Fluids and Electrolytes

General Principles

Remember that children --

- have a larger interstitial volume
- are more susceptible to increased fluid losses
- have a larger surface area
- have a higher turnover of fluid especially ECF

Maintenance Fluids and Electrolyte Requirements

- Maintenance fluids
  - Used in a child who cannot be fed enterally
  - Most commonly necessary in preoperative and postoperative patients
- Replacement fluids
  - Continued excessive losses
- Deficit replacement
  - dehydration

- Goals of Maintenance Fluids
  - Prevent dehydration
  - Prevent electrolyte disorders
  - Prevent ketosis
  - Prevent protein degration

Daily Water Losses

- all losses must be replaced for homeostasis
- types of losses:
  - sensible
  - insensible

Maintenance Fluid Requirements

- maintenance fluids
  - amount of fluid the body needs for replacement of usual daily losses
- methods of computation
  - Holliday-Segar Method
  - Body Surface Area Method

Holliday-Segar Method

- total maintenance water requirement is directly related to caloric expenditure
- equal to 1 ml/cal expended per day
- not suitable for:
  - neonates < 14 days old
  - conditions associated with abnormal losses

Weight	Daily Requirements
0-10 kg	100 ml/kg
11-20 kg	1000 ml + 50 ml/kg for each kg > 10 kg
> 20 kg	1500 ml + 20 ml/kg for each kg > 20 kg

Body Surface Area Method

- based on the assumption that caloric expenditure is proportional to surface area
- not suitable for < 1 year or < 10 kg

	Requirements
Water	1500 ml/m2/day
Na+	30-50 meq/m2/day
K+	20-40 meq/m2/day

Maintenance Fluid Requirements

- Case 1

  Anna is a 5/F weighing 18 kg who was placed on NPO. She is for elective surgery in the morning.

  Maintenance fluid requirement?

  TFI?

Maintenance Fluid Requirements

- Case 2

  Ben is a 16/M with possible CNS Leukemia, placed on NPO for Cranial CT. He weighs 116 kg and has a height of 179 cm.

  BSA?

  Maintenance fluid requirement?

Factors Modifying Fluid Requirements

- Additional Fluids Needed

fever	12% for each ºC > 37.5ºC
sustained hyperventilation or excessive muscular activity	25-50%
hypermetabolic states	25-75% for burns: 2% increase per 1% BSA with burns
diarrhea and vomiting	volume per volume
sweating	10-25%
room temperature > 31ºC	30% per ºC rise > 31ºC
newborn under radiant warmer or phototherapy	25%

Factors Modifying Fluid Requirements

- Less Fluids Needed

hypothermia	12% per ºC fall below 37.5ºC
very high humidity	30%
humidified inspired air	25%
oliguria or anuria	individualized
sedated or paralyzed	40%

Adjustments in Maintenance Water

	Causes if Increased Water needs	Causes of Decreased Water needs
Skin	Radiant warmer Phototherapy Fever Sweat Burns	Incubator (premature infants)
Lungs	Tachypnea Tracheostomy	Humidified ventilator
GIT	Diarrhea Emesis NGt	
Renal	Polyuria	Oliguria/anuria
Miscellaneous	Surgical drain Third spaces	hypothyroidism

Factors Modifying Fluid Requirements

- Case 3

  Carla is a 2/F weighing 12 kg intubated for pneumonia, currently on continuous ambu-bagging with an RR of 50. She has a fever of 38.5ºC.

  Factors to consider in determining maintenance fluids?

  Maintenance fluid requirement?

Daily Electrolyte Requirements

- urine is the major source of electrolyte losses in children
- Na+ and K+ are also lost through the skin and sweat
- no electrolyte loss occurs during ventilation

Electrolyte	Daily Requirement (meq/kg/day)
Na+	2.5-3.0
K+	2.0-2.5

Daily Electrolyte Requirements

- Case 4

  Donna is a 6 mos/F weighing 7 kg who came in for seizures. Currently under observation, she has been placed on NPO. She has a fever of 39ºC.

  Maintenance fluid requirement?

  Maintenance Na+ and K+?

  Which IVF to use?

IVF	Na+ (meq/L)	K+ (meq/L)	Cl- (meq/L)	HCO3- (meq/L)	Mg++ (mg/dL)	Ca++ (mg/dL)
pLR	130	4	109	28 (lactate)	-	3
pNSS	154	-	154	-	-	-
D5 0.3NaCl	51	-	51	-	-	-
D5IMB	25	20	22	-	3	-
D5NR	140	5	98	27 (acetate)	-	-
D5NM	40	13	40	16 (acetate)	3	-

Daily Electrolyte Requirements

- Case 5

Jon is a 4/M admitted for status epilepticus. He later develops cerebral edema with signs of increased ICP. You decide to start Mannitol.

Maintenance fluid requirement?

Maintenance Na+ and K+?

Which IVF to use?

Write down your IVF orders.

Fluids in Dehydration

Dehydration

- most common cause in children is diarrhea
- types of dehydration:
  - isotonic
  - hypotonic (hyponatremic)
  - hypertonic (hypernatremic)

Correction of Dehydration

- assess severity of dehydration

  (Clinical Assessment of Severity of Dehydration – AAP)

- determine the fluid deficit

Severity of Dehydration	Infant	Child (>10 kg)
mild	50 cc/kg	30 cc/kg
moderate	100 cc/kg	60 cc/kg
severe	150 cc/kg	90 cc/kg

Correction of Dehydration

- determine the maintenance fluid requirement
- give the ½ of the fluid deficit over the 1st 8 hours then ½ over the next 16 hours
- re-assess hydration status periodically
- for moderate to severe dehydration, check serum electrolytes

Correction of Dehydration

- Case 6

  Fanny is a 5 mos/F weighing 6 kg noted to have episodes of vomiting. On admission she was irritable, with a sunken anterior fontanel and dry mucous membranes. Extremities are slightly cool but with full pulses and CRT of 2 secs.

  Severity of dehydration and fluid deficit?

  Maintenance fluid requirement?

  Write down your IVF orders for correction of dehydration.

WHO Dehydration Protocol

	No dehydration	Some dehydration	Severe dehydration
Condition	Well, alert	Restless, irritable	Lethargic or unconscious
Eyes	Normal	Sunken	Sunken
Thirst	Drinks normally, not thirsty	Thirsty, drinks eagerly	Drinks poorly, or not able to drink
Skin pinch	Goes back quickly	Goes back slowly	Goes back very slowly
Treatment	Plan A	Plan B	Plan C
Fluid deficit	< 5% of body wt or < 50 ml/kg body wt	5-10% of body wt or 50-100 ml/kg of body wt	> 10% of body wt or > 100 ml/kg of body wt

Plan A

- ORS
- Give as much fluid as the child wants until diarrhea stops
- Children < 2 years of age : 50-100 ml of fluid
- Children 2 years - 10 years : 100-200 ml
- Older children and adults : As much as they want

Plan B

- Amount of ORS required (in ml) = multiplying the patient's weight in kg by 75
- Except for breast milk, food should not be given during the initial 4 hour rehydration period. However children continued on treatment Plan B longer than 4 hours should be given some food every 3-4 hours as in Plan A.
- After 4 hours, reassess the child. Children who continue to have some dehydration even after 4 hours should receive ORS by nasogastric tube or RL intravenously (75 ml/kg in 4 hours).

Plan C

- Give pLR

Age	First give 30 ml/kg n	Then give 70 ml/kg in
Infants	1 hour *	5 hours
Older children	30 min *	2½ hours

Other Stuff

Fluids in the Neonate

- maintenance fluid requirements in the neonate

BW	0-2 days	3-14 days	15-30 days
750-1000 g	110	140	150
1000-1250 g	100	130	140
1250-1500 g	90	120	130
> 1500 g	80	110	130

Fluids in the Neonate

- initial IVF: D10W
- determine serum electrolytes on the 12th HOL (preterm) or 24th HOL (full term) and change IVF accordingly

Glucose Infusion Rate

- determines adequacy of infused glucose
- $\frac{(\text{dextrosity})(\text{drip rate in cc/hr})(0.167)}{\text{body weight (kg)}}$
- desired GIR = 5-8 mg/kg/min

Glucose Infusion Rate

- Case 8A

  Baby Planta is a 2 day-old/M weighing 3 kg referred for persistent hypoglycemia. He is on NPO with an IVF of D5IMB at 12.5 cc/hr.

  TFI?

  GIR?

  What to do?

Dextrosity of Fluids

- D5W contains 5 g of glucose per 100 ml
- changing dextrosities of fluids –

$$\text{factor} = \frac{\text{desired dextrosity} - \text{lower dextrosity}}{\text{higher dextrosity} - \text{lower dextrosity}}$$

amount of D50 to be added to actual IVF =
(factor)(actual IVF being given)

Dextrosity of Fluids

- Case 8B

  You decide to change the dextrosity of Baby Planta's IVF from D5IMB to D10IMB.

  Write down your new IVF orders.

Infusions / Drips

- Dopamine

$$\text{amount (cc)} = \frac{\text{dose (mcg/kg/min) x BW (kg) x 480}}{40{,}000}$$

- Dobutamine

$$\text{amount (cc)} = \frac{\text{dose (mcg/kg/min) x BW (kg) x 480}}{12{,}500}$$

- Epinephrine

amount (cc) = 0.6(BW) + sterile water to make 100 cc

0.1 mcg/kg/min = 1 cc/hr

Infusions / Drips

- general formula

$$\text{drip rate} = \text{dose} \times \text{BW} \times 60 \times \frac{\text{total volume}}{\text{volume per amp}}$$