Fluid and Electrolytes Management in a Surgical Patient

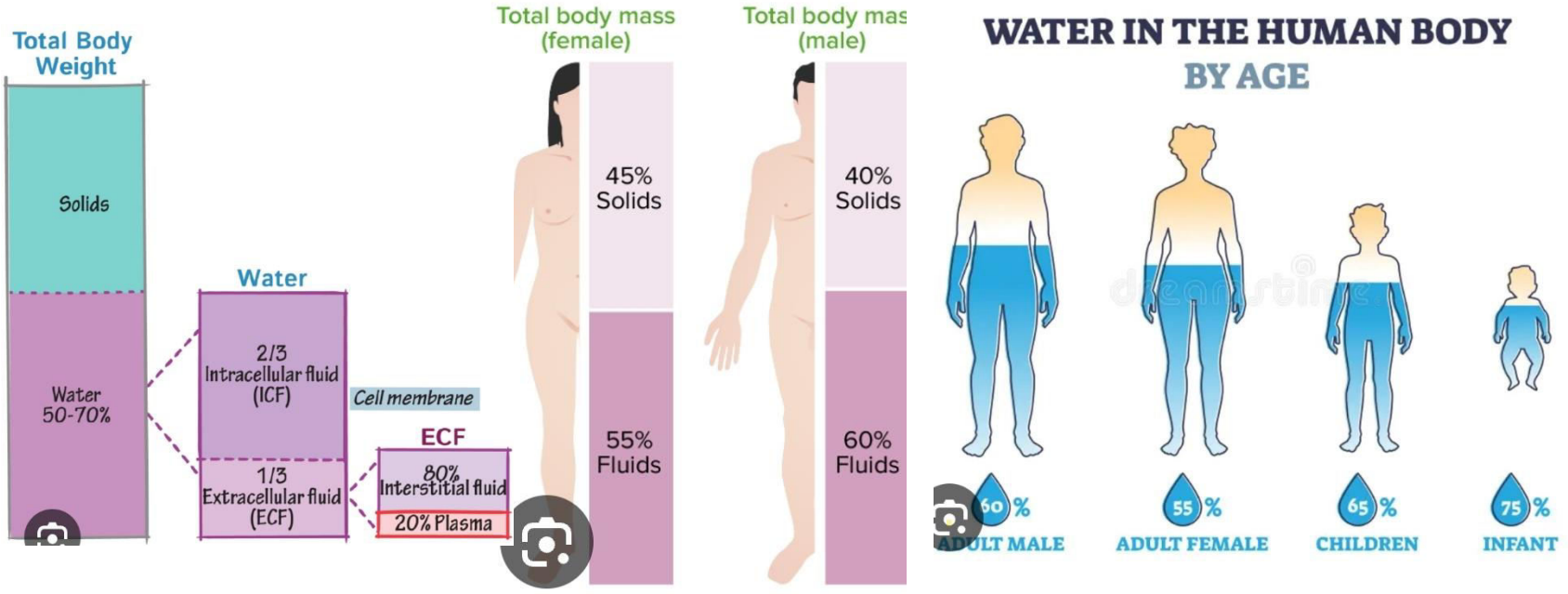
Total body water

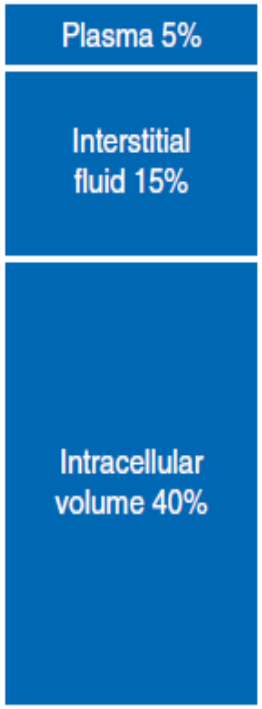
- Approximately 60 %of body weight is water, and it varies according to:

  age,gender and body habitus

- Eg : infants have more water content in their bodies more than adults ,males have more water in their bodies than females ,

In obese there is lesser amount of water.


Total Body Weight
Solids
Water 50-70%
Water
2/3 Intracellular fluid (ICF)
1/3 Extracellular fluid (ECF)
Cell membrane
ECF
80% Interstitial fluid
20% Plasma
Total body mass (female)
45% Solids
55% Fluids
Total body mas (male)
40% Solids
60% Fluids
WATER IN THE HUMAN BODY
BY AGE
60 %
ADULT MALE
55 %
ADULT FEMALE
65 %
CHILDREN
75 %
INFANT



% of Total body weight	Volume of TBW	Male (70 kg)	Female (60 kg)
Plasma 5%	Extracellular volume	14,000 mL	10,000 mL
Interstitial fluid 15%	Plasma	3500 mL	2500 mL
	Interstitial	10,500 mL	7500 mL
Intracellular volume 40%	Intracellular volume	28,000 mL	20,000 mL
		42,000 mL	30,000 mL

Figure 3-1. Functional body fluid compartments. TBW = total body water.

- Physiological route for losing water from the body:

1. Through the respiratory tract
2. Through the urinary tract
3. Through the skin by sweating
4. Through gastrointestinal tract

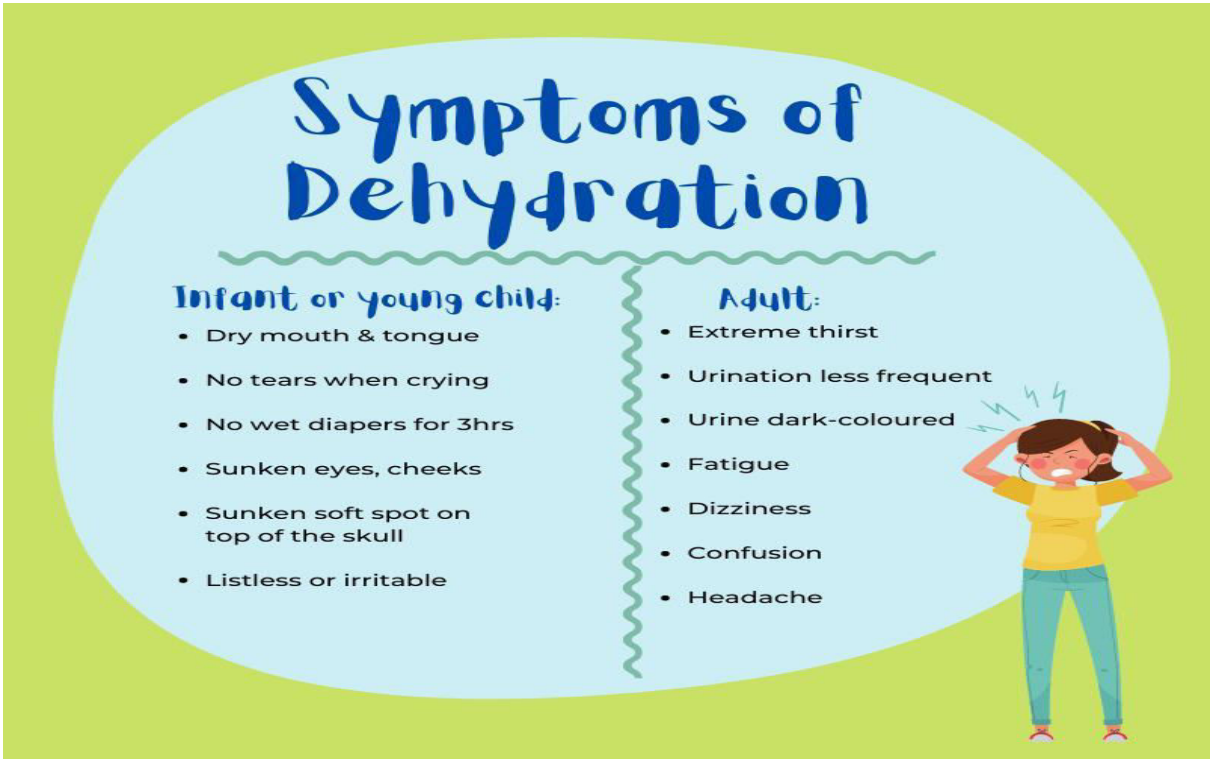
- Most adults lose nearly 2.5-3 liter per day and it increases in hot weather.

Table 2.1 Normal daily fluid losses

Fluid loss	Volume (mL)	Na^+ (mmol)	K^+ (mmol)
Urine	2000	80–130	60
Faeces	300		
Insensible	400		
Total	2700		

Preoperative valuation of fluid status

- Mental status
- Blood pressure,supine and standing
- Heart rate
- Skin turgor
- Urine output



Emphasis on Surgical Patients

- Extracellular volume deficit is the most common fluid disorder in surgical patients.

- Acute or chronic
- Acute volume deficit is associated with cardiovascular and central nervous system signs

- chronic deficits display tissue signs, such as a decrease in skin turgor and sunken eyes

Intravenous fluid therapy

- Infusion of crystalloids,Colloids or both
- Indication:

1. Volume resescutation
2. Vehicle for IV drug

Crystalloids
Vs.
Colloids
??!

Table 1.10 Composition of commonly administered intravenous fluids

	Na^+ (mmol/l)	K^+ (mmol/l)	Cl^- (mmol/l)	HCO_3^- (mmol/l)	Ca^{2+} (mmol/l)	Mg^{2+} (mmol/l)	Oncotic pressure (mmH_2O)	Typical plasma half-life	pH
5% dextrose	–	–	–	–	–		0	–	4.0
0.9% NaCl	154	0	154	0	0		0	–	5.0
Ringer's lactate (Hartmann's solution)	131	5	112	29*	1	1	0	–	6.5
Haemaccel (succinylated gelatin)	145	5.1	145	0	6.25		370	5 hours	7.4
Gelofusine (polygeline gelatin)	154	0.4	125	0	0.4	0.4	465	4 hours	7.4
Hetastarch	154	0	154	0	0		310	17 days	5.5
Human albumin solution 4.5% (HAS)	150	0	120	0	0		275	–	7.4

*The lactate present in Ringer's lactate solution is rapidly metabolized in the liver. This generates bicarbonate ions. Bicarbonate cannot be directly added to the solutions because it is unstable (tends to precipitate).

Crystalloid

=Solutions of inorganic ions and small organic molecules dissolved in water

-The main solute is either glucose or sodium chloride (saline) and the solutions may be isotonic, hypotonic or hypertonic with respect to plasma

-Used for volume expansion, maintenance infusion and correction of electrolyte disturbances.

#Crystalloids with an ionic composition close to that of plasma may be referred to as “balanced” or “physiological”.

Table 3-12

Electrolyte solutions for parenteral administration

SOLUTION	ELECTROLYTE COMPOSITION (mEq/L)						
	Na	Cl	K	HCO_3^-	Ca	Mg	mOsm
Extracellular fluid	142	103	4	27	5	3	280–310
Lactated Ringer's	130	109	4	28	3		273
0.9% Sodium chloride	154	154					308
D_5 0.45% Sodium chloride	77	77					407
D_5W							253
3% Sodium chloride	513	513					1026

D_5 = 5% dextrose; D_5W = 5% dextrose in water.

1) Hypotonic solutions

Dextrose 5% *contains 5 g of dextrose (d-glucose) per 100 ml of* water.

-This glucose is rapidly metabolized and the remaining free water distributes rapidly and evenly throughout the body's fluid compartments.

-So, shortly after the intravenous administration of 1000 ml 5% dextrose solution:

about 670 ml of water will be added to the intracellular fluid compartment (IFC)

and about 330 ml of water to the extracellular fluid compartment (EFC), of which about 70 ml will be intravascular(10%)

Dextrose solutions are therefore have a little value as resuscitation fluids to expand intravascular volume.

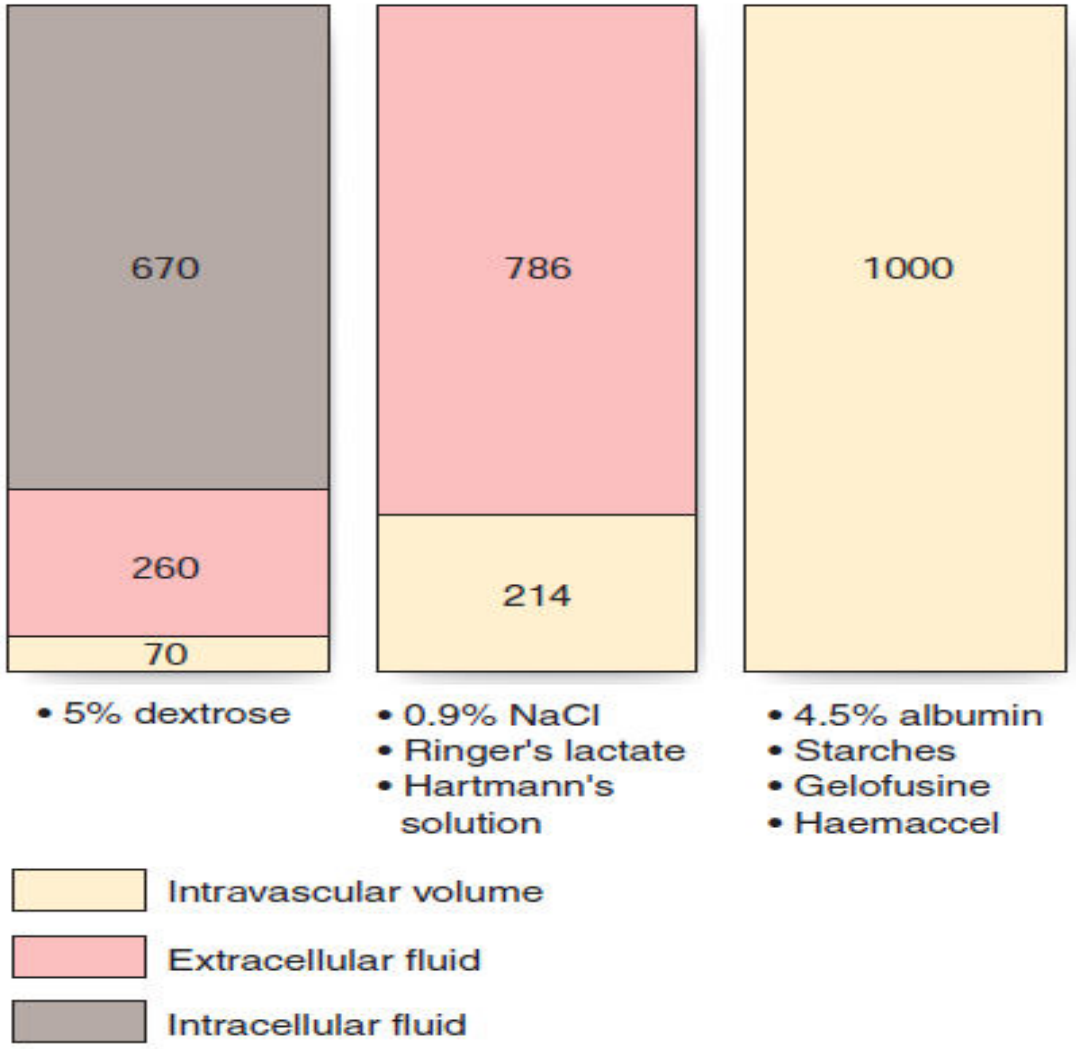


Fig. 1.6 Distribution of different fluids in the body fluid compartments 30–60 minutes after rapid intravenous infusion of 1000 ml.

2) Isotonic solutions

Sodium chloride 0.9% and **Hartmann's solution :**

are isotonic solutions of electrolytes in water.

-Sodium chloride 0.9% (also known as normal saline) contains 9 g of sodium chloride dissolved in 1000 ml of water

-Hartmann's solution (Ringer lactate) has a more physiological composition, containing lactate, potassium and calcium in addition to sodium and chloride ions.

-Both normal saline and Hartmann's solution have an osmolality similar to that of extracellular fluid (about 300 mOsm/l) and after intravenous administration they distribute rapidly throughout the ECF compartment.

-Only 25% remain intravascular. -No change in ICF volume

→ Isotonic crystalloids are appropriate for correcting EFC losses (e.g. gastrointestinal tract or sweating)
and for the initial resuscitation of intravascular volume, although only about 25% remains in the intravascular space after redistribution (often less than 30–60 minutes).

3) Hypertonic solutions

-eg: 3% NS (normal saline)

-Hypertonic saline solutions induce a shift of fluid from the IFC to the EFC so reducing tissues fluid and increasing intravascular volume and serum sodium concentration.

-Potential indications include the treatment of cerebral oedema and raised intracranial pressure, hyponatraemic seizures and ‘small volume’ resuscitation of hypovolaemic shock or burns

Colloids

=High Molecular Weight substances, unable to pass through semi permeable membrane → Remains confined to intra-vascular compartment and thus generating oncotic pressure

-Colloid solutions used in clinical practice for fluid therapy are divided into :

1) the semi-synthetic colloids :gelatins, dextrans and hydroxyethyl starches

2) the naturally occurring human plasma derivatives : human albumin solutions, fresh frozen plasma, and immunoglobulin solution.

*Most colloid solutions are presented with the colloid molecules dissolved in isotonic saline or isotonic glucose, hypertonic saline and isotonic balanced or “physiological” electrolyte solutions are also used.

✓Decrease tissue edema.

Colloids

-When administered, colloid remains largely within the intravascular space until the colloid particles are removed by the reticuloendothelial system.

-The intravascular half-life is usually between 6 and 24 hours and such solutions are therefore appropriate for fluid resuscitation. Thereafter, the electrolyte-containing solution distributes throughout the EFC.

-Synthetic colloids are more expensive than crystalloids and have variable side effect profiles.
-Recognized risks include coagulopathy (used in surgeries) , reticuloendothelial system dysfunction, pruritus and anaphylactic reactions.
HES (Hydroxyethyl starch) in particular appears associated with a risk of renal failure when used for resuscitation in patients with septic shock.

-The theoretical advantage of colloids over crystalloids is that, as they remain in the intravascular space for several hours → more prompt restoration of tissue perfusion → smaller volumes are required.

→ **However,** overall, current evidence suggests that crystalloid and colloid are equally effective for the correction of hypovolaemia (EBM 1.1).

EBM	**1.1 Crystalloid vs colloid to treat intravascular hypovolaemia**
'There is no evidence that resuscitation with colloids reduces the risk of death, compared to resuscitation with crystalloids, in patients with trauma, burns or following surgery.'	
Perel P. et al., Cochrane Database Syst Rev. 2007 Oct 17;(4):CD000567	
'The use of 4% albumin for intravascular volume resuscitation in critically ill patients is associated with similar outcomes to the use of normal saline.'	
Finfer S. et al. The SAFE study. New Engl J Med 2004; 350:2247–2256.	

Maintenance fluid requirements

Maintenance fluids can be calculated using the following formula:

For the first 0 to 10 kg → Give 100 mL/kg per day
For the next 10 to 20 kg → Give an additional 50 mL/kg per day
For weight > 20 kg → Give 20 mL/kg per day

E.g.: 70 Kg patient

1st 10 Kg ⟶ 1000 ml

2nd 10 Kg ⟶ 500 ml

All the rest ⟶ 1000 ml

Total Maintenance fluid requirements per day = 2500 ml

(2500/24= 104 ml/hour)

Maintenance fluid requirements

- Under normal conditions, adult daily sodium requirements (80 mmol) may be provided by the administration of **500–1000 ml of 0.9% sodium chloride**.

- The remaining water requirement to maintain fluid balance is typically provided as 5% dextrose.

- Daily potassium requirements (60–80 mmol) are usually met by adding potassium chloride KCl to maintenance fluids, but the amount added can be titrated to measured plasma concentrations.
- Potassium should not be administered at a rate greater than 10–20 mmol/h except in severe potassium deficiency and, in practice, 20 mmol are added to alternate 500 ml bags of fluid

Treatment of postoperative hypovolaemia and/or hypotension

-Hypovolaemia is common in the postoperative period and may present with one or more of the following: **tachycardia**, cold extremities, pallor, clammy skin, collapsed peripheral veins, oliguria and/or hypotension.

-Hypotension is more likely in hypovolaemic patients receiving epidural analgesia as the associated sympathetic blockade disrupts compensatory vasoconstriction.

-Intravascular volume should be rapidly restored with a series of fluid boluses (e.g. 250– 500 ml) with the clinical response being assessed after each bolus .

Electrolyte Abnormalities And Correction

Potassium Abnormalities

- It's the major **Intracellular** cation
- Only 2% of total body K located in ECF.
- Normal serum concentration : **3.5 – 5.3 mmol/L**

- 90% of K is **Renally** excreted .
- 10% In stool .

Hyperkalemia

Etiology :

(1) Increased intake

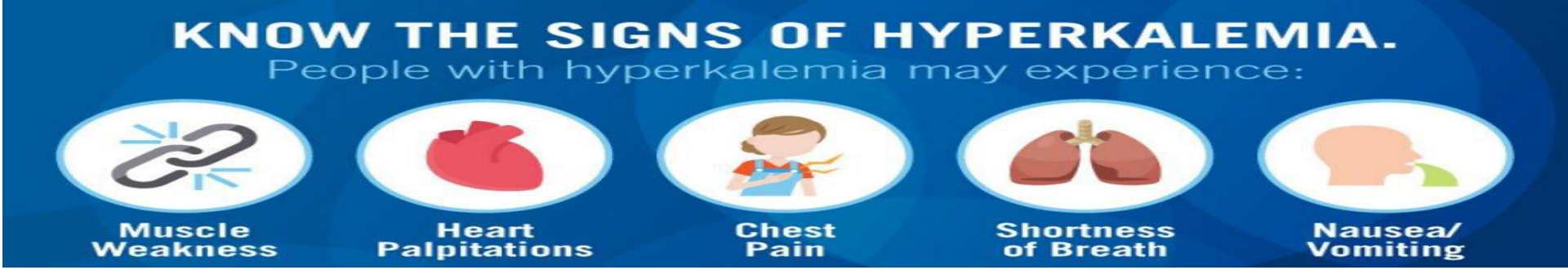
- K+ supplementation
- Blood transfusion

(2) Shift from IC to EC space

- Acidosis
- Rapid rise of EC osmolality (hyperglycemia or manitol)
- Endogenous load / destruction: hemolysis, rhabdomyolysis, crush injury, GIT hemorrhage
- Beta-Blocker * Digitalis

(3) Impaired excretion

- K+ sparing diuretics
- Renal insufficiency / failure



Symptoms of Hyperkalemia

→**Mild :** Asymptomatic . (K+ < 6 mmol/l)

→**Sever :** >6.5 mmol/L

(1) Gastrointestinal

- Nausea , vomiting , colic , diarrhea.

(2) Neuromuscular

- Hyper/HypoReflexia, weakness, paralysis , Respiratory failure.

(3) Cardiovascular

- Arrhythmias , Arrest.
- ECG changes (peaked T wave, flattened P wave, prolonged PR interval, widened QRS complex, ventricular fibrillation)

Hyperkalemia Correction:

→Mild :

Treated with reduction K intake

You can add loop diuretic and

Stop any medication that may cause hyperKalemia .

→Sever : ……

- **The Goals Of The Therapy :**

1- Protect the cells from the effects of ↑ K+ (Counteract cardiac effect) :

- Calcium gluconate 5 – 10 ml of 10% solution

2- Shifting K+ from EC to IC space :

- Glucose 1 ampule of 50% dextrose and regular insulin 5 – 10 units I.V.
- Salbutamol inhaler .
- Bicarbonate 1 ampule I.V.

3- Reducing total body Potassium (K+ Removal) :

- Kayexalate

Oral administration is 15 – 30 g in 50 – 100 ml of 20% sorbitol

Rectal administration is 50 g in 200 ml 20% sorbitol

- Hydration with normal saline and loopdiuretic
- Dialysis

Hypokalemia

Etiology of Hypokalemia

(1) Inadequate intake (rare)

- Dietary, potassium free i.v. fluids, potassium-deficit TPN

(2) Excessive potassium Excretion

- Hyperaldosteronisn
- Medications (loop diuretics)

(3) Losses

- GIT (diarrhea, vomiting, NGT)
- Renal loss
- Burns

(4) Intracellular shift

- Metabolic alkalosis, insulin therapy, Refeeding syndrome

Symptoms of Hypokalemia

→**Mild :** Asymptomatic

→ **Sever :** < 3mmol/L

(1) Gastrointestinal

- Ileus & constipation

(2) Neuromuscular

- Decreased reflexes, fatigue, weakness, paralysis

(3) Cardiovascular

- Arrest
- **ECG changes** (Ectopy , T wave depression ,U wave)

Hypokalemia Correction :

1- Mild or asymptomatic : ORAL repletion with potassium chloride

2- I.V repletion :

- If required , not more than **10** mEq/h in unmonitored setting .
- Can be increased to **40** mEq/h when accompanied by continuous ECG monitoring .

Remember to correct hypomagnesemia first if present

Phosphorus Abnormalities

- Phosphorus is the primary **intracellular** divalent anion and is abundant in metabolically active cells
- ECF contains less than 1% of total body stores.
- Normal level : **2.5 - 4.5 mg/dL**
- Phosphorus balance is regulated by a number of hormones that also control calcium metabolism.
- It is necessary to produce **(ATP)**
- Predominantly excreted through the **kidneys.**

Hyperphosphatemia

#Etiology :

1- Decreased urinary excretion :

- Renal impairment
- Hypoparathyroidism or hyperthyroidism also can decrease urinary excretion of phosphorus .

2- Increased intake

- Excessive phosphate administration (phosphorus-containing laxatives)

3- Increased release of endogenous phosphorus.

- **With cell destruction** (rhabdomyolysis, tumor lysis syndrome, hemolysis, sepsis, etc) , Acidosis , Insulin deficiency .

4- Post operative hypoparathyroidism.

#Signs and Symptoms :

- Most cases are asymptomatic.
- In the short term, include hypocalcemia and tetany.
- In contrast, soft tissue calcification and secondary hyperparathyroidism occur with chronicity .

Hypophosphatemia

#Etiology:

1- Decrease phosphorus intake

- Malnutrition or malabsorption.

2- Intracellular shift of phosphorus

- Respiratory alkalosis, insulin therapy, refeeding syndrome*

3- Increase urinary excretion

- Acidosis , alkalosis , acetazolamide .

4- Decrease intestinal phosphate absorption

- Vit D deficiency , malabsorption, use of phosphate binders .

#Signs and Symptoms :

- **Mild to Moderate** hypophatemia : Asymptomatic
- **Sever** (< 1 mg/dL)
  - Respiratory muscle dysfunction
  - Muscle weakness and paralysis
  - Cardiac dysfunction

Hyperphosphatemia Correction

- Eliminate the phosphorus source
- Remove phosphorus from the circulation:
  - hydration and diuresis (acetazolamide)
  - Phosphate binders (aluminum hydroxide)
- Correct any coexisting hypocalcemia.
- Dialysis : in extreme conditions

Hypophosphatemia Correction

- **In Moderate to sever :** Replace with I.V. potassium phosphorus or sodium phosphorus .

Sodium Abnormalities

- Normal person consumes 3-5g of NaCl daily
- Sodium balance is maintained mainly by the **kidneys**
- Normal Na Concentration: **135 – 145 mmol/L.**

- Serum Na concentration is **inversely proportional to total body water** .Therefore, abnormalities in TBW are reflected by abnormalities in serum Na.

Hyponatremia

- A low serum Na occurs when there is excess of extracellular water relative to Na .

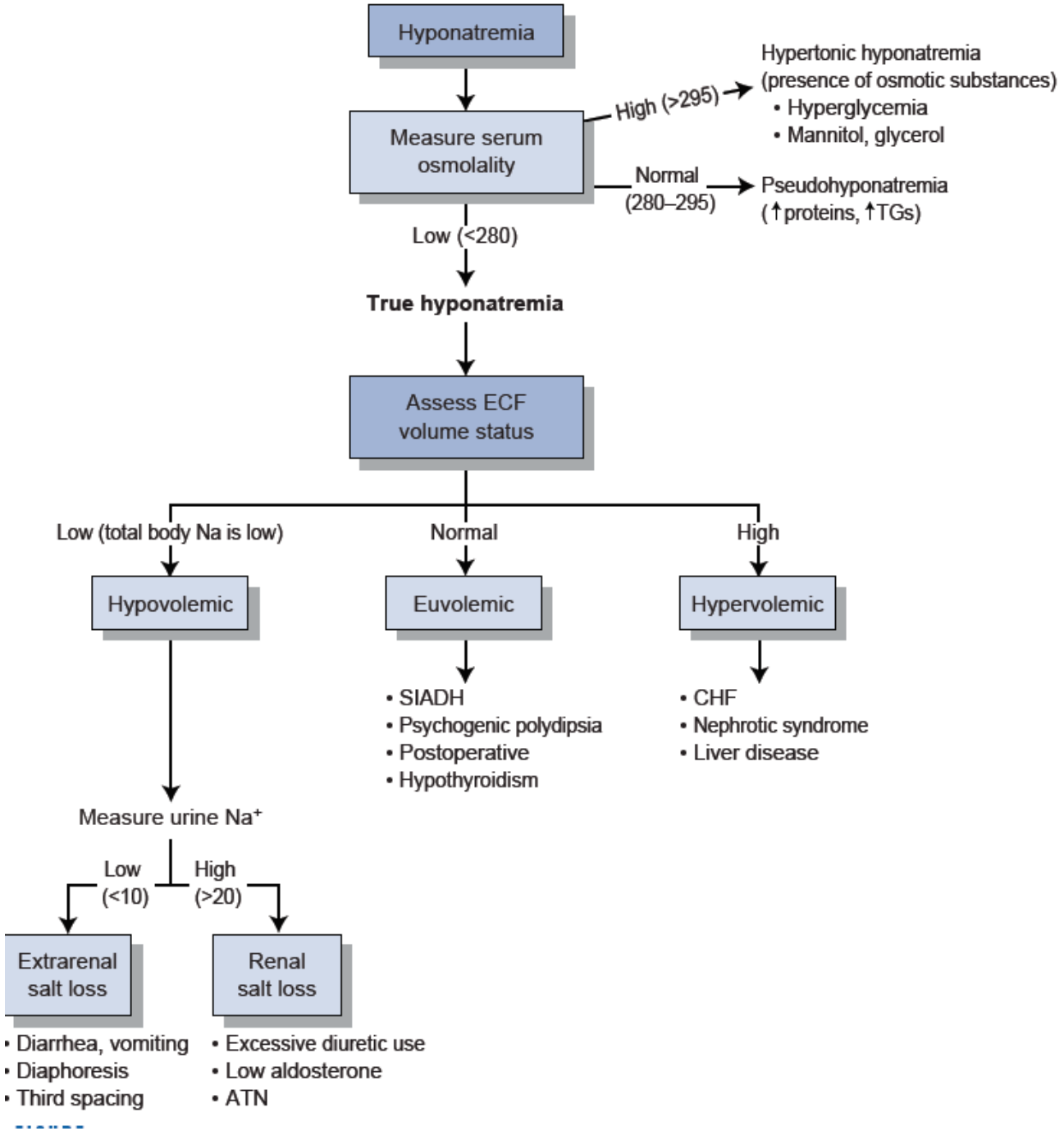
- In acute drop : 120-130 may produce symptoms
- In chronic hypoNa : symptomatic 110-120 mEq/L.

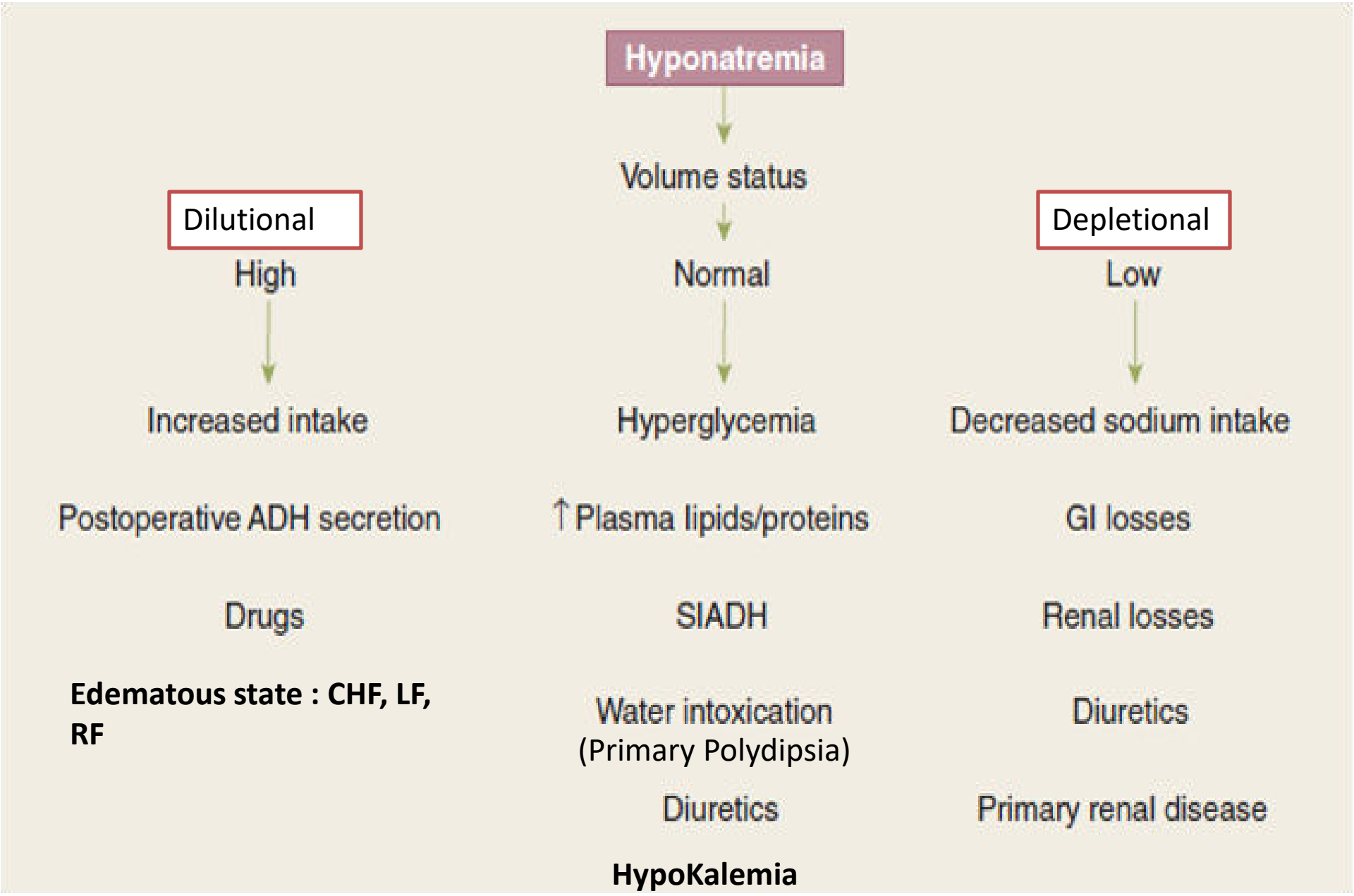
- The first step is to repeat the test to exclude lab error then calculate the Plasma osmolality to determine if it is:

1-hypertonic hypoNa : as in hyperglycemia (osmotic substance)

2- isotonic hypoNa (pseudohyponatremia) : as in hyperlipidemia or increased proteins in the serum

3- hypotonic hypoNa : in which you have to assess volume status because it is classified according to the ECV.


Hyponatremia
Measure serum osmolality
High (>295)
Hypertonic hyponatremia
(presence of osmotic substances)
• Hyperglycemia
• Mannitol, glycerol
Normal (280–295)
Pseudohyponatremia
(↑proteins, ↑TGs)
Low (<280)
True hyponatremia
Assess ECF volume status
Low (total body Na is low)
Normal
High
Hypovolemic
Euvolemic
Hypervolemic
• SIADH
• Psychogenic polydipsia
• Postoperative
• Hypothyroidism
• CHF
• Nephrotic syndrome
• Liver disease
Measure urine Na+
Low (<10)
High (>20)
Extrarenal salt loss
Renal salt loss
• Diarrhea, vomiting
• Diaphoresis
• Third spacing
• Excessive diuretic use
• Low aldosterone
• ATN


Hyponatremia
Volume status
Dilutional
High
Increased intake
Postoperative ADH secretion
Drugs
Edematous state : CHF, LF, RF
Normal
Hyperglycemia
↑Plasma lipids/proteins
SIADH
Water intoxication
(Primary Polydipsia)
Diuretics
HypoKalemia
Depletional
Low
Decreased sodium intake
GI losses
Renal losses
Diuretics
Primary renal disease

Signs and Symptoms

Body System	Hyponatremia
CNS	Headache, confusion, hyper/ hypoactive deep tendon reflexes, seizures, coma, increased intracranial pressure
Musculoskeletal	Weakness, fatigue, muscle cramps, twitching
GIT	Anorexia, nausea, vomiting, watery diarrhea
CVS	Hypertension & bradycardia if significant increase in intracranial pressure
Tissue	Lacrimation, salivation
Renal	Oliguria

Hyponatremia Correction

1- If Hypovolemic HypoNa: give 0.9%NS .

2- Other types: mostly treated by **water restriction**.

3- If severe(<110) or neurologic symptoms : 3% NS (hypertonic saline)

Correction should be slowly

(The rate of correction shouldn't exceed 12meq/L /day OR 0.5mEq/l/h)

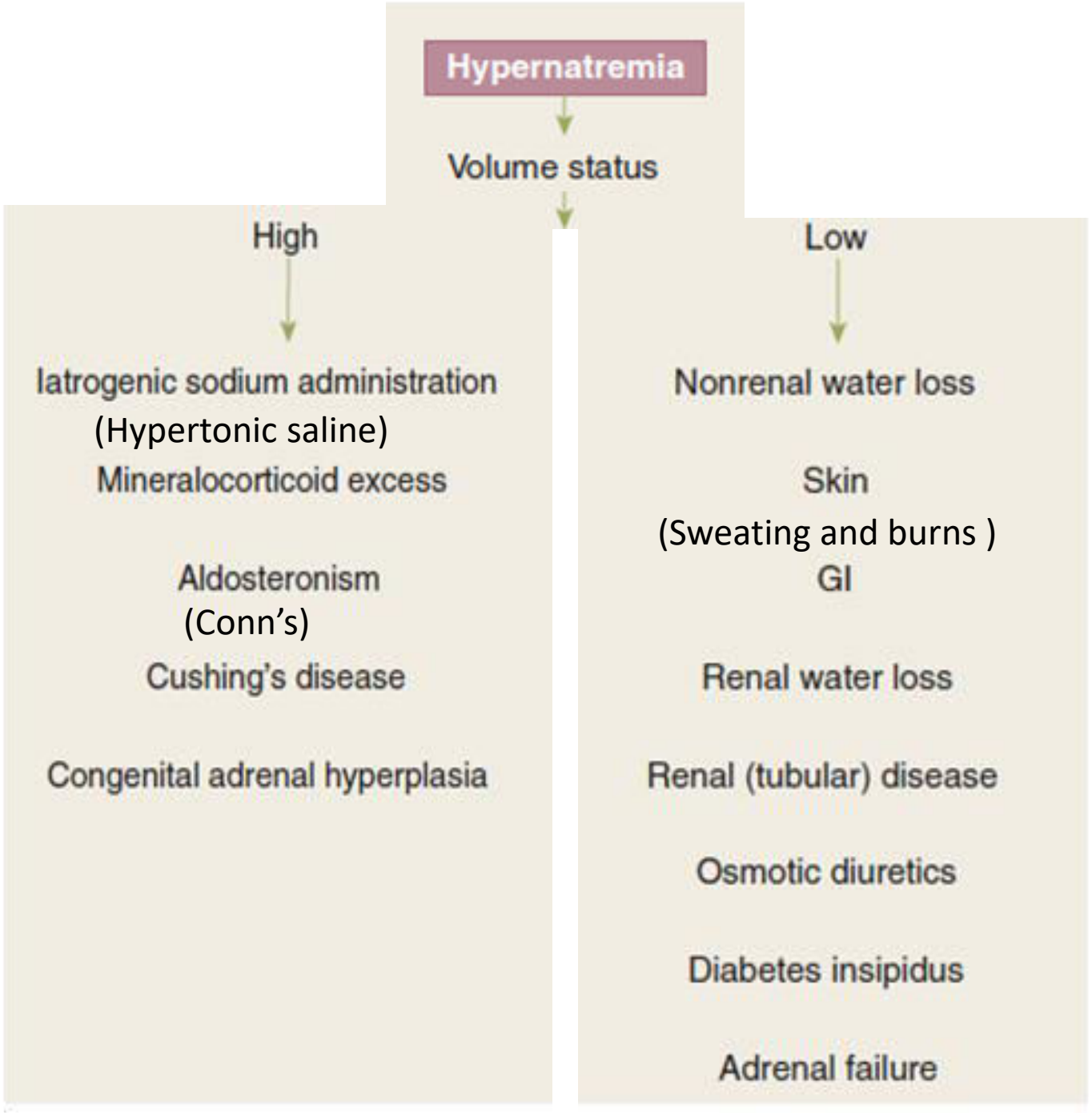
→Rapid correction can result in **Central pontine demyelination.** **(Locked-in syndrome)**

Hypernatremia

- Hypernatremia (Na+ > 145 mmol/l) results from either

1- loss of free water or

2- gain of sodium in excess of water


Hypernatremia
Volume status
High
Iatrogenic sodium administration
(Hypertonic saline)
Mineralocorticoid excess
Aldosteronism
(Conn's)
Cushing's disease
Congenital adrenal hyperplasia
Low
Nonrenal water loss
Skin
(Sweating and burns)
GI
Renal water loss
Renal (tubular) disease
Osmotic diuretics
Diabetes insipidus
Adrenal failure

Signs and Symptoms

Body System	Hypernatremia
CNS	Restlessness, lethargy, ataxia, irritability, tonic spasm, delirium, seizures, coma
Musculoskeletal	Weakness
Cardiovascular	Tachycardia, hypotension, syncope
Tissue	Dry sticky mucus membranes, red swollen tongue, decreased saliva and tears
Renal	Oliguria
Metabolic	Fever

Hypernatremia Correction

- Treat associated water deficit first.

→ In **Hypovolemic Hypernatremic** patients:

1- Restore the volume with normal saline.

2- Once adequate volume achieved (hemodynamic stable)
> Replacement of free water (WD) using a hypotonic fluid .

Water deficit (L) =
(Serum Na – 140)/140 x TBW

(TBW = 60% × body wt)

RAPID correction can lead to brain edema and herniation

→ In **Hypervolemic Hypernatremic** :

Give loop diuretic.

Calcium Abnormalities

- 99% of Ca is stored in bones and 1% circulates in blood
- Normal Serum Calcium : **8.5 – 10.5 mg/dL**

- Serum Calcium **exists in 3 forms**:

  (1)- Ionized **(50%)**

  (2)- Protein bound **(40%)**

  (3)- Complex with phosphate and other anions **(10%)**

- Only **free ionized Ca** is physiologically active
- Normal Ionized Ca level : **4.6 – 5.1 mg/dL**

- Normal Ca metabolism is under the influence of **PTH and Vit D** .

- When measuring the total serum Ca, the albumin concentration should be taken in consideration.

((Each 1 g/dL reduction in serum albumin will lower the total serum Ca by 0.8 mg/dL , w/o affecting the ionized Ca conc.))

- Unlike changes in albumin, changes in pH affect the ionized Ca concentration.

((Acidosis decreases protein binding, thereby increasing the ionized Ca .

While alkalosis increases protein binding , which decreases ionized Ca levels.))

Hypercalcemia

- Increase in Ionized Ca or Total Serum Ca.
- The **Ionized Ca** fraction is responsible for the neuromuscular stability and can be measured directly.

- **Hypercalcemia Etiology :**

➢ Primary hyperparathyroidism (outpatient)

➢ Malignancy (associated bony metastasis or due to secretion of parathyroid hormone-related protein) (hospitalized patients)

Causes of Hypercalcemia

knowmedge

Mnemonic: "Chimpanzees"

Hypercalcemia Causes

NURSEBUFF

- **C** alcium supplements
- **H** yperparathyroidism
- **I** atrogenic, immobilization
- **M** ultiple myeloma
- **P** arathyroid hyperplasia
- **A** lcohol
- **N** eoplasm

Signs And Symptoms :

- Mild : Asymptomatic

- Sever :

-**Cardiac Effect:**

HTN and

QT interval

Shortening.

Hypercalcemia / Hyperparathyroidism Signs

Mnemonic: "Bones, Stones, Groans, Moans"

knowmedge

Painful Bones	Painful bone condition (Classically osteitis fibrosa cystica)
Renal Stones	Kidney Stones (Can ultimately lead to Renal failure)
Abdominal Groans	GI symptoms: Nausea, Vomiting, Constipation, Indigestion
Psychiatric Moans	Effects on nervous system: lethargy, fatigue, memory loss, psychosis, depression

Hypocalcemia

Etiology:

1- Calcium Sequestration:

-Pancreatitis

-Massive Blood transfusion with citrate binding.

-Rhabdomyolysis and Tumor-lysis syndrome

-Massive soft tissue infections (necrotizing fasciitis)

-Increased osteoblastic activity as in prostate or breast ca.

2- Vit D deficiency

-Renal failure

3- Hypoparathyroidism

4-Post parathyroidectomy or thyroidectomy .

5-Abnormalities in Mg

Signs and Symptoms

→Symptoms don't occur until ionized fraction falls below 2.5 mg/dL .

(1) Neuromuscular

- Hyperactive reflexes, Stridor , Tetany, Parasthesia, carpopedal spasm, seizures .

(2) Cardiovascular

- Arrhythmias , Heart failure due to decreased cardiac contractility.

(3) ECG changes

- Prolonged QT interval, T-wave inversion, heart block, ventricular fibrillation.

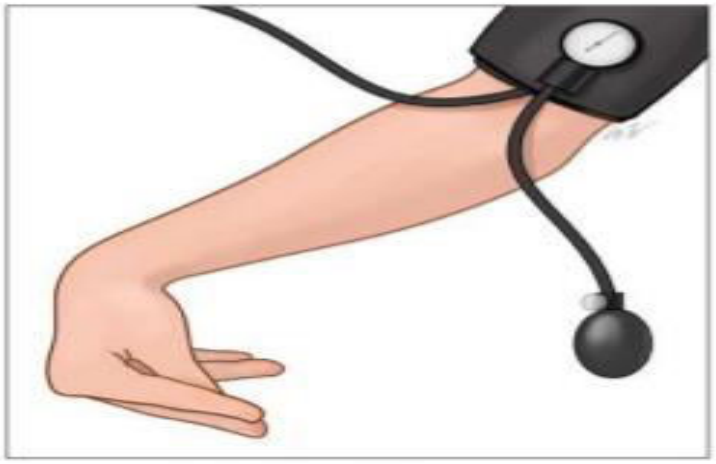
- Chevostek's sign: Twitching resulting from taping over the facial nerve

- Trousseau's sign: Spasm resulting from pressure applied to the nerves and vessels of the upper extremity, as when obtaining BP)

Physical Exam Findings

- Chvostek's sign
  - Sensitivity 70%
  - Specificity 75%

- Trousseau's sign
  - Sensitivity 94%
  - Specificity 99%



Jesus, J.E and Landry, A. Chvostek's and Trousseau's Signs. N Engl J Med 2012, 367:e15 DOI 10.1056/NEJMicm1110569

Hypercalcemia Correction

- If **mild** (<12) : Calcium restriction and treat the underlying disorder.
- If more sever:
  - NS with Loop Diuretics
  - Salmon calcitonin .

Hypocalcemia Correction

- Asymptomatic: can be treated with oral or I.V. Ca Ca carbonate and Ca gluconate
- Symptomatic: should be treated by I.V. Ca Ca chloride (10 ml calcium of 10% calcium gluconate within first 10 min then maintenance with 1-2 ml/h) .
- Don't forget to check the levels of Mg, Phosphorus, K

Magnesium Abnormalities

- Mg is the 4th most common mineral in the body and is found primarily in the **intracellular** compartment
- Normal Range : **1.3 – 2.2 mEq/L.**
- Of the fraction found in the EC space, 1/3rd is **bound to serum albumin**, therefore, serum Mg is poor indicator of total body stores in the presence of hypoalbuminemia
- **The kidneys** play the major role in regulating Mg .
- Mg should be maintained at the upper limit of normal > to prevent QT interval prolongation and arrythmias.

Hypermagnesemia

- Rare,
- Can be seen with impaired renal function

- **Causes**:

1- **Iatrogenic : Excess intake** (TPN, Mg containing laxatives & antacids).

2- **Renal failure** .

- **Mild** Hypermagnesemia : Asymptomatic

Symptoms of Hypermagnesemia

(Sever >8mEq/L)

(1) Gastrointestinal

- Nausea & vomiting

(2) Neuromuscular

- Decreased reflexes, Weakness of muscles, lethargy

(3) Cardiovascular

- Hypotension & sinus bradycardia ,Arrest

(4) ECG changes

- Similar to those seen in **hyperkalemia.**

(Prolonged PR, QRS, QT intervals).

Hypomagnesemia

- **Causes:**

(1) Poor intake (Rare)

Starvation, alcoholism, prolonged use of I.V. fluid & TPN with inadequate supplementation of Mg.

(2) Increased renal excretion

(alcohol, most diuretics as loop , primary hyperaldosteronism , Drugs as amphoterecin B, aminoglycosides or cyclosporine)

(3) GIT losses (diarrhea)

Malabsorption, acute pancreatitis, diabetic ketoacidosis.

(4) Shift from EC to IC space

With MI , alcohol withdrawal, or after receiving glucose saline .

(5) Post parathyroidectomy .

Symptoms of Hypomagnesemia

(1) Neuromuscular

- Neuromuscular and nervous system hyperactivity & symptoms similar to those **Hypocalcemia.**

(2) Cardiovascular

- Arrhythmias (As **Hypokalemia**)

(3) ECG changes

- Prolonged QT & PR intervals, ST segment depression, flattening or inversion of P waves.

- **Hypomagnesemia** is usually accompanied by hypokalemia and hypophosphatemia.
- **Hypomagnesemia** is important not only for its direct effects on the nervous system but also because it can produce hypocalcemia and leads to persistent hypokalemia.
- When hypokalemia or hypocalcemia **coexist** with hypomagnesemia, **Mg should be aggressively replaced** to assist in restoring K or Ca homeostasis.

Hypermagnesemia Correction

- prevent exogenous sources
- Calcium gluconate 10%
- Normal saline with loop diuretics
- Dialysis

Hypomagnesemia Correction

- Mild/Asymptomatic : Oral supplement.
- Sever (<1 mEq/L) / Symptomatic: IV $MgSO_4$

Thank You !