Hyponatremia

Physiology of water and sodium balance

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HYPONATREMIA

- Hyponatremia is very important clinically.
- Acute hyponatremia can cause substantial morbidity and mortality.
- Adverse outcomes including mortality and morbidity are higher in hyponatremic patients with a wide range of underlying diseases.

HYPONATREMIA AND ADVERSE OUTCOMES

- Independently associated with high mortality in patients with heart failure.
- High mortality and association with Hepatorenal syndrome in patients with cirrhosis.
- Associated with high rate of hepatic encephalopathy and death in Cirrohosis.

HYPONATREMIA AND ADVERSE OUTCOMES

- Preoperative hyponatremia is an independent marker of peri-operative complications including 30 days morbidity and mortality.
- Patients with hyponatremia demonstrate significant Gait instability --- which resolved with improvement in hyponatremia.
- Hyponatremia is associated with increased risk of falls.

HYPONATREMIA AND ADVERSE OUTCOMES

- Hyponatremia is associated with increased bone loss , osteoporosis and fracture risk.

PHYSIOLOGY OF WATER BALANCE

- Water and Sodium balance are regulated independently by specific pathways.
- Designed to prevent large changes in the Plasma Osmolality and effective circulatory volume.

Difference between sodium and water balance

- Too much water → Hyponatremia
- Too little water → Hypernatremia

- Too much sodium → Edema
- Too little sodium → Volume depletion

HYPONATREMIA

- Hyponatremia is the most common disorder of the electrolytes encountered in clinical practice
- It is seen in up to 15-30% of acutely or chronically hospitalized patients
- Most cases are mild and asymptomatic.

Dysnatremia

- Central point in understanding Dysnatremia.
- Plasma sodium is regulated by the changes in water balance and not by changes in the sodium balance.

Plasma sodium and Osmolality

- Plasma osmolality = 2X Na+glucose/18+urea/2.8
- In normal subjects the effective plasma osmolality can be simplified to
- Effective P Osm = 2 X Na

Plasma Sodium Concentration & Extracellular volume

- There is no predictable relationship between plasma sodium concentration and extracellular volume.
- Plasma sodium concentration is determined by the ratio amount of sodium and water
- Extracellular volume is determined by the absolute amount of sodium and water present.

Plasma sodium and Osmolality

- Alteration in Sodium leads to alteration in plasma osmolality.
- Alteration in plasma sodium leads to changes in intracellular fluid volume.

Hyponatremia vs hyernatremia

Hyponatremia → Fluid movement into the cells

Hypernatremia →Fluid movement out of cells

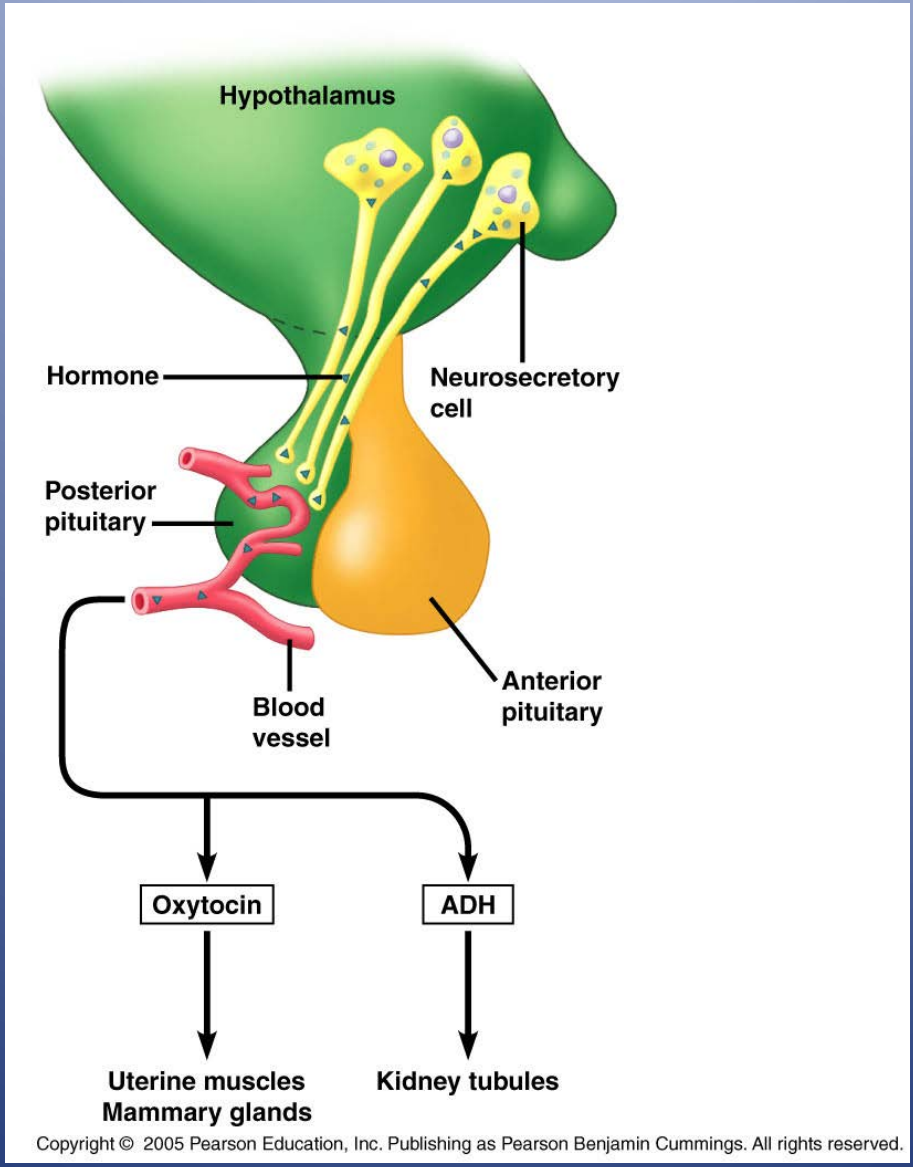
Dysnatremias

- Changes in the volume of the brain cells are largely responsible for the symptoms associated with Dysnatremias.

Antidiuretic Hormone(ADH) / AVP

- Synthesized in the Hypothalamus
- Stored in the posterior pituitary after appropriate stimuli.
- Major determinant of free water excretion or retention.
- It acts on the collecting duct where water can be absorbed independent of sodium

Antidiuretic Hormone



Antidiuretic Hormone

- In the basal state the luminal membrane is essentially impermeable to water
- The major effects of ADH are mediated through V2 receptors which activate ADC
- Activation of adenylcyclase by ADH activates a sequence of events leading to movement of preformed water channels which fuse with the luminal membrane (Aquaporins)

Physiology of water balance

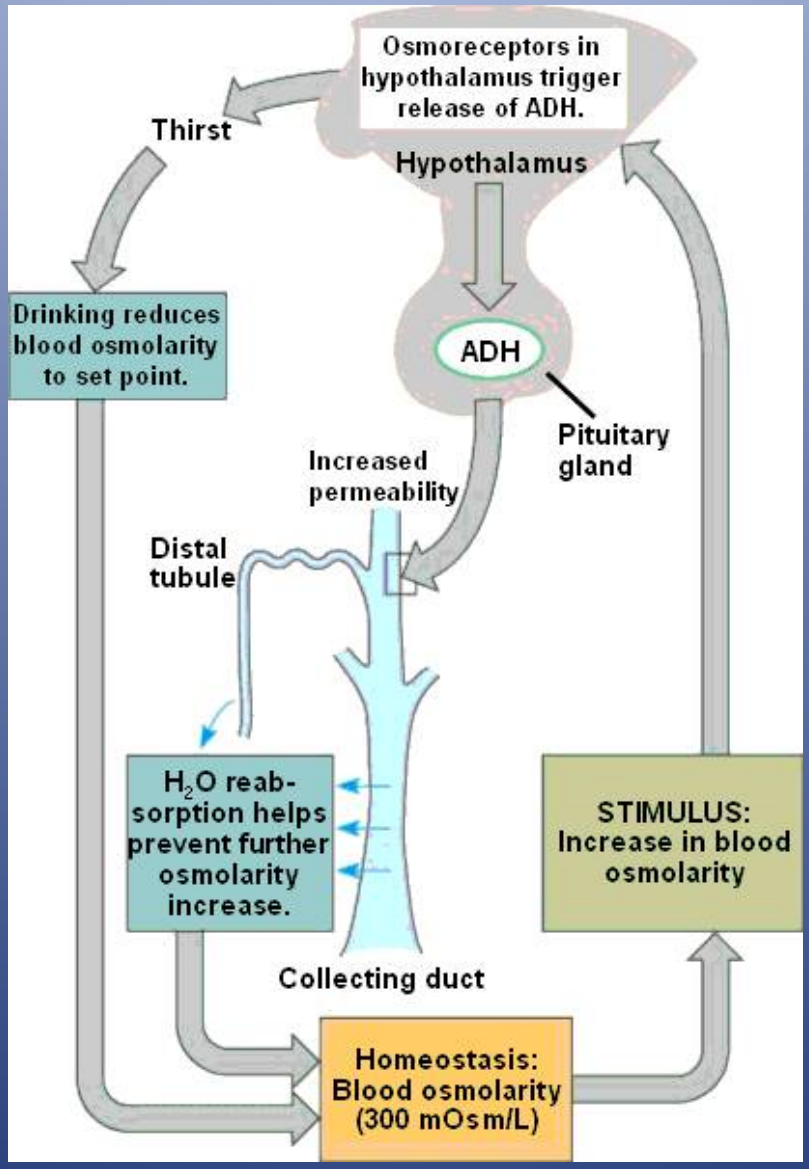
- Urine osmolality can be as high as 1000-1200 mosm/kg in the presence of high levels of ADH

- Urine osmolality can be as low as 50 mosm/kg in the absence of ADH.

Physiology of water balance

- Major stimuli to ADH secretion :
  - Hyperosmolality
  - Volume depletion
- In normal people
  - -Hypernatremia leads to high ADH
  - -Hyponatremia leads to depressed ADH

ADH and Water Balance



Hyponatremia and water balance

- Central role of impaired water regulation, not sodium regulation in the development of hyponatremia.
- Central concept---- the regulation of plasma osmolality and its major determinant, the plasma sodium is achieved by alteration in the water intake and excretion.

Hyponatremia and osolality

- The two main determinant of water intake and excretion :
  - ADH release
  - Thirst
- Addition of sodium without water will raise the P Na
- Addition of water without sodium will decrease P Na

Hyponatremia and Osmolality

- Plasma osmolality = 2 X P Na
- Plasma osmolality = Osmolality of total body water(osmolality of all body water is same)
- Plasma osmolality = 2XNa + 2XK/total BW
- Plasma sodium = Na + K / TBW

Role of potassium on plasma sodium

- Indirect involving transcellular shift.
- In hypokalemia potassium comes out of cell.

- To balance the electroneutrality equal amounts of sodium move into the cell.

Hyponatremia

- Hyponatremia can only occur in two ways:
  - Loss of solute (sodium and potassium)
  - Retention of water.
- Solute loss as occurs in vomiting and diarrhea always occurs in iso-osmotic fluid which can not directly cause hyponatremia.
- Retention of water in excess to the solute is the common denominator.

Hyponatremia is excess of water

- Water retention resulting in hyponatremia generally occurs when there deficit in water excretion.
- Only exception is in patients with psychogenic polydypsia. (Fluid intake can overwhelm the normal water excretory capacity)

Diagnosis of Hyponatremia

- Mild Hyponatremia 130- 135
- Moderate hyponatremia 120-129
- Severe hyponatremia < 120
- History, physical exam, labs

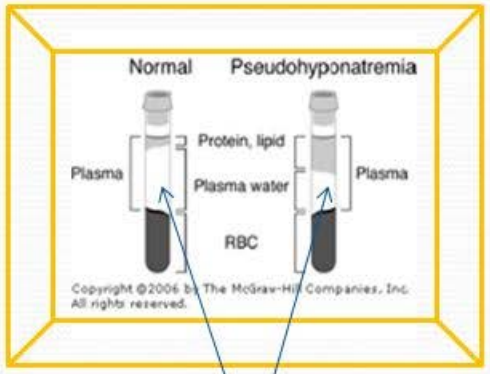
  creatinine, serum K, urine and serum osm ,

  urine sodium.

PseudoHyponatremia

Pseudohyponatremia

- Each liter of plasma contains
  - ~ 930 ml water
  - ~ 70 ml proteins and lipids
- High lipids or proteins reduce plasma water; thus plasma [Na^+], *measured per liter of plasma*, is artifactually low
- Plasma osmolality is unaffected
  - Osmometer measures only the Na+ activity in the *plasma water*



Measurement by an osmometer

What is the normal physiologic sodium concentration?

~ 151 mEq/L plasma water

Hyponatremia in hyperglycemia

- Hyperglycemia increases serum osmolality, resulting in movement of water out of the cells and subsequently in a reduction of serum sodium levels ([Na^+]) by dilution. Therefore, in hyperglycemic patients, the corrected [Na^+] should be taken into account, which is calculated by adding to measured [Na^+] 1.6 mmol/L for every 100 mg/dL increment of serum glucose above normal; a correction factor by 2.4 mmol/L is used when serum glucose concentrations are higher than 400 mg/dL

Incidence of hyponatremia

- Hyponatremia is the most common disorder of electrolytes
- Occuring in 15-30% of acultely or chronically hospitalized patients.
- Most cases are mild and asymptomatic.
- Incidence of severe hyponatremia 1% or less

Clinical importance of hyponatremia

- Acute severe hyponatremia can cause substantial morbidity and mortality

- Rapid correction of chronic hyponatremia can cause severe neurological deficits and death.

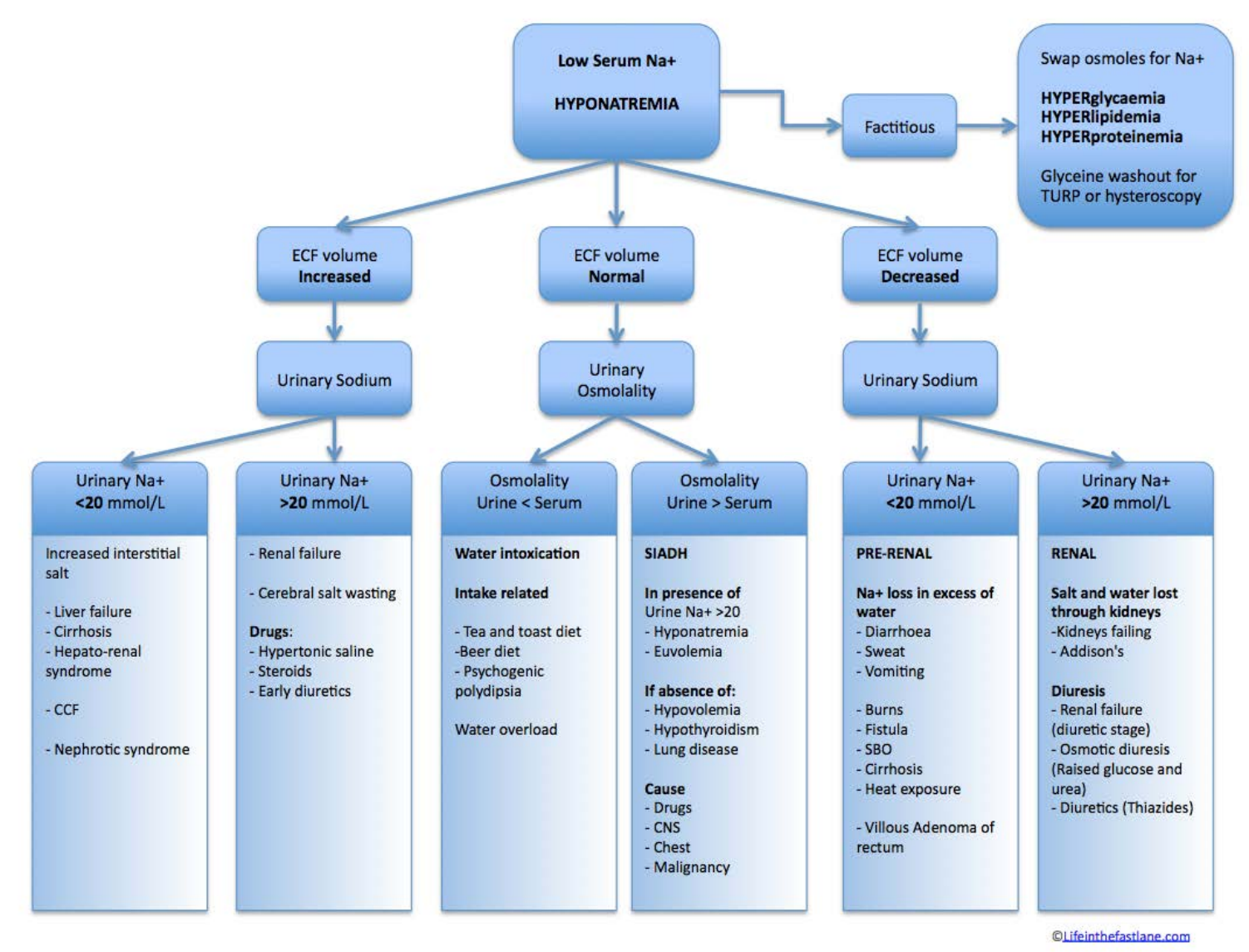
Clinical importance of hypontremia

- Adverse outcomes higher in wide range underlying disease.
- Independently associated with high mortality in patient with heart failure.
- High mortality and association of hepatorenal syndrome, hepatic encephalopathy and death in patients with liver cirrhosis.
- Worse outcome in entire range of inpatient care

Clinical importance of hyponatremia

- Preoperative hyponatremia is an independent marker of perioperative complications including 30 days mortality and morbidity.
- Pts with hyponatremia demonstrated significant gait instability which resolved with improvement in hyponatremia.
- Associated with increased risk of falls.
- Increased bone loss, fracture and osteoporosis.

Classification of Hyponatremia



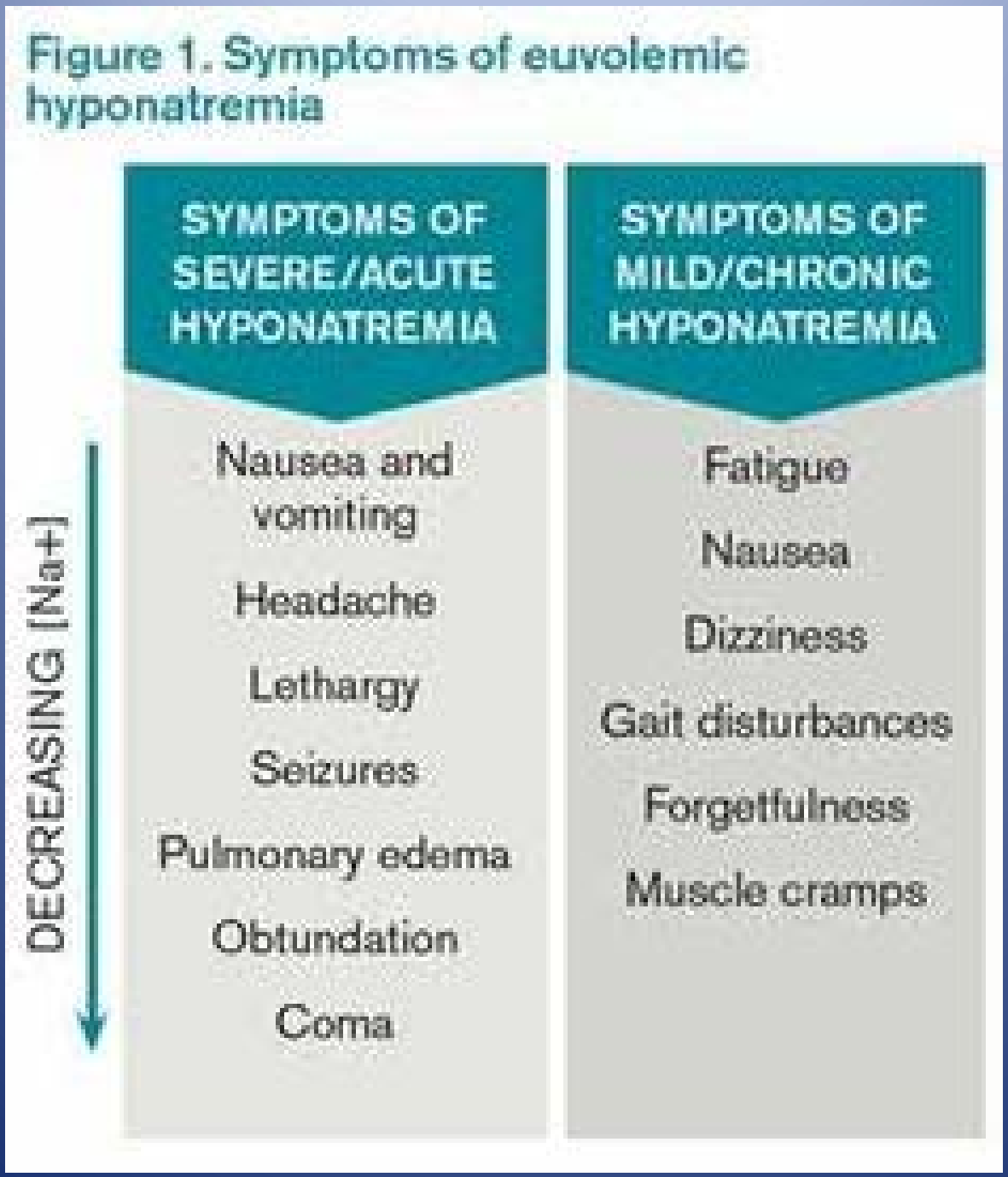
Correction of Hyponatremia

- Etiology or method used to correct hponatremia does not affect susceptibility to complications from overly rapid correction.
- Rate of correction MUST always be the most important consideration before treating hyponatremia.
- When hyponatremia is corrected too rapidly the brain's ability to recapture lost osmolytes can be outpaced leading to osmotic demyelination.

Correction of Hyponatremia

- Pts with acute hyponatremia(<48 hours) may present with alarming neurological findings and sometimes can die of brain edema and brain herniation.
- In chronic hyponatremia(>48 hours) brain cells extrude organic solutes allowing intracellular osmolality to equal plasma osmolality and present with more modest symptoms.

Figure 1. Symptoms of euvolemic hyponatremia



Rate of correction, rcommendations

- Brain herniation, the most dreadful complication of hyponatremia is seen almost exclusively with acute hyponatremia(usually less than 24 hour)
- A review of literature suggest that a 4-6 mmol increase in the serum Na is sufficient to reverse the most serious manifestation of hyponatremia.

Correction of Hyponatremia

- Studies have suggested that a 5 mmol increase in serum Na with hypertonic saline can promptly reverse the clinical signs of herniation and reduce the intracranial pressure by nearly 50%.

Correction of Hyponatremia

- Consensus conference on symptomatic hyponatremia in marathon runner recommends that 100 ml bolus of 3% saline given over 10 minutes in symptomatic acute hyponatremia, can be repeated twice if needed.
- This regimen can be used in the hospitalized patients or in the emergency room.

Correction of Hyponatremia

- Alternatively 3 % saline can be given with infusion at a rate of 0.5-1 ml/Kg per hour with frequent assessment of serum sodium.
- Once 4-6 mmol increase is achieved to reverse the serious sign and symptoms, further correction should be extremely controlled to avoid the neurological sequelae of osmotic demyelination.

Correction of Hyponatremia

Rule of Sixes:

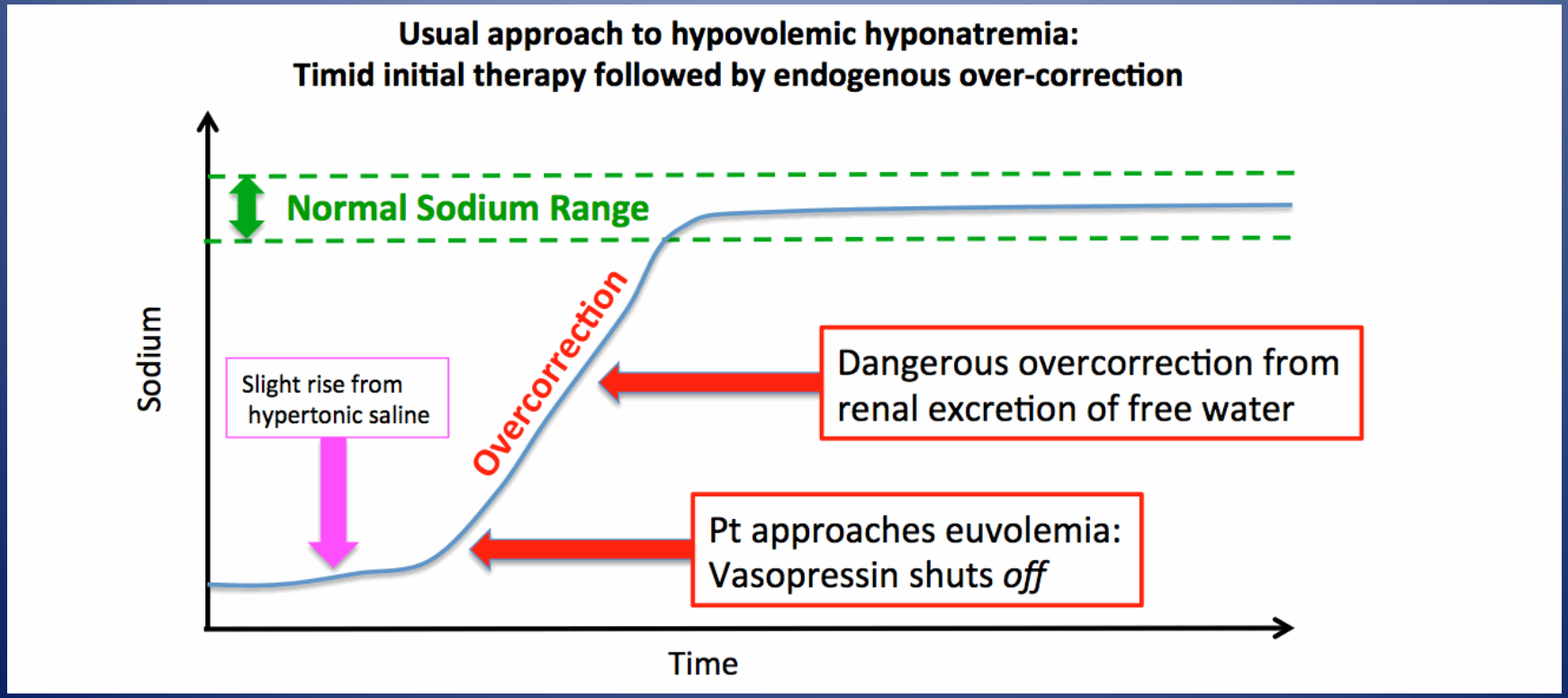
- Six-a-day makes sense for safety
- Six in six hours for severe sxs and *stop*

Explanation:

For all patients with chronic hyponatremia, the goal is 6 mEq/L during the initial 24 hours. For those with severe symptoms (seizure, severe delirium, and unresponsiveness), the goal is preloaded in the first six hours, postponing subsequent efforts to increase serum sodium level until the next day.

Autocorrection in hyponatremia treatment

- Complication of therapy often occurs with rapid autocorrection.



Osmotic Demyelination Syndrome

Osmotic demyelination syndrome…

- Classically associated with demyelination of the central pons- central pontine myelinolysis.
- Extra pontine myelinolysis is also equally common.
- Clinical symptoms start 2 to 6 days after the correction and include dysarthria, dysphagia, paraparesis or quadriparesis, behavioral disturbances, lethargy, confusion, disorientatio n, obtundation and coma.
- Seizures although uncommon are seen.
- Severe cases, patients are ‘locked in’;

Risk factors for Osmotic Demyelination Syndrome (ODS)

- Prior cerebral anoxic injury
  -Hypokalemia
  -Malnutrtion, especially secondary to alcoholism

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QUESTIONS?