IV Fluids- electrolytes

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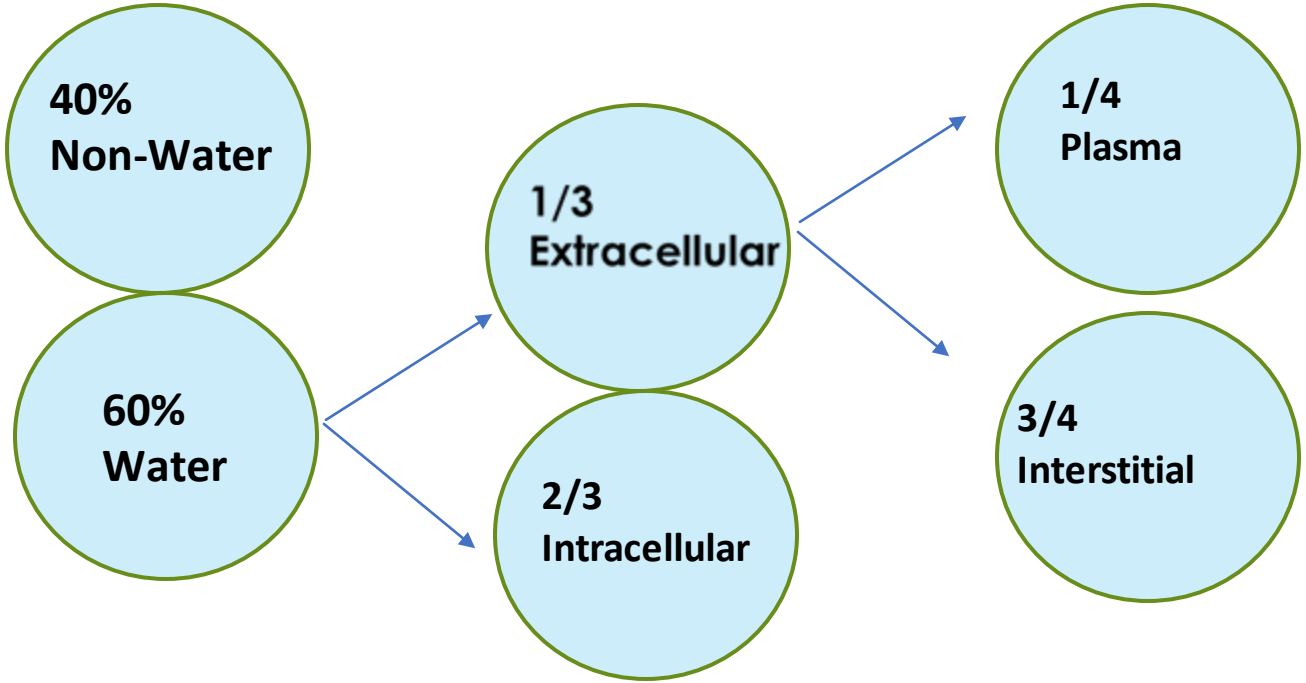
IV Fluids

Fluid compartments



Fluid Intake and Output

- Normal oral **intake** ~2 L/day
- **Output**:
  - Urine: 1.0 L/day
  - Insensible losses:
    - Stool: 0.25 L/day
    - respiration, sweating: 0.75 L/day
- Insensible losses: ↑ pathologic states
  - Fever
  - Burns

IV fluid therapy indications

- **IV fluid therapy is used to maintain homeostasis when:**
  - **intake is insufficient**
  - **to replace any additional losses.**

- **These losses may occur from:**
  GIT (due to severe vomiting, diarrhoea),
  urinary tract (eg, diabetes insipidus),
  blood loss from trauma or surgery.
  In addition, insensible losses can increase during fever or after suffering from burns because the barrier function of the skin is impaired.

Types of IV fluids

Crystalloid solutions

- **Contain water and salts (NA+,K+,CL-,CA+2,HC03-) dont stay intravascular spread to interstitium**
- **Examples:**
  - **Normal saline (isotonic)**
  - **Lactated ringers (isotonic)**
  - **half normal saline (hypotonic)**
  - **D5W (hypotonic)**
  - **Hypertonic saline.**
- **infusion : fluid loss ratio = 1:1**
- **infusion : blood loss ratio = 4:1**

Colloid solutions

- Contain water and large molecules
- Mainly remains in the intravascular compartment.
- used for resuscitation in severe hypovolemia , blood loss and burns.
- Examples: albumin, gelatin, dextran solutions, hydroxyethyl starches
- Expensive
- infusion : blood loss ratio = 1:1

osmolarity

- Osmosis: simple diffusion of water from high conc of water to low conc of water across semi permeable membrane.
- **Osmolarity** of solution is equal to number of osmoles per **liter** of solution.
- Normal range of osmolarity in plasma is about 280-295 milli-osmoles per liter.
- **Tonicity** is the total conc. of solutes which make an osmotic force across a membrane.
- The term tonicity is used to describe the osmolarity of a solution relative to **plasma.**
  - Isotonic (osmolarity of a solution ~ to **plasma**)
  - hypertonic (osmolarity of a solution > to **plasma**)
  - hypotonic (osmolarity of a solution < to **plasma**)

Normal Saline

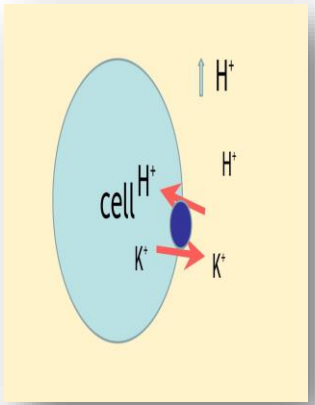
0.9% Normal Saline

- Approximately same osmolarity as plasma
  - [Na] = [Cl] = 154 mmol/liter
  - total osmolarity = 308 mOsmol/liter vs. 285 m0sm/L plasma
- **isotonic**
- 25% remains in intravascular space
- Used for volume replacement ?
  - Hypovolemic shock
  - Septic shock

Normal Saline

- Normal Saline Results in influx of chloride ions (Cl)
- Causes shift of bicarbonate ions (HCO_3) into cells
- Causes acidosis (pH)
- Acidosis → potassium shift out of cells
- ↑ serum potassium
- Contraindications:

CHF, CKD, Liver cirrhosis



Lactated Ringers

- Sodium, chloride, potassium, calcium, and lactate.
- "Balanced fluid"
- Isotonic: osmolarity 286 mOsm/L
- Lactate converted to bicarbonate
- Acts as buffer in acidotic states

Used for?

trauma resuscitation

INDICATION ?

- ✓ **1) First-line replacement therapy in the perioperative period.**
- **2) Fluid resuscitation after a blood loss due to trauma, surgery, or a burn injury.**
- **3) Replace GI tract fluid losses.**
- **4) Metabolic acidosis.**

CONRTAINDICATION?

1) Poor liver function.
(cant metabolize lactate)
2) Hyperkalemia
(renal patient)
3) Citrated blood transfusions
(Clumping of red cells if it is co-administered with blood products)

Half Normal Saline

0.45% Normal Saline

- [Na] = [Cl] = 77 mmol/liter
- total osmolarity = 154 mOsmol/liter vs. 285 m0sm/L plasma
- **Hypotonic** solution concentration of sodium chloride
- Does not remain intravascular
- Used as "maintenance fluids"
- Replaces daily losses of sodium and water
- 5% dextrose often added: D5 half NS
- Potassium can be added: D5 half NS with 20mEq K
- Often used when oral intake is low

Avoid with ? Hyponataremia ,burns,head trauma

Dextrose 5% in water (D5W)

5% Dextrose

- **Contains Dextrose and free water.**
- **Dextrose is metabolized leaving only free water**
- **Used for:**

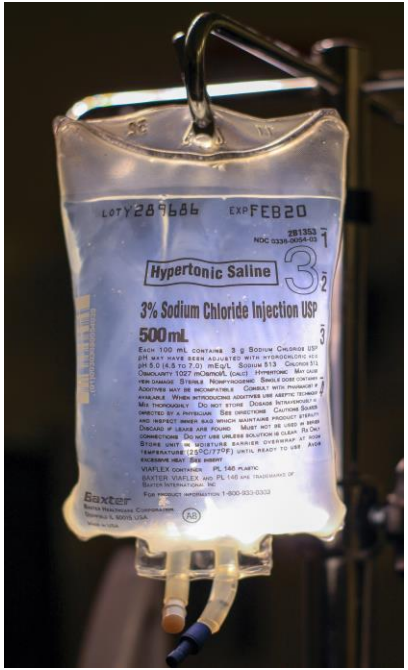
hypernatremia to dilute sodium.

Used Cautiously with renal patients.

Hypertonic Saline

3% Saline

- **Hypertonic: ~900 mOsm/liter**
- **Draws fluid out of tissues into vascular space**
- **ICF ⟶ ECF**
- **Used for:**
- **Elevated intracerebral pressure**
- **Severe hyponatremia**



Hypovolemia

- **Causes:**
  - **Vomiting/diarrhea**
  - **Poor oral intake**
  - **Third spacing/fluid leak: sepsis, trauma**
- **Clinical features:**
  - **Decreased urine output**
  - **Dry mucous membranes**
  - **Poor skin turgor**
- **Treatment:**

  Oral intake

  IV fluids

Hypervolemia

- **Causes:**
  - **Heart failure**
  - **Cirrhosis**
  - **Nephrotic syndrome**
- **Clinical features:**
  - **Weight gain**
  - **Pitting edema**
  - **Elevated jugular venous pressure**
  - **Pulmonary edema**
- **Treatment:**
  Diuretics

Maintenance of Fluids:

(4-2-1 rule)

(4ml/kg for the first 10kg) + (2ml/kg for 11-20kg) + (1ml/kg for every kg above 20) = hourly rate

Example: Calculate the hourly maintenance fluid rate for a 70kg patient who is NPO
(4ml x 10kg) + (2ml x 10kg) + (1ml x 50kg)
40ml + 20ml + 50ml = 110ml/hr

Maintenance of electrolytes:

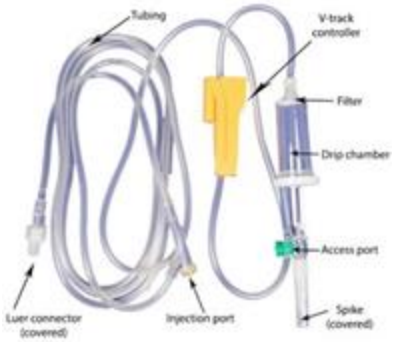
Na+: 3 mEq/kg/day, K+ : 1 mEq/kg/day

e.g. Calculate a 50 kg patient's maintenance requirements
- **Fluid = 40 + 20 + 30 = 90 mL/hour = 2160 mL/day**
- **Na+ = 150 mEq/day**
- **K+ = 50 mEq/day**

Equipment of IV therapy

- 1. Solution containers.

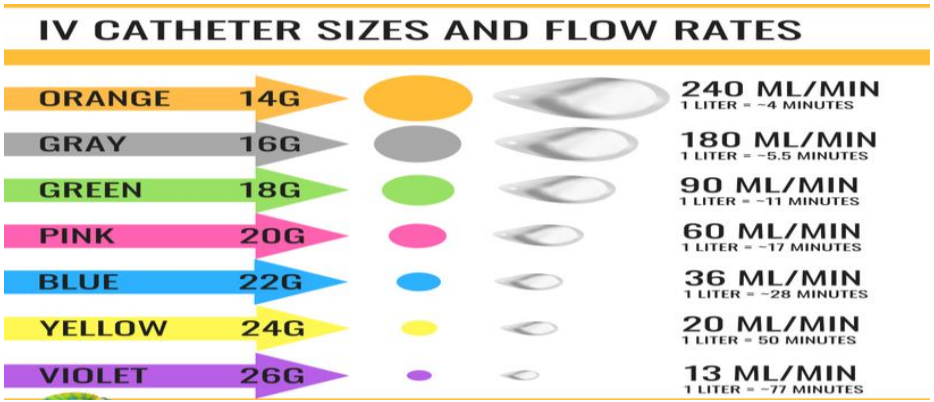
- 2. I.V. administration sets.



3-IV CANNULA

- universal color coding for easy recognition of IV cannulas.
- Present day IV cannulas are available from sizes 14 gauge to 26 gauge
- Smaller the gauge, wider the cannula and higher the flow rate.

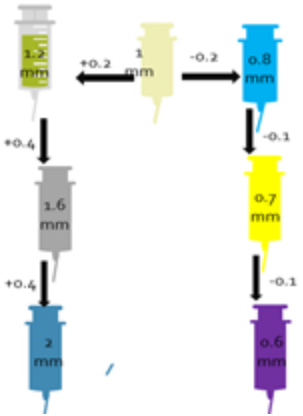
- Normal adult size: 18-20 G
- Preferred pediatric size: 22 G
- Infants and neonates: 24-26 G

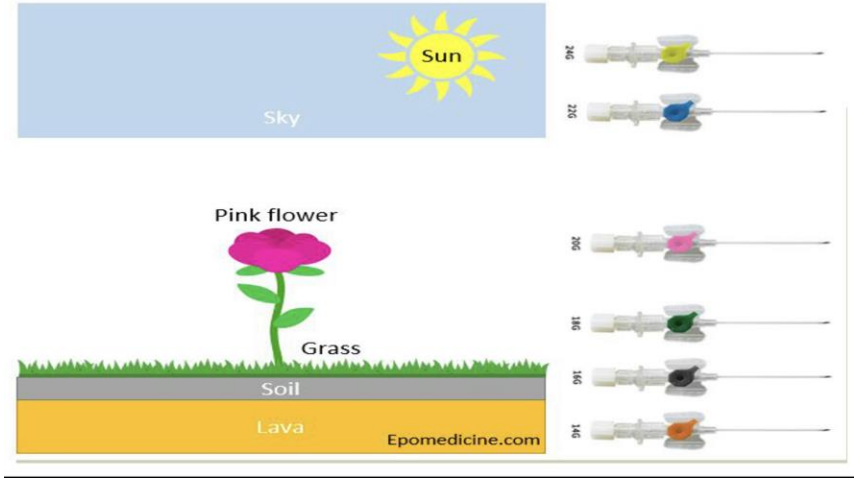


- Situations requiring rapid fluid transfusion like trauma: 14-16 G
- +pink(20 G) is most commonly used

External diameter of cannulas :

- Remember the pink (20 G) cannula is **1 mm** in diameter.
- For cannulas next to pink: 1 +/- 0.2 mm
- 18 G (**green**): 1+0.2= 1.2 mm
- 22 G (**blue**): 1-0.2= 0.8 mm
- For cannulas smaller than 18 G:
- 16 G (**grey**): 1.2 + 0.4 = 1.6 mm
- 14 G (**orange**):1.6 + 0.4 = 2 mm
- For cannulas larger than 22 G:
- 24 G (**yellow**): 0.8 – 0.1 = 0.7 mm
- 26 G (**purple**): 0.7 – 0.1 = 0.6 mm





Normal sodium level 135-145

Sodium

Hyponatremia

- Hyponatremia when the serum sodium less than 135 mEq/L

  mild 130–134 mEq/L

  moderate, 120–129 mEq/L

  severe, <120 mEq/L
- Any patient show low level of sodium we calculate serum osmolality (normal 275-290 mOsm/kg) to identify if it false or true hyponatremia .

$$Posm(mOsm/kg) = 2\times Na+ + [glucose]/18+BUN/2.8$$

- False hyponatremia

  mainly high or normal osmolality due to increase of other molecules in blood like in :

- **1- hyperglycemia**
- In poorly controlled diabetes
- It will make dilution effect as H2O will be drawn into the intravascular space → HIGH serum osmolality

- **2- mannitol** usage in increased ICP cases
- Works in the same dilution effect → HIGH serum osmolality

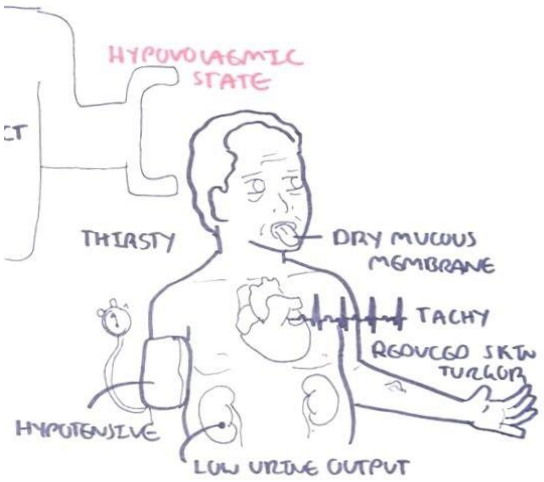
- **3-hyperlipidemia and hyperproteinemia**
- -As in MM and recent IV IG therapy
- → NORMAL serum osmolality
- Cause: lipids and proteins interfere with lab analysis of the serum (lab error)

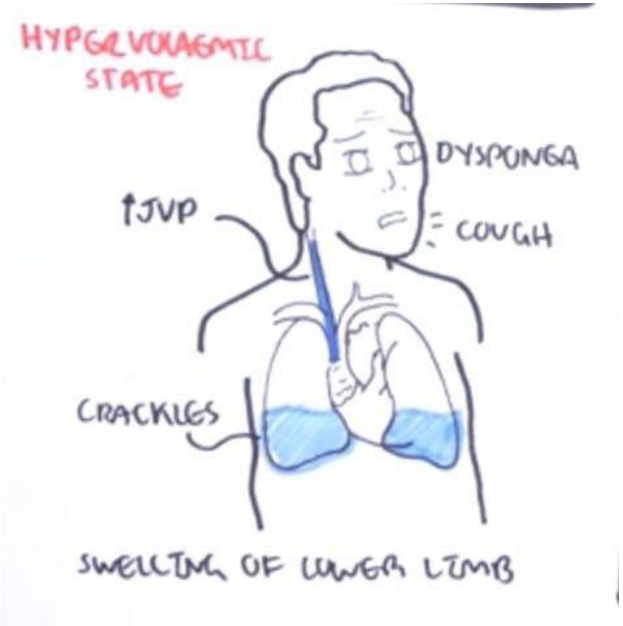
- **4-TURP**
- -sorbitol/mannitol + glycine are used in the procedure and do dilution effect

- ● HYPO-VOLEMIC : NG suction , burns , pancreatitis , diaphoresis
- EU-VOLEMIC : SIADH , CNS
- HYPER-VOLEMIC : RF, CHF , LIVER FAILURE , DILITUIONAL , FLUID OVERLOAD

- Signs and symptoms

signs and symptoms as result of fluid disturbance caused by hyponatremia :





Hyponatremia isn't a disease but it's a manifestation of
Other disease

Clinical feature due to hyponatremia

seizures , confusion lethargy , coma weakness

- Management

- Mild and asymptomatic hyponatremia (no treatment)
- Moderat and asymptomatic (strict fluid restriction 750ml to 1L then slow isotonic saline)
- Acute sever hyponatremia or rapied hyponatremia , management should be quick to prevent cerebral edema and noncardiogenic pulmonary edema (resuscitation then fluid restriction then slow hypertonic saline to increase serum sodium level)
- Always don't forget to correct hyponatremia slowly (0.25–0.5 mEq/L per hour), to avoid central pontine myelinolysis.

HYPERNATREMIA

- Hypernatremia is defined as a sodium level greater than 145mEq/L
- (moderate, 146–159 mEq/L; severe, ≥160 Eq/L).

➢ Hypernatremia is caused by increase water loss or increase in sodium intake .

To diagnose patient with hypernatremia :

1. history (to ask patient if he had hyper aldosteronism or if he has been getting hypertonic saline and ask patient about diarrhea , vomiting and burn)
2. Urine osmolarity (if the urine osmolality is low so there is renal water loss and in high urine osmolality it will be extra renal water loss)
3. Sodium concentration in urine to differentiate between extra renal water loss (low sodium in urine)

   and sodium gain (high sodium in urine) .

- Clinically :

  seizures ,confusion, tremors .respiratory paralysis .

➢ Management :

the most common cause is water loss so give them back water

how much water you have to give ?

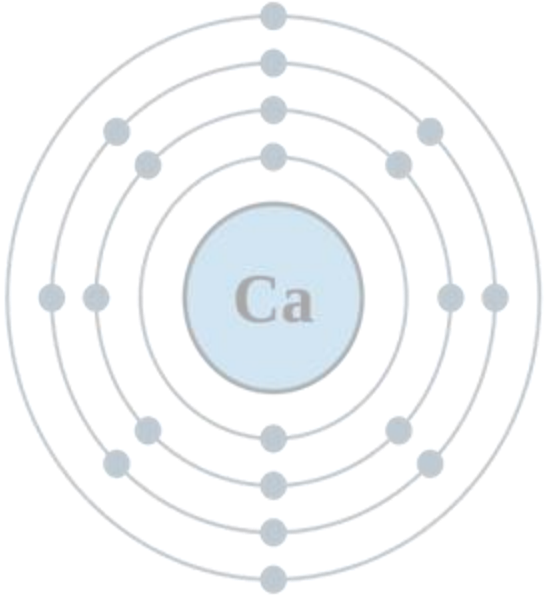
free water deficit (L) = (serum sodium – normal sodium level)/140 * TBW

Total body weight = weight(Kg)*constant (constant in male 0.6 in female 0.5)

1. tell patient to drink water
2. If patient cant drink water give back water by NG or OG tube
3. Give patient IV FLUID like D5W or ½ NS , ¼ NS

➢ Slow lowering of serum sodium is very important less than 12 mEq/day TO AVOID SEZIURES . (brain edema) .

Calcium



Done by: farah mohammad

Calcium in our bodies

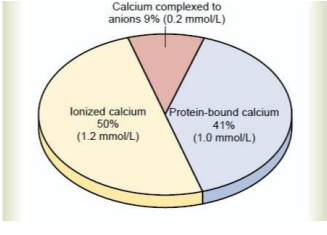
- The most abundant **metal** in our bodies.
- 99% in bones, 1% in serum and soft tissue .
- **Normal value** ***: 8.5 - 10.5 mg/di.***

• Calcium in plasma or serum exists in three forms:

1. Protein-bound calcium (40%) **most calcium ions** are bound to albumin, so the total calcium concentration fluctuates with the protein (albumin) concentration.

2. **Ionized or free calcium (50%)**is the physiologically **active form .**

3. Complexed or chelated calcium(10%) is bound to phosphate, bicarbonate, sulfate, citrate, and lactate.



Corrected Ca 2 + = measured Ca + 0.8 × [4 - measured albumin]

Calcium Regulation

- **by Hormonal control, Albumin, and Blood's pH.**

1. **Hormonal Control** Maintenance of calcium balance is a function of PTH ↑, calcitonin ↓, and vitamin D ↑, and their target organs bone,kidney, and gut.

Acidosis (low pH) (high H^+)

-high H^+ will repel Ca^+ from albumin$^-$ which will lead to high amount of ionized calcium in serum → **Hypercalcemia**

Alkalosis (high pH) (low H^+)

-albumin$^-$ will bind with ionized calcium leading to low amount of it in serum → **Hypocalcemia.**

(-)

Hyperalbuminemia

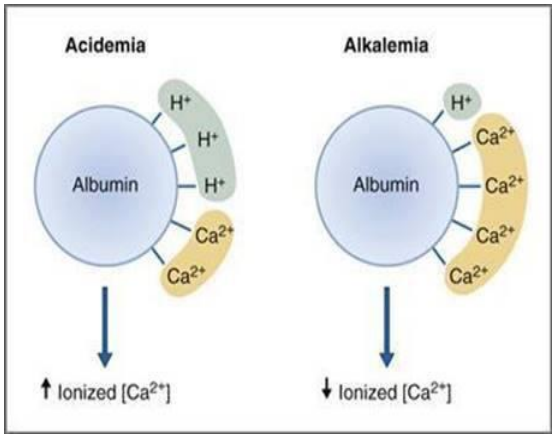
-non diffusible calcium will bind w/ excess albumin, but free ionized Ca+ will stay the same ; hormone control.

→**Pseudo** hypercalcemia.

Hypoalbuminemia

-loss of total calcium with albumin loss, but free ionized Ca+ will stay the same ; hormone control.

→**Pseudo** hypocalcemia



Hypercalcemia

Serum calcium **>10.1mg/dl**

Causes:

1. **Hyperparathyroidism**

   (most common in outpatients)

   ↑ **PTH** → **Osteoclastic bone resorption.**

2. **Malignant tumor (PTH-rp)**

   (most common cause in inpatients) bony metastases, Multiple Myeloma

3. **Excess Vitamin D.**
4. **Medications** → **Thiazide diuretics.**

Hypercalcemia -What Do You See ?

Sign and symtoms

Fatigue, confusion, lethargy, coma.

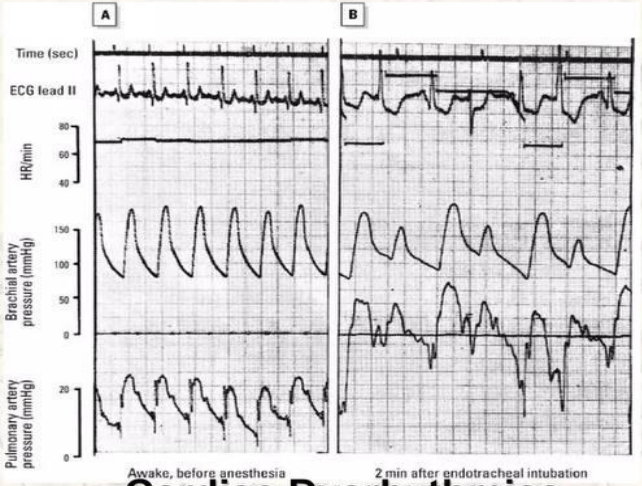
Muscle weakness, hyporeflexia.

Bradycardia > cardiac arrest.

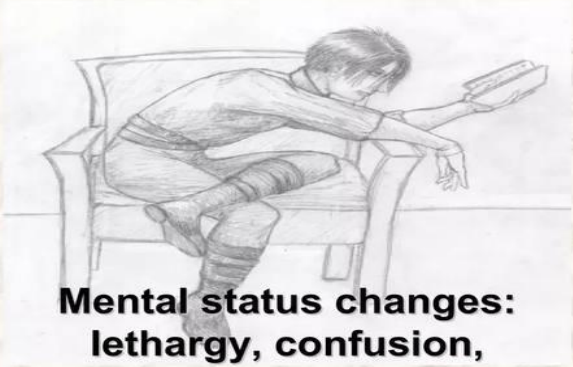
Anorexia, nausea/vomiting, decreased bowel sounds, constipation.

Polyuria, renal calculi, renal failure.

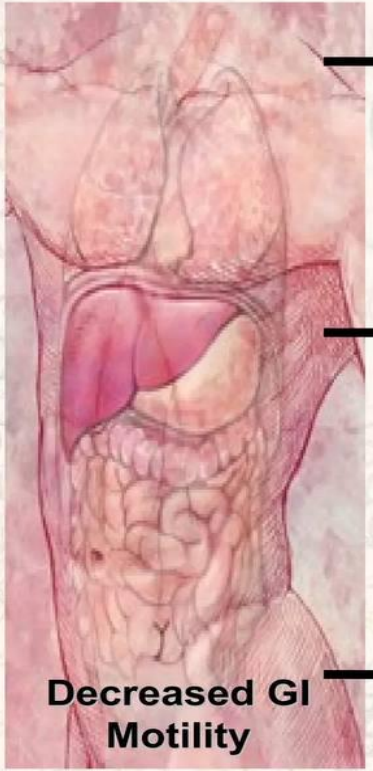
CLINICAL MANIFESTATIONS OF HYPERCALCEMIA



Cardiac Dysrhythmias



Mental status changes: lethargy, confusion, memory loss



Decreased GI Motility

Constipation

Nausea

Vomiting

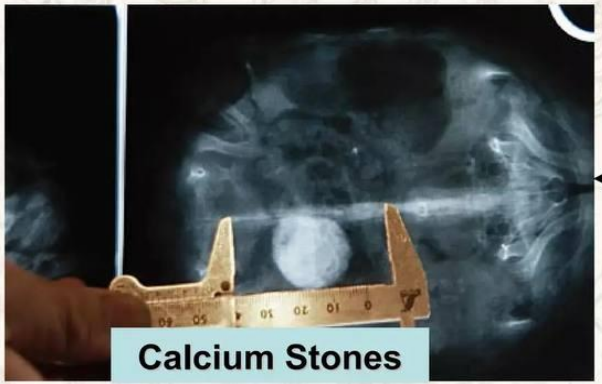
CLINICAL MANIFESTATIONS OF HYPERCALCEMIA

Immobilization

Bone Demineralization

Calcium accumulates in the ECF and passes through the kidneys

Ca Precipitation



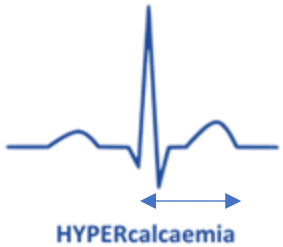
Calcium Stones

Hypercalcemia

Diagnosis

1. **High Ca^{+2} in blood >10.5 mg/dl**
2. **ECG → Bradycardia , AV block**

Short QT interval



3. Lab Tests (to know underlying cause).

Magnesium, albumin, and ionized calcium.

Amylase/ lipase / Serum PO43 / PTH.

What do we do?

Treatment

To lower Ca^{+2} levels.

1. Increase urinary retention.

   [IV Fluids; first step]

   [loop diuretics ; Furosemide]
2. Increase GI excretion.

   [glucocorticoids]
3. Prevent bone resorption

   [bisphosphonates & calcitonin]

hypocalcemia < 1.8 mmol/l

causes

the commonest; after thyroid surgery, renal failure and pancreatitis

1-hypoparathyroidism

2-hypomagnesemia [patients on iv.feeding for long time]

3-severe pancreatitis

4-renal failure; acute and chronic

ca absorption is helped by active form of vit.d which is done in the kidney. in renal failure that does not happen.however low ca can lead to hyperparathyroidism causing hypercalcemia with bone changes

5-severe trauma [blood loss] [albumin loss]

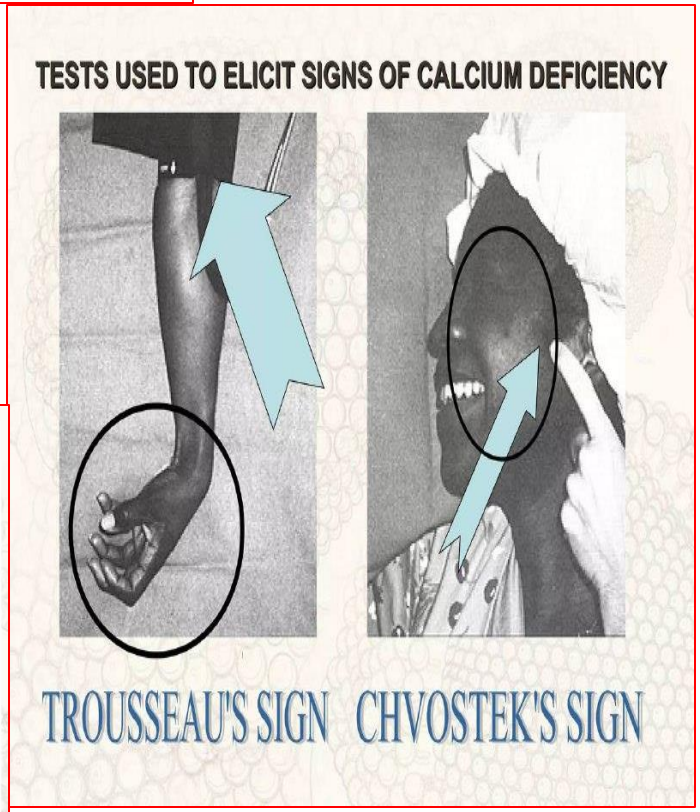
6-massive blood trasfusion

7-crush injury [renal failure]

all soft tissue injury can cause hypocalcemia

hypocalcemia - what do you see?

1 . Tetany (involuntary muscle movements).
2 . Chvostek's sign (facial nerve twitch) .
3 . Trousseau's sign (wrist spasms).
4 . Muscle cramps / abdominal pain / perioral tingling / seizures

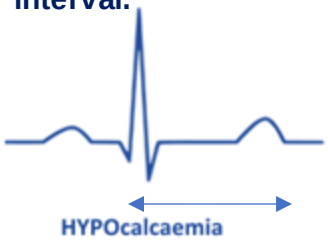


Hypocalcemia

Diagnosis

1. **low Ca^{+2} in blood <8.5 mg/dl**
2. **ECG → Prolonged ST segment**

proLonged QT interval.



3. Lab Tests (to know underlying cause).

Magnesium, albumin, and ionized calcium.

Amylase/ lipase / Serum PO43 / PTH.

Treatment

1. **If symptomatic**, provide emergency treatment with IV calcium gluconate.

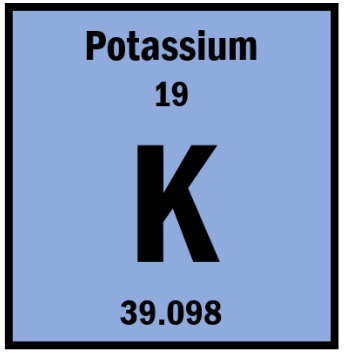
2. **For long-term management**, use oral calcium supplements (calcium carbonate) and vitamin D.

3. **It is also important to correct hypomagnesemia**. It is very difficult to correct the calcium level if the magnesium is not replaced first.

Potassium

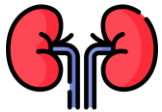
3.5-5 MEQ/L

Potassium



- Normal serum potassium: **3.5 – 5 mEq/L**.
- Most of our body's potassium **found Intracellular 98%.**
- Needed for **heart** and **skeletal** MUSCLES.

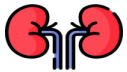
- Hypo/hyper effects:
  - **Weakness**
  - ECG changes
  - Arrhythmias
- **Potassium Secretion**: most of the excretion of potassium occurs through **Kidneys** (80%) and the reminder occurs via GI tract.



Hypokalemia – Causes

- **Gastrointestinal losses**:
  - Vomiting
  - Diarrhea
  - N/G tube
  - Intestinal Malabsorption

- **Renal Losses**:

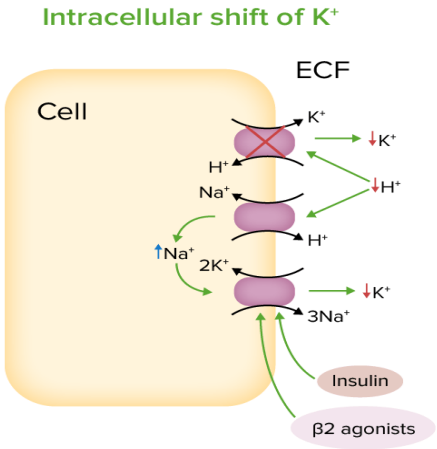


  - Diuretics
  - Renal tubular or parenchymal disease
  - Primary or secondary hyperaldosteronism

- **Hypomagnesemia**

  - Promotes urinary K loss
  - Cannot correct k until Mg is corrected!!

- **K+ Redistribution into cells**
  - Insulin
  - Beta- Agonists : Albuterol, Dobutamine
  - Alkalosis

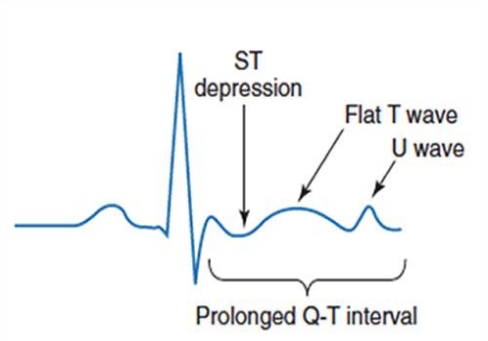


Hypokalemia - Signs/Symptoms

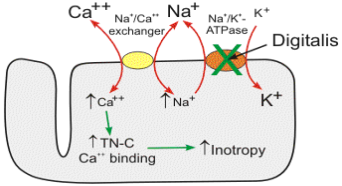
- **Muscle Weakness**
  - Fatigue.
  - Paralysis.

- **Arrhythmias**
  - Prolong normal cardiac conduction.
  - PACs, PVCs, Bradycardia.

- **ECG Changes**
  - **Flattened T-wave and** maybe inverted if severe.
  - U-wave appearance.



- Polyuria and polydipsia.
- Increase sensitivity to Digoxin toxicity.



Hypokalemia - Treatment

- **Treat** the **underlying cause** and stop any medication that may cause hypokalemia.
- Increase dietary k+.
- **Oral vs IV Potassium**
  - **Oral** KCL is the preferred safest method of replacement.
  - **IV** Potassium is irritant, painful can cause phlebitis or arrythmias if infused quickly used in sever cases of hypokalemia.

- **CORRECT HYPOMAGNESIMIA !!**

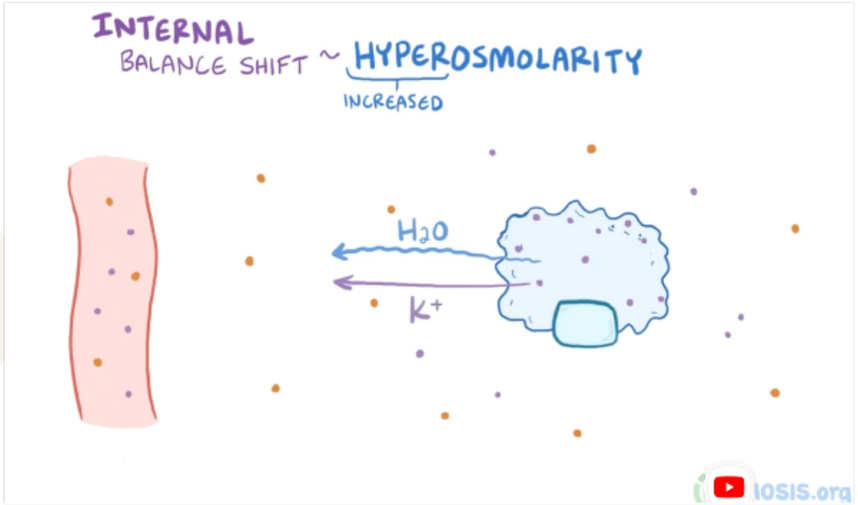
Hyperkalemia

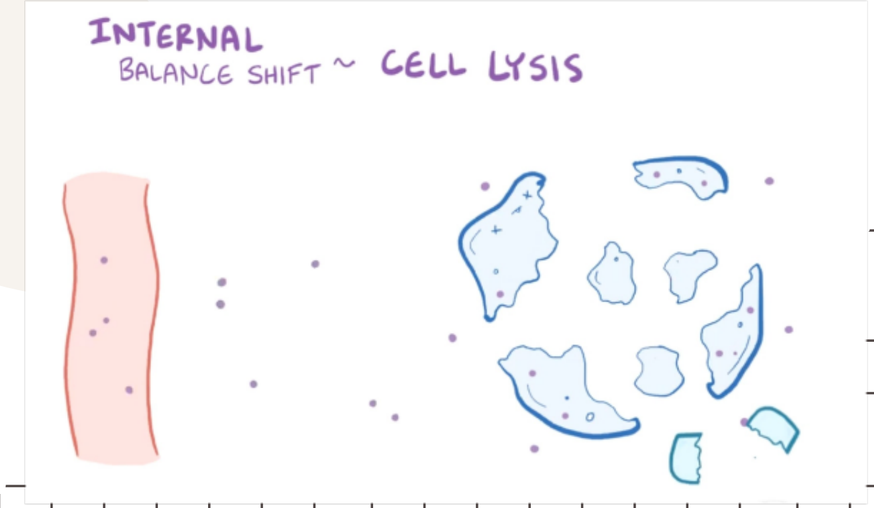
Definition :
Hyperkalemia is defined as a serum potassium (K+) concentration > 5.2 mEq/L.

Etiology

The etiologies of hyperkalemia can be grouped into 5 categories:

1. Transcellular shifts (Acidosis and Hyperosmolality)
2. Tissue breakdown (Tumor lysis syndrome , Burns)
3. Inadequate renal excretion (Renal failure ➡ ⬇ Glomerular filtration rate)
4. Drug-induced (ACE inhibitors , Angiotesin receptor blockers ARB)
5. Pseudohyperkalemia.





Clinical presentation

The most severe symptoms of hyperkalemia are impaired electrical conduction in the heart

Cardiac symptoms are more likely to occur with increasing severity and acuity of hyperkalemia. Muscular symptoms may be observed, and these include weakness and paralysis,

Muscular symptoms

- Muscle weakness
- Paralysis
- Decreased deep tendon reflexes
- Paraesthesia

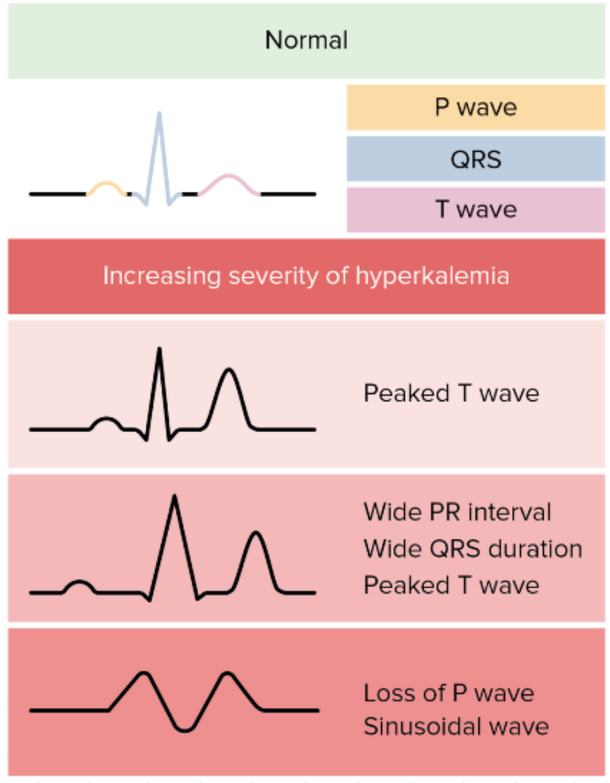
Cardiac symptoms

Arrhythmias:

- Sinus bradycardia
- Ventricular tachycardia, ventricular fibrillation, and/or asystole if severe

ECG changes :

- Peaked T waves and short QT interval
- PR interval prolongation and QRS widening
- Loss of P waves QRS widens



Management

If Hyperkalemia is severe ?

ECG changes, arrhythmia, or severe muscle weakness/paralysis

Serum K+ usually > 6.5 mEq/L

Options for emergency treatment:

1. IV calcium gluconate to stabilize myocardium
2. 10 units of Insulin with dextrose I.V to shift K+ into cells
3. Sodium bicarbonate corrects acidosis

- Monitor serum K+ frequently
- Cardiac monitoring and/or repeat ECG while treating

- Remove potassium from the body :
- Kayexalate
- Hemodialysis

Magnesium

Normal range: 1.5-2.2 mg/dL

4th most abundant cation in the body

Mg+ distribution in the body:

- Skeleton: 55%
- Soft tissue: 45%
- ECF: 1%

Hypomagnesemia

Definition

Serum magnesium concentration < 1.5 mEq/dL

Gastrointestinal (inadequate intake, malnutrition, malabsorption)
Renal Causes (Acute kidney injury)
Endocrine (Syndrome of inappropriate antidiuretic hormone secretion)
Cell shift (Blood transfusion)
Medications (Loop diuretics,Thiazide diuretics)

Clinical features

Gastrointestinal: anorexia, nausea, vomiting

Neuromuscular

1. Muscle weakness, lethargy
2. Tremor
3. Tetany
4. Muscle cramps
5. Hyperreflexia

Metabolic disturbances

Abnormalities of calcium metabolism

1. Hypocalcemia (in severe hypomagnesemia)
2. Hypoparathyroidism
3. PTH resistance
4. ⬇ Calcitriol synthesis

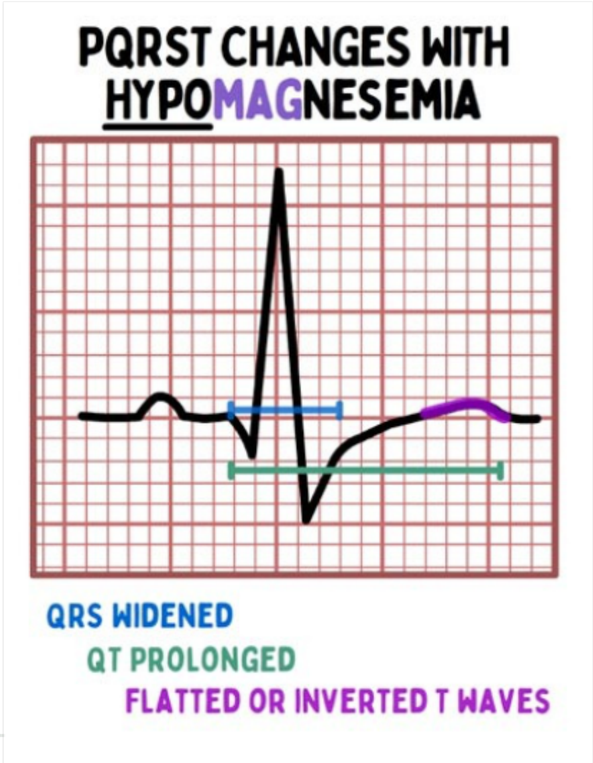
- **Hypokalemia**

Clinical presentation

Cardiac symptoms

ECG changes

1. Prolonged PR interval
2. Widening of QRS complex
3. Prolonged QT interval
4. T wave flattening



Arrhythmias

1. Supraventricular tachycardias
2. Ventricular arrhythmias

Hypomagnesemia- Treatment

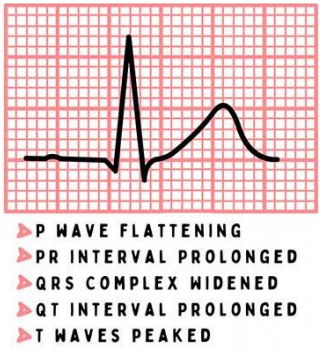
- **For mild hypomagnesemia**
  - oral Mg2+ (e.g., magnesium oxide)
- **For severe hypomagnesemia**
  - parenteral Mg2+ (e.g., magnesium sulfate)

Hypermagnesemia- caus

- **Renal failure (most common cause)**
- **severe acidosis**
- **Rhabdomyolysis**
- **Iatrogenic**—usually in the obstetric setting in women with preeclampsia or eclampsia being treated with magnesium sulfate

Hypermagnesemia-
Signs/ Symptoms

- **Nausea, weakness**
- **Facial paresthesia**
- **Progressive loss of deep tendon reflexes** (classically the first sign)
- **ECG changes** resemble those seen with **hyperkalemia**
  - increased P-R interval, widened QRS complex, and elevated T waves
- **Death** is usually caused by respiratory failure or cardiac arrest



Hypermagnesemia-Treatment

- Withhold exogenously administered magnesium.
- Prescribe **IV calcium gluconate** for emergent symptoms (cardio protection as in hyperkalemia).
- Administer **saline** and **furosemide**.
- Order **dialysis** in renal failure patients.
- Prepare to **intubate** if respiratory depression is severe.