Chapter 33

Nephrology

Assessing Kidney Function in Children

- To estimate glomerular filtration rate (GFR), use the Schwartz formula
  - Two points are needed for this GFR calculation: patient height (in centimeters), and a stable serum creatinine measurement

$$\text{Estimated GFR (eGFR)} = \frac{\text{(height [cm]) (k)}}{\text{(serum creatinine mg/dL)}}$$

  - Typical "k" values are as follows:
    - Preemies: 0.33
    - Infants (< 12 mo old): 0.45
    - Children and female adolescents: 0.55
    - Male adolescents: 0.7
  - If serum creatinine is rising, estimate GFR as 0 or < 20 mL/min/1.73 m^2
- When kidney function is questionable, dose all medications based on eGFR
- If GFR < 40 mL/min/1.73 m^2, especially in the presence of chronic kidney disease, associated findings include:
  - Anemia: due to erythropoietin deficiency, as well as the iron deficiency caused by the chronic disease; supplement with iron and epoetin alfa (if possible)
  - Secondary hyperparathyroidism: manifesting with high levels of intact parathyroid hormone (iPTH), phosphate, alkaline phosphatase, and low levels of calcium
    - Treat with calcium supplementation at meals to bind phosphate and raise calcium levels
    - Administer 1,25-dihydroxyvitamin D to suppress iPTH
  - Acidosis
    - Treat acidosis with citric acid/sodium citrate and calcium carbonate supplementation to neutralize hydrogen ion and promote growth

  - Elevated potassium causes severe acidosis and decreases GFR in children
    - Treat with sorbitol or osmolar potassium-binding resin to encourage rectal excretion of potassium
    - If urine output is present, consider a high-dose diuretic

Acute Kidney Injury

- Acute kidney injury is evident when GFR < 50 mL/min/1.73 m^2, or when creatinine rises by 0.5 mg/dL in children or 1.0 mg/dL in adolescents
- The most common cause in a field or combat environment is inadequate renal perfusion (inadequate intravascular volume)
  - Clinical examination of intravascular fluid status includes:
    - Checking blood pressure (BP) and heart rate to assess for evidence of shock
    - Examining mucous membranes, fontanelle, weight, etc
    - Checking urine sodium if possible; if the child is hypotensive, urine sodium is < 20 mmol/L, regardless of serum sodium
    - Urine osmolarity or urine-specific gravity
    - Assessing oncotic pressure with serum albumin as a cause of low renal perfusion
- Other causes of acute kidney injury in the field environment
  - Obstructive uropathy (eg, neurogenic bladder, posterior urethral valves, single kidney with renal stones, etc)
    - Look for lower extremity atrophy, sacral dimple, and hair tuft for spina bifida occulta, etc
    - Use kidney ultrasound to assess
    - Place Foley to drain
    - Watch serum creatinine after decompression
  - Acute glomerular injury
  - Hypertension
    - Cuff size should measure two-thirds the distance from the patient's olecranon to acromion; the bladder portion of the cuff should wrap completely around the arm
    - Hypertension criteria:

      - < 12 months old: 100/70
      - Quick formulas for children ages 1–10 years old
        - Systolic BP: age × 2 + 100 (95th percentile)
        - Diastolic BP: age × 1.5 + 70 (95th percentile)
      - > 10 years old: use adult measurement
  - Proteinuria with acute hematuria (gross or microscopic); red blood cell (RBC) casts and dysmorphic RBCs can be seen in a urine microscopic evaluation
  - Edema
  - Acute tubular necrosis (this is the same as acute glomerulonephritis above, except a granular cast is seen on urine microscopic evaluation)
- Treating acute kidney injury
  - Bolus initially with normal saline (NS; 20 mL/kg), or blood products or albumin 25% (1 g/kg); slowly (over 1–2 h) to establish intravascular volume and restore BP (some patients may be euvolemic or hypervolemic)
  - Place a urine Foley to drain and watch urine output
  - Place patient on ⅓ maintenance fluids (¼ NS without potassium)
  - Replace hourly urine output with an equal volume of ½ NS
  - Control or maintain BP with vasodilators or vasopressors based on the patient's BP
    - Low BP: use vasopressors
    - High BP: use diuretics or calcium-channel blockers
    - Titrate medications based on response
  - If the patient becomes oliguric or anuric, consider furosemide 3–5 mg/kg to establish urine output and help with volume status
  - Stabilize electrolytes, especially potassium, through established cellular shift and excretion methods
  - If access to Army Knowledge Online (AKO) is available, contact the nephrology consult service (nephrology.consult@us.army.mil)

Nephrotic Syndrome

- Hypoalbuminemia (< 2.5 g/dL)
- Hyperproteinuria

  - Spot urine protein-to-creatinine ratio > 2.0

OR

  - Urine dipstick or urinary analysis shows protein to be 2+ or more
- Hypercholesterolemia (total cholesterol > 200 mg/dL, low-density lipoprotein > 130 mg/dL)
- Edema presents with weight gain, tibial and eyelid swelling (usually first to show), and ascites
- Noted to be absent: hypertension, elevated serum creatinine or decreased GFR, active urine sediment (no RBC casts, etc)

Treating Edema and Nephrotic Syndrome

- Treat edema if the following are present:
  - Severe hyponatremia
  - Severe pleural effusion with respiratory distress
  - Severe anasarca with skin breakdown or severe swelling in the scrotum or labial areas
- Treat edema with albumin 25% (1 g/kg) over 4 hours
- Monitor on a cardiorespiratory monitor (if possible) to watch respiratory status
- Follow with furosemide (1 mg/kg intravenous [IV]), then albumin again in the same order over 4 hours ("albumin-furosemide-albumin sandwich"); this treats edema by increasing oncotic pressure and renal perfusion; diuretic therapy excretes free water
- Treatment of nephrotic syndrome: most cases will respond to prednisone at 2 mg/kg daily
- Contact nephrology consultation service on AKO if available

Renal Stones

- Renal stones are rare in children, but because of the climate and a lack of potable water, they are more common in current combat theaters
- Calcium oxalate kidney stones are the most common type found in children. Their clinical presentation is similar to that in adults and includes:
  - Gross hematuria (presents with pink or red urine)
  - Inguinal pain reproducible with palpation of the flank or abdomen
  - Fever, flank pain, and dysuria or a burning sensation, which

may present if the patient passes gravel or a stone (infection develops behind obstructing stones)

- Physical examination
    - Perform a urinary analysis; look for hematuria
    - Do a renal ultrasound or computed tomography scan, if available
    - If possible, send urine for a spot check for both calcium and creatinine levels, then calculate the calcium-to-creatinine ratio (a urine calcium-to-creatinine ratio > 0.2 is high)
- Treatment
    - Hydrate: 1.5 L/day of fluid in younger children (< 20 kg), or 2 L/day in older children
    - Consider citrate for increasing pH of urine, if possible, to decrease stone formation in the urinary tract
    - Maintain good urine output (5 voids per day)