

Sodium Disorders

Hyponatremia
and
Hypernatremia

Serum Osmolarity

A quantity that approximates serum electrolyte concentration.

$$\text{Serum Osmolarity} = 280\text{-}300 \text{ mOsm/kgH}_2\text{O}$$
$$2X[\text{Na}^+] + \text{Glucose}/18 + \text{Bun}/2.8$$

- * Difference between calculated and measured osmolarity should agree within 10 or Pseudohyponatremia

$$\text{True Serum Osmolarity} =$$
$$[\text{Total Cations} + \text{Total Anions}]$$

Effective vs Ineffective Osmoles

Difference is determined by the substances ability to be freely permeable across cell membranes and as a result cause fluid to shift between compartments.



Effective

- Sodium
- Glucose
- Mannitol
- Membrane Impermeant
- Cause change or shift in fluid distribution between ICF and ECF

Ineffective

- Ethanol
- Urea
- Membrane permeant
- Cause no change or shift in fluid distribution between ICF and ECF

Osmolarity Regulation

- ICF Osm. = ECF Osm.
- Interstitial Osm = Serum Osm.
- Hypothalamus is the serum osmostat. It stimulates thirst and ADH secretion.
- Primary Defense for  Osmolarity = Thirst
- Primary Defense for  Osmolarity = Renal excretion of water via ADH effect

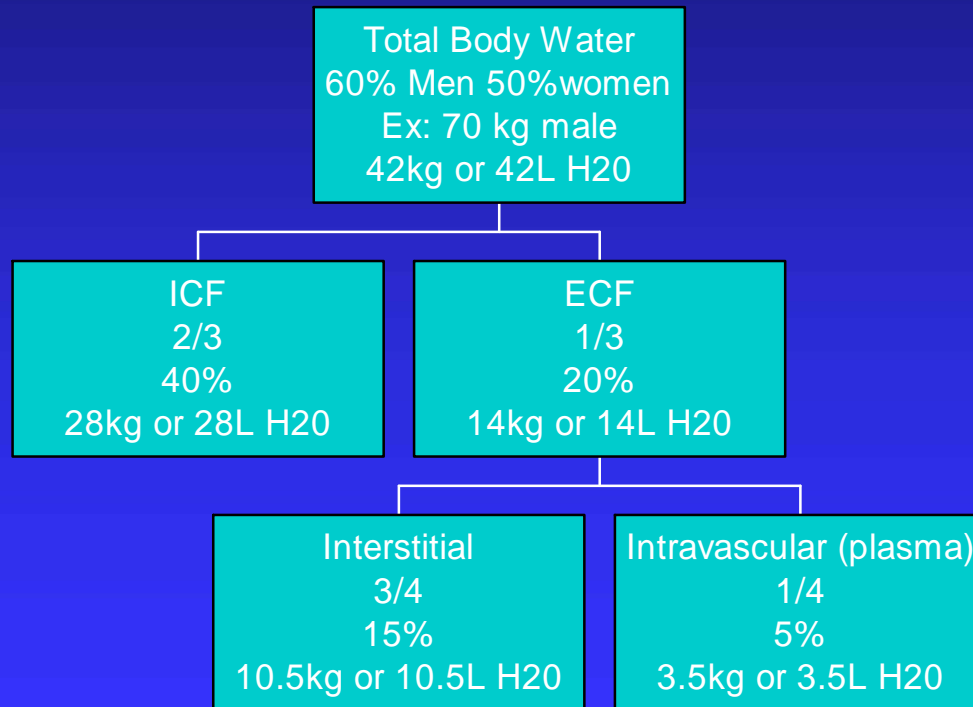
Osmolarity Regulation

- Maximum concentrating ability of kidney is approximately 800-1600mOsm/kg H₂O
- Max. ADH effect decreases urine output to approximately 500 cc/day
- No ADH release increases urine output to 15-20 Liters per day. $U_{osm} = 40 - 80$ mOsm/kg H₂O

Lean Body Mass

Fluid Distribution

Fluid Compartments and Distribution of Total Body Water



Osmolar Distribution

* H₂O freely permeable shift is dependent upon osmolar gradient!!!

- | | |
|--------------------------------------|---|
| ■ Intracellular Osmoles | ■ Extracellular Osmoles |
| ■ Cations = K, Mg, Na | ■ Cations = Na |
| ■ Anions = PO ₄ , Protein | ■ Anions = Cl, HCO ₃ , Protein |

Hypervolemia Hypovolemia

Sx&Sx

- peripheral and presacral edema
 - pulmonary edema
 - jugular venous distension
 - hypertension
 - decr. hct,
 - decr. serum prot
 - decr. bun/cr
 - Una no help
- poor skin turgor
 - dry mucous membranes
 - flat neck veins
 - hypotension
 - incr. Hct
 - incr. serum prot.
 - Incr bun/cr ratio >20:1
 - Una < 20 meq/l

- S_{Na} = measure of concentration
- Reflects water balance or balance of water with sodium.
- Does not necessarily correlate with total body sodium (ECV).
- ECV correlates directly with Total body sodium.

Hyponatremia

- $S_{Na} < 135$ meq/L
- Very common (1-2%) of hospitalized patients
- Most asymptomatic
- Sx usually if $S_{Na} < 125$ meq/L in < 24 hours most everyone sx if $S_{Na} < 115$ meq/L
- Headache, N/V, lethargy, hyperreflexia, spasticity
=> Seizures => Coma=> Respiratory Arrest and Death
- Chronic Hyponatremia if developed beyond 48 hours more associated with lethargy, confusion, muscle cramps

Isoosmolar hyponatremia

- $S_{osm} = 280-300 \text{ meq/L}$
- $S_{osm}(\text{calculated}) - S_{osm}(\text{measured}) > 10$
- Usually pseudohyponatremia patient usually euvolemic
- Iatrogenic Isotonic infusion of glucose mannitol or glycine
- Triglycerides > 1500
- Elevated serum protein >10

Hyperosmolar hyponatremia

- $S_{osm} > 300$
- Patient usually euvolemic
- Fluid shift from ICF to ECF
- Iatrogenic hypertonic infusion of glucose or mannitol
- Hyperglycemia
- Correction factor Na is lowered 1.6meq/L for every 100mg/dl glucose

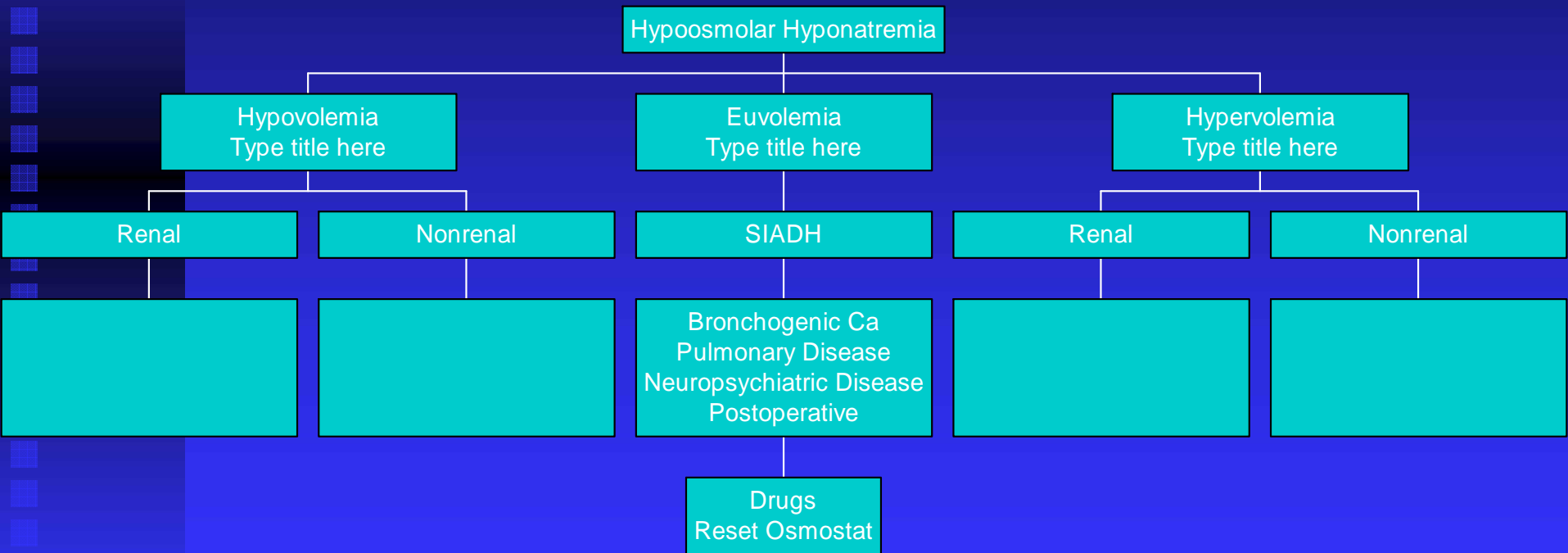
Hypoosmolar hyponatremia

- $S_{osm} < 280$
- Follow Algorithm

Algorithm

- Step 1 $S_{Na} > 145 \Rightarrow$ Hyponatremia
- $S_{Na} < 135 \Rightarrow$ Hyponatremia
- Step 2 Calculate Serum Osmolarity
- Hyponatremia = Hyperosmolar
- Hyponatremia = Is it Hypoosmolar, Isoosmolar or Hyperosmolar
- Step 3 Does calculated serum osmolarity agree with measured serum osmolarity to within 10 meq/l.
- Step 4 Determine ECV status euvolemic, hypovolemic, or hypervolemic (ECV status)
- Step 5 Obtain Urine Sodium and Urine Osmolarity.
- Is Urine sodium $<or>$ 20 meq/l ?
- Is Urine osmolarity $<or>$ 400 meq/l ?

Hypoosmolar Hyponatremia



Euvolemic hypoosmolar hyponatremia

- SIADH
- Increase in total body H₂O not Sodium
- Normal total body sodium
- Diagnosis of exclusion
- Often assoc. with hypouricemia
- ADH level increased

Etiologies of SIADH

- Bronchogenic Ca
- Pulmonary disease i.e. Pneumonia
- Neuropsychiatric disease
- Postoperative

SIADH

- 3 mechanisms of drug action
- 1) Stimulation of ADH release
- 2) Potentiators of ADH action
- 3) Both stimulate and Potentiate
- Drugs (potentiate ADH action) Nsaids, Fibrin acid derivatives
- Drugs (stimulate ADH release) narcotics, barbiturates, chemotx, anticonvulsants, NSAIDs,
- (Both mechanisms) oral sulfonylureas, thiazide diuretics.

Euvolemic Hypoosmolar Hyponatremia

- Other etiologies include
- Reset Osmostat (ADH release varies with changes in S_{osm})
- Psychogenic Polydipsia

Hypovolemic Hypoosmolar Hyponatremia (↓ Total Body Na)

- $U_{Na} < \text{or} > 20 \text{ meq/L}$
- $U_{osm} > \text{or} < 400 \text{ meq/L}$

Hypovolemic Hypoosmolar Hyponatremia

- $U_{Na} < 20$
- $U_{osm} > 400$
- Nonrenal Na Losses
- DDX
 - GI losses (vomiting, diarrhea)
 - Skin losses (burns, fever)
 - Sequestration (Pancreatitis, Peritonitis)
- $U_{Na} > 20$
- $U_{osm} < 400$
- Renal Na losses
- Diuretics
- Mineralocorticoid deficiency
- Osmotic diuresis (glucose, bicarbonate, ketones)
- Chronic Pyelonephritis
- Interstitial Nephritis

Hypervolemia Hypoosmolar Hyponatremia

- $U_{Na} < 20$
 - $U_{osm} > 400$
 - DDX
 - CHF
 - Cirrhosis
 - Nephrotic Syndrome
- $U_{Na} > 20$
 - $U_{osm} < 400$
 - DDX
 - Acute or Chronic Renal Failure

Hyperosmolar Hypernatemia

- $S_{Na} > 145 \text{ meq/L}$
- Less frequent than hyponatremia, 1% hosp Pts.
- $TBW > \text{Total Body Na}$
- Excess H_2O loss or excess Na retention
- Iatrogenic i.e. hypertonic saline or bicarbonate
- Since $S_{osm} \uparrow$ then ADH \uparrow Thirst \uparrow

Hyperosmolar Hyponatremia

- Assess ECV
- Decreased, Normal or Increased
- Check Una and Uosm

Hypovolemic Hypernatremia

- Incr total body Na
- $U_{Na} < 20$, $U_{osm} > 800$
- Extrarenal losses
- Skin
- GI (vomiting, diarrhea, NG tube)
- Incr. total body Na
- $U_{Na} > 20$, $U_{osm} < 800$
- Renal losses
- Diuretics
- Post obstructive diuresis
- Glucose, mannitol, urea
- Nonoliguric ATN

Euvolemic Hypernatremia

- Free H₂O loss
 - Normal total body Na
 - Uosm > 800 Una <20
 - Extrarenal causes
 - Pulmonary and cutaneous insensible losses
- Free H₂O loss
 - Normal total body Na
 - Uosm < 800 Una >20
 - Renal causes
 - Central DI
 - Nephrogenic D.I. (Li, Glyburide, Demeclocycline)

Hypervolemic Hyponatremia

- Iatrogenic
- Replacing hypotonic insensible losses with hypertonic saline

Treatment

- ***Treat underlying cause
- Hypovolemia (IVF replacement, stop medications, cortisol)
- Hypervolemia (Salt and fluid restriction, diuresis, d/c hypertonic saline)
- SIADH fluid restrictions, stop medications
- Central D.I. – DDAVP
- Nephrogenic D.I. – decr salt intake will decr polyuria