Management of IV Fluids and Electrolytes

Definitions

- Intracellular – fluid within the cell
- Extracellular – fluid outside the cell but in the interstitial space and in intravascular fluid
- Interstitial – fluid between the cells – in the interspaces of a tissue – situated between the parts
- Intravascular – within the vessel or vessels
- Homeostasis – the tendency of biological systems to maintain relatively constant conditions in the internal environment, while continuously interacting with and adjusting to changes that originate within the system and outside the system

Transport of fluids

- Diffusion – the movement of molecules/solutes through a semipermeable membrane from a high concentration to a low concentration
- Osmosis – the one way passage of water through a semipermeable membrane from a low concentration of particles to a high concentration of particles
- Filtration – fluid going through a filter under pressure or passage through a material that prevents passage of certain molecules
- Active transport – electrolytes move from a low concentration to a high concentration by moving against the concentration gradient. ATP provides the energy needed to do this.

IV therapy

- As many as 75% of patients admitted into hospital receive some type of IV therapy
- 50%-70% of the average human is body fluids

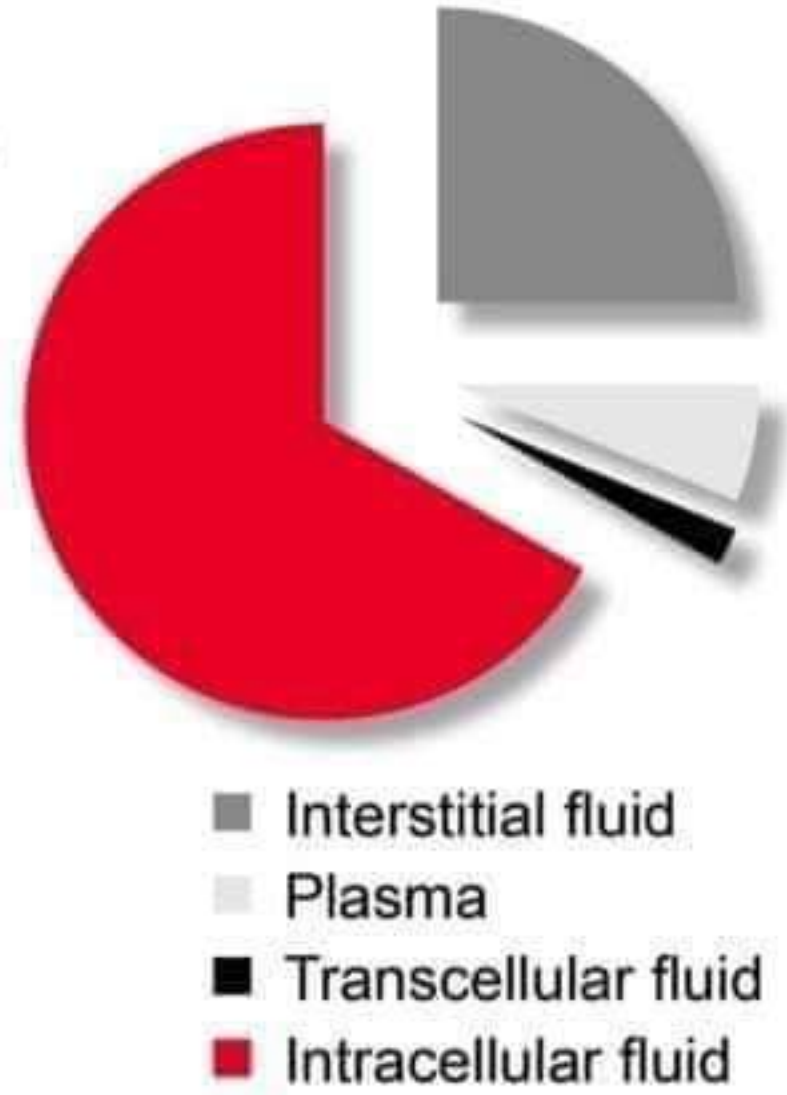
Distribution of fluid in the body is:

1/3 extracellular fluid

- Interstitial fluid
- Plasma or intravascular fluid
- Transcellular fluid

2/3 intracellular fluid

- Fluid within a cell
- Red blood cells
- Other cells



Uses of IV therapy

- Establish or maintain fluid and/or electrolyte balance
- Administer medication continuously or intermittently
- Administer bolus medication
- Administer fluid to maintain venous access in case of an emergency
- Administer blood or blood products
- Administer intravenous anaesthetics
- Maintain or correct a patient's nutritional status
- Administer diagnostic reagents
- Monitor haemodynamic functions
- Correct acidosis or alkalosis

IV therapy

Types of IV fluids

1. Crystalloids
2. Colloids
3. Blood and blood products

Crystalloids

- Crystalloids are water with electrolytes that form a solution that can pass through semi permeable membranes
- They are lost rapidly from the intravascular space into the interstitial space
- They can remain in the extracellular compartment for about 45 minutes
- Because of this, larger volumes than colloids are required for fluid resuscitation
- Eventually, water from crystalloids diffuses through the intracellular fluid

Common crystalloids

Solution	Type	Uses	Nursing considerations
Dextrose 5% in water (D5W)	**Isotonic**	Fluid loss Dehydration Hypernatraemia	Use cautiously in renal and cardiac patients Can cause fluid overload May cause hyperglycaemia or osmotic diuresis
0.9% Sodium Chloride (Normal Saline-NaCl)	**Isotonic**	Shock Hyponatraemia Blood transfusions Resuscitation Fluid challenges Diabetic Keto Acidosis (DKA)	Can lead to overload Use with caution in patients with heart failure or oedema Can cause hyponatraemia, hypernatraemia, hyperchloraemia or calorie depletion
Lactated Ringer's (Hartmanns)	**Isotonic**	Dehydration Burns Lower GI fluid loss Acute blood loss Hypovolaemia due to third spacing	Contains potassium, don't use with renal failure patients Don't use with liver disease, can't metabolise lactate
0.45% Sodium Chloride (1/2 Normal Saline)	**Hypotonic**	Water replacement DKA Gastric fluid loss from NG or vomiting	Use with caution May cause cardiovascular collapse or increased intracranial pressure Don't use with liver disease, trauma or burns
Dextrose 5% in ½ normal saline	**Hypertonic**	Later in DKA	Use only when blood sugar falls below 250mg/dl
Dextrose 5% in normal saline	**Hypertonic**	Temporary treatment from shock if plasma expanders aren't available Addison's crisis	Contra-indicated for cardiac or renal patients
Dextrose 10% in water	**Hypertonic**	Water replacement Conditions where some nutrition with glucose is required	Monitor blood sugar levels

Colloids

- Colloids contain solutes in the form of large proteins or other similar sized molecules
- They cannot pass through the walls of capillaries and into cells
- They remain in blood vessels longer and increase intravascular volume
- They attract water from the cells into the blood vessels
- But this is a short term benefit and
- Prolonged movement can cause the cells to lose too much water and become dehydrated

Common colloids

Colloid	Action/use	Nursing considerations
Albumin (Plasma protein) 4% or 20%	Keeps fluids in vessels Maintains volume Primarily used to replace protein and treat shock	May cause anaphylaxis (a severe, often rapidly progressive allergic reaction that is potentially life threatening) – watch for/report wheeze, persistent cough, difficulty breathing/talking, throat tightness, swelling of the lips, eyes, tongue, face, loss of consciousness. May cause fluid overload and pulmonary oedema
Dextran (Polysaccharide) 40 or 70	Shifts fluids into vessels Vascular expansion Prolongs haemodynamic response when given with HES	May cause fluid overload and hypersensitivity Increased risk of bleeding Contraindicated in bleeding disorders, chronic heart failure and renal failure
Hetastarch (HES) (synthetic starch) 6% or 10%	Shifts fluids into vessels Vascular expansion	May cause fluid overload and hypersensitivity Increased risk of bleeding Contraindicated in bleeding disorders, chronic heart failure and renal failure
Mannitol (alcohol sugar) 5% or 10%	Oliguric diuresis Reduces cerebral oedema Eliminates toxins	May cause fluid overload May cause electrolyte imbalances Cellular dehydration Extravasation may cause necrosis

Blood and blood products

Plasma	Plasma is the liquid part of the blood. It is often used to add volume to the blood system after a large loss of blood. Cryoprecipitate is a concentrated source of certain plasma proteins and is used to treat some bleeding problems
Red blood cells	Red Blood Cells carry oxygen from the lungs to other parts of the body and then carry carbon dioxide back to the lungs. Severe blood loss, either acute haemorrhagic or chronic blood loss, dietary deficit or erythropoetic issue of the bone marrow can result in a low red blood cell count – called anaemia. A transfusion of whole blood or packed red blood cells may be needed to treat acute blood loss or anaemia.
White blood cells	White Blood Cells help fight infection, bacteria and other substances that enter the body. When the white blood cell count becomes too low, it is called Neutropenia. G-CSF injections may be needed to treat Neutropenia.
Platelets	Platelets help blood to clot. Platelet transfusions are given when the platelet count is below normal.

Complications of IV Therapy

- Local complications at the site including

  Extravasation

  Phlebitis/Thrombophlebitis

  Haematoma

  Infection
- Fluid overload – Acute Pulmonary Oedema (APO)
- Electrolyte imbalance – Cardiac arrhythmias
- Transfusion reactions – Anaphylaxis
- Air embolus

Electrolytes

Electrolytes are minerals in body fluids that carry an electric charge

Electrolytes affect the amount of water, the acidity of blood (pH), muscle function, and other important processes in the body

There are six major electrolytes

- Sodium – Na^+ Major cation in extracellular fluid (ECF)
- Potassium – K^+ Major cation in intracellular fluid (ICF)
- Calcium – Ca^{++} Major cation found in ECF and teeth and bones
- Chloride – Cl^- Major anion found in ECF
- Phosphate – PO_4^{3-} Major anion found in ICF
- Magnesium – Mg^{++} Major cation found in ICF (closely related to Ca^{++} and PO_4)

Sodium (Na^+)

Normal Serum Level 135-145 mmol/L

Function

- Maintains extracellular function (ECF) osmolarity
- Influences water distribution
- Affects concentration, excretion and absorption of potassium and chloride
- Helps regulate acid-base balance
- Aids nerve and muscle fibre impulse transmission

Sodium

signs and symptoms of imbalance

Hyponatraemia

- Fatigue
- Muscle weakness
- Muscle twitching
- Decreased skin turgor
- Headache
- Tremor
- Seizures
- Coma

Hypernatraemia

- Thirst
- Fever
- Flushed skin
- Oliguria
- Disorientation
- Dry sticky membranes

Potassium (K^+)

Normal Serum Level 3.5 – 5.0 mmol/L

Function

- Maintains cell electro-neutrality
- Maintains cell osmolarity
- Assists in conduction of nerve impulses
- Directly affects cardiac muscle contraction (re-polarisation in the action potential)
- Plays a major role in acid-base balance
- Sodium – Potassium gradient plays a major role in fluid balance between extracellular (ECF) and intracellular (ICF) compartments

Potassium signs and symptoms of imbalance

Hypokalaemia

- Decreased peristalsis, skeletal muscle and cardiac muscle function
- Muscle weakness or irritability/cramps
- Decreased reflexes
- Fatigue
- Rapid, weak irregular pulse
- Cardiac arrhythmias/cardiac arrest
- Decreased blood pressure
- Decreased bowel motility
- Paralytic ileus

Hyperkalaemia

- Muscle weakness
- Nausea
- Diarrhoea
- Oliguria
- Paraesthesia (altered sensation) of the face, tongue, hands and feet
- Cardiac arrhythmias/ cardiac arrest

Note: Potassium is a heavy solute that needs to disperse thoroughly in IV fluid - care should be taken when administering to avoid fatal consequences

Calcium (Ca^{++})

Normal Serum Level 2.15-2.55 mmol/L

Function

- Enhances bone strength and durability
- Helps maintain cell-membrane structure, function and permeability
- Affects activation, excitation and contraction of sino-atrial node (intrinsic cardiac pacemaker), cardiac and skeletal muscles
- Participates in neurotransmitter release at synapses
- Helps activate specific steps in blood coagulation
- Activates serum complement in immune system function

Calcium

signs and symptoms of imbalance

Hypocalcaemia

- Muscle tremor
- Muscle cramps
- Tetany
- Tonic-clonic seizures
- Parasthesia
- Bleeding
- Arrhythmias
- Hypotension
- Numbness or tingling in fingers, toes and around the mouth

Hypercalcaemia

- Lethargy
- Fatigue
- Depression
- Confusion
- Headache
- Muscle flaccidity
- Nausea, vomiting
- Anorexia
- Constipation
- Hypertension
- Polyuria
- Cardiac arrhythmias and ECG changes (shortened QT interval and widened T wave

Chloride (Cl^-)

Normal Serum Level 95-110 mmol/L

Function

- Maintains serum osmolarity
- Combines with major cations to create important compounds, such as sodium chloride (NaCl), hydrochloride (HCl), potassium chloride KCl) and calcium chloride ($CaCl_2$) which contribute to acid/base and/or electrolyte balance

Chloride

signs and symptoms of imbalance

Hypochloraemia

- Increased muscle excitability
- Tetany
- Decreased respirations

Hyperchloraemia

- Headache, difficulty concentrating
- Drowsiness, stupor
- Rapid, deep breathing (hypercapnia)
- Muscle weakness

Phosphate (PO_4)

Normal Serum Level 0.8-1.5 mmol/L

- Function
- Helps maintain bones and teeth
- Helps maintain cell integrity
- Plays a major role in acid-base balance (as a urinary buffer)
- Promotes energy transfer to cells
- Plays essential role in muscle, red blood cell and neurological function

Phosphate

signs and symptoms of imbalance

Hypophosphataemia

- Parasthesia (circumoral and peripheral)
- Lethargy
- Speech defects (such as stuttering)
- Muscle pain and tenderness

Hyperphosphataemia

- Renal failure
- Vague neuro-excitability to tetany and seizures
- Arrhythmias and muscle twitching with sudden rise in phosphate (PO_4) level

Magnesium (Mg^{++})

Normal Serum Level 0.70-1.05 mol/L

Function

- Activates intracellular enzymes; active in carbohydrate and protein metabolism
- Acts on myo-neural vasodilation
- Facilitates Na^{+} and K^{+} movement across all membranes
- Influences Ca^{++} levels

Magnesium

signs and symptoms of imbalance

Hypomagnesaemia

- Dizziness
- Confusion
- Seizures
- Tremor
- Leg and foot cramps
- Hyperirritability
- Arrhythmias
- Vasomotor changes
- Anorexia
- Nausea

Hypermagnesaemia

- Drowsiness
- Lethargy
- Coma
- Arrhythmias
- Hypotension
- Vague neuromuscular changes (such as tremor)
- Vague GI symptoms (such as nausea)
- Peripheral vasodilation
- Facial flushing
- Sense of warmth
- Slow, weak pulse

IV Solution Cheat Sheet

A quick reference guide on the different intravenous solutions.

Type	Use	Special Considerations
Normal Saline (NS) • 0.9% NaCl in Water • Crystalloid Solution • Isotonic (308 mOsm)	• Increases circulating plasma volume when red cells are adequate • Shock • Fluid replacement in patients with diabetic ketoacidosis • Hyponatremia • Blood transfusions • Resuscitation • Metabolic Alkalosis • Hypercalcemia	• Do not use in patients with heart failure, edema, or hypernatremia, because NSS replaces extracellular fluid and can lead to fluid overload. • Replaces losses without altering fluid concentrations. • Helpful for Na+ replacement
1/2 Normal Saline (1/2 NS) • 0.45% NaCl in Water • Crystalloid Solution • Hypotonic (154 mOsm)	• Water replacement • Raises total fluid volume • DKA after initial normal saline solution and before dextrose infusion • Hypertonic dehydration • Sodium and chloride depletion • Gastric fluid loss from nasogastric suctioning or vomiting.	• Use cautiously; may cause cardiovascular collapse or increase in intracranial pressure. • Don't use in patients with liver disease, trauma, or burns. • Useful for daily maintenance of body fluid, but is of less value for replacement of NaCl deficit. • Helpful for establishing renal function. • Fluid replacement for clients who don't need extra glucose (diabetics)
Lactated Ringer's (LR) • Normal saline with electrolytes and buffer • Isotonic (275 mOsm)	• Replaces fluid and buffers pH • Hypovolemia due to third-space shifting. • Dehydration • Burns • Lower GI tract fluid loss • Acute blood loss	• Has similar electrolyte content with serum but doesn't contain magnesium. • Has potassium therefore don't use to patients with renal failure as it can cause hyperkalemia • Don't use in liver disease because the patient can't metabolize lactate; a functional liver converts it to bicarbonate; don't give if patient's pH > 75. • Normal saline with K+, Ca++, and lactate (buffer) • Often seen with surgery

Type	Use	Special Considerations
D_5W • Dextrose 5% in water Crystalloid solution • Isotonic (in the bag) • *Physiologically hypotonic (260 mOsm)	• Raises total fluid volume. • Helpful in rehydrating and excretory purposes. • Fluid loss and dehydration • Hypernatremia	• Solution is isotonic initially and becomes hypotonic when dextrose is metabolized. • Not to be used for resuscitation; can cause hyperglycemia • Use in caution to patients with renal or cardiac disease, can cause fluid overload • Doesn't provide enough daily calories for prolonged use; may cause eventual breakdown of protein. • Provides 170-200 calories/1,000cc for energy. • **Physiologically hypotonic**: the dextrose is metabolized quickly so that only water remains - a hypotonic fluid
D_5NS • Dextrose 5% in 0.9% saline • Hypertonic (560 mOsm)	• Hypotonic dehydration • Replaces fluid sodium, chloride, and calories. • Temporary treatment of circulatory insufficiency and shock if plasma expanders aren't available • SIADH (or use 3% sodium chloride). • Addisonian crisis	• Do not use in patients with cardiac or renal failure because of danger of heart failure and pulmonary edema. • Watch for fluid volume overload
D_5 1/2 NS • Dextrose 5% in 0.45% saline • Hypertonic (406 mOsm)	• DKA after initial treatment with normal saline solution and half-normal saline solution – prevents hypoglycemia and cerebral edema (occurs when serum osmolality is reduced rapidly).	• In DKA, use only when glucose falls < 250 mg/dl • Most common postoperative fluid • Useful for daily maintenance of body fluids and nutrition, and for rehydration.
D_5LR • Dextrose 5% in Lactated Ringer's • Hypertonic (575 mOsm)	• Same as LR plus provides about 180 calories per 1000cc's. • Indicated as a source of water, electrolytes and calories or as an alkalinizing agent	• Contraindicated in newborns (≤ 28 days of age), even if separate infusion lines are used (risk of fatal ceftriaxone-calcium salt precipitation in the neonate's bloodstream). • Contraindicated in patients with a known hypersensitivity to sodium lactate.
Normosol-R • Normosol • Isotonic (295 mOsm)	• Replaces fluid and buffers pH • Indicated for replacement of acute extracellular fluid volume losses in surgery, trauma, burns or shock. • Used as an adjunct to restore a decrease in circulatory volume in patients with moderate blood loss	• Not intended to supplant transfusion of whole blood or packed red cells in the presence of uncontrolled hemorrhage or severe reductions of red cell volume

Case Study Follow-Up

You have been asked to start an IV and administer IV fluid to a 32-year-old female who is dehydrated after running a marathon in hot and humid weather. In the medical supply area, you find a variety of IV fluids, including isotonic crystalloids, hypertonic crystalloids, hypotonic crystalloids, and a refrigerator of colloid solutions.

Knowing that the patient requires IV fluid to both increase the blood volume and rehydrate the cells, you look at the crate containing isotonic crystalloids. In the crate, you find and retrieve a 1,000-milliliter bag of 0.9% NSS. Your assistant, who is not an EMT, asks why you did not use any of the other solutions. You inform him that a colloid solution and a hypertonic crystalloid would just increase the blood volume by pulling water into the blood vessels from the cells. Although the blood volume would be increased, the cells could become further dehydrated. You continue by stating that the low concentration of solutes in a hypotonic solution would cause water to shift from within the blood vessels to the cells. This would be advantageous to the cells, but the volume of blood would not be increased and may even be further reduced.

After administering the IV fluid to the patient, she states that she feels much better and is eventually released by the physician. Later, your assistant tells you that he is so impressed with your knowledge that he has decided to enroll in the next EMT class.

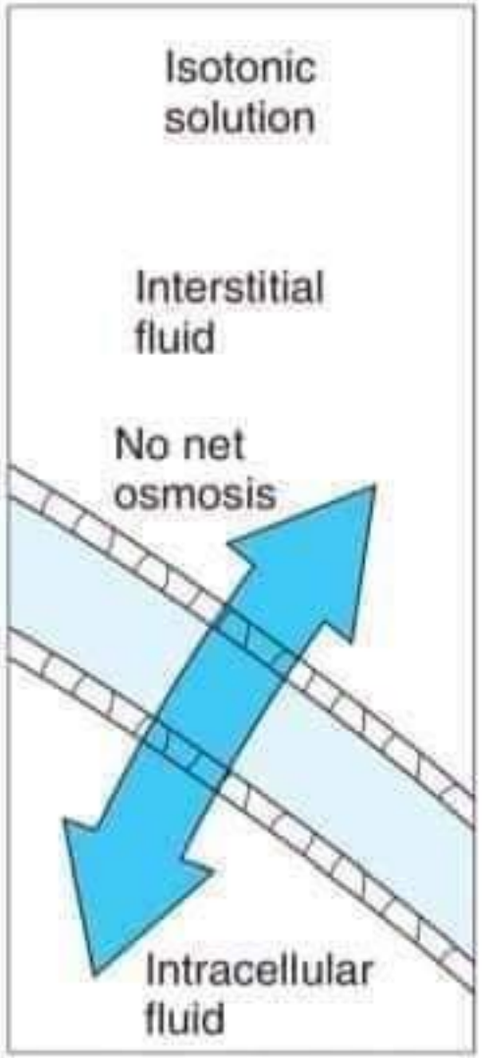


Figure 3-2. Isotonic solutions do not result in any significant fluid shifts across cellular or vascular membranes.

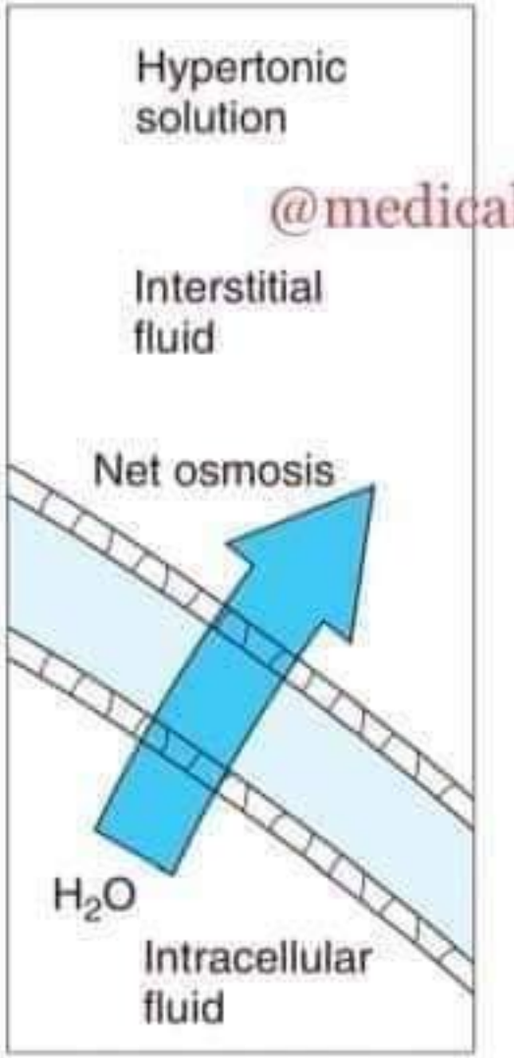


Figure 3-3. A hypertonic solution given IV will draw fluids from the cells and interstitial spaces into the vasculature.

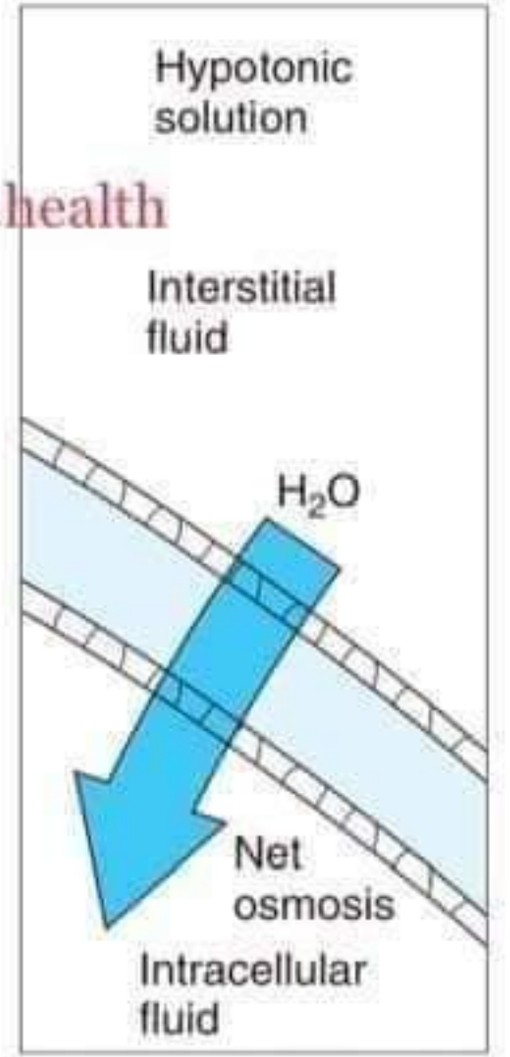


Figure 3-4. A hypotonic solution given IV will cause fluids to leave the vasculature for the interstitial and intracellular spaces.