


Practical Biochemistry

**Estimation Of
Blood Glucose In
Diabetes Mellitus**

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- ✓ **Comparison Of Type 1 And Type 2 Diabetes Mellitus.**
 - ✓ **Laboratory Tests For Glucose .**
 - ✓ **Criteria for Diagnosis of Diabetes Mellitus.**
 - ✓ **Urinalysis using dipstick.**
 - ✓ **Measurement Of Blood Glucose Level Using Glucometer**

Introduction into Blood Glucose

➤ **Blood glucose** is normally regulated and maintained within a narrow range under various conditions by **insulin** (decrease blood glucose), **glucagon** (increase blood glucose) and other hormones ¹.

➤ **Diabetes Mellitus (DM)** is the most common disorder of carbohydrate metabolism, characterized by **high blood glucose level (hyperglycemia)** i.e. unbalance of this regulation.

➤ **Common signs, symptoms & Lab results of DM:**

Hyperglycemia

Polyuria² and
Glucosuria³

Polydipsia⁴

Polyphagia⁵

➤ **Measurement of blood glucose*** is one of the most commonly performed tests in clinical biochemistry labs of hospitals. *for diagnosis of DM, after that to monitor effect of medication & disease progression.

1: other hormones like: **Growth hormone, Cortisol & Epinephrine** which increase blood glucose.

2: production of abnormally large volumes of dilute urine.

3: Glycosuria or glucosuria is the excretion of glucose into urine.

4: Excessive thirst as a symptom of disease (such as diabetes).

5: Excessive hunger

Comparison Of Type 1 And Type 2 Diabetes Mellitus

➤ Diabetes has two types:

	Type 1 Diabetes	Type 2 Diabetes
Age of onset	Usually during childhood or puberty	Frequently after age 35
Prevalence %	10% of diagnosed diabetics	90% of diagnosed diabetics
Defect or Deficiency	β cells are destroyed, eliminating insulin production (Type 1= defect in β cells)	Insulin resistance combined with inability of β cells to produce appropriate quantities of insulin (Type 2= Insulin R. + defect in β cells)
Ketoacidosis ¹	Common	rare
Plasma Insulin	Low to absent	High → early in disease low → in disease of long duration
Treatment	Insulin is always necessary	<ol style="list-style-type: none"> 1. Diet and exercise 2. Oral hypoglycemic drugs 3. +/- insulin, required at advance stages, not from the beginning.

*Know the difference between the two types, b/c they might give a case & ask for diagnosis

1: Diabetic ketoacidosis is a serious complication of diabetes that occurs when your body produces high levels of blood acids called ketones. The condition develops when your body can't produce enough insulin

Laboratory Tests For Glucose

Lab tests for Glucose

Fasting plasma glucose: is a measurement of plasma glucose after 12 hours of fasting (no caloric intake). **Normal blood glucose range: 3.9 – 5.6 mmol/L (70–100 mg/dL)**

Oral Glucose tolerance Test (OGTT) and 2-hour post-prandial test: Serial measurement of plasma glucose before and after a specific amount of glucose given orally (75g glucose). Normal level: <140 mg/dl (< 7.8 mmol/L)

HEMOGLOBIN A_{1c} measurement: used to estimate glycemic control in the last 1-2 months & Recommended for **the detection of type 2 DM**. Normal level : 4 – 5.6 %

Random Plasma Glucose Level

Doctor mentioned that normal values will be given in the exam, but it's better if you memorize them. Only know **mg/dl** (divide by 18 to get values in mmol/L)

HEMOGLOBIN A_{1c}:

- Hemoglobin A_{1c} (A_{1c}) is produced due to non-enzymatic glycosylation of hemoglobin.
- It is used to estimate glycemic control in the last 1-2 months.
- Recommended for the detection of **type 2 Diabetes Mellitus**.
- **HBA_{1c}** and **fasting plasma glucose** are effective in diagnosing diabetes.
- Cut-off point of **≥ 6.5 %** is used to diagnose diabetes.

Q: When does someone is said to have an impaired glucose tolerance (Pre-diabetes state) ?

- **When fasting plasma glucose OR 2-hour postprandial glucose level is above normal but below diabetic level.**

CRITERIA FOR DIAGNOSIS OF DIABETES MELLITUS

Categories Of Increased Risk of DM & Diagnosis Of DM		
Test performed	Pre-diabetes	Diabetes
Fasting Plasma Glucose (FPG)	FPG or [IFG] ¹ : 100 - 125 mg\dl 5.6 - 6.9 mmol/L	(fasting= No caloric intake for at least 8hs) 126 mg\dl and over 7 mmol/L and over
2 hours post glucose on the 75-g OGTT	OGGT or [IGT] ² : 140 – 199 mg\dl 7.8 – 11.0 mmol/L	200 mg\dl and over 11.1 mmol/L and over
HA _{1c}	5.7% - 6.4 %	6.5% and over
Random Plasma Glucose Level	—	200 mg/dl and over 11.1 mmol/L and over + signs and symptoms of hyperglycemia or hyperglycemic crisis

You can memorize values in **mg/dl** only (divide by 18 to get values in mmol/L)

Ketone Bodies, what are they ?

A: They are Produced by the liver and utilized for energy production by peripheral tissues (common in type I DM).

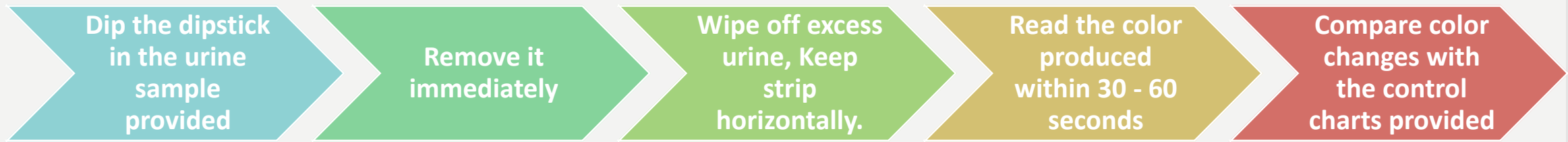
- Acetone (exhaled by lungs, gives characteristic “fruity” smell in diabetic ketoacidotic patients) → Acetone breath
- Acetoacetate
- β-Hydroxybutyrate

URINALYSIS USING DIPSTICK

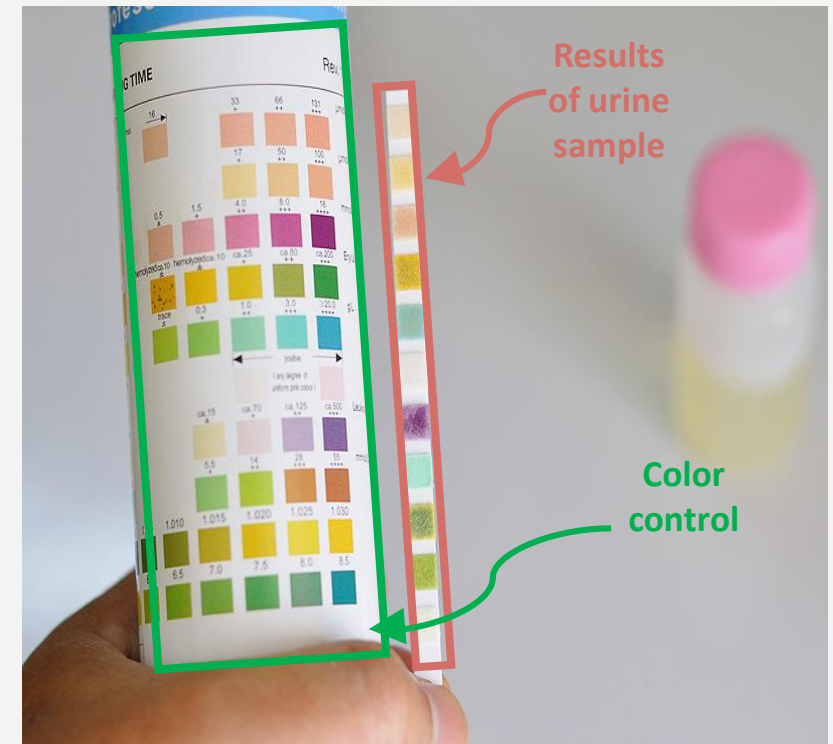
Principle :

- **Dipsticks** are plastic strips impregnated with chemical reagents which react with specific substances in the urine to produce color-coded visual results.
- They provide quick determination of → pH, protein, glucose and ketones.
- The depth of color produced is directly proportional to the conc. of the substance in urine.
- Color controls “the references” are provided against which the actual color produced by the urine sample can be compared. **“You must know how to compare color changes with the control charts.”**
- The reaction times of the impregnated chemicals are standardized.

Procedure :



(Color changes after 2 mins are of no significance)



Changes In Urine Dipstick Observed In Diabetic Patients And Their Interpretation

Physical examination		
Parameter	Results	Interpretation
Appearance	Clear	Normal
Color	Colorless	Polyuria
Odor	Fruity (in case of DKA ¹)	↑ Ketogenesis
Chemical parameters "important"		
Test	Results	Interpretation
Urine Glucose	+	Glucosuria
Urine Protein	May be present (in case of nephropathy)	Proteinuria
Urine Ketones	+	↑ Ketogenesis/ Ketonuria
Urine PH	Acidic (in DKA) → 6	Aciduria

*Extra picture, not related to schedule:



You might get a picture similar to this in the exam , and be asked to fill the schedule based on comparing the urine dipstick test of patient with color control.

Extra: Presence of nitrate in urine indicates infection * الجدول كله عبارة عن خصائص اليورن تيست لمرضى السكري

Measurement Of Blood Glucose Level Using Glucometer

Instructions:

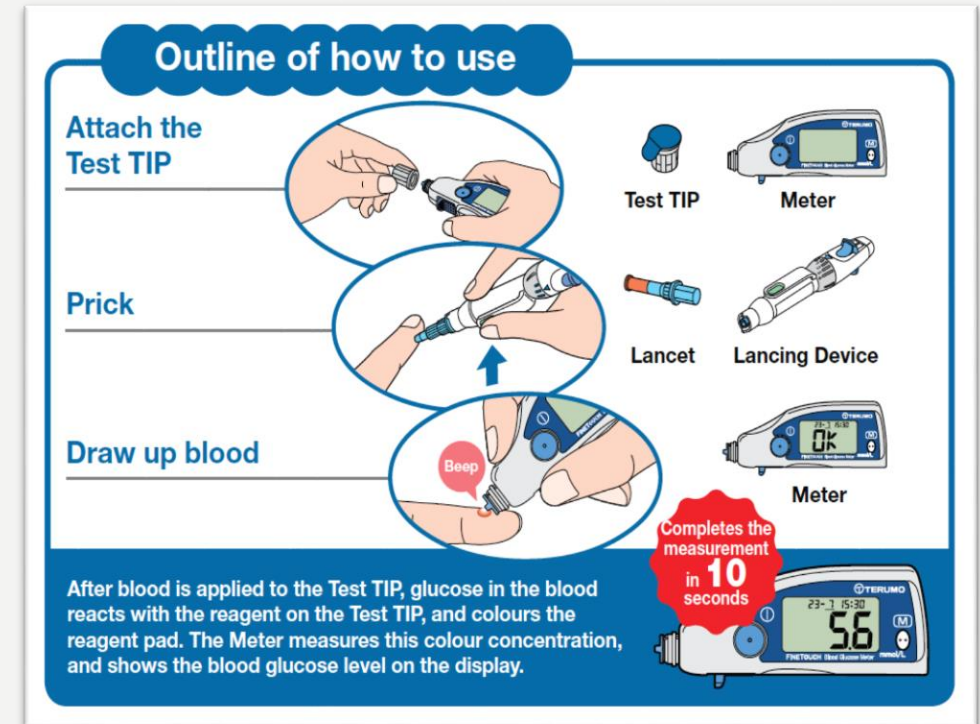
طريقة عمل التست غالبًا ما راح تجي بالاختبار ، لكن ما يمنع تقرونها :

1. Attach the test tip to the glucometer as shown.
2. The meter will read "OK" indicating that it is working properly.
3. Disinfect your fingertip using an alcohol swab. Let it dry.
4. Prick the finger using the lancing device.



BIOHAZARD! The lancet in the lancing device is for single use only. Discard it after use.

6. Draw up blood until the glucometer beeps.
7. Wait for 10 seconds until results are displayed.
8. Results can be read as **mmol/L** or **mg/dL**.
9. Interpret your results.



Benefits Of Self-monitoring Of Blood Glucose Level: (Important)

It allows patients to detect their blood glucose levels without visiting a clinic

It helps patients to immediately confirm hypo or hyperglycemia to avoid complications

It facilitates patient education about diabetes and its management by giving them more self-care responsibilities

It helps to promote well-being of patients

TEST YOUR SELF !

Q1) What is your Interpretation of the patient's results :

	Patient A	Patient B	Patient C
FPG	12 mmol/L	6.5 mmol/L	10.2 mmol/L
Hb A1C	10%	6%	9%
Serum ketones	50 mg/dl	Negative	Negative
Urine Ketones	+++	Negative	Negative
Urine Glucose	+++	Negative	++
Protein	+++	Negative	+++
PH	5	7	6.5

Patient A:

- ✓ Very High FPG **"Hyperglycemia"** and this indicates that the patient is diabetic
- ✓ HbA1C is raised which shows his blood glucose level was uncontrolled for the last 2 months, this confirms diabetes.
- ✓ **"Ketonemia"** and **"ketonuria"** indicate that the patient has DKA.
- ✓ **"Glucosuria"** indicates the glucose filtration level is abnormally higher than the kidney threshold.
- ✓ The presence of protein in urine **"proteinuria"** is caused by nephropathy (complication of uncontrolled DM).
Low pH of urine **"Acidic urine"** indicates metabolic acidosis due to increase production of ketone bodies.

The diagnosis is: Diabetes ketoacidosis

Patient B:

- ✓ FPG is higher than normal BUT not diabetic **"Pre-diabetic"** and shows Increase risk of diabetes.
- ✓ HbA1C is raised and shows his blood glucose level was uncontrolled **"high"** for the last 2 months.

The diagnosis is: Impaired Fasting Glucose "PreDiabetes"

Patient C:

- ✓ High FPG **"Hyperglycemia"** and this indicates that the patient is diabetic
- ✓ HbA1C is raised and shows his blood glucose level was uncontrolled **"high"** for the last 2 months.
- ✓ The presence of glucose in urine **"Glucosuria"** which this also indicates the patient has high blood glucose level.
- ✓ And the glucose filtration level is abnormally higher than the kidney threshold.

The diagnosis is: Diabetes Mellitus with nephropathy

Patient A results



TEST YOUR SELF !

Q1) A 50 year male came to the clinic with symptoms of dehydration, polyuria and polydipsia.
A urine sample was taken from him with the following results:

	Observation	Comment
Protein	+++	Proteinuria
Glucose	+++	Glucosuria
Ketone bodies	-	Normal
PH	6	Acidic



Q) What is the most likely diagnosis ?
Diabetes mellitus

Q) What is the reason of presence of protein in the urine sample ?
Nephropathy

N.B: You might be asked to fill the “comment” column .

TEST YOUR SELF !

Q1) A known diabetic was presented to the emergency room with symptom of confusion, weakness, fruity breath, nausea and vomiting, the picture shows the results of his urine dipstick test:

	Observation	Comment
Color	Colorless	Polyuria
Odor	Fruity	Ketones
Protein	-	Normal
Glucose	+++	Glucosuria
Ketone bodies	+++	Ketonuria
PH	6	Acidic



Q) What is your most likely diagnosis ?
Diabetic ketoacidosis

Q) Name the three molecules of ketone bodies ?

- ✓ Acetoacetate
- ✓ Acetone
- ✓ β -Hydroxybutyrate

TEST YOUR SELF !

Q) 60 year old female presented with polyphagia, fatigue and blurred vision. She is retired since 13 years staying at home most of the time. Despite losing weight, her BMI is 33. She mentioned that she had to wake up during the night to urinate in the pas 3 weeks. She has no family history of diabetes. The general practitioner ordered a blood glucose tests and the results were as the following:

	Result	Normal Range
OGTT	231 mg\dl (12.8 mmol\L)	<140 mg\dl < 7.8 mmol\L
HA _{1c}	7.1 %	4 – 5.6 %

Q) What is the most likely diagnosis ?

Diabetes mellitus type 2

Q) What are the factors which predisposed her to such a condition ?

- ✓ **Obesity.**
- ✓ **Sedentary life style.**
- ✓ **Aging**

Q) Name two complications associated with her situation ?

- ✓ **Retinopathy**
- ✓ **Neuropathy**

Q) What is the main underlying cause of her disease ?

Insulin resistance

**Good
Luck
with
your
Exam**



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