NINGA NERD NOTES :

What is Hyponatremia?

- **Definition:** Low sodium in the blood **(<135 mmol/L)**
- **Cause: Too much water compared to sodium** (water excess or sodium loss)
- **Main danger:** Brain cells swell (due to osmotic shift), which can lead to coma or death.

How to Classify Hyponatremia?

We classify based on **serum osmolality**:

Type	Serum Osmolality	Main Mechanism
Hypotonic (true)	**<280 mOsm/kg**	Water retention or sodium loss
Isotonic (pseudo)	**~280 mOsm/kg**	Lab artifact (proteins/lipids)
Hypertonic	**>295 mOsm/kg**	Glucose pulls water from cells

Let's focus on **Hypotonic hyponatremia**, which is the most important.

I. Hypotonic Hyponatremia

Now, we divide this into:

1. **Hypovolemic**
2. **Euvolemic**
3. **Hypervolemic**

1. Hypovolemic Hypotonic Hyponatremia

- **Loss of sodium > loss of water**

Feature	Explanation
ADH	↑ high (trying to retain water)
Aldosterone	↑ high (trying to retain sodium)

Causes:

- **Low urine Na+ (<10):** Extrarenal losses *vomiting, diarrhea, sweating, third-spacing (burns, pancreatitis)*
- **High urine Na+ (>20):** Renal sodium wasting *diuretics, ACEi, adrenal insufficiency, ATN*

Why does this happen?

- Body loses volume → activates RAAS → aldosterone tries to save Na+
- Volume loss also triggers ADH (even if osmolality is low) → retains water → dilutes Na+ more

2. Euvolemic Hypotonic Hyponatremia

- **Water gain but no sodium change (volume is normal)**

Feature	Explanation
ADH	↑ high (inappropriate or pathologic)
Aldosterone	normal or ↓

Causes:

- **SIADH:** ADH is secreted even when not needed → water retention → dilutional hyponatremia *CNS issues, cancer (SCLC), drugs (SSRIs, oxytocin), surgery, infections*
- **Hypothyroidism**
- **Adrenal insufficiency**
- **Primary polydipsia** (too much water intake, low ADH but kidneys overwhelmed)
- **Low solute intake** ("tea & toast," beer potomania)

Why does this happen?

- ADH is high without reason → kidney keeps water → Na+ diluted
- No sodium is lost, so ECF volume looks normal

3. Hypervolemic Hypotonic Hyponatremia

- **Water gain > sodium gain (both increase, but water increases more)**

Feature	Explanation
ADH	↑ high (due to low effective volume)
Aldosterone	↑ high (to retain Na+)

Causes:
- **Heart failure (CHF)**
- **Liver cirrhosis**
- **Nephrotic syndrome**

Why does this happen?
- There's fluid in the body, but it's not in the blood vessels (third-spacing) → kidney thinks you're hypovolemic
- Triggers RAAS and ADH → retains more water → worsens hyponatremia

II. Isotonic Hyponatremia (Pseudohyponatremia)

Feature	Explanation
ADH	normal
Aldosterone	normal

  - Seen when there are lots of proteins/lipids in plasma (e.g., multiple myeloma)
- It's a lab error — real sodium amount is normal

III. Hypertonic Hyponatremia
- **Osmotic substances pull water out of cells → dilutional hyponatremia**

Feature	Explanation
ADH	normal or ↑
Aldosterone	normal

Causes:
- **Hyperglycemia** → pulls water out from cells → dilutes sodium
- **Mannitol, sorbitol, radiocontrast agents**

Clinical Symptoms

Due to **water entering brain cells**:
- Headache, confusion, seizures
- GI: nausea, vomiting
- Muscles: twitching, weakness
- Severe: coma, brain herniation

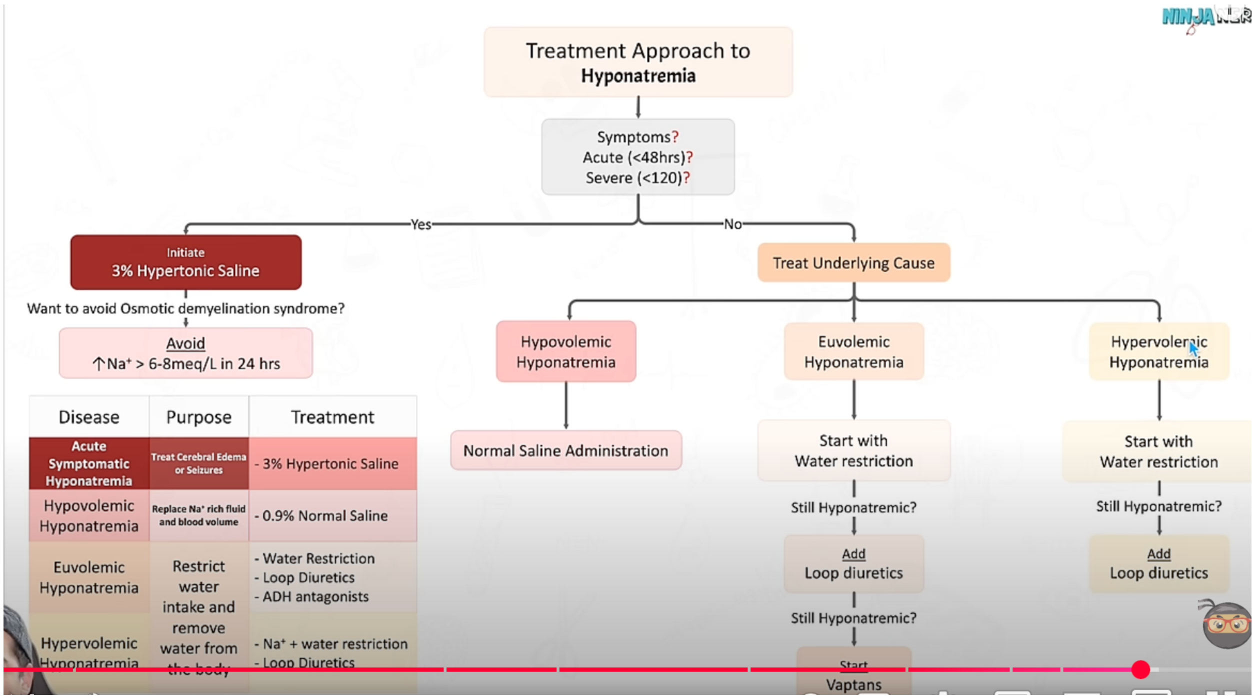
Diagnosis Summary Table

Test	What It Shows
Serum osmolality	Low in true hyponatremia
Urine osmolality	Low in polydipsia, high in SIADH
Urine sodium	Low in volume depletion, high in SIADH/renal loss

Treatment Overview

Severity	Sodium (mEq/L)	Management
Mild	120–130	Stop free water, maybe salt tablets
Moderate	110–120	Loop diuretics + saline
Severe/Sx	<110 or symptoms	Hypertonic saline (slowly!)

⚠️ **Important!** Don't correct too fast:
- Max: **8 mEq/L in 24h**
- Risk: **Central pontine myelinolysis**



Types of Hypotonic Hyponatremia with ADH & Aldosterone

Type	ADH	Aldosterone	Main Cause
Hypovolemic	↑ High	↑ High	Loss of both Na+ and water (more Na+ loss)
Euvolemic	↑ High	Normal/↓	Water retention only (SIADH, hypothyroid)
Hypervolemic	↑ High	↑ High	Water > Na+ (CHF, liver, kidney)

What is Hypernatremia?

- **Definition:** Plasma sodium > **145 mmol/L**
- It's not just "too much salt" — it's **too little water** relative to sodium.

Classification of Hypernatremia

Based on **ECF volume** (clinical assessment):

Type	Water Status	Sodium Status
Hypovolemic	↓↓ Water lost	↓ Na+ lost (but less)
Isovolemic	↓ Water lost	Na+ normal
Hypervolemic	↑ Water gained	↑↑ Na+ gained (more)

Let's now explain each one with **ADH** and **aldosterone**:

1. Hypovolemic Hypernatremia

What's happening?

- You're losing both sodium and water (e.g., diarrhea, sweating), but **you lose more water** than sodium → blood becomes concentrated → hypernatremia.

Hormone	Behavior	Why?
ADH	↑ High	Trying to hold on to water
Aldosterone	↑ High	Trying to retain sodium and water

Examples:

- **Renal loss:** Diuretics, osmotic diuresis (e.g., in diabetes), renal failure
- **Extrarenal loss:** Diarrhea, diaphoresis, respiratory water loss

2. Isovolemic Hypernatremia

What's happening?

- **Only water is lost**, sodium levels are normal. Most common cause: **Diabetes insipidus (DI)**

Hormone	Behavior	Why?
ADH	↓ Low (central DI) or Normal (nephrogenic DI)	Can't conserve water
Aldosterone	Normal or ↓ Low	No major volume or sodium stimulus

Examples:

- **Central DI:** Brain fails to produce ADH (CNS trauma, tumors)
- **Nephrogenic DI:** Kidneys don't respond to ADH (lithium, hypercalcemia)
- **Other:** Tachypnea (insensible water loss)

3. Hypervolemic Hypernatremia

What's happening?

- Sodium is being added (e.g., $NaHCO_3$ therapy) and water follows — but **more sodium than water** is retained.

Hormone	Behavior	Why?
ADH	↑ High	Body tries to dilute the extra sodium
Aldosterone	↑ High	Often the source of Na+ gain (e.g., primary hyperaldosteronism)

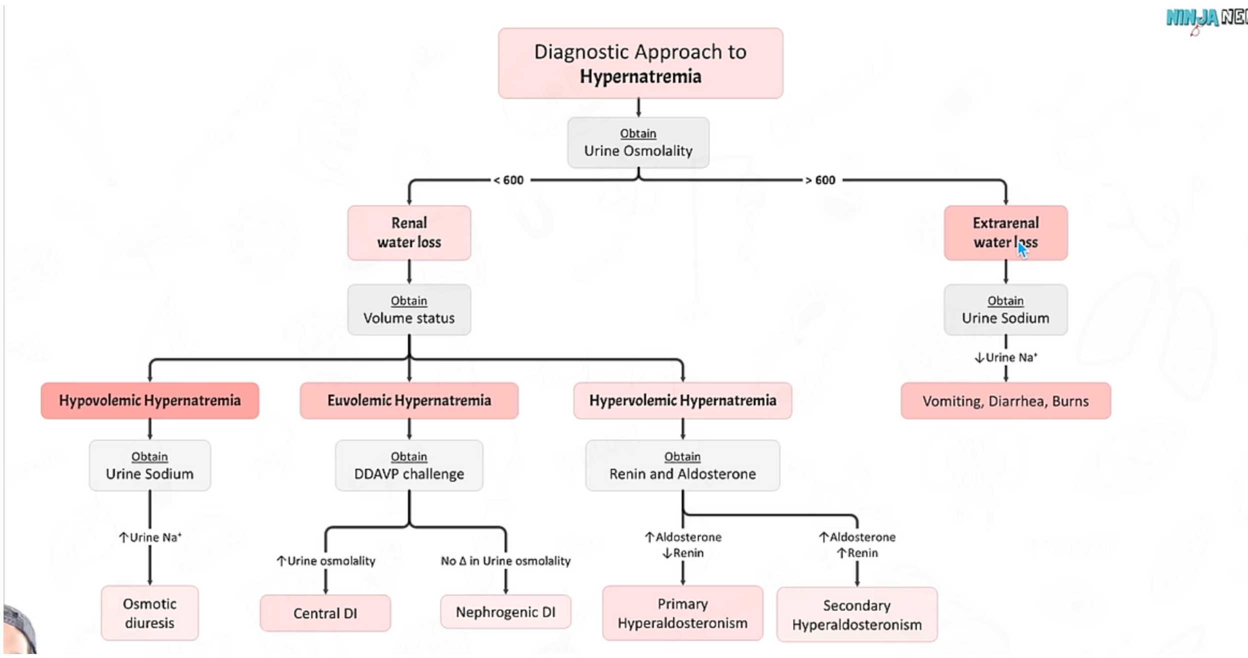
Examples:

- Iatrogenic: Too much IV $NaHCO_3$ or TPN
- Cushing syndrome, saltwater drowning
- Primary hyperaldosteronism

Clinical Features

Main System Affected	Symptoms
Brain (osmotic shift)	Confusion, irritability, seizures, coma
Mucosal dryness	Dry mouth, ↓ salivation
Restlessness, focal deficits	Due to brain cell dehydration

Key Danger: If sodium is corrected too quickly, water will rush **into** brain cells → **cerebral edema** → **Max correction: <12 mEq/L/day** (preferably <8 in 24h)



Slides

Term	Meaning
Hypernatremia	Sodium >145 mEq/L in blood
Hyponatremia	Sodium <135 mEq/L in blood
Hypervolemia	Too much blood fluid (volume overload)
Hypovolemia	Too little blood fluid (volume depletion)
Hypovolemia vs Dehydration	Hypovolemia = water + salt loss; Dehydration = pure water loss

Proportionate Disorder	Equal loss of water and salt
Disproportionate Disorder	More water or more salt lost
Hyperosmolar vs Hypertonic	Hyperosmolar = more particles (including urea, glucose); Hypertonic = pulls water from cells (glucose, Na; NOT urea)
Pseudohyponatremia	Falsely low Na due to hyperlipidemia/protein
Translocation Hyponatremia	Water moves into blood because of glucose or mannitol
Acute vs Chronic	Acute <48 hours; Chronic >48 hours

The Concept of Balance and Steady State

Our body maintains many balances to stay healthy:

- **Hydrogen ion balance:** for acid-base (pH) stability.
- **Electrolyte balance:** Potassium, calcium, phosphorus, magnesium.
- **Water balance:** Intake = output.
- **Sodium and Volume balance:** Salt and fluid regulation.
- **Energy balance:** Calories eaten vs calories burned.

🔔 Balance keeps our blood volume, blood pressure, pH, and cells working normally.

Water Balance

💧 Numbers you should memorize:

Measurement	Value
Daily Water Filtration by Kidneys	180 liters
Daily Sodium Filtration by Kidneys	25,000 mEq
Normal Sodium Intake	100–300 mmol/day
Sodium Loss in Stool	~5 mmol/day
Sweat Loss	~5 mmol/day

➡️ Kidneys match sodium intake and output carefully.

Body Sodium Distribution

Location	Percentage of Body Sodium
Bones and Tissues	25%
Extracellular Fluid (Blood and Interstitial Fluid)	75%

🔔 So most sodium is outside the cells (in blood and body fluids).

🎯 **Total Body Water and Sodium**

Factor	Details
Total Body Sodium	~50 mEq/kg
Total Body Water	Depends on **sex** and **age**

  - More in young people.
- More in males than females (because of muscle mass).

🎯 **Calculated and Measured Serum Osmolality**

Formula	Meaning
Calculated Osmolality	= 2 × Na + glucose + urea
Measured Osmolality	Normal 280–290 mOsm/kg
Normal Osmolal Gap	(Measured – Calculated) = –14 to +10

If gap is bigger → suspect toxins like methanol, ethylene glycol.

🎯 **Example of Normal Saline Composition**

Item	Value
Water	1000 mL
NaCl	9000 mg
Sodium	154 mmol
Chloride	154 mmol
Osmolality	308 mOsm/kg

🧠 Normal saline is close to blood osmolality → that's why we call it **isotonic saline**.

Two Systems for Regulation

System	Sensors	Effectors
Tonicity Disorders (Water problems)	Osmoreceptors	ADH (Antidiuretic hormone) and thirst
Volume Disorders (Sodium problems)	Baroreceptors (low and high pressure)	RAAS system

🔵 **Tonicity disorders** are about **how concentrated** blood is (water balance). 🟠 **Volume disorders** are about **how full** blood vessels are (fluid and sodium balance).

🎯 **Effect of High Serum Sodium**

When sodium rises too high (hypernatremia):

- Water leaves brain cells → Cells shrink
- Result = **CNS symptoms**:
- Confusion
- Irritability
- Seizures
- Coma

⚡ Blood concentration affects the **brain** first!

🎯 **AVP (ADH) Receptor Subtypes**

Receptor	Location	Function
V1A	Blood vessels, platelets, liver	Vasoconstriction, clotting, glycogen breakdown
V1B	Anterior pituitary	Stimulates ACTH release (stress hormone)
V2	Kidney collecting ducts	Reabsorbs free water back into the blood

🔵 **Main receptor for water regulation = V2 receptor.**

🎯 **Volume vs Water Disorders**

Disorder Type	Affected System
Volume disorders	Cardiovascular system (blood pressure, heart performance)
Water disorders	Central Nervous System (brain swelling/shrinking)

🎯 **Water and Volume Disorders Categorized**

❖ **Pure Disorders:**

- **Volume Disorders:**

- Hypervolemia (too much volume, isotonic)
- Hypovolemia (too little volume, isotonic)
- **Water Disorders:**
- SIADH (too much ADH → water retention → hyponatremia)
- Diabetes Insipidus (too little/ineffective ADH → water loss → hypernatremia)

❖ **Mixed Disorders:**

- Hypervolemic hyponatremia (e.g., heart failure)
- Hypovolemic hyponatremia (e.g., vomiting, diarrhea)
- Hypervolemic hypernatremia (rare, sodium overload)
- Hypovolemic hypernatremia (e.g., dehydration)

Criteria for Diagnosis of SIADH (Syndrome of Inappropriate ADH Secretion)

✅ To diagnose SIADH, all these must be true:

Criterion	Meaning
Hyposmolar hyponatremia	Low plasma osmolality with low sodium
Euvolemia	No signs of dehydration or fluid overload (patient looks normal)
Urine osmolality >100	Urine is concentrated (kidneys still trying to save water)
Normal kidney, heart, liver, endocrine function	To exclude other diseases
No diuretics or major stress	To exclude false causes
Urine sodium >20 mEq/L	Sodium wasting (because volume is normal)
Low serum uric acid (UA)	Common in SIADH

Graph: Plasma Osmolality vs Plasma AVP (ADH)

Normal People:

- As plasma osmolality rises, ADH rises linearly.

In SIADH:

- ADH is **high even when plasma osmolality is low**.
- This is abnormal and explains water retention in SIADH.

🔵 Summary: SIADH = "too much ADH at the wrong time."

🎯 **Common Disorders Associated with SIADH**

Category	Example
Malignancy	Lung cancer (especially small cell), duodenal cancer, pancreatic cancer, lymphoma
Pulmonary Disorders	Infections (like pneumonia), respiratory failure, positive pressure ventilation (IPPB)
CNS Disorders	Brain infections, trauma, tumors (SOL = space-occupying lesion), stroke (CVA), psychosis

🔔 Think about cancer, lung infections, or brain problems when you see SIADH.

🎯 **Drugs Associated with Hyponatremia**

Drugs can cause hyponatremia in three ways:

Mechanism	Examples

ADH Analogs (mimic ADH)	Chlorpropamide, nicotine, carbamazepine (Tegretol), narcotics, clofibrate, antipsychotics
Enhance ADH Action	NSAIDs, cyclophosphamide (Cytoxan), chlorpropamide
Unknown Mechanism	Haloperidol, amitriptyline

💊 So, always check the medication list if you suspect SIADH!

Treatment of Hyponatremia

Before treating, consider:

Factor	Why?
Patient volume status	Is patient hypovolemic, euvolemic, or hypervolemic?
Degree of hyponatremia	How low is sodium?
Severity of symptoms	Any confusion, seizures?
Duration of hyposmolality	Acute (<48h) or Chronic (>48h)?

🔔 Treatment is different based on these points!

🎯 **Osmotic Demyelination Syndrome**

⚡ **Danger if you correct sodium too fast!**

- In chronic hyponatremia, brain cells lose osmolytes to adapt.
- If you correct sodium fast, brain cells shrink rapidly → Damage → Osmotic Demyelination Syndrome (ODS).

ODS symptoms:

- Weakness
- Paralysis
- "Locked-in" syndrome

⚡ RULE: **Correct sodium slowly!** (not more than 8–10 mEq/L per 24 hours)

Causes of Diabetes Insipidus (DI)

DI = Loss of ability to **concentrate urine** → leads to **massive water loss** → hypernatremia.

There are two types:

❖ **Central Diabetes Insipidus (Brain Problem)**

Cause	Example
Idiopathic	Unknown reason
Post-traumatic	Head injury
Tumors	Brain tumors
Infections	Meningitis, encephalitis
Granulomas	Sarcoidosis, tuberculosis
Histiocytosis	Rare disease causing organ damage

🔵 **Problem:** Pituitary or hypothalamus can't make or release ADH.

❖ **Nephrogenic Diabetes Insipidus (Kidney Problem)**

Cause	Example
Congenital	Genetic mutations (since birth)

Acquired	Hypercalcemia, hypokalemia, lithium drug use, renal cystic disease, interstitial kidney diseases

🔵 **Problem:** Kidneys don't respond to ADH even if it's present.

🎯 **Water-Deprivation Test**

Test to differentiate between Central DI, Nephrogenic DI, Primary Polydipsia, and normal states.

Condition	Urine Osmolality (after deprivation)	Plasma AVP	Urine Osmolality (after giving ADH)
Normal	>800	>2 pg/mL	Little/no change
Complete Central DI	<300	Undetectable	Big increase
Partial Central DI	300–800	<1.5 pg/mL	>10% increase
Nephrogenic DI	<300–800	>5 pg/mL	Little/no change
Primary Polydipsia	>500	<5 pg/mL	Little/no change

✅ Key Point:

- Central DI = improves after giving ADH.
- Nephrogenic DI = no improvement after giving ADH.

🎯 **Treatment of Hypernatremia**

Goal: Bring sodium **down slowly** while restoring normal volume and osmolality.

Step	Explanation
1	Restore normal blood volume first.
2	Slowly correct hypernatremia over 48 hours.
3	Formula to calculate water deficit:
	Water Deficit = 0.6 × Weight (kg) × [(Serum Na / 140) – 1]
4	Replace continuous ongoing water losses.
5	Treat the underlying cause (like DI, sweating, diarrhea).

Pseudohyponatremia (Isotonic Hyponatremia)

📚 **Pseudohyponatremia** means:

- Lab test shows low sodium, but blood water is normal.
- Sodium concentration looks falsely low because **too much fat or protein** in the blood.

How does it happen?

- **Hyperlipidemia**: High fat (cholesterol, triglycerides).
- **Hyperproteinemia**: High blood proteins (like in multiple myeloma).

Diagram explanation:

- **Normal blood:** 93% water + 7% solids → Sodium distributed normally.
- **Hyperlipidemia/proteinemia blood:** 86% water + 14% solids → Less water space → Sodium concentration looks lower.

🔔 *Measured Osmolality will be normal!* (Because osmolality measures particles per water unit, not solids.)

🎯 **Serum Osmolality Reminder**
Calculated Serum Osmolality = 2 × Na + glucose + urea
If **measured osmolality > calculated osmolality**, think about other hidden particles like alcohol, ethylene glycol, mannitol.

Salt and Water Rules (I)
Very important basic concepts:

Rule	Meaning
Sodium and volume regulation are separate.	Sodium regulates water (via thirst and ADH), not directly blood volume.
Plasma sodium is mainly controlled by water intake/excretion.	Not just salt intake!
Hyponatremia mostly happens because the body can't excrete water.	ADH is persistently high.
Acute hyponatremia symptoms = cerebral edema (brain swelling).	
Chronic hyponatremia = usually no symptoms.	Brain adapts by losing osmolytes.

🔔 Always **correct chronic hyponatremia slowly** to avoid brain damage!

🎯 **Salt and Water Rules (II)**
More concepts:

Rule	Meaning
The body always tries to return to steady state.	Intake = Output over time.
Diuretics have maximal effect at first dose.	Afterward, body fights back (counter-regulation).
Chronic diuretic use leads to a new steady state with lower volume.	
Kidneys can excrete big amounts of water, sodium, potassium, bicarbonate.	If they don't → there's a kidney problem.

🎯 **The Concept of Normal Steady State**
In a healthy body:
- Water intake ≈ Water output
- Sodium intake ≈ Sodium output
- Body maintains plasma osmolality and volume within narrow normal ranges.

🎯 **Isotonic Hypovolemia (Pure Hypovolemia)**
📚 Definition:
- Loss of both **salt and water** in equal amounts.
- Blood concentration (osmolality) remains normal.
- Only **volume** decreases.

Common Causes:
- Diuretics
- Vomiting
- Diarrhea
- Bleeding (hemorrhage)
- Decreased fluid intake (not drinking enough)

Hypertonic Dehydration

📚 **Hypertonic Hypovolemia** = More water loss than salt loss.
🔵 Blood becomes **hypertonic** (higher osmolality). 🔵 Water leaves the cells → **cells shrink**.

Causes:

Cause	Example
Hyperventilation	Breathing fast → losing water vapor
High fevers	Sweating out pure water
Watery diarrhea	Losing water more than salt (ex: cholera)
Diabetes Insipidus	Huge loss of dilute urine
Diabetic Ketoacidosis	Osmotic diuresis
Prolonged NPO (nothing by mouth)	No water intake

🎯 **Hypotonic Hypovolemia**

📚 **Hypotonic Hypovolemia** = More salt loss than water loss.
🔵 Blood becomes **hypotonic** (lower osmolality). 🔵 Water moves **into cells** → **cells swell**.

Causes:

Cause	Example
Heat exhaustion	Sweating salt and water loss
Severe vomiting/diarrhea	Losing salt-rich fluids
Adrenal insufficiency	Aldosterone deficiency → sodium wasting

Why is it dangerous?

- Causes **brain swelling** → headache, confusion, coma (especially in heat stroke).

🎯 **Types of IV Fluids (Important)**

💉 Fluids are classified based on their osmolarity compared to plasma:

Fluid Type	Example	What Happens
Isotonic Fluids	0.9% NaCl (Normal Saline), Ringer's Acetate (RA), Ringer's Lactate (RL)	Same osmolality as blood; stays in ECF (blood vessels)
Hypotonic Fluids	Water, 0.45% NaCl (Half Normal Saline), D5W (after sugar is used)	Less solutes than blood; goes into cells
Hypertonic Fluids	3% NaCl, D5NS	More solutes than blood; pulls water from cells into blood vessels

🎯**Fluid Distribution After Infusion**

📚 How fluids distribute depends on the type:

Isotonic Infusion (e.g., Normal Saline)

- Increases mainly **ECF** (Extracellular Fluid = plasma + interstitial fluid)
- **800 mL** to ECF
- **200 mL** to plasma

(Used for replacing blood volume loss.)

Hypotonic Infusion (e.g., D5W)

- Enters both ECF and ICF (cells).
- **660 mL** into cells (ICF)
- **255 mL** into interstitial fluid (ISF)
- **85 mL** into plasma

(Used for dehydration affecting cells.)

Osmotic Pressure Relation

💧 What controls where water moves?

- **Osmotic pressure** = Water moves **toward the higher solute concentration**.
- Sodium (Na^+) is the major extracellular solute controlling osmotic pressure.
- If blood is more concentrated → Water leaves cells.
- If blood is diluted → Water enters cells.

🎯 **Relation of Volume and Osmotic Force**

🧠 **Summary of fluid shifts:**

Blood Condition	What Happens to Cells
Hypertonic blood (high sodium)	Cells shrink (water leaves cells)
Hypotonic blood (low sodium)	Cells swell (water enters cells)
Isotonic blood	No major shift of water

🔔 Important for treating sodium disorders safely!

🎯 **Pure Hypervolemia**

📚 **Definition:** Excess fluid (isotonic gain) without major sodium change.

Signs of Hypervolemia:

Location	Clinical Signs
Intravascular	High blood pressure (HTN), S3 gallop sound in heart, elevated jugular vein pressure (JVP), hepatic (liver) congestion
Interstitial	Pitting edema (legs), pulmonary rales (lung crackles)
Third spacing	Ascites (fluid in abdomen), pleural effusion (fluid around lungs)

🎯 **Pure Hypovolemia**

📚 **Definition:** Loss of fluid (isotonic loss) without major sodium change.

Signs of Hypovolemia:

Severity	Clinical Signs
Mild	Orthostatic hypotension (drop in BP when standing), fast pulse, flat neck veins

Severe	Shock (very low BP)
Interstitial signs	Decreased skin turgor (loose skin), dry mouth, dry mucous membranes (MM), reduced eye pressure

🎯 **New York Nursery Catastrophe Example**

A real-world example where fluid and sodium balance was dangerously disturbed, leading to catastrophic dehydration and hypernatremia in newborns.

🔔 **Reminder:** Managing fluids and sodium carefully is critical, especially in vulnerable patients (like babies).

🎯 **: Hypervolemic Hypernatremia (Acute)**

📚 **Definition:** Both sodium and water increase — but sodium increases **more**.

Symptoms:

System	Clinical Signs
CNS	Lethargy, irritability, spasticity, confusion, stupor, coma, focal neurological deficits
Other	Intense thirst, vomiting (emesis), fever, labored (difficult) breathing

🎯 **Hypervolemic Hypernatremia (Chronic - >48h)**

🧠 If hypernatremia persists >48 hours:

- The brain adapts slowly by producing new osmolytes.
- **But:** Risk of damage if you correct sodium too fast later → same Osmotic Demyelination Syndrome danger.

Hypovolemic Hyponatremia (Acute)

📚 **Definition:** Loss of both sodium and water — but **more sodium lost** than water.

Symptoms:

System	Clinical Signs
Circulatory (shock)	Very low blood pressure (hypotension), rapid weak pulse
GI	Anorexia (loss of appetite)
CNS	Lethargy, headache, confusion, stupor, seizures, coma

⚡ Danger: Cells swell (brain swelling) → life-threatening if acute.

🎯 **Hypovolemic Hyponatremia (Chronic - >48h)**

🧠 Chronic hypovolemic hyponatremia:

- Brain adapts slowly by losing osmolytes.
- Patient might seem **more stable** (fewer brain symptoms).
- **BUT:** If sodium is corrected too quickly → big risk of Osmotic Demyelination Syndrome (brain damage).

🎯 **Hyperosmolar Isotonic State (Chronic Renal Failure - CRF)**

📚 What happens in CRF:

- Blood urea builds up (uremia).
- Urea increases plasma osmolality but does NOT pull water like sodium or glucose.
- Plasma can become **hyperosmolar** but **isotonic** (no strong water shift).

🔵 Urea is an ineffective osmole — doesn't move water significantly across cell membranes.

🎯 **Hyperosmolar Hypertonic State**

📚 Happens when blood is full of true osmoles (that pull water).

Causes:

Cause	Example
Hyperglycemia	Diabetes with high blood glucose
Mannitol use	Given for brain swelling or kidney protection
Contrast agents	Used during imaging scans

🧠 These substances pull water out of cells → causing **cell shrinkage** and hypernatremia.

🎯**Isovolemic Hyponatremia (Acute)**

📚 **Definition:** Sodium is low, but blood volume looks **normal**.

Common Causes:

Cause	Example
SIADH	Syndrome of inappropriate ADH secretion
Hypothyroidism	Low thyroid hormones
Hypoadrenalism	Low cortisol (adrenal insufficiency)
Pregnancy	Mild dilution effect
Pain, Emotional Stress, Surgery	Stimulate ADH release
Drugs	Thiazide diuretics
Primary Polydipsia	Excessive water drinking (e.g., psychiatric patients)

🎯**Isovolemic Hyponatremia (Chronic - >48h)**

🧠 Chronic phase:

- Patient adapts to low sodium.
- Symptoms are often **mild or absent**.
- **But still:** risk of brain damage if sodium corrected too quickly.

Diagnostic Algorithm for Hyponatremia

📚 When a patient has hyponatremia, here's the step-by-step approach:

Step 1: Assess Plasma Osmolality

Finding	Meaning
Normal (Isotonic)	Pseudohyponatremia (lab artifact)
High (Hypertonic)	Translocation hyponatremia (e.g., hyperglycemia)
Low (Hypotonic)	True hyponatremia → move to Step 2

Step 2: Assess Volume Status

Volume Status	Description
Hypovolemia	Low blood volume (dehydrated signs)

Euvolemia	Normal volume (no edema, no dehydration)
Hypervolemia	High blood volume (edema, ascites)

Step 3: Check Urine Sodium (U[Na+])

| If Hypovolemic | U[Na+] <20 → Extra-renal losses (vomiting, diarrhea)
 U[Na+] >20 → Renal losses (diuretics, adrenal insufficiency) | | If Euvolemic | Suspect SIADH, hypothyroidism, adrenal insufficiency | | If Hypervolemic | U[Na+] <20 → Heart failure, cirrhosis, nephrotic syndrome
 U[Na+] >20 → Renal failure |

🔔 Always connect **volume status** + **urine sodium** to narrow the cause!

🎯Adrogue-Madias Formula for Predicting Sodium Correction

📚 When giving saline, we want to predict how much sodium will rise:

Change in Na^+ = (Infusate Na^+ + K^+ – Actual Na^+) / (Total Body Water + 1)

- **Total Body Water (TBW):**
- Males: 0.6 × body weight (kg)
- Females: 0.5 × body weight (kg)

This formula helps avoid rapid correction (which could cause brain damage).

🎯 Treatment of Hyponatremia Example

📚 Case Example:

- 70-year-old male, serum Na = 110
- Weight = 70 kg

Step 1: Calculate TBW:

TBW = 0.6 × 70 = 42 liters

Step 2: Calculate Excess Water:

Excess Water = 42 - (110/120 × 42) = 3.5 liters

Step 3: How does treatment change sodium?

- Received 200 mL of 3% saline.
- Urine output: 1000 mL (urine Na+K = 100).

New TBW = 42 – 0.8 = 41.2 liters New serum Na^+ = 4620 ÷ 41.2 = ~112 mEq/L

🔵 **Key Point:** Always monitor carefully. Correct slowly. Calculate TBW. Watch urine output!

🎯 Aquaresis

📚 **Aquaresis** = Water loss without electrolyte loss.

Feature	Meaning
Measured by	Urine volume, plasma and urine sodium and potassium
Effects	Increased urine output, low urine osmolality
Difference from Diuresis	Diuresis = water + electrolytes lost

Vaprisol® (Conivaptan)

Drug used to treat hyponatremia due to water retention (especially SIADH).

Vaprisol® is indicated for:

Condition	Description
Euvolemic hyponatremia	SIADH, hypothyroidism, adrenal insufficiency
Hypervolemic hyponatremia	Heart failure, liver cirrhosis

Not for:

- Congestive heart failure (no clear proven benefit).