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FLUID ELECTROLYTE BALANCE

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ABSTRACT

Water makes up the majority of the human body, with two thirds of it being intracellular and one third being extracellular. Numerous proteins and chemical and mineral salts are dissolved in bodily fluids. In each compartment, these substances are electrochemically balanced and quantified in millimoles. Each compartment has a variable ratio of cations to anion concentrations. Hydrostatic, osmotic, and oncotic forces control how fluid moves through the body. The Starling equation determines the rate of extravasation. Based on the stress response, temporal fluid shifts take place in perioperative medicine and critical care. This response should be followed by volume and tonicity management of the fluids.

INTRODUCTION

With the ever-expanding scope of the speciality, however, more surgically extensive procedures increasingly are being performed on more medically compromised patients. To optimize comprehensive patient care, Oral & Maxillofacial surgeons are obligated to possess a firm knowledge of basic principles of fluid management because the knowledge of these principles can be lifesaving in certain conditions.

FLUID BALANCE

Daily balance between amount of water gained & amount of water lost to environment.
Maintenance of normal fluid balance involves regulating content and distribution of body water in fluid compartments.

ELECTROLYTE BALANCE

Balances gains and losses of all electrolytes(ions).
Primarily involves balancing rates of absorption across digestive tract with loss at kidneys & sweat glands.

ACID BASE BALANCE

Precisely balances production & loss of H+ ions.
The body generates acids during normal metabolism, tends to reduce Ph.
Kidneys: secretes H+ ions into urine.
Generates buffers that enter the blood stream in distal segments of DCT & collecting system.
Lungs: Affect Ph balance through elimination of CO2.

Importance of water/fluid balance: In homeostasis

Transport mechanism
Metabolic reaction
Maintenance of tissue texture.

Water requirements increase by 100-150ml/day for each degree centigrade of body temperature elevation.

Regulatory mechanisms

Baroreceptor reflex- Responds to fall in arterial blood pressure. Constricts the afferent arterioles of kidneys & so retention of fluid.

Volume receptors- Responds to fluid excess in atria & great vessels. Stimulation causes strong renal response that increases urine output.

Renin-angiotensin-aldosterone mechanism- Renin: By kidneys when arterial pressure/volume drops.

Angiotensin: Vasoconstrictor to increase BP.

Body fluid & electrolyte disturbances

Volume changes: Hypovolemia
Hypervolemia
Concentration changes: Hyponatremia
Hypernatremia
Composition changes: Acid/Base balance
Potassium abnormalities
Magnesium abnormalities
Calcium abnormalities

Normal exchange of Fluid and Electrolytes: The internal fluid environment is maintained by intimate interactions between the brain, kidneys, lungs, gastrointestinal tract & skin.

Surgical stresses that compromise any one of these systems may alter the balance.

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FLUIDS

Water makes up to **50% to 70% of Total Body Weight** and varies with age, gender and body habits.
Adult males : 60-65% of body wt., average=60%.
Adult females : 45-50% of body wt., average=50%.
Infant : 80% of body wt.
Obese patients have lessTBW/kg than lean body adult.

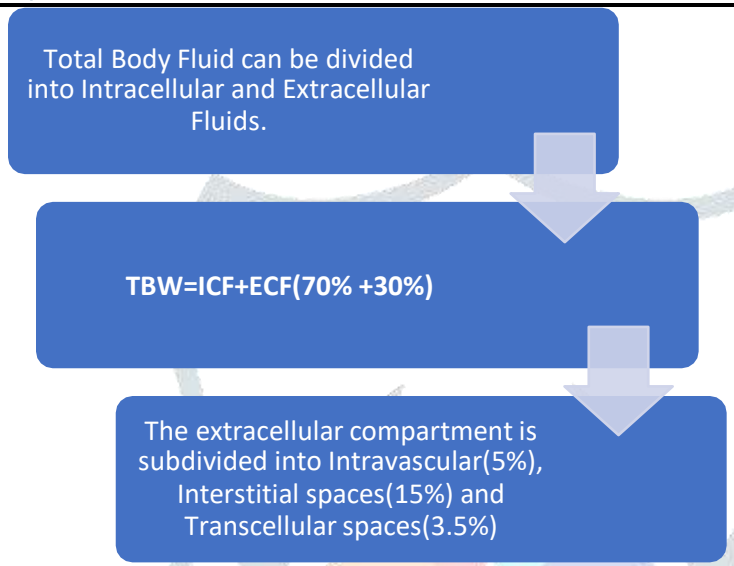


FIG 1: TOTAL BODY FLUID

Fluid imbalances: Dehydration
Hypovolemia
Hypervolemia
Water intoxication

Table 3
Water exchange (70-kg man)

Route	Average daily volume (mL)	Minimal (mL)	Maximal (mL)
H_2O gain			
Sensible			
Oral fluids	800–1500	0	1500/h
Solid Foods	500–700	0	1500
Insensible			
Water of oxidation	250	125	800
Water of solution	0	0	500
H_2O loss			
Sensible			
Urine	800–1500	300	1400/h
Intestinal	0–250	0	2500/h
Sweat	0	0	4000/h
Insensible			
Lungs and skin	600	600	1500

TABLE 1: WATER EXCHANGE

Water Depletion

Pure water depletion is due to diminished intake usually.
Causes: Lack of availability, fever, infections, burns severe odontogenic infections long operative procedures persistent postoperative vomiting & diarrhoea, painful conditions of mouth, pharynx/obstruction in the oesophagus.
Pure water depletion may also be followed due to increased loss from lungs after procedures like Tracheostomy.

Dehydration

Loss of fluids: increased concentration of solutes in the blood & rise in serum Na+ levels.
Fluid shifts out of cells into blood to restore balance.
Cells shrink from fluid loss & can no longer function properly.
At risk: comatose, confused, bed ridden elderly.
Treatment: Fluid replacement oral /IV over 48hMonitor symptoms & vital signs & Maintain IV access
Skin & mouth care.

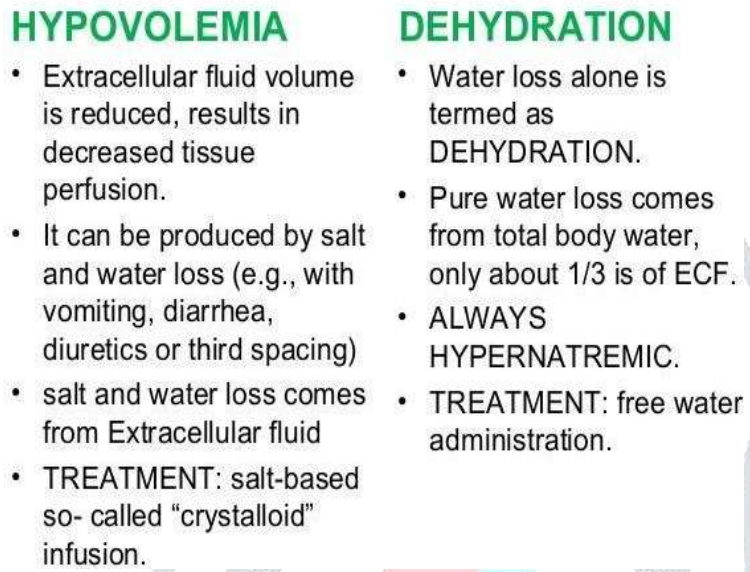


FIG 2 : DIFFERENCE BETWEEN HYPOVOLEMIA AND DEHYDRATION

Hypervolemia

Excess fluid in the extracellular compartment as a result of fluid/sodium retention, excessive intake/renal failure.
Occurs when compensatory mechanisms fail to restore fluid balance.
Leads to CHF & Pulmonary oedema.

Treatment: fluid & Na+ restriction, Diuretics, Monitor vital signs,Monitor ABGs & lab values

Water Intoxication

Hypotonic ECF shifts into cells to attempt to restore balance that leads to swelling of cells.
Causes: SIADH
rapid infusion of hypotonic solution
Enemas
Psychogenic polydypsia.

Treatment: prevention is the best treatment
fluid restrictions
Asses neuro-status
Monitor vital signs
Monitor serum Na+
Seizure precautions.

Table 2
Electrolyte composition of intracellular and extracellular fluid

Fluid	Plasma	Interstitial fluid	Intracellular
Cations			
Na^+	140	146	12
K^+	4	4	150
Ca^{2+}	5	3	10^{-7}
Mg^{2+}	2	1	7
Anions			
Cl^-	103	114	3
HCO_3^-	24	27	10
SO_4^{2-}	1	1	0
HPO_4^{3-}	2	2	116
Organic anions	5	5	0
Protein	16	5	40

TABLE 2 : COMPOSITION OF ECF AND ICF

Concentration changes : **HYPONATREMIA**

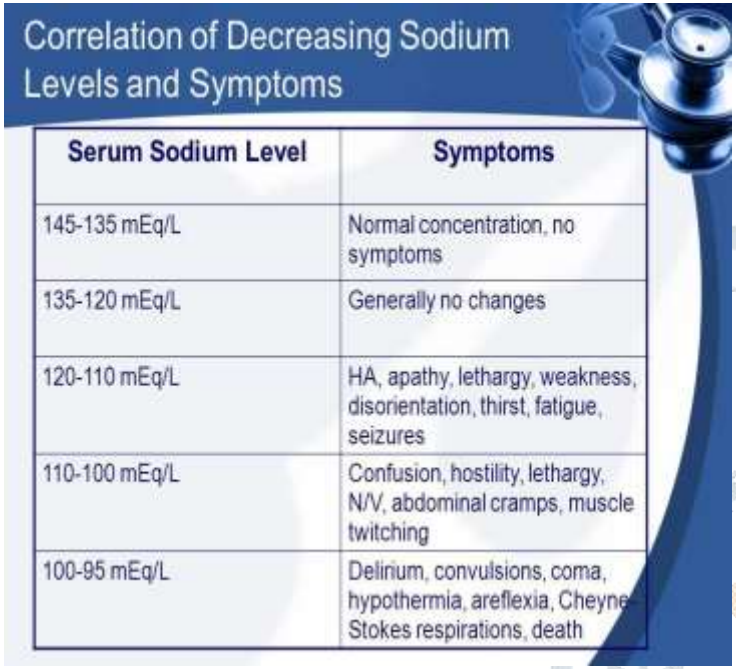


FIG 3: SODIUM LEVELS

Table 6
Etiology and management of hyponatremia

Hyponatremia	Etiology	Treatment
Iso-osmotic	Pseudohyponatremia (hyperlipidemia and hyperproteinemia), isotonic infusions, laboratory error	Correct lipids and protein levels
Hyperosmotic	Hyperglycemia or hypertonic infusions	Correct hyperglycemia[a] discontinue hypertonic fluids
Hypo-osmotic		
Hypovolemic–hypo-osmotic	Urine Na^+ >20: renal losses: RTA, adrenal insufficiency, diuretics, partial obstruction Urine Na^+ <10: extrarenal losses: vomiting, diarrhea, skin and lung loss, pancreatitis	Na^+ deficit[b] replaced as isotonic saline
Euvolemic–hypo-osmotic	H_2O intoxication, renal failure, syndrome of inappropriate antidiuretic hormone Hypothyroidism, pain drugs, adrenal insufficiency	Water restriction
Hypervolemic–hypo-osmotic	Urine Na^+ <10: nephritic syndrome, congestive heart failure, cirrhosis Urine Na^+ >20: iatrogenic volume overload, acute/chronic renal failure	Water restriction

[a] Corrected sodium = .016 (measured glucose − 100) + measured Na^+.
[b] Sodium deficit = (0.6 × weight in kg) × (140 − Na^+).

TABLE 3 : ETIOLOGY AND MANAGEMENT OF HYPONATREMIA

POTASSIUM

Normal daily dietary intake of K+ is approx 50-100mEq/day & normal range : 3.5-5.1mEq/l..Majority is excreted out in urine(0-700meq/day). 98% is located in the ICF at 150mEq/l & is the major cation of ICF.

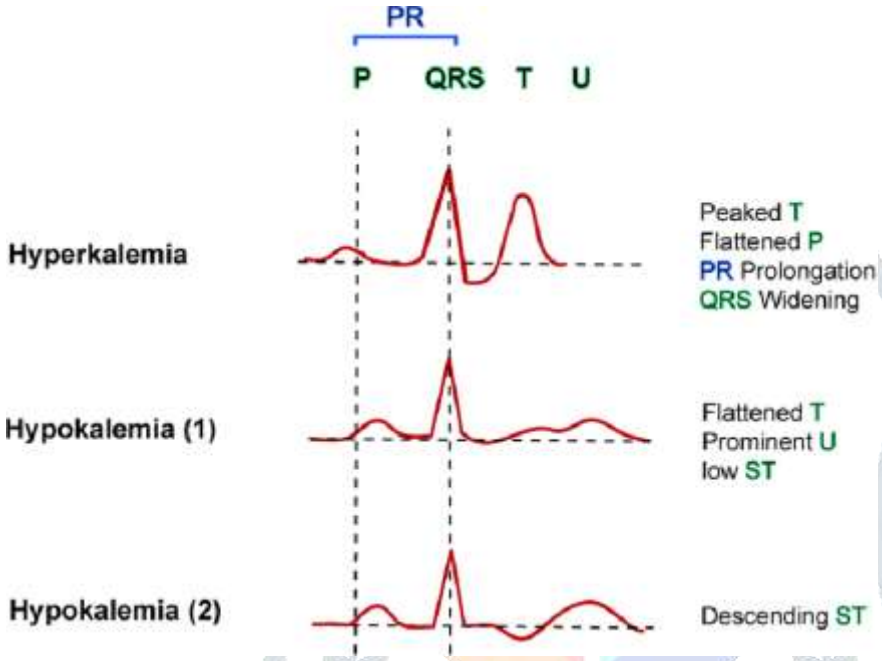


FIG 4 : ECG CHANGES IN POTASSIUM ABNORMALITY

CALCIUM Abnormalities:

Calcium is an ECF cation with plasma conc. Of 8.8-10.5mg/dl.
Exists in 3 forms: bound to protein
free non ionised
free ionized
Hypocalcaemia- serum. Calcium-<8.5mg/dl
Hypercalcaemia- serum. Calcium->10.5mg/dl

MAGNESIUM abnormalities:
Magnesium conc. In the ECF ranges from 1.5-2.4mg/dl.
hypomagnesimia-<1.8mg/dl.
Hypermagnesimia- >2.4mg/dl.

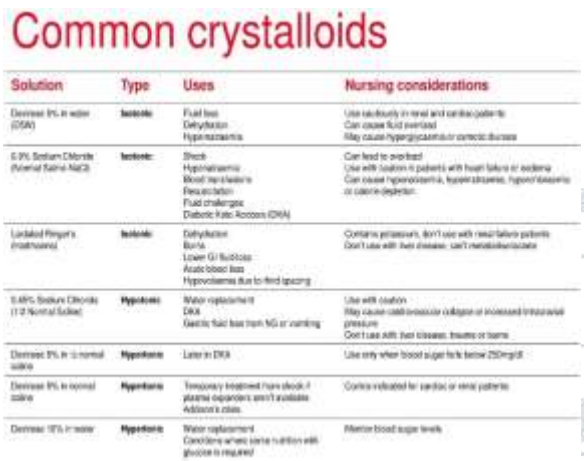
PHOSPHATE Abnormalities:
Normal phosporous levels : 2.5-4.9mg/dl.
Hypophosphatemia: <1mg/dl
Hyperphosphatemia:>5mg/dl

FIG 5: ACID – BASE IMBALANCE.

4/2/1 rule a.k.a weight+40

4/2/1 rule
4ml/kg/hr for first 10kg(=40ml/hr)
2ml/kg/hr for next 10kg(=20ml/hr)
1ml/kg/hr for any no. of kgs beyond
This gives 60ml/hr for first 20kg +1ml/kg/hr for each kg over 20kg.

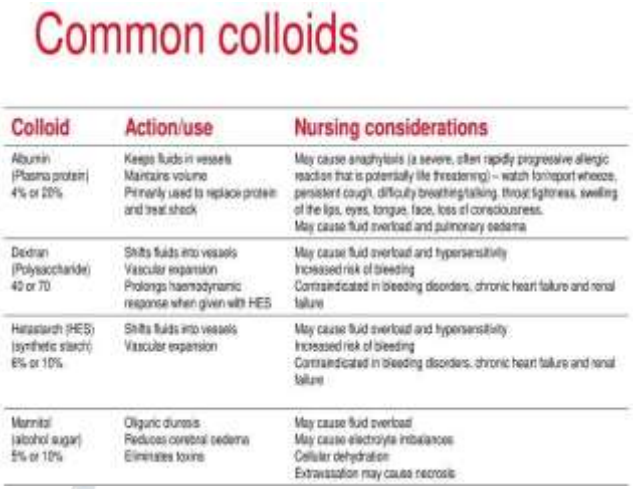
4/2/1 rule → weight in kg + 40ml (maintenance IV rate)



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 hyperchloraemia, hyperchloraemic, hyponatraemia or calcium depletion
Lactated Ringer's (Hartmann's)	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 cerebrovascular collapse or increased intracranial pressure Don't use with liver disease, trauma or burns
Dextrose 5% in ½ normal saline	Hypotonic	Later in DKA	Use only when blood sugar falls below 250mg/dl
Dextrose 5% in normal saline	Hypotonic	Temporary treatment hypo shock if plasma expanders aren't available Addison's crisis	Contra indicated for cardiac or renal patients
Dextrose 10% in water	Hypotonic	Water replacement Conditions where some nutrition with glucose is required	Monitor blood sugar levels

FIG: 6 : COMMON CRYSTALLOIDS



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%	Diuretic Reduces cerebral oedema Eliminates toxins	May cause fluid overload May cause electrolyte imbalances Cellular dehydration Extravasation may cause necrosis

FIG: 7 : COMMON COLLOIDS

POSTOPERATIVE FLUID REGIME

This is always essential to make fluid intake and output chart. This will figure in, intake- oral intake and through IV drip. In output chart- urine output and aspiration along with the vomitus are recordedIn the first 24hours after the surgery there is an increased secretion of aldosterone and ADH. There is conservation of Na+ and loss of less water than in the normal individual. 5% dextrose solution is probably the best in this period and 2L will suffice in 24hours. If there is operative blood loss, this should be replaced. It must be remembered that it is unwise to administer. K+ at this stage unless definite K+ deficiency exists.

CONCLUSION

Fluid and electrolyte balance is critical for maintaining the proper physiological functioning of the human body. A review of various studies highlights the importance of fluid and electrolyte balance while underscoring the consequences of imbalances.

Dehydration is a significant concern, and several studies show its detrimental effects. A study by Shirreffs and Maughan (2019) reveals that dehydration negatively impacts blood volume, causing blood pressure to drop and heart rate to increase. Another study by Chiu et al. (2017) found that dehydration can result in decreased antioxidant capacity, which may lead to oxidative stress.

High sodium intake is another issue that can lead to cardiovascular diseases. Sodium contributes to an increase in blood pressure, which affects the cardiovascular system. A review by Mente et al. (2016) shows that high sodium intake increases the risk of heart attacks and strokes, and a study by O'Donnell et al. (2014) reveals that reducing sodium intake could prevent 1.65 million deaths globally annually.

While electrolytes play a crucial role in the body's proper functioning, imbalances in their levels can lead to various health concerns. Low levels of electrolytes can lead to muscle weakness, heart arrhythmias, and in severe cases, cardiac arrest. On the other hand, high levels of electrolytes can lead to electrolyte imbalance or toxicity and may cause adverse reactions.

Fluid and electrolyte balance is crucial for maintaining optimal health. Dehydration can cause a decrease in blood volume, leading to increased heart rate and decreased blood pressure, while high sodium intake can lead to cardiovascular diseases. Electrolyte imbalances can also lead to various health problems. Maintaining proper fluid and electrolyte balance through a well-balanced diet and adequate hydration is essential for overall health and wellbeing. More research is required to explore the relationship between fluid and electrolyte balance and ensure modern diets and lifestyles are in check

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