Fluid and Electrolytes Management of the Surgical Patient
Objectives

- Review basic fluid physiology
- Outline causes and clinical manifestations of common fluid and electrolyte disturbances
- Outline management
Basic fluid physiology

- Total Body Water (TBW) = 60% of BW
  = 42 L in 70 kg
- TBW = Intracellular fluid (ICF) + Extracellular fluid (ECF)
- ICF = 40% of BW = 28 L in 70 kg
- ECF = 20% of BW = 14 L in 70 kg
## Compartment of body fluid

<table>
<thead>
<tr>
<th>Intracellular fluid</th>
<th>Interstitial fluid</th>
<th>Plasma</th>
</tr>
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<tbody>
<tr>
<td>40% of BW</td>
<td>15% of BW</td>
<td>5% of BW</td>
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Classification of body fluid change

- Volume change
- Concentration change
- Composition change
Volume deficit

Common causes

• GI loss e.g. vomiting, NG suction, fistula drainage, etc.
• Non GI loss e.g. non-oliguric renal failure, diabetes insipidus, etc.
• Fluid sequestration “Third Spacing” e.g. burn, peritonitis, etc.
Volume deficit

Manifestations

- CNS signs e.g. apathy, sleepiness
- CVS signs e.g. narrow pulse pressure, tachycardia, hypotension
- Tissue signs e.g. skin perfusion, dry lips, sunken eyeballs
Volume excess

Common causes
- Iatrogenic
- Renal failure
- Heart failure
Volume excess

Manifestations

- Early: obscure, rapid weight gain
- Late: pulmonary edema
Concentration change

Sodium concentration responsible for the serum osmolarity

Serum Osmolarity = 2 x Sodium + Glucose/18 + BUN/2.8
Notice on Concentration Disturbances Management

• Clinical manifestations usually not specific to a particular electrolyte change, e.g., seizures

• Implies an underlying disease process

• Treat the electrolyte change, but seek the cause
Notice on Concentration Change Management

• Clinical manifestations determine urgency of treatment, not laboratory values
• Speed and magnitude of correction dependent on clinical circumstances
• Frequent reassessment of electrolytes required
Hyponatremia

- Serum Sodium < 136 mEq/L
- Hypo-osmolar hyponatremia
  - Euvolemic: e.g. SIADH
  - Hypovolemic e.g. diarrhea
  - Hypervolemic e.g. CHF, cirrhosis
- Normo- or hyperosmolar hyponatremia
  - Translocational hyponatremia
Hyponatremia

Manifestations

• Neurologic: decrease mental status, confusion, convulsion, etc.
• Cardiovascular: hypertension, bradycardia, etc.
Hyponatremia – Treatment

- Hypovolemic ↓ Na – give normal saline
- Hypervolemic ↓ Na – increase free H₂O loss
- Euvolemic hyponatremia
  - Restrict free water intake
  - Increase free water loss
  - Normal or hypertonic saline
- Correct slowly due to possibility of osmotic demyelinating syndromes
Hyponatremia: Treatment

1. Normal brain (normal osmolality)
2. Immediate effect of hypotonic state
3. Water gain (low osmolality)
4. Rapid adaptation
5. Proper therapy (slow correction of the hypotonic state)
6. Loss of organic osmolytes (low osmolality)
7. Slow adaptation
8. Loss of sodium, potassium, and chloride (low osmolality)
9. Water
10. Improper therapy (rapid correction of the hypotonic state)

Osmotic demyelination
Hyponatremia

In case of hypertonic saline needed

Change in Serum Na\(^+\) after administration of 1 L of fluid

Change in \(S_{Na^+}\) = (Infusate Na\(^+\) - Serum Na\(^+\)) / TBW + 1
Hypernatremia

- Serum Sodium > 145 mEq/L
- Etiology – ↑ H₂O loss, ↓ H₂O intake, ↑ Na intake
- Manifestations – neurologic, muscular
- H₂O deficit (L) =
  \[
  \left[ 0.6 \times \text{wt (kg)} \right] \times \left[ \frac{\text{obs Na} - 1}{140} \right]
  \]
Hypernatremia – Treatment

- Provide intravascular volume replacement
- Consider giving one-half of free H$_2$O deficit initially
- Reduce Na cautiously: 0.5-1.0 mmol/L/hr
- Secondary neurologic syndromes with rapid correction
Hypernatremia: Treatment

- **Normal brain (normal osmolality)**
- **Immediate effect of hypertonic state**
- **Water loss (high osmolality)**
- **Rapid adaptation**
- **Proper therapy (slow correction of the hypertonic state)**
- **Cerebral edema**
- **Improper therapy (rapid correction of the hypertonic state)**
- **Accumulation of organic osmolytes (high osmolality)**
- **Slow adaptation**
- **Accumulation of electrolytes (high osmolality)**
Composition changes

Concentration changes of
• Potassium
• Calcium
• Magnesium
• Phosphate
Hypokalemia

- Serum Postassium < 3.5 mEq/L
- Etiology – renal loss, extrarenal loss, transcellular shift, decreased intake
- Manifestations – cardiac, neuromuscular, gastrointestinal
- Deficit poorly estimated by serum levels
Hypokalemia

- Titrate administration of K⁺ against serum level and manifestations
- Correct hypomagnessemia
- ECG monitoring with emergent administration
- Allowable maximum iv dose per hour controversial
Hyperkalemia

- Serum Potassium > 5 mEq/L
- Etiology – renal failure, transcellular shifts, cell death
- Manifestations – cardiac, neuromuscular
Hyperkalemia – Treatment

- Stop intake
- Give calcium for cardiac toxicity
- Shift K⁺ into cell – glucose + insulin, NaHCO₃
- Remove from body – diuretics, sodium polystyrene sulfonate, dialysis
- Treat hyperkalemia urgently in acidosis
Other Electrolyte Deficits
Ca, PO$_4$, Mg

• May produce serious but nonspecific cardiac, neuromuscular, respiratory, and other effects
• All are primarily intracellular ions, so deficits difficult to estimate
• Titrate replacement against clinical findings
Calcium

Fact

• 99% of body calcium: bone
• Normal serum calcium: 8.9-10.3 mg/dl
• 50% of serum calcium: albumin bound
• “corrected” calcium: 0.8 mg/dl for 1 gm/dl of hypoalbuminemia
Hypocalcemia

Causes

• Acute pancreatitis
• Massive soft tissue infection
• Hypoparathyroidism
• Massive blood transfusion
Hypocalcemia

Management

• Calcium chloride or gluconate
• Bolus + continuous infusion
Hypercalcemia

Causes

• Cancer with bony metastasis
• Hyperparathyroidism
• Prolong immobilization
Hypercalcemia

Management

• Rehydration with normal saline
• Loop diuretics
• Correct cause
Magnesium deficiency

Causes

• Prolong starvation
• Prolong TPN with Mg free solution
Please complete reading of fluid and electrolyte disturbances covered in the Schwartz Principles of Surgery Textbook.