Acute Renal Failure

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Acute Renal Failure

Definition

- Acute decrement in GFR
- May heal partially or completely or progress to more severe renal insufficiency, including end-stage renal disease
Acute Renal Failure
Classification

• Pre-renal (functional)
• Renal (structural)
• Post-renal (obstruction)
Acute Renal Failure
Pre-renal Causes

- Intravascular volume depletion
  - Hemorrhage
  - Sodium depletion
- Redistribution of ECF
  - “Third space” accumulation
  - Edematous disorders
- Drugs
Renal Blood Flow

\[ F = \frac{\Delta P}{R} \]

\[ RBF = \frac{R_{AP} - R_{VP}}{R_{aff} + R_{eff}} \]

\[ RBF \approx \frac{R_{AP}}{R_{aff} + R_{eff}} \]
Pre-Renal Azotemia
Pathophysiology

• Renal hypoperfusion
  – Decreased RBF and GFR
  – Increased filtration fraction (GFR/RBF)
• Increased Na and H₂O reabsorption
  – Oliguria, high $U_{\text{osm}}$, low $U_{\text{Na}}$
  – Elevated BUN/Cr ratio
Acute Tubular Necrosis
Classification

- Ischemic
- Nephrotoxic
Acute Tubular Necrosis
Acute Tubular Necrosis
Acute Renal Failure
Nephrotoxic ATN

• Endogenous Toxins
  – Heme pigments (myoglobin, hemoglobin)
  – Myeloma light chains

• Exogenous Toxins
  – Antibiotics (e.g., aminoglycosides, amphotericin B)
  – Radiocontrast agents
  – Heavy metals (e.g., cis-platinum, mercury)
  – Poisons (e.g., ethylene glycol)
Acute Tubular Necrosis
Acute Tubular Necrosis
Acute Interstitial Nephritis

Causes

- Allergic interstitial nephritis
  - Drugs
- Infections
  - Bacterial
  - Viral
- Sarcoidosis
Allergic Interstitial Nephritis
Clinical Characteristics

• Fever
• Rash
• Arthralgias
• Eosinophilia
• Urinalysis
  – Microscopic hematuria
  – Sterile pyuria
  – Eosinophiluria
Acute Interstitial Nephritis
Cholesterol Embolization
Contrast-Induced ARF Prevalence

- Less than 1% in patients with normal renal function
- Increases significantly with renal insufficiency
Contrast-Induced ARF
Risk Factors

- Renal insufficiency
- Diabetes mellitus
- Multiple myeloma
- High osmolar (ionic) contrast media
- Contrast medium volume
Contrast-induced ARF
Clinical Characteristics

- Onset - 24 to 48 hrs after exposure
- Duration - 5 to 7 days
- Non-oliguric (majority)
- Dialysis - rarely needed
- Urinary sediment - variable
- Low fractional excretion of Na
Contrast-induced ARF Prophylactic Strategies

- Use I.V. contrast only when necessary
- Hydration
- Minimize contrast volume
- Low-osmolar (nonionic) contrast media
- N-acetylcysteine, fenoldopam
Acute Renal Failure
Post-renal Causes

- **Intra-renal Obstruction**
  - Acute uric acid nephropathy
  - Drugs (e.g., acyclovir)
- **Extra-renal Obstruction**
  - Renal pelvis or ureter (e.g., stones, clots, tumors, papillary necrosis, retroperitoneal fibrosis)
  - Bladder (e.g., BPH, neuropathic bladder)
  - Urethra (e.g., stricture)
Acute Renal Failure Diagnostic Tools

• Urinary sediment
• Urinary indices
  – Urine volume
  – Urine electrolytes
• Radiologic studies
Urinary Sediment (1)

- Bland
  - Pre-renal azotemia
  - Urinary outlet obstruction
Urinary Sediment (2)

- RBC casts or dysmorphic RBCs
  - Acute glomerulonephritis
  - Small vessel vasculitis
Red Blood Cell Cast
Red Blood Cells

Monomorphcic

Dysmorphic
Dysmorphic Red Blood Cells
Dysmorphic Red Blood Cells
Urinary Sediment (3)

- **WBC Cells and WBC Casts**
  - Acute interstitial nephritis
  - Acute pyelonephritis
White Blood Cells
White Blood Cell Cast
Urinary Sediment (4)

- RTE cells, RTE cell casts, pigmented granular (“muddy brown”) casts
  - Acute tubular necrosis
Renal Tubular Epithelial Cell Cast
Pigmented Granular Casts
Acute Renal Failure
Urine Volume (1)

- **Anuria (< 100 ml/24h)**
  - Acute bilateral arterial or venous occlusion
  - Bilateral cortical necrosis
  - Acute necrotizing glomerulonephritis
  - Obstruction (complete)
  - ATN (very rare)
Acute Renal Failure
Urine Volume (2)

- Oliguria (100-500 ml/24h)
  - Pre-renal azotemia
  - ATN
- Non-Oliguria (> 500 ml/24h)
  - ATN
  - Obstruction (partial)
# Acute Tubular Necrosis

## Clinical Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Oliguric ATN</th>
<th>Non-Oliguric ATN</th>
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</thead>
<tbody>
<tr>
<td>Incidence</td>
<td>41%</td>
<td>59%</td>
</tr>
<tr>
<td>Toxin-induced</td>
<td>8%</td>
<td>30%</td>
</tr>
<tr>
<td>UV (ml/24h)</td>
<td>&lt; 400</td>
<td>1,280 ± 75</td>
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<tr>
<td>$U_{\text{Na}}$ (mEq/L)</td>
<td>68 ± 6</td>
<td>50 ± 5</td>
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<tr>
<td>$FE_{\text{Na}}$ (%)</td>
<td>6.8 ± 1.4</td>
<td>3.1 ± 0.5</td>
</tr>
<tr>
<td>Dialysis required</td>
<td>84%</td>
<td>26%</td>
</tr>
<tr>
<td>Mortality</td>
<td>50%</td>
<td>25%</td>
</tr>
</tbody>
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Hydronephrosis
Normal Renal Ultrasound
Hydronephrosis

Right kidney
Longitudinal

Dilated Renal Pelvis
Hydronephrosis