Academic Half Day – Acute Kidney Injury
Facilitator Guide

Agenda
1:00-2:25pm Cases
2:25-2:30 Expert questions

Case 1

Mr. Reno is a 67-yo male with history of HTN, obesity, diabetes mellitus type II complicated by neuropathy, and prostate cancer presents to the ED with 2 days of fever, shaking chills, right lower quadrant abdominal pain, nausea, and vomiting.

Medical History:
DM2 (HgA1c 7.0)
HTN
Prostate Cancer s/p radiation 2 years ago

Home Medications:
Metformin
Atorvastatin
Glyburide
Gabapentin
Lisinopril
HCTZ
Aspirin

Physical Exam:
VS: T 102.0, HR 111, BP 100/62, RR 18, SpO2 97% on RA, Weight 220lbs
GEN: Ill-appearing and diaphoretic, no respiratory distress.
HEENT: Mucous membranes are tacky.
CV: Tachycardic, normal S1 and S2, no murmurs, flat neck veins
Pulmonary: Normal respiratory effort, CTAB, no wheezes, crackles or rhonchi
Abd: normal BS, soft, RLQ tenderness is present, but no rebound or guarding. Right CVA tenderness is present.
GU: Normal prostate, no enlargement or nodules
Ext: Warm, no rashes, no edema

1. **What is your differential diagnosis and how would you support this with information from the history and exam?**
   - Sepsis –Facilitators, use this opportunity to review sepsis, qSOFA, and SIRS:
     - qSOFA predicts in-hospital mortality risk
       - 1 point for AMS (GCS < 15), RR>=22, and SBP<=100
       - Our patient's score is 1 for SBP
       - Score >=2 suggests a high risk of poor outcome in patients with suspected infection.
     - SIRS more sensitive less specific than qSOFA, need 2/4 criteria
       - Temp >100.4 or <96.8, HR>90, RR>20, WBC<4 or >11
       - Positive from Temp and HR, don't have WBC yet
   - Pyelonephritis
     - CVA tenderness, abdominal pain, nausea/vomiting, fever/chills suggest this diagnosis
     - Patient also has risk factors for GU infection (prostate cancer and DM2)
   - Intra-abdominal infection
     - Given location of pain, consider appendicitis, diverticulitis, IBD, infectious colitis, abscess, peritonitis.

2. **What labs and/or imaging studies would you order on this patient and why? Consider how each test would potentially change your management.**

Facilitators, as the learners as for lab results you may ask them first why the results might change their management / why it is an important lab to order, then provide them with the results (if listed). Learners are not provided with the lab values for this case.

Potential Labs	Results
CBC	WBC – 22 (80% PMNs, 22% lymphs) H/H – 14 and 42 PLT - 400
Renal Profile	138 | 106 | 55 / ---------- 222 5.2 | 20 | 2.6 \ Baseline cr: 1 *Why is the BUN elevated? Prerenal state results in increased sodium absorption in the proximal tubule and water follows. A gradient then develops where BUN is more concentrated in the urine than the serum so BUN diffuses down across that gradient and back into the serum.* This is independent of ADH, so explains why BUN is not elevated in SIADH.
Urinalysis	SG 1.025; +Leuk Esterase; +Nitrites Microscopic: 1-4 RBC; 10-20 WBC; 3+ Bacteria; 8-10 Hyaline casts
Hepatic Profile	Normal
CXR	Normal
EKG	Normal
Urine Electrolytes	Urine Na 145, Urine Urea 40, Urine Cr 200 [FeNa = 1.3% and FeUrea = 0.9%]
Lactate	3.1
Abdominal CT or U/S	See below
Blood cultures	Pending

Facilitators, you may discuss the utility of a FeNa in this patient who is (presumably) non-oliguric and has evidence of dehydration on physical examination. With a FeNa of 1.3% (indicating intrinsic renal etiology) will this change your initial management? You may refer to the Choosing Wisely article on FeNa

If your team asks for imaging (either CT or ultrasound), direct them to the American College of Radiology website to review the ACR appropriateness criteria for imaging in acute pyelonephritis. QR code is below (FYI learners do not have this- help them find the website or download the ACR app so they will have it for the future!)

Discuss when to obtain additional imaging such as an Ultrasound or CT A/P
• Evaluation for obstruction
• Evaluation for perinephric abscess
• Obtain if persistent symptoms after 48-72 hours of appropriate antimicrobial therapy, recurrent symptoms, worsening symptoms, positive blood cultures, or other evidence of urinary obstruction (i.e. decreased UOP).

For now if they ask, advise that the scan is pending.

3. **What is your differential diagnosis now and how would you support this with your history, physical AND supplemental data?**
   Pyelonephritis and acute kidney injury
   - pyuria, bacteria, +LE, +nitrite indicate an infection of the urinary system.
   - leukocytosis with neutrophil predominance
   - other systemic signs of infection as hopefully noted with initial differential diagnosis

4. What are the definitions of the stages of AKI based on KDIGO?

Stage	Creatinine Criteria	UOP Criteria
1	SCr 1.5-1.9x baseline	<0.5ml/kg/h for 6-12 hours
2	SCr 2-2.9x baseline	<0.5ml/kg/h for > 12 hours
3	SCr >3x baseline OR SCr>/= 4mg/dl (+ acute rise >0.5), OR Initiation of HD/CRRT	<0.3ml/kg/h for > 24 hours OR anuria > 12 hours

5. What kind of renal injury does this patient have? How do you decide this? What is the pathophysiology?
   - Pre-Renal Acute Kidney Injury
     - Patient has hypovolemia suggested by tachycardia, tacky mucous membranes, flat neck veins, and nausea/vomiting.
     - Urinalysis showed hyaline casts, high SG, and BUN/Cr > 20
     - FeNa is 1.3%, which suggests an intrinsic etiology… why??
       - FeNa can be affected by things that affect our excretion of sodium. Examples are diuretics (thiazides and loops) and CKD (tubules do not absorb sodium as well when GFR<30).
     - FeUrea is 0.9%, which suggests pre-renal etiology (FeUrea < 35% is pre-renal).
       - Cytokines and sepsis can affect the function of the tubules, so FeUrea is not always reliable in infectious states.
   - Pathophysiology:
     - Decreased renal perfusion pressure (which is dependent on both the arterial and venous pressures).
     - What else can cause a pre-renal AKI?

        - Low arterial pressure: Dehydration, hypotension, cardiorenal syndrome, liver failure
        - High venous pressure: abdominal compartment syndrome, diastolic heart failure
        - Impaired Autoregulation: NSAIDs, ACEi/ARB, cyclosporine

6. Where would you admit this patient? What is your initial management?

- Location: Admit to Telemetry or floor.
    - Discuss who needs admission for pyelonephritis vs who can be managed outpatient.
        - Hospitalization is advised for patients with hemodynamic instability, obstructive disease, pregnancy, complicating comorbidities, known pathogen resistance, inability to tolerate PO, or lack of follow-up/reliable home supervision.
- Medications:
    - Encourage discussion about home medications and whether to continue/hold/change

Medication	**Continue in setting of acute kidney injury?**
Atorvastatin	Continue
Aspirin	Continue
Gabapentin	Renally dose depending on GFR
Glyburide	Hold- do this in general inpatient, but can exacerbate risk of hypoglycemia in AKI since it is renally cleared
Metformin	Hold- We almost always hold for all admission and it is renally cleared and contraindicated in severe kidney injury.
Lisinopril	Hold- Can be re-started once kidney function improves
HCTZ	Hold- Can counteract efforts at rehydration so this should be held. Also, if GFR is <30, HCTZ is pretty much ineffective.

- Admission orders:
    - Fluids, 30 cc/kg in first 3 hours
    - Antibiotics -> which ones would you be more careful consider given AKI? What bugs are you trying to cover with your antibiotic choices?
        - Select a cephalosporin, penicillin/beta-lactamase, but NOT fluoroquinolone for patients without risk factors for obstruction or drug-resistant organisms
            - 50% community resistance to fluoroquinolones to most common bugs
        - Select carbapenem with ESBL coverage +/- vancomycin for patients with concern for obstruction or drug-resistant organism (i.e. MRSA or Enterococcus).
    - Strict I/Os
- AKI Specific
    - Consider factors we should try to control for in someone with acute kidney injury
        - Glucose control, Avoid nephrotoxins, Avoid contrast, Achieve appropriate fluid resuscitation, Avoid hypo- and hyper-tension.

7. What would your cross-coverage sign-out for the night team say?

- Night Float Sign-Out
    - Vital sign check during the night. Prior to signing out you should probably make sure that his HR and BP are headed in the right direction with fluid boluses.
- In the morning, be sure to monitor UOP

Over the next 48 hours, Mr. Reno is looking better.
Physical Exam:

VS: 98.6F, 94, 18, 140/84, 97% RA, Weight 224lbs
GEN: no acute distress, appears comfortable
CV: RRR, no murmurs
Pulmonary: CTAB, no wheezes, crackles or rhonchi
Abd: normal BS, soft, non-tender except for right CVA tenderness (improved from admission)
Ext: Warm, no rashes, no edema

8. **Would there be any labs you would follow and why?**
   - Follow Renal Panel for resolution of the Acute Kidney Injury.
   - If clinically improving, there is no indication for trending any other labs.
   - Renal Panel Shows:

     134 | 103 | 82 /
     ---------- 194
     5.1 | 19 | 3.4 \
   - Once the facilitator has given the residents the Renal panel, ask *Why do you think his renal function has worsened? What is your differential diagnosis?*
     - Could repeat U/A and perform microscopy to look at sediment.
     - Likely ATN after pre-renal injury given rise in creatinine despite improvement in all other clinical signs

You are called later that evening by the RN who says, "Mr. Reno has not had any urine output this shift." He is now complaining of worsening abdominal pain. The rest of his vitals have normalized.

9. **What is the differential for this lack of urine output? Is there anything else you would ask or do?**
   - Now concerning for anuric renal failure.
   - DDx includes acute urinary obstruction
     - Risk Factors: prostate cancer (urethral stricture), DM2 (autonomic neuropathy), male with prostate (BPH).
     - Management: Check a bladder scan (shows 600 cc)à straight cath!
     - Consider foley placement of recurrent retention
   - If foley without UOP, what next?
     - Imaging, specifically renal US to eval for type of upper GU obstruction (i.e. metastasis, bilateral nephrolithiasis, etc.)

Case 2

A 45 y/o M with history of HTN, HLD, depression, and DM II is evaluated in the emergency department after being found down.

Physical Exam:
AF, BP 142/92, HR 115, RR 25, and SpO2 97% on RA
GEN: Obtunded
CV: Tachycardic, normal S1 and S2, no murmurs or rubs
Pulmonary: Tachypneic, but otherwise normal work of breathing. CTAB, no wheezes, crackles or rhonchi
Abd: normal BS, soft, non-tender

MSK: Warm, no rashes, no edema
Neuro: opens eyes to pain, withdraws to pain, inappropriate words

1. What is your initial approach to further differentiating this patient? What labs do you want?

- Can discuss GCS: his is calculated at 9. He gets 2 for eye-opening to pain, 4 for withdraws to pain, and 3 for inappropriate words
- Ask learners, how else do you work-up a patient with altered mental status? What are some clues from his presentation? (Depression, tachycardia, tachypnea – check for ingestion, DM2 – check for hypoglycemia, found down – check for rhabdo)

Lab Results:	*Learners are given the labs for this case.*
136 | 100 | 28 / ---------- 90 4.0 | 12 | 2.2 \\ Baseline cr: 0.8	Ethanol: undetected Serum osms: 314 ABG: 7.25/28 Urinalysis: crystals are present. See QR Code. *Calcium oxalate crystals are seen here. Monohydrate are dumbbell shaped and can be needle-like. Dihydrate are envelope shaped.* *Cool note: Urine will fluoresce under Wood's lamp if the patient drank ethylene glycol (because of the blue dye!)*

Urinalysis

2. What is the acid base disturbance in this patient?

Step 1: Note clinical presentation
Step 2: Test internal validity. [H+] = 24 X PCO2/HCO3……. 80-25 = 24*28/12…… 55=56
Step 3: Determine AG. AG = Na - Cl – HCO3 … AG = 136-100-12 …. AG = 24
Step 4: Draw arrows. pH ↓, PCO2 ↓, HCO3 ↓. (All in same direction = metabolic)
Step 5: Apply compensation rules:
Winter's Formula: PCO2 = (1.5 x HCO3) + 8 +/- 2…… 28 = (1.5 x 12) + 8 +/- 2 = 26 +/- 2
Step 6: Calculate the Delta/Delta. ↑ AG / ↓ HCO3
= (24-12)/(24-12) = 1… indicates pure AGMA
Step 7: Osmolar Gap.
= Measured Posm – Calc Posm = 314 – (2*Na + BUN/2.8 + glucose/18) = 314-287 = 27
Elevated if gap > 10

Anion-gap metabolic acidosis with appropriate respiratory compensation and positive osmolar gap.

3. **What is the management of this patient?**
    - Patient with ethylene glycol toxicity in setting of organ-specific toxicity (renal and CNS depression), severe acidemia, increased osmolar gap, and likely ingestion.
    - Treatment is with aggressive fluid resuscitation, fomepizole, and HD. Note that lab confirmation usually takes days.
    - Hydration: initially 250-500 cc/hr, attempting to flush toxin and limit deposition of oxalate crystals in cortex
    - Medication: Fomepizole. Traditionally IV ethanol was used but fomepizole found to be superior with few side effects. No benefit of coadministration.

Case 3

A 56 y/o male with no significant medical history is coming in for persistent fever, chills, sore throat, and myalgias for the past 3 days. He went to the ER 14 days ago for chest pain, so he got a CT chest with IV contrast, which was negative for PE. At that time, his kidney function was normal. He was discharged with ibuprofen 400 mg Q6H PRN for pain. Two days after the ER presentation (12 days ago), he went to his PCP because he was feeling unwell. He received amoxicillin and has been taking it since. His repeat renal panel at the PCP was still normal.

He reports no change in urine.

Physical Exam:
101.5 F, BP 125/72, 75 BPM, 100% on RA, and RR 12
GEN: Well- appearing
HEENT: unremarkable
CV: RRR, no murmurs
Pulmonary: CTAB, no wheezes, crackles or rhonchi
Abd: normal BS, soft, non-tender
MSK: Warm, no edema, diffuse maculopapular rash

Lab Results:	Learners are given the labs for this case.
Renal Panel	134 | 106 | 46 / ---------- 96 4.7 | 24 | 3.8 \ Baseline cr: 0.9
CBC	WBC 12.5 / Hgb 11 / Hct 33% / PLT 216
Urinalysis	SG 1.010, Protein 2+, Blood negative, Glucose negative Micro: 3-5 RBCs, 20-25 WBCs, and a cast (see QR code)

1. **What is the differential diagnosis? What do you think is most likely, why? What caused it?**
    - *Acute Interstitial Nephritis (most likely) 2/2 beta-lactam*: Suggested by exposure to inciting drug, rash, fever, and WBC casts in the urine. Beta-lactams only require about 2 weeks of exposure, so this is most likely etiology. Antibiotic acts as a hapten induces an autoimmune process

- *NSAIDs can cause AIN, however they usually don't cause fever or rash*. (PPIs also don't cause a fever or rash when they cause AIN!). Furthermore, with NSAID-induced AIN the exposure length is usually around 5 months.
- *Contrast- Induced Nephropathy (CIN)*: is on the differential. This usually causes an ATN which would be evident by muddy-brown casts. The timing is also off for this. CIN, usually occurs within 48 hours of exposure, and this patient had normal kidney function 2 days after contrast exposure.

2. What are other etiologies?

Common causes of Drug-induced AIN

- NSAIDS
- Antibiotics: Penicillins, quinolones , Anti-tuberculous medications,
- Sulfonamides (TMP-SMX, furosemide, thiazides)
- Miscellaneous: Allopurinol, cimetidine, Dilantin

Other Etiologies

- Autoimmune: Sarcoid, SLE, Sjogren's
- Toxins: Chinese herb nephropathy, Heavy metals, Light chain cast nephropathy
- Infiltrative: Leukemia, Lymphoma
- Infections: Legionella, CMV, HIV, Toxoplasma

3. How would you manage this patient's AKI?

Withdrawal of offending agent
**Trial of steroids: 1 mg/kg/day or 2 mg/kg every other day. Specially in allergic presentations.
** No randomized trials proving efficacy.

Case 4

A 35-yo male was found down by a bar one summer night. It's unclear when he was last seen. After naloxone and initial resuscitation he is alert and oriented and appears to have no significant injuries. Due to discomfort with ambulation the ED placed a foley and his collection bag shows a small amount of urine that looks concentrated and a reddish tinge. On admission his BP 120/70 and HR 80. Exam is normal except for difficulty with active movement and muscle tenderness along right side.

1. What is on your differential diagnosis based off history? What else would you like to know? Are there labs you'd like to obtain?

Down for an unknown time, concern for rhabdomyolysis, ischemic injury from hypoperfusion

Lab Results:	Learners are NOT given the labs for this case.
Renal Panel	132 | 103 |22 / ---------- 194 5.3 | 19 | 4.2 \
Urinalysis	SG 1.030, Leuk Esterase Neg, Blood large, Protein 2+ Micro: WBC Neg, RBC 0-1
Urine Lytes	FeNa 3.5% FeUrea 56%

2. What is your differential now? Support this with the information you have.

Intrinsic kidney injury—with clinical history, concern for rhabdomyolysis

- Be on the look out for large blood W/O RBCs
- Causes pigment nephropathy
- Key: In a completely anephric state, SCr should only rise by 1 within 24 hours. Larger rises should make you think about rhabdomyolysis.

2. What other disease scripts or presentations might present with this type of renal injury? What are complications you need to watch for?

Trauma, Myotoxic drugs, infection, electrolyte abnormalities, excessive exertion, heat stroke, seizures, prolonged immobilization, ETOH and drugs like cocaine

- Hyperkalemia, hyperphosphatemia, hyperuricemia, hypocalcemia, metabolic acidosis, elevated transaminases.

3. In this patient, what is the mechanism(s) of acute kidney injury?

Muscle injury leads to the release of myoglobin and other intracellular muscle contents into the circulation. The release of myoglobin causes an AKI in 2 fashions, 1st by resulting in tubular obstruction and 2nd direct toxicity to the tubules.

4. How will you initially manage this patient?

fluids!!! Usually 1-2L with initial boluses, then faster rate later upwards 200-300ml/hr take care to know what phase of AKI the patient is in. This will help determine risk of fluid overload some may bring up use of diuretics, alk urine with bicarb. None of those interventions have been shown to be effective.