 2015;38:e202–e203
6. Umpierrez GE, Reyes D, Smiley D, et al. Hospital discharge algorithm based on admission HbA_{1c} for the management of patients with type 2 diabetes. *Diabetes Care* 2014;37:2934–2939
7. Carpenter DL, Gregg SR, Xu K, Buchman TG, Coopersmith CM. Prevalence and impact of unknown diabetes in the ICU. *Crit Care Med* 2015;43:e541–e550
8. Rhee MK, Safo SE, Jackson SL, et al. Inpatient glucose values: determining the nondiabetic range and use in identifying patients at high risk for diabetes. *Am J Med* 2018;131:443.e11–443.e24
9. Institute of Medicine. *Preventing Medication Errors*. Aspden P, Wolcott J, Bootman JL, Cronenwett LR, Eds. Washington, DC, The National Academies Press, 2007
10. Gillaizeau F, Chan E, Trinquart L, et al. Computerized advice on drug dosage to improve prescribing practice. *Cochrane Database Syst Rev* 2013;11:CD002894
11. Wexler DJ, Shrader P, Burns SM, Cagliero E. Effectiveness of a computerized insulin order template in general medical inpatients with type 2 diabetes: a cluster randomized trial. *Diabetes Care* 2010;33:2181–2183
12. Wang YJ, Seggelke S, Hawkins RM, et al. Impact of glucose management team on outcomes of hospitalization in patients with type 2 diabetes admitted to the medical service. *Endocr Pract* 2016;22:1401–1405
13. Garg R, Schuman B, Bader A, et al. Effect of preoperative diabetes management on glycemic control and clinical outcomes after elective surgery. *Ann Surg* 2018;267:858–862
14. Draznin B, Gilden J, Golden SH, et al.; PRIDE investigators. Pathways to quality inpatient

- management of hyperglycemia and diabetes: a call to action. *Diabetes Care* 2013;36:1807–1814
15. Bansal V, Mottalib A, Pawar TK, et al. Inpatient diabetes management by specialized diabetes team versus primary service team in non-critical care units: impact on 30-day readmission rate and hospital cost. *BMJ Open Diabetes Res Care* 2018;6:e000460
 16. Ostling S, Wyckoff J, Ciarkowski SL, et al. The relationship between diabetes mellitus and 30-day readmission rates. *Clin Diabetes Endocrinol* 2017;3:3
 17. Rushakoff RJ, Sullivan MM, MacMaster HW, et al. Association between a virtual glucose management service and glycemic control in hospitalized adult patients: an observational study. *Ann Intern Med* 2017;166:621–627
 18. Arnold P, Scheurer D, Dake AW, et al. Hospital guidelines for diabetes management and the Joint Commission-American Diabetes Association Inpatient Diabetes Certification. *Am J Med Sci* 2016;351:333–341
 19. Society of Hospital Medicine. Glycemic Control for Hospitalists [Internet]. Available from http://www.hospitalmedicine.org/Web/Quality_Innovation/Implementation_Toolkits/Glycemic_Control/Web/Quality___Innovation/Implementation_Toolkit/Glycemic/Clinical_Tools/Clinical_Tools.aspx. Accessed 24 September 2018
 20. Umpierrez GE, Hellman R, Korytkowski MT, et al.; Endocrine Society. Management of hyperglycemia in hospitalized patients in non-critical care setting: an Endocrine Society clinical practice guideline. *J Clin Endocrinol Metab* 2012;97:16–38
 21. Agiostratidou G, Anhalt H, Ball D, et al. Standardizing clinically meaningful outcome measures beyond HbA_{1c} for type 1 diabetes: a consensus report of the American Association of Clinical Endocrinologists, the American Association of Diabetes Educators, the American Diabetes Association, the Endocrine Society, JDRF International, The Leona M. and Harry B. Helmsley Charitable Trust, the Pediatric Endocrine Society, and the T1D Exchange. *Diabetes Care* 2017;40:1622–1630
 22. NICE-SUGAR Study Investigators, Finfer S, Chittock DR, et al. Intensive versus conventional glucose control in critically ill patients. *N Engl J Med* 2009;360:1283–1297
 23. Sathya B, Davis R, Taveira T, Whitlatch H, Wu W-C. Intensity of peri-operative glycemic control and postoperative outcomes in patients with diabetes: a meta-analysis. *Diabetes Res Clin Pract* 2013;102:8–15
 24. Umpierrez G, Cardona S, Pasquel F, et al. Randomized controlled trial of intensive versus conservative glucose control in patients undergoing coronary artery bypass graft surgery: GLUCO-CABG trial. *Diabetes Care* 2015;38:1665–1672
 25. Cobaugh DJ, Maynard G, Cooper L, et al. Enhancing insulin-use safety in hospitals: practical recommendations from an ASHP Foundation expert consensus panel. *Am J Health Syst Pharm* 2013;70:1404–1413
 26. Boyd JC, Bruns DE. Quality specifications for glucose meters: assessment by simulation modeling of errors in insulin dose. *Clin Chem* 2001;47:209–214

27. U.S. Food and Drug Administration. Blood Glucose Monitoring Test Systems for Prescription Point-of-Care Use: Guidance for Industry and Food and Drug Administration Staff [Internet], 2016. Available from <https://www.fda.gov/downloads/medicaldevices/deviceregulationandguidance/guidancedocuments/ucm380325.pdf>. Accessed 23 October 2018
28. Wallia A, Umpierrez GE, Rushakoff RJ, et al.; DTS Continuous Glucose Monitoring in the Hospital Panel. Consensus statement on inpatient use of continuous glucose monitoring. *J Diabetes Sci Technol* 2017;11:1036–1044
29. Umpierrez GE, Klonoff DC. Diabetes technology update: use of insulin pumps and continuous glucose monitoring in the hospital. *Diabetes Care* 2018;41:1579–1589
30. Gomez AM, Umpierrez GE. Continuous glucose monitoring in insulin-treated patients in non-ICU settings. *J Diabetes Sci Technol* 2014;8:930–936
31. Krinsley JS, Chase JG, Gunst J, et al. Continuous glucose monitoring in the ICU: clinical considerations and consensus. *Crit Care* 2017;21:197
32. Maynard G, Wesorick DH, O'Malley C, Inzucchi SE; Society of Hospital Medicine Glycemic Control Task Force. Subcutaneous insulin order sets and protocols: effective design and implementation strategies. *J Hosp Med* 2008;3(Suppl.):29–41
33. U.S. Food and Drug Administration. FDA Drug Safety Communication: FDA requires label warnings to prohibit sharing of multi-dose diabetes pen devices among patients [Internet], 2015. Available from <https://www.fda.gov/Drugs/DrugSafety/ucm435271.htm>. Accessed 24 September 2018
34. Brown KE, Hertig JB. Determining current insulin pen use practices and errors in the inpatient setting. *Jt Comm J Qual Patient Saf* 2016;42:568–575
35. Horne J, Bond R, Sarangam P. Comparison of inpatient glycemic control with insulin vials versus insulin pens in general medicine patients. *Hosp Pharm* 2015;50:514–521
36. Veronesi G, Poerio CS, Braus A, et al. Determinants of nurse satisfaction using insulin pen devices with safety needles: an exploratory factor analysis. *Clin Diabetes Endocrinol* 2015;1:15
37. Bueno E, Benitez A, Rufinelli JV, et al. Basal-bolus regimen with insulin analogues versus human insulin in medical patients with type 2 diabetes: a randomized controlled trial in Latin America. *Endocr Pract* 2015;21:807–813
38. Umpierrez GE, Smiley D, Jacobs S, et al. Randomized study of basal-bolus insulin therapy in the inpatient management of patients with type 2 diabetes undergoing general surgery (RABBIT 2 surgery). *Diabetes Care* 2011;34:256–261
39. Giugliano D, Chiodini P, Maiorino MI, Bellastella G, Esposito K. Intensification of insulin therapy with basal-bolus or premixed insulin regimens in type 2 diabetes: a systematic review and meta-analysis of randomized controlled trials. *Endocrine* 2016;51:417–428
40. Bellido V, Suarez L, Rodriguez MG, et al. Comparison of basal-bolus and premixed insulin regimens in hospitalized patients with type 2 diabetes. *Diabetes Care* 2015;38:2211–2216
41. Baldwin D, Zander J, Munoz C, et al. A randomized trial of two weight-based doses of insulin glargine and glulisine in hospitalized subjects with type 2 diabetes and renal insufficiency. *Diabetes Care* 2012;35:1970–1974
42. Schmeltz LR, DeSantis AJ, Thiyagarajan V, et al. Reduction of surgical mortality and morbidity in diabetic patients undergoing cardiac surgery with a combined intravenous and subcutaneous insulin glucose management strategy. *Diabetes Care* 2007;30:823–828
43. Shomali ME, Herr DL, Hill PC, Pehlivanova M, Sharretts JM, Magee MF. Conversion from intravenous insulin to subcutaneous insulin after cardiovascular surgery: transition to target study. *Diabetes Technol Ther* 2011;13:121–126
44. Tripathy PR, Lansang MC. U-500 regular insulin use in hospitalized patients. *Endocr Pract* 2015;21:54–58
45. Lansang MC, Umpierrez GE. Inpatient hyperglycemia management: a practical review for primary medical and surgical teams. *Cleve Clin J Med* 2016;83(Suppl. 1):S34–S43
46. Umpierrez GE, Gianchandani R, Smiley D, et al. Safety and efficacy of sitagliptin therapy for the inpatient management of general medicine and surgery patients with type 2 diabetes: a pilot, randomized, controlled study. *Diabetes Care* 2013;36:3430–3435
47. Pasquel FJ, Gianchandani R, Rubin DJ, et al. Efficacy of sitagliptin for the hospital management of general medicine and surgery patients with type 2 diabetes (Sita-Hospital): a multi-centre, prospective, open-label, non-inferiority randomised trial. *Lancet Diabetes Endocrinol* 2017;5:125–133
48. Garg R, Schuman B, Hurwitz S, Metzger C, Bhandari S. Safety and efficacy of saxagliptin for glycemic control in non-critically ill hospitalized patients. *BMJ Open Diabetes Res* 2017;5:e000394
49. U.S. Food and Drug Administration. FDA Drug Safety Communication: FDA adds warnings about heart failure risk to labels of type 2 diabetes medicines containing saxagliptin and alogliptin [Internet], 2016. Available from <http://www.fda.gov/drugs/drugsafety/ucm486096.htm>. Accessed 24 September 2018
50. Mendez CE, Umpierrez GE. Pharmacotherapy for hyperglycemia in noncritically ill hospitalized patients. *Diabetes Spectr* 2014;27:180–188
51. Umpierrez GE, Korytkowski M. Is incretin-based therapy ready for the care of hospitalized patients with type 2 diabetes? Insulin therapy has proven itself and is considered the mainstay of treatment. *Diabetes Care* 2013;36:2112–2117
52. U.S. Food and Drug Administration. FDA Drug Safety Communication: FDA revises labels of SGLT2 inhibitors for diabetes to include warnings about too much acid in the blood and serious urinary tract infections [Internet], 2015. Available from <http://www.fda.gov/Drugs/DrugSafety/ucm475463.htm>. Accessed 24 September 2018
53. U.S. Food and Drug Administration. FDA strengthens kidney warnings for diabetes medicines canagliflozin (Invokana, Invokamet) and dapagliflozin (Farxiga, Xigduo XR) [Internet], 2016. Available from <http://www.fda.gov/drugs/drugsafety/drugsafetypodcasts/ucm507785.htm>. Accessed 24 September 2018
54. Akirov A, Grossman A, Shochat T, Shimon I. Mortality among hospitalized patients with hypoglycemia: insulin related and noninsulin related. *J Clin Endocrinol Metab* 2017;102:416–424
55. Dendy JA, Chockalingam V, Tirumalasetty NN, et al. Identifying risk factors for severe hypoglycemia in hospitalized patients with diabetes. *Endocr Pract* 2014;20:1051–1056
56. Ulmer BJ, Kara A, Mariash CN. Temporal occurrences and recurrence patterns of hypoglycemia during hospitalization. *Endocr Pract* 2015;21:501–507
57. Maynard G, Kulasa K, Ramos P, et al. Impact of a hypoglycemia reduction bundle and a systems approach to inpatient glycemic management. *Endocr Pract* 2015;21:355–367
58. Milligan PE, Bocox MC, Pratt E, Hoehner CM, Krettek JE, Dunagan WC. Multifaceted approach to reducing occurrence of severe hypoglycemia in a large healthcare system. *Am J Health Syst Pharm* 2015;72:1631–1641
59. Curl M, Dinardo M, Noschese M, Korytkowski MT. Menu selection, glycaemic control and satisfaction with standard and patient-controlled consistent carbohydrate meal plans in hospitalised patients with diabetes. *Qual Saf Health Care* 2010;19:355–359
60. Ojo O, Brooke J. Evaluation of the role of enteral nutrition in managing patients with diabetes: a systematic review. *Nutrients* 2014;6:5142–5152
61. Mabrey ME, Setji TL. Patient self-management of diabetes care in the inpatient setting: pro. *J Diabetes Sci Technol* 2015;9:1152–1154
62. Shah AD, Rushakoff RJ. Patient self-management of diabetes care in the inpatient setting: con. *J Diabetes Sci Technol* 2015;9:1155–1157
63. Houlden RL, Moore S. In-hospital management of adults using insulin pump therapy. *Can J Diabetes* 2014;38:126–133
64. Umpierrez GE. Basal versus sliding-scale regular insulin in hospitalized patients with hyperglycemia during enteral nutrition therapy. *Diabetes Care* 2009;32:751–753
65. Pichardo-Lowden AR, Fan CY, Gabbay RA. Management of hyperglycemia in the non-intensive care patient: featuring subcutaneous insulin protocols. *Endocr Pract* 2011;17:249–260
66. Corsino L, Dhataria K, Umpierrez G. Management of diabetes and hyperglycemia in hospitalized patients. In *Endotext* [Internet]. Available from <http://www.ncbi.nlm.nih.gov/books/NBK279093/>. Accessed 24 September 2018
67. Kwon S, Hermayer KL, Hermayer K. Glucocorticoid-induced hyperglycemia. *Am J Med Sci* 2013;345:274–277
68. Brady V, Thosani S, Zhou S, Bassett R, Busaidy NL, Lavis V. Safe and effective dosing of basal-bolus insulin in patients receiving high-dose steroids for hyper-cyclophosphamide, doxorubicin, vincristine, and dexamethasone chemotherapy. *Diabetes Technol Ther* 2014;16:874–879
69. Smiley DD, Umpierrez GE. Perioperative glucose control in the diabetic or nondiabetic patient. *South Med J* 2006;99:580–589
70. Buchleitner AM, Martínez-Alonso M, Hernández M, Solà I, Mauricio D. Perioperative glycaemic control for diabetic patients undergoing surgery. *Cochrane Database Syst Rev* 2012;9:CD007315

71. Demma LJ, Carlson KT, Duggan EW, Morrow JG 3rd, Umpierrez GE. Effect of basal insulin dosage on blood glucose concentration in ambulatory surgery patients with type 2 diabetes. *J Clin Anesth* 2017;36:184–188
72. Umpierrez GE, Smiley D, Hermayer K, et al. Randomized study comparing a basal-bolus with a basal plus correction insulin regimen for the hospital management of medical and surgical patients with type 2 diabetes: Basal Plus Trial. *Diabetes Care* 2013;36:2169–2174
73. Kitabchi AE, Umpierrez GE, Miles JM, Fisher JN. Hyperglycemic crises in adult patients with diabetes. *Diabetes Care* 2009;32:1335–1343
74. Vellanki P, Umpierrez GE. Diabetic ketoacidosis: a common debut of diabetes among african americans with type 2 diabetes. *Endocr Pract* 2017;23:971–978
75. Harrison VS, Rustico S, Palladino AA, Ferrara C, Hawkes CP. Glargine co-administration with intravenous insulin in pediatric diabetic ketoacidosis is safe and facilitates transition to a subcutaneous regimen. *Pediatr Diabetes* 2017;18:742–748
76. Hsia E, Seggelke S, Gibbs J, et al. Subcutaneous administration of glargine to diabetic patients receiving insulin infusion prevents rebound hyperglycemia. *J Clin Endocrinol Metab* 2012;97:3132–3137
77. Andrade-Castellanos CA, Colunga-Lozano LE, Delgado-Figueroa N, Gonzalez-Padilla DA. Subcutaneous rapid-acting insulin analogues for diabetic ketoacidosis. *Cochrane Database Syst Rev* 2016;1:CD011281
78. Kitabchi AE, Umpierrez GE, Fisher JN, Murphy MB, Stentz FB. Thirty years of personal experience in hyperglycemic crises: diabetic ketoacidosis and hyperglycemic hyperosmolar state. *J Clin Endocrinol Metab* 2008;93:1541–1552
79. Umpierrez GE, Latif K, Stoeber J, et al. Efficacy of subcutaneous insulin lispro versus continuous intravenous regular insulin for the treatment of patients with diabetic ketoacidosis. *Am J Med* 2004;117:291–296
80. Duhon B, Attridge RL, Franco-Martinez AC, Maxwell PR, Hughes DW. Intravenous sodium bicarbonate therapy in severely acidotic diabetic ketoacidosis. *Ann Pharmacother* 2013;47:970–975
81. Shepperd S, Lannin NA, Clemson LM, McCluskey A, Cameron ID, Barras SL. Discharge planning from hospital to home. *Cochrane Database Syst Rev* 1996;1:CD000313
82. Agency for Healthcare Research and Quality. Readmission and adverse events after hospital discharge [Internet], 2018. Available from <http://psnet.ahrq.gov/primer.aspx?primerID=11>. Accessed 24 September 2018
83. Bansal N, Dhaliwal R, Weinstock RS. Management of diabetes in the elderly. *Med Clin North Am* 2015;99:351–377
84. Pasquel FJ, Powell W, Peng L, et al. A randomized controlled trial comparing treatment with oral agents and basal insulin in elderly patients with type 2 diabetes in long-term care facilities. *BMJ Open Diabetes Res Care* 2015;3:e000104
85. Lipska KJ, Ross JS, Miao Y, Shah ND, Lee SJ, Steinman MA. Potential overtreatment of diabetes mellitus in older adults with tight glycemic control. *JAMA Intern Med* 2015;175:356–362
86. Rubin DJ. Hospital readmission of patients with diabetes. *Curr Diab Rep* 2015;15:17
87. Jiang HJ, Stryer D, Friedman B, Andrews R. Multiple hospitalizations for patients with diabetes. *Diabetes Care* 2003;26:1421–1426
88. Maldonado MR, D'Amico S, Rodriguez L, Iyer D, Balasubramanyam A. Improved outcomes in indigent patients with ketosis-prone diabetes: effect of a dedicated diabetes treatment unit. *Endocr Pract* 2003;9:26–32
89. Wu EQ, Zhou S, Yu A, et al. Outcomes associated with post-discharge insulin continuity in US patients with type 2 diabetes mellitus initiating insulin in the hospital. *Hosp Pract (1995)* 2012;40:40–48
90. Hirschman KB, Bixby MB. Transitions in care from the hospital to home for patients with diabetes. *Diabetes Spectr* 2014;27:192–195
91. Tuttle KR, Bakris GL, Bilous RW, et al. Diabetic kidney disease: a report from an ADA Consensus Conference. *Diabetes Care* 2014;37:2864–2883

16. Diabetes Advocacy: *Standards of Medical Care in Diabetes—2019*

American Diabetes Association

Diabetes Care 2019;42(Suppl. 1):S182–S183 | <https://doi.org/10.2337/dc19-S016>

The American Diabetes Association (ADA) “Standards of Medical Care in Diabetes” includes ADA’s current clinical practice recommendations and is intended to provide the components of diabetes care, general treatment goals and guidelines, and tools to evaluate quality of care. Members of the ADA Professional Practice Committee, a multidisciplinary expert committee, are responsible for updating the Standards of Care annually, or more frequently as warranted. For a detailed description of ADA standards, statements, and reports, as well as the evidence-grading system for ADA’s clinical practice recommendations, please refer to the Standards of Care Introduction. Readers who wish to comment on the Standards of Care are invited to do so at professional.diabetes.org/SOC.

Managing the daily health demands of diabetes can be challenging. People living with diabetes should not have to face additional discrimination due to diabetes. By advocating for the rights of those with diabetes at all levels, the American Diabetes Association (ADA) can help to ensure that they live a healthy and productive life. A strategic goal of the ADA is that more children and adults with diabetes live free from the burden of discrimination. The ADA is also focused on making sure cost is not a barrier to successful diabetes management.

One tactic for achieving these goals has been to implement the ADA’s Standards of Care through advocacy-oriented position statements. The ADA publishes evidence-based, peer-reviewed statements on topics such as diabetes and employment, diabetes and driving, insulin access and affordability, and diabetes management in certain settings such as schools, child care programs, and correctional institutions. In addition to the ADA’s clinical documents, these advocacy statements are important tools in educating schools, employers, licensing agencies, policy makers, and others about the intersection of diabetes medicine and the law and for providing scientifically supported policy recommendations.

ADVOCACY STATEMENTS

Partial list, with the most recent publications appearing first

Insulin Access and Affordability Working Group: Conclusions and Recommendations (1)
(first publication 2018)

The ADA’s Insulin Access and Affordability Working Group compiled public information and convened a series of meetings with stakeholders throughout the insulin supply chain to learn how each entity affects the cost of insulin for the consumer. Their conclusions and recommendations are published in the ADA statement “Insulin Access and Affordability Working Group: Conclusions and Recommendations” (<https://doi.org/10.2337/dci18-0019>).

Suggested citation: American Diabetes Association. 16. Diabetes advocacy: Standards of Medical Care in Diabetes—2019. Diabetes Care 2019;42(Suppl. 1):S182–S183

© 2018 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. More information is available at <http://www.diabetesjournals.org/content/license>.

Diabetes Care in the School Setting (2)
(first publication 1998; latest revision 2015)

A sizable portion of a child's day is spent in school, so close communication with and cooperation of school personnel are essential to optimize diabetes management, safety, and academic opportunities. See the ADA position statement "Diabetes Care in the School Setting" (<https://doi.org/10.2337/dc15-1418>).

Care of Young Children With Diabetes in the Child Care Setting (3)
(first publication 2014)

Very young children (aged <6 years) with diabetes have legal protections and can be safely cared for by child care providers with appropriate training, access to resources, and a system of communication with parents and the child's diabetes provider. See the ADA position statement "Care of Young Children With Diabetes in the Child Care Setting" (<https://doi.org/10.2337/dc14-1676>).

Diabetes and Driving (4)
(first publication 2012)

People with diabetes who wish to operate motor vehicles are subject to a great variety of licensing requirements applied by both state and federal jurisdictions, which may lead to loss of employment or significant restrictions on a person's license. Presence of a medical condition that can lead to significantly impaired consciousness or cognition may lead to drivers being evaluated for their fitness to drive. People

with diabetes should be individually assessed by a health care professional knowledgeable in diabetes if license restrictions are being considered, and patients should be counseled about detecting and avoiding hypoglycemia while driving. See the ADA position statement "Diabetes and Driving" (<https://doi.org/10.2337/dc14-S097>).

Editor's note: Federal commercial driving rules for individuals with insulin-treated diabetes changed on 19 November 2018. These changes will be reflected in an updated ADA statement.

Diabetes and Employment (5)
(first publication 1984; latest revision 2009)

Any person with diabetes, whether insulin treated or noninsulin treated, should be eligible for any employment for which he or she is otherwise qualified. Employment decisions should never be based on generalizations or stereotypes regarding the effects of diabetes. When questions arise about the medical fitness of a person with diabetes for a particular job, a health care professional with expertise in treating diabetes should perform an individualized assessment. See the ADA position statement "Diabetes and Employment" (<https://doi.org/10.2337/dc14-S112>).

Diabetes Management in Correctional Institutions (6)
(first publication 1989; latest revision 2008)

People with diabetes in correctional facilities should receive care

that meets national standards. Because it is estimated that nearly 80,000 inmates have diabetes, correctional institutions should have written policies and procedures for the management of diabetes and for the training of medical and correctional staff in diabetes care practices. See the ADA position statement "Diabetes Management in Correctional Institutions" (<https://doi.org/10.2337/dc14-S104>).

References

1. Cefalu WT, Dawes DE, Gavlak G, et al.; Insulin Access and Affordability Working Group. Insulin Access and Affordability Working Group: conclusions and recommendations [published correction appears in *Diabetes Care* 2018;41:1831]. *Diabetes Care* 2018;41:1299–1311
2. Jackson CC, Albanese-O'Neill A, Butler KL, et al. Diabetes care in the school setting: a position statement of the American Diabetes Association. *Diabetes Care* 2015;38:1958–1963
3. Siminerio LM, Albanese-O'Neill A, Chiang JL, et al. Care of young children with diabetes in the child care setting: a position statement of the American Diabetes Association. *Diabetes Care* 2014;37:2834–2842
4. American Diabetes Association. Diabetes and driving. *Diabetes Care* 2014;37(Suppl. 1):S97–S103
5. American Diabetes Association. Diabetes and employment. *Diabetes Care* 2014;37(Suppl. 1):S112–S117
6. American Diabetes Association. Diabetes management in correctional institutions. *Diabetes Care* 2014;37(Suppl. 1):S104–S111

Disclosures: *Standards of Medical Care in Diabetes—2019*

Diabetes Care 2019;42(Suppl. 1):S184–S186 | <https://doi.org/10.2337/dc19-SDIS01>

Committee members disclosed the following financial or other conflicts of interest covering the period 12 months before December 2018

Member	Employment	Research grant	Other research support	Speakers' bureau/honoraria	Ownership interest	Consultant/advisory board	Other
Professional Practice Committee							
Joshua J. Neumiller, PharmD, CDE, FASCP, Chair	Washington State University	None	None	<i>Diabetes Spectrum</i> (Editorial)	None	None	None
Christopher P. Cannon, MD	Brigham and Women's Hospital	Amgen*, Boehringer Ingelheim*, Bristol-Myers Squibb*, Daiichi Sankyo*, Janssen*, Merck*	None	None	None	Alnylam, Amarin, Amgen, Boehringer Ingelheim*, Bristol-Myers Squibb, Eisai, Janssen, Kowa, Merck, Pfizer, Regeneron, Sanofi*	None
Jill Crandall, MD	Albert Einstein College of Medicine	None	None	Data and Safety Monitoring Board for National Institutes of Health-sponsored studies	None	None	None
David D'Alessio, MD	Duke University, Division of Endocrinology	Merck, Eli Lilly, vTv Therapeutics	None	<i>Diabetes Care, Diabetes</i> (Editorial)	None	Eli Lilly	Endocrine Society
Ian H. de Boer, MD, MS	University of Washington	None	Medtronic, Abbott	None	None	Ironwood	None
Mary de Groot, PhD	Indiana University School of Medicine Diabetes Translational Research Center	None	None	<i>Diabetes Care</i> (Editorial)	None	Johnson & Johnson Diabetes Institute, Eli Lilly	None
Judith Fradkin, MD	National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK)	None	None	None	None	None	None
Kathryn Evans Kreider, DNP, APRN, FNP-BC, BC-ADM	Duke University Medical Center	None	None	None	None	Amgen	None

Member	Employment	Research grant	Other research support	Speakers' bureau/ honoraria	Ownership interest	Consultant/ advisory board	Other
Matthew P. Petersen	American Diabetes Association	None	None	None	None	None	None
Sacha Uelmen, RDN, CDE	American Diabetes Association	None	None	None	None	None	None
Shamera Robinson, MPH, RDN	American Diabetes Association	None	None	None	None	None	None

*≥\$10,000 per year from company to individual; #grant or contract is to university or other employer.

Index

- A1C, **S14–S15, S61–S63**. *see also* glycemic targets
 advantages of, S15
 age and, S15
 cardiovascular disease and, S64, S65
 in children and adolescents, S20, S62, S151, S156
 continuous glucose monitoring
 reduction of, S76
 discharge planning, S178–S179
 ethnic variability in, S15, S62
 glucose assessment, S62–S63
 goals, S63–S64
 goals, setting/modifying, S64–S66
 hemoglobinopathies, S14, S15
 HIV and, S41
 limitations of, S62
 microvascular complications and, S63–S65
 in older adults, S141, S142
 other conditions affecting, S15
 performance of, S14–S15
 physical activity benefits, S52
 prediabetes, S17
 pregnancy values, S14, S15, S166, S167
 race/ethnicity, S15
 recommendations, S14, S61, S63
 testing frequency, S61–S62
- acarbose, S96
 ACCORD BP trial, S104–S106
 ACCORD MIND trial, S140
 ACCORD study, S40, S64, S65, S67, S127
 ACE inhibitors
 children and adolescents, S153, S154
 chronic kidney disease, S128–S129
 hypertension, S106–S108
 pregnancy, S169
 retinopathy, S131
- acute kidney injury, S126
 ADA evidence-grading system, **S2**
 ADAG study, S62, S66
 ADA statements, S1
 adolescents. *see* children and adolescents
 ADVANCE BP trial, S105
 ADVANCE study, S64, S65, S67
 advocacy position statements, S6, **S182–S183**
 aerobic exercise, S52
 Affordable Care Act, S9, S160
 African Americans
 A1C as predictive in, S17
 A1C variability in, S15, S52, S62
 BMI cut point, S20
 exercise targets in, S52
 food insecurity in, S10
 hemoglobinopathies in, S15
 hypoglycemia in, S67
 idiopathic type 1 diabetes in, S16
 risk-based screening, S18
- agave syrup, S51
 age, S15, S20
 α -glucosidase inhibitors, S31, S96
 AIM-HIGH trial, S112
 albiglutide, S116
 alcohol, S49, S51
 alogliptin, S96, S117, S118, S176
 American Indians, S18
- amylin mimetics, S83, S96
 angiotensin receptor blockers (ARBs)
 children and adolescents, S153, S154
 chronic kidney disease, S128–S129
 hypertension, S106–S108
 pregnancy, S169
 retinopathy, S131
- anorexia nervosa, S144, S145
 anticholinergics, S83
 anticonvulsants, S83
 antidepressants, S83
 antihistamines, S83
 antihyperglycemics
 cardiovascular disease, S115–S119
 heart failure, S118
 hospital care, **S175–S176**
 obesity management, S83
 type 2 diabetes, S92, S93
- antihypertensives
 cardiovascular disease, S104, S106–S108
 chronic kidney disease, S128
 pregnancy, S169
- antioxidant supplementation, S51
 antiplatelet agents, S113–S114
 antipsychotics, S83
 antiretroviral (ARV) therapies, S41
 anti-VEGF, S129–S131
 anxiety disorders evaluation, S42, S55
 ARRIVE trial, S113
 ASCEND trial, S113, S114
- Asians Americans
 BMI cut point, S17, S20
 idiopathic type 1 diabetes in, S16
 metabolic surgery, S85, S86
 prediabetes/type 2 criteria, S18
 risk-based screening, S18, S19
- Aspart, S97
 Aspart 70/30, S97
 ASPIRE study, S76
 aspirin
 cardiovascular disease and, S113–S114
 preeclampsia, S167–S169
 resistance, S114
 retinopathy and, S129
- ASPREE trial, S113
 assisted living facilities, S144, S145
 atorvastatin, S111
 autoimmune diseases, S39, S152
 automated insulin delivery, **S77**
 autonomic neuropathy
 cardiac, S131, S132
 diagnosis, S132
 genitourinary, S132
 glycemic control, S132
 physical activity and, S53
 pre-exercise evaluation, S52–S53
 prevention, S131
 screening, S131
 treatment, S131, S132
- bariatric surgery referrals, S55
 BARI 2D trial, S132
- basal insulin analogs, S97–S99
 bedside blood glucose monitoring, **S175**
 behavioral therapy, **S82–S83**
 β -blockers, S114
 beverage consumption, S5
 biguanides, S96
 bile acid sequestrants, S96
 blood glucose meter accuracy, S74
 blood pressure control. *see* hypertension
 blood pressure targets, S104
 BMI, ethnicity and, S17, S20
 board certified-advanced diabetes management (BC-ADM), S47
 bromocriptine, S96
- canagliflozin, S96, S98, S115–S116, S128
 cancer evaluation, S39
 CANVAS-Renal (CANVAS-R) trial, S115–S118
 CANVAS trial, S115–S119, S127, S128
 carbohydrates, S49, S50
 cardiovascular disease, **S103–S119**
 A1C and, S64, S65
 antihyperglycemics, S115–S119
 antiplatelet agents, S113–S114
 atherosclerotic, defined, S103
 atherosclerotic, pharmacology in
 type 2, S92, S98
 cardiac testing, S114–S115
 children and adolescents, S153–S155, S159
 chronic kidney disease and, S128–S129
 fats (dietary) and, S51
 heart failure, S103, S114, S118–S119
 hypertension, **S104–S113**
 lifestyle interventions, S115
 obesity management and, S82
 pharmacology, S115–S119
 pharmacology outcomes, S98
 physical activity benefits, S52
 prevention of, S31
 primary prevention/aspirin, S113–S114
 primary prevention/statins, S110
 recommendations, S114
 revisions summary, S5
 risk assessment, S36, S103–S104
 risk factors, S17, S20, S66
 screening, S114, S115
 secondary prevention/statins, S111
 statins, S109–S113
 stroke. *see* stroke
 treatment, S114
- care delivery systems
 Affordable Care Act, S9, S160
 background, **S8**
 care team, S8
 chronic care model, **S8–S9**, S34
 social context in, **S9–S10**
 system-level improvement strategies, S8
 telemedicine, S4, S5, S8–S9, S31, S129
- carotene, S51
 Caucasians

- A1C/mean glucose levels in, S52
 BMI cut points in, S20
 exercise levels in, S52
 hemoglobinopathies in, S15
 celiac disease, S152–S153
 certified diabetes educator (CDE), S47
 CGM. *see* continuous glucose monitoring (CGM)
 Charcot foot, S134
 child care/school, S150
 children and adolescents, **S148–S160**
 A1C targets in, S151, S156
 A1C validity in, S20, S62
 autoimmune conditions in, S152
 cardiac function testing, S159
 cardiovascular risk factor management, S153–S155
 celiac disease, S152–S153
 complications prevention/management, S158–S160
 continuous glucose monitoring in, S149, S151
 diabetic ketoacidosis in, S149, S156, S157
 DSMES, S149
 dyslipidemia, S153–S154, S159
 eating disorders in, S151
 glycemic control/type 1, S151–S152
 glycemic control/type 2, S156–S157
 hypertension, S153
 hypoglycemia in, S67
 immune-mediated diabetes, S16
 immunizations, S36
 insulin pumps, S72–S73
 lifestyle management, S156
 metabolic surgery, S158
 monogenic diabetes in, S25
 nephropathy, S154
 neuropathy, S155, S158
 new-onset management algorithm, S157
 nutrition therapy, S149, S156
 obesity management, S150, S155, S156
 pediatric to adult care transition, S160
 pharmacology, S156–S158
 physical activity/exercise, S51, S52, S149–S150, S156
 preconception counseling, S150, S151
 psychosocial issues, S150–S151, S159–S160
 real-time CGM in, S75
 retinopathy, S154–S155, S158–S159
 revisions summary, S6
 school/child care, S150
 shared decision making, S150–S151
 smoking, S154
 thyroid disease, S152
 type 2 diabetes in, S17, S18, **S155–S160**
 type 1 diabetes in, S13–S14, **S148–S155**
 chronic care model, **S8–S9**, S34
 chronic kidney disease, **S124–S129**
 acute kidney injury, S126
 albuminuria screening, S125
 albuminuria treatment, S128
 antihypertensives, S128
 cardiovascular disease and, S128–S129
 children and adolescents, S154, S158–S159
 complications of, S126
 diagnosis of, S125
 eGFR assessment, S125
 epidemiology, S125
 glucose-lowering medications, renal effects, S127
 glycemic targets, S127
 hypertension and, S124, S128–S129
 nutrition therapy, S50, S53, S124, S127
 pharmacology, S92, S97, S125, S127–S128
 recommendations, S124–S125
 referrals, S129
 renal replacement treatment, S125, S129
 screening, S124
 staging of, S125–S126
 surveillance, S126–S127
 treatment, S124–S129
 CKD. *see* chronic kidney disease
 classification, S4, **S13–S14**
 clopidogrel, S113, S114
 closed-loop pump system, S91
 clozapine, S83
 cognitive impairment/dementia
 evaluation, S39–S40
 older adults, **S140**
 risk factors, S67
 statins and, S113
 colesevelam, S96
 community health workers, S10
 community screening, S20
 community support, S10
 comorbidities, S4, S36, **S39–S43**
 concentrated human regular insulin, S97, S99
 consensus reports, S1–S2
 contact dermatitis, S77
 continuous glucose monitoring (CGM), **S74–S77**
 accuracy, S74, S75
 A1C measurement with, S15
 A1C reduction, S76
 A1C testing and, S62
 basal insulin/oral agents, S73–S74
 children and adolescents, S149, S151
 as complementary method, S73
 flash, S76–S77
 function, applications of, S75
 glucose assessment, S62–S63
 glycemic control impacts, S75
 hospital care, S175
 hypoglycemia impacts, S67, S75, S76
 intensive insulin regimens, S73
 optimization, S73
 pregnancy, S169
 real-time, S75–S76
 recommendations, S74–S76
 continuous subcutaneous insulin injection (CSII), S72–S73
 contraception, S170
 counterfeit strips, S74
 CREDENCE trial, S128
 CVD. *see* cardiovascular disease
 cystic fibrosis, S13
 cystic fibrosis–related diabetes, **S23**
 Da Qing Diabetes Prevention Study, S30
 DASH diet, S48, S109
 degludec, S97
 dental care, S20, S41
 depression evaluation, S42, S55
 detemir, S97
 Diabetes Control and Complications Trial (DCCT) trial, S65, S66, S67, S72, S91, S127, S140, S152
 diabetes distress, S54–S55
 Diabetes Prevention Program (DPP), S17, S29, S30, S31
 Diabetes Prevention Program Outcomes Study (DPPOS), S30, S51, S96
 Diabetes Prevention Recognition Program (DPRP), S31
 diabetes self-management education and support (DSMES), S9, S10
 benefits of, S47
 children and adolescents, S149
 older adults, S141
 principles of, **S46–S47**
 psychosocial issues and, S54
 recommendations, **S32**
 reimbursement, S47
 social determinants of health and, S9, S10
 diabetic ketoacidosis
 in children and adolescents, S149, S156, S157
 epidemiology, S13–S14
 glycemic targets and, S68
 hospital care, S178
 nutrition therapy, S48, S50
 pregnancy, S169
 as pump complication, S72, S73
 referrals, S55
 risk factors, S16
 in type 2 diabetes, S18
 diabetic kidney disease. *see* chronic kidney disease
 diabetic macular edema, S129, S131
 diabetic retinopathy. *see* retinopathy
 Diabetic Retinopathy Study (DRS), S130–S131
 diagnosis
 A1C. *see* A1C
 CFRD, **S23**
 community screening, S20
 confirming, S15–S16
 criteria, S15
 fasting plasma glucose (FPG), S14, S15, S20, S23
 IFG, S17
 MODY, S13, **S25**
 monogenic diabetes syndromes, S13, **S24–S25**
 neonatal diabetes, S24, **S25**
 one-step strategy, GDM, S21–S22
 oral glucose tolerance test (OGTT), S14, S20, S22
 posttransplantation diabetes mellitus, **S23–S24**
 revisions summary, S4
 testing interval, S20
 2-h plasma glucose (2-h PG), S14, S15
 two-step strategy, GDM, S21, S22
 type 1 diabetes, S15, **S16–S17**
 type 2 diabetes, **S17–S20**
 DIAMOND study, S76
 Dietary Reference Intakes (DRI), S168
 discharge planning, S178–S179

- disordered eating behavior evaluation, S42–S43
- DKA. *see* diabetic ketoacidosis
- dopamine-2 agonists, S96
- DPP-4 inhibitors
- in combination therapy, S93–S94, S97–S98
 - costs, S96
 - heart failure, S118
 - hospital care, S176
 - indications, considerations, S93
 - older patients, S143–S145
 - in renal transplant recipients, S24
- dulaglutide, S96
- duloxetine, S132
- dumping syndrome, S86
- e-cigarettes, S5, S6, **S53–S54**, S154
- economic costs of diabetes, S8
- EDIC study, S64–S67, S127
- ELIXA trial, S116–S118
- empagliflozin, S96, S98, S115, S116, S119, S128
- EMPA-REG OUTCOME trial, S115, S117–S119, S127, S128
- end-of-life/palliative care, S141, S144, **S146**
- enteral/parenteral feedings, S177
- eplerenone, S129
- erectile dysfunction, S133
- ertugliflozin, S96
- erythropoietin therapy, S15
- ETDRS, S130–S131
- ethnicity, S15, S20, S62. *see also* specific ethnicities
- evolocumab, S111
- EXAMINE trial, S117, S118
- Exenatide, Exenatide ER, S96
- exercise. *see* physical activity
- EXSCEL trial, S116–S118
- eye disease. *see* diabetic retinopathy
- ezetimibe, S111, S113
- fasting plasma glucose (FPG), S14, S15, S20, S23
- fats (dietary), S49–S51
- fenofibrate, S112
- fibrates, S112
- finerenone, S129
- Finland study, S16
- Finnish Diabetes Prevention Study, S30
- flash CGM, S76–S77
- food insecurity, S10
- foot care
- hyperbaric oxygen therapy, S134–S135
 - infections, S134
 - loss of protective sensation, S131, S134
 - neuropathy, **S133–S135**
 - patient education, S134
 - peripheral arterial disease, S133, S134
 - recommendations, S133
 - revisions summary, S5
 - treatment, S134
 - ulcers/amputations risk, S133–S134
- footwear, S134
- FOURIER trial, S111
- fractures, S40–S41
- frailty, S141–S142
- FRAX score, S41
- gabapentin, S5, S83
- gastrointestinal neuropathy, S132
- gastroparesis, S133
- genitourinary autonomic neuropathy, S132
- German study, S16
- gestational diabetes mellitus, S6, S13, **S20–S23**, S76, **S167–S170**
- GI surgery. *see* metabolic surgery
- glargine, glargine biosimilar, S97
- glimepiride, S96
- glipizide, S96
- GLP-1 receptor agonists
- cardiovascular disease outcomes, S65, S98, S114, S116
 - in CKD, S127, S128
 - in combination therapy, S93–S94, S97–S99
 - costs, S95, S97
 - heart failure, S118–S119
 - hospital care, S176
 - indications, considerations, S93
 - obesity management, S85
 - older patients, S143–S145
 - stroke and, S116
 - type 1 diabetes, S92
 - type 2 diabetes prevention/delay, S31
- glucagon, S66–S68
- glucocorticoids, S83, S177
- glucose oxidase systems, S74
- glulisine, S97
- gluten-free diets, S152, S153
- glyburide, S96, S167
- glycemic index/glycemic load, S50
- glycemic targets, **S61–S68**. *see also* A1C
- cardiovascular disease and, S64, S65
 - continuous glucose monitoring impacts, S75
 - evaluation of, S36, S39, **S61–S63**
 - glucose assessment, S62–S63
 - hospital care, **S174–S175**
 - intercurrent illness and, S68
 - management algorithm, S35
 - moderate vs. tight control, S174–S175
 - nonpregnant adults, S66
 - physical activity and, S52
 - in pregnancy, **S166–S167**, S169
 - preprandial, S67
 - revisions summary, S5
- G6PD deficiency, S4, S14, S15
- HAPO study, S21, S167
- Harmony Outcomes trial, S116
- hearing impairment evaluation, S41
- hemodialysis, S15
- hemoglobinopathies, S14, S15
- hepatitis B vaccine, S36, S38–S39, S127
- herbal supplements, S49, S51
- Hispanics. *see* Latinos
- HIV evaluation, S41
- homelessness, S10
- honey, S51
- hospital care, **S173–S179**
- admission considerations, S173–S174
 - admission/readmission prevention, **S179**
 - antihyperglycemics, **S175–S176**
 - bedside blood glucose monitoring, **S175**
- continuous glucose monitoring, S175
- delivery standards, **S173–S174**
- diabetes care providers in, S174
- diabetic ketoacidosis, S178
- discharge planning, S178–S179
- enteral/parenteral feedings, S177
- glucocorticoid therapy, S177
- glucose abnormalities definitions, S174
- glycemic targets, **S174–S175**
- hyperglycemia management, S24
- hyperosmolar hyperglycemic state, S178
- hypoglycemia, **S176–S177**
- insulin, IV to subcutaneous transition, S176
- insulin therapy, S174–S176
- medical nutrition therapy, **S177**
- noninsulin therapies, S176
- perioperative care, S177–S178
- physician order entry, S174
- quality assurance standards in, S174
- revisions summary, S6
- self-monitoring of blood glucose, **S177**
- stroke, S174
- type 1 diabetes, S176
- HOT trial, S105
- HPS2-THRIVE trial, S112
- Human NPH, S97
- human regular insulin, S97
- hydralazine, S106
- hyperbaric oxygen therapy, S134–S135
- hyperglycemia
- ARV-associated, S41
 - defined, S174
 - evaluation of, S40
 - exercise-induced, S149–S150
 - maternal, S22
 - postprandial as predictive, S66
 - posttransplant, S23
 - risk factors, S10
- hyperosmolar hyperglycemic state, S178
- hypertension, **S104–S113**
- antihypertensives, S104, S106–S108
 - bedtime dosing, S107
 - blood pressure targets, S104
 - children and adolescents, S153
 - chronic kidney disease and, S124, S128–S129
 - defined, S104
 - hyperkalemia/acute kidney injury, S107–S108
 - lipid management, **S109–S113**
 - meta-analyses of trials, S106
 - multiple-drug therapy, S107, S108
 - in older adults, S141
 - pharmacologic interventions, S107–S113
 - in pregnancy, S104, S106
 - randomized clinical trials, S104–S106
 - resistant, S108, S109
 - screening/diagnosis, S104
 - treatment algorithm, S108
 - treatment goals, S104
 - treatment strategies, S107–S113
 - treatment targets individualization, S106
- hypertriglyceridemia, S112

- hypoglycemia, **S66–S68**
 A1C testing and, S62
 anxiety disorders and, S42
 cardiovascular disease and, S65
 continuous glucose monitoring impacts, S75, S76
 definitions, S67
 exercise-induced, S53, S149–S150
 hospital care, **S176–S177**
 insulin therapy and, S91
 moderate vs. tight glycemic control, S174–S175
 in older adults, S67, **S140**, S145
 postprandial, post-RYGB, S86
 predictors of, S176
 prevention, S68, S176–S177
 pumps and, S73
 recommendations, S66–S67
 risk, evaluation of, S39, S40
 risk factors, S10, S64
 symptoms of, S67
 treatment of, S67–S68
 triggering events, S176
 hypoglycemia unawareness, S42, S66–S68
- IADPSG criteria, S22–S23
 idiopathic type 1 diabetes, S16
 IFG, S17
 immune-mediated diabetes, S16
 immunizations, S36–S39
 IMPROVE-IT trial, S111
 improvement. *see* quality of care
 incretin-based therapies, S143. *see also* DPP-4 inhibitors; GLP-1 receptor agonists
 Indian Diabetes Prevention Programme (IDPP-1), S31
 influenza vaccine, S36, S38
 inhaled insulin, S91, S97, S99
 injection-related anxiety, S42
 insulin pumps, S72–S73, S76, S91
 insulin resistance, S18
 insulin secretagogues, S143. *see also* sulfonylureas
 insulin syringes/pens, S71–S72
 insulin therapy
 automated delivery, **S77**
 basal insulin, S98–S99
 carbohydrates and, S49, S50
 children and adolescents, S156, S157
 concentrated products, S97, S99
 costs, S97–S99
 critical care setting, S175
 delivery technology, **S71–S73**
 gestational diabetes mellitus, S167, S168
 hospital care, S174–S176
 hypoglycemia and, S91
 indications, considerations, S93, S96–S97
 inhaled insulin, S91, S97, S99
 injection technique, S91
 intravenous to subcutaneous transition, S176
 noncritical care setting, S175–S176
 older adults, S142–S143, S145
 prandial insulin, S99
 premixed insulin, S97, S99
 type 1 diabetes, S90–S92
 type 2 diabetes, S96, S98–S99
 insurance, S47, S77
 intermediate-acting insulin analogs, S97
 intermittently scanned CGM, S76–S77
- Internet-based DSMES, S47
 islet transplantation, S92
- JDRF CGM trial, S75, S76
- ketoacidosis. *see* diabetic ketoacidosis
 kidney disease. *see* chronic kidney disease
 Kumamoto Study, S64
- labetalol, S106
 language, S10, S35–S36
 laropiprant, S112
 Latinos
 A1C variability in, S62
 exercise targets in, S52
 food insecurity in, S10
 risk-based screening, S17, S18
 LEADER trial, S116–S118, S127, S128
 legacy effect, S66
 lifestyle management, **S46–S55**
 cardiovascular disease, S115
 children and adolescents, S156
 cost effectiveness, S31
 DSMES, S9, S10, **S31–S32**, **S46–S47**, S54
 gestational diabetes mellitus, S167
 hypertension, S107
 medical nutrition therapy. *see* medical nutrition therapy
 older adults, **S141–S142**
 revisions summary, S4–S5
 technology-assisted interventions, S31
 type 2 diabetes prevention/delay, **S29–S31**
 weight loss, S48–S51
 linagliptin, S96
 lipid management, **S109–S113**
 children and adolescents, S153–S154, S159
 combination treatment, S110–S112
 HDL cholesterol, S109, S112, S159
 LDL cholesterol, S109, S113, S159
 lifestyle modification, S109
 lipid profile/panel, S109
 statins, S109–S113
 triglycerides, S109, S112, S159
 lipohypertrophy, S91
 liraglutide, S85, S95, S97, S98, S116, S128
 Lispro 50/50, S97
 Lispro 75/25, S97
 Lispro, Lispro biosimilar, S97
 lixisenatide, S97, S116
 long-term care facilities, S144, S145
 Look AHEAD trial, S41, S82–S83
 Lorcaserin, Lorcaserin XR, S84
 loss of protective sensation (LOPS), S131, S134
 low-carbohydrate diets, S30, S48, S50
- macular edema, S129, S131
 MAO inhibitors, S83
 mature minor rule, S150–S151
 meal planning, S5, S48, S49
 medical evaluation, **S36–S39**
 components of, S36–S38
 immunizations, S36–S39
 recommendations, S36
 referrals, S40, S55
 medical nutrition therapy, **S47–S51**. *see also* nutrition
 alcohol, S49, S51
 carbohydrates, S49, S50
- children and adolescents, S149, S156
 eating patterns, S48–S50
 fats (dietary), S49–S51
 gestational diabetes mellitus, S167–S168
 goals of, S48
 herbal supplements, S49, S51
 hospital care, **S177**
 macronutrient distribution, S48–S50
 meal planning, S5, S48, S49
 micronutrients, S49, S51
 nonnutritive sweeteners, S5, S49, S51
 protein, S49, S50
 recommendations, S49
 sodium, S49, S51
 weight management, S48–S51
 Medicare, S47, S77
 medication adherence, S9
 medication reconciliation, S178
 Mediterranean diet, S30, S40, S48, S50, S51, S109
 meglitinides, S96
 mental health
 children and adolescents, S150–S151, S159–S160
 diabetes distress, S54–S55
 evaluation of, S41–S42, **S54–S55**
 homelessness, S10
 illness, serious, S43, S55
 issues, post-surgery, S86–S87
 referrals, S40, S55
 metabolic memory, S66
 metabolic surgery
 adverse effects, S86
 benefits of, S86
 children and adolescents, S158
 indications, S86
 obesity management, **S85–S87**
 outcomes, S86
 recommendations, S85–S86
 referrals, S55
 metformin
 cardiovascular disease, S114, S116–S118
 children and adolescents, S156–S158
 in chronic kidney disease, S127
 costs, S96
 gestational diabetes mellitus, S167, S168
 indications, considerations, S93
 initial therapy, S92–S97
 older patients, S143
 type 1 diabetes, S92
 type 2 diabetes, S92
 type 2 diabetes prevention/delay, **S31**
 vitamin B12 deficiency and, S51, S92
 methyldopa, S106
 metoclopramide, S133
 micronutrients, S49, S51
 microvascular complications, S5, S63–S65, **S124–S135**. *see also* specific conditions
 miglitol, S95
 MiG TOFU study, S168
 mineralocorticoid receptor antagonists, S109, S129
 MODY, S13, **S25**
 monogenic diabetes syndromes, S13, **S24–S25**
 multiple daily injections (MDI), S72–S73, S76, S91
- naltrexone/bupropion ER, S84
 nateglinide, S96
 neonatal diabetes, S24, **S25**
 nephropathy. *see* chronic kidney disease

- neuropathy, **S131–S133**. *see also* autonomic neuropathy; peripheral neuropathy
 characterization, S131
 children and adolescents, S155, S158
 diagnosis, S131–S132
 distal symmetric polyneuropathy, S131
 erectile dysfunction, S133
 foot care, **S133–S135**
 gastrointestinal, S132
 gastroparesis, S133
 neuropathic pain, S132, S133
 orthostatic hypotension, S133
 pharmacology, S132–S133
 recommendations, S131
 screening, S131
 treatment, S131, S132
- niacin, S112
 NICE-SUGAR study, S174
 nifedipine, S106
 NODAT, S23
 nonalcoholic fatty liver disease (NAFLD), S4, S6, **S40**, S158–S159
 non-Hispanic whites. *see* Caucasians
 nonnutritive sweeteners, S5, S49, S51
 nonproliferative diabetic retinopathy, S53
 NPH/Regular 70/30, S97, S99, S175
 nucleoside reverse transcriptase inhibitors (NRTIs), S41
- nutrition. *see also* medical nutrition therapy
 medical evaluation of, S40
 micronutrients, S49
 obesity management, **S82–S83**
 revisions summary, S4
 type 2 diabetes prevention/delay, **S30**
- obesity management, **S81–S87**
 antihyperglycemics, S83
 approved medications, S83–S85
 assessment, **S81–S82**
 behavioral therapy, **S82–S83**
 benefits of, S81
 cardiovascular disease and, S82
 children and adolescents, S150, S155, S156
 concomitant medications, S83
 hypertension, S107
 lipohypertrophy, S91
 medical devices, S85
 medical nutrition therapy, S48–S51
 metabolic surgery, **S85–S87**
 nutrition, **S82–S83**
 pharmacotherapy, S83–S84
 physical activity, **S82–S83**
 pregnancy, S169
 revisions summary, S5
 treatment options, S82
 type 2 diabetes, S82–S83
 weight loss, S48–S51
- obstructive sleep apnea, S41, S158, S159
 olanzapine, S83
 older adults, **S139–S146**
 A1C in, S141, S142
 aspirin and, S113–S114
 complications, reduced functionality, S64, S141
 DSMES, S141
 frailty in, S141–S142
 healthy, good functional status, S141, S142
 hypertension in, S141
 hypoglycemia in, S67, **S140**, S145
 hypoglycemic admissions prevention, **S179**
 insulin therapy, S142–S143, S145
 lifestyle management, **S141–S142**
 long-term care facilities, S144, S145
 neurocognitive function, **S140**
- palliative/end-of-life care, S141, S144, **S146**
 pharmacology, S94, S96–S97, **S142–S145**
 physical activity recommendations, S51
 recommendations, S139
 revisions summary, S6
 screening, S139–S140
 skilled nursing facilities, S144, S145
 stroke in, S139, S142
 treatment goals, **S140–S142**
 treatment simplification/deintensification/deprescribing, S144
- one-step strategy, GDM, S21–S22
 oral glucose tolerance test (OGTT), S14, S20, S22
 orlistat, S84
 orthostatic hypotension, S133
 oxygen in meter accuracy, S74
 palliative/end-of-life care, S141, S144, **S146**
 pancreas transplantation, S92
 pancreatitis, S13, **S40**, S112, S116
 parenteral/enteral feedings, S177
 patient-centered care
 collaborative model of, **S34–S36**
 pharmacology, S92, S93
 population health, S7–S8
- PCSK9 inhibitors, S111, S113
 pediatrics. *see* children and adolescents
 periodontal disease screening, S41
 peripheral arterial disease, S133, S134
 peripheral neuropathy
 characterization, S131
 diagnosis, S131–S132
 micronutrients/supplements, S51
 pharmacology, S31
 physical activity and, S53
 pre-exercise evaluation, S52–S53
 treatment, S131
- pharmacology, **S90–S99**. *see also* specific medications, medication classes
 cardiovascular disease, S115–S119
 cardiovascular disease outcomes, S98
 children and adolescents, S156–S158
 combination injectable, S99
 combination therapy, S93–S94, S97–S98
 costs, S96, S98
 dual therapy, S92
 gestational diabetes mellitus, S168
 hypertension, S107–S113
 initial therapy, S92–S97
 injectables, S5, S97–S98
 medication adherence, S9
 medications as risk factor, S20
 obesity management, S83–S84
 older adults, S94, S96–S97, **S142–S145**
 patient-centered care, S92, S93
 patient factors, S5
 revisions summary, S5
 type 1 diabetes, **S90–S92**
 type 2 diabetes, **S92–S98**
 type 2 diabetes prevention/delay, **S31**
- phentermine, S84
 phentermine/topiramate ER, S84
 photocoagulation therapy, S129–S131
 physical activity, **S51–S53**
 autonomic neuropathy and (*see* autonomic neuropathy)
 benefits, S52
 children and adolescents, S51, S52, S149–S150, S156
 DPP goals, S30
 frequency/type of, S52
 glycemic control and, S52
 hypoglycemia and, S53
 kidney disease, S50, S53
 obesity management, **S82–S83**
 peripheral neuropathy and (*see* peripheral neuropathy)
 pre-exercise evaluation, S52–S53
 recommendations, S51
 retinopathy and, S53
 revisions summary, S5
 type 2 diabetes prevention/delay, **S30–S31**
- physician order entry, S174
 pioglitazone, S96
 pneumococcal pneumonia vaccine, S36, S38
 point-of-care meters, S175
 polycystic ovary syndrome, S159, S167, S168
 population health
 care delivery systems, **S8**
 community screening, S20
 defined, S7
 patient-centered care, S7–S8
 recommendations, S7
 posttransplantation diabetes mellitus, **S23–S24**
 pramlintide, S92, S96
 preconception counseling
 children and adolescents, S150, S151
 contraception, S170
 pregnancy, **S165–S166**
- prediabetes
 diagnosis, **S17–S20**
 gestational diabetes mellitus, S170
 HIV and, S41
 physical activity recommendations, S51
 serious mental illness and, S43
 type 2 diabetes prevention/delay, **S30–S32**
- pregabalin, S132
 pregnancy, **S165–S170**
 A1C values in, S14, S15, S166, S167
 antihypertensives and, S106
 contraception, S170
 diabetes, preexisting, **S168–S169**
 diabetes risks in, S165
 diabetic ketoacidosis, S169
 drugs contraindicated, S106, S169
 gestational diabetes mellitus, S6, S13, **S20–S23**, S76, **S167–S170**
 glucose monitoring in, S166–S167
 glycemic targets in, **S166–S167**, S169
 hypertension in, S104, S106
 insulin physiology in, S166
 low-carbohydrate diets, S30, S48, S50
 medical nutrition therapy, S48, S51
 obesity management, S169
 OGTT values in, S22, S169
 postpartum care, **S169–S170**
 preconception care, S166
 preconception counseling, **S165–S166**
 preeclampsia, S106, S167–S169
 real-time CGM in, S76
 retinopathy and, S129, S130
 revisions summary, S6
- premixed insulin products, S97, S99, S175
 progestins, S83
 proliferative diabetic retinopathy, S53
 protease inhibitors (PIs), S41
 protein, S49, S50

- psychosocial/emotional disorders evaluation, S41–S42, **S54–S55**
- P2Y12 inhibitors, S113, S114
- pump. *see* insulin pump
- quality of care
 evaluation of, S9
 hospital care delivery standards, **S173–S174**
 quality assurance standards in, S174
 scientific evidence-grading system, **S2**
 system-level improvement strategies, S8
- ranibizumab, S129, S130
- rapid-acting insulin analogs, S97
- real-time CGM, S75–S76
- referrals, S40, S55, S129
- repaglinide, S96
- resistance exercise, S52
- retinal photography, S130
- retinal screening, S5
- retinopathy, **S129–S131**
 adjunctive therapy, S131
 anti-VEGF, S129–S131
 children and adolescents, S154–S155, S158–S159
 epidemiology, S129–S130
 macular edema, S129, S131
 photocoagulation therapy, S129–S131
 physical activity and, S53
 pregnancy and, S129, S130, S166
 proliferative, S130
 recommendations, S129
 screening, S129, S130
 treatment, S129–S131
 type 1 diabetes, S129, S130
 type 2 diabetes, S129, S130
- Risk Estimator Plus, S104
- risperidone, S83
- rosiglitazone, S96
- rosuvastatin, S111
- Roux-en-Y gastric bypass, S86
- SAVOR-TIMI trial, S117, S118
- saxagliptin, S96
- schizophrenia, S43
- school/child care, S150
- scientific evidence-grading system, **S2**
- scientific reviews, S2
- SEARCH study, S154
- self-monitoring of blood glucose (SMBG), **S73–S74**
 accuracy, S74, S75
 A1C testing and, S62
 basal insulin/oral agents, S73–S74
 glucose assessment by, S62–S63
 hospital care, **S177**
 intensive insulin regimens, S73
 optimization, S73
 recommendations, S73
- semaglutide, S96, S98, S116
- SGLT2 inhibitors
 cardiovascular disease and, S65, S92, S98, S114–S116
 in chronic kidney disease, S127, S128
 in combination therapy, S93–S94, S97–S98
 contraindications, S176
 costs, S96
- heart failure, S119
- hospital care, S176
- indications, considerations, S93
- low-carbohydrate eating plans and, S50
- older patients, S145
- stroke and, S115–S116
- type 1 diabetes, S92
- shoes, S134
- short-acting insulin analogs, S97
- sickle cell disease, S14
- simvastatin, S111
- sitagliptin, S96
- skilled nursing facilities, S144, S145
- sleep
 hypoglycemia prevention, S68, S170
 obstructive sleep apnea, S41, S158, S159
 pattern/duration assessment, S36
 pregnancy and, S170
 quality effects, S36
- smoking, S31, **S53–S54**, S154
- social determinants of health, **S9–S10**
- sodium, S49, S51
- sodium consumption, S5
- sotagliflozin, S92
- spironolactone, S106, S129
- SPRINT trial, S105–S106
- SSRIs, S83, S84
- statins
 cognition, effects on, S40
 cognitive function and, S113
 in combination treatment, S111, S112
 diabetes with, S112–S113
 dosing strategies, S111
 patients <40 years, S111–S112
 primary prevention, S110
 randomized trials, S110–S113
 recommendations, S109–S110
 risk-based therapy, S110
 secondary prevention, S111
 type 1 diabetes, S111–S112
 type 2 diabetes, S110
- stroke
 in children and adolescents, S158
 combination therapy and, S112
 CVD outcomes trials, S115–S117
 GLP-1 receptor agonists and, S116
 hospital care, S174
 hypertension treatment and, S105–S106
 ischemic, S112, S114
 in older adults, S139, S142
 risk reduction, S65, S105–S106, S111, S113
 screening, S114
 SGLT2 inhibitors and, S115–S116
- structured discharge communication, S178–S179
- sulfonylureas
 in combination therapy, S93–S94, S97–S98
 costs, S96
 gestational diabetes mellitus, S168
 indications, considerations, S93
 older patients, S143
- SUSTAIN-6 trial, S116–S118, S127
- sweeteners, S5
- tai chi, S51
- tapentadol, S132–S133
- TCAs, S83
- technology. *see also* continuous glucose monitoring (CGM); self-monitoring of blood glucose (SMBG)
 definitions, S71
 in diabetes management, **S71–S77**
- in diabetes prevention, S29, S31
- insulin pumps, S72–S73, S76, S91
- point-of-care meters, S175
- TECOS trial, S117, S118
- telemedicine, S4, S5, S8–S9, S31, S129
- temperature in meter accuracy, S74
- testosterone level evaluation, S41
- thiazolidinediones
 in combination therapy, S93–S94, S97–S98
 costs, S96
 heart failure, S118
 indications, considerations, S93
 older patients, S143
 in renal transplant recipients, S24
 type 2 diabetes prevention/delay, **S31**
- thought disorders, S43
- thyroid disease, S152
- tobacco use, S31, **S53–S54**, S154
- TODAY study, S157–S158, S160
- 2-h plasma glucose (2-h PG), S14, S15
- two-step strategy, GDM, S21, S22
- type 1 diabetes
 albuminuria in, S127
 autoimmune conditions in, S152
 autoimmune diseases evaluation, S39
 cardiovascular disease and, S65
 celiac disease, S152–S153
 CGM in, S76
 in children and adolescents, S13–S14, **S148–S155**
 classification, S13–S14
 diagnosis, S15, **S16–S17**
 eating patterns, S48
 hospital care, S176
 idiopathic, S16
 noninsulin treatments, S91–S92
 pathophysiology, S14
 pharmacology, **S90–S92**
 physical activity benefits, S52
 preconception care, S166
 pregnancy, **S168–S169**
 recommendations, S16
 retinopathy, S129, S130
 risk screening, S16–S17
 staging, S14
 statins, S111–S112
 surgical treatment, **S92**
 thyroid disease, S152
- type 2 diabetes
 cancer evaluation, S39
 cardiovascular disease and, S65
 CGM in, S76
 children and adolescents, S17, S18, **S155–S160**
 chronic kidney disease and, S128
 classification, S13–S14
 combination therapy, S93–S94, S97–S98
 diagnosis, **S17–S20**, S155–S156
 DKA in, S18
 dyslipidemia in, S112
 insulin therapy, S95, S98–S99
 Internet-based DSMES, S47
 obesity management, S82–S83
 pathophysiology, S18
 pharmacology, **S92–S98**
 pharmacology, algorithm, S94
 pregnancy, **S168–S169**
 prevention/delay, **S29–S32**, S52
 retinopathy, S129, S130
 risk factors, S18, S20, S30
 screening/testing, S17–S20, S155

-
- statins, S110
 - U-500 Human Regular insulin, S97
 - UK Prospective Diabetes Study (UKPDS), S64, S66, S115
 - vaccinations, S36–S39
 - VADT study, S64, S65
 - vitamin B12 deficiency, S31, S92
 - vitamin C, S51
 - vitamin E, S51
 - water intake, S5
 - weight loss. *see* obesity management
 - whites. *see* Caucasians
 - yoga, S51



American
Diabetes
Association®

79TH
SCIENTIFIC
SESSIONS

SAN FRANCISCO, CA • JUNE 7 - 11, 2019

CALL FOR BREAKTHROUGH RESEARCH

ABSTRACT SUBMISSION CLOSES JANUARY 7, 2019

Submit your research to the world's largest, most prominent meeting on diabetes—The American Diabetes Association's Scientific Sessions. Share your research with colleagues from around the world. Accepted abstracts are published in the journal *Diabetes*®. A limited number of travel grants are available to qualified early career investigators.

Late breaking abstract submission opens on February 1, 2019 and closes on March 11, 2019.

Visit our website at scientificsessions.diabetes.org.