Interpretation of Kidney Function Test & Urine Analysis

Kidney Function Tests

- **Components:**
  - **Blood urea & blood urea nitrogen (BUN)**
  - **Serum creatinine**
  - **Urea–creatinine ratio**
  - **Measured & estimated GFR**
  - **Assessment of proteinuria**

Blood Urea & Blood Urea Nitrogen

Definition

- **Urea:** primary metabolite from dietary & tissue protein turnover

Production

- **Protein → amino acids → NH_3 (toxic) → urea (non-toxic)**

Elimination

- **<10%** via sweat & gut
- **Majority** excreted by kidneys in urine

Filtration & Reabsorption

- **Freely filtered**
- **~50% reabsorbed** in PCT with water
- **Secreted** in thin limb
- **Reabsorbed** in collecting duct with water
- Important for **medullary osmolar gradient**

Importance

- **Ammonia detoxification**
- **Water conservation**

Normal Values

- **Blood urea: 15–45 mg/dL (2.5–7.8 mmol/L)**
- **BUN: 7–20 mg/dL**
- **Conversion:**
  - **BUN = 0.446 × blood urea**
  - **Urea to SI: 0.167**
  - **BUN to SI: 0.357**

- ✧ **Increased Urea**
  - ◈ **Renal failure (AKI/CKD)**
  - ◈ **Dehydration**
  - ◈ **↓ Renal perfusion:** heart failure, shock, hypotension
  - ◈ **GI bleeding**
  - ◈ **High-protein diet**
  - ◈ **Catabolic states:** trauma, infection, starvation, corticosteroids
- ✧ **Decreased Urea**
  - ◈ **Pregnancy**
  - ◈ **Low-protein diet**
  - ◈ **Overhydration**
  - ◈ **Advanced liver disease**
  - ◈ **Urea-cycle defects**

Serum Creatinine

- ✧ **Definition**
  - ◈ Product of **muscle creatine catabolism**
  - ◈ **Molecular weight: 113 Da**
- ✧ **Characteristics**
  - ◈ **Endogenously produced**
  - ◈ **Freely filtered**
  - ◈ Less affected by diet than urea
  - ◈ Rises only after **significant renal damage**
- ✧ **Normal Values**
  - ◈ **Adult male: 0.6–1.2 mg/dL**
  - ◈ **Adult female: 0.5–1.1 mg/dL**
  - ◈ **Pregnancy upper limit: 0.8 mg/dL**
  - ◈ **1 mg/dL = 88.5 µmol/L**
- ✧ **Factors Affecting Creatinine**
  - ◈ **↓:** older age, female sex, vegetarian diet, malnutrition, amputation
  - ◈ **↑:** African race, cooked meat ingestion, muscular body habitus
  - ◈ **No change:** obesity

Urea–Creatinine Ratio

- ✧ **Normal Range**
  - ◈ **5–20**
- ✧ **Increased Ratio**
  - ◈ **Dehydration**
  - ◈ **Heart failure**
  - ◈ **GI bleeding**
  - ◈ **High-protein diet**
  - ◈ **Catabolic states**
  - ◈ **Prerenal AKI:** shock, hypovolemia, hypotension

- ✧ **Decreased Ratio**
  - ◈ Low-protein intake
  - ◈ Advanced liver disease
  - ◈ Sickle cell anemia
  - ◈ Hypothyroidism
  - ◈ Rhabdomyolysis
  - ◈ Acetazolamide

Measured & Estimated GFR

- ✧ **Definition**
  - ◈ Volume of plasma filtered per unit time
- ✧ **Ideal Filtration Marker**
  - ◈ Freely filtered
  - ◈ Stable plasma level
  - ◈ No reabsorption or secretion
  - ◈ **Inulin** (gold standard)
- ✧ **Clearance Formula**
  - ◈ $Cx = Ux \times V / Px$
- ✧ **Estimated GFR Equations**
  - ◈ Cockcroft–Gault
  - ◈ MDRD
  - ◈ CKD-EPI
- ✧ **When to Measure GFR Directly**
  - ◈ Extremes of age/body size
  - ◈ Malnutrition or obesity
  - ◈ Muscle disease
  - ◈ Paraplegia/quadriplegia
  - ◈ Vegetarian diet
  - ◈ Rapidly changing renal function
  - ◈ Pregnancy

Proteinuria

- ✧ **Normal Excretion**
  - ◈ Adults: ≤150 mg/day
  - ◈ Children: <140 mg/m²/day
- ✧ **Definition**
  - ◈ >150 mg/day
- ✧ **Grades**
  - ◈ Microalbuminuria: 30–300 mg/day
  - ◈ Mild: <1000 mg/day
  - ◈ Moderate: 1000–2000 mg/day
  - ◈ Heavy: >2000 mg/day
  - ◈ Nephrotic range: >3500 mg/day

- ✧ **Causes by Quantity**
  - ◈ **0.15–2 g/day:** mild glomerular, tubular, overflow
  - ◈ **2–4 g/day:** glomerular
  - ◈ **>4 g/day:** always glomerular
- ✧ **Classification**
  - ☑ **Transient**
    - ◈ **Benign & self-limited**
    - ◈ Causes: fever, exercise, stress, CHF, seizures, orthostatic
  - ☑ **Persistent**
    - ◈ **Glomerular:** albumin, RBC casts
    - ◈ **Tubular:** LMW proteins, usually **<1 g/day**
    - ◈ **Overflow:** monoclonal light chains (MM)

Assessment of Proteinuria

- ✧ **Methods**
  - ◈ **Dipstick**
  - ◈ **Sulfosalicylic acid test**
  - ◈ **24-hour urine protein** (gold standard)
  - ◈ **Protein/creatinine ratio**
- ✧ **Dipstick Proteinuria**
  - ◈ **Trace: 10–30 mg/dL**
  - ◈ **1+: 30**
  - ◈ **2+: 100**
  - ◈ **3+: 300**
  - ◈ **4+: ≥1000**

Urine Analysis

- ✧ **Proper Collection**
  - ◈ Discard **first 200 mL** morning urine
  - ◈ **Midstream** clean-catch
  - ◈ Analyze within **30–60 minutes**
- ✧ **Macroscopic Examination**
  - ◈ **Normal color:** pale yellow → amber
  - ◈ **Frothy urine:** proteinuria
  - ◈ **Cloudy:** UTI, stones, nephrotic syndrome
- ✧ **Dipstick**
  - ◈ **pH: 4.5–8.0**
  - ◈ **Specific gravity: 1.005–1.025**
  - ◈ **Blood:** hematuria vs hemoglobinuria/myoglobinuria
  - ◈ **Glucose:** DM, tubular disease, SGLT2 inhibitors
  - ◈ **Ketones:** DM, pregnancy, starvation
  - ◈ **Nitrite:** specific for nitrate-reducing bacteria
  - ◈ **Leukocyte esterase:** pyuria

- ✧ **Microscopy**
  - **Dysmorphic RBCs / RBC casts:** glomerulonephritis
  - **WBC casts:** UTI or interstitial disease
  - **Squamous cells >15–20/hpf:** contamination

Urinary Casts

- **Formed in DCT & collecting duct**
- **Promoted by:** low flow, high salt, low pH
- ✧ **Types**
  - **Hyaline:** normal or dehydration
  - **Granular:** ATN
  - **Waxy/broad:** advanced CKD
  - **RBC casts:** glomerulonephritis
  - **WBC casts:** pyelonephritis
  - **Fatty casts:** nephrotic syndrome

Urinary Crystals

- **Calcium oxalate:** ethylene glycol
- **Uric acid:** hyperuricosuria
- **Triple phosphate:** UTI (Proteus)
- **Cystine:** cystinuria
- **Indinavir crystals**