Fluid Therapy

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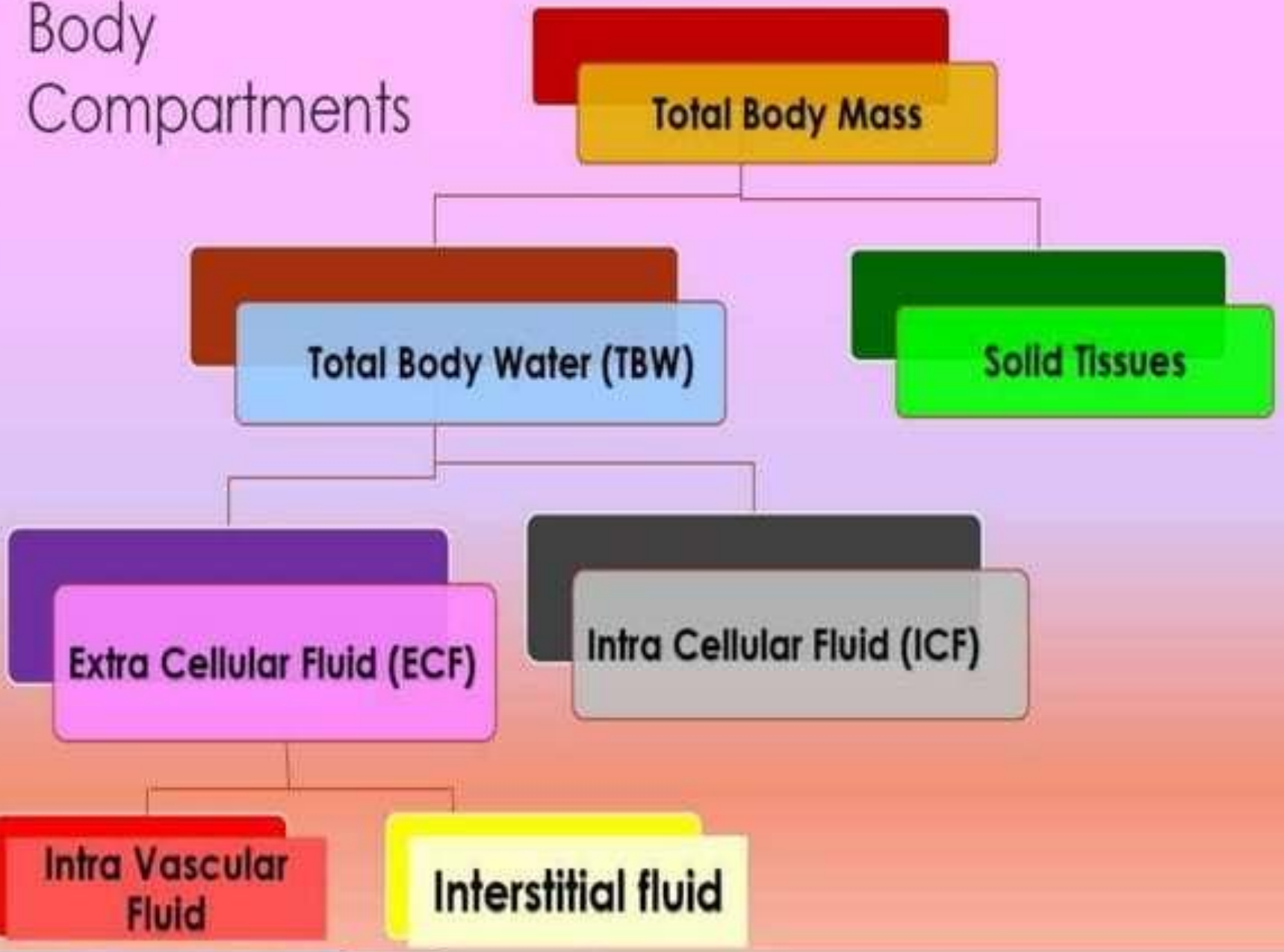
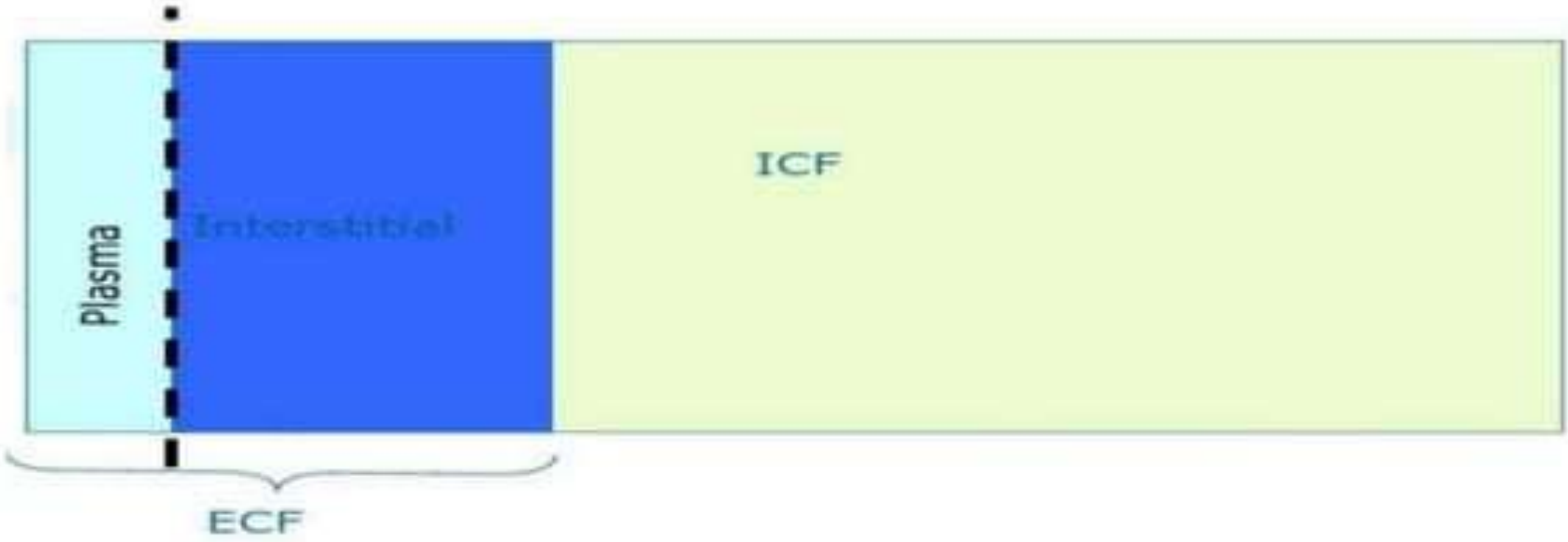
water

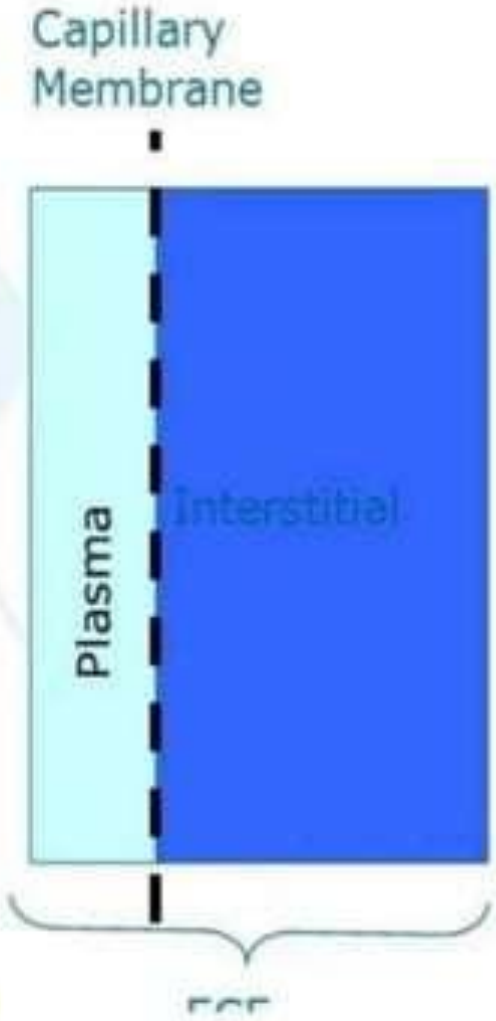
- most important Body constituent
- Constitutes 60% Of the total body weight in male
- Constitutes 50% Of the total body weight in female
- The lesser percentage in females because of larger fat content. Fat cells have minimal ICF.
- Elderly less water because of less muscle mass.
- Water is found in each and every tissue of the body, including bones and cartilages!

Body Compartments



Fluid compartments





Capillary membrane freely permeable to water and electrolytes but not to large molecules such as proteins (albumin).

Definitions:

- Total Body Water (TBW) :
- The sum of intracellular water and extracellular water (volume)
- The latter consisting of
- the interstitial or tissue fluid
- the intravascular fluid or plasma.

- The Extra-Cellular Fluid (ECF): The water content found outside the body cells
- Constitutes two major compartments
  - Intra-vascular & interstitial
- Intravascular space/: is 1/4th of ECF.
- Interstitial fluid is 3/4th of ECF

- 60-40-20 rule:
- TBW =60% Of body weight.
- ICF= 40% Of body weight.
- ECF =20% Of body weight.

- Eg in 75 kg person
  TBW 75 x 0.6= 45
- ICF= 75 x 0.4= 30
- ECF=75 x 0.2= 15L
- 15 L of ECF= 10L of interstitail fluid+ 5 L of intravacular compartment

- Intra Cellular Fluid (ICF):
- a fluid within cell membranes of the tissue cells, throughout
- most of the body

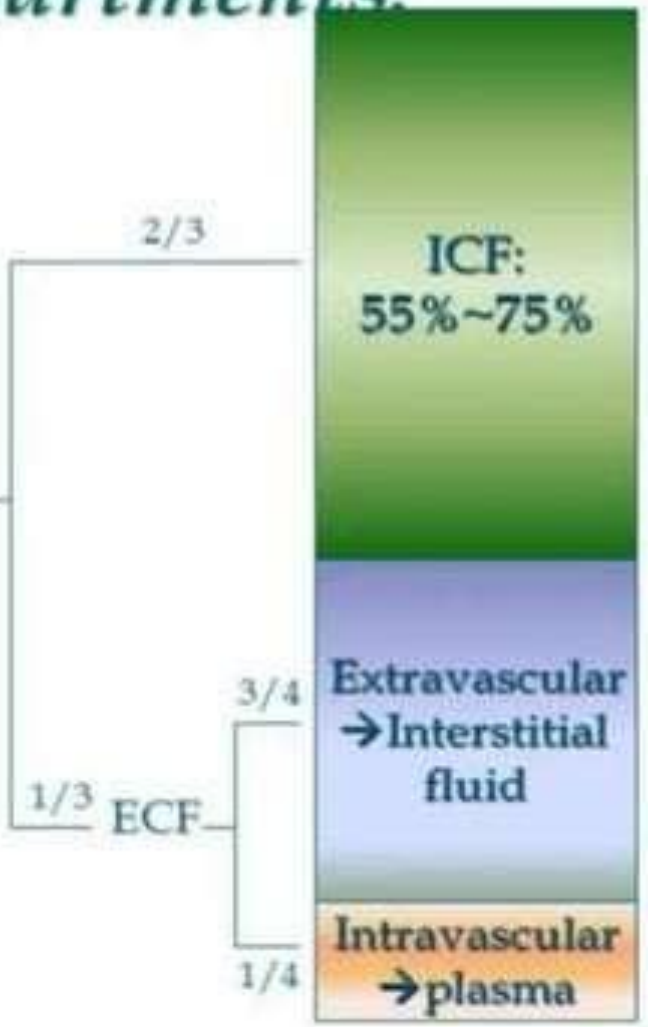
- Interstitial Fluid :
- fluid between the cells and interspaces of tissues.

- Intravascular Fluid :
- within the vessels

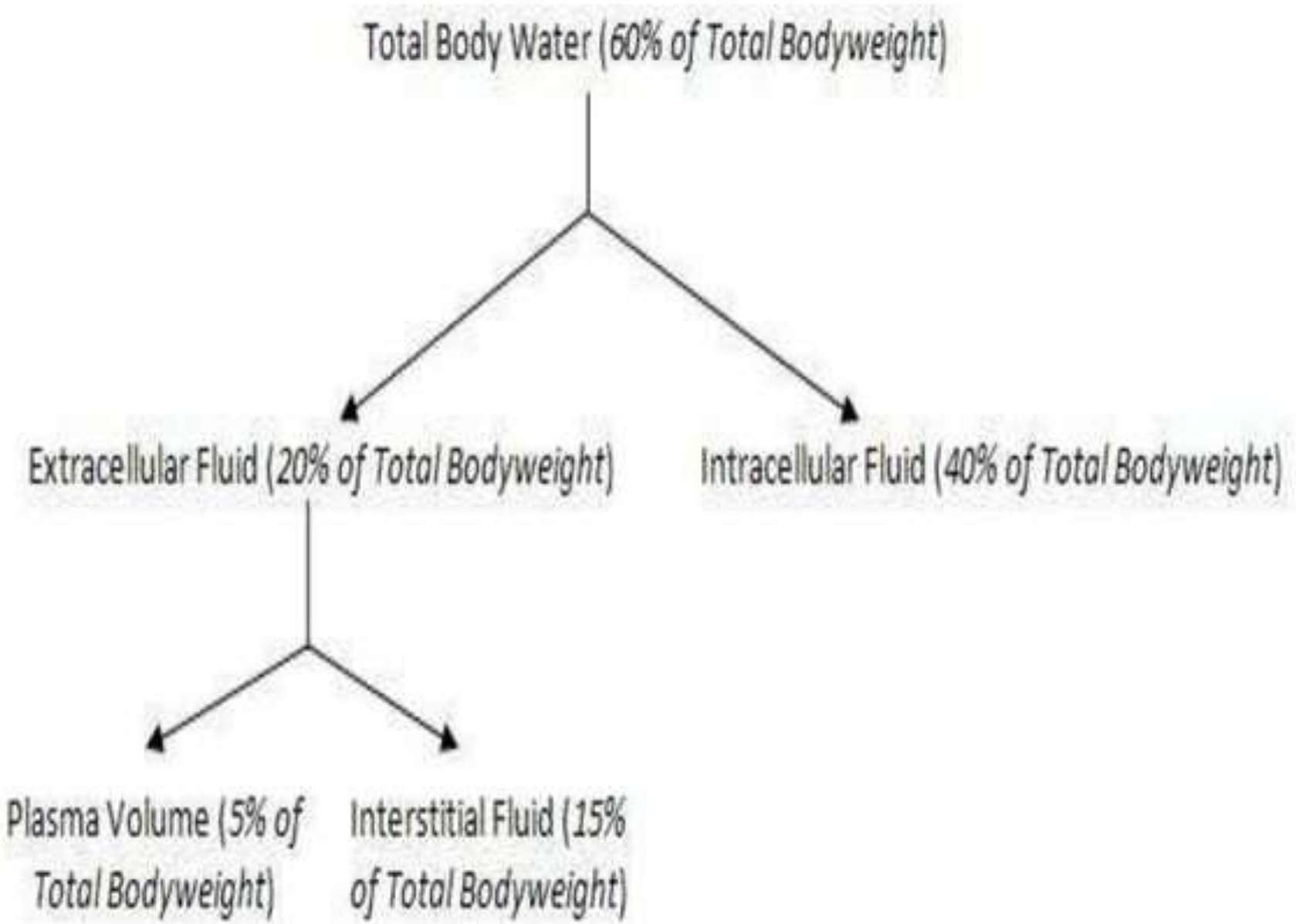
- Third Space:
- space in which fluid does not collect in body in large amount
- Eg pleural and peritoneal cavity.

Body Fluid Compartments:

X 50~70%
lean body weight



- Male (60%) > female (50%)
- Most concentrated in skeletal muscle
- TBW=0.6xBW
- ICF=0.4xBW
- ECF=0.2xBW


Total Body Water (60% of Total Bodyweight)
Extracellular Fluid (20% of Total Bodyweight)
Intracellular Fluid (40% of Total Bodyweight)
Plasma Volume (5% of Total Bodyweight)
Interstitial Fluid (15% of Total Bodyweight)

- Solutes in ECF:
- Primary intravascular/ECF Cation is Na+
- Very small contribution of K+, Ca2+,and Mg 2+

- Primary intravascular/ECF anion is Cl- and Hco-3
- Smaller contribution from SO4 & PO4 , organic acids, and protein.

- Solutes in ICF:
- Primary ICF cation is K+.
- Smaller contribution from Mg 2+ & Na .
- Major anion are protein and organic phosphates.

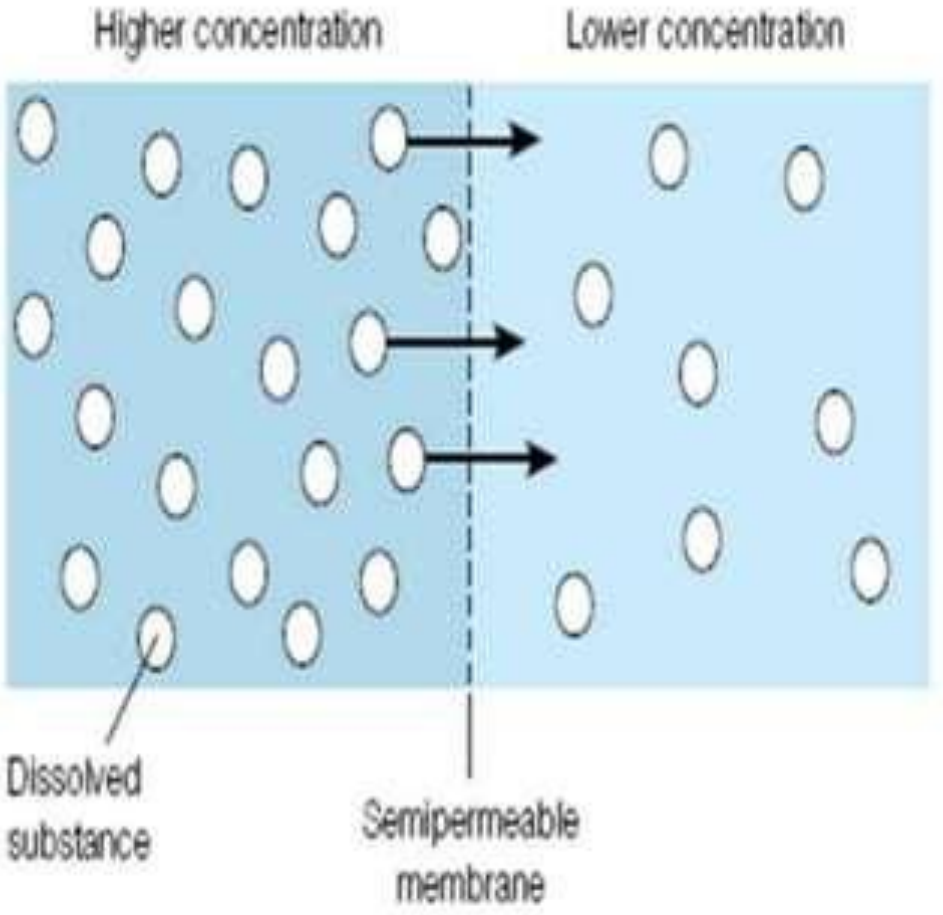
- Osmolality :
- No of osmotically active particles of solute per kg of solvent (m Osmol/Kg).

- Osmolarity:
- No of osmotically active particles of solute per liter of solvent.(m Osmol/L)

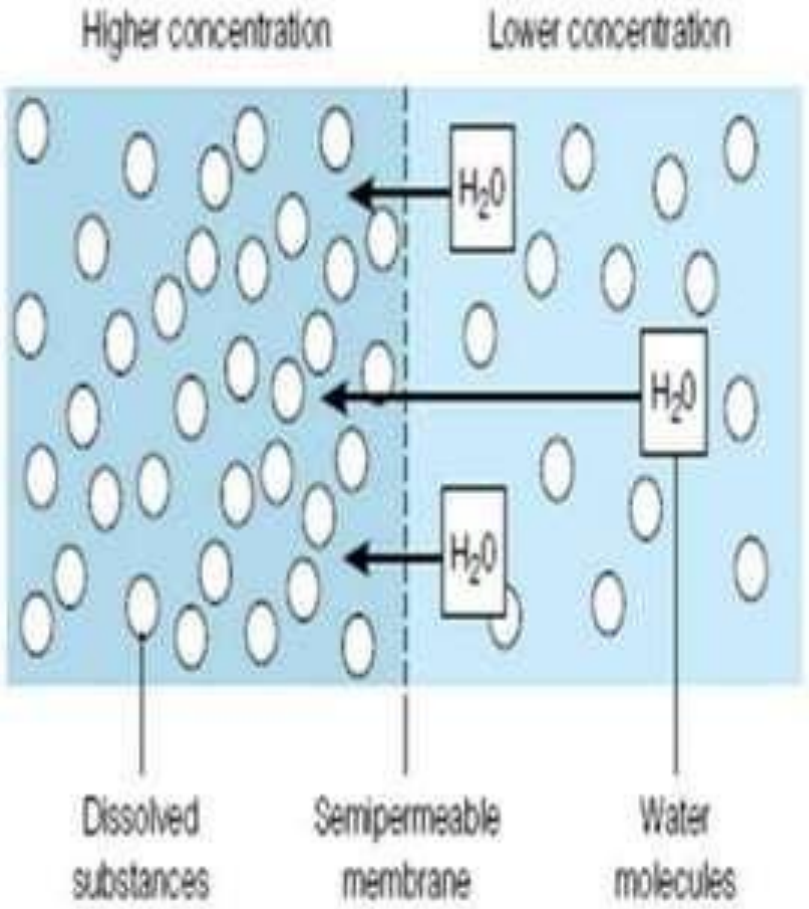
Transport Of fluids

Diffusion

- It is a passive movement of particles down the elctrochemi-gradient.

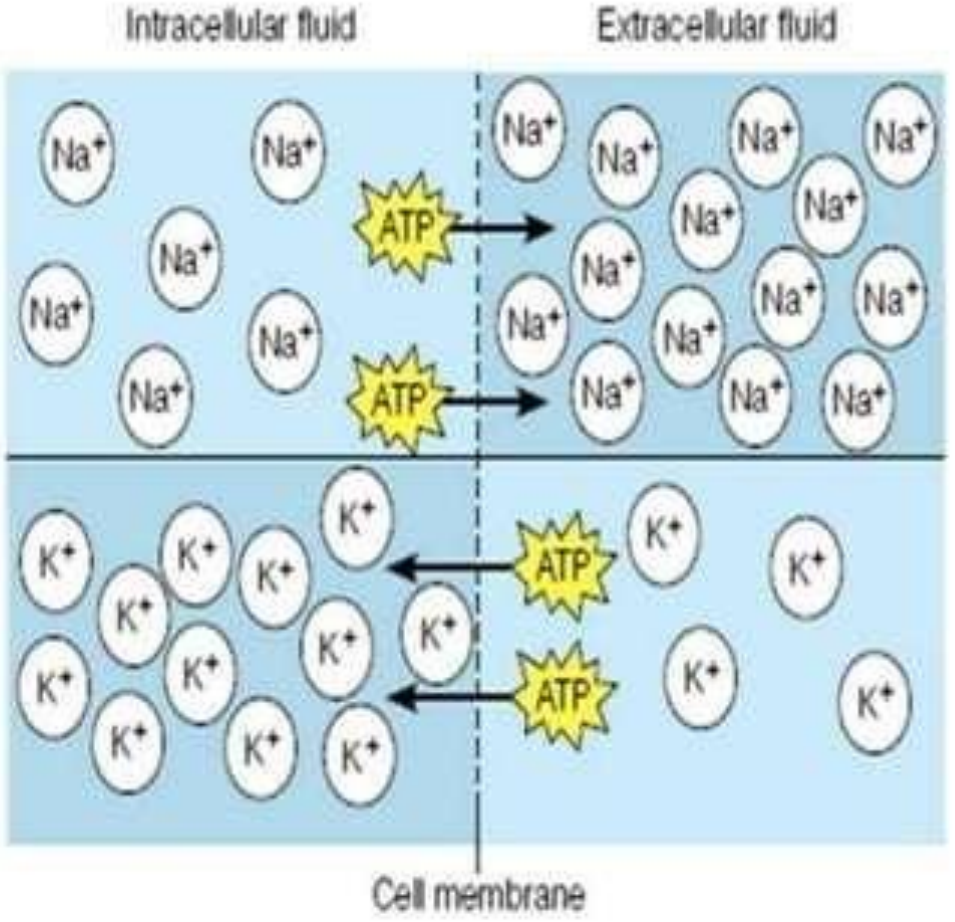


- ***Osmosis*** is the *net movement* of water across a semi permeable membrane. The movement is caused by a concentration gradient due to different solute concentrations on each side of the membrane.
- ***Osmotic Pressure*** is the pressure caused by the solutes within the solution. The solute concentration prevents water movement across the membrane.



Active Transport

It is a movement of particles against the electrochemical gradient with the expenditure of energy.



- Tonicity:

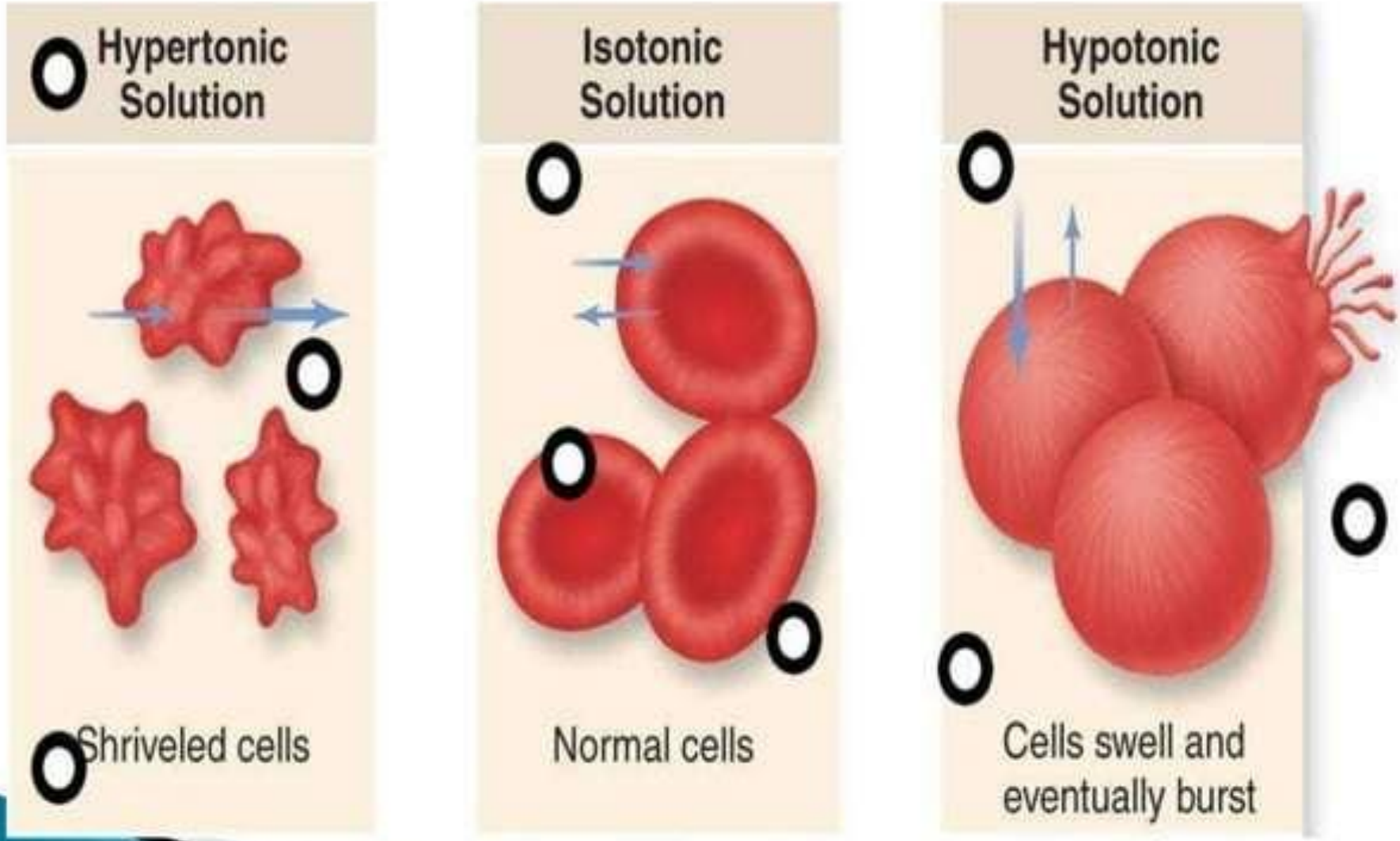
- Tonicity is the term used to compare the osmotic pressure of different solutions.

- Is equal to the sum of the concentrations of the solutes which have the capacity to exert an osmotic force across the membrane.

- A hypotonic solution is one that has an osmotic pressure lower than plasma.
- • Hypotonic means water enters the cell makes it to expand and possibly explode.

- A isotonic solution is one that has an osmotic pressure the same as plasma. Water entering exiting is equal.

- A hypertonic solution is one that has an osmotic pressure higher than plasma.
- • If the environment is hypertonic, the cell will shrink due to water leaving the cell.


Hypertonic Solution
Shriveled cells
Isotonic Solution
Normal cells
Hypotonic Solution
Cells swell and eventually burst

Plasma Osmolality

- Plasma or Serum Osmolality is Number of solutes dissolved in plasma.
- Normal range is : 275 -295 m Osmols/ Kg of Plasma.
- Calculated serum Osmolality = 2(Na)+glucose/18+urea/2.8.

- Oliguria is urine output < 500 mL in 24 h (0.5 mL/kg/h) in an adult

Electrolytes (mEq/L)	ECF: Cations	ECF: Anions	ICF: Cations	ICF: Anions
Sodium Na+	135 - 145	-	8 -10	
Potassium K+	3.5 - 5.5		148 -152	
Calcium Ca++	7 - 10		0.001	
Magnesium Mg++	1.5 - 4		40!	
Chloride Cl-		95 -105		1-2
Bicarbonate HCO3 -		20 - 24		4-7
Phosphate HPO4 + Sulphate SO4		145 - 155		5 - 9

Daily Intake and Output

SOURCES		loSSES	
Water	1500	Urine	1500
Food	800	Stool	200
Oxidation	300	Skin	500
		Resp	400
Total	2600	Total	2600

Daily water requirements

- Adult : 35- 40ml/kg/day
- Child :
- 1st 10 kgs = 4ml/kg/hr
- Next 10kgs=2ml/kg/hr
- Greater than 20kgs =1ml/kg/hr

Daily water requirements cont...

- Daily water requirements increase in :
- Fever :
- Sweating
- Burns
- Tachypnea
- Surgical drains
- Fistula and sinuses
- Diarhea
- Polyurea
- for each degree rise of temp above 37C, Water requirement increases 100-150ml/day or add extra 10% of calculated water for 1c rise in temp
- Or add 2.5ml/kg/day to insensible losses .

Daily water requirements cont…

- Decreased water intake is required in:
- oliguric renal failure
- the use of humidified air
- edematous states,
- hypothyroidism.

Daily requirements of important electrolytes

- Na =1.5-2mmol/kg/day
- K=1-1.5mmoml/kg/day
- Ca 0.2-0.3mmol/kg/day
- Mg 0.35-0.45mmol/kg/day

- **Loss of isotonic fluid:**
- E.g hemorrhage,isotonic urine, vomiting, diachrea.
- a) ECF volume contarct
- b) No fluid change in compartments as there is no change in osmolarity between compartments
- c) HCT increases
- d) BP decreases

- **Infusion Of Isotonic Fluid:**
- a)Expansion Of ECF volume
- b)No change in osmolarity Of ECF
- c) No fluid shift between the compartments
- d) HCT decreases
- e)Bp rises

- **Loss Of Hypotonic Fluid:** eg sweating, DI
- A) decrease in volume of ECF
- b)increase in osmolarity Of ECF
- C) fluid shift from ICF to ECF
- D volume decreases overall , HCT increases
- E) osmolarity increases , HCT increases
- F) net > no effect on hct.

- **Gain of hypotonic fluid :**
- Eg tape water infusion, water intoxication, SIADH
- a) osmoloarity of ECF decreases
- b volume Of ECF increases
- b) Fluid shift from ECF to Icf
- d) volume increases ,HCT decreases
- E) osmolarity decreases, HCT increases
- F) as net effecr > noeffect on hct.

- **Loss OF Hypertonic saline**: eg Primary adrenal insufficiency
- a) decrease in volume of ECF
- B) decrease in osmolarity Of ECF
- C) Fluid shift from ECF to ICF
- D) osmolarity decreses
- E) volume decreses

- **Gain of Hypertonic saline**
- a)Osmolarity Of ECF increases
- b)Fluid shift from ICF to Ecf
- c)Volume of ECF increases > hct decreases
- d)Volume of ICF decreases
- E) cells shrink> hct decreases

Types Of Iv Fluids

- **Crystalloid:**
- Balanced salt/electrolyte solution; forms a true solution and is capable of passing through semipermeable membranes.

- May be isotonic, hypertonic, or hypotonic.

- Normal Saline (0.9% NaCl NaCl),
- Lactated Ringer s,
- Hypertonic saline (3, 5, & 7.5%),
- Ringer solution.

Crystalloid cont

- Useful for volume expansion (mainly interstitial).
- For maintanance infusion
- Correcting electrolyte abnormality.
- No risk of allergic reactions.

Isotonic crystalloids

- Because an isotonic solution stays in the intravascular space, it expands the intravascular compartment.
- Only 25% remain intravascularly.
- Osmolarity is the same as serum osmolarity
- 0.9% NaCl (Normal Saline)
- Lactated Ringers
- D5W (In the bag)

Hypotonic crystalloids

- •A hypotonic solution shifts fluid out of the intravascular compartment, hydrating the cells and the interstitial compartments. Osmolarity is lower than serum osmolarity .

- Less than 10% remain intravascularly, inadequate for fluid resuscitation.

- D5W (in the body)
- 0.25% NaCl
- 0.45% NaCl (half normal saline)

Hypertonic crystalloids

- •A hypertonic solution draws fluid into the intravascular compartment from the cells and the interstitial compartments.

- Osmolarity is higher than serum osmolarity .

- D5 NaCl
- D5 in Lactated ringers
- D5 0.45% NaCl

Types Of Iv fluids cont...

- **Colloid Solutions:**

- High-molecular-molecular weight solutions, do not readily migrate across capillary walls.

- draw fluid into intravascular compartment via oncotic pressure .

- Plasma expanders, as they are composed of macromolecules, and are retained in the intravascular space.

- •They remain in blood vessels longer and increase intravascular volume

- •They attract water from the cells into the blood vessels

Colloids cont...

- •But this is a short term benefit and
- •Prolonged movement can cause the cells to lose too much water and become dehydrated .
- May exacerbate hypovolumia after 24-36 hrs when it moves into 3rd space itself.
- Albumin, Hetastarch Hetastarch, Plasma, Dextran .

Colloids cont...

- Albumin:
- 5% and 20%.
- It is a naturally occuring colloid prepared from human plasma.
- 5% albumin is used in hypovolumia.
- 20% is used to treat severe hypoalbuminaemia.

- Dextran:
- It is a artificial colloid composed of branched chain polysaccharides.
- It can interfere with platelete function.
- Can induce anaphylactic shock.

- Hydroxyethyl starches:
- Composed of chains of glucose and are produced from maize.
-

- Gelatin:
- It is formed from hydrolysis of bovine collagen
- 3 types
- 1.succinylated Gelatin : gelofusin
- 2. urea cross linked gelatins : haemacel
- 3. Oxyplygelatins.

- Rapid excretion throught urine.
- Plasma clearance of 3days .
- Can not be given with blood.
- Not more than 1L in 24 hrs.
-

CI:

- Shock due to septicemia, cardiogenic anaphylactoid reaction.

Composition of common IV Fluids

Solution	Sodium mEq/L	Chloride mEq/L	Glucose g/L	Potassium mEq/L	Calcium mEq/L	Lactate mEq/L
D2.5W			25			
D5W			50			
D10W			100			
0.45NaCl	77	77				
0.9NaCl	154	154				
3% NaCl	513	513				
D5 +0.2NaCl	34	34	50			

Solution	Sodium mEq/L	Chloride mEq/L	Glucose g/L	Potassium mEq/L	Calcium mEq/L	Lactate mEq/L
D5 + 0.45NaCl	77	77	50			
D5 + 0.9NaCl	154	154	50			
Ringer's	147	154		4	4	
Lactated Ringer's	130	109		4	3	28
D5 + Ringer's	147	156	50	4	4	
5% Sodium Bicarb	595	595				

TABLE 61-5 -- Fluids Used for Resuscitation

	NaCl (0.9%)	RINGER'S LACTATE	NaCl (3%)	ALBUMIN (5%)	HETASTARCH (6%)	DEXTRAN 70 + NaCl
Na(mEq/L)	154	130	513	130–160	154	154
Cl (mEq/L)	154	109	513	130–160	154	154
K(mEq/L)	0	4	0	0	0	0
Osmolarity (mOsm/L)	308	275	1025	310	310	310
Oncotic P (mm Hg)	0	0	0	20	30	60
Lactate (mEq/L)	0	28	0	0	0	0
Maximum Dose (mL/kg/24 hr)	None	None	Limited by serum Na^+	None	20	20
Cost (L)	$1.26	$1.44	$1.28	$100	$27.30	$35.08

Normal Saline (0.9% NaCl):

- Isotonic salt water.
- 154mEq/Na+, 154 mEq /L Cl , 308mosl/L;
- Cheapest and most commonly used resuscitative crystalloid.
- High [Cl-] above the normal serum 103 mEq /L imposes on the kidneys an appreciable load of excess Cl that cannot be rapidly excreted.
- A dilutional acidosis may develop by reducing base bicarb relative to carbonic acid. Thus exist the risk of hyperchloremic acidosis.
- Only solution that may be administered with blood products.
- Does not provide free water or calories.
- Restores NaCl deficits

Saline – Induced hyperchloremic metabolic acidosis

- Normal saline is hyperchlremic (154)as compared to body (95-105).
- NacCl +H20>>>>>Hcl + NaOH .
- Strong acid (hcl) and strong base (NaOH) should cancel eachother with no effect on PH.
- Normal concentration of Na (145) and Cl(105), addinf saline causes Cl to increase more than Na, this causes acid base balance more towards HCl than Na .
- Causing metabolic acidosis.

Lactated Ringer's (RL)

- Isotonic, 273 mOsm/L
- Contains 130 mEq/L of Na, 109mEq/L of Cl, 28mEq/L of lactate and 4mEq/L K.
- Lactate is used instead of bicarb because it s more stable in IVF during storage.
- as minimal effects on normal body fluid composition and pH.
- More closely resembles the electrolyte composition of normal blood serum. Does not provide calories.

Lactated Ringer's (RL) cont...

- Lactate is converted readily to bicarb by the liver.
- It is given to patients who have metabolic acidosis not lactic acidosis.
- Don't give in liver diseases.
- Be cautious in pts with severe renal failure because of potassium.
- Do not give to pt with pH > 7.5.

Dextrose 5%

- It is considered isotonic solution when in bag.
- In the body dextrose is metabolized and becomes hypotonic and causes fluids shift into the cells.
- It provides free water and expands both compartments.
- It provides calories, no elctrolytes.
- Can cause fluid overload in pt with cardiac and renal failure.
- It can increases cerebral edema.
- Never mix with blood causes blood to hemolyse.

D5W/1/4NS:

- Hypertonic, 406 mOsm /L
- Provides 170 calories/L from 5% dextrose .
- Provides free water for insensible losses and some Na to promote renal function and excretion.
- With added K this is an excellent maintenance fluid in postop period.
- Prevents excess catabolism and limits proteolysis.

Hypertonic Saline (3% NaCl)

- 1026 mOsm /L & 513 mEq /L Na .
- Increases plasma osmolality and thereby acts as a plasma expander, increasing circulatory volume via movement of intracellular and interstitial water into the intravascular space.
- Risk of hypernatremia thus careful neuro monitoring .
- Hyper tonic fluid should be infused in large vein with large blood volume to dilute to dilute fluid.

- Volume deficits are best estimated by acute changes in weight.
- Less than 5% loss is very difficult to detect clinically.
- loss of 15+% will be associated with severe circulatory compromise.
- Mild deficit represents a loss of ~ 4% body wt.
- Moderate deficit --- a loss of ~ 6-8% body wt.
- Severe deficit --- a loss of ~ >10% body wt.

Initial assessment

- Assess previous limited intake, thirst, abnormal losses, comorbidities.

- Indicators that a patient may need urgent fluid resuscitation include:

- systolic blood pressure is less than 100 mmHg
- heart rate is more than 90 beats per minute
- capillary refill time is more than 2 seconds or peripheries are cold to touch
- respiratory rate is more than 20 breaths per minute
- National Early Warning Score (NEWS) is 5 or more
- passive leg raising suggests fluid responsiveness[2].

- Laboratory assessments: FBC, urea, creatinine and electrolytes

- If patients need IV fluid resuscitation, use crystalloids that contain sodium in the range 130–154 mmol/l, with a bolus of 500 ml over less than 15 minutes.
- Reassess the patient using the ABCDE approach .
- Give a further fluid bolus of 250–500 ml of crystalloid if the patient still need fluid resuscitation
- Seek expert help when >2000 ml given or patient have signs of shock?
- Do not use tetrastarch for fluid resuscitation.
- Consider human albumin solution 4–5% for fluid resuscitation only in patients with severe sepsis.

Routine Maintenance

- Normal daily fluid and electrolyte requirements:
- 25–30 ml/kg/d water

- 1 mmol/kg/day sodium, potassium*, chloride

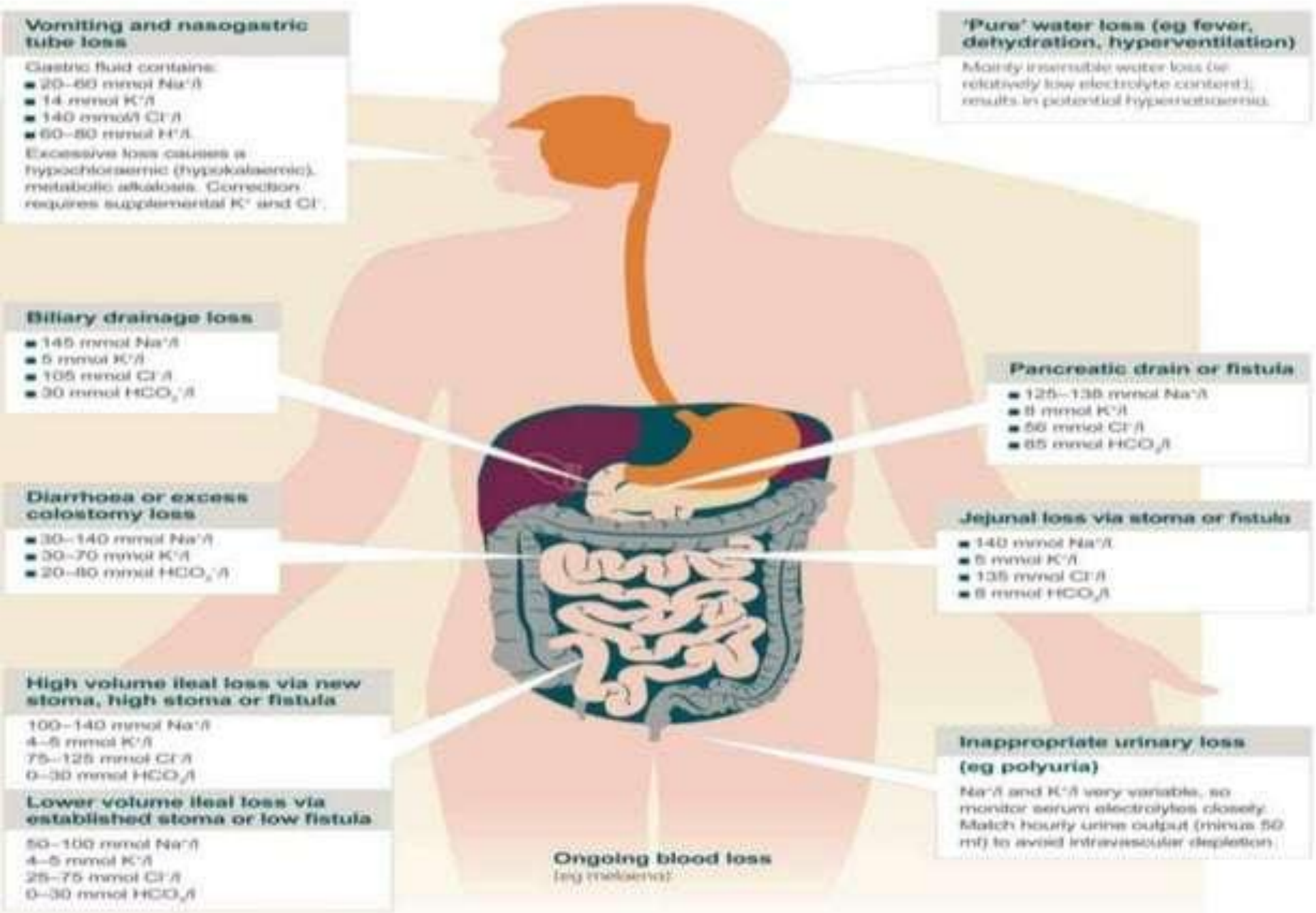
- 50–100 g/day glucose (e.g. glucose 5% contains 5 g/100ml) approximately to limit starvation ketosis.

- Consider prescribing less fluid (for example, 20–25 ml/kg/day fluid) for patients who:
- are older or frail
- have renal impairment or cardiac failure
- are malnourished .

MAINTENANCE FLUID THERAPY

- undertaken when the patient is not expected to be able to eat or drink normally for a prolonged period of time.
- The serum sodium concentration provides the best estimate of water balance in relation to solute.
- A normal serum sodium concentration implies that the patient is in water balance in relation to sodium but does not provide any information on volume status.
- Weighing the patient daily provides the best means for estimating net gain or loss of fluid

- When prescribing for routine maintenance alone, consider using 25–30 ml/kg/ day sodium chloride 0.18% in 4% glucose with 27 mmol/l potassium[3] on day 1 (there are other regimens to achieve this).
- Prescribing more than 2.5 litres per day increases the risk of hyponatraemia.
- These are initial prescriptions and further prescriptions should be guided by monitoring.
- Consider delivering IV fluids for routine maintenance during daytime hours to promote sleep and wellbeing.


Vomiting and nasogastric tube loss
Gastric fluid contains:
- 20–60 mmol Na^+/l
- 14 mmol K^+/l
- 140 mmol/l Cl^-/l
- 60–80 mmol H^+/l

Excessive loss causes a hypochloraemic (hypokalaemic), metabolic alkalosis. Correction requires supplemental K^+ and Cl^-.
'Pure' water loss (eg fever, dehydration, hyperventilation)
Mainly insensible water loss (ie relatively low electrolyte content); results in potential hypernatraemia.
Biliary drainage loss
- 145 mmol Na^+/l
- 5 mmol K^+/l
- 105 mmol Cl^-/l
- 30 mmol HCO_3^-/l
Pancreatic drain or fistula
- 125–135 mmol Na^+/l
- 8 mmol K^+/l
- 50 mmol Cl^-/l
- 85 mmol HCO_3/l
Diarrhoea or excess colostomy loss
- 30–140 mmol Na^+/l
- 30–70 mmol K^+/l
- 20–80 mmol HCO_3^-/l
Jejunal loss via stoma or fistula
- 140 mmol Na^+/l
- 5 mmol K^+/l
- 135 mmol Cl^-/l
- 8 mmol HCO_3/l
High volume ileal loss via new stoma, high stoma or fistula
100–140 mmol Na^+/l
4–5 mmol K^+/l
75–125 mmol Cl^-/l
0–30 mmol HCO_3/l
Lower volume ileal loss via established stoma or low fistula
50–100 mmol Na^+/l
4–5 mmol K^+/l
25–75 mmol Cl^-/l
0–30 mmol HCO_3/l
Inappropriate urinary loss (eg polyuria)
Na^+/l and K^+/l very variable, so monitor serum electrolytes closely. Match hourly urine output (minus 50 ml) to avoid intravascular depletion.
Ongoing blood loss
(eg melaena)

- Reassess and monitor the patient
- Stop IV fluids when no longer needed.
- Nasogastric fluids or enteral feeding are preferable when maintenance needs are more than 3 days

Gastric outlet obstruction / Vomiting:

- Vomitus contain Na+, H+ ,Cl, K
- It leads to metabolic alkalosis.
- Increased aldosterone>>> increased K and H excretion.
- Increased renal losses of HCO3, which leads to hyponatremia.
- To cmpensate hyponatremia renal absorbtion of Na along with loss of H ion, which worsens alkalosis.> Hypokalemic Metabolic Alkalosis with paradoxical aciduria.
- Fluid of choice: 0.9%Nacl + k supplementation

Diarrhoea

- In diarrhoea, hco3 rich small gut, pancreatic and biliary secretions are lost.
- So
- Metabolic acidosis
- Hypokalemia
- Hyponatremia

- **Fluid of choice:**
- Ringers lactate
- As it contain Na, K and lactate which is converted to bicarbonate.
- Also supplemental K.

Sweating

- Well acclimitized person
- Oral fluid / 5% D/w as it will be distributed throughout the body.

- Not well acclimatized person :

- Oral fluids with electrolyte supplementation.
- Ns or R/L

Pancreatic Fistula:

- Every 1L loss of pancreatic fluid 1L of fluid along with 50mmol of sodium bicarb should be replaced.


Thank
you