The kidney function tests

Role of the Kidney

- The **kidneys** are a pair of bean-shaped organs located in the posterior abdominal cavity, one on each side of the spine.
- They are vital for **homeostasis**, and their functions are numerous and complex.

Major Functions of the Kidney

1. Excretion of Metabolic Waste

- Urea (from protein metabolism)
- Creatinine (from muscle metabolism)
- Uric acid (from purine metabolism)
- Drugs and toxins

2. Regulation of Fluid and Electrolyte Balance

- Maintains the balance of:
  - Sodium (Na^+)
  - Potassium (K^+)
  - Calcium (Ca^{2+})
  - Chloride (Cl^-)
  - Phosphate (PO_4^{3-})
- Adjusts water content based on hydration status

3. Acid-Base Balance

- Maintains blood pH by excreting hydrogen ions (H^+) and reabsorbing bicarbonate (HCO_3^-)

4. Regulation of Blood Pressure

- Produces **renin**, which activates the **renin-angiotensin-aldosterone system (RAAS)**

5. Hormonal Function

- **Erythropoietin**: stimulates red blood cell production in response to hypoxia
- **Calcitriol** (active form of Vitamin D): involved in calcium and phosphate metabolism

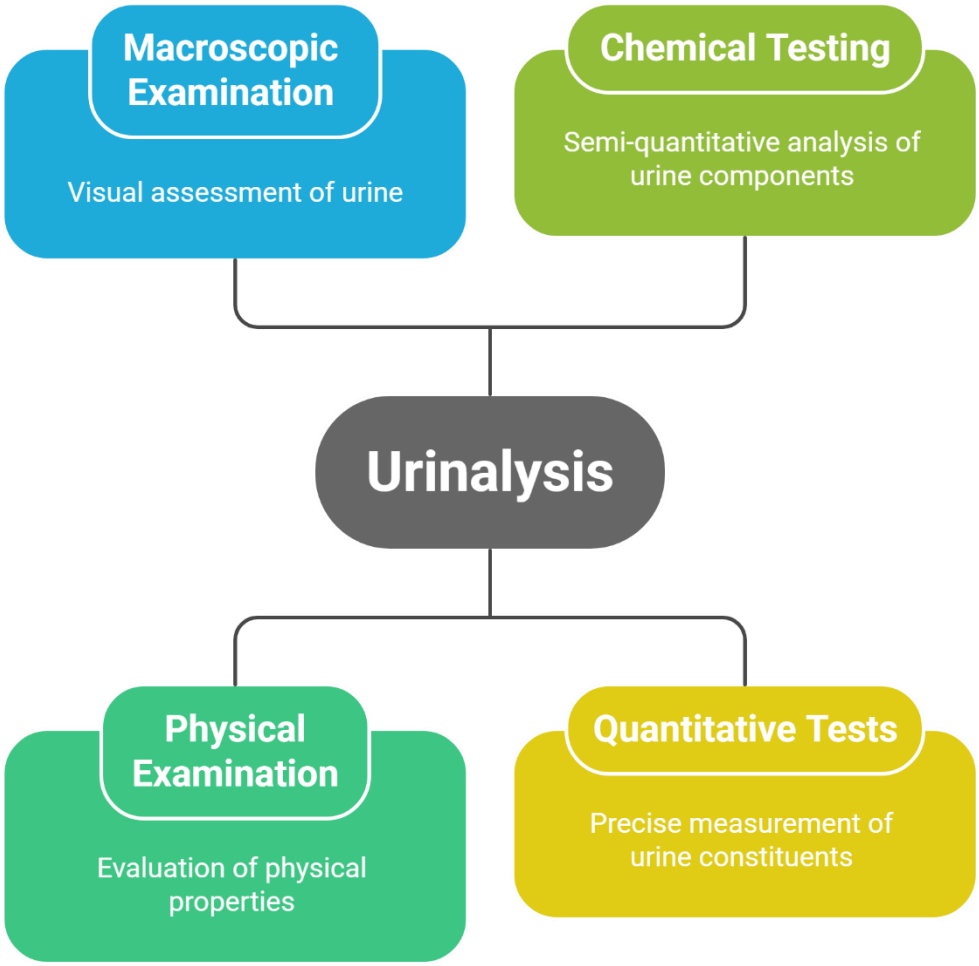
6. Gluconeogenesis

- Under fasting/starving conditions, the kidneys can synthesize glucose from non-carbohydrate sources

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Urine Analysis (Urinalysis)

- Urinalysis is a **basic but powerful tool** to assess kidney function, detect infection, monitor systemic disease, and screen for metabolic conditions.
- It includes:
    1. **Macroscopic Examination**
    2. **Physical Examination**
    3. **Chemical Testing (Semi-Quantitative)**
    4. **Quantitative Tests**



Macroscopic Examination

- This involves **visual observation** of urine's **color**, **clarity**, and **volume**.

Parameters:

Parameter	Normal Findings	Abnormal Findings & Causes
Color	Pale yellow to amber (due to urochrome pigment)	Red (hematuria), brown (myoglobinuria), milky (chyluria or infection), dark yellow (concentrated urine)
Clarity	Clear to slightly cloudy	Cloudy/turbid: presence of cells, crystals, bacteria, mucus, or pus

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Volume (24-hour urine)	800–2000 mL/day (varies with fluid intake)	<400 mL/day: oliguria; >3000 mL/day: polyuria

Physical Examination

Measures **physical properties** of urine using visual or simple instrumental techniques.

Parameter	Normal Range/Appearance	Abnormal Findings	Possible Causes
Specific Gravity	1.005 – 1.030	↑ Increased: >1.030 ↓ Decreased: <1.005	↑ Dehydration, glycosuria ↓ Diabetes insipidus, renal damage
pH	4.5 – 8.0	↓ Acidic ↑ Alkaline	↓ High protein diet, metabolic acidosis ↑ Vegetarian diet, UTI
Odor	Slightly aromatic	Foul, fruity, or ammonia-like odors	Foul: Infection Fruity: Ketones (diabetic ketoacidosis) Ammonia: Decomposition
Turbidity	Clear	Cloudy	Infection, crystals, cells, mucus

Chemical Testing (Semi-Quantitative Tests)

- Performed using **urine dipstick** or **reagent strips**. Most are colorimetric and give **semi-quantitative** results based on color change.

Parameter	Normal Result	Positive/Abnormal Finding	Possible Causes	Test Principle
Protein	Negative or trace (<150 mg/day)	Positive	Glomerular damage, nephrotic syndrome, HTN, diabetes	Protein error of indicators (e.g., tetrabromophenol blue)
Glucose	Negative	Positive	Diabetes mellitus, renal glycosuria	Glucose oxidase–peroxidase reaction
Ketones	Negative	Positive	Diabetic ketoacidosis, starvation, prolonged vomiting	Sodium nitroprusside reaction (detects acetoacetate)
Blood (Hematuria / Hemoglobinuria / Myoglobinuria)	Negative	Positive	UTI, trauma, glomerulonephritis, hemolysis, muscle injury	Peroxidase-like activity of hemoglobin

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pH	4.5 – 8.0	Acidic or Alkaline	Acidic: High protein diet, acidosis Alkaline: UTI, diet	Indicator dyes (methyl red, bromthymol blue)
Specific Gravity	1.005 – 1.030	Increased or Decreased	Hydration status, renal concentrating ability	Based on ionic concentration (not true SG)
Leukocyte Esterase	Negative	Positive	WBCs in urine → UTI, inflammation	Detects granulocyte enzyme activity
Nitrites	Negative	Positive	Bacterial UTI (esp. nitrate-reducing bacteria like E. coli)	Detects conversion of nitrate to nitrite
Bilirubin	Negative	Positive	Liver disease, bile duct obstruction	Diazo reaction (in most strips)
Urobilinogen	Normal (0.1–1.0 EU/dL)	Elevated or Absent	↑ Hemolysis, liver disease ↓ Bile duct obstruction	Ehrlich's reaction or similar

Quantitative Tests

These tests **measure the exact amount** of substances in urine, typically in **24-hour urine collections**.

A. 24-Hour Urinary Protein

- Measures total protein excreted
- **Normal**: <150 mg/day
- **Increased**: Glomerulonephritis, nephrotic syndrome

B. Creatinine Clearance Test

- Evaluates **glomerular filtration rate (GFR)**
- Requires:
  - Serum creatinine
  - Urine creatinine (from 24-hour urine)
  - Urine volume
- **Formula**:

$$\text{Creatinine Clearance (mL/min)} = \frac{(U_{Cr} \times V)}{P_{Cr} \times T}$$

- Where:
  - U_{Cr}: Urine creatinine (mg/dL)

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- V: Urine volume (mL)
- P_{Cr}: Plasma creatinine (mg/dL)
- T: Time in minutes

C. Microalbuminuria

- Early marker for diabetic nephropathy
- **Normal**: <30 mg/day
- **Microalbuminuria**: 30–300 mg/day
- **Macroalbuminuria**: >300 mg/day

D. Urinary Electrolytes

- Sodium, potassium, calcium, phosphate
- Helps differentiate **prerenal vs renal causes** of kidney dysfunction

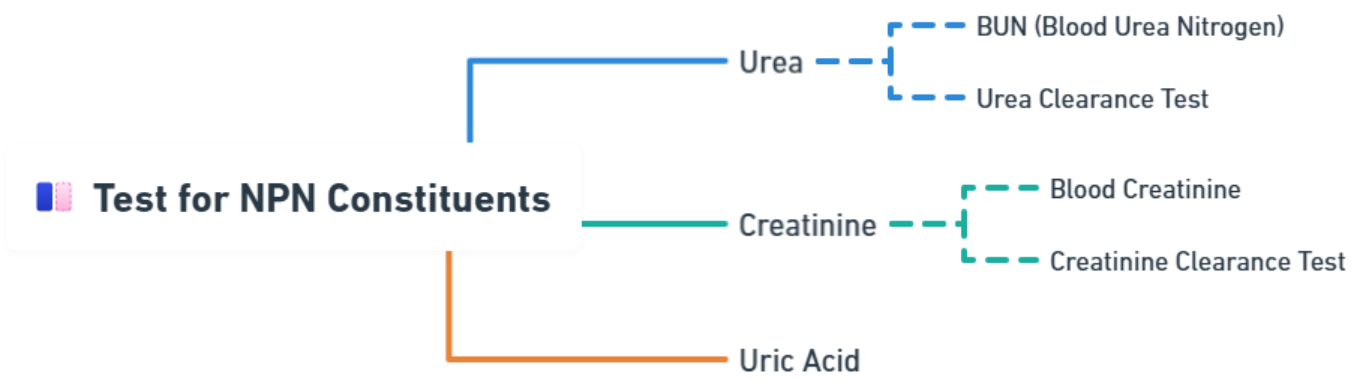
E. Urinary Osmolality

- Measures the concentrating ability of kidneys
- Normal: 300–900 mOsm/kg
- Low in **renal tubular dysfunction**

Test for NPN Constituents

What are NPN Substances?

- Non-Protein Nitrogen (NPN) compounds are nitrogenous waste products in the blood that are not part of proteins.
- These are typically excreted by the kidneys. Common NPN substances include:
  - **Urea**, **Creatinine**, **Uric acid**, Others (like ammonia, amino acids, etc.)
- These are used as markers of renal (kidney) function, especially of the **glomerular filtration rate (GFR)**, which indicates how well the kidneys are filtering blood.



A. Urea

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