Happy

Pediatric Electrolyte Disorders

Sodium (Na)

Case-based Approach

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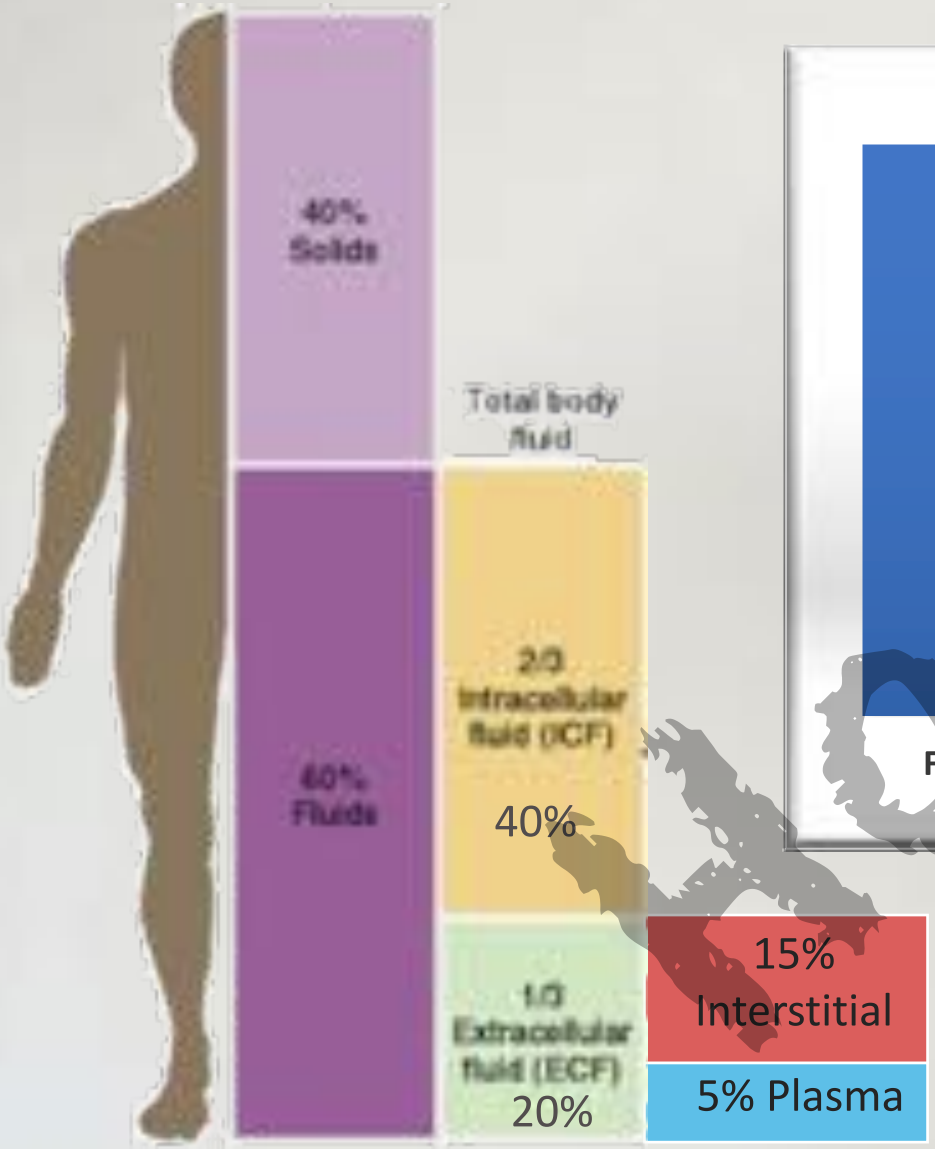
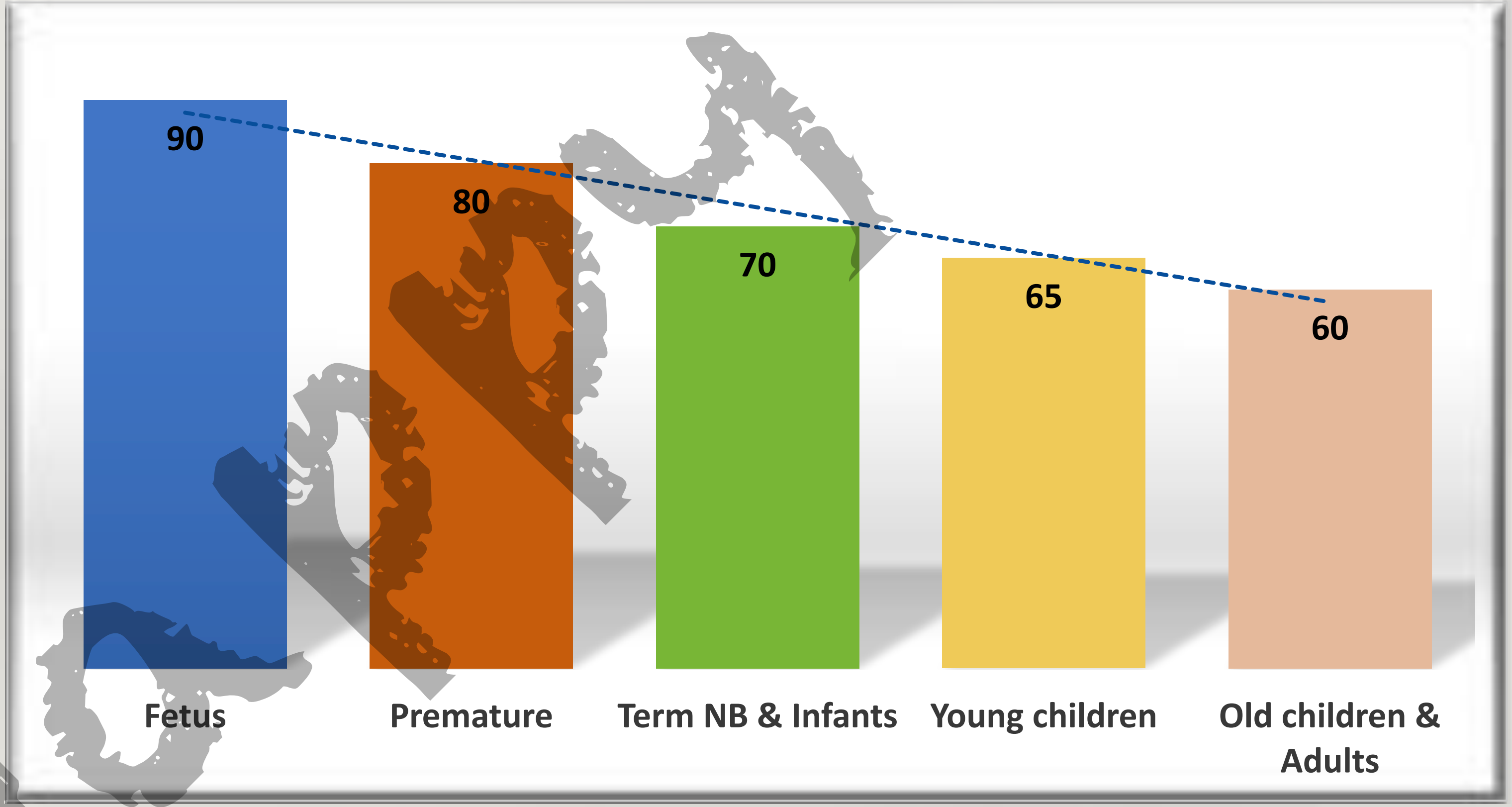
Total Body Water (TBW)

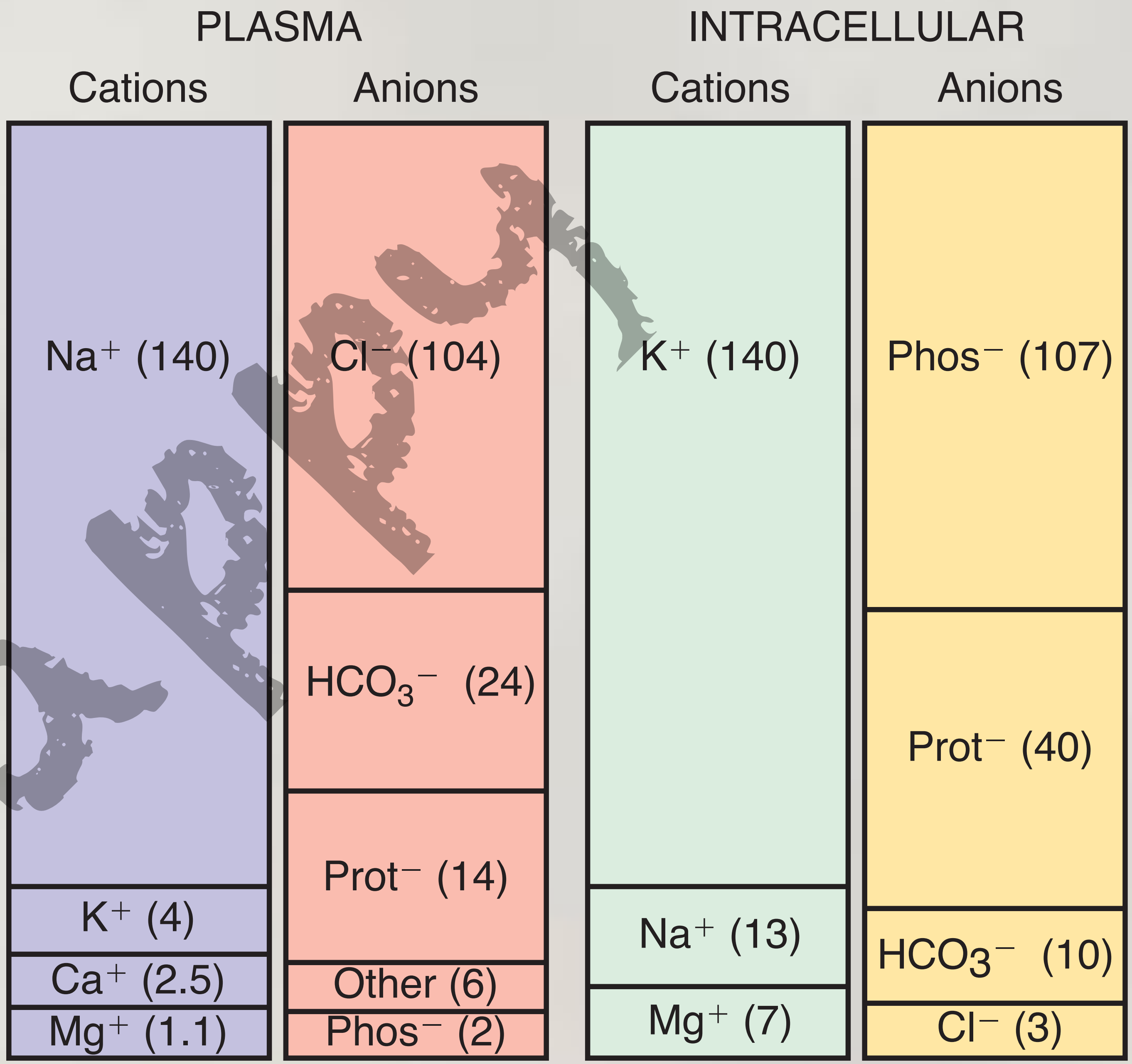




Lean individuals >> greater % of TBW

Fat individuals >> smaller % of TBW

ICF & ECF
Electrolytes distribution



Definitions

- **Osmolality:**

  A measure of all solute particles/ weight of solvent.

  Calculated osmolality = [2 x Na] + [BUN/2.8] + [glucose/18]

  Normal osmolality = 280-295 mOsm/kg

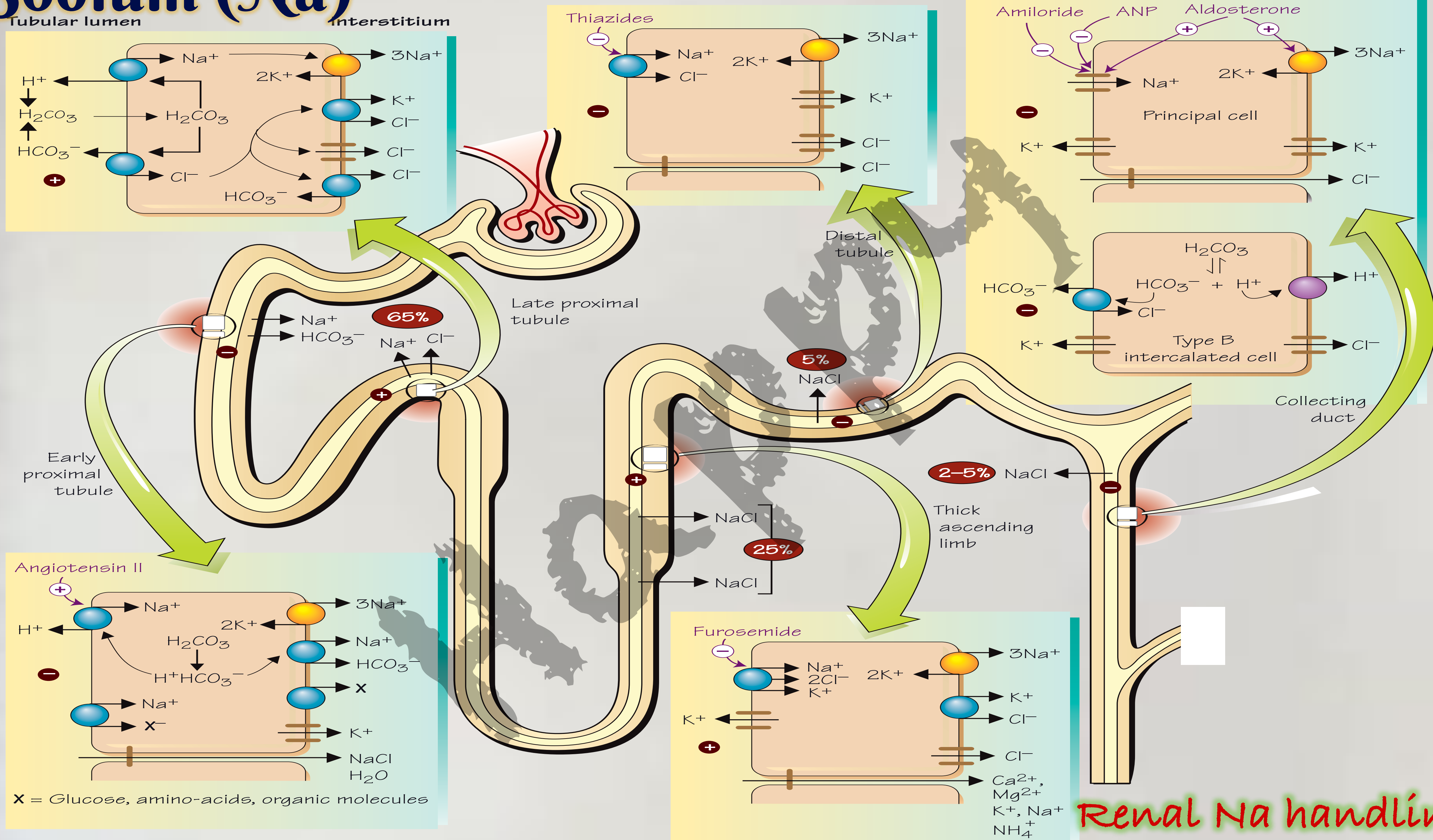
- **Tonicity**

  A measure of the "EFFECTIVE OSMOLS" in a particular weight of solvent.

  EFFECTIVE OSMOLS: determined by solutes that hold water (Na and glucose not urea)

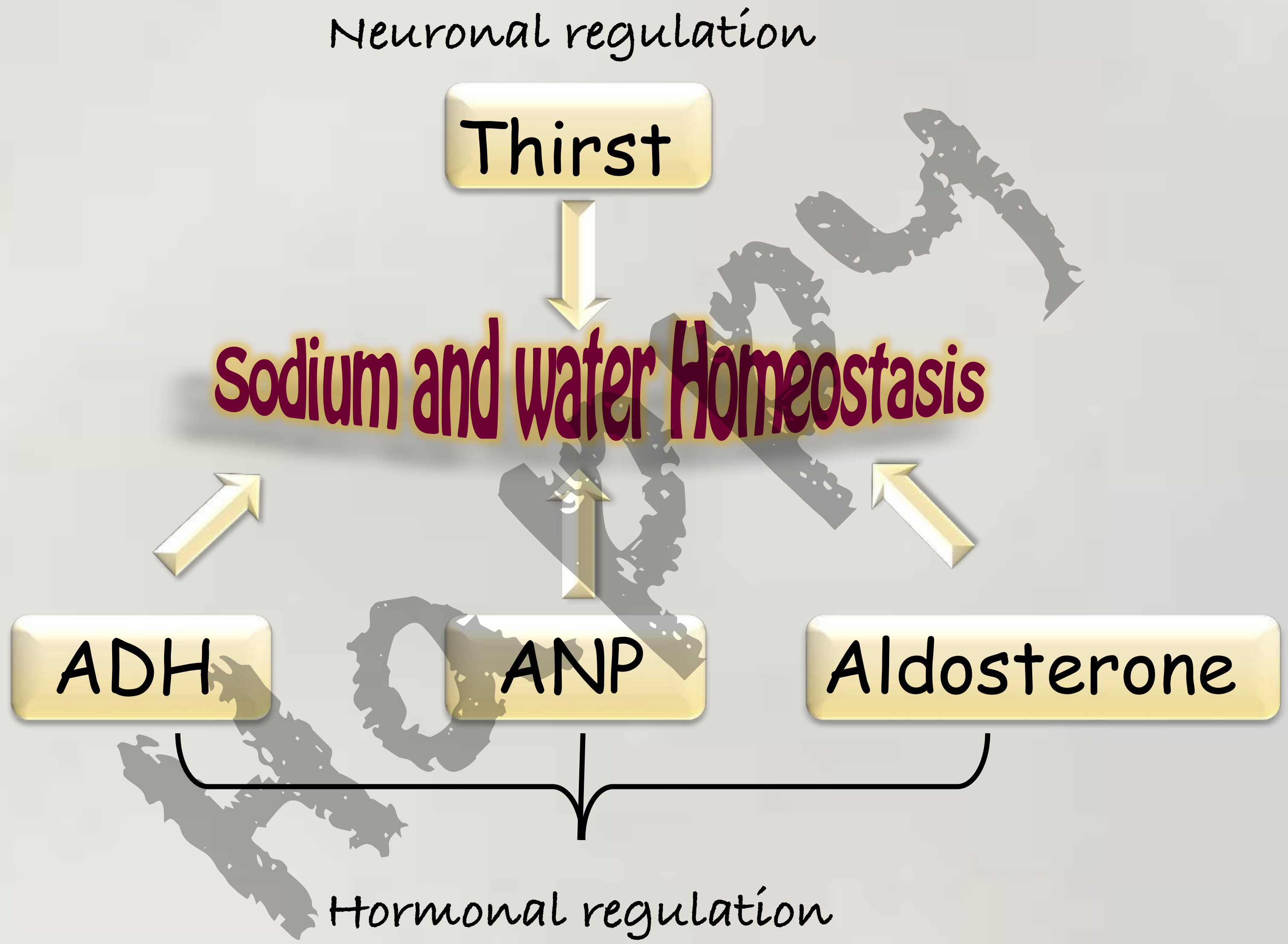
Sodium (Na)

- **Requirements:** 2-3 mEq/100ml H_2O/day



Note: In all figures the tubular lumen is to the left of the cell

Renal Na handling


Neuronal regulation
Thirst
Sodium and water Homeostasis
ADH
ANP
Aldosterone
Hormonal regulation

Na in Neonates and Pre-term Infants

- In the immediate period after birth, neonates manifest a **NEGATIVE** Na balance associated with increased urinary Na excretion and high FeNa.

- Urinary Na excretion in the early neonatal period is due to effect of ANP released as a result of atrial stretch after birth. ANP is implicated in increase GFR (dilates renal vessels) and inhibition of RAS.

- So there is **an initial balance between low GFR (decrease Na excretion) and natriuretic effect of ANP resulting in negative Na balance.**

Na in Neonates and Pre-term Infants

- After sometime, maturational change resulting in increase GFR and **simultaneous tubular maturation and decrease ANP release** >>> positive Na balance to compensate **low Na in breast milk.**

N.B. Urinary excretion of Na is inversely related to gestational age.... Premature < 30 weeks have FeNa near 5% where full-term NB has FeNa 3%.

N.B. Initial negative Na balance is needed to eliminate excess ECW and Na

Hyponatremia

- **Definition:**

  Serum Na < 130 mEq/l

- **Symptoms:**

Acute

- Onset < 48 h.
- Symptoms related to brain edema (H2O moves to brain cells).
- Impaired conscious, seizures and death.

Chronic

- Onset > 48 h.
- Na is usually > 120 mEq/l
- Asymptomatic (brain protective mechanisms)
- GIT symptoms: anorexia, nausea & vomiting

Hyponatremia

Hypotonic Hyponatremia
Low osmolality
<280 mosm/kg

→ True hyponatremia

Isotonic Hyponatremia
Normal osmolality
280-295 mosm/kg

→ Hyperlipidemia
hyperproteinemia

Hypertonic Hyponatremia
High osmolality
>295 mosm/kg

→ Hyperglycemia
Mannitol

→ Na Trend

Actual Na =

Measured Na + 1.6 x each 100 mg/dl glucose

True Hyponatremia

Hypovolemic

U Na > 20 meq/L

- Diuretics
- Mineralocorticoid deficiency
- RTA
- Cerebral salt wasting
- Salt losing nephropathy

U Na < 20 meq/L

- GE
- CF
- Third space loss e.g. Burns, I.O., chylous effusion, etc…

Euvolemic

U Na > 20 meq/L

- SIADH
- Glucocorticoid deficiency
- Hypothyroidism

U Na < 20 meq/L

- Polydipsia
- ? malnutrition

Hypervolemic

U Na > 20 meq/L

- Renal failure

U Na < 20 meq/L

- Liver cirrhosis
- CHF
- Nephrotic $

Na and Renal Failure

- Progressive CRI is typified by an adaptive increase in Na excretion rate/nephron as the total GFR declines. This increase is caused, at least in part, by the effect of ANP & other natriuretic peptides, whose release is augmented in the setting of volume expansion and renal failure.

- As GFR progressively declines towards ESRD, total renal Na excretion eventually decreases, and extracellular volume expansion, hypertension, and edema develop

Correction of Hyponatremia

Goals of treatment

Restoration of normal volume

Symptomatic cases require more rapid correction

Symptomatic hyponatremia within 2 hours
Asymptomatic hyponatremia over 24-48 hours

Changes in serum Na should not exceed 0.5 meq/L /h (12-15 meq/day)

Monitoring of serum Na should be done at least thrice daily

Correction of Hyponatremia

Case 1

An infant 10 kg with gastroenteritis, presented with generalized convulsions. The mother reported trial of correction of GE by water only.

Assessment: moderate dehydration, within normal KFT, serum Na 120 meq/l.

Deficit = (expected - observed) x 0.6(fraction of TBW) x Wt. = mmol

Na Deficit = (125-120) x 0.6 x 10 = 30 mmol (over 1-2 hours)

hypertonic saline : 30 mmol = 60 ml

isotonic saline: 30 mmol = 200 ml

Volume deficit = 80 x 10 = 800 ml (over 6 hours)

So, isotonic saline only can be given over 1.5 hours and then correct the deficit volume over next 4.5 hours.

Monitor serum Na after 6 hours

Correction of Hyponatremia

Case 2

A 17-month-old boy with GE over the last 3 days, moderate dehydration, serum Na 118 meq/l, serum creatinine 1.2 mg/dl. Urine output 0.7 ml/kg/hour. He is fully conscious. No history of convulsions. His weight is 10 Kg.

Deficit = (expected - observed) x 0.6 (fraction of TBW) x Wt. = mmol

Fluid & Na requirements for 24 hours (deficit + maintenance + ongoing losses)

Fluid requirements

Deficit = 80 x 10 = 800 ml

Maintenance = 100 x 10 = 1000 ml

Total = 1800 ml/ 24 h

Na requirements

Na deficit independent of any volume loss= (125-118) x 0.6 x 10 = 42 mmol

Na deficit associated with volume loss = 140 meq/l = 140 x 0.8 = 112 mmol

Na maintenance = 3meq/kg = 3 x10 =30 mmol

Total = 184 mmol/ 24 h

Fluid & Na requirements for 24 hours

Fluid 1800 ml and Na 184 meq

½ of the volume should be given over the 1st 8 hours then the rest over next 16 hours.

- 900 ml G5% : saline (1:2) over the first 8 hours (100 meq Na)
- 900 ml G10%: saline (1:1) over the next 16 hours (75 meq Na)
- Don't forget to add K

Specific Treatment of Euvolemic Hyponatremia

- Fluid restriction
- Diuretics
- Vaptans

Hypernatremia

Disorder of total body water rather than plasma Na concentration

Dehydration vs Volume Depletion

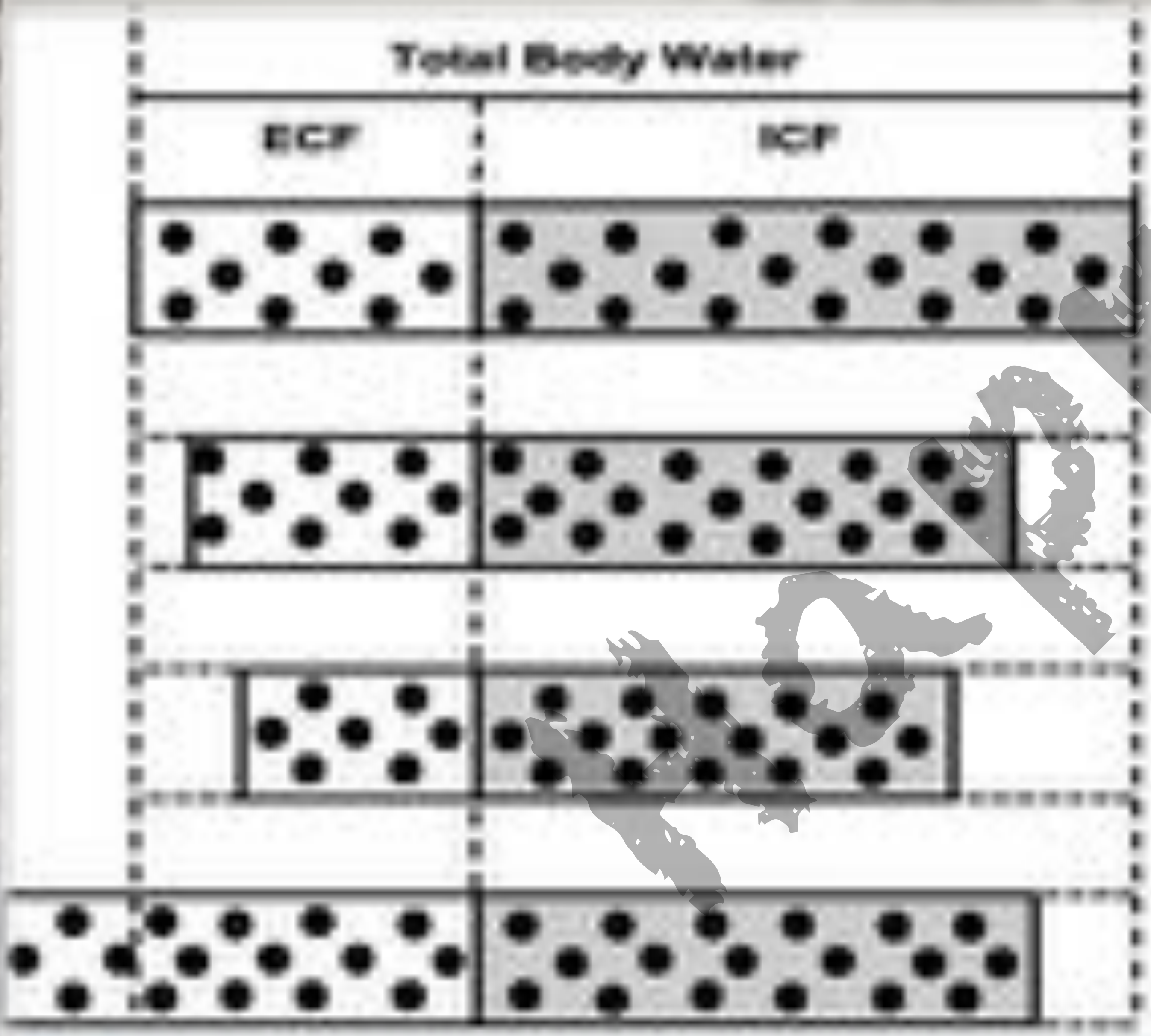
Dehydration	Volume depletion
Body water deficits (intracellular) and disturbance in H_2O metabolism	Extracellular fluid volume depletion. Net loss of TB sodium + ↓IV volume
Dx: measurement of plasma Na / Calculation of plasma tonicity	**Dx**: history and physical examination (e.g. neck veins, etc…)
TTT: replace free water deficit	**TTT**: replace fluid volume deficit

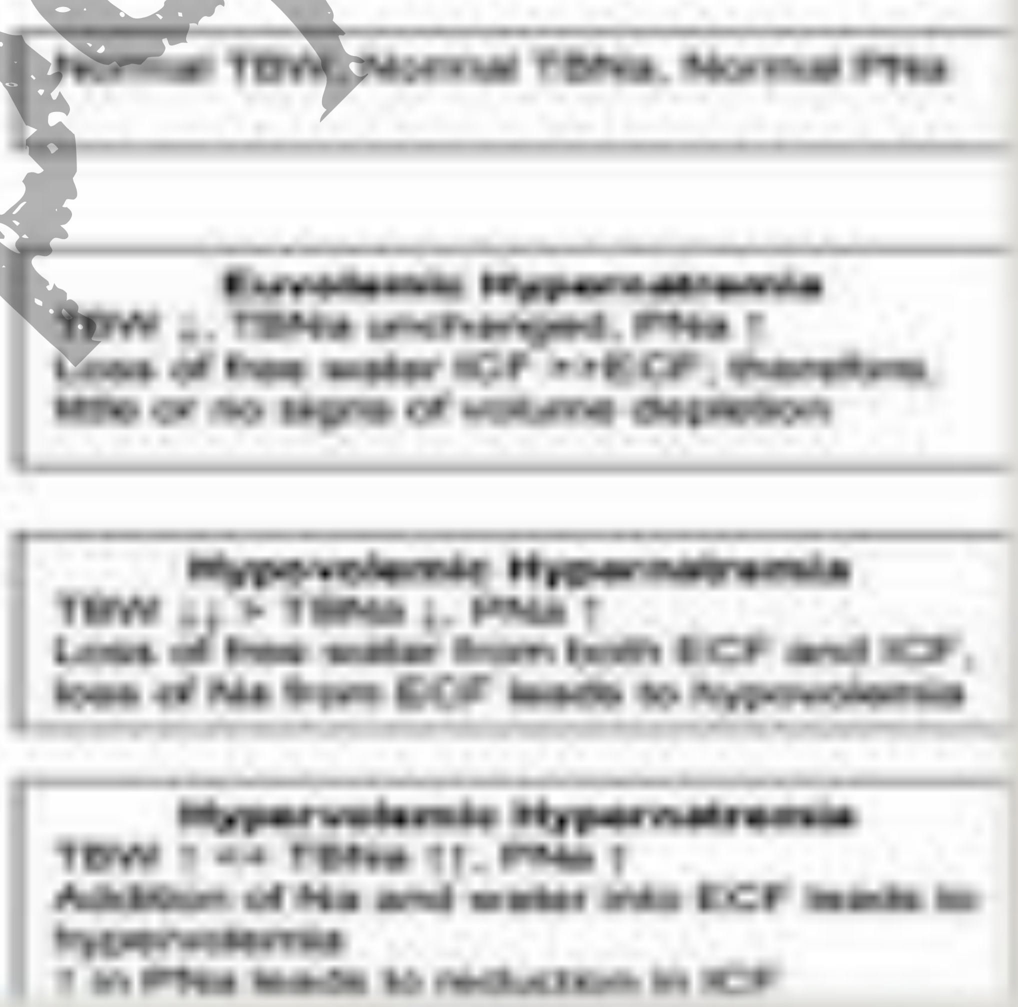
Volume Depletion Versus Dehydration: How Understanding the Difference Can Guide Therapy. Am J Kidney Dis. 2011;58(2):302-309

Hypernatremia

- **Definition:**

  Serum Na >150 mEq/l





Hypernatremia

Hypovolemic TBW ↓ ↓ TB Na ↓		Euvolemic TBW ↓ TB Na ---	Hypervolemic TBW ↑ TB Na ↑ ↑
U Na > 20 meq/L **Renal losses** - Diuretics - Post-obstructive - Renal diseases	**U Na < 10 meq/L** **Extra-renal losses** - GE - Burns	**U Na Variable** ➢ **Diabetes insipidus** -Central - Nephrogenic - psychogenic polydipsia ➢ **Increase insensible loss** - Ineffective breast feeding - Child neglect - Phototherapy	**U Na normal or increased** -Hyperaldosteronism - Cushing $ - Na HCO_3 excessive intake

presumably due to the adve
ate infant formulas and the increased use
availability of oral rehydration solutions.

A group at high risk for developing hypernatremia in the outpatient setting is that of the breastfed infant [30]. Breastfeeding-associated hypernatremia is on the rise. Over 15 % of mother-infant diads have difficulty establishing successful lactation during the first week postpartum. This is of particular concern for the primiparous infant. Reasons for lactation failure are multifactorial, including physiological factors which require
days for optimal breast milk production
factors resulting in a

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Hypernatremia Signs and Symptoms

"you are fried"

Fever (low grade), flushed skin

Restless (irritable)

Increased fluid retention and increased bp

Edema (peripheral and pitting)

Decreased urinary output, dry mouth

Correction of Hypernatremia

Goals of treatment

Emergency phase: shock should receive prompt response

Use of 0.9% NaCl 20ml/kg over 30 min

Rehydration phase: calculate

Free water deficit (in L) = [(current Na÷145)-1] x TBW x B.Wt.

+ Manitenace fluid = Total fluid over 48 hours

- Changes in serum Na should not exceed 0.5 meq/l /h (12-15 meq/day)
- Dehydration should be corrected over 48-72 hours
- Consider dialysis if serum Na > 180-200 meq/l

Correction of Hypernatremia

Hypovolemic Hypernatremia

Goals

- First to correct IV (ECF) fluid volume deficit
- Then correct free water deficit
- Correct underlying cause

Euvolemic hypernatremia

Goals

- First correct free water deficit
- Pharmacological ttt of DI

Hypervolemic Hypernatremia

Goals

- First correct free water deficit
- Then discontinue any sodium source and induce natriuresis

Case 1

An infant 1 year, 10 kg, with gastroenteritis, presented with marked irritability. The mother reported trial of correction of GE by ORS (improper dilution).

<u>Assessment</u>: severe dehydration, urine output < 1ml/kg/hour, serum creatinine= 1.4 mg/dl, serum Na 170 meq/l.

Free H_2O deficit = [(current Na/145)-1] x TBW x B.Wt.

[(170/145)-1] x 0.7 x 10 = 1.2 L = 1200 ml

- Maintenance fluid over 48 hours = 1000 x 2 = 2000 ml
- Total fluid = 3200 ml over 48 hours

Na

. Maintenance = 3 x10 = 30 meq/d = 60 meq/ 48 h

. Deficit = 1.2 x 140 x 0.6 = 100 meq

K

- Maintenance = 2 x 10 = 20 meq/d = 40 meq/48 h

- Deficit = 1.2 x 120 x 0.4 = 57 meq

	Water	Na	K
Maintenance /48h	2000 ml	60 meq	40 meq
Water deficit	1200 ml		
Na deficit		100 meq	
K deficit			57 meq
Total	3200 ml/48 h	160 meq/48 h	97 meq/48 h

Rate of infusion = 66 ml/h (1600 ml over 24 h)

1600 ml fluids /day should contain Na 80 meq Na and 50 meq K (~ Na 50 meq/L and K 30 meq/L)

Type of fluids = G5% : isotonic saline = 2:1 (add 15 ml K ~ 30 meq/L)

Monitor serum Na every 6-8 hours


Thank You