Acute Kidney Injury

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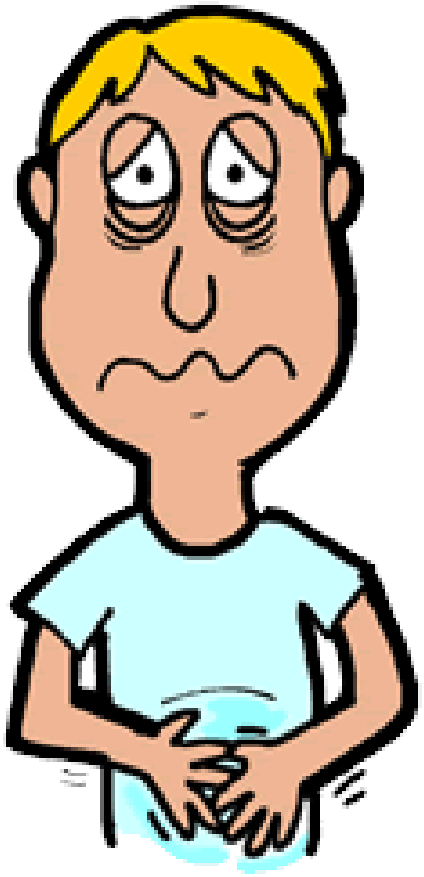
Objectives

- Acute Kidney Injury
  - Signs and Symptoms
  - Causes
  - Management
- Dialysis Indications

AKI: Signs and Symptoms

- Hyperkalemia
- Nausea/Vomiting
- HTN
- Pulmonary edema
- Ascites
- Asterixis
- Encephalopathy



AKI: Focused History

- Hx of heart disease, liver disease, previous renal disease, kidney stones, BPH?
- Nausea? Vomiting? Diarrhea?
- Any recent illnesses?
- Any edema,
- Change in urination?
- Any new medications?
- Any recent radiology studies?
- Rashes?

Physical Exam

- Volume Status
  - Mucus membranes, orthostatics
- Cardiovascular
  - JVD, rubs
- Pulmonary
  - Decreased breath sounds
  - Rales
- Rash
- Large prostate ; Enlarged / palpable bladder
- Extremities (Skin turgor, Edema)

Acute Kidney Injury

- Rapid decline in the GFR over days to weeks.
- A rise in serum creatinine of 25% or >0.5 mg/dl or doubling of serum creatinine or needing dialysis
- May or may not be associated with a decrease in urine output
- Rise in serum creatinine lags behind the actual change in GFR

Factors affecting Creatinine other than GFR

Red meat, creatine ingestion

Muscle breakdown

Medications:

- Fenofibrate (TRICOR)
- Trimethoprim, block distal tubule secretion of creatinine
- cimetidine, block distal tubule secretion of creatinine

Factors affecting BUN

1. Increased production of urea
    1. Exogenous – high protein diet, protein drinks, TPN
    2. Endogenous – Sepsis, GI Blood loss, trauma, corticosteroids, tetracycline
2. Decreased production
    1. Starvation, liver disease

Definitions

Anuria: No UOP

Oliguria: UOP<400-500 mL/24 hours

Non Oliguria: UOP > 400-500mL/24 hours

Azotemia: Incr Cr, BUN

- May be Prerenal, renal, post renal
- Does not require any clinical findings

Chronic Renal Insufficiency

- Deterioration over months-yrs
- CKD stages 1-5; abnormal creatinine over three months to diagnose CKD

ESRD - no renal function

Acute Kidney Injury – Diagnostic Tools

- Blood tests such as renal panel
- Urinalysis
- Urinary sediment
- Urinary Indices
  - Urine Volume
  - Urine Electrolytes
- Radiologic Studies (Ultrasound or CT)

Urinalysis in AKI

- RBC casts: Indicative of acute glomerulonephritis. Rare.
- WBC cast: Most suggestive of acute interstitial nephritis, accompanied by sub-nephrotic range proteinuria
- Granular casts: ATN, especially when not accompanied by significant hematuria or above. Free renal epithelial cells may also be found
- Hyaline casts – Not helpful. Number may be increased in pre-renal azotemia
- Urinary Eosinophils- No longer believed to be particularly sensitive or specific. Peripheral Eosinophilia may be seen with AIN and Atheroemboli

Urinary Sediment

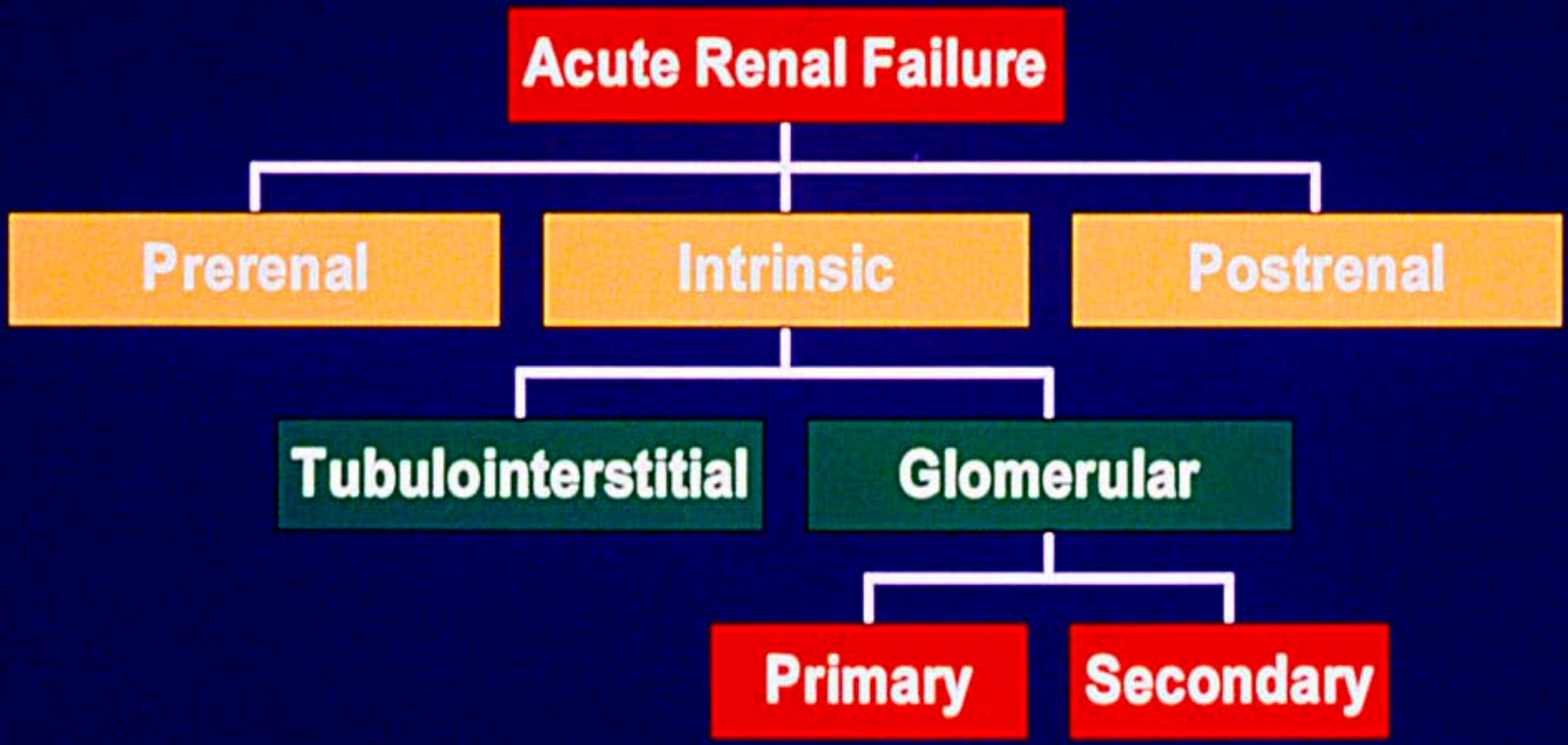
- Bland
  - Consider: Pre renal azotemia; Urinary outlet obstruction
  - No RBCs or WBCs
- Active Sediment / Nephritic
- _ Consider RPGN

	Ref. Range	2/16/2013 12:02	2/23/2013 12:38	3/2/2013 12:22		
BACTERIA	Latest Range: NEGATIVE		NEGATIVE	NEGATIVE	NEGATIVE	1+ (A)
WBC, URINE	Latest Range: 0-5 /HPF		9 (A)	7 (A)	4	
RBC	Latest Range: 0-4 /HPF	5 (A)	36 (A)	6 (A)	19 (A)	15 (A)

Acute Versus Chronic

- Acute
  - sudden onset
  - rapid reduction in urine output
  - Usually reversible
  - Tubular cell death and regeneration
- Chronic
  - Progressive
  - Not reversible
  - Nephron loss
- 75% of function can be lost before its noticeable

Work-up of Acute Renal Failure



Causes of AKI

- Pre-renal =
  - vomiting, diarrhea, poor fluid intake, fever, use of diuretics, and heart failure
  - cardiac failure, liver dysfunction, or septic shock
- Intrinsic
  - ATN (ischemia, toxins) Interstitial nephritis, acute glomerulonephritis, Vasculitis,
- Post-renal =
  - prostatic hypertrophy, cancer of the prostate or cervix, or retroperitoneal disorders
  - neurogenic bladder
  - bilateral renal calculi, bladder carcinoma, and fungus

Work up for AKI

- CMP, CBC
- Urine
  - UA complete
  - Urine electrolytes and Urine Cr to calculate FeNa
  - Urine sediment: casts, cells, protein
- Kidney U/S - r/o hydronephrosis

Acute Kidney Injury

- Usually asymptomatic
- Complicates approx 5% of hospital admissions
- Complicates approx 30% ICU admissions

Causes of Acute Kidney Injury

- Pre-renal azotemia
- Intrinsic disease
  a. glomerular
  b. tubular
  c. Interstitial
  d. vascular
- Post – renal
  - Urethra, prostate, bladder, UV junction, ureters, renal pelvis

Pre-Renal causes

- Intravascular volume depletion
  - Hemorrhage
  - Vomiting, diarrhea
  - “Third spacing”
  - Diuretics
- Reduced Cardiac output
  - Cardiogenic shock, CHF, tamponade, huge PE....
- Systemic vasodilation
  - Sepsis
  - Anaphylaxis, Antihypertensive drugs
- Alterations in renal vascular resistance
  - Afferent arteriolar vasoconstrition
  - Efferent arteriolar vasodilation
  - Impaired autoregulation (normalizing BP in cases of severe HTN)

Risk of Pre-Renal AKI increases with the following:

- Advancing age
- Renal vascular disease
- Drugs:
  - NSAIDS of any type can impair afferent vascular tone
  - Direct vasoconstriction of afferent arteriole results from CSA/tacrolimus, ampho B, hypercalcemia
  - ACEi/ ARBs impair efferent tone

AKI PRE-RENAL

- Identification of reduced extracellular fluid volume
- Bland /Benign urinalysis / urine microscopy
- Normal renal imaging (Ultrasound or CT scan)
- Indices supporting intact tubular function
- FeNa<1% (FeUrea<35%;FeUric Acid<7%)
- Pre-renal azotemia is characterized by an elevated BUN/Creat ratio >20:1

Urinary Indices

Used to differentiate a pre-renal cause of AKI from ATN

- **Pre-renal**
  - FeNa 1% (suggests intact tubules)
  - Urine Na < 20 (suggests intact tubules)
- **ATN**
  - FeNa > 2%
  - Urine Na >20 (damaged tubules can't reabsorb Na)

Calculating FeNa after pt has gotten Lasix...

- Caution with calculating FeNa if pt has gotten Loop Diuretics in past 24-48 h
- Loop diuretics cause natriuresis (incr urinary Na excretion) that raises U Na-even if pt is pre-renal
- So if FeNa>1%, you don't know if this is because the pt is euvolemic or because Lasix increased the U Na
- **So, still helpful if FeNa <1%, but not if FeNa >1%**

Causes of Acute Kidney Injury

- Pre-renal azotemia
- Intrinsic disease
  a. glomerular
  b. tubular
  c. Interstitial
  d. vascular
- **Post – renal**
  - **Urethra, prostate, bladder, UV junction, ureters, renal pelvis**

Post Renal AKI -Obstruction

- May occur anywhere from renal pelvis to tip of urethra
- Will not improve if not addressed
- Urine output may be decreased, unchanged or increased
- Renal US not 100% sensitive especially with early blockage, tumor, concurrent volume depletion

Post-renal AKI –Renal Vein thrombosis

- Uncommon cause of acute renal failure
- Can present with flank pain and gross hematuria
- Predisposed include pregnant patients, nephrotic syndrome (especially membranous nephropathy),
- Hypercoaguable states
- Presentation can mimic acute nephrolithiasis – flank pain and hematuria

Intrinsic Causes of AKI

- Pre-renal azotemia
- Intrinsic disease
  a. Interstitial
  b. Tubular
  c. Glomerular
  d. Vascular
- **Post – renal**
  - **Urethra, prostate, bladder, UV junction, ureters, renal pelvis**

Intrinsic AKI –Interstitial Nephritis

- Fever
- Rash
- Arthralgia
- Urinalysis
  - Microscopic hematuria
  - Sterile Pyuria
  - Eosinophiluria

Causes of interstitial nephritis

Drugs

- B- lactam
- Sulfa
- PPI
- NSAIDS
- Riampin, phenytoin, other antibiotics

Infections

- Bacterial; Viral

Autoimmune

- Sjogrens, SLE, sarcoidosis

Neoplasia

Toxic-Chinese herb nephropathy

Intrinsic AKI – Tubular Disorders

- Approximately 45% of the cases of ARF are caused by ATN
  - Ischemic Damage – *most common*
  - Nephrotoxic Damage
    - Medications
    - Contrast

Ischemic ATN

- Classically seen with Hypotension
- More common in the elderly, chronically hypertensive, post – operatively
- Have clinical features of ATN without a documented hypotensive episode
- Any cause of pre – renal azotemia which is prolonged or severe can eventually produce tubular injury

Nephrotoxic ATN

- Endogenous Toxins
  - Heme pigments (hemoglobin or myoglobin)
  - Myeloma light chains
- Exogenous Toxins
  - Antibiotics (eg: Aminoglycosides, Amphotericin B)
  - Radiocontrast Agents
  - Heavy Metals, mercury
  - Poisons (eg: Ethylene Glycol)

Heme Pigment Nephropathy

- Free hemoglobin and myoglobin are toxic to renal epithelial cells
- Implicated in 10-15 % of Hospitalized pts w/ ARF
- Breakdown of muscle fibers that releases nephrotoxic intracellular contents (ie myoglobin) into systemic circulation (rhabdomyolysis)
- Common causes of muscle injury include: seizures, pressure necrosis 2/2 coma, alcohol abuse and limb ischemia

Contrast Nephropathy

- Estimated to occur in 10-20% of angiograms
- Creatinine rises within 48 hours of insult
- Peaks in 3-5 days and then returns to baseline within 7-10 days
- No evidence that prophylactic hemodialysis ameliorates insult or changes natural course

Nephrotoxic ATN summary

- Self –limited although can develop irreversible tubular abnormalities with repeated or prolonged exposure
- Prevention: saline hydration is protective
- N-acetylcystine

Intrinsic AKI- Glomerular

- Uncommon Cause of ARF
- Accounts for 5% of cases in Intrinsic Acute Renal Failure
- Acute Glomerulonephritis usually signifies an inflammatory process causing renal dysfunction over days to weeks / also termed as RPGN
- Presenting s/s: Edema, Hypertension and
- Hematuria (Nephritic urine)

Summary of AKI

- AKI is relatively common
- AKI is an independent risk factor for poor outcome
- Majority of cases are related to decreased renal perfusion(pre-renal vs ischemic ATN)
- ATN is better prevented

Acute Renal Failure Management

- Make/think about the diagnosis
- Treat life threatening conditions
- Identify the cause if possible
  - Hypovolemia
  - Toxic agents (drugs, myoglobin)
  - Obstruction
- Treat reversible elements
  - Hydrate
  - Remove drug
  - Relieve obstruction

Indications for Dialysis

- Oliguria/ Anuria
- Hyperammonemia
- Hyperkalemia or severe electrolyte abnormalities
- Severe acidemia
- Severe azotemia
- Pulmonary edema
- Drug overdose
- Anasarca
- Rhabdomyolysis

Case Study #1

25 year old male presented to ED with weakness, fatigue, light-headedness. He was in the sun all day at a concert and drank ~5 beers.

PMH includes: SLE, last flare ~5 months ago.

Meds: HTN well controlled on HCTZ. Reports taking Ibuprofen earlier today.

PE: Well nourished male, appears fatigued, Afebrile, A/o x 3; No edema or rash; BP sitting 98/52, pulse 98 and increases to 110 upon standing with BP that decreases to 90/44

Labs: BUN/Creat 21/1.1; K+ 5.0; HCO3 26,

Urine: FeNa: 1% ; UA: 1.025, pH 6.5, trace blood, trace protein, 3-5 hyaline casts

Which of the following is the most likely diagnosis?

AIN, ATN, SLE nephritis, Pre-renal Azotemia, post obstructive nephropathy

References

- Primer on Kidney Diseases, 3rd Edition

- Current; Medical Diagnosis and Treatment 2015
- Comprehensive Clinical Nephropathy, 2nd edition

- *Special thanks to Dr. Kevin Nash, Dr. Neenoo Khosla and Dr. Menaka Sarav for slides, case studies*