IN THE NAME OF GOD

FLUID AND ELECTROLYTE THERAPY

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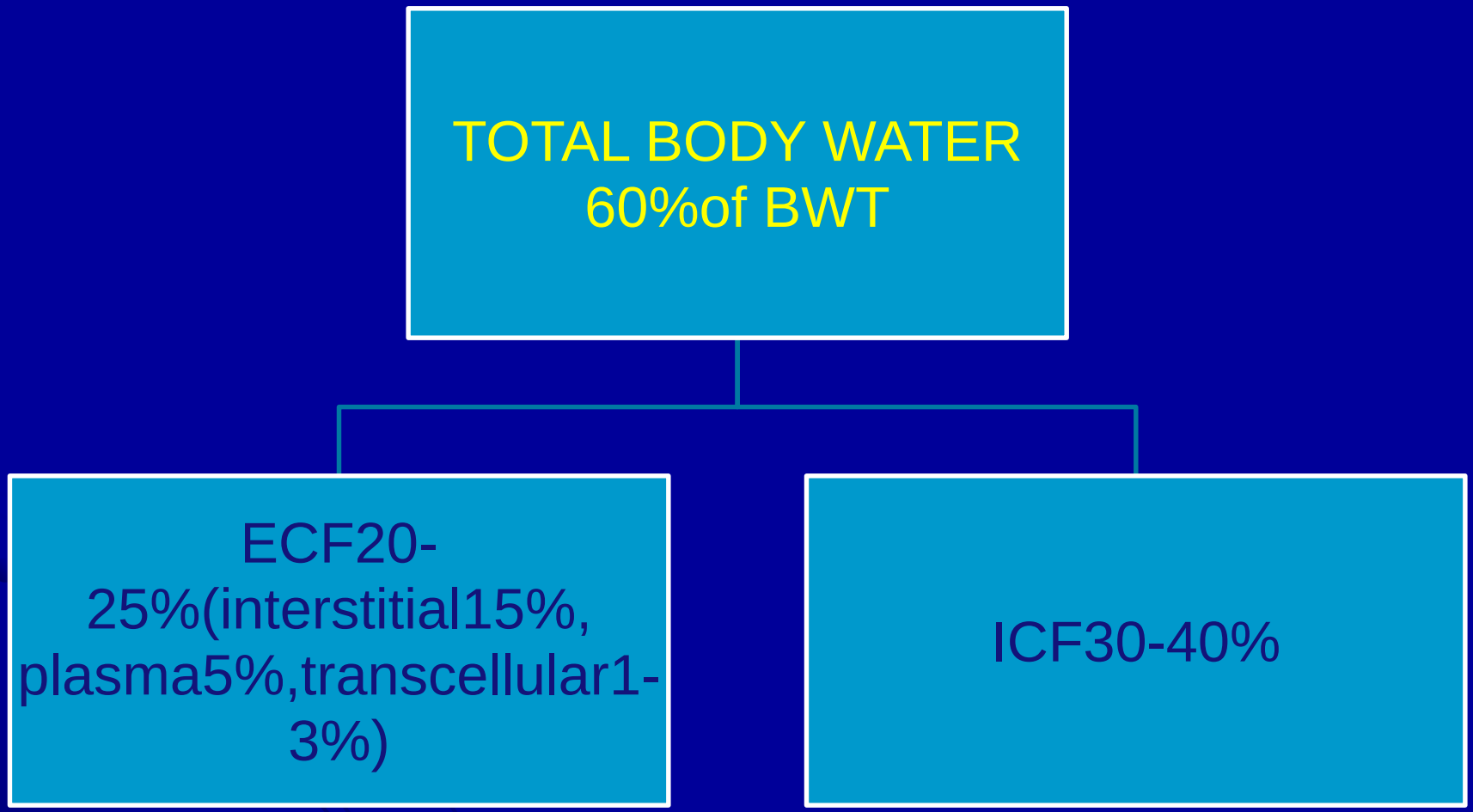
Objectives

- Understand maintenance fluid therapy
  - Fluid composition
  - Fluid rate
- Calculate fluid therapy in dehydration
- Understand differences in fluid therapy for different types of electrolyte disturbances

FLUID AND ELECTROLYTES

- Important factors of Discussion:H2O,Na,K,CL-
- TBW -75% of body wt. in full term infant
- TBW-60% of body wt. in adult(M60%,F50%)
- TBW divided between 2 main component (ICF&ECF)
- In the fetus &neonate ECF is >ICF
- At one year ECF(20-25%)BWT & ICF(30-40%)as adults


TOTAL BODY WATER
60%of BWT
ECF20-25%(interstitial15%, plasma5%,transcellular1-3%)
ICF30-40%

Fluid compartments - total body water

Age	% Body weight
12-week fetus	90
New born	75
One year	60
Adult	60

Regulation of Body Fluids

- Plasma osm.285-295mosm/kg H2O
- **Osm**.= (*2xserum Na+glucose/18)* © +BUN/2.8
- Maint.of serum osm. By osmoreceptors and volume receptors
- Osmoreceptors: in hypoth. ,portal vein &panc.
- Volume receptors: baroreceptors in atrium &vasc.bed
- 1-2%Change in osmolality or 8-10% change in volume
- If osmolality and volume decreases :volume maintained

© effective osmolality or tonicity

Water &Electrolyte Balance

- Balance of intake and output
- Output:60%urine+5%stool+ IWL*[35%(skin &lungs)]

ECF	ICF
Na140meq/l	Na 10meq/l
K 4meq/l	K 150meq/l

*IWL**insensible water loss

- Maint. by Na-K-ATPase

Approach to Fluid Calculations

- 1. Maintenance: Determined by a 'system':
  - a. Caloric expenditure method
  - b. ***Holliday-Segar method***
  - c. Surface area method

1957

- 2. Deficit: Determined by acute weight change or clinical estimate
- 3. Ongoing losses: Determined by measuring

Maintenance Fluids

Holliday-Segar cont.

WEIGHT (kg)	FLUIDS
0 - 10	100 ml/kg/day
11 – 20	1000 ml + 50 ml/kg for each kg above 10
>20	1500 ml + 20 ml/kg for each kg above 20

ml/kg/hr according to 4:2:1(Rule)
For a 60kg:4×10+2×10+1×40=100ml/hr

Na of 3 mEq /K 2 mEq/ Cl 2 mEq/ 100 kcal / 24 hours Equal to about 30 mEq of Na in 1000 ml which is roughly ¼ NS (hypotonic solution)
DW5%+1/2 NS+20mEq/Lit KCL* or
Dextrose saline5%+20mEq/lit KCL*the best fluid
*Newborns and prematures are not included

Fluid type versus fluid rate

- prospective, randomized, nonblinded study, 124 children admitted for surgery
- 0.9% (NS) or 0.45% (N/2) saline solution at 100% or 50% maintenance rates.
- Plasma sodium concentrations fell in both N/2 and N/S groups at T(8)
- hyponatremia more common in the NS/2 groups at T(8) (30% vs 10%; P =0 .02)
- The risk of hyponatremia was decreased by isotonic saline solution but not fluid restriction.

Neville KA et al. (2009) Prevention of hyponatremia during maintenance intravenous fluid administration: a prospective randomized study of fluid type versus fluid rate. J Pediatr doi:10.1016/j.jpeds.2009.07.059

SELECTION OF MAINTENANCE FLUIDS

- D5 1/2NS + 20 mEq/L KCl without risk factors

- D5 NS + 20 mEq/L KCl for Children with volume depletion, baseline hyponatremia, or at risk for nonosmotic ADH production (lung infections such as bronchiolitis or pneumonia) or meningitis

- Add KCL according to serum K

- Check serum electrolytes at least daily

Causes of Dehydration

1-↓Intake with NL loss

2-↑Loss with or without usual intake

3-Third spacing

Treatment:
REPLACEMENT OF DEFICIT

DEHYDRATION

DEGREE OF DEHYDRATION

(HISTORY, PE, Δ weight)

- **mild dehyd.**

  <50ml/kg(<5%def.)*

  Adult <3%

- **Mod dehyd.**

  50-100ml/kg(5-10%def.)*

  Adult 3-6%

- **severe dehyd**.

  >100ml/kg(>10%def.)*

  Adult >6%

  Infants*

Types Of Dehydration

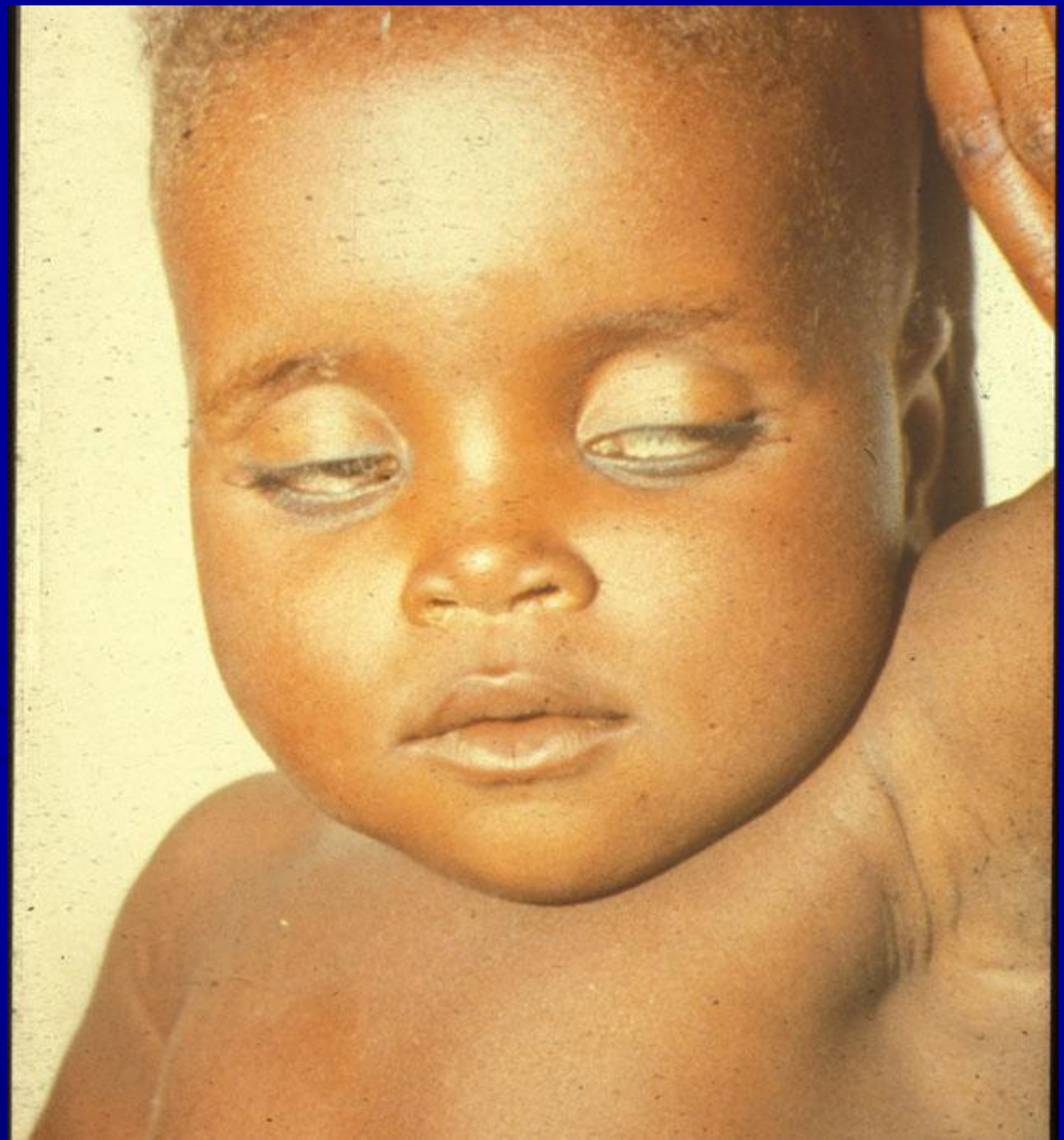
(serum Osmolality, serum Na)

- **Hyponatremic,** Na<135mEq/L
- **Isonatremic, Na**135-145mEq/
- **Hypernatremic**

  Na>145-150mEq/L

Estimation of dehydration**

Sign	*No dehyd.*	*Some dehyd.*	*Severe dehyd.*
*Temper**	*Alert*	*Irritable*	*Sleepy,uncon.*
*Turgor**	*Nl*	*↓*	*>2sec*
*Thirst**	*↑*	*↑↑*	*------*
Eye	*Nl*	*Sunken*	*Very sunken*
Tear	*Nl*	*Absent*	*Absent*
Mucus m.	*Wet*	*Dry*	*Very dry*
Fontanel	*Nl*	*Depressed*	*Very dep.*
Radial pulse	*Nl*	*Weak &rapid*	*Weak or absent*
BP	*Nl*	*Nl or ↓*	*↓↓ or non-detectable*
Urine volume & SG	*Nl -1.020*	*↓-- >1.025*	*↓↓↓-- 1.040*
Capillary refill	Nl	Delayed>1.5 s	Very delayed >3 s
BUN	Nl	*↑*	*↑↑*



Treatment of Dehydration

- Maintenance therapy
- **Deficit therapy**
- Replacement of ongoing losses

Table 56-6 Adjustments in Maintenance Water

SOURCE	CAUSES OF INCREASED WATER NEEDS	CAUSES OF DECREASED WATER NEEDS
Skin	Radiant warmer Phototherapy Fever Sweat Burns	Incubator (premature infant)
Lungs	Tachypnea Tracheostomy	Humidified ventilator
Gastrointestinal tract	Diarrhea Emesis Nasogastric suction	—
Renal	Polyuria	Oliguria/anuria
Miscellaneous	Surgical drain Third spacing	Hypothyroidism

Fluid Composition

Common name	*% NaCl*	*[Na]*
NS	0.9% NaCl	154 mEq/L
½ NS	0.45% NaCl	77 mEq/L
¼ NS	0.2% NaCl	34 mEq/L
3%NS 5%NS	3% NS %5 NS	513 meq/L 855 mEq/L

Electrolyte composition mEq/l

	Na	K	Cl	Hco*3-*
Ringer/l	**130**	**4**	**109**	**28**
Nl saline&D/S5%	**154**	**0**	**154**	**0**
½ NLsaline1/2DW	77	0	77	0
1/3,2/3DW5%	**51**	**0**	**51**	**0**
1/5,4/5DW5%	31	0	31	0
ORS *WHO*	**90**	**20**	**110**	**30**
Cholerae Ad.	140	13	104	44
Cholerae ch.	101	27	92	32
Diarrhea *non cholerae*	55	25	55	15
Small intes.juice	100	15	155	40
Gastric-juice	60	10	90	0

Fluid Management of Dehydration

- Evaluate the child for intravascular volume
- Restore intravascular vol. (fluid bolus 20ml/kg N/S in 20 min could be repeated ×3,occasionally blood, Albumin or plasma (resuscitation phase)&vasoactive
- Type of dehydration according to serum electrolytes
- Calculate 24hr maintenance &deficit of water
- If fluid bolus given at initial phase subtract its vol.
- Usually DW5%+normal saline+ 20mEq KCl /l *
- Replace ongoing losses as they occur

*KCl added after urination

Treatment of Isonatremic Dehydration(Na135-150)

- Treatment done in 24hrs
- D/W5%+NS +KCl 20mEq/L *
- Ongoing losses should be replaced properly (for replacement of diarrhea, NG draining,…….)
- Follow the patient with frequent P/E
- Monitor of serum electrolytes at least daily

*KCl added after urination

Hyponatremic Dehydration serum Na<135

- Frequently seen in children with vomiting and diarrhea who have received water as an oral replacement
- Shock is an early symptom
- Correcting Na^+ to quickly can lead to central pontine myelinolysis
- In hypo-natremic dehydration the ↑ in serum Na not more than 0.5mEq/hr

Treatment of hyponatremic dehydration Serum Na<**135**meq/L

- Treatment is similar to isonatremic dehydration
- DW5%+NS+20mEqKCl/lit*
- Na should not rise >0.5mEq/hr(10-15meq/24hr
- If convulsion with hyponatremic dehydration ,give hypertonic Na (ClNa3%)to rise serum Na by 5 mEq/L **(1 ml/Kg ClNa3%↑serum Na by 1mEq/l)**

So for a 20kg child 20×5=100ml ClNa 3% ↑ serum Na by 5mEq/L

- 1ml ClNa 3%=0.5mEq

*KCl added after urination

Hyponatremic encephalopathy

difficult to recognize

- 1. Early
  - a. Headache
  - b. Nausea and vomiting
  - c. Lethargy
  - d. Weakness
  - e. Confusion
  - f. Altered consciousness
  - g. Agitation
  - h. Gait disturbances

Important Points in Treatment of Hypornatremic Dehydration

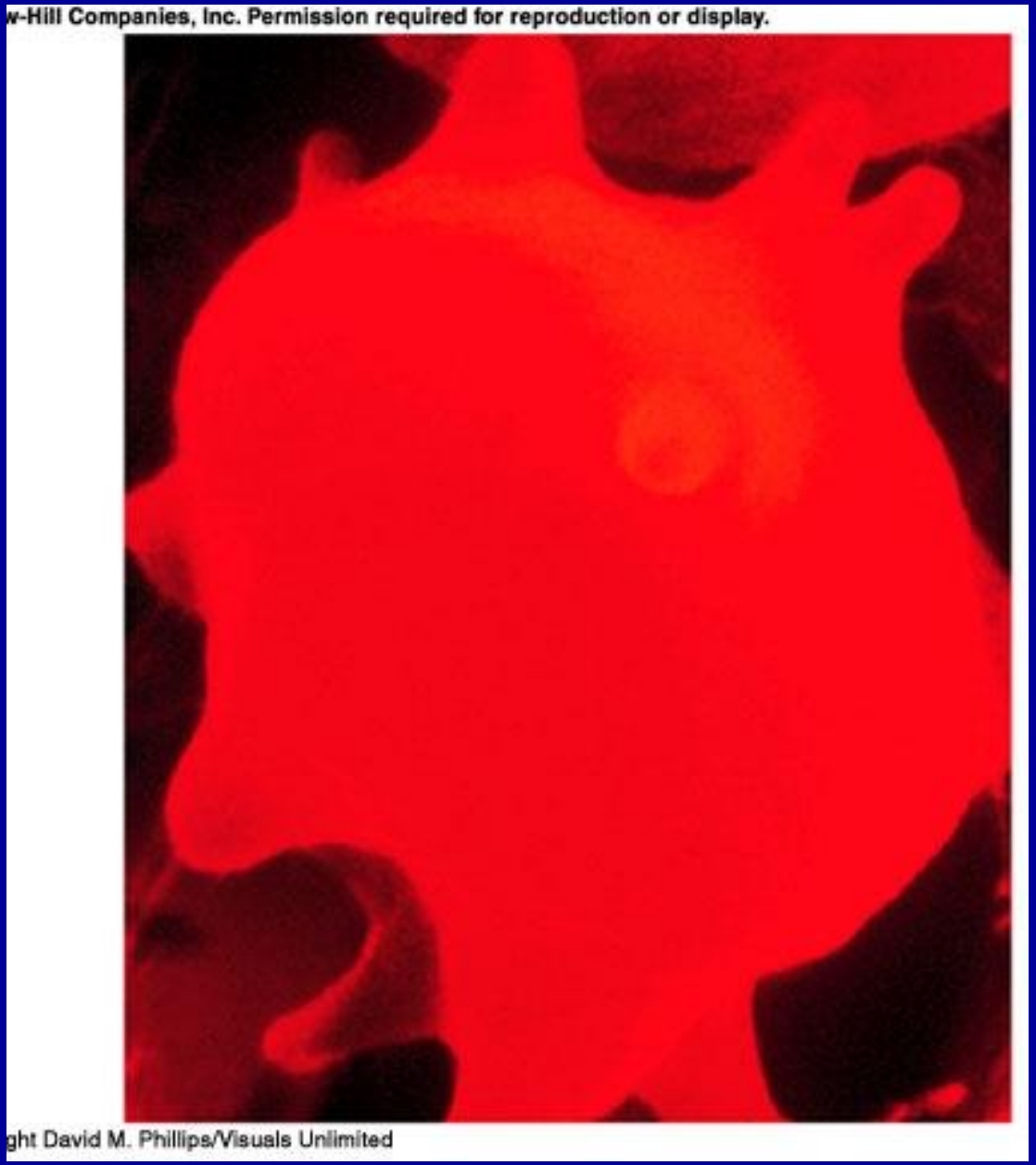
- Frequent monitoring of the patient by P/E, Δ Weight, Serum Na
- Na should not rise >0.5mEq/hr(10-15mEq/24hr
- Serum Na after 4 hrs &……..
- In chronic hyponatremia it is recommended to increase Na upto 9 meq/day

Halperin ML, Goldstein MB. Fluid, electrolyte and acidbase physiology: a problem-based approach, 3rd edn. Philadelphia, WB Saunders, 1999.

Hypernatremic Dehydration cont.

- Mortality can be high
- Often iatrogenic
- **The circulating volume is preserved at the expense of the intracellular volume and circulatory disturbance is delayed**
- The patient looks better than you would expect based on fluid loss
- Always assume total fluid deficit of at least 10%
- For Na^+ > 175 mEq/L do not correct faster than 0.5 mEq/L/hr because of risk of cerebral edema

Cell in a hypertonic solution



Hypernatremic dehydration

- Serum Na>150mEq/lit
- More water loss than Na
- ↑Na in ECF→ ↓ICF (↓cell vol.)
- Intravascular vol.maintained to some extent
- May be complicated by intracranial hemorrhage, coma, spasticity, convulsion, acidosis, hyperglycemia, hypocalcemia, hemolysis and …….
- Replacement of deficit in 48-72hrs
- To ↓serum Na not more than 10-12 mEq/24hr
- Possibility of convulsion during treatment (entry of water inside cell
- **Monitor serum electrolytes more frequently**

Treatment of hypenatremic dehydration Serum Na>**150**meq/L

- 1.25-1.5*maintenance (½ normal saline+DW5%) +20mEqKCl/lit*
- Na should not fall >0.5mEq/hr(10-12mEq/24hr
- If convulsion during treatment ,give hypertonic Na (ClNa3%)to rise serum Na by 5 mEq/L **(1 ml/Kg ClNa3%↑serum Na by 1mEq/l)**

So for a 20kg child 20×5=100ml ClNa 3% ↑ serum Na by 5mEq/L

*KCl added after urination

Important Points in Treatment of Hypernatremic Dehydration

- Frequent monitoring of the patient by P/E, Δ Weight, Serum Na
- To ↓serum Na not more than 10 -12meq/24hr
- Serum Na after 4 hrs &……..
- You may change it to higher Na or lower according to serum Na

Treatment of Hypernatremic Dehydration in Different Na Levels

- Na145-157mEq/lit:24h
- Na158-170mEq/lit:48h
- Na171-183mEq/lit:72h
- Na184-196mEq/lit:84h

- 1.25- 1.5*maintenance1/2NS+DW5%+KCl 20mEq/lit

Summary of treatment of dehyd.

- Isonatremic dehydration:maint+deficit: NS+20mEqKCL/lit
- Hyponatremic dehydration:maint+deficit:NS+20mEqKCL/lit
- Hypernatremic dehydration:maint.+1/2 deficit: 1/2NS in DW5%+ 20mEqKCL/lit
- Check Na and K at least once/day in isonatremic dehyd.
- In hypo and hypernatremic dehyd:1st Check Na and K 4hrs and then……..

The End

Treatment of hypernatremic dehydration

- Water deficit in lit=0.6×Bwt×[(actual SNa/140)-1]
- This formula may overestimate water deficit So: following formula could be used
- Change in Na conc.= [(infusate Na+k)-serum Na]/(TBW+1)
- For a 10kg child with Na 170,change in serum Na when 1Lit of 1/5,4/5 given =(30*-170)/6+1=-20

Since we should bring Na down only 10 meq/day,so we should give only ½ Lit 1/5,4/5 or.....

Hyponatremia: Management

- Rate of infusion is calculated using the **Madias Formula** which estimates the change in serum sodium caused by 1 liter of any infusate. The required volume, and thus rate, is determined by dividing the change in serum sodium desired for a given period of time by the value obtained from Madias formula.

TABLE 2. FORMULAS FOR USE IN MANAGING HYPERNATREMIA AND CHARACTERISTICS OF INFUSATES.

FORMULA*	CLINICAL USE
1. Change in serum $Na^+ = \frac{\text{infusate } Na^+ - \text{serum } Na^+}{\text{total body water} + 1}$	Estimate the effect of 1 liter of any infusate on serum Na^+
2. Change in serum $Na^+ = \frac{(\text{infusate } Na^+ + \text{infusate } K^+) - \text{serum } Na^+}{\text{total body water} + 1}$	Estimate the effect of 1 liter of any infusate containing Na^+ and K^+ on serum Na^+

INFUSATE	INFUSATE Na^+	EXTRACELLULAR-FLUID DISTRIBUTION
	mmol per liter	%
5% Dextrose in water	0	40
0.2% Sodium chloride in 5% dextrose in water	34	55
0.45% Sodium chloride in water	77	73
Ringer's lactate	130	97
0.9% Sodium chloride in water	154	100

*The numerator in formula 1 is a simplification of the expression (infusate Na^+ − serum Na^+) × 1 liter, with the value yielded by the equation in millimoles per liter.[8] The estimated total body water (in liters) is calculated as a fraction of body weight. The fraction is 0.6 in children; 0.6 and 0.5 in nonelderly men and women, respectively; and 0.5 and 0.45 in elderly men and women, respectively.[27] Normally, extracellular and intracellular fluids account for 40 and 60 percent of total body water, respectively.[27]