Na & Water Imbalance

No.16

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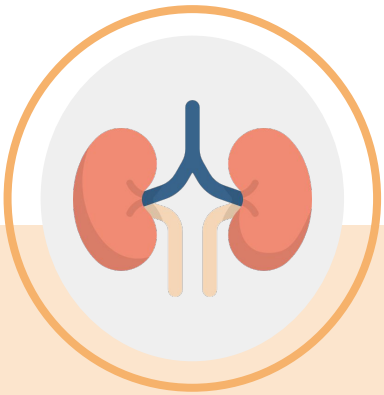

Objectives :

- ★ Short review on the body regulation of the plasma sodium.
- ★ Discuss various etiologies of sodium disorders.
- ★ Understand the diagnostic approach to hyponatremia and hypernatremia.
- ★ Learn the basic management of sodium disorder.

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Outline

We made a short video trying to simplify this lecture for you

We highly recommend checking it out before starting to study this lecture

CLICK HERE TO WATCH



1- How does hyper/hypo natremia occur?

2- Why is it important?

3- How can the body adapt to it?

4- What are the main S&S?

5- How can we classify it?

6- How to approach it?

7- How to manage it?

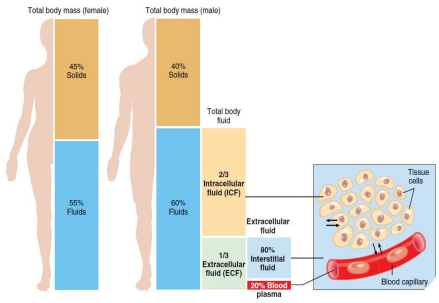
Introduction

◀ Composition of the fluid compartments & Total Body Water

Most of the body consists of fluid and the percentage varies according to age and gender. on average 55% - 60% of the body consists of fluid

➔ **Normal TBW:**
- Men: 60% of body weight
- Women: 55% of body weight
- Pediatrics: 70% of body weight
- Geriatrics: 50% of body weight

➔ **What effects TBW?**
- **TBW ↓ with age**
- TBW ↑ with obesity



◀ Distribution of Water

Total body water (60% x body weight)

Intracellular (ICF)
(2/3 of TBW)
(0.4 x Body weight)

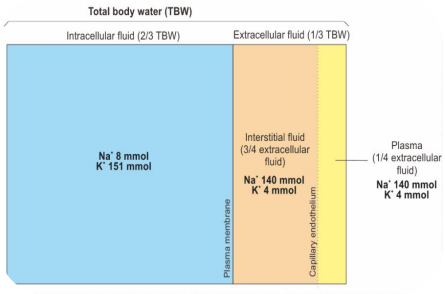
Extracellular (ECF)
(1/3 of TBW)
(0.2 x Body weight)

Interstitial Fluid (ISF)
75%-80%

Plasma
20%-25%

Venous fluid
(85% of plasma)

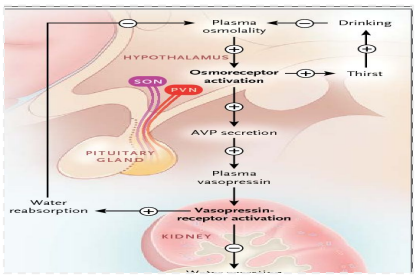
Arterial fluid
(15% of plasma)

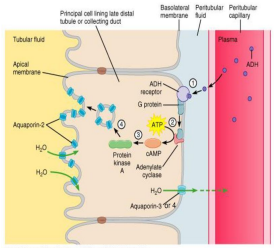


The major Cation in the ICF is **potassium (K)**, while in the extracellular fluid (ECF) it is **sodium (Na)**.
The major force maintaining the difference in cation concentration between the ICF and ECF is the **sodium–potassium pump.**

◀ Hypothalamic-pituitary axis

-Hypothalamus is the main control of the TBW content and the management of Na+
- The stimulation of the osmoreceptors causes the secretion of ADH from the posterior pituitary gland. the vasopressin (ADH) will go to the cortical collecting ducts where it will activate the receptors to release the aquaporins (water channels) so the water will move from the side of tubules to the body
- The osmolality of the blood through the hypothalamus will control the ADH which will control the absorption or excretion of the water in the urine
- Adding water channels back in to the collecting duct would allow some of that water to get reabsorbed, and that's what ADH does





Note: Sodium levels are regulated by aldosterone, natriuretic peptides, and the antidiuretic hormone (ADH) which regulates water excretion in response to changes in water intake

◀ Plasma OsmolaLity

- **Definition:** the number of osmoles per kiLo of water (mOsm/kg water).
- Normal osmolality of body fluids: 283-292 (mOsm/kg water).

★ **Plasma osmolality (mosm/kg) =**

(2 x serum [Na+]) + blood urea nitrogen + plasma glucose

Here glucose is measured in (mmol/l) If you use glucose in (mg/dl) you need to divide it by 18

Hyponatremia

◀ Introduction

- **Whether we look at hypernatremia or hyponatremia as we all know it's a ratio.**
- **Plasma sodium concentration** = ratio between the amounts of sodium and water (concentration).
- **How does hyponatremia and hypernatremia happen?**
- To get hyponatremia you can have too little sodium or too much water. **the majority of the hyponatremia cases are related to water (water excess)**

	Dysvolemia = Sodium Disorder	Dysnatremia = Water Disorder/Tonicity Disorder
Hyponatremia	**Hypovolemia** = Sodium Deficit (too little sodium) (Dehydration) (low volume = Low sodium content)	**Hyponatremia** = relative water Excess (too much water)[1] (Low sodium conc. = high water)

◀ Definition

- **Hyponatremia:** reduced serum sodium concentration (< 135 mEq/L) [1]
- Hyponatremia is common findings **in the elderly: Inpatient (15-20%, Outpatient (7-11%) settings.**

◀ Adverse Outcomes associated in chronic mild to moderate Hyponatremia

- Cognitive impairment and decline
- Falls
- Fractures and osteoporosis
- Gait instability
- Mortality
- Calcium-forming kidney stones

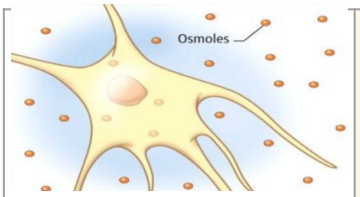
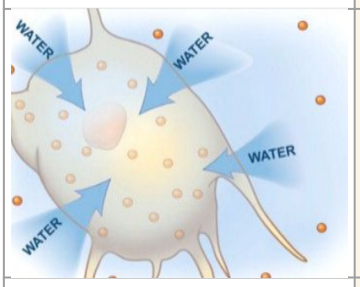
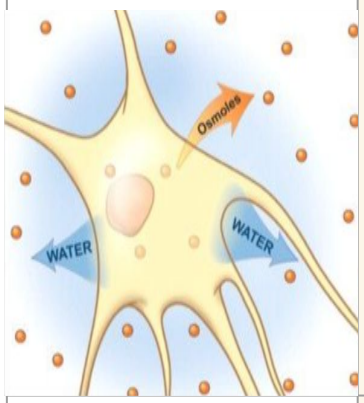
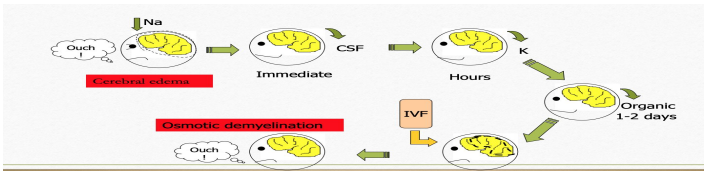
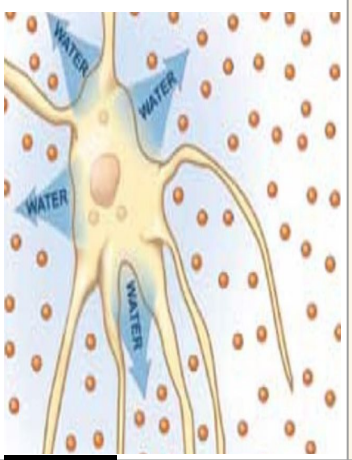
◀ Importance

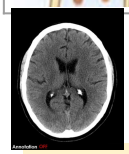
- The most common electrolyte disorder encountered in clinical practice
- **When we manage hyponatremia Two kinds of problems can happen:**
  - Complications due to hyponatremia itself
  - Complications due to overly rapid correction of hyponatremia by physicians

1:Normal serum sodium levels are in the range of 135-145 mEq/L and normal urine osmolality ranges between 40-1200 mosmol/L.

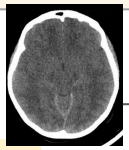
Hyponatremia

Adaptation

	**Normal state**	The extracellular fluid is in osmotic equilibrium with the intracellular fluid. including that of brain cells with no net movement of water across the plasma membrane. the major osmole outside is the sodium.
	**Acute Hyponatremia[2]** Hypernatremia > rapid correction > cerebral edema	If the extracellular fluid suddenly becomes hypotonic relative to the intracellular fluid. water is drawn into the cells by osmosis, potentially causing cerebral edema. if you have a drop in the sodium the water which moves freely between the cells will move inside the cells and they'll get swollen
	**Adaptation[1]**	Over the ensuing few days, brain cells pump out osmoles, first potassium and sodium salts and then organic osmoles (proteins), establishing a new osmotic equilibrium across the plasma membrane and reducing the edema as water moves out of the cells. 
	**Overly aggressive Rx[3] (therapy)** Hyponatremia > rapid correction > osmotic demyelination	With hypertonic saline after adaptation has occurred raises the serum sodium level to the point that the extracellular fluid is more concentrated the intracellular fluid, drawing more water out of the brain cell and causing the **syndrome of osmotic demyelination.** osmotic demyelination can cause severe demyelination of the brainstem that manifest by confusion, sleepiness and end up In Quadriplegia Osmotic Demyelination Syndrome: Damage to the myelin sheath of nerves in the CNS caused by a sudden rise in the osmolarity of blood. Most commonly caused by rapid correction of chronic hyponatremia. The most common type of osmotic myelinolysis is central pontine myelinolysis. Clinical symptoms appear 2–6 days after correction of hyponatremia and include an altered level of consciousness, coma, locked-in syndrome, dysarthria, dysphagia, diplopia, and/or worsening quadriparesis



Normal CT Brain



Acute complication of Hyponatremia[4]

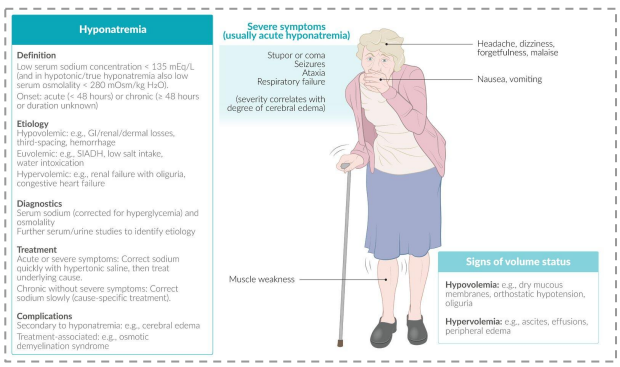
Sever Hyponatremia

Sign & Symptoms

- Often nonspecific
- Headache severe headache or a really imp sx "this is when you have to start management"
- Lethargy
- Dizziness and ataxia

CNS symptoms

- Confusion
- Psychosis
- Seizure
- Coma



1: most of the cells have adaptive mechanisms to get back to the normal size (despite the hyponatremia) these changes are potassium and protein secretion, which will maintain ECF osmolality (hyponatremia will not be resolved)
2: most of our body cells can tolerate the swelling process except our brains; the brain is contained within the skull so it doesn't have the leverage of having significant cerebral edema so in hyponatremia the swelling process within the brain cells (edema) is where you see most of the symptoms related to hyponatremia
3: If you treat hyponatremia vigorously, the cells will shrink, as they already adapted for decreased ECF. Adaptation usually take at least 2 days. Adding sodium will increase the ECF osmolarity and will lead to rapid cell shrinkage with no time to readapt. this is not an issue in all body cells except the brain, where it can lead to cerebral demyelination.
4:Patients with moderate to severe neurologic symptoms (seizures, severe somnolence, dysarthria, and hemiplegia) require urgent treatment to prevent brain herniation and death.

Hyponatremia

We have three common ways to classify Hyponatremia

1. **Severity**
2. **Duration**
3. **Tonicity**

1: Classification Based on Severity of Hyponatremia:

Mild	Serum sodium concentration of 130-135 mEq/L
Moderate	Serum sodium concentration of 120-129 mEq/L
Severe	Serum sodium concentration of <120 mEq/L; may occur at <125 mEq/L in acute settings (if you bring back serum's Na+ quickly from 135 to 125 (most patients will develop symptoms)

2: Classification of hyponatremia Based on Duration:

It is critical to classify the duration because the management will depend on it

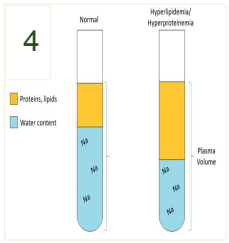
Acute	Chronic
• Hyponatremia that has developed over a period of **<48 hours** • The main pathologic consequence is the development of cerebral edema that may lead to raised intracranial pressure, cerebral herniation, hypoxia and even death • Usually results from parenteral fluid administration in postoperative patients and from self induced water intoxication	• Hyponatremia that has been present for ≥48 hours or the duration is unclear • Due to the **presence of cerebral adaptive mechanisms, many patients exhibit no or minor symptom** majority of patients are asx. However, if they are sx, the majority of symptoms will be related to the brain.

Hyponatremia Classification

◀ 3: Classification of hyponatremia Based on Tonicity:

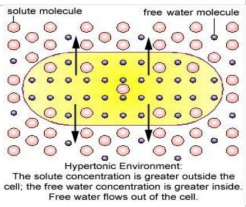
1. Isotonic hyponatremia or Pseudo-hyponatremia)[1,2]

Also known as: Factitious Hyponatremia, Normotonic Hyponatremia

Definition	• low measured serum Na+ levels and normal serum osmolality (275–295 mOsm/kg H2O) • Asymptomatic laboratory artifact falsely indicating hyponatremia when sodium has not been reduced or diluted • Increase in plasma solids lowers the plasma sodium **concentration** . But the **amount** of sodium in plasma is normal (hence, **pseudohyponatremia).** Measure the **plasma osmolarity it will be normal.**
Measuring the concentration of sodium[1]	1) Serum multi analyzers measure [Na+] using indirect potentiometry and specimen dilution. assumes that water constitutes 93% of plasma. High plasma lipid or protein con. will lower the aqueous contribution to plasma volume,leading to a falsely decreased calculated [Na+] value. 2) the second way to measure it is the serum osmolarity: both will be isotonic (normal) 
Causes[1]	• Any condition that leads to elevated protein (e.g multiple myeloma, Hypergammaglobulinemia) • any condition that leads to elevated lipids (e.g severe dyslipidemia)

2. Hypertonic hyponatremia (Translocational hyponatremia[3])

Also known as: Dilutional hyponatremia

Definition	Hyponatremia combined with plasma tonicity > 295, Worse than Pseudo-hyponatremia.
Causes	• Results from non-Na osmoles in the serum drawing Na-free H2O from cells into the intravascular space, causing a decrease in sodium concentration. • Most commonly observed in hyperglycemia. In comparison to the hypovolemic hypernatremia that is caused by hyperosmotic hyperosmolar state, transient hyponatremia occur due to osmotic shifts of water out of cells during hyperosmolar states caused by **acute hyperglycemia** or by mannitol infusion, but in these cases plasma osmolality is normal. In hypertonicemia: the water moves from inside of the cells to the outside of the cells which causes dilution of the serum sodium **but the serum osmolality is high** so it's hypertonic hyponatremia. • Other causes: Mannitol and radiocontrast, • The correction factor is a 1.6 mmol/L decrease in serum Na for every 5.6 mmol per L increase in glucose. For simplicity: for every 10 mmol per L increase in the serum glucose you should correct the serum sodium by 3 . (e.g. if the serum glucose is 15 (it's 10 mmol above 5) and the serum sodium is 133 so you should add 3 = 135). Or for every (100 mg/dl) change in glucose correct Na by (1.6 meq/l) 

1: machines measures sodium conc. by assuming a conc. of 7% for non aqueous particles (proteins and lipids). if these solid components are increased, it will lead to less sodium per unit volume, and the correction formula of the machine (7%) will be inaccurate. This is now becoming less prevalent, as new machines measures Na directly (direct potentiometry)

2:Pseudohyponatremia is a laboratory artifact that can occur in patients with extreme hypercholesterolemia (triglycerides, cholesterol, and lipoprotein X) or hyperproteinemia. Arterial blood gas (ABG) machines use "direct" ion-selective electrodes, which are immune to such artifacts. Physicians should order blood gas analysis with electrolytes using venous sample where normal Na levels are revealed.

3: Seen with hyperglycemia. Water moves from cells to the outside = dilution of serum Na+ and the osmolarity is high

Hyponatremia Classification

3. Hypotonic (hypoosmolar) Hyponatremia (true Hyponatremia)		
Definition	• low measured serum Na+ levels and low serum osmolality < 275 mOsm/kg H2O. So if I have a patient with serum sodium of 120 and it's true hyponatremia the tonicity should be (**low**-normal-high)	
Classification	**ADH Dependant** high urine osmolality is further classified based on extracellular volume status volume status - Hypovolemic Hyponatremia - Hypervolemic Hyponatremia - Euvolemic hyponatremia **Impaired Urinary Dilution**	**ADH Independant** • **Tea and toast diet.** (Low Na^+ diet) • **Beer potomania:** excessive intake of alcohol, particularly beer, together with poor dietary solute intake that leads to fatigue, dizziness, and muscular weakness • Primary polydipsia • Renal failure **Preserved Urinary Dilution** Low Uosm indicative of maximally dilute urine—typically <100 mOsm/kg H2O Vasopressin is appropriately suppress. Causes: Primary polydipsia, "tea-and-toast" diet, Beer potomania

◀ Classification of Hypotonic Hyponatremia based on the ECV status

Hypovolemic Hyponatremia		
Definition		• Decreased total body water with greater decrease in sodium level (Low extracellular fluid volume)
Causes	Extrarenal causes (urinary sodium <20 mmol/L)	• Vomiting • Diarrhoea • Haemorrhage • Dermal fluid loss (e.g., burns, sweating) • Pancreatitis
	Renal causes (urinary sodium >20 mmol/L)	• Osmotic diuresis (e.g. hyperglycaemia, severe uraemia) • Diuretics: Most common cause is thiazide diuretic therapy • Adrenocortical insufficiency (Mineralocorticoid deficiency) (Addison's disease) • Cerebral salt wasting syndrome • Tubulointerstitial renal disease • Recovery phase of acute tubular necrosis
Signs and symptoms		Signs and symptoms associated with volume depletion: Dry mucous membranes, Decreased skin turgor, Vomiting, Diarrhea, Tachycardia, Hypotension
Lab findings		**Elevated** blood urea nitrogen-to-creatinine ratio and uric acid level; To avoid volume contraction the body will try to increase urea and decrease Na excretion in urine Urinary sodium usually <20 mEq/L unless the kidney is the site of sodium loss (Urine osmolality is low -> drink lots of water. Osmoreceptors will shut down (ADH will not be secreted) so cortical collecting duct will not be absorbing any water and all of the water will be excreted = low urine osmolality)) when volume is contracted we want to preserve the serum Na so urine Na will be **low**

Hyponatremia Classification

Hypervolemic Hyponatremia		
Definition		• Increased total body water compared with sodium that occurs when kidneys cannot excrete water efficiently • High extracellular fluid volume
Causes	Extrarenal causes	• Congestive heart failure • Liver cirrhosis • Severe hypoproteinemia (e.g., nephrotic syndrome)
	Renal causes	• Renal injury (Acute or chronic renal failure with low urine output (i.e., failure to excrete free water))
Signs and symptoms[1] Gain more than 5L -> Poor perfusion of the kidney -- hypovolemic status of the kidney --- go to edematous		• Peripheral edema • Ascites • Raised jugular venous pressure • Pulmonary edema ----> crackles • Underlying illness
Lab findings		Useful diagnostic lab findings are elevated plasma levels of brain natriuretic peptide and spot urine of <20- 30 mEq/L
Euvolemic hyponatremia Accounts for the **majority** of hyponatremia cases		
Definition		• Increased total body water with normal sodium level • Normal or minimal changes in extracellular fluid volume
Causes results from an intake of water in excess of the kidneys' ability to excrete it (dilutional hyponatraemia); there is no change in body sodium content but the plasma osmolality is low.	Extrarenal causes	• Hypothyroidism • primary polydipsia • glucocorticoid deficiency 2nd common cause, usually accompanied by hyperkalemia and metabolic acidosis (Addison's disease) • Water intoxication (dilutional hyponatremia) • Decreased salt intake (e.g., "tea and toast" diet) • Renal osmostat (Misdiagnosis with SIADH is common, when the real diagnosis is renal osmostat. In this situation, the threshold for secreting ADH is decreased. Common causes are pregnancy and Hypothyroidism.) • Iatrogenic[1]
	Renal causes	• Most commonly caused by **syndrome of inappropriate antidiuretic hormone (SIADH)** 1st common cause • **Drugs:** eg. antidepressants , Glitazones
Signs and symptoms		• depend on the underlying illness
Lab findings		• Low serum uric acid levels • Normal blood urea nitrogen-to-creatinine ratio • Spot urinary sodium >20 mEq/L

1: Most commonly happens due to over-generous infusion of 5% glucose post operatively. Generally Hyponatremia with euvolemia can lead to hyponatremic encephalopathy (due to cerebral edema) this most commonly happens post surgery to premenopausal women, as their ADH levels are usually already very high. High risk population also include children, as their brain to skull ratio is higher than that of adults. if this insult has happened, Hypoxemia is the most important prognostic factor

Hyponatremia

◀ Diagnostic criteria for SIADH "HIVE"

Essential features:

H

H: Hypoosmolar Hyponatremia (Decreased serum osmolality <275 mOsm/Kg)

I

I: Inappropriate urine concentration (Urine osmolality >100 mOsm/Kg) during hypotonicity of the serum

V

V: Clinical Euvolemia[1]

E

E: Endocrine = normal Thyroid and adrenal function

\+ Urinary sodium >40 mmol/L with normal dietary salt intake and no recent use of diuretics

Supplemental features:

- Low Serum uric acid
- Low normal Serum urea serum creatinine
- Fractional sodium excretion >1%,
- fractional urea excretion >55%
- Failure to correct hyponatraemia after 0.9% saline infusion
- Might be helpful in an MCQ case:
  - Post-op neurosurgery patients with hyponatremia
  - Cystic fibrosis
  - Brain tumors
  - Small cell lung carcinoma
- Correction of hyponatremia through fluid restriction
- Abnormal water loading test (excretion <80% of a 20 mL/kg water load in 4 h)
- Elevated vasopressin levels despite hypotonicity and clinical euvolemia

◀ Etiology of SIADH

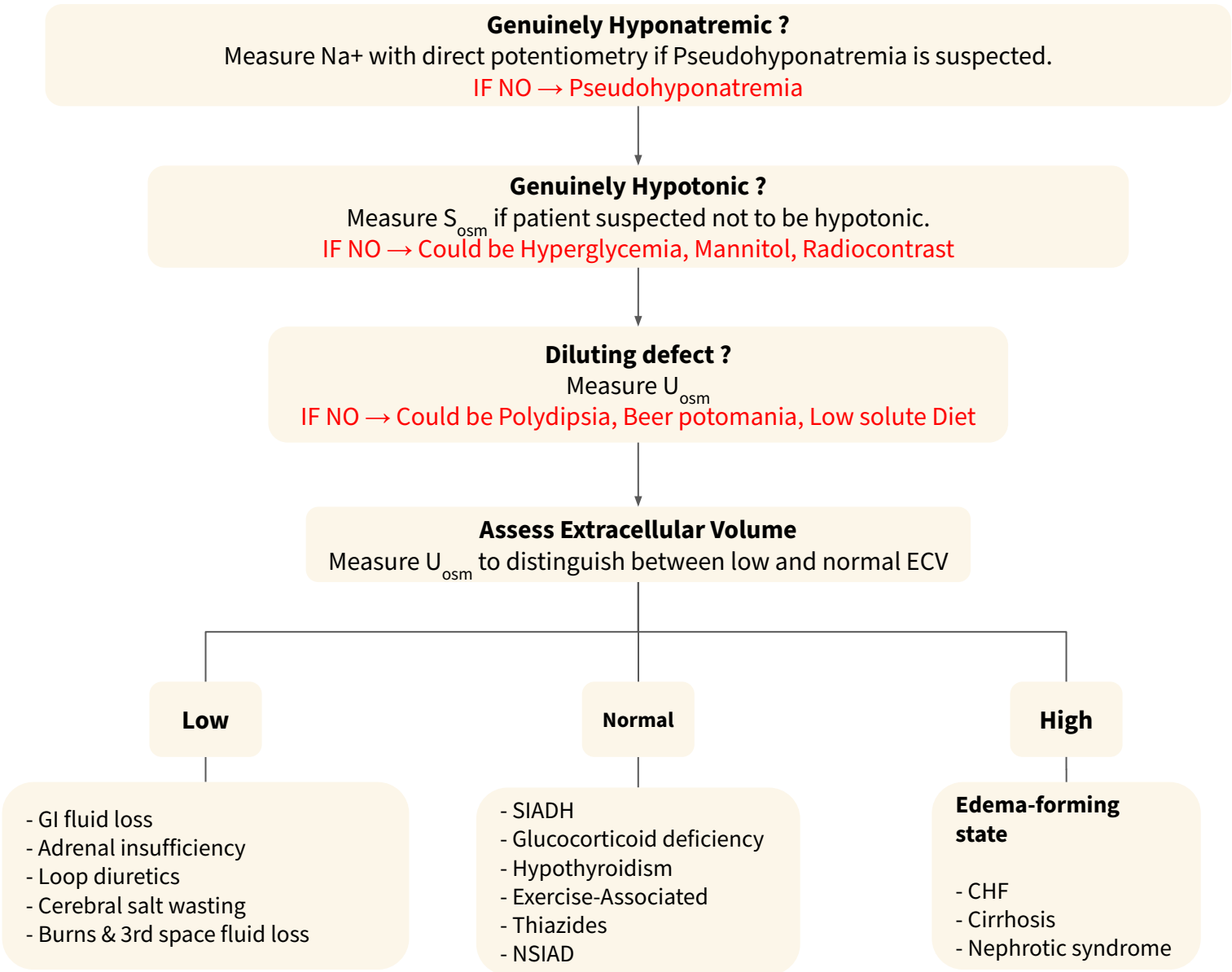
Medical Conditions	Drugs
Acute illness, emotional stress, psychosis, pain, and nausea	Antidepressants & antipsychotics: Selective serotonin reuptake inhibitors, tricyclics, venlafaxine, phenothiazines, butyrophenones, monoamine oxidase inhibitors
Exercise-associated hyponatremia	
Pulmonary diseases: Any form of pneumonia, acute respiratory failure, pneumothorax, and acute respiratory distress syndrome	Anticonvulsants: Carbamazepine, sodium valproate, lamotrigine
HIV infection, adrenal insufficiency, hypothyroidism	
Central nervous system (CNS) disorders: Stroke, hemorrhage, infection, trauma, and psychosis	Anticancer drugs: Vinca alkaloids, ifosfamide, melphalan, cyclophosphamide, methotrexate
Surgical procedures: Orthopedic surgeries (e.g., hip & knee replacement) and trans-sphenoidal pituitary surgery	Vasopressin analogues: Desmopressin, oxytocin, terlipressin, vasopressin
Ectopic production of ADH: Most often due to small cell carcinoma of the lung (extrapulmonary small cell carcinoma in a few cases). Other causes include head and neck cancer, olfactory neuroblastoma, C-cell carcinomas of the thyroid, and pancreatic cancer	Miscellaneous: Opiates, nonsteroidal anti-inflammatory drugs, MDMA (ecstasy), levamisole, clofibrate, interferon, amiodarone, bromocriptine, angiotensin-converting enzyme inhibitors
Hereditary and idiopathic causes	

1-Clinical euvolemia is an important prerequisite for the diagnosis of SIADH, which can be easily established based on history and physical examination. It is important to rule out overt hypothyroidism and adrenal insufficiency before diagnosing the patient with SIADH. The main laboratory criteria are measured serum osmolality <275 mosmol/kg, serum uric acid less than 4 mg/dL (Low), urine osmolality >100 mosmol/kg, and urine Na >40 mEq/L

Hyponatremia

Approach to Hyponatremia

1. Confirm the patient truly has a hypo-osmolar state by checking **serum osmolality** (To make sure it's true Hyponatremia)
2. Assess for serious signs or symptoms suggesting cerebral edema
3. Determine the duration of development of hyponatremia (less or more than 48 hours)
4. Assess the patient's extracellular fluid volume status using clinical examination and laboratory testing
5. Check the urine osmolality to see if the urine is appropriately dilute (< 100 mOsm/kg) or inappropriately concentrated (≥ 100 mOsm/kg). You want to exclude ADH independent before going to ADH dependent. (When you have ADH in the blood , the urine **osmolality will be high**)
6. Assess for underlying causes of hyponatremia
7. Look for drugs the patient is taking that potentiate antidiuretic hormone action (e.g., selective serotonin uptake inhibitors)



Hyponatremia

History	Physical Examination
• Inquire from patient's history possible causes of hyponatremia • History of cardiac, cancer, pulmonary, endocrine, gastrointestinal, neurologic and renal diseases • History of electrolyte-rich fluid loss (eg vomiting, diarrhea or diuretic therapy) • History of low protein intake and/or high fluid intake • Medications used (eg diuretics, Carbamazepine, selective serotonin reuptake inhibitors) • Alcohol and illicit drug use (eg beer, 3,4-methylenedioxymethamphetamine/"Ecstasy") • For athletes, training regimens because high-endurance activities can cause hyponatremia; because when they are running, they lose a huge amount of sweating (contains Na) and drink only water • History of very recent surgery	- The patient should be examined to determine volume status, looking for signs of dehydration or volume overload. - Polyuria is most common in primary polydipsia **- Signs of volume depletion include:** • Low urine output • Weight loss • Orthostatic hypotension • Decreased jugular venous pressure • Poor skin turgor • Dry mucous membranes • Absence of axillary sweat • Absence of edema. **- Signs of volume overload include:** • Edema and/or ascites • Rales or crackles on lung auscultation • Significant weight gain . Raised jugular venous pressure.

◀ Management of Hyponatremia

How to manage hyponatremia ?

1. Treat neurologic emergencies related to hyponatremia
2. Evaluate and defend intravascular volume
3. Prevent worsening hyponatremia
4. Prevent rapid overcorrection
5. Treat the Underlying cause

Prevent worsening of hyponatremia: strict fluid restriction and saline locking the IV; applied to all hyponatremic patients.

Prevent Rapid Overcorrection:-

- Target rate of sodium correction ⟶ **Rule of 6s :**
  - Six in six hours for severe symptoms then stop
  - Six a day makes sense for safety

  The rule of 6s can be helpful in guiding your correction of hyponatremia. "Six in six hours for severe symptoms and then stop" implies that if you need to rapidly increase serum sodium due to a neurologic emergency do not correct more than 6mmol. "Six a day make sense for safety" implies that you should not exceed an increase of sodium of more than 6mmol/day.

- Prevent overcorrection ⟶ **Rule of 100 :**
  - Insert a foley catheter and monitor intake and outputs.
  - If urine output >100cc/hour, send STAT urine osmolarity and urine sodium.
  - If urine osmolarity<100, consider administering Desmopressin(DDAVP) IV. Consider DDAVP for appropriate candidates.

Hyponatremia

◀ Management of Hyponatremia

Chronic (>48hours)	***1. Hypovolemic Hyponatremia*** • 1st isotonic fluid infusion • plus treat underlying cause ***2. Hypervolemic Hyponatremia*** • Fluid restriction • plus treat underlying cause • adjunct loop diuretic or spironolactone • Vasopressin receptor antagonist
Acute symptomatic hyponatremia	• Supportive care: ICU admission and close monitoring • Correct acute, severe hyponatremia with bolus(es) of hypertonic saline or sodium bicarbonate. • Goal: Raise sodium by 4–6 mmol/L and stop[1]. • 3% NaCl: 2mL/kg over 10min. If persistent symptoms, may repeat 2X until symptoms resolve • NaHCO3: 100 cc of 8.4% sodium bicarbonate (2 “ampules” of crash cart bicarb)over 10 minutes (=200 ml of 3% Saline). • The rate of sodium correction should not exceed 6 to 8 mEq/L in 24 hours or 12 to 14 mmol/L in 48 hours • Treat the underlying cause
Euvolemic Hyponatremia	• Careful monitoring during treatment • Fluid restriction • Loop diuretics plus salt tablets to replace urinary sodium losses • Urea tablets or Sodium-Glucose Transport Protein 2 (SGLT2) Inhibitors • Vasopressin receptor antagonists • Enhance solute intake if poor nutrition • Discontinue medications associated with syndrome of inappropriate antidiuretic hormone secretion (SIADH) • Treatment of underlying condition associated with SIADH (eg, antibiotics for pneumonia) • Treatment of endocrinopathy (eg, hypothyroidism) • Treatment of underlying carcinoma if ADH-secreting tumor • Demeclocycline (Declomycin)

Note:The text with gray highlight were mentioned in 439 slides and mentioned as doctor notes in our slides

1-Usually we raise the serum sodium from 6-8 mmols per day but in cases of emergency like if the patient had a seizure we can’t wait for 24 h we have to raise it quickly so we raise from 4-6 mmols in the first hours

Hypernatremia

◀ Definition

- Hypernatremia, serum sodium concentration of **145 mmol/L** a state of total body water deficiency absolute or relative to total body sodium.
- Hypernatremia is common in ICU, the older nursing home resident, usually with dementia and infant.
  - **Inpatient (1%)**
  - **Outpatient (2%)**

Clinical presentation:

- Often asymptomatic
- Irritability, nausea, weakness, altered mental status
- Brain shrinkage, resulting in vascular rupture and intracranial bleeding

◀ It can result from:

	Water loss (Euvolemic hypernatremia)	**Hypotonic fluid loss** (Hypovolemic hypernatremia)	**Hypertonic fluid gain** (Hypervolemic hypernatremia) Seen frequently in CCU or emergency
Definition	high serum Na+ levels with normal or minimal changes in extracellular volume as a result of pure water deficit	high serum Na+ levels with decreased extracellular volume as a result of hypotonic fluid loss	high serum Na+ levels with increased extracellular volume as a result of intake of hypertonic water or retention of sodium in excess of water
Causes	**Extrarenal causes:** (manifests with oliguria due to decreased water intake): e.g Lack of access to water, Impaired thirst mechanism **Renal causes:**(causes increased thirst due to polyuria) e.g.diabetes insipidus [DI]	**Extrarenal cause** (manifests with oliguria due to dehydration) Gastrointestinal loss (e.g. diarrhea,vomiting) Dermal fluid loss (e.g., burns, excessive sweating) **Renal cause** (leads to dehydration due to polyuria) Diuretics osmotic diarrhea (e.g., hyperglycemia, mannitol)	**Extrarenal causes** (initially manifests with polyuria due to fluid overload, followed by dehydration due to polyuria) **Iatrogenic** (Sodium containing fluids e.g. IV Fluid) : excessive infusion of NaCl, sodium bicarbonate solutions, or hypertonic saline **Renal causes** (causes hypertension and hypokalemia with normal urine output and no fluid overload): Primary hyperaldosteronism Cushing syndrome

◀ Pathophysiology

Hypernatremia is caused by:

- The majority of hypernatremia cases are related to Net water loss (increased loss or decreased intake)
- Rarely, sodium gain.

Patients at increased risk:

- Impaired thirst mechanism or e.g: severe dementia , insult in the brain or comatose
- Restricted access to water (e.g., those with altered mental status, intubated patients, infants, older adults).

Hypernatremia

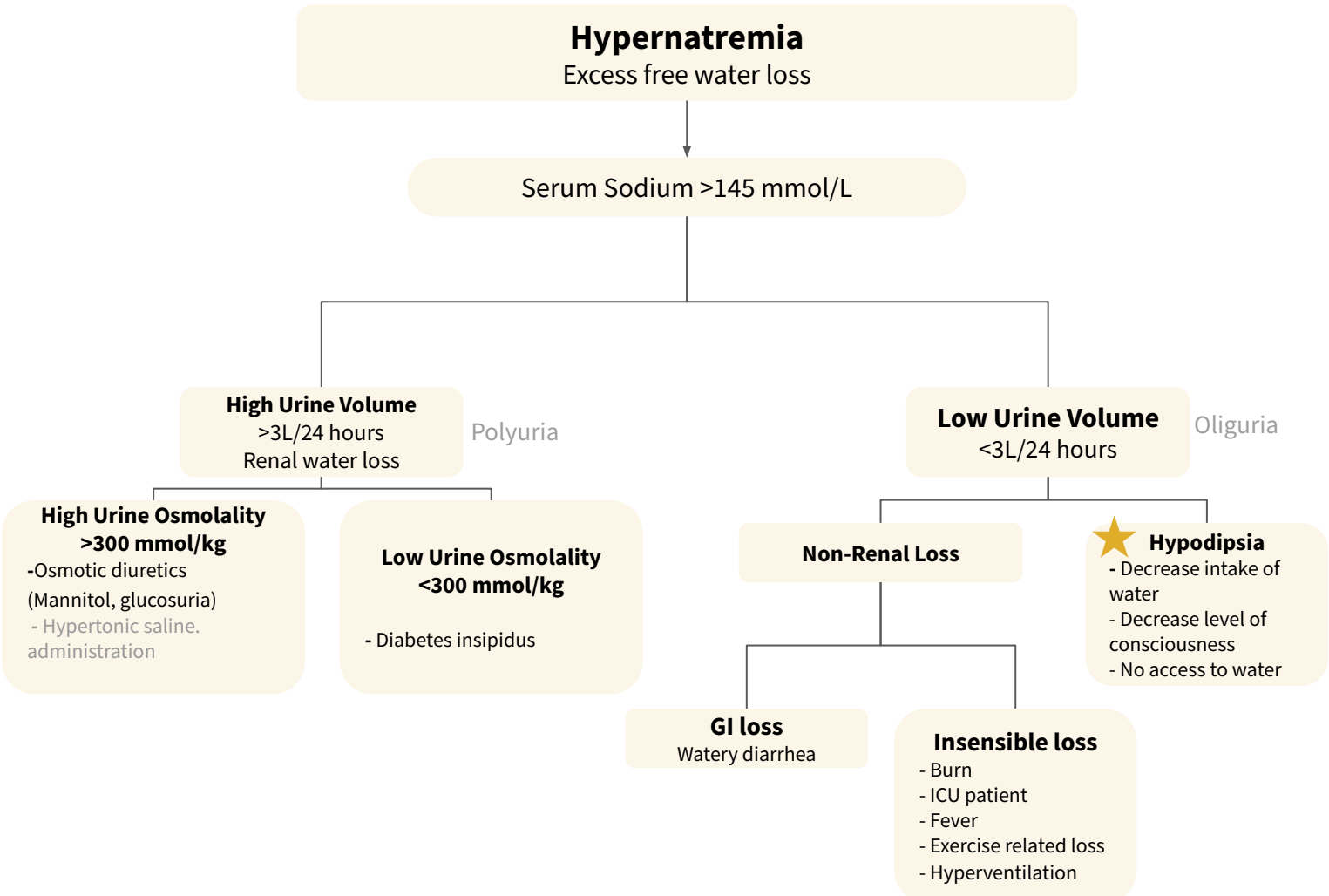
◀ Approach to Hypernatremia

- Detailed History AND Urine Osmolality can reveal most of the cases:
  - Water loss (GI loss or Insensible loss or Polyuria)
  - Lack of access to water or Primary neurological disease

- 1-In hypernatremia, the ADH and urine osmolality should be high however, If You look for the urine volume and the patient has polyuria (more than 3L/day) and low urine osmolality then the only cause is **Diabetes insipidus** whether central or nephrogenic

  2- High urine osmolality (more than 300) and polyuria means there is osmose in the urine that dives the polyuria most common osmose is glucose **(hyperglycemia)**

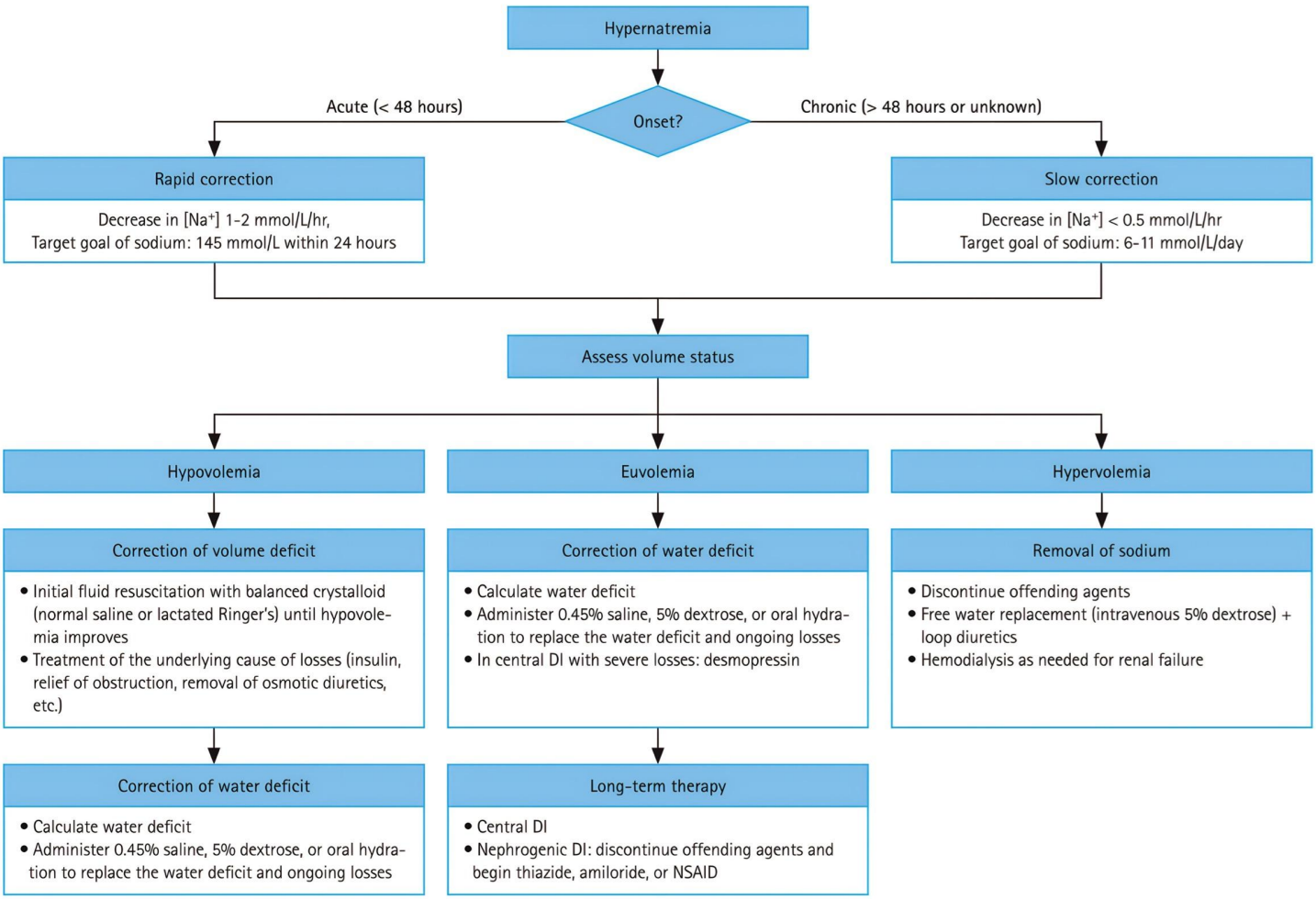
  3- low urine volume(oliguria) and high urine osmolality happen in cases of hypodipsia (mental disease, ..) and loss of liquid with sodium through GIT (diarrhea) or skin



Hypernatremia

◀ Approach to Hypernatremia

- **Determine whether the extracellular volume is hypovolemic, euvolemic, or hypervolemic** using the history and physical examinations
- **Measure urine sodium:**
  - Volume depletion exhibit decreased sodium excretion in the urine (< 20 mmol/L).
  - Elevated urine sodium concentration (> 20 mmol/L): Osmotic diuresis, the use of diuretics, postobstructive nephropathy, or the recovery phase from acute tubular necrosis
- **Measure urine volume and Urine osmolality:**
  - A Uosm < 300 mOsm/kg and polyuria (> 3 L/day or > 40 mL/kg/day) suggest the presence of diabetes insipidus; Administration of exogenous AVP enables the distinction between central and nephrogenic diabetes insipidus
  - If Uosm is between 300 and 800 mOsm/kg, this may reflect a process of osmotic diuresis



◀ Water Deficit Calculation

Free Water Deficit (FWD) = TBW x (serum [Na] -140) / 140 depend on age and gender

- TBW = wt (kg) x 0.6 (male) or 0.5 (female). If elderly use, 0.5 (male) and 0.45 (female)
- E.g. Serum Sodium 150 mmol/l in 70 Year old gentleman with a body weight of 60 Kg
  - TBW = 0.5 x 60 = 30 L
  - FWD = 30 L x (150 -140) /140)= 2,1 L

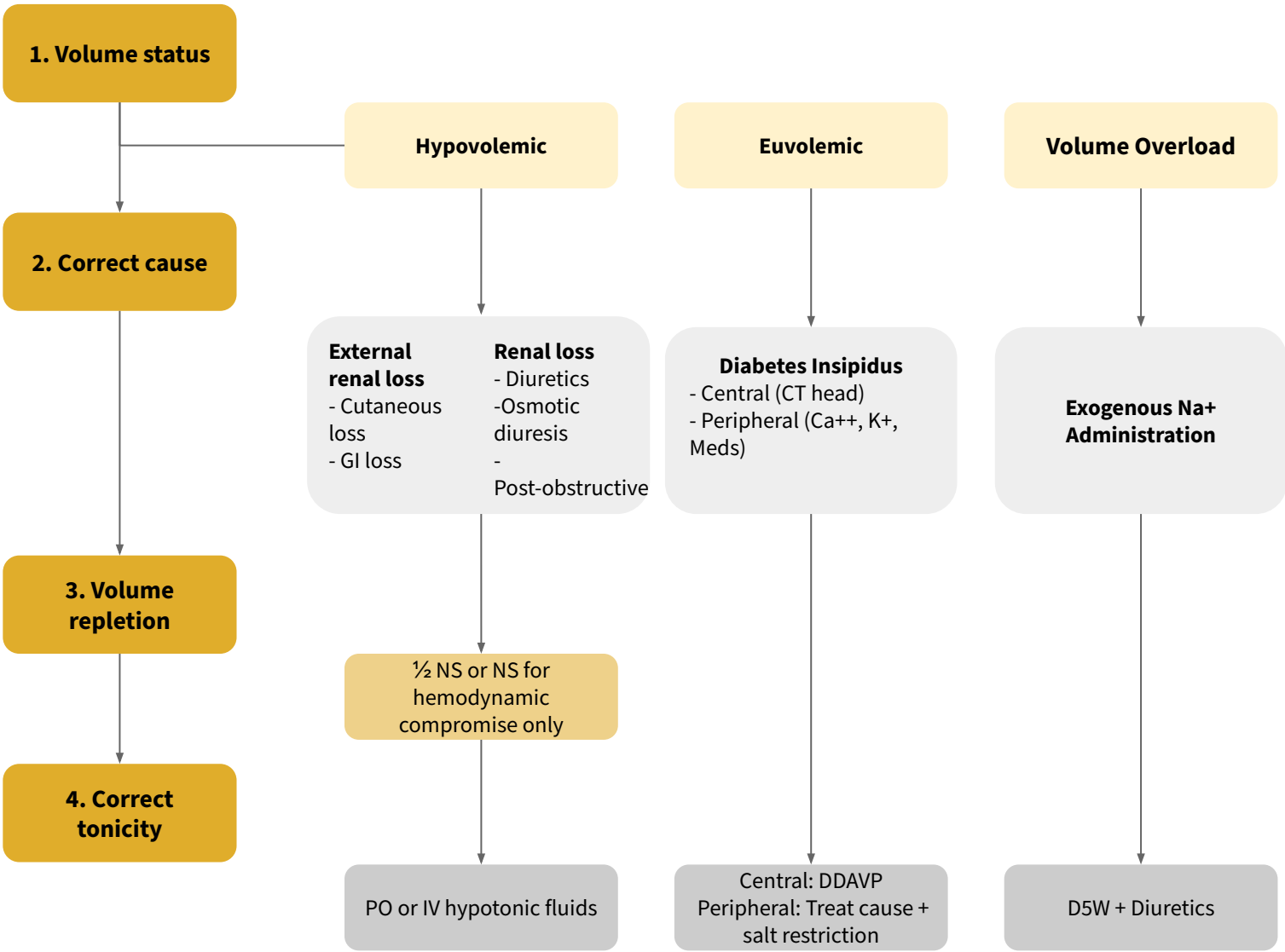
    How do we replace it? through a vein or GIT and the best way is GIT unless the patient is vomiting give it intravenously

Hypernatremia

◀ Management of Hypernatremia

Note:The whole slide were mentioned in 439 slides

- Hypernatremia for 48 hours is considered acute; sodium correction rate can be up to 1 mEq/L per hour. Don't rush to correction
- Hypernatremia of 2 days or unknown duration is considered chronic and should be corrected gradually, ,0.5 mEq/L per hour (approximately 10 mEq/L per day).
- The initial step in management is **identification of the cause** of hypernatremia and its correction (Insulin, Anti-Pyretics, that's why history and physical examination is going to be quite critical in these cases to be able to find out the best way of management



Cases (Doctor's slides)

◀ Case 1

Mr. P is a 66-year-old man who comes to the emergency department with a chief complaint of headache. Shortly after arrival he has a generalized seizure. Initial labs reveal a serum sodium concentration of **122 mEq/L.**
Due to Mr. P.'s seizure and subsequent postictal state, Mr. P cannot give a medical history. His vital signs are BP, 140/95 mm Hg; pulse, 90 bpm;temperature, 36.0°C; RR, 18 breaths per minute. His neck veins are flat. His lungs are clear to auscultation. Cardiac exam reveals a regular rate and rhythm. There is no jugular venous distention (JVD), S3
gallop, or murmur. His abdomen is obese with no clear mass. No ascites is appreciated. Extremity exam reveals no edema.
Mr. P's laboratory studies reveal a glucose of 7.8 mmol/l; K+, 3.9 mEq/L; BUN, 3 mmol/l; creatinine, 70 umol/l; and a serum osmolality of 254 mOsm/L. Urine osmolality is **80** mOsm/L.

What would you do?

1. First ABC because he had a seizure we have to maintain his airway and circulation ,if he can't breathe he will die in few minutes
2. hypertonic saline (the only treatment for acute hyponatremia with seizure)

What other investigations you would order?

- Serum osmolality
- urine osmolality

What is the most likely Diagnosis?

Hypotonic hyponatremia (true) → Primary polydipsia (due to low urine osmolality)

- ❖ This scenario happens a lot with marathon runners because they sweat heavily (lose salts) and drink lots of water (gain fluids) so by the end of the race they will have hyponatremia with high ADHD, the paramedics will immediately give them 100cc of hypertonic saline if they still have seizure they will give them another 100 cc of hypertonic Saline

◀ Case 2

a 48-year-old man, is a heavy cigarette smoker who presents with increasing cough, hemoptysis, and drowsiness. He is taking no medications. During the last year, he lost approximately 10 kg, and his current weight is 65 kgs. His mucous membranes are moist, skin turgor is normal, and he does not have an orthostatic fall in blood pressure. Other than nicotine stains on his right index and middle fingers, his physical examination is normal.
Chest radiograph reveals a 4-cm right lung mass. His serum sodium is 123 mEq/L, potassium is 4.3 mEq/L, and creatinine is 80 umol/l.

Which of the following is your initial investigation?
(A) Serum osmolality
(B) Serum uric acid
(C) Urine osmolality
(D) Urine sodium

All answers are correct but the initial investigation is **A** (we want to know if it is true hyponatremia or not)

Measured osmolality is 270 mOsm/kg H2O, What is the next step in this patient's work up?
(A) Serum Glucose
(B) Serum uric acid
(C) Urine osmolality
(D) Urine sodium

270 (low osmolality) so hypotonic hyponatremia, the next step will be **urine osmolality** to see if it ADH dependent or not. Exclude serum glucose because it's not euvolemic

Urine osmolality is 600 mOsm/kg, uric acid level is 250 mmol/l (Low), and urine sodium is 45 mEq/L. Thyroid stimulating hormone and cortisol level are normal.
Diagnosis?

- SIAHD with bronchogenic carcinoma (small cell lung cancer)
- Ectopic ADH secretion by malignant cells

SIAHD :Polyuria , high urine osmolality , low uric acid , low urea, high urine sodium and underlying malignancy most likely is lung small cell carcinoma with Adh section
Diabetes insipidus is hyperNa not hypoNa, primary polydipsia has high urine osmolality, it's not Pseudohyponatremia because the serum osmolality is low

◀ Case 3

A 44- year old man comes to the emergency department with polyuria and polydipsia. Over the past 3 days, he has noticed increased urination with nearly constant thirst. Physical examination is normal.

Admission laboratory results included serum sodium of 155 mmol/L, plasma glucose of 8.3 mmol/L, and urine osmolality of 117 mosm/kg.

What is the most likely cause of the hypernatremia?
(A) Diabetes insipidus
(B) Diabetes mellitus
(C) Vomiting
(D Primary polydipsia

- Why not polydipsia ? → because it'll lead to hyponatremia and here we are dealing with hypernatremia
- Why not vomiting ? → if you vomit what will happen to the urine osmolality ? it will increase (loss of fluid)
- Why not diabetes mellitus ? → Urine osmolality should be high, and in this patient it is low.

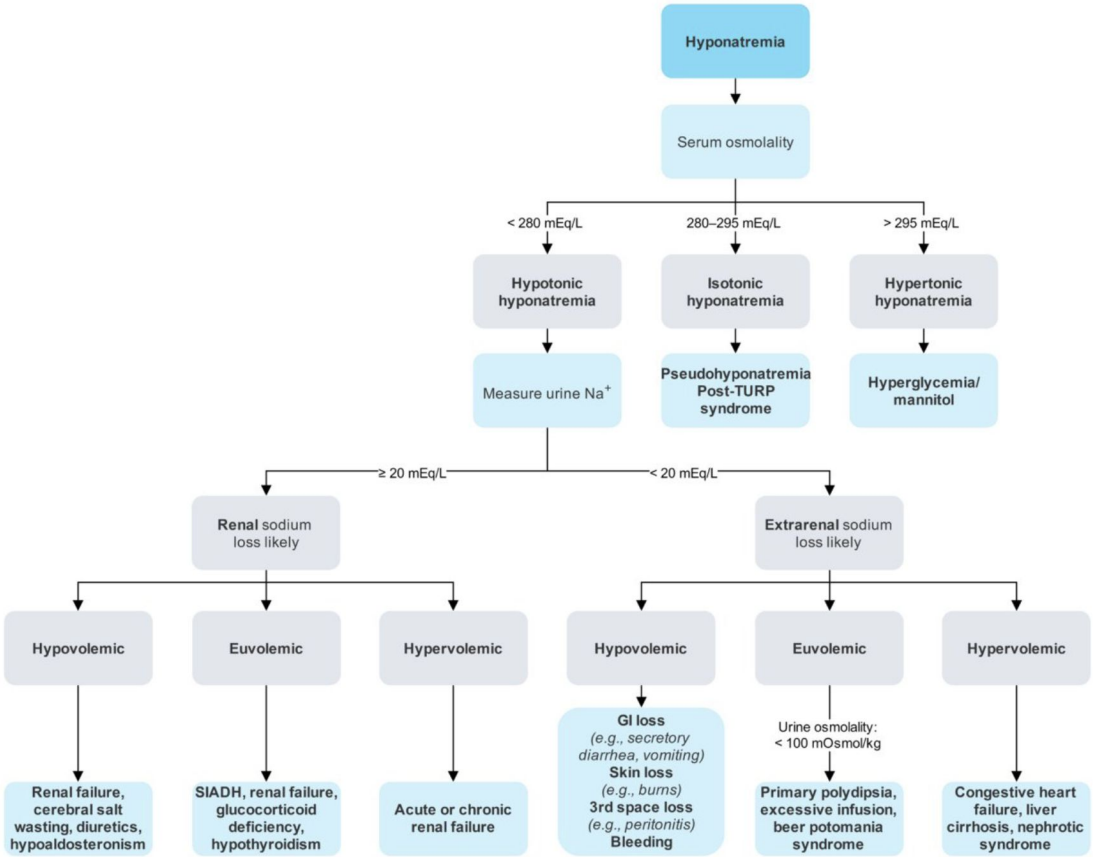
Answer is A

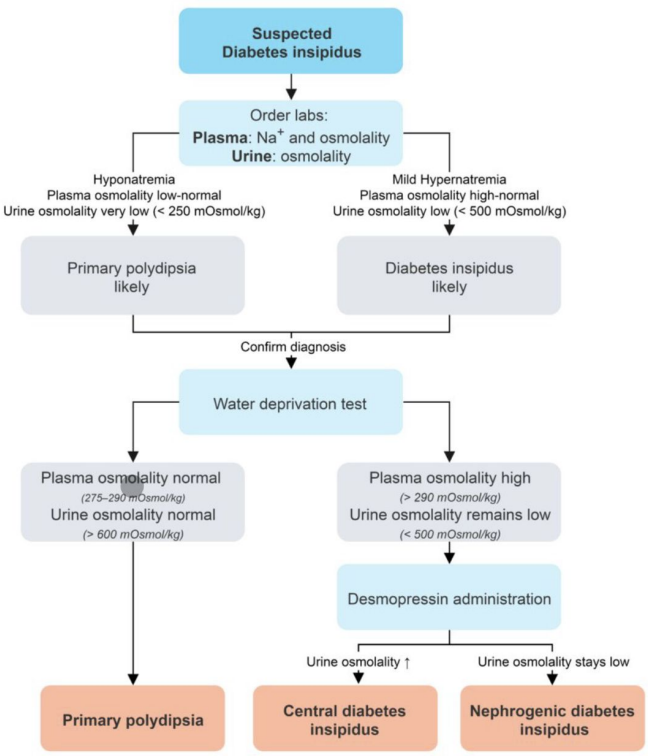
Summary

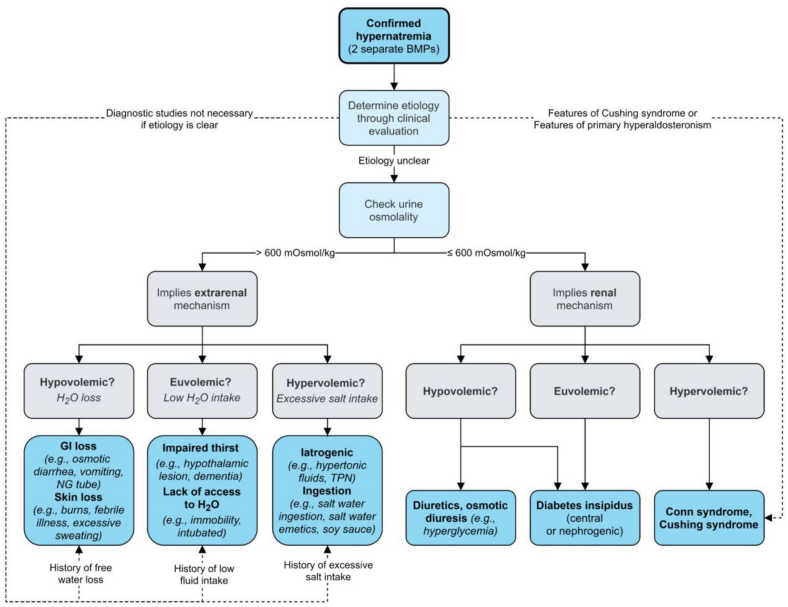
Hyponatremia			
Definition	reduced serum sodium concentration (< 135 mEq/L)		
Sign & Symptoms	None, Headache, Lethargy, Dizziness and ataxia, Confusion, Psychosis, Seizure, Coma		
Classification			
Severity	**Mild** Na conc :130-135 mEq/L	**Moderate** Na conc :120-129 mEq/L	**Severe** Na conc : <120mEq/L
Duration	**Acute:** Hyponatremia that has developed over a period of **<48 hours** **Chronic:** Hyponatremia that has been present for ≥48 hours or the duration is unclear		
Tonicity	**Isotonic hyponatremia:** low measured serum Na+ levels and normal serum osmolality. E.g. multiple myeloma, severe dyslipidemia	**Hypertonic hyponatremia:** Hyponatremia and plasma tonicity > 295 E.g.hyperglycemia, mannitol and radiocontrast	**Hypotonic Hyponatremia:** **Hypovolemic**: Decreased total body water with greater decrease in sodium level Causes: renal (urinary sodium >20 mmol) e.g.diuretics, Extrarenal (urinary sodium <20 mmol) e.g.vomiting, diarrhoea **Hypervolemic:** : Increased total body water compared with sodium. Causes: renal (e.g.diuretics), Extrarenal: (e.g. heart failure, liver cirrhosis) **Euvolemic hyponatremia:** Increased total body water with normal sodium level. renal (e.g.SIADH), Extrarenal: (e.g. primary polydipsia, glucocorticoid deficiency Hypothyroidism)

Hypernatremia	
Definition	Hypernatremia, serum sodium concentration of 145 mmol/L a state of total body water deficiency absolute or relative to total body sodium.
Clinical presentation	• Often asymptomatic • Irritability, nausea, weakness, altered mental status • Brain shrinkage, resulting in vascular rupture and intracranial bleeding
It can result from	• water loss e.g.diabetes insipidus [DI] • hypotonic fluid loss e.g. osmotic diarrhea • Hypertonic fluid gain e.g. Sodium containing fluids
Management	• Hypernatremia for ,48 hours is considered acute; sodium correction rate can be up to 1 mEq/L per hour. • Hypernatremia of 2 days or unknown duration is considered chronic and should be corrected gradually, ,0.5 mEq/L per hour (approximately 10 mEq/L per day).

Helpful Figures







Lecture Quiz

Q1: A 33 y/o male marathon runner presented to the ER with dizziness when standing and weakness. On examination, his JVP was low with reduced skin turgor . His HR = 132. Which of the following is the best initial treatment?

A- Administration of Hypertonic saline
B- Administration of Isotonic saline
C- Administration of Hypotonic saline
D- No intervention, only observe the patient

Q2: A 83 y/o patient admitted with heart failure and a sodium level of 113 mEq/L. He is behaving aggressively towards staff and does not recognize family members. When the family expresses concern about his behavior, the doctor would respond most appropriately by stating:

A- He may be suffering from dementia, and the hospitalization has worsened the confusion
B- Most older adults get confused in the hospital
C- His sodium levels are low, and the confusion will resolve as they normalize
D- His sodium levels are high, and his behavior is a result of dehydration.

Q3: A 47 y/o male presented to the ER with 2 days history of diarrhea. His vitals are BP=75/45, HR=113 , RR=23. How would you manage this patient?

A- Normal saline
B- Half normal saline
C- Quarter normal saline
D- 5% Dextrose

Q4: A 27 y/o female patient presented to you with pain in her right forearm associated with redness, warmth of the skin and tissues after she had an IV fluid because of her hypovolemia. What is the most likely cause of her symptoms?

A- Administration of Ringer's lactate
B- Administration of ½ Na
C- Administration of pure water
D- Administration of Na

Q5: A nurse would evaluate which of the following patients to be at risk for developing hypernatremia?

A- 50 y/o with pneumonia, diaphoresis and high fever
B- 62 y/o with CHF taking loop diuretics
C- 39 y/o with vomiting and diarrhea
D- 60 y/o with lung cancer and SIADH

Answers: Q1:B | Q2:C | Q3:A | Q4:C | Q5:A |

Answers Explanation File!

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