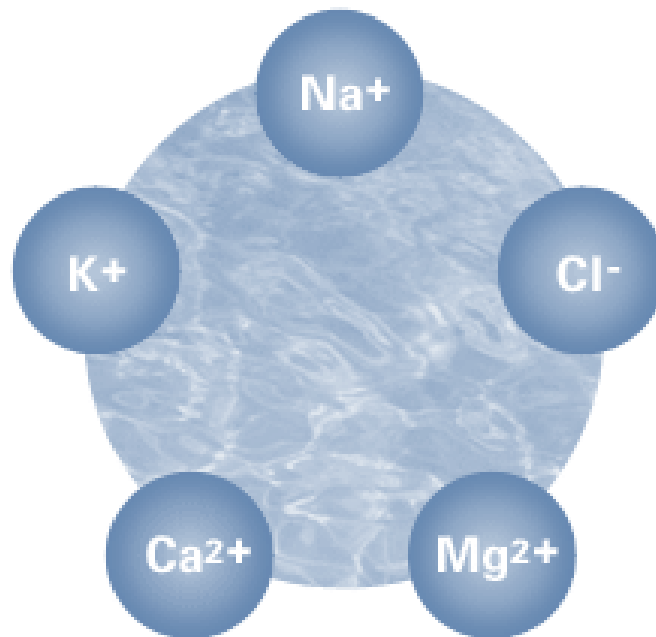


Instrumental determination of electrolytes in urine

The main electrolytes in Body Fluid.



Na ⁺	Sodium Ion
Cl ⁻	Chloride Ion
Mg ²⁺	Magnesium Ion
Ca ²⁺	Calcium Ion
K ⁺	Potassium Ion

Each ion has its own rules, and body movement is a result of the function of these ions.

Amal Alamri

What is the Electrolytes?

Electrolytes are positively and negatively charged ions,

Found in ...

Within body's cells extracellular fluids, including blood plasma.

e.g.

Na⁺

K⁺

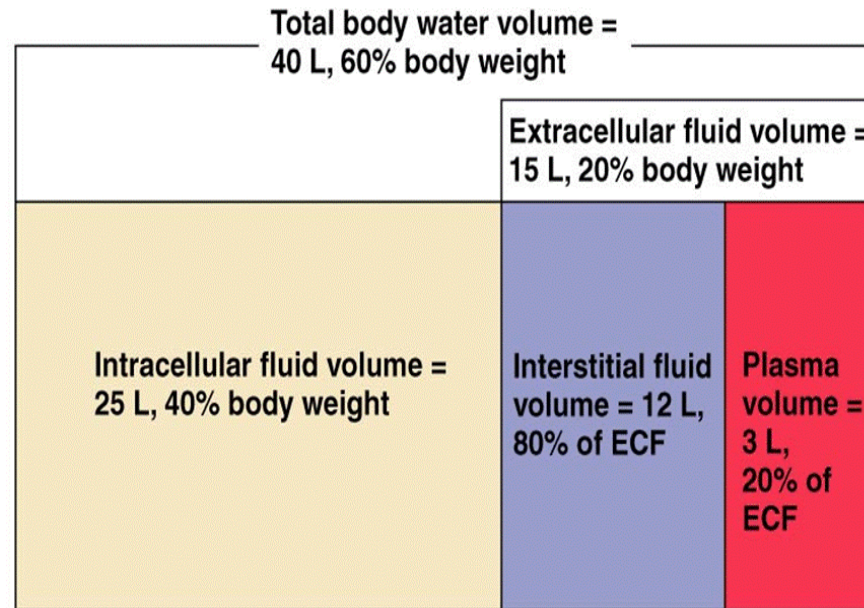
Cl⁻

HCO₃⁻

Ca²⁺

PO₄³⁻

Mg²⁺



1- Potassium (K^+)

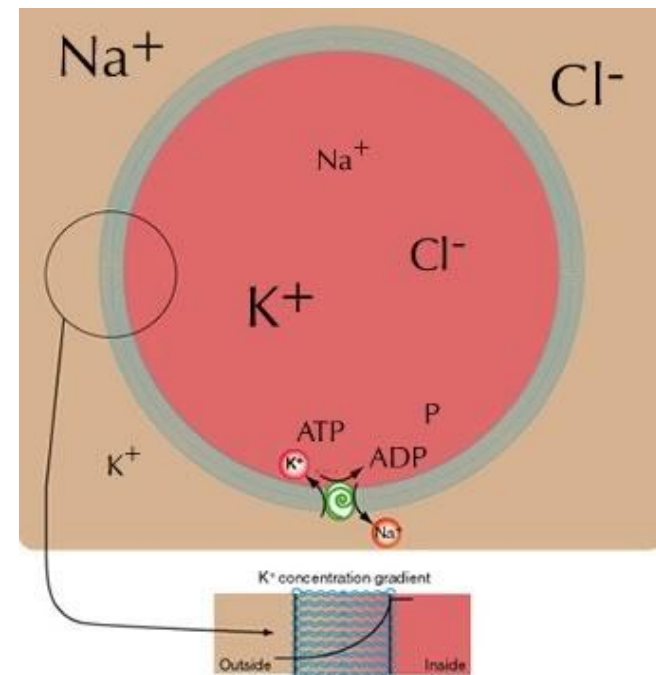
Hyperkalemia is the most significant and life-threatening complication of renal failure.

K^+ is like Na^+ , K^+ is freely filtered by the kidney.

*in the distal tubule Na^+ is reabsorbed and K^+ is secreted.

In **renal failure**, → the combination of decreased filtration and decreased secretion → **increased plasma K^+** .

Electrolytes distribution in cells



What Abnormal Results Mean?

Hyperkalemia High urine Potassium (K⁺) level

Hyperkalemia is also commonly caused by hemolytic anemia (release from hemolysed red blood cells),

may be due to:

- Diabetic acidosis and other forms of metabolic acidosis
- Eating disorders (anorexia, bulimia)
- Kidney problems, such as damage to kidney cells called tubule cells (acute tubular necrosis)
- Low blood magnesium levels (hypomagnesemia)

What Abnormal Results Mean?

Hypokalemia Low urine **Potassium (K⁺)** level

may be due to:

- Certain medicines, including beta blockers, nonsteroidal anti-inflammatory drugs (NSAIDs)
- Adrenal glands releasing too little hormone (hypoadosteronism)
- alkalosis
- diarrhea and vomiting
- excessive use of thiazide diuretics,
- Cushing's disease

Abnormal K^+ cannot be treated without reference to HCO_3^- which is a measure of the **buffering capacity of the plasma**.

$NaHCO_3$ and dissolved **CO₂** act together as a buffer to resist changes in blood pH

***Hypokalemia** Should not be treated by administration of potassium, but by identifying and eliminating the cause of the alkalosis.*

- *Administration of potassium would result in hyperkalemia when the acid-base disturbance is corrected*

2- Sodium /Na⁺

Na⁺ is the principal extracellular cation and potassium the principal intracellular cation. Na⁺ levels are directly related to the **osmotic pressure** of the plasma.

In fact, since an anion is always associated with sodium (usually Cl⁻ or NaHCO₃), the plasma osmolality;(total dissolved solute concentration) can be estimated.

Since water follow Na⁺ by diffusion:

i)loss of Na⁺ →→→ to **dehydration**

ii)retention of sodium →→→ to **edema**.

What Abnormal Results Mean ?(Hypernatremia)

may be due to:

- Certain medicines such as water pills (diuretics)
- Low function of the adrenal glands
- Inflammation of the kidney that results in salt loss (salt-losing nephropathy)
- Too much salt in the diet

What Abnormal Results Mean? (Hyponatremia)

- Addison's disease (adrenocortical under-activity).
- Syndrome of inappropriate secretion of antidiuretic hormone (SIADH)
- Burns
- Diarrhea Vomiting and fluid loss or Not enough fluid in the body (dehydration)
- Heart failure
- overuse of diuretics** (drugs that promote lower blood pressure) often result in **↓ of Na⁺ and K⁺.**

3-Chloride

- Chloride is one of the most important electrolytes in the blood. It helps keep the amount of fluid inside and outside of cells in balance. It also helps maintain proper blood volume, blood pressure, and pH of body fluids.
- Most of the chloride in body comes from the salt (sodium chloride) . Chloride is absorbed by intestines when digest food. Extra chloride leaves your body in urine.

What Abnormal Cl- Results Mean?

A higher than normal urine chloride level may be due to:

- Low function of the adrenal glands
- Inflammation of the kidney that results in salt loss (salt-losing nephropathy)
- Production of an unusually large amount of urine (polyuria)
- Too much salt in the diet

Decreased urine chloride levels may be due to:

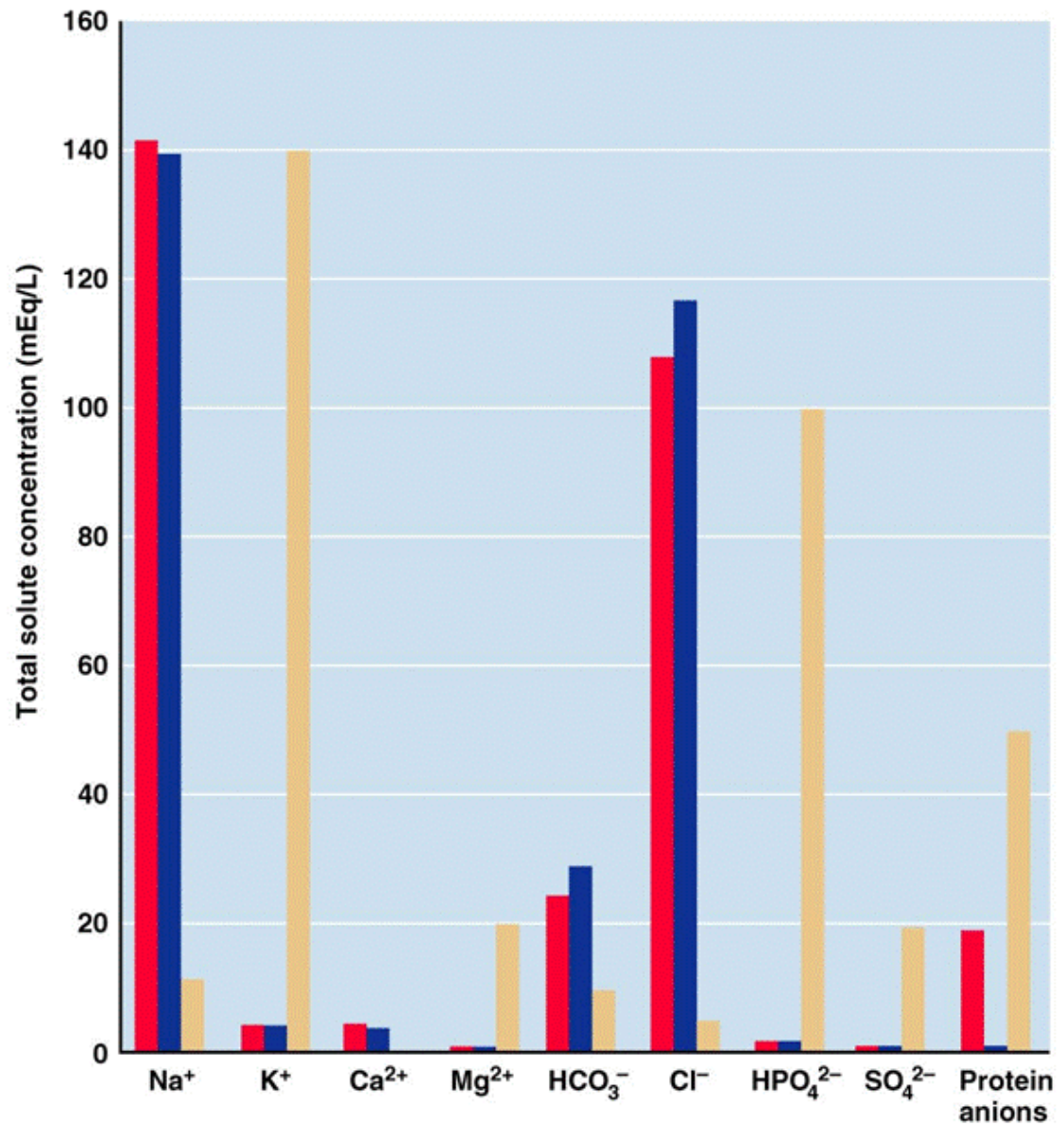
- Body holding in too much salt (sodium retention)
- Cushing syndrome
- Decreased salt intake
- Fluid loss that occurs with diarrhea, vomiting, sweating, and gastric suction

Key to fluids:

- = Blood plasma
- = Interstitial fluid
- = Intracellular fluid

Key to symbols:

- Na^+ = Sodium
- K^+ = Potassium
- Ca^{2+} = Calcium
- Mg^{2+} = Magnesium
- HCO_3^- = Bicarbonate
- Cl^- = Chloride
- HPO_4^{2-} = Hydrogen phosphate
- SO_4^{2-} = Sulfate

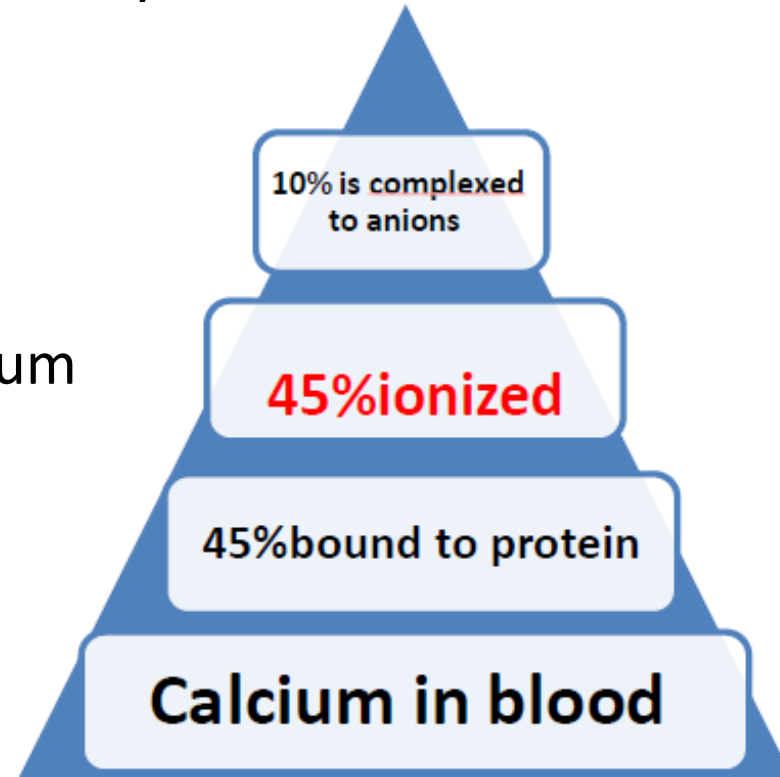


4- Calcium Ca^{2+}

Only the **ionized** calcium is **physiologically active**, and the level of ionized calcium is regulated by parathyroid hormone (PTH) via negative feedback ($\uparrow\uparrow$ ionized Ca inhibits secretion of PTH).

Ca^{2+} and phosphorus are measured together because they are both likely to be abnormal in bone and parathyroid disease states.

Differential diagnosis of an abnormal serum calcium is aided by the **measurement of ionized calcium (Ca^{2+})**.



What Abnormal Results Mean?

High levels of urine calcium /Hypercalcimea Ca^{2+}

- Chronic kidney disease
- Leaking of urine from the kidneys, which causes calcium kidney stones
- Taking too much calcium
- hyperparathyroidism Use of water pills called loop diuretics
- Very high vitamin D levels
- malignancies (those that secrete parathyroid hormone-related protein
- multiple myeloma

*only hyperparathyroidism, malignancy, and acidosis cause an
 \uparrow ionized Ca^{2+} .*

What Abnormal Results Mean?

Low levels of urine calcium total Ca^{2+}

Hypocalcemia

- hypoparathyroidism
- thiazide diuretic
- Very low levels of vitamin D
- VDDR vitamin D dependent rickets
- renal failure
- Hypoalbuminemia

*In vitamin D dependent rickets (VDDR), $\downarrow \text{Ca}^{2+}$ and $\downarrow \text{PO}_4^-$

*In vitamin D resistant rickets (VDRR): Ca^{2+} is normal and $\downarrow \text{PO}_4^-$

- *Only Hypoparathyroidism (and alkalosis) will result in \downarrow ionized Ca^{2+}*

5- Magnesium/ Mg^{2+}

increased Serum Mg^{2+} levels :

hemolytic anemia

Mg^{2+} based antacids

Pancreatitis

antibiotics and drugs

Decrease Serum Mg^{2+} levels :

- Mg^{2+} is needed for secretion of PTH, and therefore, a $\downarrow Mg^{2+}$ in serum can \uparrow hypocalcemia.

-Chronic alcoholism is the most common cause of a $\downarrow Mg^{2+}$ owing to poor nutrition.

- Mg^{2+} deficiency is very common in regions where the water supply does not contain sufficient magnesium salts.

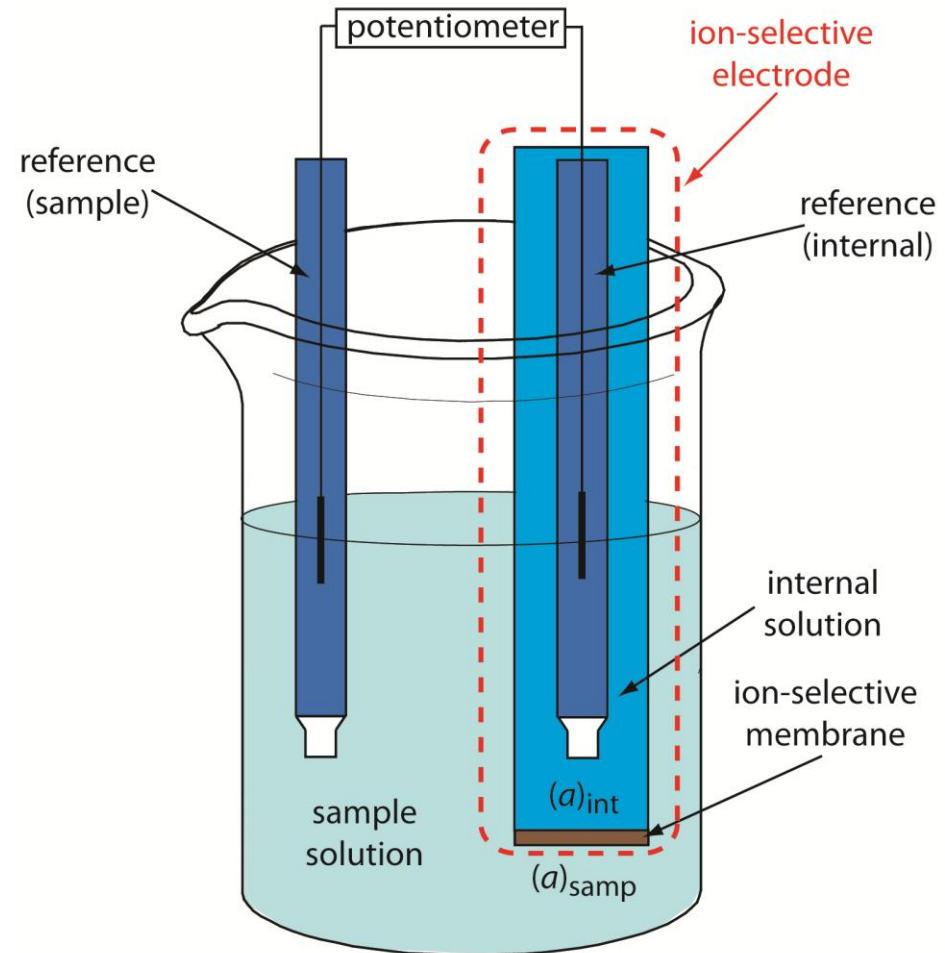
- Mg^{2+} acts as a Ca^{2+} channel blocker, when cellular $\downarrow Mg$ is, \uparrow intracellular Ca^{2+} results leads to hypertension, tachycardia, and tetany.

-Unfortunately serum total Mg levels *do not correlate well* with intracellular Mg levels, and serum measurement is not very sensitive for detecting chronic deficiency because of compensatory contributions from bone. **Ionized magnesium** levels are better correlated with intracellular levels because the ionized form can move freely between the cells and extracellular fluids.

METHOD

Electrolytes are measured by a process known as **potentiometry**.

This method measures the *voltage* that develops between the inner and outer surfaces of an ion selective electrode. The electrode (membrane) is made of a material that is **selectively permeable to the ion being measured**.



References

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<http://www.nlm.nih.gov/medlineplus/ency/article/003601.htm>