

## **Renal/Electrolyte Emergencies**

### **1. Hypertensive Urgency & Emergency**

#### **Background:**

- Hypertension: Either the systolic and/or diastolic BP  $\geq 95^{\text{th}}$  percentile measured on three or more occasions.
  - Stage 1: Systolic and/or diastolic BP between the 95<sup>th</sup> percentile and 5 mmHg above the 99<sup>th</sup> percentile.
  - Stage 2: Systolic and/or diastolic BP  $\geq 99^{\text{th}}$  percentile plus 5 mmHg.
- Etiologies:
  - Neonate: Renovascular disease or congenital renal anomalies.
  - Children: Glomerulonephritis, renovascular disease, congenital renal anomalies.
  - Adolescents: Renal parenchymal disease, preeclampsia, sympathomimetic drug ingestion.
- Hypertensive Urgency: Severe elevation of BP *without* severe symptoms or evidence of acute target organ damage.
- Hypertensive Emergency: Severe symptomatic elevation of BP *with* evidence of acute target organ damage.
- Pathogenesis: Elevation of BP beyond vascular autoregulatory zone resulting in increased vascular permeability, endothelial damage, tissue edema/necrosis and vasoconstriction, increased renin release and proinflammatory cytokine induced inflammation and tissue damage, oxidative stress and reduced nitric oxide levels, and endothelial dysfunction.
- Risk factors for Hypertensive Emergency:
  - Hematuria, edema or decreased urine output (parenchymal renal disease).
  - History of umbilical artery or vein catheterization (renovascular disease).
  - Recent streptococcal infection of skin or pharynx (poststreptococcal glomerulonephritis).
  - Pregnancy (preeclampsia or eclampsia).
  - Drug use: Cocaine, amphetamines, pseudoephedrine, OCPs, corticosteroids.
  - Weight loss, anxiety, and heat intolerance (hyperthyroidism).
  - Tachycardia, anxiety, headaches, diaphoresis (pheochromocytoma).

#### **Signs and Symptoms:**

- Hypertensive Urgency: The patient may be asymptomatic or have only minor symptoms (headache, nausea, vomiting).
- Hypertensive Emergency: Altered mental status, lethargy, coma, seizure, vision changes, focal neurologic changes, renal insufficiency, heart failure, shortness of breath, diaphoresis, tachypnea, flank pain, dysuria, hematuria, oliguria.

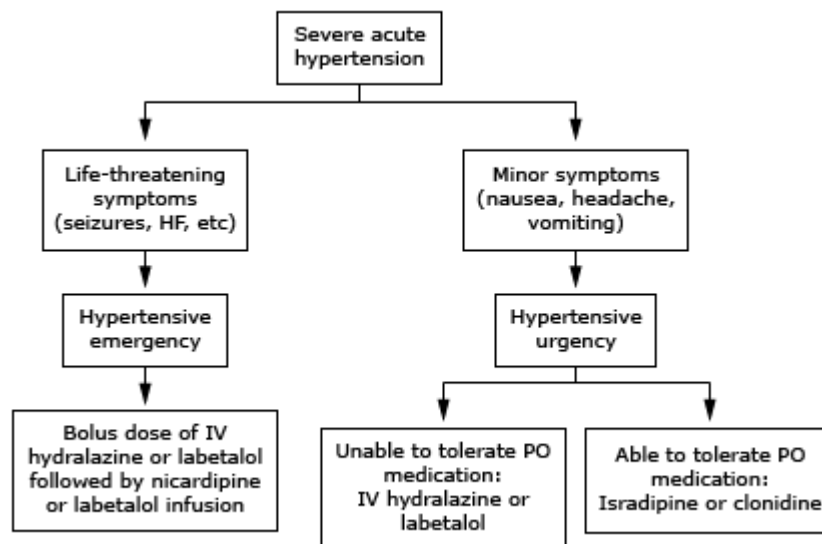
#### **Evaluation:**

- Pediatric Advanced Life Support (PALS) for initial evaluation and stabilization.
- Physical exam: Vital signs with appropriate size BP cuff (a cuff that is too small will artificially elevate the BP reading), four limb BP measurements, general appearance (edema), fundoscopic exam (papilledema, retinal hemorrhage), cardiopulmonary exam (tachypnea, pulmonary edema, gallop, murmur).
- Labs: CBC with differential, reticulocyte count, complete metabolic profile, urinalysis and urine culture, urine pregnancy test (postmenarchal females), urine drug screen.
- Head CT, ECG, CXR; consider ECHO.

#### **Management:**

- Obtain vascular access.
- Hypertensive Urgency and able to tolerate PO medication:
  - Consult Pediatric Nephrology.
  - Isradipine (0.05 mg/kg/dose; max 2.5 mg/dose) PO once.
- Hypertensive Emergency or Hypertensive Urgency and unable to tolerate PO:

- Consult Pediatric Critical Care and Pediatric Nephrology.
- Lower BP by no more than 25% over first 8 hours using IV medications.
- Labetalol (0.2 mg/kg/dose; max 20 mg/dose) IV once.
  - Contraindicated in asthma and acute heart failure.
- Hydralazine (0.2 mg/kg/dose; max 20 mg/dose) IV once.
- For continued severe acute hypertension refractory to above interventions:
  - Nicardipine (starting dose 0.5 mcg/kg/min; max starting dose 5 mg/hr) infusion IV titrated by 25% every 15 minutes to decrease BP by no more than 25% during first 8 hours of treatment.
- For volume overload:
  - Furosemide (0.5 mg/kg/dose; max 20 mg/dose) IV once.
- For seizure activity:
  - See Seizure section under Neurologic Emergencies.



*Flynn, JT, Tullus, K. Severe hypertension in children and adolescents: pathophysiology and treatment. Pediatr Nephrol 2008.*

## 2. Hyperkalemia

### Background:

- Definition: Serum or plasma potassium >5.5 mEq/L; severe hyperkalemia >7 mEq/L is a medical emergency.
- Pathophysiology:
  - Excessive potassium intake.
  - Transcellular movement of intracellular potassium into the extracellular space:
    - Cellular injury (rhabdomyolysis, extreme exercise, severe hemolysis).
    - Metabolic acidosis.
  - Decreased renal excretion of potassium:
    - Acute and chronic kidney disease.
- Pseudohyperkalemia:
  - Most commonly caused by hemolyzed blood samples.

- May be seen in patients with severe thrombocytosis or leukocytosis.

Signs and Symptoms:

- Mild (<6 mEq/L) or moderate (6-7 mEq/L) hyperkalemia: Most patients are asymptomatic.
- Severe hyperkalemia (>7 mEq/L):
  - Muscle weakness or paralysis.
  - Cardiac dysrhythmias (palpitations, syncope, asystole).

Evaluation:

- Physical exam and vital signs:
  - Hypertension and edema may indicate renal disease.
  - Muscular tenderness in patients with rhabdomyolysis.
  - Tachycardia, hypotension may indicate shock, metabolic acidosis and renal injury.
- Labs: Basic metabolic panel from a free flowing blood sample; CBC, LDH and creatine kinase to evaluate for hemolysis and muscle injury; UA, urine electrolytes, and urine culture to evaluate for renal disease.
- ECG:

POTASSIUM LEVEL (MEQ/L):	ECG FINDINGS:
5.5-6.5	Tall peaked T waves, shortened QT interval
6.5-8.0	Peaked T waves, prolonged PR interval, decreased P wave, wide QRS
>8.0	Absent P wave, bundle branch block, wide QRS, ventricular fibrillation, asystole

Management:

- For patients with confirmed severe hyperkalemia (>7 mEq/L), significant ECG changes (wide QRS, absent P wave), or conditions which cause rapidly rising potassium (tumor lysis syndrome, crush injury):
  - Consult Pediatric Critical Care.
  - Calcium gluconate (75 mg/kg/dose; max 3000 mg/dose) IV once over 30 minutes.
  - Albuterol INH (2.5-5 mg/dose) nebulized once.
  - Dextrose (0.5 gm/kg) IV over 30 minutes **AND** Insulin (0.1 units/kg/dose; max 10 units/dose).
    - If <5 years of age: Dextrose 10% (100 mg/mL) 5 mL/kg/dose IV once.
    - If ≥5 years of age: Dextrose 25% (250 mg/mL) 2 mL/kg/dose IV once (max 25 gm/dose).
  - Sodium bicarbonate (1 mEq/kg/dose; max 50 mEq/dose) IV once over 15 minutes.
    - If <6 months of age: 2 mL/kg of 4.2% solution.
    - If ≥6 months of age: 1 mL/kg of 8.4% solution.
  - Furosemide (1 mg/kg/dose; max 40 mg/dose) IV once.
  - Sodium polystyrene sulfonate (Kayexalate; 1 gm/kg/dose; max 15 gm/dose) PO/PR once.
- For patients with hypovolemia: 0.9% NS (20 mL/kg; max 1000 mL) IV over 30-60 minutes.
- For severe or refractory hyperkalemia: Dialysis may be indicated.

### 3. Hyponatremia

Background:

- Definition: Serum or plasma sodium <135 mEq/L.
- Incidence: Up to 45% of hospitalized children develop hyponatremia
- Risk factors: hypovolemia, fever, head injury, CNS infection, respiratory illness, hypotonic fluid administration.

- Pathogenesis and Etiologies:
  - Hypovolemia and appropriate ADH levels:
    - GI losses (gastroenteritis) and excessive free water intake, diuretic use, renal salt wasting, intense exercise.
  - Normovolemia and inappropriate ADH levels: Pulmonary and oncologic disorders, recent surgery.
  - Hypervolemia: Renal failure, nephrotic syndrome, heart failure.
- Chronic hyponatremia may be seen in patients with chronic cardiac dysfunction or renal disease.

Signs and Symptoms:

- Acute hyponatremia:
  - Sodium level >125 mEq/L: Symptoms related to underlying illness.
  - Sodium level <125 mEq/L: Neurologic symptoms (headache, lethargy, nausea).
  - Sodium level <120 mEq/L: Depressed mental status, seizure.
- Chronic hyponatremia: Patients may have mild or no neurologic symptoms.

Evaluation:

- Physical exam: General appearance, volume status, neurologic and cardiopulmonary status.
- Labs: Basic metabolic panel, plasma and urine osmolality, urine sodium.

Management:

- Pediatric Advanced Life Support (PALS) for initial evaluation and stabilization.
- Treatment of underlying disease.
- For acute severe hyponatremia:
  - Consult Pediatric Critical Care.
  - Immediately correct serum sodium level to 125 mEq/L:
    - 3% hypertonic saline [2.5 mEq/kg/dose (~5 mL/kg/dose)] IV once over 20 minutes.
  - Gradually correct serum sodium to normal value by 6-8 mEq/L per 24 hours since overly rapid correction can result in osmotic demyelination syndrome and irreversible neurologic symptoms.
- For hyponatremia with mild or no neurologic symptoms:
  - Gradually correct serum sodium to normal value by 6-8 mEq/L per 24 hours.
- For mild hyponatremia with normal or increased effective circulating volume:
  - Fluid restriction to 60% of usual daily maintenance fluid requirements.
- For mild hyponatremia with decreased effective circulating volume (ECV):
  - Hypervolemia with decreased ECV (nephrotic syndrome, heart failure):
    - Treat underlying condition and fluid restriction.
  - Hypovolemia with decreased ECV (gastroenteritis):
    - Isotonic fluid (0.9% NS) resuscitation to restore intravascular volume.
- For chronic hyponatremia:
  - Identify trend and trajectory of prior sodium levels.
  - If asymptomatic: No specific therapies indicated.
  - If symptomatic (acute on chronic hyponatremia):
    - See acute severe hyponatremia management above.

## 4. Hypernatremia

Background:

- Definition: Serum or plasma sodium >150 mEq/L.
- Etiologies:
  - Water loss that is not replaced: GI losses (gastroenteritis with vomiting and/or diarrhea), central or nephrogenic diabetes insipidus, renal disease, osmotic diuresis (glucosuria), inadequate water intake.
  - Excessive salt intake relative to water intake.

Signs and Symptoms:

- Acute hypernatremia: Irritability, lethargy, weakness, vomiting, altered mental status, seizure, coma.
- Chronic hypernatremia: Typically asymptomatic due to cerebral adaptation.

Evaluation:

- Physical exam: General appearance, volume status, neurologic and cardiopulmonary status.
- Basic metabolic panel, plasma and urine osmolality, urine sodium and creatinine.
  - Fractional excretion of sodium [(FENa (%))]:
    - $[(\text{urine sodium} \times \text{serum creatinine}) / (\text{serum sodium} \times \text{urine creatinine})] \times 100$ .
    - FENa <1% suggests prerenal acute kidney injury due to water loss.
    - FENa >2% suggests acute tubular necrosis.
  - Urine sodium is typically low (<25 mEq/L) with hypernatremic hypovolemia (GI losses).
  - Urine sodium is typically high (>200 mEq/L) with salt poisoning.

Management:

- Consult Pediatric Nephrology to determine optimal replacement fluids and infusion rate.
- For patients with acute hypernatremia and mild to moderate hypovolemia:
  - Isotonic (0.9% NS) fluid bolus (20 mL/kg) IV once over 30 minutes.
- For patients with acute hypernatremia and severe hypovolemia (Shock):
  - See Sepsis and Septic Shock section in Infectious Emergencies.
- Rate of sodium correction should NOT exceed 0.5 mEq/L per hour (risk for cerebral edema).