Acute Kidney Injury

MICU Resident Lecture Series
Definition of AKI

- Acute rise in serum creatinine ≥ 0.5 mg/dL
  - If creatinine is over 2.5 mg/dL, then an increase in serum creatinine of over 20%
- Urine output less than 0.3 mL/kg.hr
  - Oliguria < 400cc / 24hrs
  - Anuria < 100 cc / 24 hrs
- Signs or symptoms of uremia
Acute kidney injury is common (and fatal)

- Incidence of about 5-7% in hospital
  - ~25% of ICU patients

- Overall in-hospital mortality rate 20%
  - Increased with need for dialysis (40-50%)
  - Increased in ICU patients (50-70%)
Risk Factors for AKI

- Increased age
- Sepsis
- Cardiac surgery
- Diabetes
- Rhabdomyolysis
- Pre-existing renal disease
- Hypovolemia
- Shock
Acute Kidney Injury Etiology

**Prerenal**
1. Decrease in intravascular volume
2. Ineffective arterial volume
3. RAS
4. Meds (ACE, NSAID)

**Intrinsic**
1. Vasculitis
2. Glomerular nephritis
3. Interstitial nephritis
4. Acute tubular necrosis (ATN)

**Postrenal**
- Bladder or collecting duct obstruction
History and Physical

- **“Prerenal”**
  - GI or blood loss, pancreatitis, CHF or cirrhosis
  - Orthostatic, poor skin turgor, dry MM

- **“Intrinsic disease”**
  - Nephrotoxins, IV contrast, severe and prolonged hypotension, rhabdo, pulmonary renal disease (Goodpastures, Wegener’s)
  - Edema, palpable purpura, muscle tenderness

- **“Post renal”**
  - Decreased stream or anuria, flank pain
  - Distended bladder or prostate enlargement
Nephrotoxic agents

- Antibiotics:
  - Aminoglycosides
  - Piperacillin/tazobactam
  - Amphotericin
  - Bactrim
- NSAIDS
- Contrast – cardiac catheterization and CT
Initial work up

- History and exam
  - Evaluate volume status and etiology
    - CVP
    - Blood pressure, orthostatics

- Urine electrolytes, urine creatinine, and urine BUN (affected by diuretics)

- Urine sediment

- Urine eosinophils

- Placement of foley catheter or bladder scan

- Renal ultrasound
Renal Ultrasound: normal kidneys
Degrees of Hydronephrosis

Mild  Moderate  Severe
Renal Ultrasound: hydrenephrosis
Calculations

- **FENa** = \( \frac{U_{na}/\text{serum}_{Na}}{U_{cr}/\text{serum}_{Cr}} \) * 100
  - <1% prerenal disease

- **FEUrea** = \( \frac{\text{Serum}_{Cr} \cdot U_{\text{Urea}}}{\text{Serum}_{\text{Urea}} \cdot U_{Cr}} \) * 100
  - <35% prerenal disease
  - Can be used in pts on diuretics

- **BUN / creat ratio**
  - > 20:1 in prerenal states
# Urine sediment and routine labs

## Table 3. Urinalysis, Urine Chemistries, and Osmolality in Acute Renal Failure

<table>
<thead>
<tr>
<th></th>
<th>Hypovolemia</th>
<th>Acute Tubular Necrosis</th>
<th>Acute Interstitial Nephritis</th>
<th>Glomerulonephritis</th>
<th>Obstruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sediment</td>
<td>Bland</td>
<td>Broad, brownish granular casts</td>
<td>White blood cells, eosinophils, cellular casts</td>
<td>Red blood cells, red blood cell casts</td>
<td>Bland or bloody</td>
</tr>
<tr>
<td>Protein</td>
<td>None or low</td>
<td>None or low</td>
<td>Minimal but may be increased with NSAIDs</td>
<td>Increased, &gt;100 mg/dL</td>
<td>Low</td>
</tr>
<tr>
<td>Urine sodium, mEq/L*</td>
<td>&lt;20</td>
<td>&gt;30</td>
<td>&gt;30</td>
<td>&lt;20</td>
<td>&lt;20 (Acute) &gt;40 (Few days)</td>
</tr>
<tr>
<td>Urine osmolality, mOsm/kg</td>
<td>&gt;400</td>
<td>&lt;350</td>
<td>&lt;350</td>
<td>&gt;400</td>
<td>&lt;350</td>
</tr>
<tr>
<td>Fractional excretion of sodium, %†</td>
<td>&lt;1</td>
<td>&gt;1</td>
<td>Varies</td>
<td>&lt;1</td>
<td>&lt;1 (Acute) &gt;1 (Few days)</td>
</tr>
</tbody>
</table>

Abbreviation: NSAIDs, nonsteroidal anti-inflammatory drugs.

*The sensitivity and specificity of urine sodium of less than 20 in differentiating prerenal azotemia from acute tubular necrosis are 90% and 82%, respectively (N = 85).†

†Fractional excretion of sodium is the urine to plasma (U/P) of sodium divided by U/P of creatinine × 100. The sensitivity and specificity of fractional excretion of sodium of less than 1% in differentiating prerenal azotemia from acute tubular necrosis are 96% and 95%, respectively (N = 85).
WBC cast

Granular cast

RBC cast
Management

- Reverse underlying cause
- Avoid nephrotoxic agents
- Treat hyperkalemia
- Early involvement of renal consultants
- Adjust medication doses
  - Antibiotics
  - Pain medications
- Initiate hemodialysis
Treat hyperkalemia

- Cardiac membrane stabilization
  - Calcium

- Peripheral uptake of potassium intracellularly
  - Bicarbonate
  - Insulin / D50
  - Albuterol

- Elimination of potassium
  - Loop diuretics
  - Binding resins – Kayexalate
  - Dialysis
Indications for acute dialysis

- “A-E-I-O-U”
  - Acidosis (pH<7.1)
  - Electrolyte abnormalities (hyperkalemia, sodium)
  - Intoxicants (lithium, toxic alcohols, others)
  - Overload (fluid)
  - Uremia (mental status, pericarditis, neuropathy)
Prevention strategies

• Avoid nephrotoxic agents if possible

• Sepsis
  • Dose Abx once vs. 3X per day
  • Amphotericin alternative (liposomal)

• Contrast
  • Adequate volume with bicarbonate containing IVF
  • NAC (Mucomyst)
  • Consider other imaging techniques (MRI or US)
Prevention strategies

- **Rhabdomyolysis**
  - Bicarb and volume replacement

- **Liver failure**
  - TIPS
  - Albumin in SBP patients
  - Possible octreotide

- **Surgery** — maintain adequate intravascular volume

- **Negative trials**
  - Dopamine, diuretics, nesiritide (Natrecor), fenoldapam (Corlopam)
Cases
Case 1 – Decreasing urine output in CHF

- 67 yo woman with respiratory failure secondary to CHF, EF 25% now with decreasing urine output
  - BP 95/45, orthostatic
  - Edematous, JVD, and pulmonary edema
  - BUN 45, creat 1.0
  - Urine Na 15
  - FENA = 1%
  - FEUN = 20%

CHF with ineffective circulating volume
- Treat with dobutamine
Case 2 – Elevated creatinine in the ICU

- 75 yo man with elevation in baseline creatinine of 1.0 to 2.5, on Zosyn for pneumonia
  - Normotensive and no edema
  - BUN 25, creat 2.5
  - Urine Na 45
  - FENA = 2%
  - FEUN = 55%
  - Sediment with muddy brown casts
  - Urine eosinophils negative

ATN
- Stop offending drug
Case 3 – Anuria

- 45 yo morbidly obese man admitted for respiratory distress and hypercapnea, now with no urine output
  - Normotensive and no edema
  - No urine output, no foley

Bladder outlet obstruction
  - Place foley
Case 4 – Decreased urine output in GI bleeding

- 82 yo woman admitted for a GI bleed, now with decreasing urine output to 10 cc per hour
  - Normotensive but orthostatic
  - BUN 25, creat 1.0
  - Urine Na <5
  - FENA = 0.3%
  - FEUN = 15%
  - Sediment bland

Hypovolemic
- Give fluid bolus
Questions?
Abbreviated bibliography


