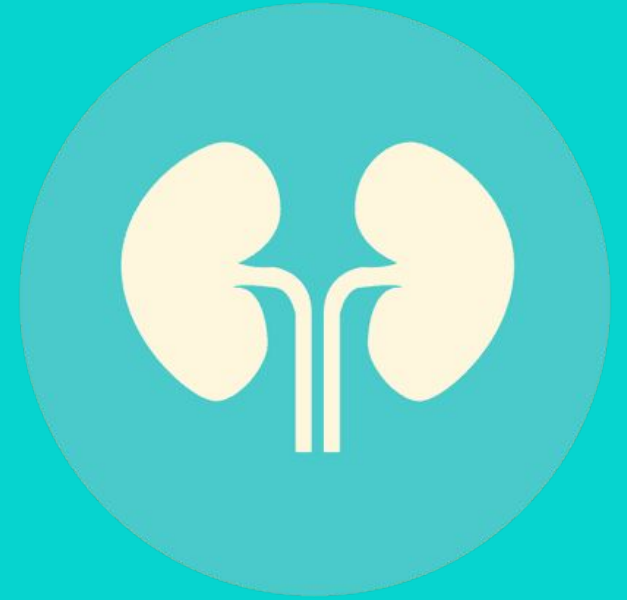


Chemical Examination Of Urine





Objectives:

- ✓ Differentiate between normal and abnormal constituents of urine including: Proteins, sugars, ketone bodies, nitrite, bile pigments, blood etc.
- ✓ To acquire knowledge on the different types of proteinuria (pre-renal, renal and post-renal), blood-uria (hematuria) and glycosuria etc. with clinical examples of each



Overview:

- ☆ Introduction
- ☆ Normal composition of urine
- ☆ Abnormal composition of urine
- ☆ Proteinuria:
 - ★ Prerenal (multiple myeloma)
 - ★ Renal
 - ★ Postrenal
- ☆ Glycosuria:
 - ★ fructosuria
 - ★ galactosuria
- ☆ Ketonuria
- ☆ Hematuria
 - ★ hemoglobinuria



Color Index:

- Important
- Dr's notes
- In females' slides only
- In males' slides only

Urine

- ▶ a fluid excreted by most animals including humans.
- ▶ formed in the **kidneys** "renal glomeruli".
- ▶ Undergoes chemical changes before it is excreted.
- ▶ Normal urine excretion by a healthy person is about **1.5 L** per day.

composition of urine

★ Normal

organic¹

- 1- Non-protein nitrogen (NPN) compounds (mainly)²
- 2- Organic acids³
- 3- Sugars "small amount"
- 4- **Traces**⁴ of :
 - proteins "**<200 mg/day**"
 - vitamins
 - hormones
 - pigments

Inorganic salts

- 1- Sodium
- 2- Potassium
- 3- Chloride
- 4- **Small amounts** of :
 - Ca •Mg •Sulfur •Phosphates
- 5- **Traces**⁴ of :
 - Fe •Cu •Zn •I₂

Abnormal

- 1- Proteinuria "**>200 mg/day**"
- 2- Glycosuria
- 3- Ketonuria
- 4- Choloria
- 5- Nitrites
- 6- Hematuria



Dr's notes :

1. **Organic** : contains carbon & hydrogen
2. **NPNs**: compounds contain nitrogen and not classified as proteins.
e.g.:
 - 1- urea
 - 2- ammonia
 - 3- creatinine
 - 4- uric acid
3. **Organic acids** :
Compounds found as an **intermediate** in many pathways
e.g. uric acid
4. **Traces**: very small
* need unique machine to be indicated

Proteinuria

★ **Definition:** Excretion of abnormal amounts of protein in urine.

	★ Definition	Pathogenesis	★ Example
1. Pre-renal	<p>diseases or abnormal conditions increase plasma protein levels</p> <p>not involving the kidneys. (before reaching it)</p>	<ol style="list-style-type: none"> ↑ plasma protein levels ↑ filtration of proteins in the kidneys exceeding the normal reabsorptive capacity of renal tubules "exceeds renal threshold" overflow of proteins in the urine. 	<p>Multiple Myeloma.</p>

💡 **Extra info :**

1. Antibody: a specialized immune Protein

💡 **Females' doctor notes :**

2. To separate the proteins based on their molecular weight

3. Modification of the electrophoresis by adding specific antibodies against the protein
"more specific & sensitive"

4. to detect the special physical properties of Bence jones proteins

5. these properties are **Specific** for Bence-jones proteins

★ Multiple myeloma:

Cancer (proliferative disorder) of the antibody-producing plasma cells¹

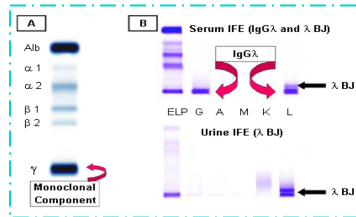
▶ Its serum contains elevated levels of **Bence-Jones protein** diagnosed by :

- Serum electrophoresis²
- Immunoelectrophoresis "immuno-fixation" (for conformation)³
- Blood sample heating⁴

★ Bence-Jones protein:

- ▶ light-chain monoclonal antibodies
- ▶ coagulates at 40-60 °C⁵
- ▶ dissolves at 100 °C⁵

★ Not important



A: serum protein electrophoresis demonstrating the M component.

★ Normally: The most thick band is albumin "because Most of our proteins is albumin" and the others are immunoglobulin.

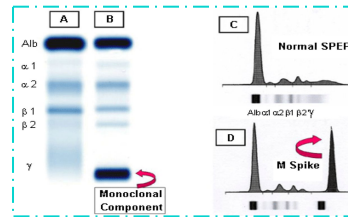
B: serum and urine **immuno-fixation** electrophoresis

★ Antibodies are added that detect:

G : IgG K : kappa light chain
A : IgA L : lambda light chain
M : IgM

★ only the light chains are excreted in urine

★ In this patient the type of Bence-Jones protein is: IgGA



A: normal serum.

B: multiple myeloma showing Monoclonal component in the γ region.

C: densitometry tracing of "A" showing the 5 zones of the high resolution agarose electrophoresis.

D: densitometry of the M component of B, termed the M Spike.

Proteinuria



Males' doctor notes :

1. Recall from the previous lecture: glomerular basement membrane has a molecular size cutoff value of approximately 66 kDa. so high molecular weight proteins > 66 kDa normally can't cross



Females' doctor notes :

2. How do they diagnose it? By taking urine sample after overnight sleeping "after rest"

3. Normal range of albumin in urine (5-10 mg/day)



Extra info :

4. Because they only detect high amounts

2. Renal

	★ Definition	Types	★ Example
<p>Associated with renal disease</p> <p>★ There's involvement of the kidneys</p>		<p>Glomerular proteinuria:</p> <p>1) ↑ glomerular permeability</p> <p>2) filtration of high molecular weight proteins¹</p>	Glomerulonephritis
		<p>Tubular proteinuria:</p> <p>1) ↓ tubular reabsorption with normal glomerular permeability</p> <p>2) excretion of low molecular weight proteins</p>	Chronic nephritis
		<p>Orthostatic (postural) proteinuria²:</p> <p>Persistent benign (physiological) proteinuria</p> <ul style="list-style-type: none"> ★ Common in young adults ★ due to : ↑ pressure on the renal vein ★ Disappears in horizontal posture 	<p>- Periods of vertical posture (body position)</p> <p>- Muscular exercise.</p>
		<p>Transient proteinuria:</p> <ul style="list-style-type: none"> ★ Differentiated from other types of proteinuria by making repeated tests "making the patient stop exercising or after the fever is settled" 	<p>- Heavy exercise.</p> <p>- High fever.</p>
		<p>Microalbuminuria:</p> <ul style="list-style-type: none"> ★ Small amounts of albumin in the urine 20-200 mg/L³ ★ Cannot be detected by ordinary urine testing⁴ → Needs special tests for detection 	<p>Early indicator of glomerular dysfunction due to:</p> <ol style="list-style-type: none"> 1) Uncontrolled diabetes mellitus 2) Hypertension

Proteinuria

	★ Definition	★ Examples
3. Post-renal	<p>Proteins added to the urine after kidney filtration</p> <p>While passing through the lower urinary tract</p> <ul style="list-style-type: none"> • Ureters • bladder • urethra • prostate • vagina 	<ol style="list-style-type: none"> 1) Lower urinary tract infection 2) Trauma 3) Tumors 4) Stones

Glycosuria

★ Definition: presence of sugar in urine.

	★ Definition	Examples
1. Glucosuria	Presence of detectable amount of glucose in urine	<ol style="list-style-type: none"> 1) Uncontrolled Diabetes mellitus : Plasma glucose level exceeds renal threshold ¹ 2) Renal disease (renal glucosuria) : <ul style="list-style-type: none"> • Normal plasma glucose level with proximal tubular malfunction → ↓ renal threshold <p>★ Gestational diabetes ★ Fanconi's syndrome ²</p>
2. Fructosuria	Presence of fructose in urine	<ol style="list-style-type: none"> 1) Alimentary (Nutritional) cause : ↑ fructose intake ³ 2) Metabolic cause : ↓ fructokinase or aldolase B in the liver ⁴
3. Galactosuria	Presence of galactose in urine	<ol style="list-style-type: none"> 1) Alimentary (Nutritional) cause : ↑ galactose intake ³ 2) Metabolic cause : ↓ galactokinase or galactose-1-PO4 uridyl transferase in the liver ⁴



Males' doctor notes :

1. Recall from the previous lecture:
Renal threshold for glucose is: **180 mg/dL**



Females' doctor notes :

2. **Fanconi's syndrome**: a syndrome of inadequate reabsorption in the proximal renal tubules of the kidney. It can be caused by various underlying congenital Diseases, acquired diseases, or by Drug toxicity

3. **Fructose**: in fruits
Galactose: in milk

4. These enzymes are involved in the metabolic (degradation) pathway of (fructose or galactose)

★ ketonuria

Definition	Major Ketone bodies	Examples ¹
Presence of ketone bodies in urine.	Acetone	1) Diabetic ketoacidosis ² (most common)
	Acetoacetic acid "also termed, acetoacetate"	2) Starvation
	β-hydroxybutyric acid	3) Prolonged vomiting 4) Unbalanced diet: high fat & Low Carbohydrate Diet
		5) Phenylketonuria (PKU) ³ : inborn error of amino acid metabolism

Choluria

★ **Definition:** Presence of bile, bilirubin and bile salts in urine

	Definition	Examples
Bilirubin /bile salts	Detection of Bilirubin in urine "normally not detected in urine"	1) Hepatocellular damage 2) Obstruction of bile duct: • Stones (extrahepatic) • Hepatic tumors (intrahepatic)

Urobilinogen

★ Normally present in trace amounts

★ High Urobilinogen is found in :

- 1
 - 2
- 1 Hemolytic anemia

2 Hepatocellular damage



Females' doctor notes :

1 These conditions shift to fatty acid degradation (beta oxidation) to provide energy which produces ketone bodies as byproducts

2 Associated with type 1 diabetes because Type 1 is caused by insulin deficiency unlike type 2 which is caused by insulin resistance

* in the absence of insulin the body start using the fat as an energy source

**that's why patients with type 1 DM are thin unlike type 2 which usually are overweight

3 causes phenyl ketones to build up in the body

In females slides only

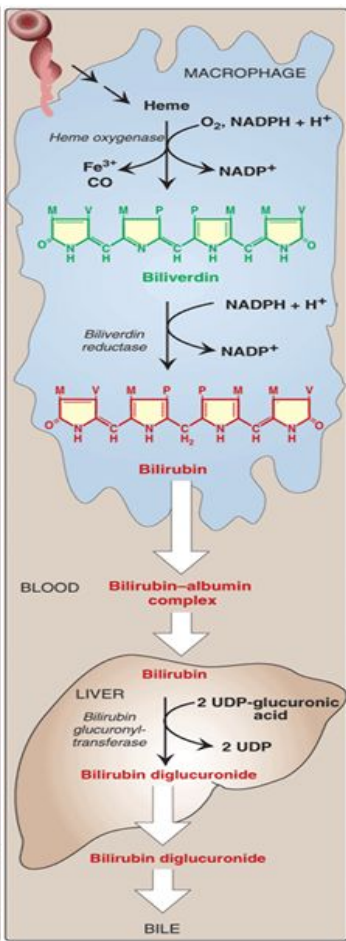
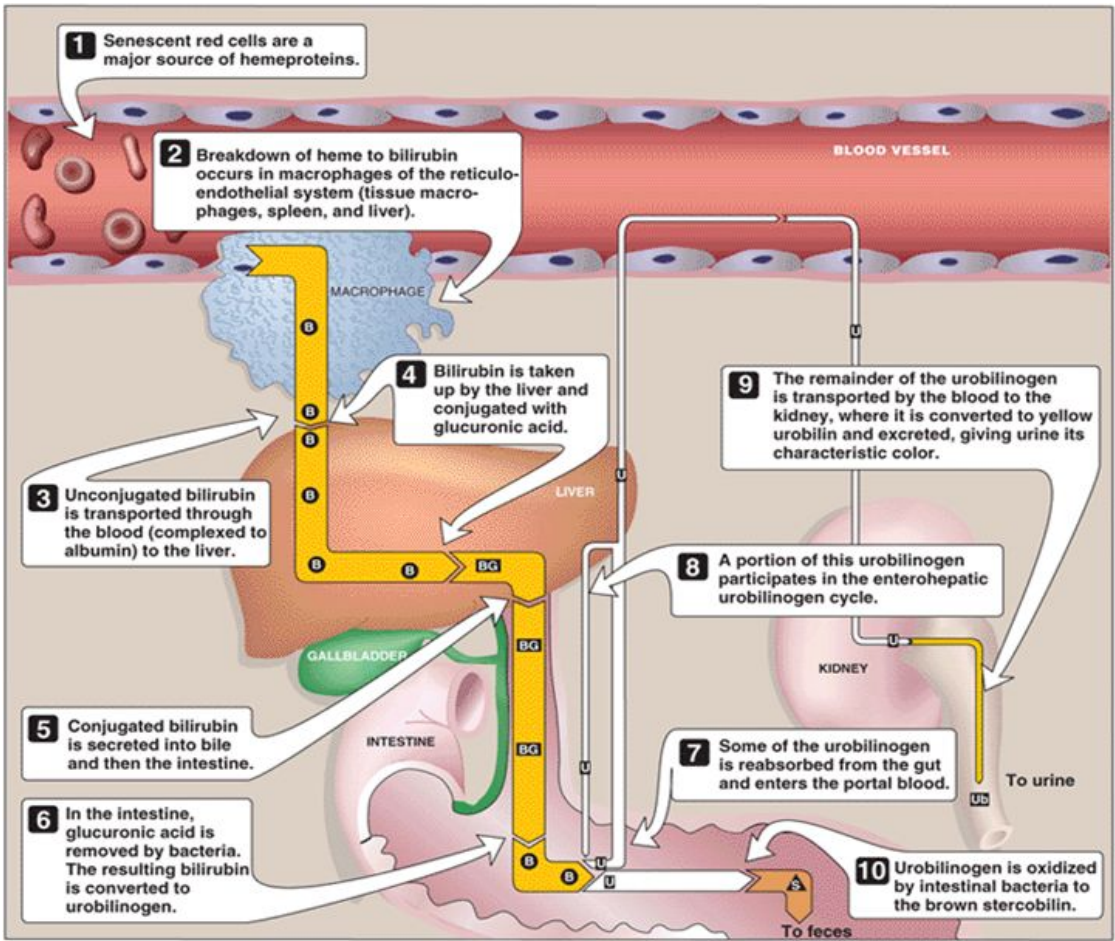
☆ Not important

Catabolism of heme



Females' doctor notes :

- Heme is found in hemoglobin which is a component of RBCs
- RBCs lifespan is 120 days after that they're lysed in macrophages of the reticuloendothelial system
- Bilirubin is transported from the macrophages to the liver by albumin "because bilirubin is insoluble"
- The liver conjugate bilirubin (add 2 sugar molecules) and makes it soluble.
- Then it comes out into the intestine
- Intestinal bacteria conform bilirubin into Urobilinogen
- Some of urobilinogen goes to the kidney and get converted into urobilin "gives urine its characteristic color"
- Remaining Urobilinogen is further oxidized by intestinal bacteria and convert to stercobilin "gives brown color to feces"



★ Nitrites

Positive nitrite test indicates **bacteria** in urine¹
(Urinary tract infection)

💡 **Extra info :**

1. The bacteria has an enzyme that converts nitrate to nitrites

💡 **Doctor notes :**

★ **Haematuria:**
RBC's are intact, no rupture.

★ **Hemoglobinuria:**
RBC's lost their shape, ruptured.

Hematuria

★ **Definition:** Presence of detectable amount of **blood** in urine

★ Due to :

1 Acute / chronic glomerulonephritis

2 Local disorders of kidney and genito-urinary tract

- Trauma
- Cystitis
- Renal calculi
- Tumors

3 Bleeding disorders

Hemophilia

Hemoglobinuria

★ **Definition:** Presence of **hemolysed** blood in urine

★ Due to :

1 Transfusion reaction

Blood group incompatibility

2 Malaria

Caused by infection of **P. falciparum**

3 Hemoglobinopathies

- Sickle cell anemia
- Thalassemia

Quiz

MCQs :

Q1: One of the clinical presentations of hepatocellular damage is:

- a) Urobilinogen b) Hemoglobinuria c) Hematuria d) Glucosuria

Q2: The presence of intact RBC in urine is termed as:

- a) Choluria b) Hematuria c) Hemoglobinuria d) Microalbuminuria

Q3: Which of the following can cause Hemoglobinuria?

- a) trauma b) Hemophilia c) Sickle cell anemia d) Multiple myeloma

Q4: One of the normal organic composition of urine:

- a) Chloride b) Fructose c) Potassium d) Glucose

Q5: A child was presented with Increased pressure on the renal vein in the vertical position and proteinuria what's the diagnosis?

- a) Multiple myeloma b) Microalbuminuria c) Orthostatic (Postural) Proteinuria d) None of the them

Q6: Microalbuminuria is:

- a) Pre-renal proteinuria b) Renal proteinuria c) Post-renal proteinuria d) None of the them

Q7: In which case of proteinuria proteins have low molecular weight?

- a) Pre-renal b) Post-renal c) Tubular d) Glomerular

Q8: In chronic nephritis:

- a) High glomerular permeability b) Low tubular reabsorption
c) Filtration of high molecular weight d) Low glomerular permeability

Q9: Hypertension causes what type of proteinuria?

- a) Pre-renal b) Renal c) Post-renal d) None of the them

SAQs :

Q1: What is the normal composition of urine?

Q2: Post-renal proteinuria is due to what?

Q3: One of the most important diagnostic features of multiple myeloma in the serum is?

Q4: What are the conditions which cause presence of bilirubin in the urine?

Q5: What are the conditions which cause presence of high urobilinogen in the urine?

Q6: list ketone bodies

★ **MCQs Answer key:**

1) A 2) B 3) C 4) D 5) C 6) B 7) C 8) B 9) B

★ **SAQs Answer key:**

1) Organic & inorganic (slide 3)

2) 1-lower urinary tract infection 2-stones 3-trauma 4-tumors

3) Elevated levels of light-chain monoclonal antibodies (Bence-Jones protein)

4) Hepatocellular damage & bile duct obstruction (due to stones or tumors)

5) Hemolytic anemia & hepatocellular damage

6) Acetone, acetoacetic acid and β -hydroxybutyric acid

☆ Team members :

Girls team:

- Ajeed Al-rashoud
- Alwateen Albalawi
- Abeer Alkhodair
- Elaf Almusahel
- Haifa Alessa
- Lama Alassiri
- Lina Alosaimi
- Nouf Alhumaidhi
- Noura Alturki
- Nouran Arnous
- Reem Algarni
- Rema Alkahtani
- Shahd Alsalamh
- Taif Alotaibi

Boys team:

- ★ Alkassem binobaid
- Fahad Alsultan
- ★ Fares Aldokhayel
- ★ Naif Alsolais
- ★ Sultan Alhammad

☆ Team leaders :

Deema Almaziad

Mohannad Alqarni

☆ Do something today that your future self will thank you for



We hear you