Pediatric Dehydration

I. **Triage History**
   A. History from parents can help rule-out dehydration
   B. Findings correlated with adequate hydration
      1. No decreased oral intake
      2. No decrease in urine output
      3. No history of Vomiting
   C. References
      1. *Porter (2003) Ann Emerg Med 41:196-205*

II. **Signs and symptoms: Minimal or subclinical Dehydration**
   A. Deficit: 1-2% (10-20 ml/kg)
   B. Symptoms and signs
      1. Increased Thirst
      2. Mild Oliguria

III. **Signs and symptoms: Mild Dehydration**
   A. Deficit
      1. Child: 3% deficit (30 ml/kg)
      2. Infant: 5% deficit (50 ml/kg)
   B. Signs and Symptoms
      1. Dry lips
      2. Thick Saliva
      3. Decreased Tears
      4. Anterior Fontanelle flat
      5. Decreased Urine output

IV. **Signs and symptoms: Moderate Dehydration**
   A. Deficit
      1. Child: 6% deficit (60 ml/kg)
      2. Infant: 9% deficit (90 ml/kg)
   B. Signs and symptoms
      1. Eyes sunken
      2. Tears absent
      3. Dry mucus membranes
      4. Sunken Fontanelle
      5. Pulse weak and rapid
      6. Skin turgur decreased
      7. Delayed capillary refill (>2 seconds)
      8. Skin slowly retracts (tenting)
      9. Listless and Irritable
      10. Urine characteristics
         a. Dark color
         b. Oliguria (Urine output <1-2 cc/kg/hour)
         c. Urine Specific Gravity = 1.030
      11. Blood Urea Nitrogen (BUN) increased
      12. Arterial pH <7.30

V. **Signs and symptoms: Severe Dehydration**
   A. Deficit
      1. Child: 10% deficit (100 ml/kg)
      2. Infant: 15% deficit (150 ml/kg)

- B. Signs and symptoms
  1. Limp and cold
  2. Lethargy or coma
  3. Acrocyanosis
  4. Thready pulse
  5. Grunting
  6. Deep and rapid Respiratory Rate
  7. Decreased Blood Pressure
  8. Skin retracts >2 sec
  9. Oliguria or Anuria
  10. Specific Gravity >1.035
  11. Capillary refill >4 seconds
  12. Blood Urea Nitrogen (BUN) markedly increased
  13. Arterial pH <7.10

VI. **Management**

Pediatric Dehydration Management

I. **See Also**
- A. Pediatric Dehydration

II. **Replace Phase 1 Acute Resuscitation**
- A. Give LR OR NS at 10-20 ml/kg IV over 30-60 minutes
- B. May repeat bolus until circulation stable

III. **Calculate 24 hour maintenance requirements**
- A. Formula
  1. First 10 kg: 4 cc/kg/hour (100 cc/kg/24 hours)
  2. Second 10 kg: 2 cc/kg/hour (50 cc/kg/24 hours)
  3. Remainder: 1 cc/kg/hour (20 cc/kg/24 hours)
- B. Example: 35 Kilogram Child
  1. Hourly: 40 cc/h + 20 cc/h + 15 cc/h = 75 cc/hour
  2. Daily: 1000 cc + 500 cc + 300 cc = 1800 cc/day

IV. **Calculate Deficit (See Pediatric Dehydration)**
- A. Mild Dehydration: 4% deficit (40 ml/kg)
- B. Moderate Dehydration: 8% deficit (80 ml/kg)
- C. Severe Dehydration: 12% deficit (120 ml/kg)

V. **Calculate remaining deficit**
- A. Subtract fluid resucitation given in Phase 1

VI. **Calculate Replacement over 24 hours**
- A. First 8 hours: 50% Deficit + Maintenance
- B. Next 16 hours: 50% Deficit + Maintenance

VII. **Determine Serum Sodium Concentration**
- A. Pediatric Hypertonic Dehydration (Serum Sodium > 150)
- B. Pediatric Isotonic Dehydration
- C. Pediatric Hypotonic Dehydration (Serum Sodium < 130)

VIII. **Add Potassium to Intravenous Fluids after patient voids**
- A. Potassium source
  1. Potassium Chloride
  2. Potassium Acetate for Metabolic Acidosis
- B. Potassium dosing
  1. Weight <10 kilograms: 10 meq/liter KCl
  2. Weight >10 Kilograms: 20 meq/liter KCl

Pediatric Hypertonic Dehydration

I. **See Also**
   A. Pediatric Dehydration Management
II. **Definition**
   A. Pediatric Dehydration
   B. Serum Sodium > 150
III. **Example Case**
   A. Weight: 35 kg Child
   B. Dehydration: 10%
   C. Serum Sodium: 158
IV. **Calculate Replacement and Replace Phase 1 Fluids**
   A. Approach as per Pediatric Dehydration Management
   B. Deficit: 3500 cc - 700 cc (Replaced Phase 1)
   C. Replacement
      1. Replacement given over 48-72 hours
      2. Total = 2800cc + 75 cc/h x 48 hours = 6400cc/48 hours
      3. Hourly rate = 133 cc/hour for 48 hours
V. **Choose Saline solution**
   A. Start with D5 1/2 Normal Saline
   B. Monitor Serum Sodium every 2-4 hours
      1. Decrease Serum Sodium 1/2 meq/L/hour (10 meq/L/day)
      2. Do not lower Serum Sodium by >15 meq/L/day
   C. Serum Sodium not correcting
      1. Switch to D5 1/4 Normal Saline
   D. Serum Sodium still not correcting
      1. Calculate Total Body Water Deficit (TBWD)
         a. TBWD = 4 cc/kg x (weight kg) x (Serum Sodium - 145)
         b. TBWD = (4 cc/kg x 35 kg) x (158 - 145) = 1820 cc
      2. Replace Total Body Water Deficit (TBWD)
         a. Replace TBWD with D5W over 48 hours
         b. Total: 1820 cc/48 hours
         c. Hourly: 38 cc/hour D5W
      3. Replace remainder with maintenance fluids
         a. Balance: 133 cc/hour - 38 cc/hour
         b. Hourly: 95 cc/hour D5 1/2 Normal Saline
VI. **Summary: 35 kg Child, hypertonic severe dehydration**
   A. Start: D5 1/2NS with 20 KCl at 133 cc/hour for 48 hours
   B. No Serum Sodium change:
      1. Switch: D5 1/4NS with 20 KCl at 133 cc/h for 48 hours
   C. Still no Serum Sodium change
      1. TBWD Replacement: D5W at 38 cc/h for 48 hours
      2. Maintenance: D5 1/2NS with 20 KCl at 95 cc/h for 48h

Pediatric Isotonic Dehydration

I. **See Also**
   A. Pediatric Dehydration Management
II. **Definition**
   A. Pediatric Dehydration
   B. Serum Sodium: 130 - 150
III. **Example Case**
   A. Weight: 35 kg Child
   B. Dehydration: 10%
   C. Serum Sodium: 140 (Normal)
IV. **Calculate Maintenance Fluid Requirements**
   A. See Pediatric Dehydration Management
   B. Hourly = 75 cc/hour for 35 kg child
      1. First 10 kg: (4 cc/kg/hour x 10 kg)
      2. Next 10 kg: (2 cc/kg/hour x 10 kg)
      3. Remaining 15 kg: (1 cc/kg/hour x 15 kg)
   C. Daily: 1800 cc/day
V. **Calculate Remaining Deficit to be replaced**
   A. See Pediatric Dehydration Management
   B. Estimate level of dehydration
      1. Mild Dehydration (3%) = 30 ml/kg
      2. Severe Dehydration (12%) = 120 ml/kg
   C. Subtract Phase 1 Resuscitation already replaced
   D. Calculation
      1. Phase 1: 20 cc/kg/bolus x 35 kg x 1 bolus = 700 cc
      2. Deficit (10%): 100 ml/kg x 35 kg = 3500 cc
      3. Remaining Deficit: 3500 cc - 700 cc = 2800 cc
VI. **Divide 2800 cc Remaining Deficit over 24 hours**
   A. First 8 hours: 75 cc/h + 1400cc/8h = 250 cc/hour
   B. Next 16 hours: 75 cc/h + 1400cc/16h = 163 cc/hour
VII. **Saline guide (Rough):**
   A. Weight <28 kg: D5 1/4NS (38 meq/L)
   B. Weight >28 kg: D5 1/2NS (77 meq/L)
VIII. **Summary: 35 kg Child with isotonic dehydration**
   A. First 8 hours: D5 1/2NS with 20 KCl at 250 cc/hour
   B. Next 16 hours: D5 1/2NS with 20 KCl at 163 cc/hour

Pediatric Hypotonic Dehydration

I. **See Also**
   A. Pediatric Dehydration Management
II. **Definition**
   A. Pediatric Dehydration
   B. Serum Sodium < 130
III. **Example Case**
   A. Weight: 35 kg Child
   B. Dehydration: 10%
   C. Serum Sodium: 120
IV. **Calculate Replacement and Replace Phase 1 Fluids**
   A. Approach as per Pediatric Dehydration Management
   B. Deficit: 3500 - 700cc (Replaced Phase 1)
   C. Replacement
      1. First 8 hours
         a. Total: 1400 + (75 cc/hour for 8 hours)
         b. Hourly: 250 cc/hour for 8 hours (2 Liters over 8h)
      2. Next 16 hours
         a. Total: 1400 + (75 cc/hour for 16 hours)
         b. Hourly: 163 cc/hour for 16 hours (2.6L over 16h)
V. **Calculate Sodium Deficit and Sodium Requirement**
   A. Calculate Deficit
      1. Formula: 0.6 x (weight kg) x (135 - Serum Sodium)
      2. Example: (0.6 x 35 kilograms) x (135-120) = 315 meq
   B. Add Maintenance
      1. Formula: 3 meq/kg/day x (weight kg)
      2. Example: 35 kg x 3 meq = 105 meq Sodium/24 hours
   C. Subtract Replacement given Phase 1
      1. Phase 1 Fluid bolus
         a. Formula: 1000 cc contains 150 meq Sodium
         b. Example: 700 cc contains 105 meq Sodium
      2. Remaining Sodium Required: 315 - 105 = 210 meq
VI. **Choose Appropriate solution to replace sodium deficit**
   A. Available solutions
      1. 1/4 Normal Saline contains 38 meq/L Sodium
      2. 1/3 Normal Saline contains 51 meq/L Sodium
      3. 1/2 Normal Saline contains 77 meq/L Sodium
      4. Normal Saline contains 154 meq/L Sodium
   B. Example
      1. First 8 hours: Replace half sodium deficit
         a. Sodium 157 meq in 2 Liters (78 meq/L)
         b. Fluid: 1/2 Normal Saline (77 meq/L)
      2. Next 16 hours: Replace half sodium deficit
         a. Sodium 157 meq in 2.6 Liters (60 meq/L)
         b. Fluid: 1/2 Normal Saline (77 meq/L)
VII. **Example Summary: 35 kg Child with hypotonic dehydration**
   A. First 8 hours: D5 1/2NS with 20 KCl at 250 cc/hours

B. Next 16 hours: D5 1/2NS with 20 KCl at 163 cc/hours

VIII. **Monitoring**
   A. Monitor Serum Sodium every 2-4 hours
   B. Raise Serum Sodium <= 2 meq/L/hours
IX. **Special Circumstance: Hyponatremic Seizure**
   A. Background
      1. Serum Sodium raised 5 meq/L with 6 ml/kg of 3% NaCl
   B. Protocol
      1. Give 3% NaCl (0.5 meq NaCl/ml) IV over 1 hour
      2. Give 3% NaCl at 6 ml/kg/hour until Seizure stops

Oral Rehydration Solution

Pedialyte

Homemade cereal based ORS

WHO-ORS

I. **WHO-ORS**
   A. Instructions
      1. Dissolve WHO packet in 1 Liter Water
   B. Ingredients of WHO packet
      1. Sodium Chloride 3.5 grams (90 meq/L Sodium)
      2. Potassium Chloride 1.5 grams (20 meq/L Potassium)
      3. Glucose 20 grams (2% Carbohydrate)
      4. Sodium Bicarbonate 2.5 grams (30 meq/L bicarbonate)
         a. Alternative: Trisodium Citrate 2.9 grams
II. **Commercial ORS**
   A. Pedialyte
   B. Rehydrate
   C. Infalyte
III. **Homemade cereal based ORS**
   A. Instructions
      1. Better nutrient absorption
      2. Easy & safe to prepare
      3. Solution should be thick, but pourable and drinkable
   B. Ingredients
      1. 1/2 cup of dry, precooked baby rice cereal
      2. 2 cups water
      3. 1/4 teaspoon salt

Total Body Sodium Deficit

Total Body Water
Free Water Deficit
Total Body Water Excess

I. **Indications**
   A. Hypoosmolar Hyponatremia
II. **Calculation: Total Body Water (TBW)**
   A. Men
      1. TBW = 0.6 x (kilograms Lean Body Mass)
   B. Women
      1. TBW = 0.5 x (kilograms Lean Body Mass)
III. **Calculations based on total body water (TBW)**
   A. Total Body Water Excess (Hyponatremia)
      1. Normal TBW = TBW x (Serum Sodium / 140)
      2. Excess TBW = TBW - Normal TBW
   B. Free Water Deficit (Hypernatremia)
      1. FWD = TBW x (Serum Sodium - 140) / 140
IV. **Calculations: Total Body Sodium Deficit**
   A. Sodium deficit = TBW x (140 - Serum Sodium)

Urine Specific Gravity

I. **Normal**
   A. Specific Gravity: 1.005-1.030
II. **Increased**
   A. Dehydration
   B. Fever
   C. Vomiting
   D. Diarrhea
   E. Diabetes Mellitus and other causes of Glycosuria
   F. Congestive Heart Failure
   G. Syndrome Inappropriate ADH Secretion (SIADH)
   H. Adrenal Insufficiency
   I. X-Ray contrast
III. **Decreased**
   A. Diabetes Insipidus
   B. Excessive hydration
   C. Glomerulonephritis
   D. Pyelonephritis
   E. Diuretics
   F. Adrenal Insufficiency
   G. Aldosteronism
   H. Renal insufficiency
IV. **Falsely decreased specific gravity**
   A. Alkaline urine
V. **Falsely increased specific gravity**
   A. Intravenous dextran or radiopague dye
   B. Proteinuria

Blood Urea Nitrogen
BUN

I. **Pathophysiology**
    A. Increases by 10-20 mg/dl/day if Renal Function absent
    B. Serum Creatinine is a better measure of Renal Function
        1. BUN is Protein dependent
            a. High protein diet
            b. Catabolism
        2. BUN is reabsorbed at renal tubules
            a. Prerenal Failure
                i. Dehydration
                ii. Congestive Heart Failure
            b. Postrenal Failure
                i. Obstructive Uropathy

II. **Increased BUN**
    A. Medications
        1. Aminoglycosides
        2. Diuretics
        3. Lithium
        4. Corticosteroids
    B. Dehydration
    C. Gastrointestinal Bleeding
    D. Decreased Renal blood flow
        1. Shock
        2. Congestive Heart Failure
        3. Myocardial Infarction
    E. Renal disease
        1. Glomerulonephritis
        2. Pyelonephritis
        3. Diabetic Nephropathy
    F. Urinary Tract Obstruction

III. **Decreased BUN**
    A. Liver disease
    B. Poor nutrition
    C. Overhydration
    D. Third trimester of pregnancy

Fontanelle

I. **See Also**
   A. Newborn Head and Neck Exam
   B. Newborn Neurologic Exam
   C. Head Circumference
   D. Craniosynostosis
II. **Definitions**
   A. Fontanelle size measurement
      1. Obtain anteroposterior diameter (AP)
      2. Obtain transverse diameter (T)
      3. Size = (AP + T) / 2
   B. Anterior fontanelle
      1. Junction of coronal Suture and sagittal Suture
      2. Mean newborn size: 2.1 cm (larger in black infants)
      3. Often enlarges in first few months of life
      4. Closes between 4 to 26 months (median 13.8 months)
      5. Closes by 3 months in 1% of infants
      6. Closes by 24 months in 96% of infants
   C. Posterior fontanelle
      1. Junction of lambdoidal Suture and sagittal Suture
      2. Mean newborn size: 0.5 to 0.7 cm
      3. Closes by 2 months
III. **Exam: Anterior fontanelle**
   A. Palpate fontanelle with infant sitting upright quietly
      1. Fontanelle should feel soft
      2. Fontanelle should not be sunken or bulging
   B. Other examination features
      1. Auscultate for bruit (suggests AV malformation)
      2. Macewen's Sign (percussion of fontanelle)
         a. Dull cracked-pot sound suggests increased ICP
IV. **Causes of abnormal anterior fontanelle**
   A. Bulging fontanelle causes
      1. Crying, coughing or Vomiting
      2. Increased Intracranial Pressure
         a. Hydrocephalus
         b. Meningitis or Encephalitis
         c. Hypoxic-ischemic injury
         d. Trauma
         e. Intracranial Hemorrhage
         f. Dermoid tumors of the scalp
   B. Sunken fontanelle causes
      1. Decreased Intracranial Pressure (dehydration)
   C. Large fontanelle or delayed closure
      1. Congenital Hypothyroidism
      2. Trisomy 21 (Down Syndrome)
      3. Rickets
      4. Achondroplasia

5. Increased Intracranial Pressure

D. Small fontanelle or early closure
   1. Early closure may be normal
   2. Always evaluate for Microcephaly
   3. See Craniosynostosis