Acute Kidney Injury

Acute Renal Failure (ARF)

Definition: Abrupt failure of the kidneys to carryout normal functions

- Accumulation of uremic toxins
- Dysregulation of fluid, electrolytes and acid-base balance
- Traditionally defined by increased creatinine outside of reference range
- Mortality rate ranges from 50-60% and many deaths occur shortly after diagnosis

Acute Kidney Injury (AKI)

- Represents a spectrum of disease severity from clinically non-detectable to severe dysfunction and ARF
- ARF is the most severe stage of AKI
    - Late recognition of disease
    - Mortality rates often exceed 60%
- Detection of AKI at an earlier stage may lead to improved outcomes

IRIS AKI Grading

- Grade is based on creatinine, need a 0.3 mg/dl increase in serum creatinine within 48 hours (can be 72 hours, not a hard cutoff)
- Grade I is a non-azotemic AKI
- Grade II is a mild AKI with static or progressive azotemia
- Grade III-V is a moderate to severe AKI depending on the creatinine levels with increasing severities of azotemia and functional renal failure
- Each grade is further sub-graded on the basis of
    - Non oliguric or oligoanuria
    - Requirement for renal replacement therapy

Creatinine and Early AKI Diagnosis

- Creatinine concentrations vary
    - Age, gender, muscle mass, and hydration status
- 75% of renal function needs to be compromised before elevations are outside the reference range
- Critical evaluations of creatinine may aid in earlier AKI diagnosis
    - Look for creatinine trends
- Need for markers to diagnose AKI early
    - We need an injury marker “ALT” for the kidney
    - More sensitive function markers
- Neutrophil Gelatinase Associated Lipocalin (NGAL)

    - Upregulated by compromised renal epithelium
    - Can be measured in blood and urine
    - NGAL concentrations increase soon after renal damage
    - In humans, NGAL increases significantly earlier than creatinine (by days) during renal injury
- Urinary Clusterin (uClusterin)
    - Synthesized by various tissues including renal tubular cells during damage
- sInosine
    - Nucleic acid involved in purine metabolism
    - Recent studies show that adenosine is deaminated to inosine in proximal tubule cells
        - Decreases during kidney injury
- Urinary Cystatin B (uCysB)
    - Cystatins are a family of cysteine protease protein inhibitors
    - Intracellular protein
    - Low concentration in circulating serum
    - Released in urine from ruptured renal tubular cells
    - Not perfect but can be helpful in early detection

What should be done if an AKI is suspected?

- Discontinue all nephrotoxic agents
- Ensure volume status and perfusion pressure
- Consider functional hemodynamic monitoring
- Monitor serum creatinine and urine output
- Avoid hyperglycemia
- Consider alternatives to radiocontrast procedures
- If already stage I or greater: Consider a more invasive diagnostic workup
- If stage II or greater: Check for changes in drug dosing, consider renal replacement therapy, consider ICU admission

Common causes of AKI

Dog	Dog and Cat	Cat
Grape/raisin toxicity Leptospirosis Lyme nephritis	Pyelonephritis Hemodynamic instability (hypo/hypertension) Acute pancreatitis Drugs (aminoglycosides, amphotericin B, NSAIDS) Other nephrotoxins Ethylene Glycol Melamine/Cyanuric acid	Lily toxicity Urethral obstruction Renal lymphoma FIP

Evaluating the AKI Patient

- PHYSICAL EXAMINATION is crucial!
    - Hydration status
    - Cardiovascular Status
        - Bradycardia from hyperkalemia
        - Underlying cardiac disease
    - Respiratory status
        - Pulmonary edema
        - Pleural effusion
        - Leptospirosis lung
        - ARDS (uremic pneumonitis)
    - Neurologic Status
    - Abdominal palpation
        - Check kidney and bladder size
        - Other intra-abdominal disease +/- pain
    - Oral examination
        - Uremic ulcers
        - Mucous membranes (can be tacky because of halted salivary production)
    - Rectal examination
        - Melena
    - Evaluate for other underlying problems

Immediate Evaluation of Electrolytes

- Hyperkalemia
- Metabolic Acidosis
    - Uremic and lactic acids
- Electrocardiogram
    - Hyperkalemia induced cardiomyopathy
- Blood pressure

Thorough History

- Nephrotoxin exposure
    - NSAIDS, grapes, raisins, ethylene glycol
- Leptospirosis
    - Hiking, camping, swimming
    - Vaccination status
- Recent anesthesia
- Previous Medical History
    - CKD, UTI, etc.

Workup for the AKI Patient

- Complete blood count, serum chemistry screen
- Urinalysis
- Urine culture
- Blood pressure and fundic exam
- Abdominal ultrasound +/- radiographs (thoracic and abdominal)
    - Acute early ureteral obstruction
    - Partial obstruction
    - Dehydration present on initial US examination
    - Staghorn calculi
- Titers, toxin evaluation etc.

Clinical Consequences and Treatment of AKI

- Hyperkalemia
    - Cause: decreased renal excretion exacerbated by iatrogenic potassium administration
    - Consequences: cardiomyopathy, muscle weakness
    - Treatment: sodium bicarbonate IV to facilitate intracellular potassium movement. Regular insulin with dextrose to facilitate intracellular potassium movement. You need to add the supplemental dextrose to prevent hypoglycemia.
        - Calcium gluconate as a cardioprotective
        - Lasix may increase potassium excretion if the patient has urine output
        - Beta-agonists are rarely used
        - Hemodialysis is also an option
- Hydration status!
    - Dehydrated/hypovolemic patients
        - Hypovolemic/hypotensive patients
            - IVF bolus as indicated until stable
            - Fluid prescription
                - Deficit
                - Maintenance
                - Ongoing losses
                - REASSESS your patients!!! Fluids are prescription medications!
    - Euhydrated patient
        - Fluid “challenge” to elevate UOP
        - IVF prescription to maintain euhydration
    - Overhydrated patient
        - Discontinue IVF!

        - Respiratory compromise
        - Non-responsive hypertension
            - Progressive renal damage
        - Renal parenchymal edema
            - Progressive injury and oliguria
        - If patient is oliguric or anuric and compromised by overhydration, hemodialysis is an option and likely needed!
    - Monitoring
        - Repeated physical examinations
        - Body weigh
        - Respiratory rate (increases in overhydrated patients)
        - PCV/TS
        - Blood pressure
        - Urinary output

Oliguria/Anuria

- Causes
    - Pre-renal or volume responsive
    - Renal
        - Tubular swelling
        - Inflammation / necrosis
            - Exacerbated by fluid overload
        - Cast deposition within tubules
        - Altered renal blood flow
    - Post-renal
        - Urinary tract obstruction
            - Upper vs Lower
- Treatment
    - Ensure adequate hydration
        - Fluid challenge (if indicated) to rule out pre-renal
    - Mannitol
        - Osmotic diuretic
        - Free-radical scavenger
    - Lasix
        - Loop diuretic/natriuretic
    - Hemodialysis
    - Dopamine (dogs)
        - Pre-glomerular vasodilation/increased RBF
        - Use with caution and is not currently recommended
    - Surgical intervention

        - Urinary tract obstruction
    - *If anuria persists, discontinue fluids!

Metabolic Acidosis

Similar with CKD, caused by increased production of acidic uremic toxins, decreased bicarbonate production, and dehydration leading to lactic acidosis

Consequences of metabolic acidosis include a disruption in cellular metabolism, exacerbation of hyperkalemia, increased protein and bone turnover and increased morbidity

Correct hypovolemia to correct the lactic acidosis and then administer sodium bicarbonate slowly IV

Hypertension

Similar to CKD, ensure accurate blood pressure measurement and interpretation of results. Minimize stress and iatrogenic increase. Ensure you have the appropriate cuff size and interpret these results as a whole, taking into account the patient's demeanor/stress level, heart rate, respiratory rate, consistency of measurements and adjunctive fundic exam.

If left untreated, hypertension can lead to retinal detachment, hypertensive encephalopathy (seizures), progressive renal damage, cerebral hemorrhage, and other end-organ damage

- Treatment
    - Prevent/treat overhydration
    - Amlodipine
        - Calcium channel blocker
        - Negative inotrope and chronotrope
        - Titrate to effective dose
        - Do NOT exceed 0.8 mg/kg/day (cardiotoxic)
        - Can give rectally in vomiting patients
        - Repeated bp measurements are important for monitoring response
- If refractory
    - Acepromazine
    - Hydralazine
        - Reflex tachycardia
        - +/- beta blocker
    - Nitroprusside
    - ACE*i* in high grade AKI?

Pain Management

- Nephritis

- Ureteral obstruction
- Ulcerative stomatitis
- GI pain
- Esophagitis
- Other underlying disease processes
    - Pancreatitis

Respiratory Disease

- Causes
    - Fluid overload
        - Pulmonary edema
            - Diuretics
            - Appropriate fluid administration
        - Pleural effusion
            - Thoracocentesis
        - Aspiration pneumonia
            - Appropriate abx therapy
    - Leptospirosis lung
        - Careful anticoagulant therapy
        - Treat leptospirosis – ampicillin/doxycycline
    - ARDS (Uremic lung)

Anemia

- Causes
    - GI hemorrhage
    - Decreased RBC lifespan
    - Increased bleeding tendency
        - Uremic toxins affect platelet function
    - Iatrogenic sampling
    - Deficient erythropoietin production
    - Losses through hemodialysis
- Treatment
    - Treat gastritis
    - Blood transfusion (IF indicated)
    - Prevention
        - Judicious blood sampling
    - Erythropoiesis stimulating agents
        - Darbepoeitin (Aranesp)
        - Not always indicated
    - Feeding tubes

        - Nutrition
        - Medications
        - Fluids
        - Free water administration
        - Different types
            - Nasogastric/Nasoesophageal
            - Esophageal
            - Gastric

Hyperphosphatemia

- Causes
    - Increased phosphorus retention
    - Renal secondary hyperparathyroidism
- Treatment
    - Renal diet
    - Phosphate binders (if eating)
        - Aluminum hydroxide powder
        - Fosrenol
        - Epakitin

Hemodialysis

- Indications for renal replacement therapy
    - Significant fluid overload
    - Oliguria / anuria
    - Uncontrollable hyperkalemia
    - Sever azotemia and clinical signs
- Considerations
    - Heparinization (Increased bleeding risk!)
        - Need to think about other potential surgical procedures!