

Kidney Function Tests

Formation of Urine

- Urine formation occurs through three steps: **glomerular filtration, tubular reabsorption, tubular secretion.**
- **Glomerular filtration:**
 - GFR = **120–125 mL/min** in a 70-kg adult.
 - Produces **170–180 L/day** of filtrate.
 - Filtrate contains water + crystalloids (Na⁺, Cl⁻, glucose, amino acids, small molecules).
 - **Cells and plasma proteins are retained.**
- Only **1.5 L/day** is finally excreted ? most of the water is reabsorbed.
- Filtration barrier allows Hb (67 kDa) to pass but retains albumin (69 kDa).
 - Earliest sign of glomerular dysfunction = **albumin in urine.**

Functions of the Tubules

- Tubules modify filtrate via reabsorption and secretion.
- **Proximal Convoluted Tubule (PCT):**

- Reabsorbs **70% water, Na⁺, Cl⁻**.
- Reabsorbs **100% glucose, amino acids, K⁺**.
- Partial reabsorption of **urea, phosphate, calcium**.
- **Loop of Henle:**
 - Creates **countercurrent multiplier**.
 - Thick ascending limb reabsorbs Na⁺/K⁺/Cl⁻ but is water-impermeable.
- **Distal Convoluted Tubule (DCT):**
 - Fine-tuning of electrolytes.
 - Aldosterone-dependent Na⁺ reabsorption and K⁺ secretion.
- **Collecting Tubule:**
 - ADH-controlled water reabsorption.
 - Determines final urine concentration.
- Major processes: solute reabsorption, solute secretion, water reabsorption.

Renal Threshold

- Threshold substances are those whose **urinary excretion depends on plasma concentration**.
- At normal levels ? **fully reabsorbed**, absent in urine.

- When plasma level exceeds threshold ? reabsorptive capacity saturates ? substance appears in urine.
- Examples: glucose, amino acids, phosphate, bicarbonate.
- Clinical utility:
 - **Glycosuria** in diabetes (high load).
 - Aminoaciduria in metabolic disorders.
 - Tubular disorders.

Tubular Maximum (T_m)

- T_m = **maximum reabsorptive capacity** of renal tubules for a substance.
- Represents saturation of transport systems.
- When filtered load exceeds T_m ? excess is excreted in urine.
- Example: **Glucose T_m ? 375 mg/min.**
- Helps distinguish overflow glycosuria (high glucose load) from renal glycosuria (low T_m due to tubular defect).

Abnormal Constituents of Urine

- Healthy urine contains **no proteins, no glucose, no ketone bodies, no bile pigments, no bile salts**, and only **trace urobilinogen**.

- Presence of abnormal substances suggests **specific pathology**.
- Important abnormal constituents include:
 - **Proteins** ? glomerular/tubular disease.
 - **Glucose** ? diabetes, renal glycosuria.
 - **Ketone bodies** ? ketosis, uncontrolled diabetes.
 - **Bile salts** ? early obstructive jaundice.
 - **Bile pigments (bilirubin)** ? obstructive or hepatocellular jaundice.
 - **Blood** ? hematuria/hemoglobinuria.
 - **Pus cells** ? infection.
 - **Reducing sugars** ? glycosuria, galactosuria, fructosuria.
 - **Crystals** ? stones, metabolic disorders.
- In hemolytic jaundice ? **increased urobilinogen**.
- In hepatocellular jaundice ? **absent urobilinogen**.

Proteinuria

- Presence of **proteins in urine** indicates glomerular or tubular dysfunction.
- **Types of proteinuria:**

- **Glomerular proteinuria:**
 - Due to increased permeability of glomerular basement membrane.
 - Albumin is the major protein lost.
 - Seen in nephrotic syndrome, glomerulonephritis.
- **Tubular proteinuria:**
 - Tubules fail to reabsorb filtered proteins.
 - Smaller proteins appear in urine.
 - Seen in interstitial nephritis, toxins.
- **Overflow proteinuria:**
 - Excess production of small proteins exceeds reabsorptive capacity.
 - Example: **Bence-Jones proteins** in multiple myeloma.
- **Post-renal proteinuria:**
 - Infection or inflammation of urinary tract.
- **Transient proteinuria** may occur with fever, exercise, dehydration.
- **Detecting proteinuria:** heat test, sulfosalicylic acid test, dipstick.

Reducing Sugars in Urine

- Reducing sugars react with **Benedict's reagent** and give a positive reaction.
- Normal urine has **no reducing sugars**.
- Causes:
 - **Glucose:** Diabetes mellitus, stress, renal glycosuria.
 - **Galactose:** Galactosemia (infants).
 - **Fructose:** Essential fructosuria, hereditary fructose intolerance.
 - **Pentoses:** Xylosuria after fruit ingestion.
- Not all positive Benedict tests are glucose ? confirm with glucose-specific dipstick.

Clearance Tests (General Concepts)

- Clearance = **volume of plasma completely cleared of a substance per minute**.
- Used to measure **glomerular filtration, tubular function, renal plasma flow**.
- Clearance (C) is calculated as:

$$C = (U \times V) / P$$
 - U = urine concentration
 - V = urine flow rate
 - P = plasma concentration
- Properties of an ideal filtration marker:

- Freely filtered.
- Not reabsorbed or secreted.
- Not metabolized.
- Not protein-bound.
- High clinical value in assessing **GFR**.

Inulin Clearance Test (Gold Standard for GFR)

- Inulin is a **fructose polysaccharide**, not metabolized by the body.
- **Gold standard test** for accurate GFR measurement.
- Why inulin is ideal:
 - Freely filtered at glomerulus.
 - **Not reabsorbed** by tubules.
 - **Not secreted** by tubules.
 - Not synthesized or degraded in kidneys.
 - Not protein bound.
- Procedure:
 - Continuous IV infusion of inulin to achieve steady plasma levels.

- Collect timed urine samples and corresponding blood samples.
- Apply clearance formula.
- Normal value: **125 mL/min**.
- Limitations:
 - Labor-intensive, expensive.
 - Not used in routine clinical practice.
 - Creatinine clearance replaces inulin clearance in routine settings.

Creatinine Clearance Test

- Creatinine is produced from **creatinine in muscle** at a constant rate.
- Freely filtered at glomerulus; **not reabsorbed**.
- Tubular secretion occurs slightly ? clearance slightly **overestimates GFR**.
- Widely used clinically because:
 - Endogenous substance ? no infusion needed.
 - Easy, inexpensive.
 - Stable production rate.

- **Formula:**

$$C = (U \times V) / P$$

- U = urine creatinine
- V = urine flow rate
- P = plasma creatinine

- **Normal value: ~ 120 mL/min.**

- **Interpretation:**

- Decreased clearance ? decreased GFR ? kidney dysfunction.
- Useful for staging CKD.

- **Limitations:**

- Overestimates GFR due to tubular secretion.
- Dependent on muscle mass (elderly, malnourished ? falsely low).
- Requires accurate 24-hour urine collection.

Cystatin C

- Low molecular weight protein produced by **all nucleated cells** at a constant rate.
- Freely filtered by glomerulus.

- Completely **reabsorbed and metabolized** by proximal tubules ? **not returned to blood, not excreted in urine.**
- Serum cystatin C rises when **GFR decreases.**
- Advantages over creatinine:
 - **Unaffected by muscle mass**, age, sex.
 - More sensitive for early kidney disease.
 - Useful in elderly, children, malnourished, and cirrhosis patients.
- Interpreted via equations like **CKD-EPI cystatin C formula.**
- Increasingly preferred for early CKD detection.

Urea Clearance Test

- Urea is freely filtered but **40–70% reabsorbed** ? not an ideal GFR marker.
- Reabsorption varies with hydration status ? affects accuracy.
- Types of urea clearance:
 - **Maximal urea clearance:**
 - Performed with high urine flow rate (> 2 mL/min).
 - Normal: **75 mL/min.**
 - **Standard urea clearance:**

- When urine flow < 2 mL/min.
- Normal: **54 mL/min.**
- Clinical significance:
 - Less reliable measure of GFR.
 - Used when creatinine testing unavailable.
 - Plasma urea also rises in high protein intake, dehydration, GI bleed ? poor specificity.
- Because of low accuracy, replaced by **creatinine clearance** and **cystatin C**.

ests for Tubular Function

(Assess ability of tubules to reabsorb, secrete, concentrate, and acidify urine)

- Tubular function tests evaluate **PCT, Loop of Henle, DCT, and Collecting duct** activities.
- Main tubular functions measured:
 - **Reabsorption** (glucose, amino acids, phosphate, bicarbonate, water).
 - **Secretion** (H⁺, K⁺, NH₄⁺, organic acids/bases).
 - **Concentration** of urine (ADH-dependent).
 - **Dilution** of urine.

- **Acidification** of urine (H^+ secretion + NH_4^+ generation).

Important Tests for Tubular Function

- **Concentration test**
- **Dilution test**
- **Specific gravity measurement**
- **Urine osmolality**
- **Acidification test**
- **Fractional excretion tests** (Na^+ , HCO_3^- , phosphate)
- **Glucose reabsorption tests** (renal threshold/ T_m)

Used in clinical evaluation of **acute tubular necrosis**, **interstitial nephritis**, **CKD**, **Fanconi syndrome**, etc.

Osmolality

(Measures the concentration ability of kidneys)

- Osmolality = number of osmotically active particles per kg of water.
- Normal urine osmolality varies widely: **50 – 1200 mOsm/kg**.
- Reflects the kidney's ability to **concentrate or dilute urine**.
- Determined largely by:

- ADH secretion
- Tubular integrity
- Medullary concentration gradient
- Hydration status

Clinical Interpretation

• High urine osmolality

- Dehydration
- SIADH
- Heart failure
- Pre-renal azotemia (intact concentrating ability)

• Low urine osmolality

- Diabetes insipidus (central or nephrogenic)
- Acute tubular necrosis
- Primary polydipsia
- Medullary washout states

Comparison with Specific Gravity

- SG depends on **mass**; osmolality depends on **number of particles** ? osmolality is more accurate.

Acidification Test

(Measures the kidney's ability to excrete hydrogen ions and acidify urine)

- Normal kidneys can acidify urine to **pH < 5.5** after acid load.
- Assesses **distal tubular H⁺ secretion** and **NH₄⁺ generation**.

Procedure (Conceptual)

- Patient is given an **acid load** (e.g., ammonium chloride).
- Urine pH is monitored over a few hours.
- Normal kidney response: urine pH falls to ? **5.3**.

Interpretation

- **Normal:**
 - Urine pH drops below **5.3** ? intact distal acidification.
- **Impaired acidification:**
 - Urine pH **remains > 5.5** despite systemic acidosis.
 - Indicates **Distal Renal Tubular Acidosis (Type 1 RTA)**.
 - Also seen in:

- Interstitial nephritis
- Autoimmune diseases
- Obstructive uropathy

Complementary Measurements

- Urinary NH₄⁺ excretion
- Urinary anion gap (UAG)
- Bicarbonate levels

Concentration Test

(Assesses kidney's ability to concentrate urine — mainly function of Loop of Henle + Collecting Duct + ADH)

- Evaluates integrity of:
 - **Countercurrent mechanism** (Loop of Henle).
 - **Medullary hypertonicity**.
 - **ADH secretion and response** (Collecting duct).
- Normally, kidney can concentrate urine to **> 800 mOsm/kg** or **specific gravity > 1.022**.

Procedure (Principle-based)

- Water is **restricted** overnight (8–12 hours).
- Early morning urine sample collected.
- Measure **specific gravity** or **osmolality**.

Normal Response

- Urine osmolality **> 800 mOsm/kg**
OR
- Specific gravity **> 1.022**

Indicates Impaired Concentration

- Urine osmolality **< 600 mOsm/kg** after dehydration ? suggests tubular or ADH-related defect.

Causes of Poor Concentration Ability

- **Chronic kidney disease**
 - **Acute tubular necrosis**
 - **Nephrogenic diabetes insipidus**
 - **Central diabetes insipidus**
 - **Medullary washout** (prolonged diuretics, polydipsia)
 - **Severe electrolyte disturbances** (hypokalemia, hypercalcemia)
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Dilution Test

(Assesses kidney's ability to dilute urine — function of DCT + Collecting Duct in absence of ADH)

- Checks ability to **excrete free water**.
- Requires intact:
 - **Glomerular filtration**
 - **Active NaCl reabsorption** in thick ascending limb
 - **Suppression of ADH**

Procedure (Conceptual)

- Patient drinks **water load** (10–20 mL/kg).
- Urine samples collected over next 4 hours.

Normal Response

- Large volume of dilute urine produced.
- Urine osmolality **< 100 mOsm/kg**
OR
- Specific gravity **< 1.003**

Abnormal Response (Impaired Dilution)

- Urine remains **concentrated** despite water load.

Causes of Poor Diluting Ability

- SIADH
- Advanced renal failure
- Congestive heart failure
- Cirrhosis
- Hypothyroidism
- Adrenal insufficiency

Clearance-Based Tubular Tests

(Assess specific tubular transport functions — mainly PCT and DCT)

1. Phosphate Clearance (TmP/GFR Test)

(Assesses proximal tubular reabsorption of phosphate)

- Phosphate is **freely filtered** and **partially reabsorbed** in PCT.
- Reabsorption is regulated by **PTH**.
- TmP/GFR measures maximal tubular reabsorptive capacity.

Clinical Uses

- Detects **Fanconi syndrome** (? phosphate reabsorption).

- Diagnoses **renal phosphate wasting**.
- Differentiates causes of **hypophosphatemia**.
- Evaluates **hyperparathyroidism** (? reabsorption due to PTH).

Findings

- **Low TmP/GFR** ? proximal tubular defect or high PTH.
- **Normal/high TmP/GFR** ? extrarenal causes of phosphate loss.

2. Bicarbonate Reabsorption Test (Bicarbonate Clearance)

(Assesses proximal tubular reabsorption of bicarbonate & ability to handle acid-base balance)

- Normally, PCT reabsorbs **80–90% of filtered bicarbonate**.
- Test evaluates whether tubules can reclaim filtered HCO₃⁻.

Procedure (Conceptual)

- Raise plasma bicarbonate slightly; measure:
 - Plasma HCO₃⁻
 - Urinary HCO₃⁻ excretion
 - Calculate fractional excretion.

Clinical Uses

- Diagnoses **Proximal Renal Tubular Acidosis (Type 2 RTA)**.
- Evaluates **Fanconi syndrome**.
- Helps differentiate:
 - **Type 2 RTA** ? poor HCO?? reabsorption
 - **Type 1 RTA** ? normal HCO?? reabsorption, but impaired distal acidification

Findings

- **High bicarbonate excretion** at normal plasma HCO?? ? tubular defect.
- **Low ability to reclaim HCO??** ? Type 2 RTA.

Bile Salts in Urine

- Normally **absent** in urine.
 - Appears only in **obstructive jaundice (early phase)**.
 - Indicates obstruction to bile flow ? bile salts regurgitate into blood ? filtered into urine.
 - **Test:**
 - **Hay's sulfur test** becomes positive.
 - **Clinical significance:**
 - Early detection of **obstructive jaundice** even before severe rise in bilirubin.
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Bile Pigments in Urine (Bilirubin)

- Normal urine contains **no bilirubin**.
- Bilirubin appears in urine in:
 - **Obstructive jaundice**.
 - **Hepatocellular jaundice**.
- Not seen in **hemolytic jaundice** because unconjugated bilirubin is not water-soluble.
- **Test:**
 - **Fouchet's test** for bilirubin.
- Urine becomes **dark yellow or greenish**.

Ketone Bodies in Urine

- Ketone bodies = **acetoacetate, ?-hydroxybutyrate, acetone**.
- Normally absent; appear when fat breakdown exceeds carbohydrate availability.
- Causes:
 - **Diabetic ketoacidosis (DKA)**
 - **Starvation**, fasting
 - **Prolonged vomiting**, dehydration

- High-fat/low-carb diets
- **Tests:**
 - **Rothera's test** for acetoacetate.
 - **Ketostix** dipsticks commonly used.
- Presence of ketones indicates **poor glucose utilization** or excessive fat metabolism.

Urobilinogen in Urine

- Normally present in **trace amounts**.
- Derived from intestinal breakdown of bilirubin.
- Reabsorbed urobilinogen is partly excreted into urine.

Increased Urobilinogen

- **Hemolytic jaundice**
- **Ineffective erythropoiesis**
- **Early liver disease** (reduced hepatic uptake)

Absent/Low Urobilinogen

- **Obstructive jaundice** (bile cannot reach intestine)
- **Severe hepatocellular failure**

Tests:

- Ehrlich test
- Schlesinger's test

Markers of GFR — Summary

(Highly exam-important: differentiate markers based on accuracy & clinical use)

1. Inulin

- Gold standard (**most accurate**).
- Freely filtered.
- Not reabsorbed, not secreted, not metabolized.
- Used only in research; not practical clinically.

2. Creatinine (Endogenous)

- Most commonly used marker in clinical practice.
- Freely filtered; **slightly secreted** ? slight **overestimation** of GFR.
- Serum creatinine rises only after significant nephron loss (> 50%).

3. Creatinine Clearance

- Better approximation of GFR than serum creatinine alone.
- Requires 24-hour urine.

- Overestimates GFR by 10–20%.

4. Cystatin C

- Constant production by all nucleated cells.
- Filtered and completely metabolized in tubules.
- **More sensitive** than creatinine in early kidney disease.
- Unaffected by muscle mass ? useful in elderly & malnourished.

5. Urea

- Freely filtered, but **significantly reabsorbed** ? not reliable.
- Affected by hydration, protein intake, GI bleed.
- Used mainly as supportive marker (BUN).

6. Clearance-Based Markers (Urea, Phosphate, Bicarbonate)

- Evaluate tubular function rather than pure GFR.

Important Points to Remember — Kidney Function Tests

- Kidney performs **filtration, reabsorption, secretion, acid-base balance, electrolyte balance**, vitamin D activation, erythropoietin production.
- **GFR = 120–125 mL/min** in adults; produces **180 L/day** filtrate; only **1.5 L/day** becomes urine.

- **Earliest sign of glomerular damage = albuminuria.**
- PCT reabsorbs **100% glucose, amino acids**, and **70% water + Na⁺ + Cl⁻**.
- Threshold substances (glucose, amino acids, phosphate) appear in urine when plasma levels > tubular capacity.
- **T_m (tubular maximum)** = maximal reabsorption capacity; for glucose ? **375 mg/min**.
- In obstructive jaundice ? **bile salts + bilirubin appear in urine**.
- Ketone bodies appear in **DKA, starvation, prolonged vomiting**.
- **Urobilinogen:**
 - ? in hemolytic jaundice
 - Absent in obstructive jaundice
- Best measure of GFR: **Inulin clearance** (gold standard).
- Most used clinically: **Creatinine clearance**.
- **Cystatin C** is the most sensitive marker for early CKD.
- Urea clearance is **unreliable** due to variable reabsorption.
- Concentration ability depends on **ADH + medullary gradient + Loop of Henle integrity**.
- Dilution ability depends on **suppressed ADH** + intact thick ascending limb.
- Inability to acidify urine (<5.5) after acid load = **Distal RTA (Type 1)**.

- Fanconi syndrome affects PCT ? **phosphate, bicarbonate, glucose, amino acid losses.**
- **Specific gravity** is less accurate than **osmolality** for assessing concentration.
- Tubular function tests help diagnose **tubular necrosis, interstitial nephritis, RTA, CKD.**
- Marker of early CKD progression = **rise in cystatin C** before creatinine.
- Renal plasma flow estimated using **PAH clearance** (not discussed but high-yield conceptually).

FAQs — Kidney Function Tests (Viva + Theory Focused)

1. What is the best test for measuring GFR?

- **Inulin clearance** (gold standard).

2. Why is creatinine clearance widely used clinically?

- Endogenous, easy to measure, inexpensive, stable production rate.

3. Why does creatinine clearance overestimate GFR?

- Because creatinine is **slightly secreted** by the tubules.

4. Which marker detects early kidney dysfunction better than creatinine?

- **Cystatin C**, because it is unaffected by muscle mass.

5. Which substances appear in urine first in glomerular disease?

- **Albumin** (microalbuminuria in early diabetic nephropathy).

6. Why can glucose appear in urine even when blood glucose is normal?

- Due to **renal glycosuria** (low T_m of glucose).

7. What does presence of bile salts in urine indicate?

- **Obstructive jaundice** (early phase).

8. What does increased urobilinogen in urine suggest?

- **Hemolytic jaundice** or early hepatic disease.

9. Which ketone body is detected by routine tests like Rothera's?

- **Acetoacetate**.

10. Why is urea clearance not a reliable measure of GFR?

- Urea is **significantly reabsorbed**, affected by hydration and protein intake.

11. What is the significance of a urine pH remaining > 5.5 after acid load?

- Suggests **Distal Renal Tubular Acidosis (Type 1)**.

12. What is the renal threshold?

- Plasma concentration above which a substance begins to appear in urine because reabsorption is saturated.

13. What is T_m ?

- **Maximum rate** at which tubules can reabsorb a substance.

14. Which part of nephron is essential for concentration of urine?

- **Loop of Henle + Collecting ducts (ADH-dependent).**

15. What does low urine osmolality indicate?

- Poor concentrating ability ? DI, ATN, CKD, polydipsia.

16. What is the earliest lab indicator of recovery in obstructive jaundice?

- **Reappearance of urobilinogen** in urine.

17. Which urine test becomes positive earliest in DKA?

- **Ketone bodies** (acetoacetate with Rothera's test).

18. What is the significance of specific gravity?

- Rough indicator of urine concentration; influenced by large molecules ? less accurate than osmolality.

MCQs — Kidney Function Tests

1. The gold standard test for measuring GFR is:

- A. Creatinine clearance
- B. Cystatin C
- C. Inulin clearance
- D. Urea clearance

Answer: C

2. The earliest sign of glomerular damage is:

- A. Glucosuria
- B. Albuminuria
- C. Hematuria
- D. Ketonuria

Answer: B

3. Glucose appears in urine when:

- A. Plasma glucose exceeds renal threshold
- B. Tubular secretion increases
- C. Plasma sodium decreases
- D. Urea increases

Answer: A

4. Tubular maximum (T_m) refers to:

- A. Maximum filtration capacity
- B. Maximum secretion rate
- C. Maximum reabsorption capacity
- D. Minimum reabsorption threshold

Answer: C

5. Presence of bile salts in urine indicates:

- A. Hemolytic jaundice
- B. Obstructive jaundice
- C. Gilbert syndrome
- D. Neonatal jaundice

Answer: B

6. Which ketone body is detected by Rothera's test?

- A. Acetone
- B. Beta-hydroxybutyrate
- C. Acetoacetate
- D. All three ketone bodies

Answer: C

7. Increased urobilinogen in urine is seen in:

- A. Obstructive jaundice
- B. Hemolytic jaundice
- C. Severe hepatitis (late stage)
- D. Cirrhosis (end stage)

Answer: B

8. Creatinine clearance test slightly overestimates GFR because:

- A. Creatinine is reabsorbed
- B. Creatinine is secreted by tubules
- C. Creatinine binds to proteins
- D. Creatinine is unstable

Answer: B

9. Cystatin C level increases when:

- A. GFR increases
- B. GFR decreases
- C. Creatinine secretion increases
- D. Urine output increases

Answer: B

10. A patient with distal RTA (Type 1) will show:

- A. Urine pH < 5.3 after acid load
- B. Urine pH remains > 5.5
- C. Severe glucosuria

D. Increased bicarbonate reabsorption

Answer: B

11. A low urine osmolality after overnight dehydration indicates:

- A. Normal concentrating ability
- B. Diabetes insipidus
- C. Obstructive uropathy (early)
- D. Dehydration

Answer: B

12. Phosphate wasting with normal serum PTH suggests:

- A. Fanconi syndrome
- B. Hyperparathyroidism
- C. Hypoparathyroidism
- D. SIADH

Answer: A

13. Standard urea clearance is measured when:

- A. Urine flow > 2 mL/min
- B. Urine flow < 2 mL/min
- C. Urine is alkaline
- D. Plasma urea is normal

Answer: B

14. Specific gravity is less reliable than osmolality because:

- A. SG is affected by number of particles only
- B. SG is affected by mass of particles
- C. SG requires complex instruments
- D. SG cannot detect proteins

Answer: B

15. The major site of bicarbonate reabsorption is:

- A. Distal convoluted tubule
- B. Collecting duct
- C. Proximal convoluted tubule
- D. Loop of Henle

Answer: C

16. A positive Fouchet's test indicates presence of:

- A. Ketone bodies
- B. Bile pigments
- C. Bile salts
- D. Urobilinogen

Answer: B

17. Which is a threshold substance?

- A. Urea
- B. Creatinine
- C. Glucose
- D. PAH

Answer: C

18. Creatinine is a better marker than urea because:

- A. Not reabsorbed significantly
- B. Not secreted
- C. Unaffected by muscle mass
- D. More stable in plasma

Answer: A

19. Low TmP/GFR (phosphate reabsorption) is seen in:

- A. Hypoparathyroidism
 - B. Fanconi syndrome
-

- C. Dehydration
- D. Diabetes insipidus

Answer: B

20. Reappearance of urobilinogen in urine is an early sign of recovery in:

- A. Hemolytic jaundice
- B. Hepatocellular jaundice
- C. Obstructive jaundice
- D. Crigler–Najjar syndrome

Answer: C

Clinical Case–Based Questions — Kidney Function Tests

Case 1 — Albumin in Urine

A 32-year-old man with long-standing diabetes presents for routine checkup. Urine dipstick shows **trace albumin**. Blood glucose is mildly elevated.

Q: What is the earliest renal abnormality in this patient?

Answer: Early glomerular dysfunction (microalbuminuria).

Explanation: Albumin is the earliest indicator of glomerular damage in diabetic nephropathy.

Case 2 — Glucosuria with Normal Blood Glucose

A 20-year-old woman has **glucose in urine**, but fasting glucose is normal.

Q: What is the likely diagnosis?

Answer: Renal glycosuria (low T_m of glucose).

Explanation: Tubular defect causes glucose spill despite normal plasma levels.

Case 3 — Ketone Bodies in Urine

A young male with vomiting and dehydration shows **positive Rothera's test**.

Q: Which ketone body is detected?

Answer: Acetoacetate.

Explanation: Rothera's test detects acetoacetate (and weakly acetone).

Case 4 — Obstructive Jaundice

A patient has yellowish urine, positive **Fouchet's test**, and absent urobilinogen.

Q: What does this pattern suggest?

Answer: Obstructive jaundice.

Explanation: Conjugated bilirubin and bile salts appear in urine; urobilinogen becomes absent.

Case 5 — Hemolysis vs Obstruction

A patient with dark urine shows **high urobilinogen**.

Q: Which jaundice does this suggest?

Answer: Hemolytic jaundice.

Explanation: Increased bilirubin turnover increases urobilinogen formation.

Case 6 — Low Urine Osmolality

A 35-year-old man reports polyuria and polydipsia. After dehydration overnight, his urine osmolality remains **< 300 mOsm/kg**.

Q: What is the most likely cause?

Answer: Diabetes insipidus (central or nephrogenic).

Explanation: Inability to concentrate urine.

Case 7 — Distal RTA

After ammonium chloride loading, a patient's urine pH remains **> 5.5**.

Q: What renal tubular defect is present?

Answer: Distal Renal Tubular Acidosis (Type 1 RTA).

Explanation: Failure of distal nephron to acidify urine.

Case 8 — Proximal RTA

A child presents with metabolic acidosis, hypophosphatemia, glucosuria, and aminoaciduria.

Q: Which renal condition fits this picture?

Answer: Fanconi syndrome (Proximal RTA type 2).

Explanation: PCT fails to reabsorb multiple solutes.

Case 9 — High BUN/Creatinine Ratio

A dehydrated patient has BUN:Cr ratio **> 20:1** with low urine sodium (< 20 mEq/L).

Q: What is the likely diagnosis?

Answer: Pre-renal azotemia.

Explanation: Increased urea reabsorption due to low renal perfusion.

Case 10 — Creatinine Clearance Interpretation

A 60-year-old man's creatinine clearance = **45 mL/min**.

Q: What stage of kidney function impairment does this indicate?

Answer: Moderate reduction in GFR ? CKD Stage 3.

Explanation: Normal = 120 mL/min; 30–59 is moderate CKD.

Case 11 — Poor Concentration Ability

After water deprivation, urine specific gravity remains **1.003**.

Q: What does this indicate?

Answer: Impaired concentrating ability (e.g., CKD, DI, ATN).

Explanation: SG should rise above 1.022 with intact concentration.

Case 12 — Elevated Cystatin C

A frail elderly woman has normal serum creatinine but high **cystatin C**.

Q: What does this suggest about kidney function?

Answer: Early decline in GFR.

Explanation: Cystatin C detects early kidney impairment even when creatinine appears normal.

Case 13 — Urea Clearance

A patient shows low urea clearance but normal creatinine clearance.

Q: What explains this discrepancy?

Answer: Urea is **partially reabsorbed**, making its clearance unreliable.

Explanation: Hydration and protein intake affect urea levels.

Case 14 — Thick Ascending Limb Defect

A patient cannot dilute urine after water load; urine osmolality stays high.

Q: Which nephron segment is likely affected?

Answer: Thick ascending limb of Loop of Henle.

Explanation: Dilution requires solute reabsorption without water.

Case 15 — Borderline Albuminuria in Diabetes

A diabetic patient has **30–300 mg/day** albumin in urine.

Q: What is this condition called?

Answer: Microalbuminuria.

Explanation: Early marker of diabetic nephropathy.

Viva Voce — Kidney Function Tests

1. What is the functional unit of kidney?

Nephron.

2. What is normal GFR?

120–125 mL/min in adults.

3. What is the daily glomerular filtrate volume?

170–180 liters/day.

4. How much urine is formed daily?

About **1.0–1.5 liters/day.**

5. What is the earliest sign of glomerular damage?

Albumin in urine.

6. Name a threshold substance.

Glucose (most common).

Others: amino acids, phosphate.

7. Define tubular maximum (T_m).

Maximum rate at which tubules can **reabsorb a substance.**

8. What is the renal threshold for glucose?

Approximately **180 mg/dL.**

9. What is the gold standard test for GFR?

Inulin clearance.

10. Why is creatinine clearance commonly used?

Endogenous, easy, cheap, good estimate of GFR.

11. Why does creatinine clearance overestimate GFR?

Because creatinine is **slightly secreted** by tubules.

12. What is the most sensitive early marker of kidney dysfunction?

Cystatin C.

13. Which ketone body is detected by Rothera's test?

Acetoacetate.

14. What does a positive Fouchet's test indicate?

Presence of **bilirubin** (bile pigments) in urine.

15. In which jaundice is urobilinogen absent in urine?

Obstructive jaundice.

16. Increased urobilinogen is seen in?

Hemolytic jaundice.

17. What is the normal urine osmolality range?

50 – 1200 mOsm/kg.

18. Which nephron segment is essential for urine concentration?

Loop of Henle (countercurrent mechanism).

19. What hormone controls final urine concentration?

ADH (antidiuretic hormone).

20. What is the significance of specific gravity?

Rough indicator of urine concentration.

21. Why is osmolality better than specific gravity?

Osmolality depends on **number** of particles, not weight.

22. What does inability to acidify urine (pH > 5.5) after acid load indicate?

Distal RTA (Type 1).

23. Major site of bicarbonate reabsorption?

Proximal convoluted tubule (PCT).

24. What is PAH clearance used for?

To estimate **renal plasma flow**.

25. What is the normal range of creatinine clearance?

About **120 mL/min**.

26. Which test evaluates proximal tubular function?

Phosphate clearance or **bicarbonate reabsorption test**.

27. Which test evaluates ability to dilute urine?

Water dilution test (water load test).

28. Which test evaluates ability to concentrate urine?

Water deprivation (concentration) test.

29. What does presence of bile salts in urine indicate?

Obstructive jaundice.

30. What is the significance of microalbuminuria in diabetes?

Earliest marker of **diabetic nephropathy**.