Fluid Therapy in Pediatrics

Facts we have to know:

1) 60% of total body weight is water.
[in children its more, and in neonates it may reach 80%]

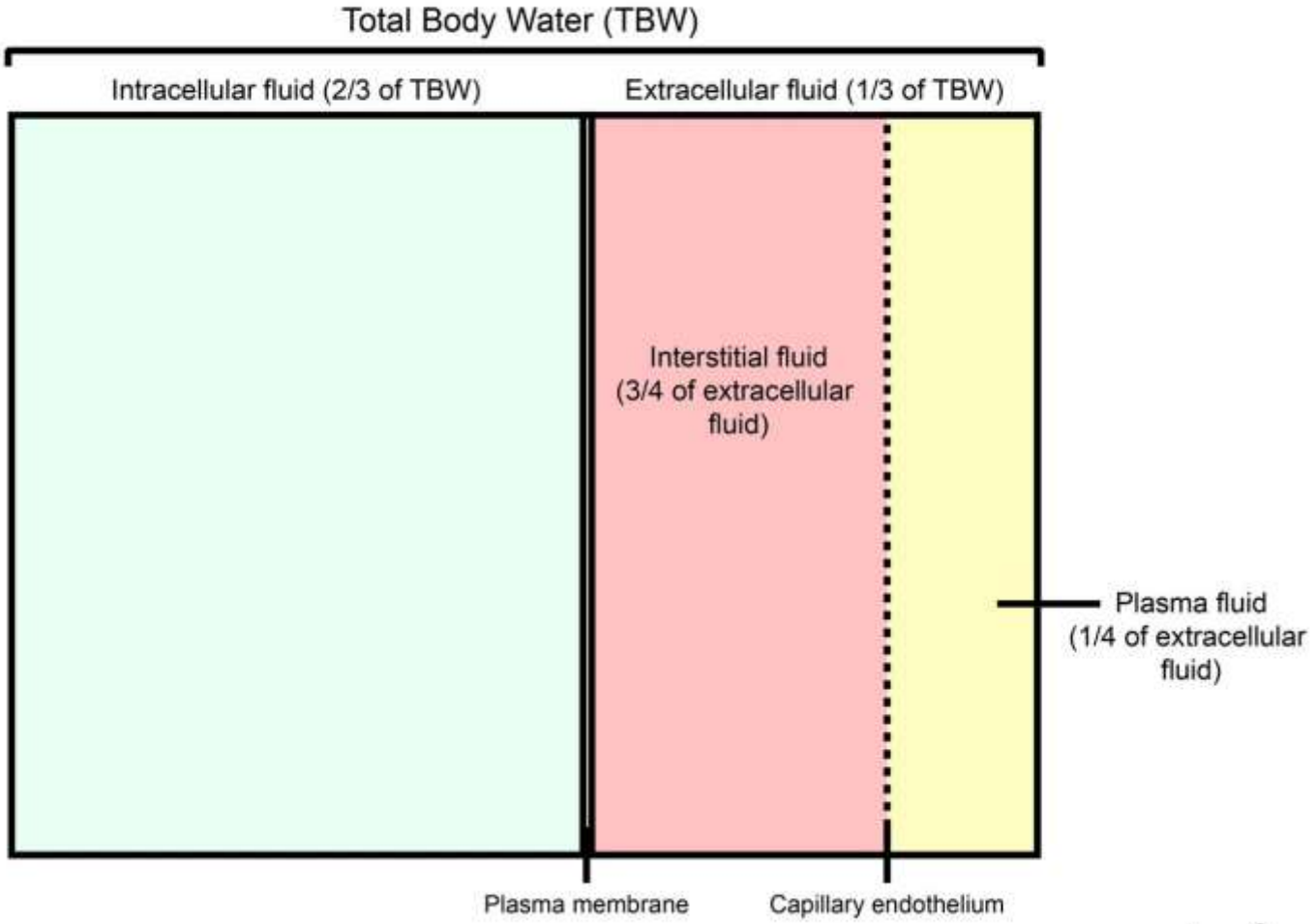
2) 2/3 of body water is intracellular and the remaining 1/3 is Extracellular .

*** Water percentage in prematures is 75-80% of their weight ,**

And in newborn is 75% of their weight and 60% in babies (> 1 year old) .

***extracellular fluid is anything outside the cells (i.e : plasma and interstitial fluid)**

Body Fluid Compartments



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Electrolytes

Electrolytes	Extracellular level	Intracellular level
Sodium (Na)	140	10
Potassium (K)	4	160
Calcium (Ca)	2.5	2.5

Fluids

D5W: contains 5g glucose in 100 ml

D10W: contains 10g glucose in 100 ml

NS: contains 154 meqNa in 1L

½ NS: contains 77 meqNa in 1L

1/3 NS : contains 51 meqNa in 1L

Clinical signs	Mild (3%-5%)	Moderate (6%-9%)	Severe (≥10%)
Systemic Signs	Increased thirst	Irritable	Lethargic
Urine Output	Decreased	Decreased (< 1mL/kg/hr)	Decreased (oliguria/anuria)
Mucus Membrane	Tacky	Dry	Parched
Skin Turgor *	Normal	Reduced	Tenting
Capillary Refill *	Normal	Mildly delayed	Markedly delayed
Skin Temperature	Normal	Cool	Cool, mottled
Anterior Fontanel	Normal	Sunken	Markedly sunken
Heart Rate	Normal	Increased	Markedly increased or ominously low
Blood Pressure	Normal	Normal to low	Low
Respirations *	Normal	Deep, may increased	Deep and increased or decreased to absent

Maintenance Therapy

Maintenance fluids :

The amount of fluids that is needed to compensate for the ongoing losses under physiological conditions . normal

→ Even if you are sitting on your chair , you are loosing water because of metabolism , sweating , breathing , and urine formation.

so daily under normal conditions , we are loosing certain amounts and we have to replace them , and if we don't replace them we will have dehydration

We have 2 ways to calculate the maintenance fluid :

1) . Holliday-Segar Method for Calculating Maintenance Fluid Requirements in Children (most commonly used) :

The first 10 Kgs of weight needs 100 cc/Kg

The second 10 Kgs of weight needs 50cc/Kg

The third and above Kgs of weight needs 20cc/Kg

Examples

Example 1 :

7Kg patient→ 7 x 100 = ***700 cc*** fluid (because 7 is from the first 10 Kgs)

Example 2 :

15 Kg patient →15= 10 + 5 → fluid = 10x100 + 5x50 =***1250 cc***

(because the 5 is from the second 10Kgs of weight so we don't multiply it by 100 like the first 10 , we multiply it by 50)

Example 3 :

25 Kg patient →25 = 10(1st 10) + 10(2nd 10) + 5(3rd 10)
Fluid = 10x 100 + 10 x 50 + 5 x 20 = **1600cc**

(and at the same time he needs 1600 calories each day)

We have 2 ways to calculate the maintenance fluid :

2) The way derived from *the surface area :*

They calculated total fluid losses under normal physiological conditions and reached this formula :

Needs = 160 cc / m2 / Hour.

Maintenance Therapy

**** Under abnormal conditions, the subject may loose more fluids from :***

-Skin : burns , fever , phototherapy (for neonates , and you will see that there maintenance dose will be more to meet this increase) , premature babies (their surface area : body weight) ratio is higher than normal and this leads to increased loss) , newborns in heaters , excessive sweating.

-Lungs : tachypnea, tracheostomy .

GI: nasogastric suction , ileustomy (no absorption of fluids)

-Others : polyurea , drain.

Electrolytes Maintenance

Electrolytes maintenance : (daily losses)

Na : 3 mEq / 100ml (2-4 mEq/100ml)

K : 2 mEq/100cc fluid , usually given as KCl.

Maintenance therapy in NPO patients

*** If somebody came to the hospital to make a certain surgery , he will stay one or two days NPO , so he will not ingest anything and we have to put him on maintenance fluid to give him his daily requirements of fluids and electrolytes .**

*** If he needs to stay more than 5 days NPO , then we should add *aminoacids and intralipids* to avoid body wasting**

Volume Depletion (Deficit)

Volume depletion occurs when you loose more than what you get .

*** Conditions leading to this imbalance :**

1) Decreased fluid ingestion : anorexia , coma , vomiting

2) Loosing fluids : polyurea , diarrhea , skin loss (e.g : burns)

Dehydration varies among individuals , but children are at higher risk to develop dehydration and hypovolemia , because :

1) They can't tell their parents that they are thirsty

2) They get gastroenteritis more often

3) Their surface area is high (more skin loss)

Volume Depletion (Deficit)

Now what happens if a patient has volume depletion ?

reduced effective circulatory volume → Decreased ECF and

mainly the intravascular compartment → Decreased tissue

perfusion → Hypoxia → Organs damage → Death

Volume Depletion (Deficit)

Before giving fluids we have to answer 2 questions :

1) what type of fluid should I give ? (water, 1/3 saline , normal saline)

2) amount of fluid ?

To answer these questions, we have to:

A -Determine the degree of dehydration : **to asses whether the situation is urgent or not and to calculate the amount to be given**

B-Determine the type of fluid lost : **to know the type of fluid we should give and the duration [we know the type by measuring the level of Na in blood.]**

Volume Depletion (Deficit)

A- How can we determine the degree of dehydration?

We have two ways:

1) Depending on the difference between the pre-illness and current weight :

we calculate the % of body weight loss and then we determine the degree of dehydration :

-% of body weight loss =(Wt preillness – Wt current) / Wpreillness

Example : a previously 10 Kg boy became 9.4 kg

W preillness=10 , W current=9.4→ dehydration= (10-9.4)/10=6%

from 3-5%→mild dehydration

from 6-9%→moderate dehydration

above 10%→sever dehydration

Volume Depletion (Deficit)

A- How can we determine the degree of dehydration?

2) Depending on the signs of dehydration :

This is useful when we don't know the pre-illness weight , and even if we have the pre-illnes weight its better to use it :

Signs of dehydration

Table 3. Clinical Signs of Dehydration

Clinical Sign	Mild Dehydration	Moderate Dehydration	Severe Dehydration
Weight loss (%)	3-5	6-9	≥10
Behavior	Normal	Normal to listless	Normal to lethargic or comatose
Thirst	Slight	Moderate	Intense
Mucous membranes	May be normal	Dry	Dry
Anterior fontanelle	Flat	Sunken	Sunken
Eyes	Normal	Sunken	Deeply sunken
Skin turgor	Normal	Decreased	Decreased
Blood pressure	Normal	Normal	Normal to decreased
Heart rate	Normal rate	Increased	Increased
Urine output	Decreased	Markedly decreased	Anuria

Data from Provisional Committee on Quality Improvement, Subcommittee on Acute Gastroenteritis.10

Types of fluids loss

1) Isonatremic dehydration : loss of Na + water
2) Hyponatremic dehydration : more Na loss than water loss
3) Hypernatremic dehydration : more water loss than Na loss

***130-135 is hyponatremia but we don't act aggressively**
***145-150 is hypernatremia but we don't act aggressively**

Isonatremic dehydration	Hyponatremic dehydration	Hypernatremic dehydration
Maintenance of fluids and electrolyte	Maintenance of fluids and electrolyte	Maintenance of fluids and electrolytes x 48 hours
Deficit of fluids and electrolytes	Deficit of fluids and electrolytes	Deficit of fluids
	Additional Na deficit mEq Na deficit = (desired Na - measured Na) x 0.6 x weight in Kg Desired Na 130 is ideal.	**Free fluid deficit** 4mL/Kg for each 1 mEq if Na >145 mEq 3mL/Kg for each 1 mEq if Na >170 mEq
		Fluid deficit containing electrolyte =Fluid deficit-free fluid deficit
Total over 24 hours	Total over 24 hours	Total over 48 hours

Deficit fluid = percentage of fluid loss X weight X 1000

First 50% of deficit should be at the first 8 hours, then other 50% during the other 16 hours.

Deficit Na = 0.6 X 140 per every 100 ml (8.4/100ml)

Deficit K = 6/100ml

Fluid resuscitation & emergency management

** **Here we should asses whether its an emergency , and calculate the amount of fluids lost , and determine whether we should give fluids orally or IV..**

--- for example if a shocked person came to the emergency , we have to intervene quickly to prevent tissue hypoxia , so we have to start by giving IV boluses without even looking at Na levels .

*__*A bolus*__ contains isotonic solution whether Normal saline (in children).

- We never add dextrose to bolus because dextrose will increase the osmolarity and this will lead to further fluid loss from body tissues.

The amount of fluids in a single bolus equals 20cc/Kg and its given over 20 to 30 minutes ,

but if the patient is a known case of renal failure or his lab tests revealed that , or if he has heart problems , then we should give him a less and slower quantity (10cc/Kg over 30 to 60 minutes) because if you overload him , it will be difficult to get rid of the excess amounts.

One liter of Normal Saline (0.9% of NaCl) contains:

154 mEq of sodium ion = 154 mmol/L
154 mEq of chloride ion = 154 mmol/L

- Half-normal saline (0.45% NaCl) contains 77 mEq/L of Na and Cl
Quarter-normal saline (0.22% NaCl) has 38 mEq/L of - Na and Cl

- Fifth … 31 meq/l

Oral or IV rehydration

1- ORS [oral rehydration solution]

It comes in packets that have to be diluted in 1 L of water , and you should teach the mother how to prepare it before she leaves the hospital and make sure that she is preparing it in the correct way

Contents of ORS : anions = cation = glucose = 110

cations : Na =90 K=20
anions : Cl=80 bicarbonate=30
Glucose :111

Doses :

- ***in mild dehydration (5 %)*** : give 50cc/kg every 4 hours

- ***in moderate dehydration (10%)*** : give 100 cc / kg every 4 hours

- every time the patient defecates give him 10cc/kg
- **When rehydration is complete, maintenance therapy should be started, using 100ml/kg/day.**

Oral or IV rehydration

2- IV fluids

-- are given in certain situations :

-if the patient has Vomiting

-in Coma / impaired consciousness

-in Sever loss such as severe diarrhea (when the loss is more than 10cc/kg/hour)

We should consider:

- Patients maintenance
- Type and degree of dehydration

Types of Dehydration

1- Hyper-Natremic dehydration

2- Hypo-Natremic dehydration

3- Iso-Natremic dehydration

Isonatremic dehydration

- 10-kg patient with 10% deficit and Na is 139 ?

maint fluid: 10x100=1000 , maint Na: 3 per 100 =30 k:2 per 100=20

Deficit: fluid:10% x 1000x 10=1000ml Na: 8.4 per100 =84 k: 6 per 100=60

Subtract bolus which is : 200 ml fluid that contans 30meq Na.

Total 1800 fluid with 84 Na …. What type of fluid? (84x1000)/1800=46

So its going to be D5/third saline.

Hypo-Natremic dehydration

* Dehydration is usually **overestimated** in hyponatremia , because fluids will shift from the extra to the intracellular compartment .

1) Calculate the maintenance fluid & electrolytes
2) Calculate the deficit fluid & electrolytes
3) Add Na. 0.6 X wt X (desired level – current level)

Don’t increase Na level more than 10-12 meq per day. Why?
Due to risk of pontine myelinolysis.

** 5.5 kg pre-illness infant dehydrated, now 5kg (10%, Na:120. bolus given once.

Maint: fluid:550ml Na: 3 per 100 =16 k: 2 per 100 =11

Deficit: fluid:550 Na : 8.4 per 100 = 42 k:6 per 100=33

subtract bolus: 110 fluid , Na:17

Added Na : .6 x 5.5 x(130-120)=33

Total: 990 ml fluid + 75 Na , how to choose fluid?

(1000 x 75)/990 = 75 meq Na in every 1 L fluid so its D5/half saline.

Hyper-Natremic dehydration

It is usually underestimated , because as a result of hypernatremia , fluids will shift from the intracellular to the extracellular compartment (from the cells to the vessels) , and we said that the extracellular compartment is the one that determines the level of dehydration , so this shift will lead to inaccurate estimation

Symptoms of Hyper-Natremic dehydration :

- **lethargy & weakness**
- **irritability & seizures**
- **doughy skin (due to intracellular fluid loss)**
- **normal skin turgor (because of the fluid)**
- **coma & death**

Treatment of hypernatremic dehydration

We have to go into 3 steps :

1) Give the patient his maintenance (the amount that is normally needed)

2) Replace the deficits (the already lost fluids)

3) Decrease the elevated Na levels

* Put in your mind that we shouldn't decrease Na levels more than 0.5-1 mEq/hour or more than 10mEq/day

WHY ?

*** Put in your mind that we shouldn't decrease Na levels more than 0.5-1 mEq/hour or more than 10mEq/day**

WHY ?

Because the patient will develop severe complications like **Cerebral edema**

(because fluids pass the BBB faster than electrolytes) .

So always avoid rapid drop of Na level and only decrease it by 10 mEq/day or a maximum of 12 mEq/day

Treatment of hypernatremic dehydration

1-- In severe cases we start by giving the patient normal saline boluses (1 or 2 bluses) until his condition becomes more stable , and here in bolus treatment we don't look for Na concentration because normal saline contains 154mEq/l and this will be less than his current Na level and will not increase it .

2--The maintenance : the daily needs (100cc/kg for the 1st 10 , 50cc/kg for the 2nd 10 , and 20cc/kg for the rest)

3-- The deficit : and this depends on the level of dehydration :

if its 10% (he lost 10% of his body weight) then we say :

10% X 1000 X Body wt

7 month old infant dehydrated, weight pre-illness was 10 and now 8.5,(lost 15%), Na:158 .

Don’t forget here pt lost more water than Na.

1)Maintenance here is per 48h.

Fluid:2000cc/48h Na:3meq per 100ml=60meq/48h

k:2meq per 100 ml = 40meq/48h

2)Deficit fluid also per 48h: 15% x 1000 x 10= 1500cc fluid depleted. But not all the fluid here is taking electrolytes, some should be free water, how to calculate? 4 x kg x (158-145)= 4x 10kg x13=520 , this is the fluid without electrolytes.

Still we have deficit with electrolytes which is:

1000 ml fluid , 84Na , 60K

Total per 48h:

Fluid : 3500 , Na:144

What type of fluid?

(144*1000)/3500= 41 meq in water so its close to D5/forth saline.

Don’t forget Na check Q4h because rapid correction = cerebral edema & seizures.