Fluids and Electrolytes

Lisa Martin, MD, MPH
Objectives

- Know maintenance water and electrolyte requirements for children.
- Assess hydration status in children.
- Determine replacement fluids (oral and iv) for dehydrated patients with a variety of electrolyte disturbances.
**Holliday-Segar Method**  
Estimates caloric expenditure from weight, assuming that for each 100 calories metabolized, 100 ml H$_2$O are required.

<table>
<thead>
<tr>
<th>Body Weight</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ml/kg/day</td>
</tr>
<tr>
<td>First 10 kg</td>
<td>100</td>
</tr>
<tr>
<td>Second 10 kg</td>
<td>50</td>
</tr>
<tr>
<td>Each additional kg</td>
<td>20</td>
</tr>
</tbody>
</table>
Example: 8 year-old weighing 25kg

- ml/kg/day
  - ________ ml/kg/day

- ml/kg/hr
  - ________ ml/kg/hr
# Maintenance Electrolytes

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>mEq/L H$_2$O (≈mEq/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na$^+$</td>
<td>3 (2-4)</td>
</tr>
<tr>
<td>K$^+$</td>
<td>2 (2-3)</td>
</tr>
<tr>
<td>Cl$^-$</td>
<td>2</td>
</tr>
<tr>
<td>Dehydration</td>
<td>Mild</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Examination</td>
<td>Older Child</td>
</tr>
<tr>
<td></td>
<td>Infant</td>
</tr>
<tr>
<td>Skin turgor</td>
<td>Normal</td>
</tr>
<tr>
<td>Skin — touch</td>
<td>Normal</td>
</tr>
<tr>
<td>Lips/ MM</td>
<td>Moist</td>
</tr>
<tr>
<td>Eyes</td>
<td>Normal</td>
</tr>
<tr>
<td>Crying/tears</td>
<td>Present</td>
</tr>
<tr>
<td>Fontanelle</td>
<td>Flat</td>
</tr>
<tr>
<td>CNS</td>
<td>Consolable</td>
</tr>
<tr>
<td>Pulse</td>
<td>Regular</td>
</tr>
<tr>
<td>Urine output</td>
<td>Normal</td>
</tr>
</tbody>
</table>
Assessing Hydration Status

- **History**
  - Volume of liquid intake
  - Frequency of wet diapers/urination
  - Frequency/quantity of diarrhea
  - Recent weight (if known)

- **Labs**
  - BMP if admitting the patient
    - Serum sodium
Classifying based on $\text{Na}^+$

- **Hyponatremic**
  - Serum $\text{Na}^+ < 130 \text{ mEq/L}$
  - Implies excess $\text{Na}^+$ loss

- **Isonatremic (isotonic)**
  - Serum $\text{Na}^+ 130-150 \text{ mEq/L}$

- **Hypernatremic**
  - Serum $\text{Na}^+ > 150 \text{ mEq/L}$
  - Implies free water (FW) loss
How dehydrated is this patient?

- A 15 month old boy has had vomiting and diarrhea for the last 3 days. He usually drinks ~40 ounces/day, but is only drinking sips. His pulse is 130, and his lips are slightly dry. He is fussy during the exam and cries a few tears. His capillary refill is brisk, and skin turgor is normal.
Fluid Resuscitation

- Phase I - Emergency Management
- Phase II - Deficit Replacement, Maintenance and Ongoing Losses
- Oral vs. IV
Deficit Replacement

- Most precise – use patient’s weight
  - Fluid deficit (L) = preillness wt (kg) – current wt (kg)
  - % dehydration = \( \frac{\text{preillness wt} - \text{current wt}}{\text{preillness wt}} \times 100\% \)

- Otherwise, estimate based on clinical exam
Oral vs. IV Replacement

- Oral rehydration therapy (ORT) is preferred for mild – moderate dehydration unless:
  - emesis is intractable
  - stool losses > 10 cc/kg/hr
  - consciousness is impaired
Oral Rehydration Therapy

- Give 5-10cc of oral rehydration solution (ORS) every 5-10 minutes, increasing the amount as tolerated.
- Deficit replacement
  - Mild dehydration: 50 cc/kg ORS over 4 hours.
  - Moderate dehydration: 100 cc/kg ORS over 4 hours.
Oral Rehydration Solutions

Acceptable
- Pedialyte
- Infalyte (Ricelyte)
- WHO/UNICEF ORS

Suboptimal
- Apple juice
- Coca-Cola
- Tea
- Chicken broth
Oral Maintenance Therapy

- GOAL: Usual diet + replace ongoing losses
- Infants
  - Resume breastfeeding or regular formula
  - Soy or other lactose-free formulas are usually unnecessary.
- Older children
  - Encourage starchy foods, clear broth soups, yogurt, fresh fruits and vegetables.
  - Avoid foods high in fat or simple sugars.
IV Emergency Replacement - AKA “Boluses”

- What fluid?
- How much fluid?
- How many boluses?
IV Maintenance Fluids

- 3 important components
  - Dextrose
    - D$_5$ for most children; D$_{10}$ in the NICU
  - Potassium (except for patients with decreased urine output or renal insufficiency)
    - Usually add 20 mEq/L
  - Sodium
# Common IV Fluids

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Na (mEq/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D$_5$W</td>
<td>0</td>
</tr>
<tr>
<td>0.9% NaCl (NS)</td>
<td>154</td>
</tr>
<tr>
<td>0.45% NaCl (1/2 NS)</td>
<td>77</td>
</tr>
<tr>
<td>0.2% NaCl (1/4 NS)</td>
<td>34</td>
</tr>
<tr>
<td>Lactated Ringers</td>
<td>130</td>
</tr>
</tbody>
</table>
Consider the patient’s daily free water and sodium needs.

- **5 kg infant**
  - FW:
  - Na⁺:
  - Fluid =

- **20 kg child**
  - FW:
  - Na⁺:
  - Fluid =
Hypernatremic Dehydration

- **Water loss**
  - Insensible
    - Fever, burns
  - Renal
    - DI, diuretic use
  - GI
    - Diarrhea
  - Hypothalamic disorders
    - Hypodipsia

- **Excess sodium**
  - Excess ingestion
    - Improper formula mixture, Munchausen-by-proxy
  - Iatrogenic
    - Hypertonic NaCl IV fluid, excess IV NaHCO₃
  - Endocrine
    - Hyperaldosteronism
Hypernatremic Dehydration

- **Symptoms**
  - Lethargy, weakness, irritability, seizures, coma, death
  - Skin may be doughy

- **Treatment Goals**
  - Replace FW deficit
  - Lower serum sodium
    - Do not lower serum sodium more than 1 mEq/L per hour.
    - Want to avoid cerebral edema
Managing Hypernatremic Dehydration

- Emergency management
- FW deficit =
  \[0.6 \times \text{body wt (kg)} \times [1- \left(\frac{140}{\text{serum Na}}\right)]\]
- Calculate replacement + maintenance rate so serum sodium falls 0.5-1 mEq/L/hour.
  - If serum sodium is 164 and goal is 140, must take at least 24 hours to replace FW deficit.
  - Therefore, *hourly* fluid rate is the usual maintenance plus 1/24\(^{th}\) of total free water deficit.
- Check serum sodium every 4-6 hours. If falling too fast, slow down FW replacement rate or increase sodium in IV fluid.
Hyponatremic Dehydration

- **GI**
  - Diarrhea
- **Water intoxication, polydipsia**
- **Diuretics**
- **Factitious**
  - Hyperglycemia, hyperlipidemia

- **SIADH**
  - CNS injury
  - Pneumonia, ARDS
    - Decreased pulmonary venous return activates release of ADH
  - Post-op patients - spinal fusion
Hyponatremic Dehydration

- **Symptoms**
  - Seizures, lethargy if sodium < 120 mEq/L

- **Treatment Goals**
  - Raise sodium acutely to 120-125 mEq/L
    - Replace Na in patients who are volume depleted.
    - Restrict water intake in normovolemic or edematous patients.
  - Treat the underlying cause.
Managing Hyponatremic Dehydration

- Emergency management
- Sodium deficit = \(0.6 \times \text{body wt (kg)} \times (140 - \text{serum Na})\)
- Give 3% saline to raise serum sodium to 120-125 mEq/L.
  \(0.6 \times \text{body wt (kg)} \times (125 - \text{serum Na})\)
- If patient is hypovolemic, continue to replace sodium deficit with fluid to raise serum sodium \(~2\) mEq/L/hour