Dehydration

728-655

Mary S. Hayney, PharmD, MPH, BCPS
Professor of Pharmacy (CHS)

Learning Objectives

- Recognize signs and symptoms of dehydration
- Estimate fluid deficit
- Recommend oral or intravenous replacement
- Recommend hydration strategies for athletes

Required reading

King CK, Glass R, Bresee JS. Duggan C. Managing acute gastroenteritis among children. Oral rehydration, maintenance, and nutritional therapy. MMWR 2003. https://www.cdc.gov/mmwr/preview/mmwrhtml/rr5216a1.htm

Suggested readings

Ofei SY, Fuchs GJ 3rd. Principles and Practice of Oral Rehydration. *Curr Gastroenterol Rep*. 2019;21(12):67. Published 2019 Dec 7. doi:10.1007/s11894-019-0734-1

Kight BP and Waseem M. Pediatric fluid management. StatPearls [Internet] 2021

https://www.ncbi.nlm.nih.gov/books/NBK560540/

Belval LN, Hosokawa Y, Casa DJ, et al. Practical Hydration Solutions for Sports. *Nutrients*. 2019;11(7):1550. Published 2019 Jul 9. doi:10.3390/nu110715-50

Study questions

A 17 month old child presents with lethargy. He has had diarrhea and vomiting for the past 18 hours.

What pertinent history do you need?

He weighed 26 pounds at his well-child visit last month, and today he weighs 24 pounds. Develop a plan for dehydration management at home. Include replacement for an episode of diarrhea in 2 hours.

BOX 2. Seven principles of appropriate treatment for children with diarrhea and dehydration

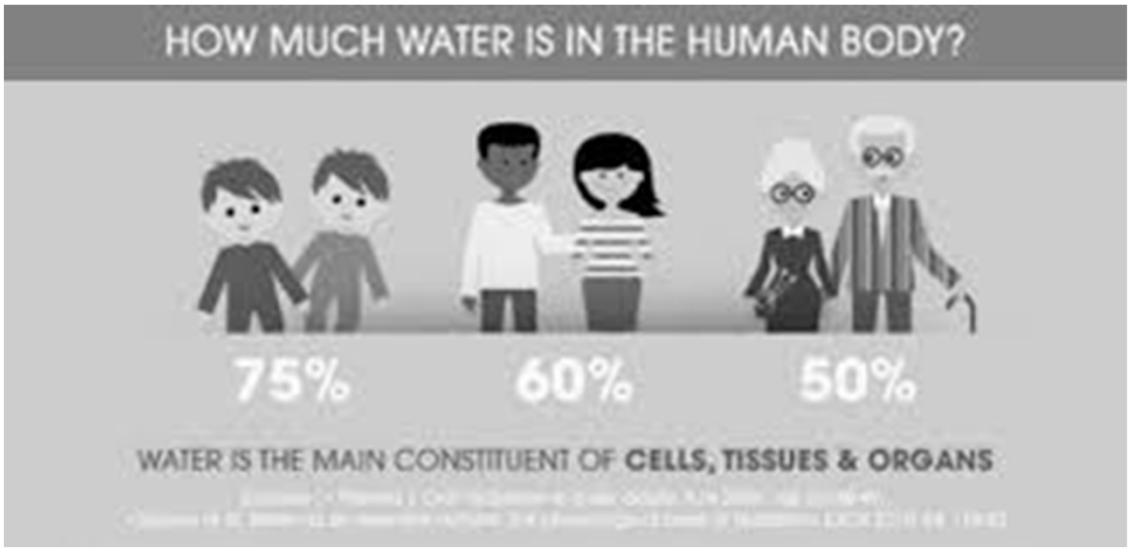
1. Oral rehydration solutions (ORS) should be used for rehydration.
2. Oral rehydration should be performed rapidly (i.e., within 3–4 hours).
3. For rapid realimentation, an age-appropriate, unrestricted diet is recommended as soon as dehydration is corrected.
4. For breastfed infants, nursing should be continued.
5. If formula-fed, diluted formula is not recommended, and special formula usually is not necessary.
6. Additional ORS should be administered for ongoing losses through diarrhea.
7. No unnecessary laboratory tests or medications should be administered.

Source: Adapted from Sandhu BK. Practical guidelines for the management of gastroenteritis in children. J Pediatr Gastroenterol Nutr 2001;33(Suppl 2):S36–9.

https://www.cdc.gov/mmwr/preview/mmwrhtml/rr5216a1.htm

https://www.usgs.gov/special-topic/water-science-school/science/water-you-water-and-human-body?qt-science_center_objects=0#qt-science_center_objects

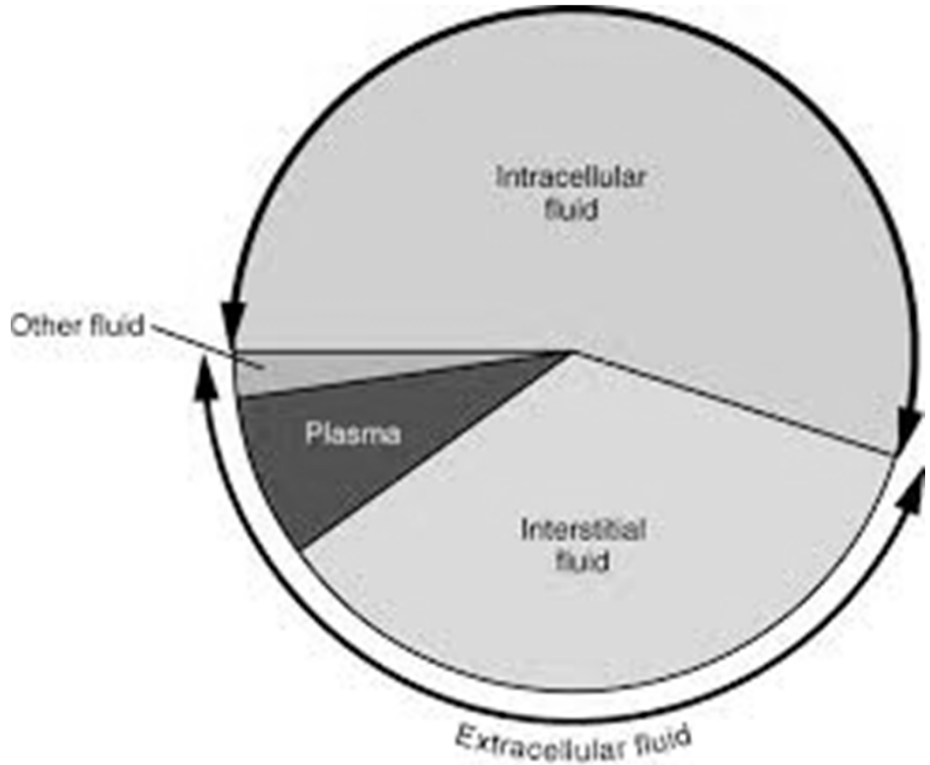
Amount of water changes with age



Lower percentage of body weight in obesity

Amount of water in the human body ...nestle-waters.com

Where the water is



Space	% TBW
Intracellular	67%
Extracellular	33%
Serum/plasma	17%

courses.lumenlearning.com

Sodium and water

- Highly regulated
- Water balance determines serum sodium concentration
- Sodium balance determines volume status

Dehydration vs hypovolemia

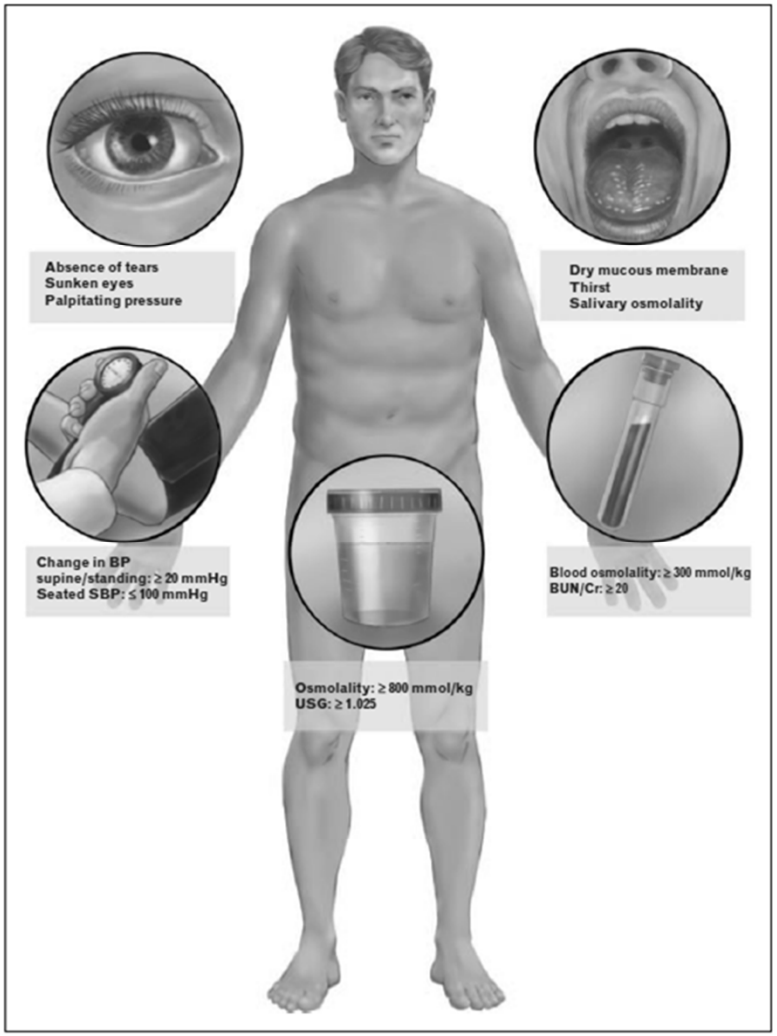
- Terms often used interchangeably
- Dehydration implies loss of water and sodium (electrolytes)
- Hypovolemia means low intravascular volume

Etiology

- Many causes
- Common causes
    - Gastroenteritis
    - Excessive sweating
- If severe and not corrected quickly, tissue hypoperfusion and organ damage

Determining degree of dehydration

- Widespread agreement for treatment but not diagnosis
- Clinical observations—most helpful in young children
    - Skin turgor
    - Mucous membrane moisture
    - Sunken eyes
    - Tear production
- Physical exam measurements
    - Orthostatic blood pressure (dilated LE vasculature post-competition)
    - Heart rate
    - Body weight
- Clinical lab
    - BUN/Scr ratio
    - Hct/Hgb ratio
    - Serum Na, osmolality
    - Urine specific gravity



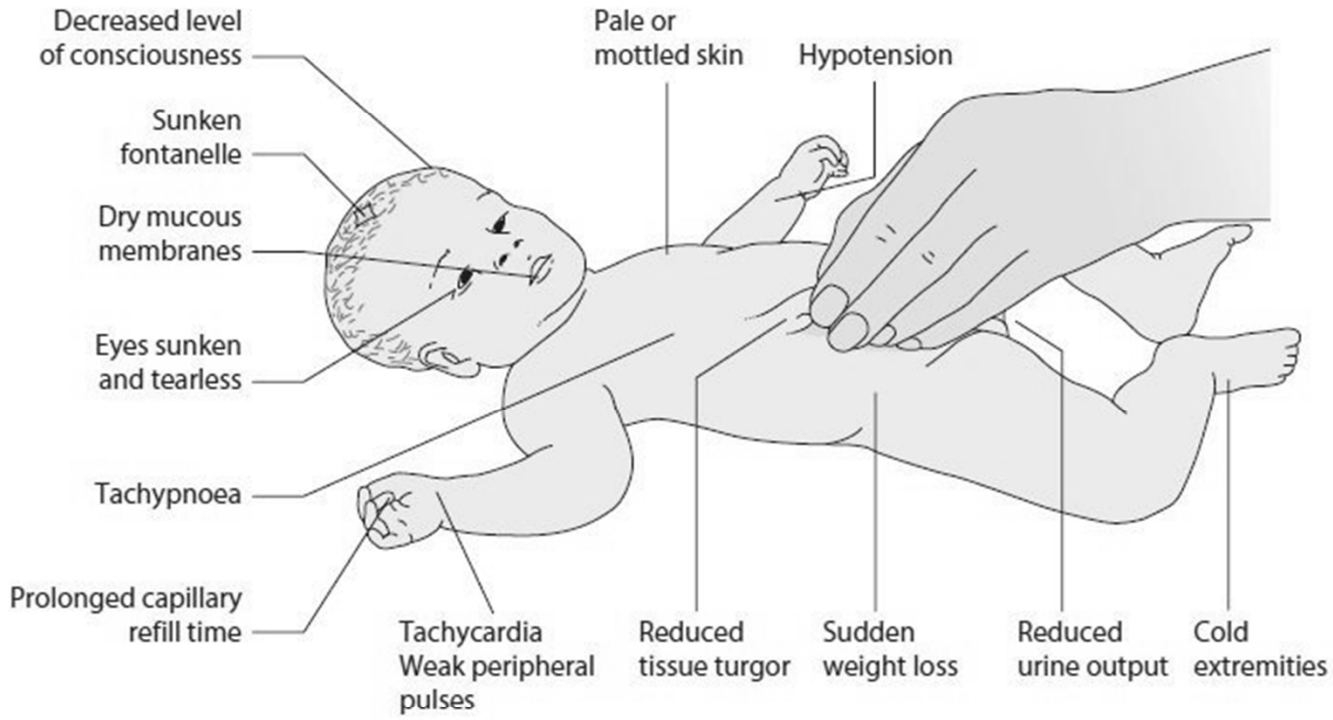
Physical examination and laboratory measurements aid diagnosis when multiple findings exist.

Armstrong LE, Curr Opin Clin Nutr Metab Care 2016

Consider dehydration in older children and adults

- Sweating-loss of up to 1-2 L/hr
- Diuretics

- Signs
  - Thirst (hypernatremia will not occur if individual has access to water)
  - Urine color
  - Respiratory rate
  - Blood pressure, heart rate, weight



Clinical features of shock from dehydration in an infant.

https://www.grepmed.com/images/3863/physicalexam-dehydration-pediatrics-symptoms-infant-shock-signs

Degree of dehydration

- In general, 1kg loss= 1L water
- Consider plasma osmolality (normal 275-290 mosmol/kg)

  Posm = 2 x [Na] + [Glucose]/18 + Blood urea nitrogen/2.8

  (Note that glucose or BUN has little effect on osm when in normal range)

TABLE 1. Symptoms associated with dehydration

Symptom	Minimal or no dehydration (<3% loss of body weight)	Mild to moderate dehydration (3%–9% loss of body weight)	Severe dehydration (>9% loss of body weight)
Mental status	Well; alert	Normal, fatigued or restless, irritable	Apathetic, lethargic, unconscious
Thirst	Drinks normally; might refuse liquids	Thirsty; eager to drink	Drinks poorly; unable to drink
Heart rate	Normal	Normal to increased	Tachycardia, with bradycardia in most severe cases
Quality of pulses	Normal	Normal to decreased	Weak, thready, or impalpable
Breathing	Normal	Normal; fast	Deep
Eyes	Normal	Slightly sunken	Deeply sunken
Tears	Present	Decreased	Absent
Mouth and tongue	Moist	Dry	Parched
Skin fold	Instant recoil	Recoil in <2 seconds	Recoil in >2 seconds
Capillary refill	Normal	Prolonged	Prolonged; minimal
Extremities	Warm	Cool	Cold; mottled; cyanotic
Urine output	Normal to decreased	Decreased	Minimal

Sources: Adapted from Duggan C, Santosham M, Glass RI. The management of acute diarrhea in children: oral rehydration, maintenance, and nutritional therapy. MMWR 1992;41(No. RR-16):1–20; and World Health Organization. The treatment of diarrhoea: a manual for physicians and other senior health workers. Geneva, Switzerland: World Health Organization, 1995. Available at http://www.who.int/child-adolescent-health/New_Publications/CHILD_HEALTH/WHO.CDR.95.3.htm.

Physical findings of volume depletion in infants and children

Finding	Mild (3 to 5%)	Moderate (6 to 9%)	Severe (≥10%)
Pulse	Full, normal rate	Rapid	Rapid and weak **or** absent
Systolic pressure	Normal	Normal to low	Low
Respirations	Normal	Deep, rate may be increased	Deep, tachypnea **or** decreased to absent
Buccal mucosa	Tacky or slightly dry	Dry	Parched
Anterior fontanelle	Normal	Sunken	Markedly sunken
Eyes	Normal	Sunken	Markedly sunken
Skin turgor	Normal	Reduced	Tenting
Skin	Normal	Cool	Cool, mottled, acrocyanosis
Urine output	Normal or mildly reduced	Markedly reduced	Anuria
Systemic signs	Increased thirst	Listlessness, irritability	Grunting, lethargy, coma

UpToDate®

Copyrights apply

Dehydration Treatment

- Initial evaluation
  - Duration of illness
  - Number of vomiting or diarrhea episode
  - Presence of fever
- Mild dehydration managed outpatient
- Moderate dehydration maybe home-maybe inpatient
- Severe dehydration—manage inpatient
- Consider both replacement and maintenance
- Rehydration should be done quickly (over a few hours)

Mild dehydration

- Continue age-appropriate diet
- 1 ml fluid for every gram of output
    - 50-100ml/kg during 2-4 hours to replace deficit
    - Additional ORS for ongoing losses
- If output cannot be measured, 10ml additional fluid /kg for each watery stool or 2ml/kg for each episode of emesis
    - 5ml ORS every 5 minutes if vomiting

Weight	**Replacement for episode of vomiting or diarrhea**
<10kg	60-120 ml
>10kg	120-240ml

Oral rehydration solution

- See https://rehydrate.org/solutions/homemade.htm
  - Consider making and tasting it
  - Caution as recipe errors can cause problems
- Commercially available products
- Products distributed by WHO
  - Available widely in much of the world
- All families should have ORS at home
- Useful to prevent and treat dehydration

Sports drinks

- Hyperosmolar and inappropriate for rehydration
- Inadequate electrolyte concentrations
- Exacerbate diarrheal disease

Mild to moderate dehydration

- Rehydration in ED
    - ORS through NG (shorter ED stays compared to IV)
    - IV rehydration
- Assure hydration progress
- Discharge with patient/parent education on ORS use and continued feeding

Severe dehydration

- Medical emergency requiring IV rehydration
- LR, or NS 20ml/kg until pulse, perfusion, mental status normal
    - 10ml/kg for small, frail or malnourished infants who may not be able to increase cardiac output
    - Multiple short boluses of iv fluid
- Electrolyte panel
    - Correct appropriately
- Change to oral rehydration-maintenance when possible
    - Mental status normal and able to take oral

Prevention of dehydration: Maintenance

- Water required physiologic functions

- <10 kg – 4ml/kg/hr
- >10-20kg – 40ml/hr for first 10 kg and 2ml/kg/hr for each kg over 10kg
- >20-80 kg – 60ml/hr for first 20kg and 1ml/kg/hr for each kg over 20 kg to maximum of 100ml/hour

Severe dehydration –older children & adults

- Adults can have relatively large water losses before apparent on physical exam
- Often replace in LR or NS boluses of 500ml iv, reevaluate and repeat

Prevention of dehydration: Maintenance

- Normal daily water requirements of inactive adult at comfortable temperature is 1.5-2.5 liters
- Na+ 50-250mEq
- K+ 50-150mEq
- Routine maintenance iv fluid
  - D5W + 0.2%NaCl + 20mEq KCL/L at 100ml/hr
    (provides 2.4L, 82 mEq Na+, 48mEq K+ per day)

Anti-diarrheal agents

- Commonly used among children and adults
- Covered in previous lecture

Antiemetics

- Usually unnecessary
- Serotonin antagonists (ondansetron) decrease vomiting and may prevent hospital admission
- Focus on rehydration!

Diet

- Continue diet
  - Breastfed infants continue to nurse on demand
  - Formula-fed infants continue usual formula after rehydration
  - Semi-solid or solid foods as usual
    - Avoid simple sugars (carbonated soft drinks, juice, gelatin desserts) due to osmotic load
  - Withholding food is inappropriate
    - Feeding decreases intestinal permeability, reduces duration of illness, improves nutritional outcomes
  - BRAT diet unnecessary (bananas, rice, applesauce, toast)
  - Complex carbohydrates, meats, yogurt, fruits and vegetables recommended

Hydration for sports

- Goal: euhydration throughout exercise
- Consensus best practices
    1. Begin exercise with euhydration
    2. Prevent excessive hypohydration
    3. Replace remaining losses prior to next exercise

Assessment

- Change in body mass pre- to post- is practical
    - Account for sweat in hair or clothes, urine excreted
- Daily changes using first morning measurements
    - Body mass
    - Thirst
    - Urine color

Exercise structure

- Risk of hypohydration varies with activity, exercise, sport
    - Availability of fluid
    - Environment
    - Intensity
- Consider that a runner with 2L/hr sweat rate runs for 2 hours has same loss as runner with 1L/hr sweat rate who runs for 4 hours

Too much fluid

- Consider the risk of hyperhydration—leads to hyponatremia
- Women at higher risk
    - Lower body weight
    - Excess water ingestion
    - Longer racing times
- 2002 Boston Marathon
    - 13% had hyponatremia
        - Weight gain, 3L intake, fluids every mile, >4 hours, female, low BMI

Hydration for exercise

- Takes planning and practice
- Risk of dehydration is low if competition is less than 45 minutes

How?

- Water
- American College of Sports Medicine recommends carbohydrate intake 30-60gm/hr
    - Increases time to exhaustion
    - Increases time trial
    - Increases submaximal exercise followed by time to exhaustion or time trial
- Combination glucose-fructose and sodium hypo-osmolar drink recommended for prolonged physical activity (>2 hours)