Objectives

• Following this session, participant should be able to:
   Calculate maintenance fluid and electrolyte requirements
   Assess and estimate % dehydration
   Calculate administration of IV fluid replenishment in isotonic and hypertonic dehydration
   Explain rationale for the treatment of hypertonic dehydration

Fluid and Electrolytes in Pediatrics

• Basic requirements for water are based upon caloric expenditure and the need to excrete an average solute load without either concentrating or diluting the urine
• This assumes a dietary intake of protein of approximately 2 grams/kg/day
• The original work was done by Holliday & Segar, published in 1955
Maintenance Fluid Requirements

- Weight
  - 1 = 10 kg
  - 10 = 20 kg
  - 20 = 80 kg

- Water Requirement
  - 100 ml/kg/24 hrs
  - 50 ml/kg/24 hrs
  - 20 ml/kg/24 hrs

- Please note that if you use 4 cc/kg/hr for the first 10 kg – you get 40 cc/hr for the 1st 10 kg and this gives you 960 cc/24 hrs: essentially the same as 1000 cc/24 hrs
- For 10-20 kgs if you use 2 cc/hr then for 24 hrs you get 480 cc instead of the 500 that you get with the previous system.
- For weights > 20 kg, use 60 cc/hr + 1cc/kg/hr and again you get almost the same answer as previously
**Maintenance Electrolyte Requirements**

- Easiest way to remember is 1...2...3
  - 1 meq/kg/day of Potassium
  - 2 meq/kg/day of Sodium
  - 3 meq/kg/day of Chloride

**Maintenance Fluid & Electrolytes For 10 kg Infant**

- Requires
  - 100 ml/kg/24hrs X 10 kg = 1000 ml water
  - K = 1 meq/kg/24 hrs X 10 kg = 10 meq K
  - Na = 2 meq/kg/24 hrs X 10 kg = 20 meq Na
  - Cl = 3 meq/kg/24 hrs X 10 kg = 30 meq Cl

This approximates 0.2% NS plus 10 meq KCl/liter over 24 hrs

**Maintenance Calculations For a 40 kg Child**

- Water Requirement
  - 100 ml/kg/24hrs X 10 kg = 1000 ml water
  - PLUS
  - 50 ml/kg/24 hrs X 10 kg = 500 ml water
    - PLUS
  - 20 ml/kg/24 hrs X 20 kg = 400 ml water

TOTAL WATER REQUIREMENT = 1900 ml
### Maintenance Calculations For a 40kg Child

- **K** = 1 meq/kg/24hrs X 40 kg = 40 meq
- **Na** = 2 meq/kg/24hrs X 40 kg = 80 meq
- **Cl** = 3 meq/kg/24hrs X 40 kg = 120 meq
- Thus, 2 liters of 0.2% NS plus 20 meq KCl/liter will approximate the requirements
- 0.2% NaCl provides 34 meq/liter of Na
- Addition of 5% Dextrose recommended

### Approach to Fluid Calculations

- Three questions always need to be asked:
  - Is this patient behind on fluids; and, if so, what is the degree(%) of dehydration?
  - What are the maintenance fluid requirements?
  - What abnormal losses of fluid and electrolytes are likely to continue?

### Clinical Signs of Dehydration

- **% Dehydration**
  - 3-5%
  - 6-10%
  - 10-15%
  - > 15%
- **Skin Turgor**
  - Normal/ sl Decrease
  - Decreased
  - Markedly Decreased
  - Cold/ Dry

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Clinical Signs of Dehydration

- % Dehydration
  - 3-5%
  - 6-10%
  - 10-15%
  - > 15%

- Mucous Membranes
  - Normal/dry
  - Dry
  - Parched (Cotton)
  - Parched

- Eye Turgor
  - Normal/Decreased
  - Decreased
  - Sunken/Decreased

- Vital Signs
  - Normal
  - Pulse up/Resp. up
  - BP normal
  - Pulse Up, Resp Up
  - BP orthostatic fall
  - Pulse weak, BP up or down, Resp. up
Clinical Signs of Dehydration

- **% Dehydration**
  - < 3-5%
  - 6-10%
  - 10-15%
  - > 15%

- **CNS Signs**
  - normal consciousness
  - irritable
  - semicomatose responsive to pain
  - comatose usually unresponsive to needlesticks

Fluid & Electrolytes Case # 1

- A one-year-old boy is brought to you with vomiting and diarrhea for the past 4 days. Initially, mother gave Pedialyte q 3-4 hrs., but for the last 24 hrs. the baby has been vomiting all feeds. Mother doesn’t know when he last urinated.

Physical Exam

- This was a sleepy infant who responded disinterestedly only when blood was drawn.
- Temp = 38° C; Pulse = 142/ min,
  Respiratory rate = 32/min, Wt = 10 kg
- Skin turgor was decreased with obvious tenting. Nail beds were pink with prompt capillary refill. Orbits were “squishy”.

Fluid & Electrolytes Case # 1

1) Please estimate the degree of dehydration
a) 3.5%
b) 7%
c) 11%
d) 15%

Fluid & Electrolytes Case # 1

2) Calculate fluid requirements for the next 24 hrs., assuming his diarrhea persists and he loses an additional 400cc of fluid over the next 24 hrs.

a) 1200 cc
b) 1600 cc
c) 2100 cc
d) 2400 cc

Fluid & Electrolytes Case # 1

Fluid Requirements

• Deficit: 10 kg X 10% = 1 kg = 1000 cc*
• Maint: 10 kg X 100 cc/kg = 1000 cc
• Losses ongoing (an estimate) = 400 cc
• Total = 2400 cc

*1 kg = 1000 cc of fluid
Fluid & Electrolytes Case # 1

3) Which of the following would represent the best choice for initial fluid orders?

a) D5W/0.2% NS to run at 100 cc/hr. Add 20 meq/liter KCl after urination
b) D5W/0.45% NS to run at 150 cc/hr for the next 8 hrs. Add 20 meq/liter KCl after urination
c) D5W/0.45% NS to run at 150 cc/hr for the next 8 hrs
d) 0.9% NS to run at 150 cc/hr for the next 8 hrs

Fluid & Electrolytes Case # 1

- One other option that was not given to you.
- At 10% dehydration, there is usually a degree of intravascular volume contraction which needs to be restored. Therefore may give a bolus of 0.9% NS at 20cc/kg as quickly as possible to restore vascular volume. May be repeated prn. Then begin Rx as before.

Fluid & Electrolytes Case # 1

4) Which of the following is most helpful in assessing the adequacy of therapy?

a) Electrolytes return to normal
b) Patient’s level of alertness, skin turgor, pulse rate and BUN.
c) Presence of diarrhea, resumption of urine output and decrease in irritability
d) Normal creatinine clearance, WBC decreasing to normal and fall in Hgb levels which were increased secondary to hemoconcentration
Fluid & Electrolytes Case # 2

An 8 month old infant is brought to the ER with a history of fever, diarrhea for 96 hrs, and vomiting for the past 24 hrs. Beginning 4 days ago, the baby developed fever and profuse diarrhea. He switched to Pedialyte but was getting no nutrition so was given boiled skim milk for the next 48 hrs. Yesterday he became irritable and began vomiting all feedings.

Physical exam reveals a very irritable infant who has a high pitched scream when disturbed. Weight = 10 kg., temperature is 38 degrees C, pulse is 130/min, BP is 80/45 mmHg. His fontanel is flat but not sunken, eyeballs feel normal and skin has an odd “silly putty” or doughy feel to it.

1) Please estimate the degree of dehydration
   a) 3.5%
   b) 7%
   c) 11%
   d) 15%
2) What would you predict the Serum Na to be in this patient at presentation?
   a) 125 meq/l
   b) 135 meq/l
   c) 145 meq/l
   d) 155 meq/l

The following electrolytes were obtained:
Na = 156 meq/l   BUN = 36 mg/dl
K = 5.4 meq/l    Creat = 1.2 mg/dl
Cl = 123 meq/l   Glucose = 126 mg/dl
HCO₃⁻ = 17 meq/l

Calculate the serum osmolality.

Formula for calculating the serum osmolality
2 X [Na] + 10 + [BUN]/3 + [Glucose]/18

2 X [156] + 10 + [36]/3 + [126]/18 = 331 mosm/l
Fluid & Electrolytes Case # 2

- Hypertonic Dehydration
  - This occurs when a child (usually an infant) has losses of hypotonic fluid and is given hypertonic fluid as replacement therapy. In most cases, you can elicit a history of added Na intake e.g. Pedialyte with added salt or boiled skim milk. Boiling removes free water thereby concentrating solutes including Na.

3) Calculate the fluid requirements for the next 24 hrs. assuming another 400 cc of diarrhea.
   a) 2000 cc
   b) 2400 cc
   c) 3000 cc
   d) 3500 cc

4) What is the optimal fluid regimen?
   a) D_{5}W/0.45\%NS to run at 150 cc/hr for 8 hrs and 100 cc/hr for the next 16 hrs. Add 20 meq KCl/l after patient urinates
   b) D_{5}W/ 0.9\% NS plus 20 meq KCl to run at 150 cc/hr X 8hrs. and then 75 cc/ hr thereafter
   c) D_{5}W/0.2\% NS plus 20 meq/l of KCl to run at 70 cc/hour for 48 hrs.
   d) Run fluid as outlined in option b) and introduce ad lib po feeds at 24 hrs.
After the first 18 hrs. of therapy, the following electrolytes were obtained:

- Na = 152 meq/l
- BUN = 27 mg/dl
- K = 5.4 meq/l
- Cr = 0.8 mg/dl
- Cl = 115 meq/l
- Glucose = 378 mg/dl
- CO₂ = 22 meq/l
5) Your next step in Rx should be:
   a) Give regular insulin 1 unit /kg SQ
   b) Give 0.1 unit/kg IV q 1 hr until blood sugar is < 200 mg/dl
   c) Remove dextrose from IV fluids
   d) Continue current Rx and give insulin only if Blood Sugar > 500 mg/dl

6) After 30 hrs of treatment electrolytes are obtained and show:
   Na    = 148 meq/l  BUN    = 23  mg/dl
   K     =  5.4  meq/l  Cr.    = 0.7 mg/dl
   Cl    = 112  meq/l  Glucose = 150 mg/dl
   CO₂   = 25   meq/l

6) Fifteen minutes later the patient develops a seizure. The most likely etiology is:
   a) Hypocalcemia
   b) Hypoglycemia
   c) Pyridoxine deficiency
   d) Intracranial hemorrhage
Calculation of Free Water Deficit

• How would you calculate the free water deficit in the above patient?
• Weight is 10 kg, [Na] = 156 meq/l
• Assume that the total rise in serum [Na] is due to water loss. Then # of Na ions is constant, only volume of water will change.
• Remember the Volume of distribution of Na is 0.6 x the Body weight

Then, 0.6 x 10 kg = 6 kg or 6 liters of H2O
• # of molecule of Na = 6 liters x 156 meq/l.
• That # will remain constant but the concentration of [Na] will change.
• 6 liters x 156 meq/liter = V_{dist} x 140 meq/l
  \[ \text{where } V_{dist} \text{ is the total volume of water that would result in the [Na] of 140 meq/l} \]

Free water deficit = V_{dist} - 6 liters.
• Hence, V_{dist} = 6 x 156/140 (answer in liters)
• Or 6.68 l – 6 liter = 0.68 liters or 680 ml is the amount of water needed to lower the concentration to 140 meq/l.
• 680 ml is the Free water deficit.
Fluid & Electrolytes Case # 3

* 10 y/o MR white female well until 4 days prior to admission for flu and cold symptoms. Treated with ASA. Oral intake of fluids well maintained until 2 days prior to admission, decreased significantly, and subsequently refused fluids. One day prior to admission, intake was poor, developed green, watery stools. 12° prior to admission, T105° with rash on face, trunk and upper extremities. Patient did not void for 2 days.

Fluid & Electrolytes Case # 3

* PE revealed semi-comatose child with generalized rash. Wt: 44 kg (S.A. 1.15 m²), BP: 70/50 supine and 50/? Sitting, P: 200/min, resp 32/min. Mucous membranes parched and peripheral extremities cold and moderately cyanotic. She had whitish tonsillar exudate and a beefy-red tongue.

Fluid & Electrolytes Case # 3

1) Estimate degree of dehydration
   A) 5%
   B) 8%
   C) 10%
   D) 15%
Fluid & Electrolytes Case # 3

2) What would your fluid therapy be:
   A) D, W/0.45% NS to run at 490cc/hour for 8 hours
   B) D, W/0.45% NS plus 20 meq/l of KC1 to run at 490 cc/hour
   C) 0.9% NS, 900 cc to run in over 30 minutes followed by D, W/0.45% NS to run at 500 cc/hr. Add 20 meq/KC1/liter when patient has urinated x2
   D) 0.9% NS, 900 cc to run over 20 minutes followed by D, W/0.45% NS plus 20 meq K1 to run at 500 cc/hr

Fluid & Electrolytes Case # 3

* Fluid Calculations
  - Deficit (0.15 X 44 X 1000 cc/kg) = 6600 cc
  - Maintenance 1500 cc + (20cc/kg x 24 kg) = 1980 cc
  - Ongoing losses - 0
  - 24 hour fluid requirements = 1980 + 6600 = 8580 cc
  - In most cases, will calculate the total fluids for one day. Give 1/2 of total in the 1st 8 hours.
  - If intravascular volume is depleted, give 20 cc/kg 0.9% NS over 20 min.

Fluid & Electrolytes Case # 3

* You have begun therapy and you obtain the following lab results 30 minutes later:
  Na = 145 meq/l  BUN = 96 mg/dl
  K = 3.3 meq/l  Creat = 6.7 mg/dl
  Cl = 100 meq/l  Hgb = 15.8 mg/dl
  HCO3 = 10 meq/l  Hct = 50%
3) Your next step is to:
   A) Decrease rate of fluid administration to insensible loss, remove KCl from IV fluids and give 1 meq/kg of sodium bicarbonate
   B) Obtain a urinalysis, urine for sodium and creatinine
   C) Decrease IV fluids rate to 2/3 maintenance and correct acidosis with a solution of D$_5$W/0.2% NS plus 50 meq/liter of sodium bicarbonate
   D) Obtain a renal ultrasound, urine culture and continue current IV fluid administration

Fluid & Electrolytes Case # 3

* Urinalysis shows
  * Spec Grav = 1.027
  * Protein = 1+
  * Ketones = 3+
  * pH = 5.0
  * Urine Na = 4 meq/dl
  * Urine Creat = 450 mg/dl

4) The data are more consistent with:
   A) Acute dehydration
   B) Acute renal failure
   C) Glomerulonephritis
   D) Chronic renal failure
Fluid & Electrolytes Case # 3

* Fractional Excretion of Na+
  * \( FE_{Na} = \frac{Ur_{Na} \times P_{Cr} \times Cr_{Na}}{Ur_{Cr} \times P_{Na} \times Na_{Cr}} \times 100 \)
  * \( = \frac{(4 \text{ meq/l} \times 6.7 \text{ mg/dl} / 450 \text{ mg/dl})}{145 \text{ meq/l}} \times (0.04) \times 100 \)
  * \( = 0.04\% \)
  * \( FE_{Na} \) of <1% is indicative of Dehydration
  * \( FE_{Na} \) of >1% is indicative of Acute Renal Insufficiency

Answer Key

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