

## Renal system

### Acute Renal Failure (ARF) / Acute Kidney Injury (AKI)

#### Introduction / Epidemiology

- Acute Kidney Injury (AKI) refers to a rapid decline in renal function over hours to days, resulting in accumulation of nitrogenous wastes (urea, creatinine) and disturbances in fluid, electrolyte, and acid-base balance.

#### Epidemiology

- Incidence: Common in hospitalized patients, especially in critical care settings.
- Around 15–20% of hospitalized patients develop AKI; incidence rises to 30–50% in ICUs.
- Higher risk in elderly, diabetic, and patients with cardiovascular disease.

#### Etiopathogenesis

AKI is classified into three major categories based on the **site and mechanism** of injury:

##### 1. Pre-Renal AKI (~60–70%)

- **Cause:** Decreased renal perfusion without damage to kidney parenchyma.
- **Examples:**
  - Hypovolemia (e.g., hemorrhage, dehydration)
  - Hypotension (e.g., sepsis, cardiogenic shock)
  - Renal artery stenosis
  - Use of NSAIDs, ACE inhibitors in volume-depleted patients

##### 2. Intrinsic (Renal) AKI (~20–30%)

- **Cause:** Direct injury to kidney tissues.
- **Examples:**
  - Acute Tubular Necrosis (ATN): ischemic or nephrotoxic (e.g., aminoglycosides, radiocontrast)
  - Glomerulonephritis (immune-mediated)
  - Acute Interstitial Nephritis (e.g., drug-induced - antibiotics, NSAIDs)
  - Vasculitis

##### 3. Post-Renal AKI (~5–10%)

- **Cause:** Obstruction of urinary outflow.
- **Examples:**
  - Benign prostatic hyperplasia (BPH)

- Ureteral obstruction (tumors, stones)
- Urethral stricture

## Clinical Features / Symptoms

- Symptoms vary depending on the severity and cause:
  - Oliguria (<400 mL/day) or Anuria (<100 mL/day)
  - Fluid overload: edema, pulmonary congestion
  - Electrolyte disturbances: hyperkalemia (arrhythmias), hyponatremia, metabolic acidosis
  - Uremic symptoms: nausea, vomiting, fatigue, confusion, pericarditis, encephalopathy
  - Signs related to underlying cause: hypotension in prerenal; rash, fever in interstitial nephritis; flank pain in obstruction

## Diagnosis & Investigations

### Laboratory Tests

- **Serum Creatinine:** ↑ acutely (>0.3 mg/dL in 48 hrs or 1.5x baseline in 7 days)
- **BUN/Creatinine ratio:**
  - 20:1 in prerenal
  - ~10–15:1 in intrinsic
- **Electrolytes:** Hyperkalemia, hyponatremia, hyperphosphatemia
- **Metabolic acidosis:** Low serum bicarbonate
- **Urinalysis:**
  - Muddy brown casts (ATN)
  - RBC casts (glomerulonephritis)
  - Eosinophils (AIN)
- **Urine sodium / FeNa (Fractional excretion of sodium):**
  - FeNa <1% = prerenal
  - FeNa >2% = ATN

### Imaging

- **Renal ultrasound:** to rule out obstruction
- **CT scan:** for tumors, stones, obstruction

### Other

- **Renal biopsy:** If glomerulonephritis or interstitial nephritis is suspected and diagnosis is uncertain.

## Treatment Goals / Therapeutic Objectives

- Identify and correct the underlying cause.
- Restore and maintain adequate renal perfusion.
- Prevent and manage complications: fluid overload, hyperkalemia, acidosis, infections.
- Avoid nephrotoxic agents.
- Initiate renal replacement therapy (dialysis) when necessary.

## Non-Pharmacological Therapy

- **Fluid resuscitation** (e.g., isotonic saline) in prerenal causes.
- **Stop nephrotoxic agents** (e.g., NSAIDs, aminoglycosides, contrast agents).
- **Nutritional support:**
  - Energy: 20–30 kcal/kg/day
  - Protein: 0.8–1.0 g/kg/day (non-dialysis); 1.2–1.5 g/kg/day (dialysis)
- **Renal replacement therapy (RRT):**
  - Indications: AEIOU
    - Acidosis (refractory)
    - Electrolyte imbalance (e.g., severe hyperkalemia)
    - Intoxication (certain drugs)
    - Overload (fluid)
    - Uremia (symptomatic)

## Pharmacological Therapy

- There are no direct drugs to “treat” AKI but supportive drug therapy includes:

| Medication                                                      | Dose                                        | Mechanism                                           | Rationale                                                   |
|-----------------------------------------------------------------|---------------------------------------------|-----------------------------------------------------|-------------------------------------------------------------|
| <b>Loop diuretics (e.g., furosemide)</b>                        | IV 20–80 mg; titrate up                     | Inhibits Na-K-2Cl in loop of Henle                  | Used only in volume-overloaded patients to promote diuresis |
| <b>Electrolyte binders (e.g., sodium polystyrene sulfonate)</b> | 15–30 g orally                              | Exchanges Na <sup>+</sup> for K <sup>+</sup> in gut | To treat hyperkalemia                                       |
| <b>Insulin + glucose</b>                                        | Regular insulin 10 units IV + D50W 25–50 mL | Drives K <sup>+</sup> into cells                    | For acute hyperkalemia                                      |
| <b>Calcium gluconate</b>                                        | 10 mL IV of 10% solution                    | Stabilizes cardiac membrane                         | First-line in hyperkalemia with ECG changes                 |
| <b>Sodium bicarbonate</b>                                       | 50–100 mEq IV                               | Buffers metabolic acidosis                          | Only if acidosis is severe                                  |

- **Note:** Dopamine and other “renal protective” agents are **not recommended**.

## Individualized Patient-Specific Therapeutic Plan

- **Elderly:** Higher risk due to reduced renal reserve; avoid volume overload; adjust all nephrotoxic drugs.
- **Pediatrics:** Dose adjustments based on body weight and renal function.
- **Pregnancy:** Careful fluid balance; avoid ACE inhibitors, NSAIDs.
- **Comorbidities:** Diabetics may need insulin adjustment; cardiac patients need tight fluid control.
- **Renal impairment:** Avoid renally cleared drugs or adjust doses (e.g., vancomycin, aminoglycosides).
- **Hepatic impairment:** Monitor for hepatorenal syndrome.
- **Allergies:** Consider non-drug-based therapies if allergy to key agents exists (e.g., contrast allergy – use non-contrast imaging).

## Controversies / Special Considerations

### 1. Fluid management:

- Liberal vs restrictive strategies: restrictive preferred in ICU based on recent data.

### 2. Biomarkers:

- NGAL, cystatin C, IL-18 under investigation for early diagnosis but not yet standard.

### 3. Dialysis timing:

- Early vs delayed initiation of RRT: Studies (e.g., AKIKI, IDEAL-ICU trials) show no significant mortality benefit with early initiation in all cases.

### 4. Preventive strategies:

- Role of N-acetylcysteine in contrast nephropathy prevention is debated.

### 5. COVID-19:

- Increased incidence of AKI reported in severe cases due to multi-organ failure, inflammation, and coagulopathy.

## Monitoring Therapy

### Clinical Parameters

- Urine output (>0.5 mL/kg/hr is target)
- Vital signs (BP, HR)
- Edema, weight changes
- Mental status (uremic encephalopathy)

### Laboratory Monitoring

- Daily:
  - Serum creatinine, BUN
  - Electrolytes ( $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Cl}^-$ ,  $\text{HCO}_3^-$ )
  - Arterial blood gases (for acidosis)
  - CBC (monitor anemia, infection)
- Urinalysis: Weekly or PRN

### **Time-Course of Response**

- Prerenal AKI improves within **24–72 hours** of fluid correction.
- Intrinsic AKI may take **days to weeks** depending on severity.
- Post-renal AKI resolves quickly after relief of obstruction.

### **Adverse Effects & Management**

- **Hyperkalemia** → Arrhythmias → ECG monitoring, calcium gluconate, insulin-glucose
- **Volume overload** → Pulmonary edema → Diuretics, dialysis
- **Infections (sepsis)** → Antibiotics, source control
- **Drug toxicities** due to impaired renal clearance → Dose adjustment, drug avoidance

### **Follow-Up and Patient Counseling**

#### **Follow-up**

- Monitor kidney function weekly until stabilization.
- Long-term monitoring: Every 3–6 months if risk factors present (e.g., diabetes, CKD progression).
- Watch for development of chronic kidney disease (CKD).

#### **Patient Counseling**

- Importance of hydration, especially during illness or surgery.
- Avoid NSAIDs, unnecessary antibiotics, contrast unless necessary.
- Alert physician before taking new medications.
- Early reporting of decreased urine output, edema, or shortness of breath.
- Dietary restrictions: potassium, sodium, and fluid as per stage of AKI.

## **Chronic Renal Failure (CRF) / Chronic Kidney Disease (CKD)**

### **Introduction / Epidemiology**

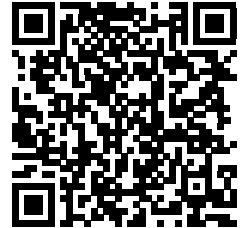


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