

Fluids and Electrolytes



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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.

Maintenance Fluids

- Holliday-Segar Method
 - Estimates caloric expenditure from weight, assuming that for each 100 calories metabolized, 100 ml H₂O are required.

| Body Weight | Water | |
|--------------------|-----------|----------|
| | ml/kg/day | ml/kg/hr |
| First 10 kg | 100 | 4 |
| Second 10 kg | 50 | 2 |
| Each additional kg | 20 | 1 |

Example: 8 year-old weighing 25kg

- ml/kg/day
 - 100 (for 1st 10 kg) x 10 kg = 1000 ml/day
 - 50 (for 2nd 10 kg) x 10 kg = 500 ml/day
 - 20 (per remaining kg) x 5 kg = 100 ml/day

1600 ml/day
- ml/kg/hr
 - 4 (for 1st 10 kg) x 10 kg = 40 ml/hr
 - 2 (for 2nd 10 kg) x 10 kg = 20 ml/hr
 - 1 (per remaining kg) x 5 kg = 5 ml/hr

65 ml/hr
(65 x 24 = 1560)

Maintenance Electrolytes

| Electrolyte | mEq/100 ml H ₂ O |
|-----------------|-----------------------------|
| Na ⁺ | 3 (2-4) |
| K ⁺ | 2 (2-3) |
| Cl ⁻ | 2 |

Assessing Hydration Status

| Dehydration | Mild | Moderate | Severe |
|--------------|-------------------|--------------------|-----------------|
| | Older Child 3% | 6% | 9% |
| | Infant 5% | 10% | 15% |
| Examination | | | |
| Skin turgor | Normal | Tenting | None |
| Skin - touch | Normal | Dry | Clammy |
| Lips/ MM | Moist | Dry | Parched/Cracked |
| Eyes | Normal | Deep set | Sunken |
| Crying/tears | Present | Reduced | None |
| Fontanelle | Flat | Soft | Sunken |
| CNS | Consolable | Irritable | Lethargic |
| Pulse | Regular | Slightly increased | Increased |
| Urine output | Normal | Decreased | Anuric |

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 Na⁺

- Hyponatremic
 - Serum Na⁺ < 130 mEq/L
 - Implies excess Na⁺ loss
- Isonatremic (isotonic)
 - Serum Na⁺ 130-150 mEq/L
- Hypernatremic
 - Serum Na⁺ > 150 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
 - Gatorade
 - 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?
 - Isotonic fluid
 - 0.9% NS, Lactated Ringers
 - NO dextrose-containing fluids
- How much fluid?
 - 20 cc/kg over 20-30 minutes.
 - Patients with congenital heart disease or renal insufficiency - ~10 cc/kg over 30-60 minutes.
- How many boluses?
 - Enough (although consider pressors if you're needing more than 60-80 cc/kg)

IV Maintenance Fluids

- 3 important components
 - Dextrose
 - D₅ for most children; D₁₀ in the NICU
 - Potassium (except for patients with decreased urine output or renal insufficiency)
 - Usually add 20 mEq/L
 - Sodium



Common IV Fluids

| Fluid | Na (mEq/L) |
|---------------------|------------|
| D ₅ W | 0 |
| 0.9% NaCl (NS) | 154 |
| 0.45% NaCl (1/2 NS) | 77 |
| 0.2% NaCl (1/4 NS) | 34 |
| Lactated Ringers | 130 |

Which fluid do I choose?

- Consider the patient's daily free water and sodium needs.
 - 5 kg infant
 - FW: $5 \text{ kg} \times 100 \text{ cc/kg/day} = 500 \text{ cc/day}$
 - Na⁺: $5 \text{ kg} \times 3 \text{ mEq/kg} = 15 \text{ mEq/day}$
 - $15 \text{ mEq}/500 \text{ cc} = 30 \text{ mEq/L} \rightarrow D_5 0.2 \text{ NS}$
 - 20 kg child
 - FW: $(10 \text{ kg} \times 100 \text{ cc/kg/d}) + (10 \text{ kg} \times 50 \text{ cc/kg/d}) = 1500 \text{ cc/day}$
 - Na⁺: $20 \text{ kg} \times 3 \text{ mEq/kg} = 60 \text{ mEq/day}$
 - $60 \text{ mEq}/1500 \text{ cc} = 40 \text{ mEq/L} \rightarrow D_5 0.45 \text{ NS}$

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 = $0.6 \times \text{body wt (kg)} \times [1 - (140/\text{serum Na})]$
- 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 1/24th 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

Cases

