Liver Function Tests (LFTs)

GNT/Hematology Block

Objectives

Upon completion of this lecture, the students should be able to:

- Understand the major metabolic functions of the liver and causes of liver dysfunction.
- Discuss markers of liver function tests such as liver enzymes, bilirubin, albumin and prothrombin time that can diagnose hepatic injury and assess hepatic function.

Major Metabolic Functions of the Liver

- **Synthetic Function**
  - Plasma proteins (albumin, globulins), cholesterol, triglycerides and lipoproteins
- **Detoxification and excretion**
  - Ammonia to urea (urea cycle), bilirubin, cholesterol, drug metabolites
- **Storage Function**
  - Vitamins A, D, E, K and B_{12}
- **Production of bile salts**
  - Helps in digestion

Some example of liver dysfunction

- Hepatocellular disease
- Cholestasis (obstruction of bile flow)
- Cirrhosis
- Hepatitis
- Jaundice
- Liver cancer
- Steatosis (fatty liver)

- *Genetic Disorders*
  - Hemochromatosis (iron storage)

Liver Function Tests (LFTs)

- Noninvasive methods for screening of liver dysfunction
- Help in identifying general types of disorder
- Assess severity and allow prediction of outcome
- Disease and treatment follow up

Liver Function Tests (LFTs)

Broadly classified as:

1. Tests to detect hepatic injury:
   - Mild or severe; acute or chronic
   - Nature of liver injury (hepatocellular or cholestasis)

2. Tests to assess hepatic function

Classification of LFTs

Group I: Markers of liver dysfunction

- Serum bilirubin: total and conjugated
- Urine: bile salts and urobilinogen
- Total protein, serum albumin and albumin/globulin ratio
- Prothrombin Time

Classification of LFTs

Group II: Markers of hepatocellular injury

- Alanine aminotransferase (ALT)
- Aspartate aminotransferase (AST)

Classification of LFTs

Group III: Markers of cholestasis

- Alkaline phosphatase (ALP)
- γ-glutamyltransferase (GGT)

Limitations of LFTs

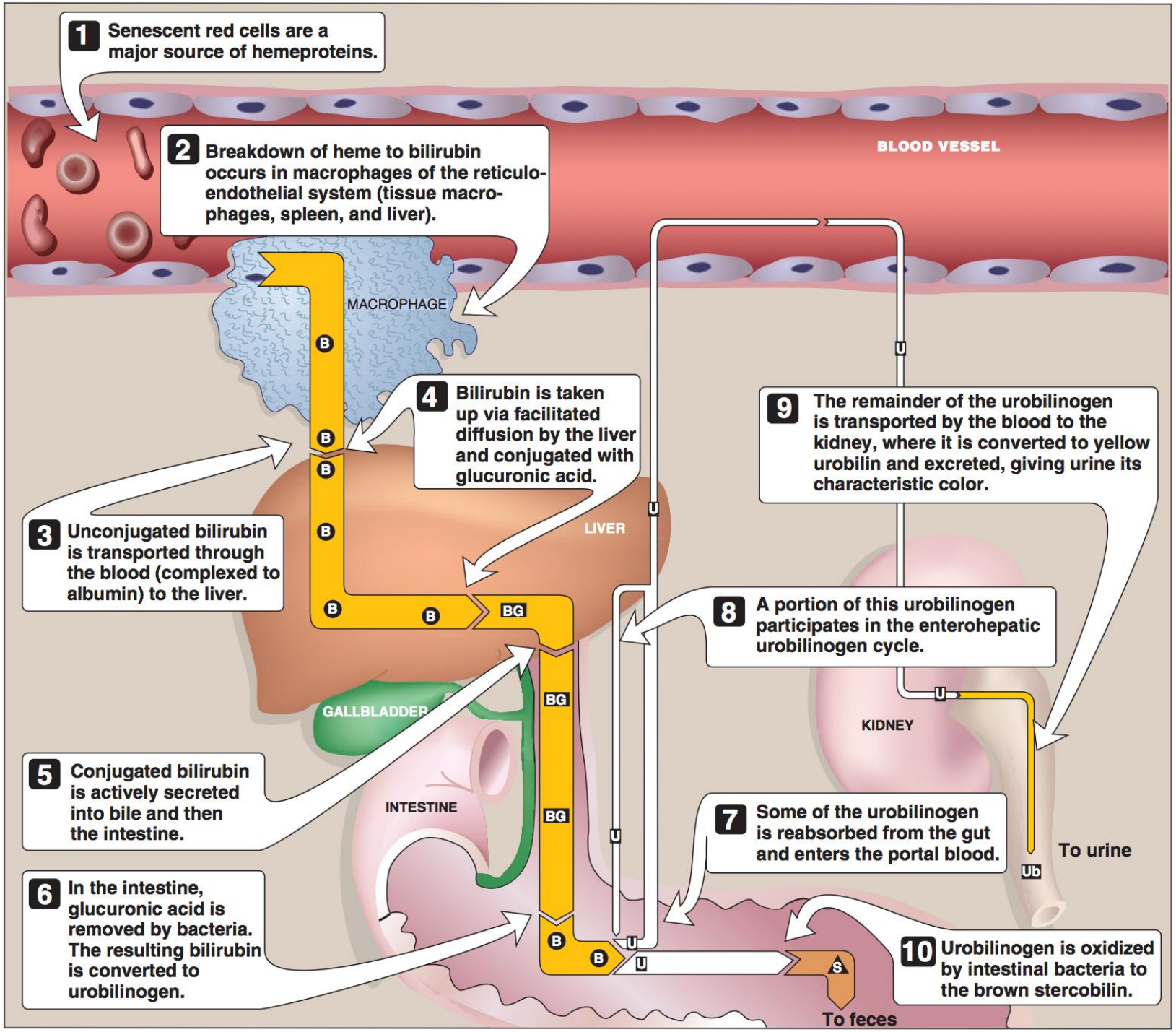
- Normal LFT values do not always indicate absence of liver disease
  - Liver a has very large reserve capacity
- Asymptomatic people may have abnormal LFT results
  - Diagnosis should be based on clinical examination

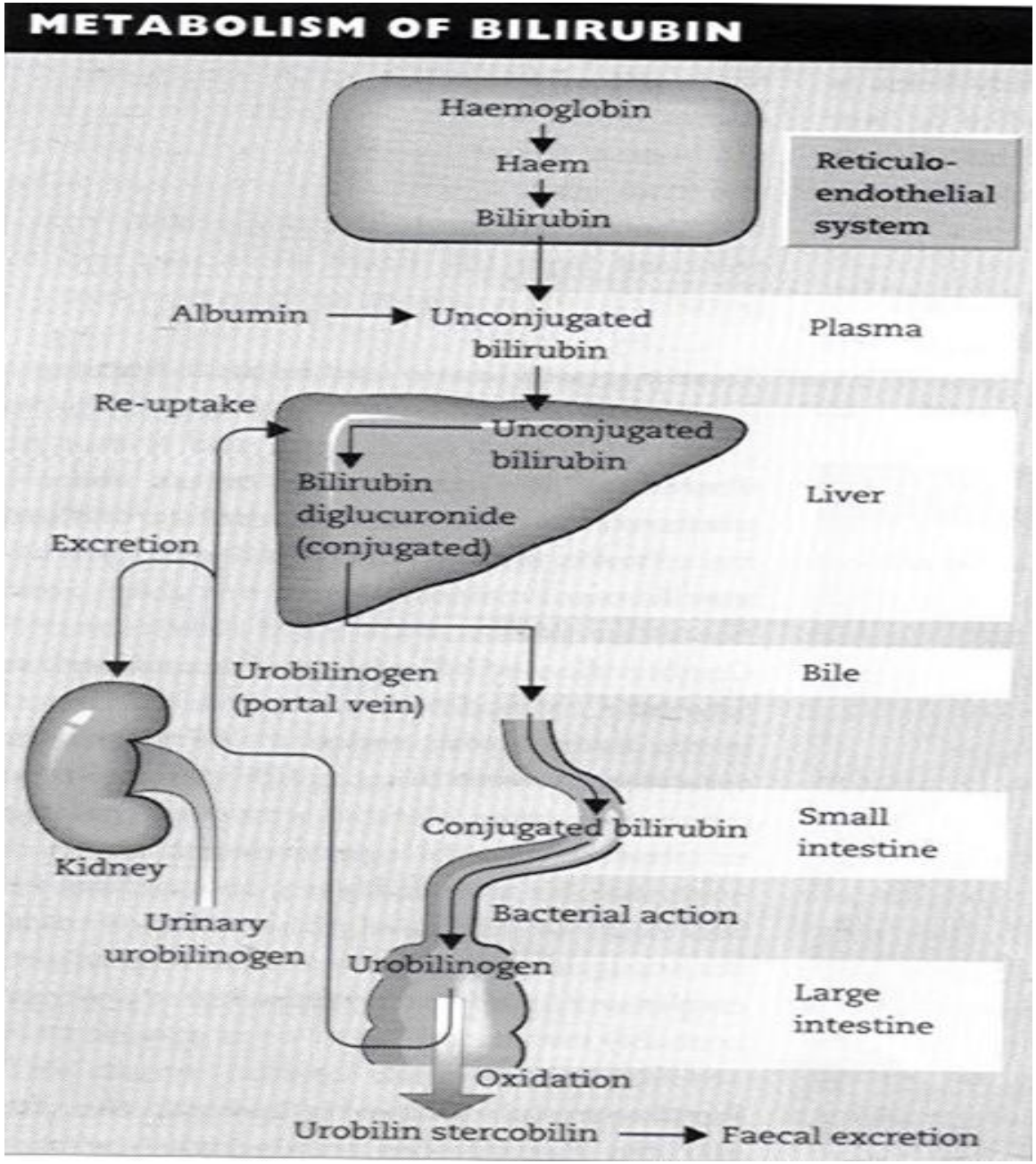
Common serum liver chemistry tests

Liver chemistry test	Clinical implication of abnormality
Alanine aminotransferase	Hepatocellular damage
Aspartate aminotransferase	Hepatocellular damage
Bilirubin	Cholestasis, impaired conjugation, or biliary obstruction
Alkaline phosphatase	Cholestasis, infiltrative disease, or biliary obstruction
Prothrombin time	Synthetic function
Albumin	Synthetic function
γ-glutamyltransferase	Cholestasis or biliary obstruction
Bile acids	Cholestasis or biliary obstruction

Bilirubin

- A byproduct of red blood cell breakdown
- It is the yellowish pigment observed in jaundice
- High bilirubin levels are observed in:
  - Gallstones, acute and chronic hepatitis


1 Senescent red cells are a major source of hemeproteins.
2 Breakdown of heme to bilirubin occurs in macrophages of the reticulo-endothelial system (tissue macrophages, spleen, and liver).
BLOOD VESSEL
MACROPHAGE
3 Unconjugated bilirubin is transported through the blood (complexed to albumin) to the liver.
4 Bilirubin is taken up via facilitated diffusion by the liver and conjugated with glucuronic acid.
LIVER
GALLBLADDER
5 Conjugated bilirubin is actively secreted into bile and then the intestine.
INTESTINE
6 In the intestine, glucuronic acid is removed by bacteria. The resulting bilirubin is converted to urobilinogen.
7 Some of the urobilinogen is reabsorbed from the gut and enters the portal blood.
8 A portion of this urobilinogen participates in the enterohepatic urobilinogen cycle.
9 The remainder of the urobilinogen is transported by the blood to the kidney, where it is converted to yellow urobilin and excreted, giving urine its characteristic color.
KIDNEY
To urine
10 Urobilinogen is oxidized by intestinal bacteria to the brown stercobilin.
To feces
B
BG
U
Ub
S


METABOLISM OF BILIRUBIN
Haemoglobin
Haem
Bilirubin
Reticulo-endothelial system
Albumin
Unconjugated bilirubin
Plasma
Re-uptake
Unconjugated bilirubin
Bilirubin diglucuronide (conjugated)
Liver
Excretion
Urobilinogen (portal vein)
Bile
Kidney
Conjugated bilirubin
Small intestine
Urinary urobilinogen
Bacterial action
Urobilinogen
Large intestine
Oxidation
Urobilin stercobilin
Faecal excretion

Serum bilirubin levels

- Normal
  - 0.2 – 0.8 mg/dL
- Unconjugated (indirect):
  - 0.2 – 0.7 mg/dL
- Conjugated (direct):
  - 0.1 – 0.4 mg/dL
- Latent jaundice:
  - Above 1 mg/dL
- Jaundice:
  - Above 2 mg/dL

Bilirubin levels and jaundice

Class of Jaundice	Causes
Pre-hepatic or hemolytic	Abnormal red cells; antibodies; drugs and toxins; thalessemia Hemoglobinopathies, Gilbert's, Crigler-Najjar syndrome
Hepatic or Hepatocellular	Viral hepatitis, toxic hepatitis, intrahepatic cholestasis
Post-hepatic	Extrahepatic cholestasis; gallstones; tumors of the bile duct, carcinoma of pancreas

Urobilinogen (UBG) and bile salts

- Most UBG is metabolized in the large intestine but a fraction is excreted in urine (less than 4 mg/day)
- Normally bile salts are NOT present in urine
- Obstruction in the biliary passages causes:
  - Leakage of bile salts into circulation
  - Excretion in urine

Serum Albumin

- The most abundant protein synthesized by the liver
- Normal serum levels: 3.5 – 5 g/dL
- Synthesis depends on the extent of functioning liver cell mass
- Longer half-life: 20 days
- Its levels decrease in all chronic liver diseases

Serum Globulin

- Normal serum levels: 2.5 – 3.5g/dL
- α and β-globulins mainly synthesized by the liver
- They constitute immunoglobulins (antibodies)
- High serum γ-globulins are observed in chronic hepatitis and cirrhosis:
  - IgG in autoimmune hepatitis
  - IgA in alcoholic liver disease

Albumin to globulin (A/G) ratio

- Normal A/G ratio: 1.2/1 – 1.5/1
- Globulin levels increase in hypoalbuminemia as a compensation

Prothrombin Time (PT)

- Prothrombin: synthesized by the liver, a marker of liver function
- Half-life: 6 hrs. (indicates the present function of the liver)
- PT is prolonged only when liver loses more than 80% of its reserve capacity
- Vitamin K deficiency also causes prolonged PT
- Intake of vitamin K does not affect PT in liver disease

Aspartate aminotransferase (AST)

- Normal range: 8 – 20 U/L
- A marker of hepatocellular damage
- High serum levels are observed in:
  - Chronic hepatitis, cirrhosis and liver cancer

Alanine aminotransferase (ALT)

- More liver-specific than AST
- Normal range (U/L):
  - Male: 13-35
  - Female: 10-30
- High serum levels in acute hepatitis (300-1000U/L)
- Moderate elevation in alcoholic hepatitis (100-300U/L)
- Minor elevation in cirrhosis, hepatitis C and non-alcoholic steatohepatitis (NASH) (50-100U/L)

Alanine aminotransferase (ALT)

- Appears in plasma many days before clinical signs appear
- A normal value does not always indicate absence of liver damage
- Obese but otherwise normal individuals may have elevated ALT levels

Alkaline phosphatase (ALP)

- A non-specific marker of liver disease
- Produced by bone osteoblasts (for bone calcification)
- Present on hepatocyte membrane
- Normal range: 40 – 125 U/L
- Modearte elevation observed in:
  - Infective hepatitis, alcoholic hepatitis and hepatocellular carcinoma

Alkaline phosphatase (ALP)

- High levels are observed in:
  - Extrahepatic obstruction (obstructive jaundice) and intrahepatic cholestasis
- Very high levels are observed in:
  - Bone diseases

γ-glutamyltransferase (GGT)

- Used for glutathione synthesis
- Normal range: 10 – 30U/L
- Moderate elevation observed in:
  - Infective hepatitis and prostate cancers
- GGT is increased in alcoholics despite normal liver function tests
  - Highly sensitive to detecting alcohol abuse

Take Home Messages

- LFTs help detect liver injury and function.
- LFTs do have some limitations.

References

- Lippincott's Illustrated Reviews Biochemistry: 6th edition, Unit IV, Chapter 21, Pages 282 - 285.

- Lecture notes: Clinical Biochemistry: 9th edition, Chapter 13, Pages 174 - 187.

- Clinical Chemistry - Techniques, Principales and Correlations: 6th edition, Chapter 24, Pages 520 -521.