MEDICAL EDUCATION RESOURCE

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 (Tm)

- Tm = **maximum reabsorptive capacity** of renal tubules for a substance.
- Represents saturation of transport systems.
- When filtered load exceeds Tm ? excess is excreted in urine.
- Example: **Glucose Tm ? 375 mg/min**.
- Helps distinguish overflow glycosuria (high glucose load) from renal glycosuria (low Tm 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 × 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 **creatine 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 × 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 **reasorbed 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?, NH??, organic acids/bases).
    - **Concentration** of urine (ADH-dependent).
    - **Dilution** of urine.

- **Acidification** of urine (H? secretion + NH?? generation).

Important Tests for Tubular Function

- **Concentration test**
- **Dilution test**
- **Specific gravity measurement**
- **Urine osmolality**
- **Acidification test**
- **Fractional excretion tests (Na?, HCO??, phosphate)**
- **Glucose reabsorption tests (renal threshold/Tm)**

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 **NH?? 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 NH?? 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)

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)

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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.

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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 HCO??.

Procedure (Conceptual)

- Raise plasma bicarbonate slightly; measure:
  - Plasma HCO??
  - Urinary HCO?? 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.

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.
- **Tm (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)

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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 Tm 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 Tm?

- **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

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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

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4. Tubular maximum (Tm) refers to:

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

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5. Presence of bile salts in urine indicates:

A. Hemolytic jaundice
B. Obstructive jaundice
C. Gilbert syndrome
D. Neonatal jaundice
Answer: B

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

A. Acetone

B. Beta-hydroxybutyrate

C. Acetoacetate

D. All three ketone bodies

Answer: C

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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

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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

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9. Cystatin C level increases when:

A. GFR increases

B. GFR decreases

C. Creatinine secretion increases

D. Urine output increases

Answer: B

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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

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11. A low urine osmolality after overnight dehydration indicates:

A. Normal concentrating ability

B. Diabetes insipidus

C. Obstructive uropathy (early)

D. Dehydration

Answer: B

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12. Phosphate wasting with normal serum PTH suggests:

A. Fanconi syndrome

B. Hyperparathyroidism

C. Hypoparathyroidism

D. SIADH

Answer: A

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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

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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

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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

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

A. Ketone bodies
B. Bile pigments
C. Bile salts
D. Urobilinogen
Answer: B

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17. Which is a threshold substance?

A. Urea
B. Creatinine
C. Glucose
D. PAH
Answer: C

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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

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

A. Hypoparathyroidism
B. Fanconi syndrome

C. Dehydration
D. Diabetes insipidus
Answer: B

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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 Tm 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

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1. What is the functional unit of kidney?

Nephron.

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2. What is normal GFR?

120–125 mL/min in adults.

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3. What is the daily glomerular filtrate volume?

170–180 liters/day.

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4. How much urine is formed daily?

About **1.0–1.5 liters/day**.

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5. What is the earliest sign of glomerular damage?

Albumin in urine.

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6. Name a threshold substance.

Glucose (most common).
Others: amino acids, phosphate.

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7. Define tubular maximum (Tm).

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

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8. What is the renal threshold for glucose?

Approximately **180 mg/dL**.

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9. What is the gold standard test for GFR?

Inulin clearance.

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10. Why is creatinine clearance commonly used?

Endogenous, easy, cheap, good estimate of GFR.

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11. Why does creatinine clearance overestimate GFR?

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

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

Cystatin C.

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

Acetoacetate.

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

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

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15. In which jaundice is urobilinogen absent in urine?

Obstructive jaundice.

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16. Increased urobilinogen is seen in?

Hemolytic jaundice.

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17. What is the normal urine osmolality range?

50 – 1200 mOsm/kg.

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18. Which nephron segment is essential for urine concentration?

Loop of Henle (countercurrent mechanism).

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19. What hormone controls final urine concentration?

ADH (antidiuretic hormone).

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20. What is the significance of specific gravity?

Rough indicator of urine concentration.

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21. Why is osmolality better than specific gravity?

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

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

Distal RTA (Type 1).

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23. Major site of bicarbonate reabsorption?

Proximal convoluted tubule (PCT).

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24. What is PAH clearance used for?

To estimate **renal plasma flow**.

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25. What is the normal range of creatinine clearance?

About **120 mL/min**.

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26. Which test evaluates proximal tubular function?

Phosphate clearance or **bicarbonate reabsorption test**.

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27. Which test evaluates ability to dilute urine?

Water dilution test (water load test).

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28. Which test evaluates ability to concentrate urine?

Water deprivation (concentration) test.

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

Obstructive jaundice.

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30. What is the significance of microalbuminuria in diabetes?

Earliest marker of **diabetic nephropathy**.