Workup and Management of Acute Kidney Injury

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Division of Nephrology
University of Washington
Disclosures

- I have nothing to disclose
Objectives

1. Review common (and uncommon) causes of acute kidney injury (AKI) in hospitalized patients

2. Discuss practical diagnostic evaluation for the hospitalized patient with AKI

3. Discuss prevention and management of select AKI etiologies
Case 1

**HPI:**
- 43 y/o woman with a history of chronic HCV, presents to ED with abdominal pain, vomiting x 3 days
- Temp 38, BP 95/60, HR 100
- Exam shows abdominal tenderness, 1+ LE edema
  - Receives 1 liter LR, vancomycin and cefepime x 1
  - F/u BP 105/70 → admitted to medicine

**PMH:**
- H/o wrist fracture 1 year ago, creatinine 0.7 mg/dL
Laboratory/imaging evaluation

Urinalysis: 1+ RBCs, 1+ protein
Urine protein/creat: 0.5 g/g

HCV viral load: 800,000 IU/L
C3, C4 both low
INR: 1.4
Total bilirubin: 6.0 mg/dL
Case 1, continued

Trend in serum creatinine

SERUM CREATININE (MG/DL)

HOSPITAL DAY

Vanco level 40

Vanco/cefepime
What is causing this patient’s AKI?

- **Acute tubular injury/necrosis**
- **Hepatorenal syndrome**
- **Acute interstitial nephritis**
- **Vancomycin nephrotoxicity**
- **Pre-renal (low EABV)**
- **GN/MPGN related to Hepatitis C**
"Acute Kidney Injury" is a clinical syndrome

<table>
<thead>
<tr>
<th>Stage</th>
<th>Serum Creatinine</th>
<th>Urine output</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5-1.9 times baseline within 1 wk or ≥ 0.3 mg/dl increase within 48 hrs</td>
<td>&lt;0.5ml/kg/h for 6-12 hrs</td>
</tr>
<tr>
<td>2</td>
<td>2.0-2.9 times baseline</td>
<td>&lt;0.5ml/kg/h for ≥ 12 hrs</td>
</tr>
<tr>
<td>3</td>
<td>3.0 times baseline or increase in serum creat to ≥ 4.0 mg/dl or initiation of RRT or in patients &lt; 18 yrs, decrease in eGFR to &lt;35ml/min per 1.73 m²)</td>
<td>&lt;0.3ml/kg/h for ≥ 24 hrs or Anuria for ≥ 12 hrs</td>
</tr>
</tbody>
</table>

KDIGO AKI Guidelines, 2012
TREATMENT OF AKI

- AKI is not a single disease entity – it is a heterogeneous group of conditions with different causes and pathophysiologic mechanisms

- There are no pharmacologic agents available for the prevention or treatment of acute kidney injury

- Thus, treatment is always
  - Identification and management of underlying disorder
  - Management of volume and metabolic complications
AKI is common in hospitalized patients!

<table>
<thead>
<tr>
<th>Total number</th>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>n=1,277</td>
<td></td>
<td></td>
<td>Sepsis, 68.4%</td>
</tr>
<tr>
<td>n=1,566</td>
<td></td>
<td></td>
<td>Pneumonia, 52.5%</td>
</tr>
<tr>
<td>n=2,738</td>
<td></td>
<td></td>
<td>Congestive heart failure, 47.4%</td>
</tr>
<tr>
<td>n=1,631</td>
<td></td>
<td></td>
<td>Acute myocardial infarction, 46.4%</td>
</tr>
<tr>
<td>n=539</td>
<td></td>
<td></td>
<td>Chronic kidney disease, 45.6%</td>
</tr>
<tr>
<td>n=758</td>
<td></td>
<td></td>
<td>Lymphoma, 33.6%</td>
</tr>
<tr>
<td>n=647</td>
<td></td>
<td></td>
<td>Liver disease, 33.1%</td>
</tr>
<tr>
<td>n=866</td>
<td></td>
<td></td>
<td>Rheumatic disease, 21.5%</td>
</tr>
<tr>
<td>n=7,735</td>
<td></td>
<td></td>
<td>Solid cancer, 21.0%</td>
</tr>
</tbody>
</table>

Zeng et al, CJASN, 2014
Urinary biomarkers for AKI – NOT YET!

Markers of glomerular function
- creatinine
- cystatin C
- hepcidin

Markers of tubular function / damage
- AAP
- ALP
- α-GST
- π-GST
- γ-GT
- hepcidin
- IGFBP7
- KIM-1
- L-FABP
- α1 / β2 microglobulin
- microRNA
- NAG
- Netrin-1
- NGAL
- RBP
- TIMP-2

Markers of inflammation & repair
- calprotectin
- IL-18
- HGF
- proenkephalin

Tubular function as a stress test

77 patients with AKI who received FST → followed for development of stage 3 AKI, RRT, death

FUROSEMIDE OUTPERFORMED URINARY BIOMARKERS FOR ALL OUTCOMES

Koyner et al, JASN, 2015
Causes of AKI

**Pre-renal**
- Volume depletion
- Cardiorenal syndrome
- Hepatorenal syndrome
- Abdominal compartment syndrome
- Renal artery occlusion/Dissection
- Renal vein thrombosis

**Intra-renal**
- Acute tubular necrosis
- Glomerular disorders
- Microvascular disorders
- Tubulointerstitial Disorders

**Post-renal**
- Ureteral obstruction
- Bladder outlet obstruction

### Decreased EABV/Renal vein congestion
Causes of AKI – An Anatomic Approach

1. Prerenal azotemia
   - Hypovolemia
   - Cardiac failure
   - Hepatorenal syndrome

2. Renal artery
   - Renal artery occlusion or dissection
   - Large- or medium-vessel vasculitis

3. Small-vessel disease
   - Thrombotic microangiopathy
   - Renal atheroembolism

4. Glomerular disease
   - Small-vessel vasculitis
   - Anti-GBM disease
   - Lupus nephritis
   - Postinfectious glomerulonephritis
   - Infective endocarditis
   - Membranoproliferative glomerulonephritis
   - Cryoglobulinemia
   - IgA nephropathy/IgA-vasculitis

5. Acute tubular necrosis
   - Ischemia
   - Nephrotoxins
   - Rhabdomyolysis
   - Radiographic contrast agents

6. Acute interstitial nephritis
   - Drugs
   - Infection
   - Systemic disease

8. Postrenal obstruction
   - Bladder outlet obstruction
   - Tumors
   - Renal calculi
   - Papillary necrosis
   - Retroperitoneal fibrosis

7. Intratubular obstruction
   - Cast nephropathy
   - Drugs
   - Crystalluria

Case 2

- 20 y/o man hospitalized for volume depletion after returning from Mexico
- Reports 5 days of 6-10 loose stools/day, nausea, poor PO intake
- BP is 80/50, dizzy with standing
- Creatinine 1 year ago 0.9.

<table>
<thead>
<tr>
<th>126</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5</td>
<td>16</td>
</tr>
</tbody>
</table>

Urine:

- $U_{Na}$: 8 mEq/L
- $U_{creatinine}$: 35 mg/dL
- $U_{osmolality}$: 560 mOsm/kg
- Fe Na: 0.6%

Urine sediment: Bland
Causes of AKI in hospitalized patients

> 90% of all AKI!

Nash et al., AJKD, 2002
<table>
<thead>
<tr>
<th>“Pre-renal”</th>
<th>ATN</th>
</tr>
</thead>
<tbody>
<tr>
<td>UOP/creatinine respond quickly to fluids (if given enough)</td>
<td>UOP/creatinine do not respond to fluids</td>
</tr>
</tbody>
</table>

**If volume status unclear:**

1. Early therapeutic trial of withholding diuretics, give 500cc-1000cc isotonic fluid over 1-4 hours

2. Watch for UOP and serum creatinine over next 12-24 hours

<table>
<thead>
<tr>
<th>low (&lt;1%)</th>
<th>FeNa not low (&gt;2%)</th>
</tr>
</thead>
</table>

Some cases have considerable overlap
FENa

FENa = Excreted Na
Filtered Na

= \frac{\text{Urine Na} \times \text{Serum Cr}}{\text{Serum Na} \times \text{Urine Cr}} \times 100

- FENa < 1% prerenal azotemia
  - Sensitivity: 90%
  - Specificity: 93%
- FENa > 1% ATN
  - Sensitivity: 93%
  - Specificity: 90%

Espinel. JAMA. 1976;236(579-581)
Miller et al. Ann Int Med. 1978;89(47-50)
ON DIURETICS?
✔FEUrea

Excreted Urea
Filtered Urea

Urine Urea x Serum Cr x 100
Serum Urea x Urine Cr

- Normal FE Urea 50-65%
- Prerenal Azotemia < 35%
What’s wrong with fractional excretion measures?

<table>
<thead>
<tr>
<th>Scenarios with FeNa &lt; 1%</th>
<th>Scenarios with FeNa &gt; 2%</th>
</tr>
</thead>
<tbody>
<tr>
<td>normal kidney function with low or moderate salt intake</td>
<td>normal kidney function with high salt intake or IV saline</td>
</tr>
<tr>
<td>acute GN</td>
<td>late urinary obstruction</td>
</tr>
<tr>
<td>early AIN</td>
<td>late AIN</td>
</tr>
<tr>
<td>acute urinary obstruction</td>
<td>glucosuria</td>
</tr>
<tr>
<td>transplant rejection</td>
<td>bicarbonaturia</td>
</tr>
<tr>
<td>FeNa &lt; 1% despite ATN</td>
<td>FeNa &gt; 2% despite prerenal AKI</td>
</tr>
<tr>
<td>AKI with liver failure or CHF</td>
<td>use of diuretics</td>
</tr>
<tr>
<td>sepsis-associated AKI</td>
<td>CKD</td>
</tr>
<tr>
<td>radiocontrast nephropathy</td>
<td>FeNa after IVF therapy</td>
</tr>
<tr>
<td>nonoliguric ATN</td>
<td>glucosuria</td>
</tr>
<tr>
<td>myoglobinuric ATN</td>
<td>bicarbonaturia</td>
</tr>
<tr>
<td>hemoglobinuric ATN</td>
<td>salt-wasting disorders</td>
</tr>
</tbody>
</table>

FeNa, fractional excretion of sodium; AIN, acute interstitial nephritis; ATN, acute tubular necrosis; CHF, congestive heart failure; IV, intravenous; IVF, intravenous fluid.

Perazella et al. CJASN 2012
MANAGEMENT OF PRERENAL AKI

• Restore renal perfusion/treat underlying condition
Decreased EABV AKI – more than “pre-renal”

<table>
<thead>
<tr>
<th>Intravascular volume depletion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemorrhage</td>
</tr>
<tr>
<td>GI or renal losses</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reduced cardiac output</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHF/cardiogenic shock</td>
</tr>
<tr>
<td>Pericardial diseases</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Systemic vasodilation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sepsis</td>
</tr>
<tr>
<td>Cirrhosis</td>
</tr>
<tr>
<td>Anaphylaxis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Renal Vasoconstriction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hepatorenal syndrome</td>
</tr>
<tr>
<td>Acute hypercalcemia</td>
</tr>
<tr>
<td>Drugs – ACEI, NSAIDS, calcineurin inhibitors</td>
</tr>
</tbody>
</table>
Other common low-EABV AKI conditions

- Type 1 cardiorenal syndrome
- Hepatorenal syndrome (HRS)
Mechanisms of CRS

Heart Disease

Hemodynamic Instability
- Impaired Cardiac Output
- Decreased perfusion
- Increased venous pressure

Nephrotoxic agents
- Contrast media
- ACE inhibitors
- ARB'S
- Diuretics

Vasocostriction Toxicity

Sympathetic Activation

RAAS activation
- BNP
- Endocrine factors
- Immunological factors
- Monocyte Activation
- Endothelial activation

Natriuresis

Cytokine release

Kidney dysfunction
- Renal hypoperfusion
- Reduced O2 delivery
- Necrosis / apoptosis
- Decreased GFR
- Resistance to ANP/BNP

Apoptosis
Clinical conundrum with acute cardiorenal syndrome, type 1

Heart failure exacerbation
- Fluid overload
- Venous congestion
- Low BP

Gentle diuresis?
Aggressive diuresis?
Mechanical ultrafiltration?

Worse vs. improved kidney function?
Diuretic dosing

- **DOSE trial**
- 308 patients with acute decompensated heart failure
- Randomized to furosemide IV bolus q12 hours vs. infusion and at either low dose (equivalent to home oral dose) vs. high dose (2.5x home oral dose)

Take home message: diuretic dosing is flexible

Felker *NEJM* 2011
Ultrafiltration

- CARRESS-HF trial
- 188 patients with acute decompensated heart failure, AKI and persistent congestion
- Stepped pharmacologic therapy (IV diuretics) vs. ultrafiltration
- No difference in weight loss between groups
- Higher rate of adverse events and greater increase in Cr in UF group

Take home message: diuresis is likely a safer strategy (vs. UF)
HEPATOURENAL SYNDROME (HRS)

Reversible functional renal impairment that occurs in patients with advanced liver disease.

- Low GFR
- Absence of shock, current infection, fluid losses, nephrotoxic drugs
- No improvement in renal function after diuretic withdrawal and expansion of volume
- Proteinuria <500 mg/d
- No obstruction
- No intrinsic renal disease (no ATN, no GN)

Typically IV albumin 1g/kg of body weight x 2 days
Precipitating factors in HRS

3 interrelated pathways:

1. Splanchnic vasodilation decreasing EABV
2. Renal sympathetic stimulation
3. Cardiac dysfunction leading to renal hypo-perfusion

Wadei et al, CJASN, 2006
HRS Treatment

**In critically ill patients:**
- Norepinephrine IV to raise MAP by 10 mmHg until no response or resolution of AKI (at least 2 days)

**In non-critically ill patients:**
- Midodrine 7.5-15mg TID
- Octreotide 100mcg-200mcg TID
- Trial x 2 days

**In non-responders:**
- Consider TIPS (controversial)
- If liver transplant candidate, dialysis as bridge to transplant
Case 3

- 20 y/o man hospitalized for volume depletion after returning from Mexico
- Reports 5 days of 6-10 loose stools/day, nausea, poor PO intake
- BP is 80/50, dizzy with standing
- Creatinine 1 year ago 0.9.

<table>
<thead>
<tr>
<th>Value</th>
<th></th>
<th>Value</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>126</td>
<td>90</td>
<td>U_{Na}</td>
<td>30 mEq/L</td>
</tr>
<tr>
<td>4.5</td>
<td>16</td>
<td>U_{creat}</td>
<td>42 mg/dL</td>
</tr>
<tr>
<td>75</td>
<td>3.5</td>
<td>U_{osm}</td>
<td>300 mOsm/kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fe Na</td>
<td>2%</td>
</tr>
</tbody>
</table>
Case 3: urine sediment
**Value of Urine Sediment**

**Table 2. Likelihood ratios for prerenal AKI and acute tubular necrosis based on urine microscopy (14)**

<table>
<thead>
<tr>
<th>Urine Findings</th>
<th>ATN</th>
<th>Prerenal AKI</th>
<th>Likelihood Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>ATN</td>
</tr>
<tr>
<td>Granular casts/LPF</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>23</td>
<td>84</td>
<td>0.23</td>
</tr>
<tr>
<td>1–5</td>
<td>73</td>
<td>21</td>
<td>2.97</td>
</tr>
<tr>
<td>6–10</td>
<td>23</td>
<td>2</td>
<td>9.68</td>
</tr>
<tr>
<td>&gt;10</td>
<td>8</td>
<td>0</td>
<td>∞</td>
</tr>
<tr>
<td>total</td>
<td>125</td>
<td>106</td>
<td></td>
</tr>
</tbody>
</table>

**Estimated % change in probability**

<table>
<thead>
<tr>
<th>Estimated % change in probability</th>
<th>+LR Power to RULE IN</th>
<th>-LR Power to RULE OUT</th>
<th>Estimated % change in probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 = 45% ↑</td>
<td>10</td>
<td>&lt; 0.1</td>
<td>0.1 = 45% ↓</td>
</tr>
<tr>
<td>5 = 30% ↑</td>
<td>5-10</td>
<td>.1-.2</td>
<td>0.2 = 30% ↓</td>
</tr>
<tr>
<td>2 = 15% ↑</td>
<td>2-5</td>
<td>.2-.5</td>
<td>0.5 = 15% ↓</td>
</tr>
</tbody>
</table>

(Shifting of post-test probability)
## NEPHROTOXINS AND ATN

<table>
<thead>
<tr>
<th>Endogenous</th>
<th>Exogenous/Drugs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myoglobin (Rhabdomyolysis)</td>
<td>Amphotericin</td>
</tr>
<tr>
<td>Uric acid (Tumor Lysis Syndrome)</td>
<td>Aminoglycosides</td>
</tr>
<tr>
<td>Hemoglobin (Hemolysis)</td>
<td>Cisplatin</td>
</tr>
<tr>
<td></td>
<td>Ifosfamide</td>
</tr>
<tr>
<td></td>
<td>Acetaminophen</td>
</tr>
<tr>
<td></td>
<td>Salicyclates</td>
</tr>
<tr>
<td></td>
<td>Radiocontrast agents (?)</td>
</tr>
<tr>
<td></td>
<td>Intravenous immunoglobulin</td>
</tr>
<tr>
<td></td>
<td>Zolendronate</td>
</tr>
<tr>
<td></td>
<td><strong>Vancomycin</strong></td>
</tr>
</tbody>
</table>
Is vancomycin nephrotoxic?

• Is it this?
  - Vanco levels → causality → Serum creatinine

• Or is it this?
  - Serum creatinine → causality → Vanco levels

Not amenable to randomized controlled trial!
Vancomycin nephrotoxicity

7 randomized and controlled trials
N = 4033

6 – vancomycin vs linezolid
1 – vancomycin vs certaroline

6/7 – vancomycin associated with higher risk of AKI

RR 2.45 (95% confidence interval, 1.69 to 3.55)

Vancomycin and the Risk of AKI: A Systematic Review and Meta-Analysis

Abhisekh Sinha Ray,* Anmar Haikal,* Kassem A. Hammoud,* and Alan S.L. Yu*

Abstract

Background and objectives Vancomycin has been in use for more than half a century, but whether it is truly nephrotoxic and to what extent are still highly controversial. The objective of this study was to determine the risk of AKI attributable to intravenous vancomycin.

Design, setting, participants, & measurements We conducted a systematic review of randomized, controlled trials and cohort studies that compared patients treated with intravenous vancomycin with a control group of patients given a comparator nonglycopeptide antibiotic and in which kidney function or kidney injury outcomes were reported. PubMed and Cochrane Library were searched from 1990 to September of 2015. Two reviewers extracted data and assessed study risk of bias, and one reviewer adjudicated the assessments. A meta-analysis was conducted on seven randomized, controlled trials (total of 4033 patients).

Results Moderate quality evidence suggested that vancomycin treatment is associated with a higher risk of AKI, with a relative risk of 2.45 (95% confidence interval, 1.69 to 3.55). The risk of kidney injury was similar in patients treated for skin and soft tissue infections compared with those treated for nosocomial pneumonia and other complicated infections. There was an uncertain risk of reporting bias, because kidney function was not a prespecified outcome in any of the trials. The preponderance of evidence was judged to be indirect, because the majority of studies compared vancomycin specifically with linezolid.

Conclusions Our findings suggest that there is a measurable risk of AKI associated with vancomycin, but the strength of the evidence is moderate. A randomized, controlled trial designed to study kidney function as an outcome would be needed to draw unequivocal conclusions.

Ray et al, CJASN 2016
Vancomycin-associated cast nephropathy
Vancomycin nephrotoxicity as a function of trough level

<table>
<thead>
<tr>
<th>Trough concentration (mg/L)</th>
<th>Toxicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 – 10</td>
<td>5%</td>
</tr>
<tr>
<td>10.1 – 15</td>
<td>3%</td>
</tr>
<tr>
<td>15.1 – 20</td>
<td>11%</td>
</tr>
<tr>
<td>20.1 – 35</td>
<td>23%</td>
</tr>
<tr>
<td>&gt;35</td>
<td>82%</td>
</tr>
</tbody>
</table>

What about “contrast nephropathy?”

- 6,000,000 hospitalized pts; no AKI on admit, LOS < 10 d
- Evaluated for hospital-acquired AKI

<table>
<thead>
<tr>
<th></th>
<th>Contrast</th>
<th>No Contrast</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.5%</td>
<td>5.6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(unadjusted)</td>
</tr>
<tr>
<td></td>
<td>5.6%</td>
<td>5.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(adjusted)</td>
</tr>
</tbody>
</table>

**Conclusions:** “…our analyses suggest that the incremental risk of AKI that can be attributed to radiocontrast is modest at worst, and almost certainly overestimated by patients, physicians, surgeons, radiologists, and other decision-makers.”
Prevention of contrast-nephropathy

My approach:

- If eGFR >45 mL/min, no change in management with any iodinated contrast scan
- If eGFR 30-45 mL/min, USUALLY no change in management → evaluate for risk factors for AKI
- If eGFR <30
  - If can tolerate fluid, give 1cc/kg/hr isotonic fluid (NS versus LR) for 6 hours pre-procedure, and for 6 hours post-procedure
  - Do not give NAC, do not withhold ACEI/ARB, statins
MANAGEMENT OF ATN

- Restore renal perfusion/treat underlying condition
- Avoid further insults if possible; if drug-related, withdraw the offending drug
- Manage accompanying volume/electrolyte/acid-base abnormalities
- Adjust renally–excreted meds to current level of kidney function
- Watch for uremic manifestations, or other indications for initiation of dialysis
Obstructive nephropathy, an uncommon cause of AKI

- Intrarenal obstruction
  - Stones
  - Transitional cell carcinoma
  - Clots
  - Papillary necrosis

- Ureteral obstruction
  - Stones
  - Transitional cell carcinoma
  - External compression
    - Tumors
    - RP fibrosis
    - Lymph nodes

- Bladder outlet obstruction
  - BPH
  - Neurogenic bladder

**Evaluation:**
- Bladder scan, bladder catheterization
- Renal u/s
Should you get a renal ultrasound in all AKI?

No, but you should at least consider....

- Large kidneys- amyloid (other infiltrative disease), AIN, HIV, diabetes
- Small kidneys- likely chronic process, unlikely to benefit from treatment
- Polycystic kidney disease
- Single kidney
Case 4

- 55 y/o man hospitalized for sepsis, found to have MRSA bacteremia 2/2 severe soft tissue infection
- Treated with IV vancomycin
- Initial labs:

<table>
<thead>
<tr>
<th>134</th>
<th>100</th>
<th>20</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5</td>
<td>20</td>
<td>1.5</td>
<td>90</td>
</tr>
</tbody>
</table>

Urine:
- $U_{Na}$: 20 mEq/L
- Fe Na: 1%

Urine sediment: dysmorphic RBCs

C3: low  C4: WNL

Creatinine subsequently climbed daily:

1.5 $\rightarrow$ 1.7 $\rightarrow$ 2.1 $\rightarrow$ 2.3 $\rightarrow$ 2.6 $\rightarrow$ 2.9
DYSMORPHIC RBCS
### GLOMERULONEPHRITIS/RPGN

<table>
<thead>
<tr>
<th>Primary Glomerular Disease</th>
<th>Mechanism</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Immune complex</td>
<td>Ig A nephropathy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MPGN (HCV)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Infection-related GN</td>
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<thead>
<tr>
<th>Systemic Disease</th>
<th>Mechanism</th>
<th>Disease</th>
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<tbody>
<tr>
<td></td>
<td>Antibody-mediated</td>
<td>Anti-GBM disease</td>
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<td></td>
<td>Pauci-immune</td>
<td>Small vessel vasculitis (GPA, MPA, Churg-Strauss)</td>
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<td>Immune complex</td>
<td>Lupus nephritis</td>
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<td>Cryoglobulinemia</td>
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**Laboratory evaluation:** Complement levels, ANCA group, anti GBM, ANA with reflexive panel, HCV PCR, cryoglobulinemia titers/cryocrit

**Definitive diagnosis:** Kidney biopsy
INFECTION-RELATED GLOMERULONEPHRITIS

- Nearly always associated with CONCURRENT staph infection
- Distinct from post-streptococcal GN
  - Post-strep GN occurs AFTER infection
- Can be accompanied by vasculitis skin rash
- Serum complements low
  - Low C3 more common than low C4
- No serologic test available; definitive diagnosis requires kidney biopsy
Clinical clues that should prompt nephrology consultation

- Concern for pulmonary-renal syndromes
- Concern for AIN
- AKI in kidney transplant
- Persistent oligoanuria with AKI
- Nephrotic syndrome
- Renal Consult
Take-home points

• >90% of AKI in hospitalized patients is low EABV (including pre-renal, cardiorenal, hepatorenal) or ATN

• Urine microscopy is a simple and useful tool
  ▫ Granular casts → if >6/lpf, likely to be ATN
  ▫ Dysmorphic RBCs → always glomerular pathology

• AKI in the contemporary hospitalized patient is often multifactorial with overlapping causes
Questions?

KIDNEY RESEARCH INSTITUTE
A collaboration between Northwest Kidney Centers and UW Medicine

Division of Nephrology
UNIVERSITY OF WASHINGTON