Fluid and electrolyte balance

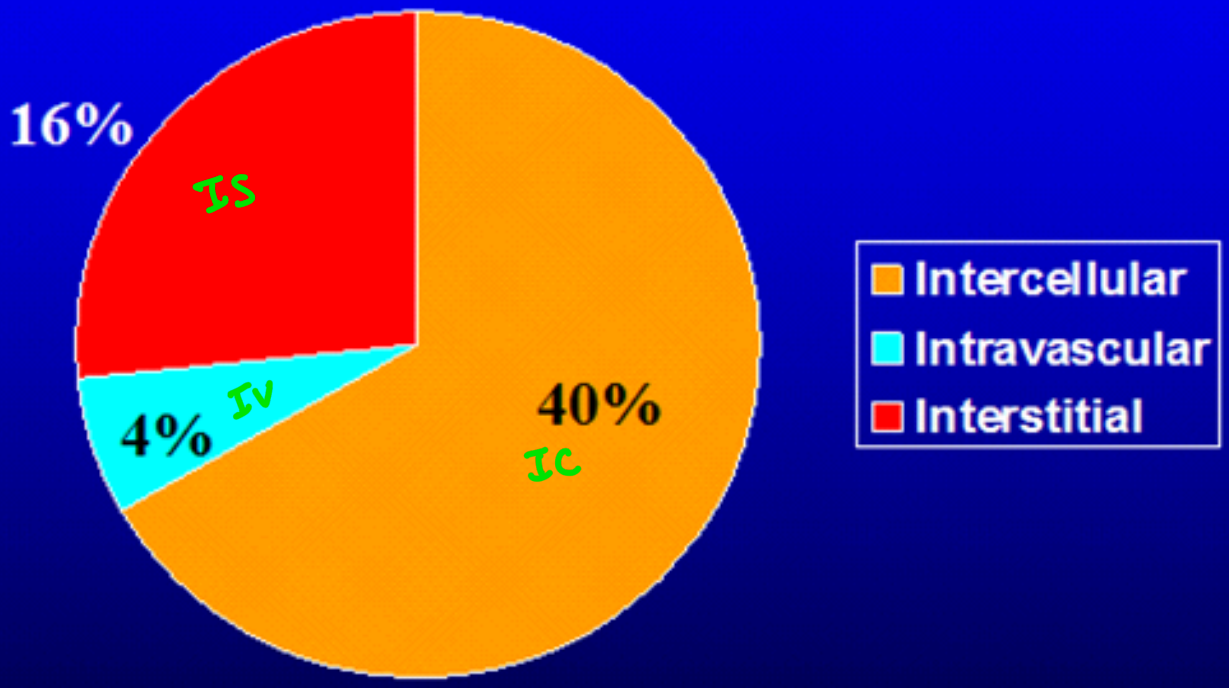


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Fluid and electrolyte balance

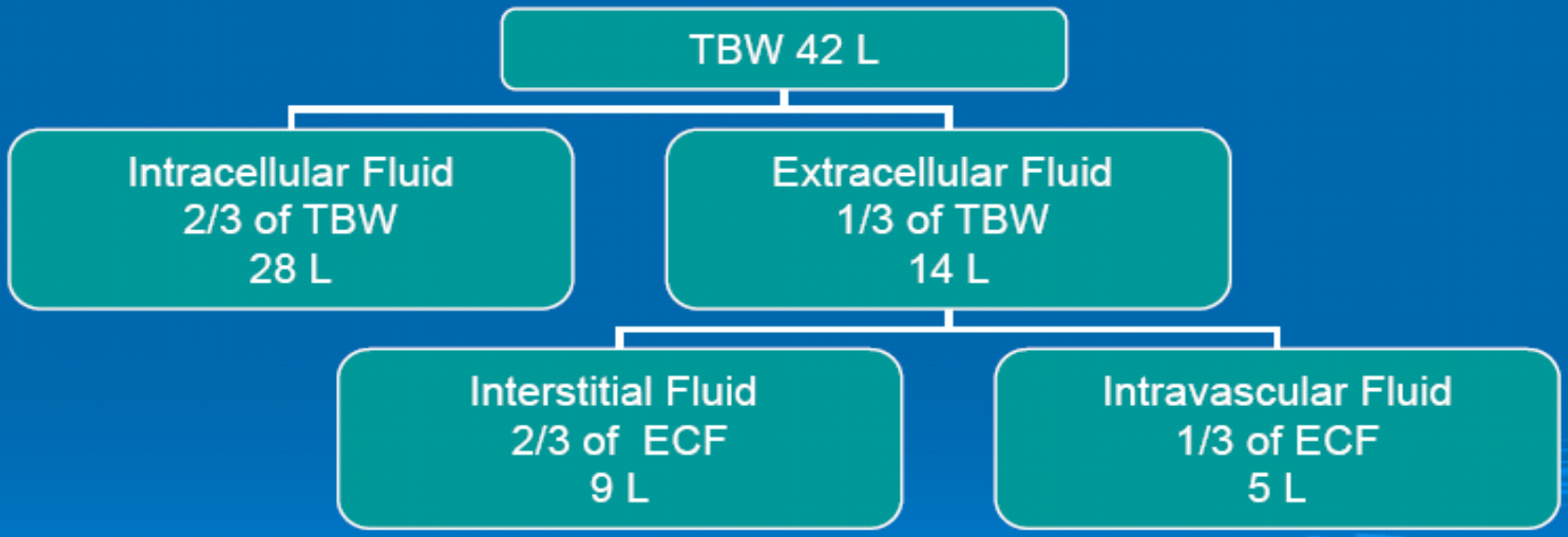
- Total body water is 60% of body weight.
- TBW is 42 liters in 70kg man , 35L in female .[in male > female]
  - has more fat which it less water content...
- Intracellular water 2/3 the TBW 28 L.
- Extracellular water 1/3 TBW 14L divided into
  - Intravascular(plasma) 4.5% - 6% of TBW
  - Interstitial fluid 14%
    - The fluid around the cells
  - Transcellular fluid 1.5%
    - not inside cells or BV or around cells..
    - as:- pleural - peritoneal - pericardial cavity fluid or joint fluid or fluid inside the Bowell or eye fluid..

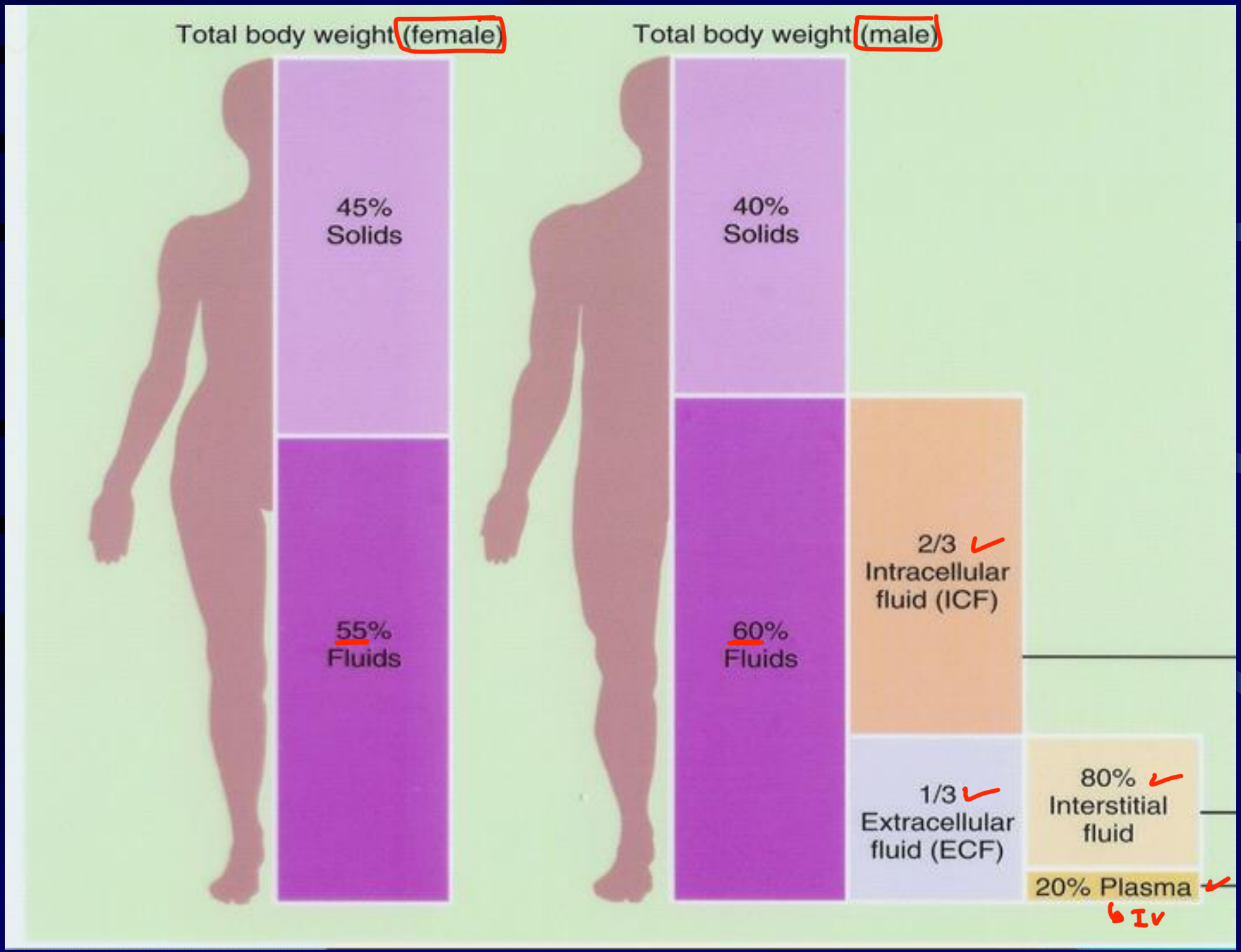
Body Fluids

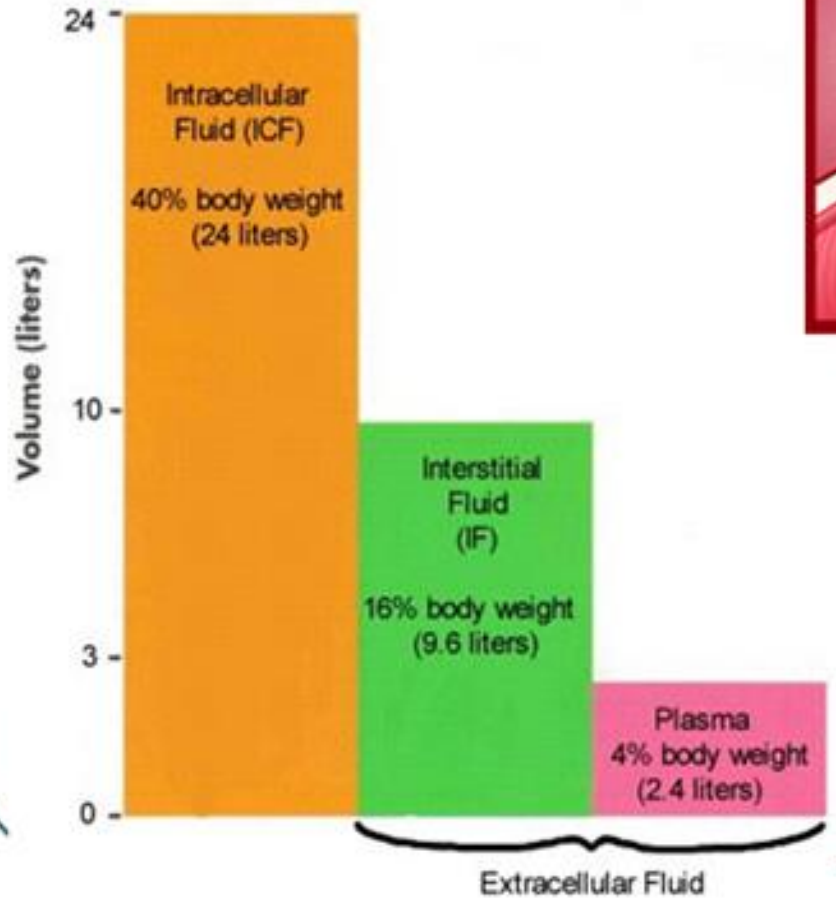


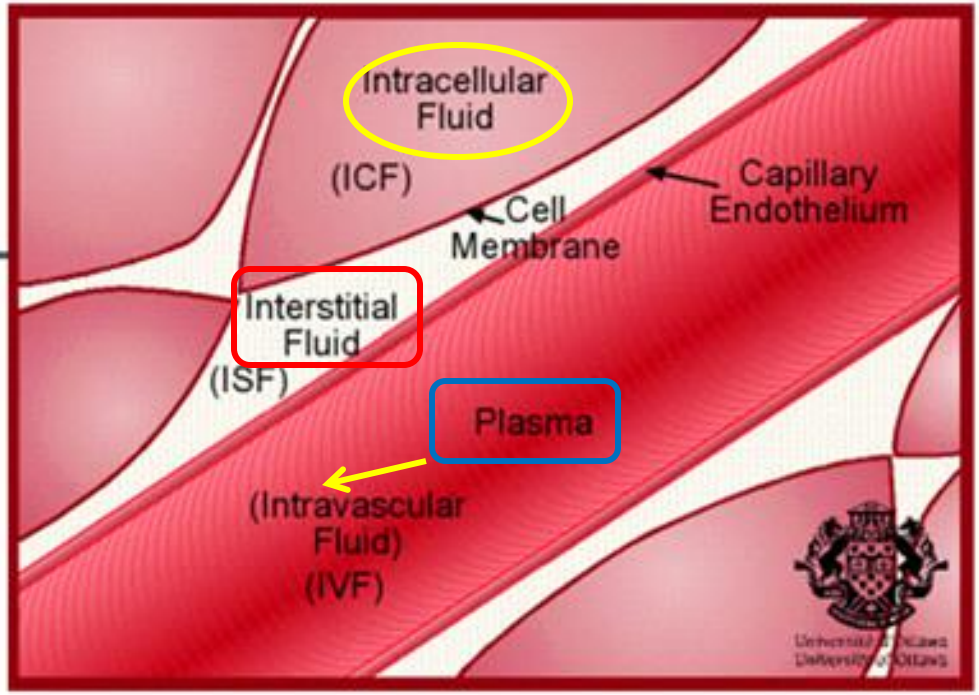
Body Water = 60% of a patient's body weight

Fluid Compartments



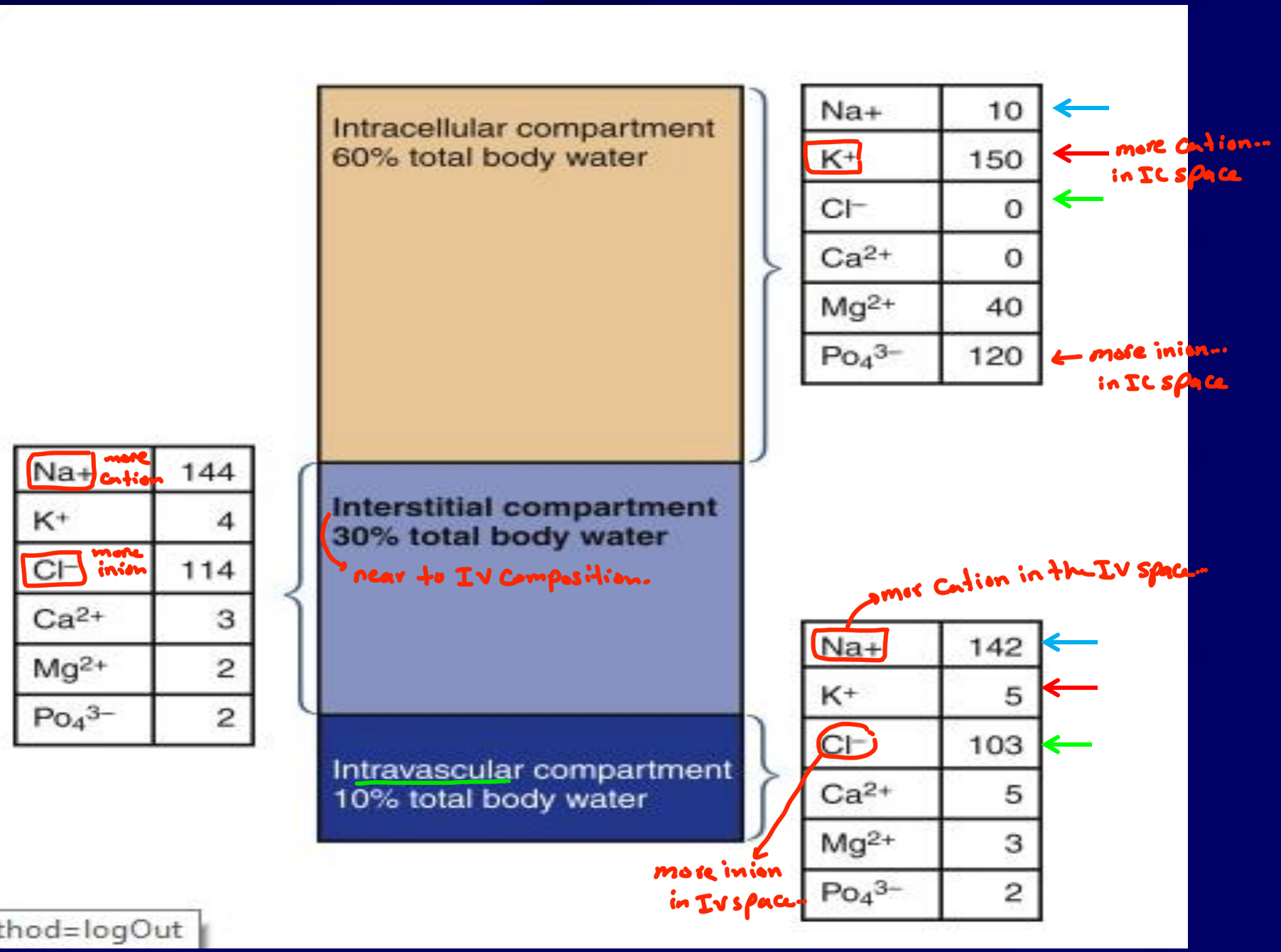

Total body weight (female)
45% Solids
55% Fluids
Total body weight (male)
40% Solids
60% Fluids
2/3 Intracellular fluid (ICF)
1/3 Extracellular fluid (ECF)
80% Interstitial fluid
20% Plasma
IV


Volume (liters)
24
10
3
0
Intracellular Fluid (ICF)
40% body weight (24 liters)
Interstitial Fluid (IF)
16% body weight (9.6 liters)
Plasma
4% body weight (2.4 liters)
Extracellular Fluid

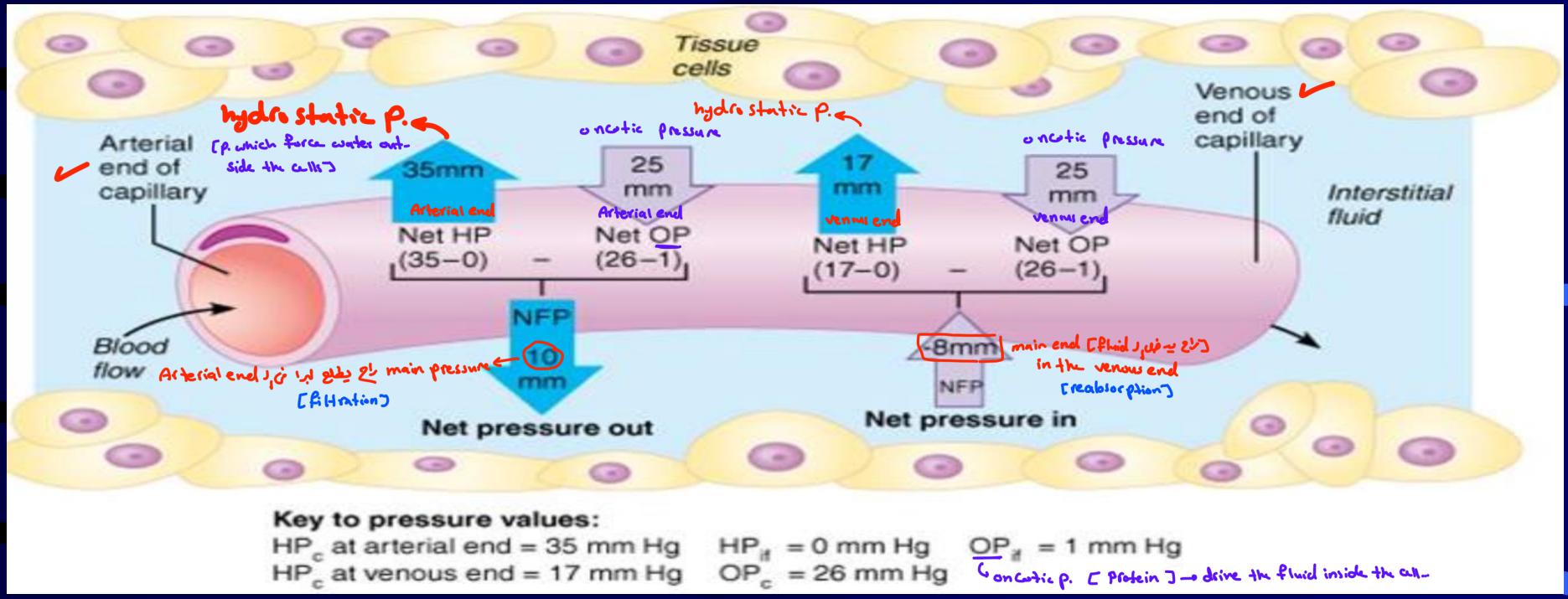

Intracellular Fluid
(ICF)
Cell Membrane
Capillary Endothelium
Interstitial Fluid
(ISF)
Plasma
(Intravascular Fluid)
(IVF)

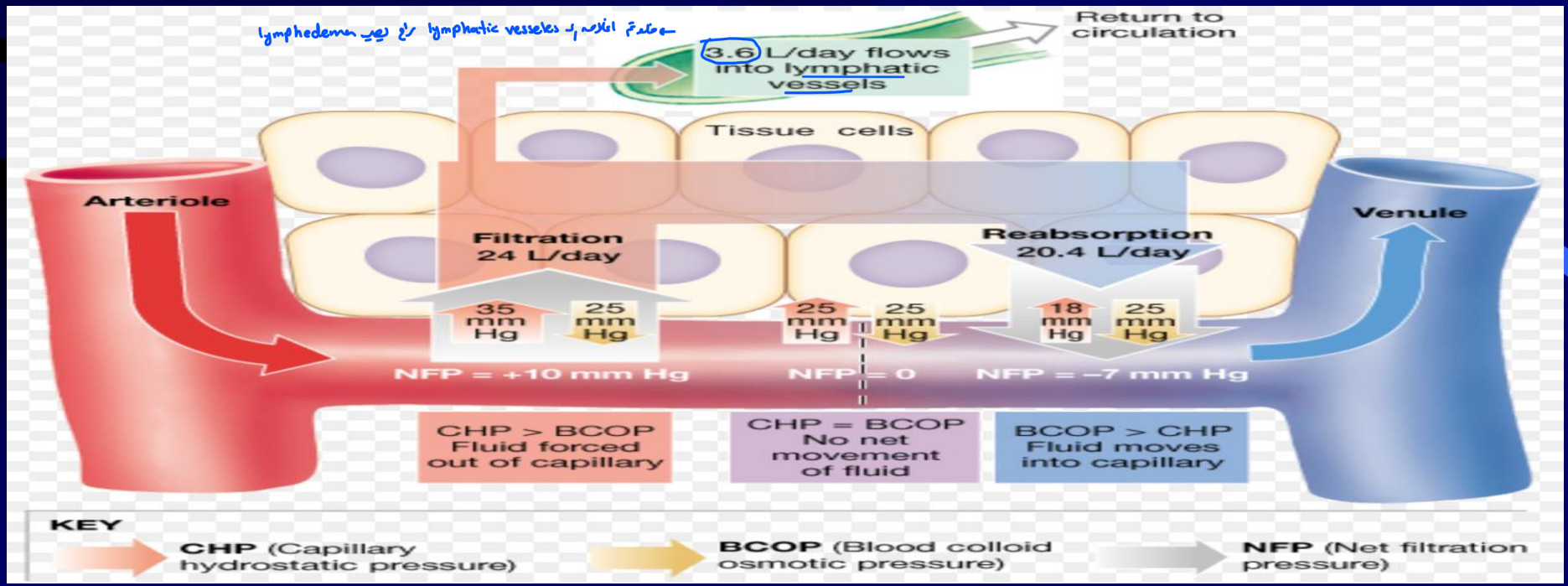
Total body water in 70 KG MAN 60%

Plasma (IV)	3.500 ML	5- 8 %
Interstitial fluid	10.500 ML	15 %
Intracellular	28.000 ML	40%


Intracellular compartment
60% total body water
Interstitial compartment
30% total body water
near to IV composition.
Intravascular compartment
10% total body water
Na+ 10
K+ 150
Cl− 0
Ca2+ 0
Mg2+ 40
Po43− 120
more cation... in IC space
more inion... in IC space
Na+ more cation 144
K+ 4
Cl− more inion 114
Ca2+ 3
Mg2+ 2
Po43− 2
more cation in the IV space...
Na+ 142
K+ 5
Cl− 103
Ca2+ 5
Mg2+ 3
Po43− 2
more inion in IV space...

thod=logOut


Tissue cells
hydro static p.
[p. which force water out-side the cells]
oncotic pressure
hydro static p.
oncotic pressure
Venous end of capillary
Arterial end of capillary
35mm
Arterial end
Net HP (35–0)
25 mm
Arterial end
Net OP (26–1)
17 mm
venous end
Net HP (17–0)
25 mm
venous end
Net OP (26–1)
Interstitial fluid
Blood flow
NFP
10 mm
Arterial end ازاي يطلع برا main pressure
[filtration]
Net pressure out
-8mm
NFP
main end [fluid يرجع برجع in the venous end [reabsorption]
Net pressure in
Key to pressure values:
HPc at arterial end = 35 mm Hg
HPc at venous end = 17 mm Hg
HPif = 0 mm Hg
OPc = 26 mm Hg
OPif = 1 mm Hg
oncotic p. [protein] → drive the fluid inside the cell


lymphedema يعني ايه lymphatic vessels مش شغالة
Return to circulation
3.6 L/day flows into lymphatic vessels
Tissue cells
Arteriole
Venule
Filtration 24 L/day
Reabsorption 20.4 L/day
35 mm Hg
25 mm Hg
25 mm Hg
25 mm Hg
18 mm Hg
25 mm Hg
NFP = +10 mm Hg
NFP = 0
NFP = –7 mm Hg
CHP > BCOP Fluid forced out of capillary
CHP = BCOP No net movement of fluid
BCOP > CHP Fluid moves into capillary
KEY
CHP (Capillary hydrostatic pressure)
BCOP (Blood colloid osmotic pressure)
NFP (Net filtration pressure)

Chemical composition of body fluids

Fluid	Na^+	K^+	Mg^+	$Hco3^-$	Protein	$PO4^-$	CL^-
Intracellular	10	150	40	10	40	120	3
Interstitial (plasma مثل)	144	4	2	30	1	3	114
Plasma	142	4	3	27	16	3	103
Ringer lactate	130	4	-	28	-	-	109

↳ has similar composition of plasma so it is the best solution to give to pt in post op period or shock or dehydration...

Composition of parenteral fluids

Fluid	Na	K	CL	Hco3	Ca
ECF	142	4	103	27	5
R lactate	130	4	109	28	3
N saline (0.9 NaCl)	154	-	154	-	-
P saline (0.18 NaCl)	30	-	30	-	-
NG tube	70	10	103	-	-

physiological saline

we preferred it in repeated vomiting - NG tube - pyloric stenosis... metabolic Alkalosis

pediatric for children (1/5 normal saline)

indicate stomach electrolyte...

pH ... NG tube ... Na ... of the stomach...

→ 1/2 strength normal saline → has 75 Na - 75 CL ...

Composition of gastrointestinal secretions

↳ daily secreat 8L of fluid → 7L re-absorped

Type of secretion	Volume	Na^+	K^+	Cl^-	Hco_3
				1L excreted to colon	
				re-absorpe 800mL	200mL instead excreted
Salivary 1L	1000	30	26	70	30
Stomach 2-2.5L	2000	80	10	100	0
Small bowel 3L	3000	140 [as plasma]	20 ↳ higher K^+ present in the SI	104	0
Bile 7.5-1L	1000	140	5	100	35
Pancreas 7.5 - 1L	1000	140	5	70	115 ↳ higher HCO_3^- present in pancrease than in Bile...
R lactate 1L	1000	130	4	109	28

if we injured the pancrease will release ↑ HCO_3^- level to Metabolic Acidosis..

* any fluid loss from SB - Bile - Colon - pancrease are replaced volume by volume via normal saline... has the same componant..

Maintenance fluid

* each 1L of SI fluid has 20 m.mol of K^+...

* each 1L of NG tube [stomach] fluid has 10m.mol of K^+...

- ***Sensible Loss*** → we can measure it...
- Urine 1500 - 2000 ml day.
- Feces 300 ml day.
- ***Insensible Loss*** → we can't measure it. roughly = 800ml.
- Skin 500 ml . [400 ml]
  - with evaporation...
- Lung 300 ml : [400 ml] (with exp.)
- Oxidation of fat + 100 ml :

(10-12 mL/Kg/day)

So the pt loss 2500 - 3000 ml fluid: so we give him 2500 - 3000 ml water maintinance per day...

- 100-200 ml loss per degree rise of temperature, 10 % of insensible loss per ^oC .
  - so need +100 - 200 mL of water supply...
- During laparotomy insensible losses reach ***700-1000*** ml/H

sensible loss is to be Bleeding إذا if he not Bleed

Maintenance fluid per kg per h

- Less than 10 kg — 4 ml/ kg/ hr.
- 11-20 kg — 2 ml/ kg/ hr.
- More than 20 — 1 ml/ kg/ hr.
- Adult — 110-125 ml/ hr.
- *Short Cuts WT in kilo + 40 = ml / Hour*
- First 10 Kg 100 ml/Kg /day
- 10-20 kg 50 mL/Kg /day
- 20 or more Kg 20 mL/Kg /day .
- *Keep Urine Output at 0.5 ml / kg/ Hour in Adult ,1ml / kg / Hour in Children*

Daily requirement for electrolytes

*mmol = meq in Cl and Na+ and K+ لأن شحنة أيونية = ١

... meq. = mmol / عدد الشحنات

- ***Na* :** 1-2 mmol /Kg /day

- ***K* :** 0.5 -1 mmol/Kg / day → any adult Pt need 60 mmol/day of K+ (maintinance)...

  ↳ 1/2 Na+

- ***Ca*** : 800-1200 mg/ day

- ***Mg*** : 300-400 mg /day

- ***Phos*** : 800-1200mg/ day

Example of maintenance fluid

- 2.5 L of 5% dextrose water + 0.5L normal saline 0.9Nacl .
- 3 L pediatric saline sol 0.18 saline + 4.3% Glucose
- 1 L dextrose 0.45% + 2L dextrose 5%.
- Add ***Kcl 20 mmol*** per each liter.

Crystalloids and colloids

has ↑ oncotic pressure
بیشه fluid را نگه میدارد
in IV space...

	Crystalliod	Colloid
		استفاده میشود
Intravascular persistence	Poor	Good
Homodynamic stabilisation	Transient	Prolonged
Required infusion volume	Large	Moderate
Risk of tissue oedema	Obvious	Insignificant
Enhancement of capillary perfusion	Poor	Good
Risk of anaphylaxis	Nil	Low to moderate
Plasma colloid osmotic pressure	Reduced	Maintained
Cost	Inexpensive	Expensive

Recognition and treatment of volume deficit

GIT and Third space loss lead to ECF deficit so lead to dehydration...

Symptom and signs of ECF deficit

- ***CNS:*** **Apathy , confusion, stupor.** - Coma.
- ***GIT:*** **Nausea ,vomiting, ileus excessive thirst .**
- ***Cardiovascular:*** **Tachycardia , hypotension .**
- ***Tissue:*** **Sunken eyes, decrease skin turgor.**
- ***Metabolic:*** **Hypothermia.** (more in children)
- ***Biochemical:*** **Hematocrit , BUN , Creatinine .**

in shock - Bleeding - vomiting - diarrhea

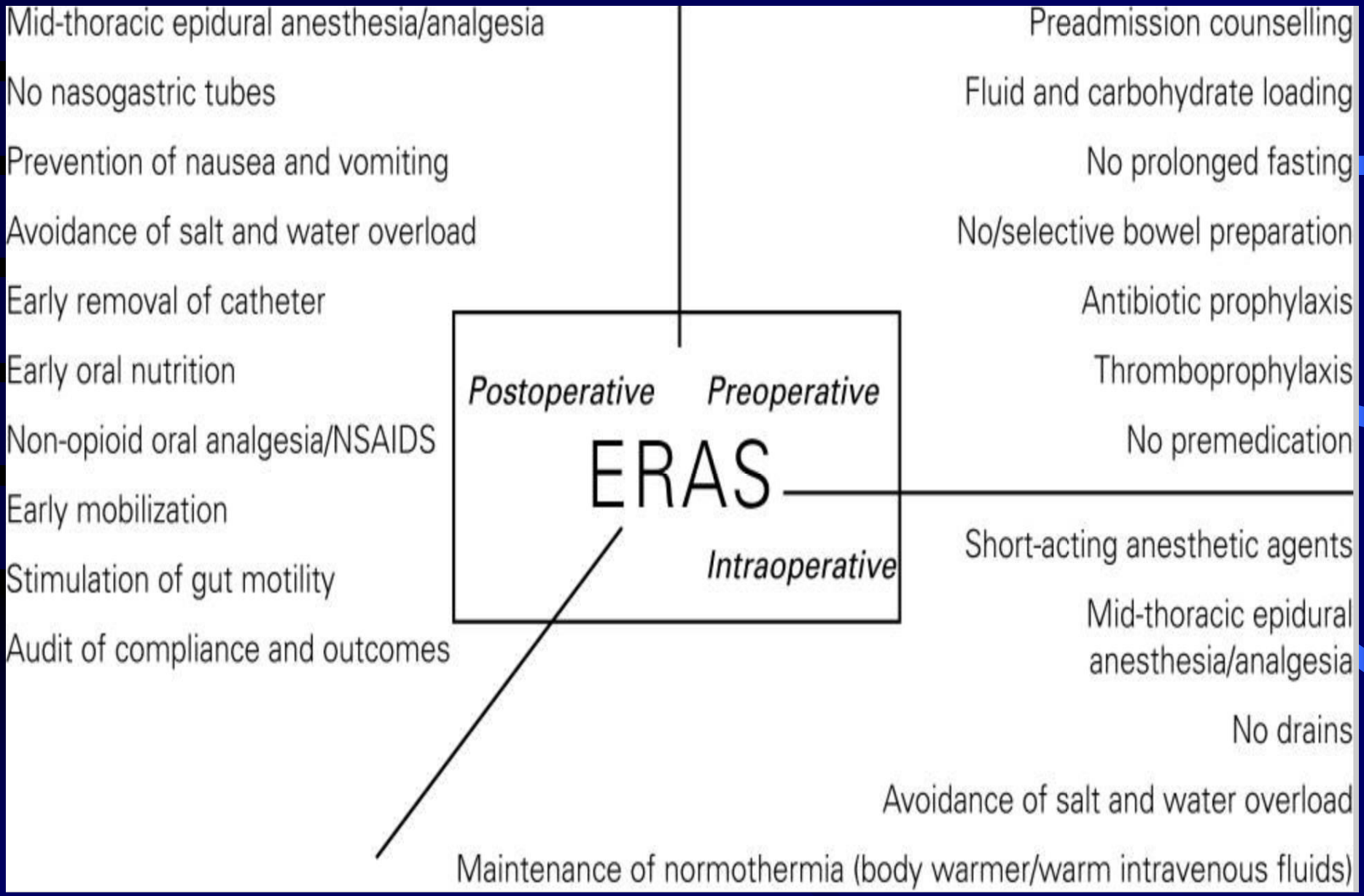
Losses from GIT

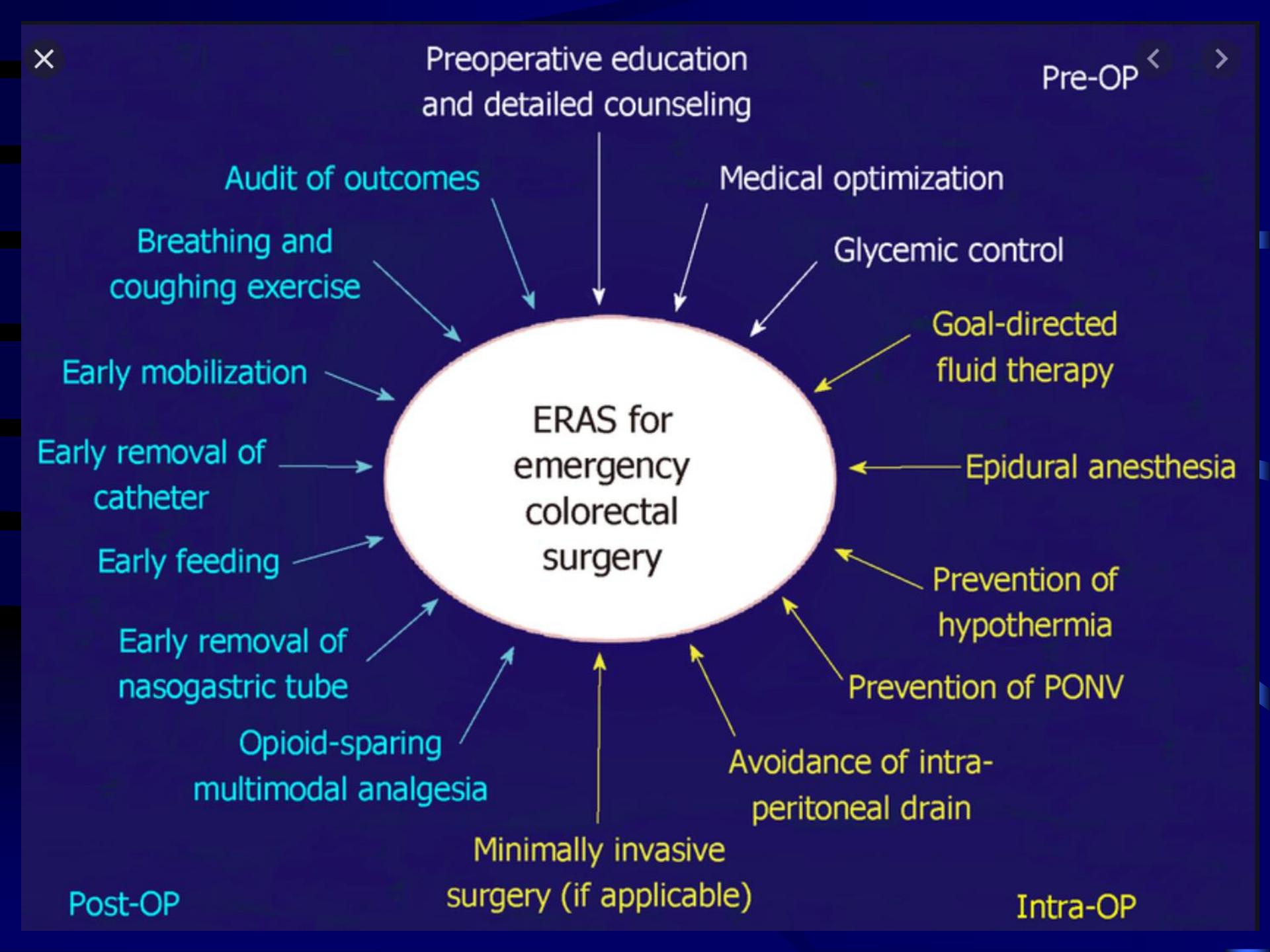
we should replaced volume by volume by normal saline--

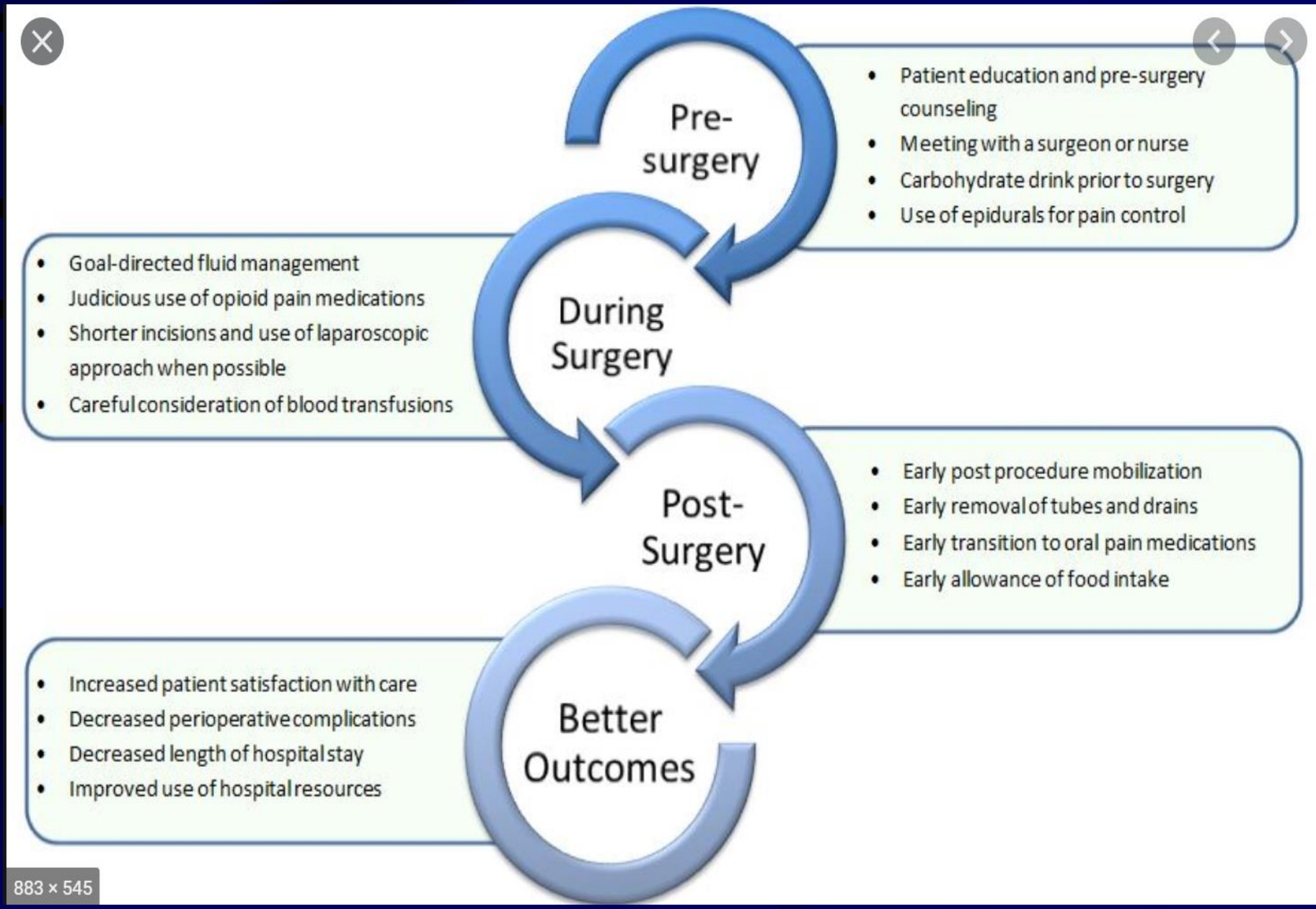
- **Vomiting, diarrhea .**
- **NG tube losses .**
- **Small bowel Fistula .**
- **Ileostomy, Colostomy losses .**
- **Pancreatic ,Biliary fistulae .**

ERAS

- ***Enhanced recovery after surgery (ERAS)*** protocols are multimodal perioperative care pathways designed to achieve early recovery after surgical procedures by maintaining pre-operative organ function and reducing the profound stress response following surgery.
- The key elements of ERAS protocols include preoperative counselling, optimization of nutrition, standardized analgesic and anaesthetic regimens and early mobilization.
- The key principles of the ERAS protocol include pre-operative counselling, preoperative nutrition, avoidance of perioperative fasting and carbohydrate loading up to 2 hours preoperatively, standardized anaesthetic and analgesic regimens (epidural and non-opiod analgesia) and early mobilization.


Mid-thoracic epidural anesthesia/analgesia
No nasogastric tubes
Prevention of nausea and vomiting
Avoidance of salt and water overload
Early removal of catheter
Early oral nutrition
Non-opioid oral analgesia/NSAIDS
Early mobilization
Stimulation of gut motility
Audit of compliance and outcomes
Postoperative
Preoperative
ERAS
Intraoperative
Preadmission counselling
Fluid and carbohydrate loading
No prolonged fasting
No/selective bowel preparation
Antibiotic prophylaxis
Thromboprophylaxis
No premedication
Short-acting anesthetic agents
Mid-thoracic epidural anesthesia/analgesia
No drains
Avoidance of salt and water overload
Maintenance of normothermia (body warmer/warm intravenous fluids)


Preoperative education and detailed counseling
Pre-OP
Audit of outcomes
Medical optimization
Breathing and coughing exercise
Glycemic control
Goal-directed fluid therapy
Early mobilization
ERAS for emergency colorectal surgery
Early removal of catheter
Epidural anesthesia
Early feeding
Prevention of hypothermia
Early removal of nasogastric tube
Prevention of PONV
Opioid-sparing multimodal analgesia
Avoidance of intra-peritoneal drain
Minimally invasive surgery (if applicable)
Post-OP
Intra-OP


Pre-surgery
Patient education and pre-surgery counseling
Meeting with a surgeon or nurse
Carbohydrate drink prior to surgery
Use of epidurals for pain control
During Surgery
Goal-directed fluid management
Judicious use of opioid pain medications
Shorter incisions and use of laparoscopic approach when possible
Careful consideration of blood transfusions
Post-Surgery
Early post procedure mobilization
Early removal of tubes and drains
Early transition to oral pain medications
Early allowance of food intake
Better Outcomes
Increased patient satisfaction with care
Decreased perioperative complications
Decreased length of hospital stay
Improved use of hospital resources

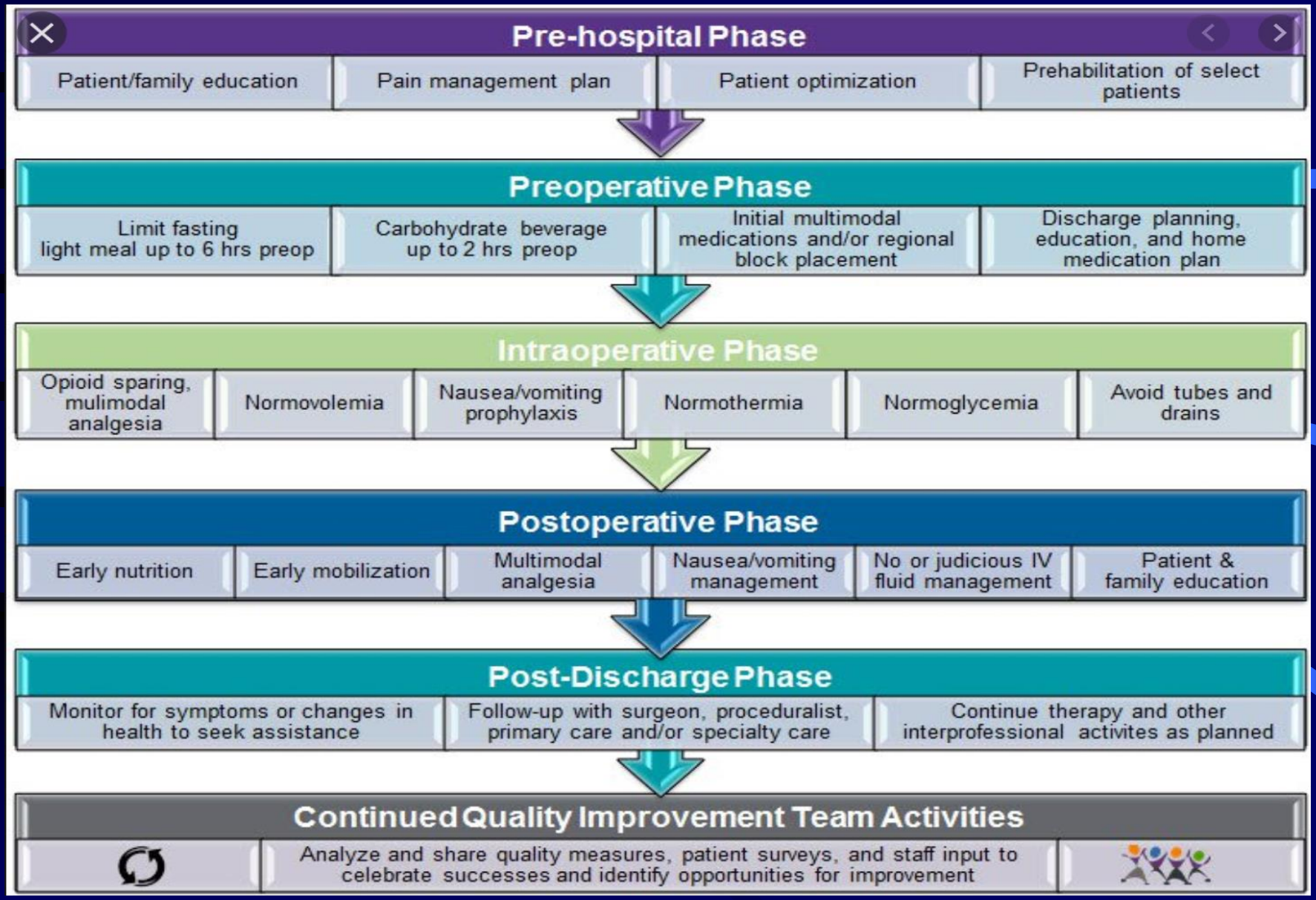
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Enhanced Recovery After Surgery protocols

Preoperative	Intraoperative	Postoperative
Patient counseling and expectations	Minimally invasive surgical approach	NSAIDs, acetaminophen, gabapentin
Avoid mechanical bowel preparation	Local anesthetic or long-acting local (liposomal bupivacaine)	Opioids only for breakthrough pain
Solids up to 6 hours prior to surgery	Keep patient warm	Regular diet within 24 hours
Clear liquids up to 2 hours prior to surgery	Intravenous fluid maintenance	Discontinue intravenous fluids within 24 hours
Consider acetaminophen, celecoxib, pregabalin, or gabapentin prior to surgery	Prophylaxis for nausea and vomiting (at least two classes of medications)	Ambulate within 24 hours
	Toradol (if appropriate)	

Frontline Medical News

Source: Adapted from ERAS Society recommendations


Pre-hospital Phase
Patient/family education
Pain management plan
Patient optimization
Prehabilitation of select patients
Preoperative Phase
Limit fasting light meal up to 6 hrs preop
Carbohydrate beverage up to 2 hrs preop
Initial multimodal medications and/or regional block placement
Discharge planning, education, and home medication plan
Intraoperative Phase
Opioid sparing, mulimodal analgesia
Normovolemia
Nausea/vomiting prophylaxis
Normothermia
Normoglycemia
Avoid tubes and drains
Postoperative Phase
Early nutrition
Early mobilization
Multimodal analgesia
Nausea/vomiting management
No or judicious IV fluid management
Patient & family education
Post-Discharge Phase
Monitor for symptoms or changes in health to seek assistance
Follow-up with surgeon, proceduralist, primary care and/or specialty care
Continue therapy and other interprofessional activites as planned
Continued Quality Improvement Team Activities
Analyze and share quality measures, patient surveys, and staff input to celebrate successes and identify opportunities for improvement

Preoperative	
1	Preoperative education
2	Carbohydrate loading preoperatively and avoidance of prolonged starving
3	Use of preoperative probiotics
4	No mechanical bowel preparation
5	No premedication
6	Pre-emptive analgesia
Intraoperative	
7	Maintenance of normothermia
8	Goal-directed perioperative fluid administration
9	Minimally invasive incision
10	Avoidance of nasogastric tubes and deep vein catheterisation
11	Avoidance of bladder catheters, if necessary early removal of bladder catheters
12	Use of tranexamic acid
13	Periarticular local injection analgesia
Postoperative	
14	Multimodal analgesia: PCA analgesia and NSAIDs; avoidance of opioid analgesia
15	Use of postoperative antiemetic and laxatives
16	Enforced early mobilisation
17	Enforced early postoperative oral feeding

NSAIDs, non-steroidal anti-inflammatory drugs; PCA, patient-controlled analgesia.

An enhanced recovery after surgery for radical cystectomy ± neobladder focusing on reduced bowel preparation and standardized feeding and analgesic regimens

---

Day before radical cystectomy

- Normal breakfast
- Admit to hospital
- Unrestricted clear fluids
- Refer to dietician
- Stoma therapist to see patient
- Assess social circumstances and refer if needed

Day of radical cystectomy

- Clear carbohydrate drinks up to 2 hours before surgery, then nil by mouth
- Restart clear fluids as tolerated when in recovery
- Start food chart
- Epidural analgesia in situ

Day 3 and 4

- Remove epidural on day 3
- Continue to mobilize and encourage self-care
- Light diet as tolerated
- Start planning for discharge

Day 5, 6 and 7

- Dietician to assess nutritional requirements on day 5
- If a patient is not eating or drinking after 5 to 6 days, but with bowel activity, then start nasogastric feeding
- If there is no bowel activity then start total parenteral nutrition

Third space loss

replaced volume by volume by normal saline..

What is third space loss?

Definition : ***Redistribution of fluid to a Site Where It is No longer Considered part of ECF.***

IC و Ec بتتكون حشى

Causes

- Burns, crush syndrome. (تتحرق وبتتسحق عليك — lead to release fluid)
- Ascites, pleural effusion.
- Severe soft tissue infections.
- Intestinal obstruction. (↳ necrotising fascitis)
- Retro- peritoneum. (↳ air fluid level)
- Site of major operative dissection. (↳ in pancreatitis - Aortic Aneurysm)

لما بتكون بالعمليات لذلك بنعطي 700ml-1L بالساعة بالعمليه

Treatment

- Fluids and electrolytes are ***Drugs*** and they need to be used in correct dose and appropriate indication.
- GIT , third space loss should be replaced volume by volume by normal saline.
- Add 10 mmol K^+cl to each liter .
- In ***Shock R L is better than N S*** as it contain less ***cl^-.***
- ***N S is better used in pyloric obstruction*** , alkalosis , Hypochloremia .
- Drinking clear liquids up to 2-3 hours pre op prevent pre-op fluid depletion and does not ↑aspiration related complications .

Electrolyte disorders

severe:- < 120
moderate:- 130 - 120
mild:- 135 - 130

- ***Hyponatremia :*** Na level less than 135 mmol /L. (in Blood.)

The causes of ↓Na depend on Serum osmolality → Hypotonic... / Hypertonic... / isotonic...
normally:- 275 - 290 mosm./L

- ***Hypertonic Hyponatremia***

High glucose, or High BUN.

glucose ↑ بزيادة 100 mg يكون
2.5 mmole ← Na+ ↓ تقديم

- ***Hypotonic Hyponatremia.*** commonest cause of Hyponatremia → Hyper volumic / Hypo volumic / iso volumic

Renal, or GIT losses replaced by hypotonic fluids.

* liver failure - cirrhosis - Renal failure - cardia failure - nephrotic Syndrome → Hyper volemic
* GIT losses → Hypovolemic * SIADH → isovolemic

- ***Isotonic Hyponatremia*** called pseudo hyper natremia → lab error غالباً يكون

Hyperproteinemia, hyperlipidemia .

Hypotonic Hyponatremia

I. ***Hypervolemic*** → organs failure...

II. ***Iso - volomic (para-neoplastic syndrome) SIADH*** (↓ urine output)

- **Early Post operative period(Stress, Narcotics , NSIDS, *Pain*,Volume depletion,(ciprofloxacin).**
- **Lung neoplasms, infections.**
- **Trauma, Head injuries.**
- **Hypothyroid.**
- **Excess water intake.**

III. ***Hypovolemic:*** ***Renal, GIT loss ,skin, third space loss.***

(commonest; has ↑ renal Na^+ [in urine]; has ↓ renal Na^+ [in urine])

Symptoms and signs

↓ osmolality ← ↓ osmolality في حيز [water] fluid ← ..cells في water في ↑ osmolality ← ↓ osmolality
[↑ solute] ← [↓ solute]

- Increased intracranial pressure.
  ↳ due to Brain edema [the water enter in Brain cells]
- Muscle twitches, convulsions. - headache.
- Hypertension +? Bradycardia. ↓ Heart rate
- Salivation , lacrimation, Diarrhea.
- Oliguria.

Hyponatremia

- **Hyponatremia is usually associated with hypo osmolality.**

- **P_{osm} = 2x (Na)+ urea/ 2.8+glucose /18**

- ***Plasma osmolality :*** **275-290 m O sm/kg H_2O.**
- ***Urine osmolality:*** **100-1200 m O sm/kg H_2O.**

- **Urinary Na < 10 mmol / L OR > 20 mmol/L.**

Treatment of Hyponatremia

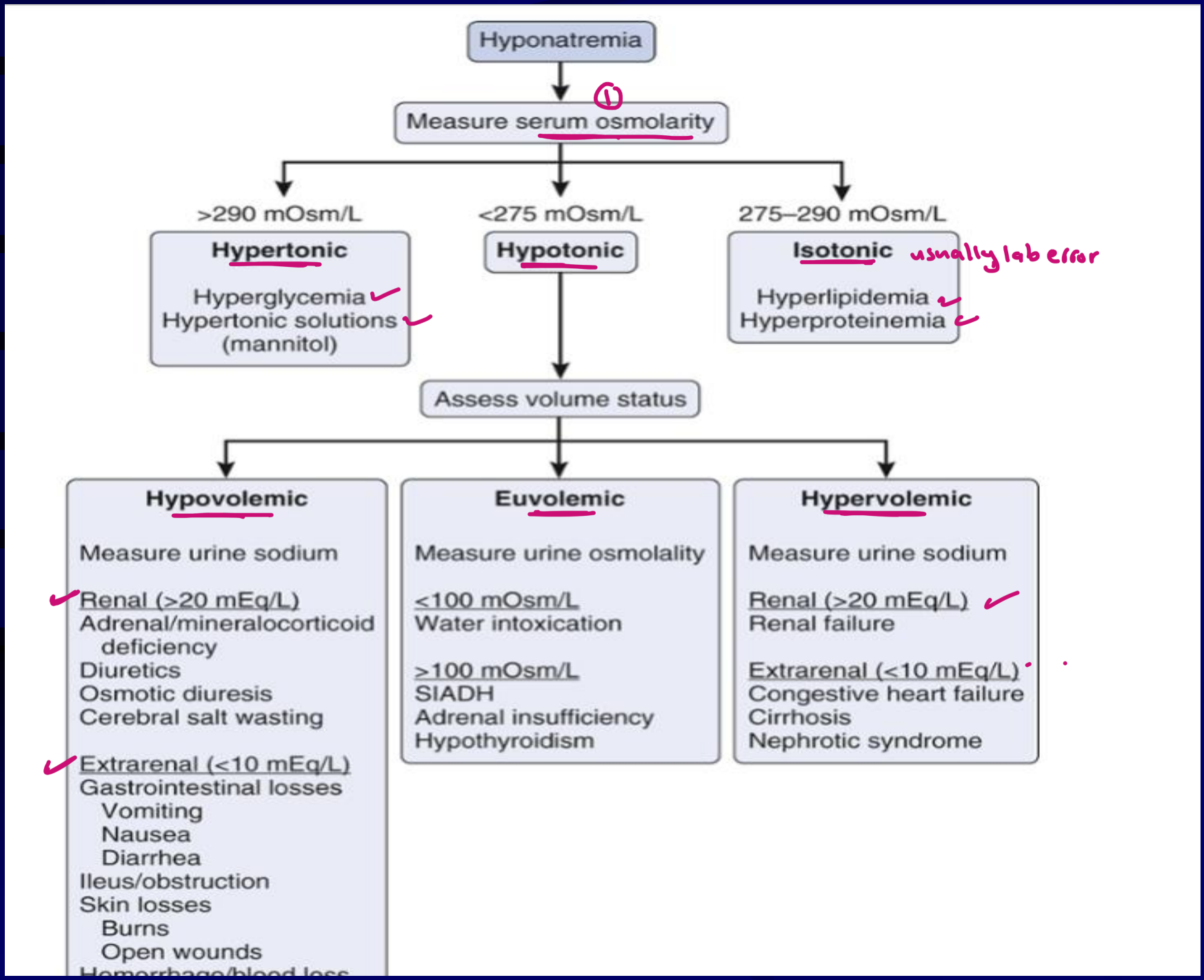
- Treat underlying causes.
- Alleviate symptoms of Hyponatremia.
  - ↑ Na^+ level
- Avoid correcting Hyponatremia too quick.
  - to avoid the central pontine demylination injury ..etc

Continue

- Na deficit = (140-patient Na) x 0.6 x weight.
- Correct half over 24h .
- Don't correct more than 8mmol /day.
- Use 3% Na , or normal saline . [Not use P. salim - half salim]

each 1L of 3% Na+ has 500 mmol of Na+

0.9% NaCl..
each 1L of NS has 154 mmol of Na+


Hyponatremia
1
Measure serum osmolarity
>290 mOsm/L
<275 mOsm/L
275–290 mOsm/L
Hypertonic
Hyperglycemia
Hypertonic solutions (mannitol)
Hypotonic
Isotonic
usually lab error
Hyperlipidemia
Hyperproteinemia
Assess volume status
Hypovolemic
Measure urine sodium
Renal (>20 mEq/L)
Adrenal/mineralocorticoid deficiency
Diuretics
Osmotic diuresis
Cerebral salt wasting
Extrarenal (<10 mEq/L)
Gastrointestinal losses
Vomiting
Nausea
Diarrhea
Ileus/obstruction
Skin losses
Burns
Open wounds
Euvolemic
Measure urine osmolality
<100 mOsm/L
Water intoxication
>100 mOsm/L
SIADH
Adrenal insufficiency
Hypothyroidism
Hypervolemic
Measure urine sodium
Renal (>20 mEq/L)
Renal failure
Extrarenal (<10 mEq/L)
Congestive heart failure
Cirrhosis
Nephrotic syndrome

*GIT loss may lead to Hypo or Hyper natremia..
(if the pt lost H2O > electrolyte
if the electrolyte loss > H2O loss..

Hypernatremia

- ***Na level more than146 mmol /L.***
- ***Always in Hypertonic State*** **(Hypo, Iso, Hypervolemia)**

- **Exercise, Sweating.**
- ***NG suction,vomiting,diarrhea.***
- **Osmotic Diuresis.** (↑urination)
- **Burns, large open wounds.**
- **Excess hypertonic fluids.**
- **Cushing syndrome .**
- **Peritonitis .**

Hypernatremia

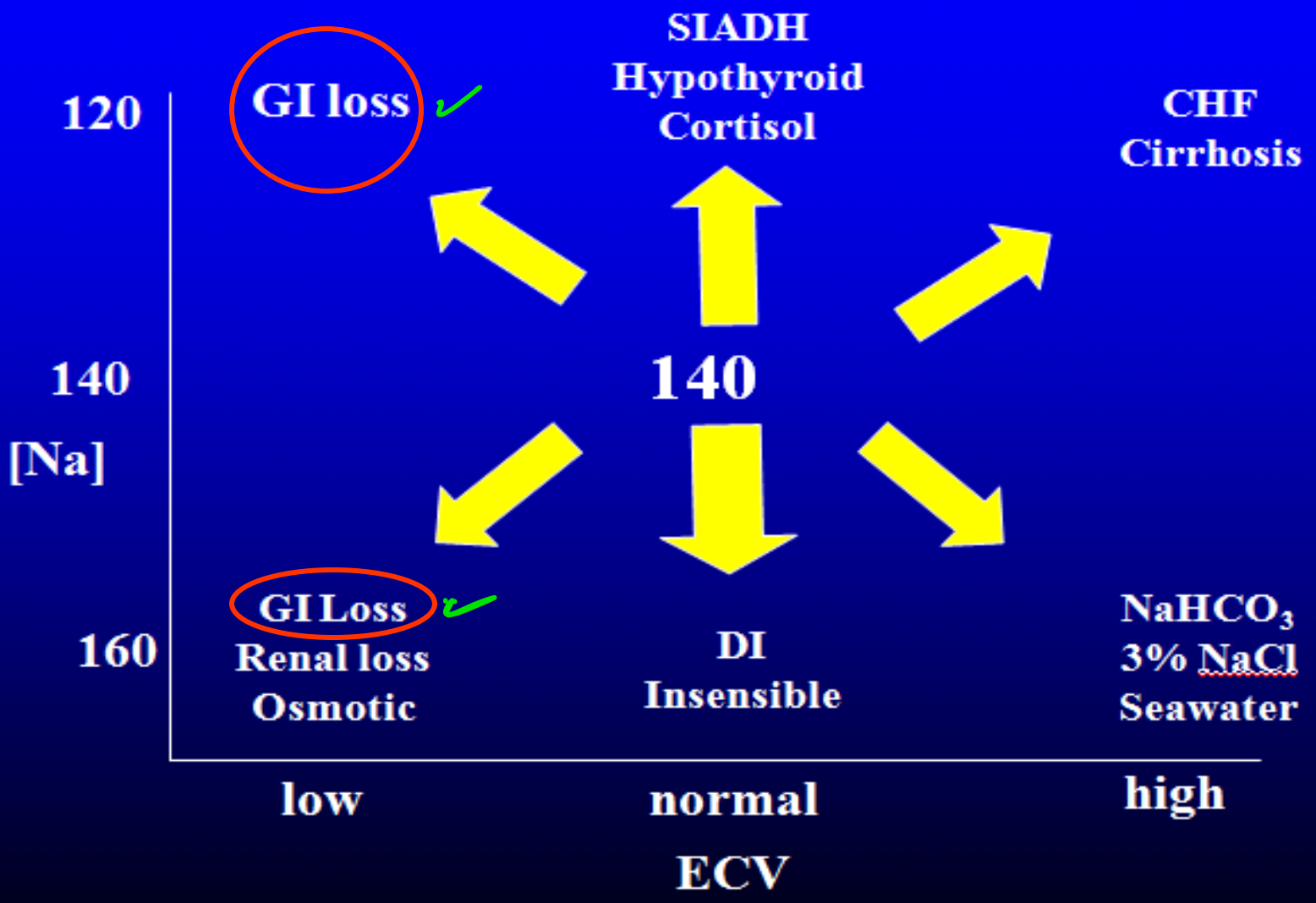
Symptoms and signs due to shrinking of Brain [↑osmolality of the serum so H2o reach the EC space from IC].
IC → EC..

- Restlessness, weakness.
- Tachycardia, hypotension.
- Dry sticky mucous membranes.
- Oliguria, Decrease Saliva and Tears.
- Fever, red swollen tongue.
- H_2O deficit = 0.6 x weight x (serumNa-140) ÷140

✦ Give hypotonic fluids.

✦ Don't correct rapidly.
↳ to avoid the Brain edema..

Fluid Status



Potassium Abnormalities

- K^+ requirement is *60* mmol per day.
  - 0.5-1 mmol / Kg
  - maintinance
- 90% K^+ is excreted in urine.
- Kidney can decrease secretion to 10-20 mmol /day.
  - Can't preserve 100% of k^+ [urine $K^+ \neq$ zero]
  - but may preserve 100% of Na^+ [urine Na^+ = zero in GI losses]
- 98% of K^+ is located intracellulary.
- Acid –base changes affect K^+ levels .
- Hypokalemia leads to Hypo Magnesemia .
  - or Both happen together..

Hypokalemia

Serum K^+ less than 3.5 mmol /liter.

Occur in 20% of Hospitalized patients.

Causes

- **Increase renal excretion.**
- **GIT losses (NG tube diarrhea , ZE syndrome , Villous Adenoma , Malabsorption , Ostomy losses) .**
- **Movement of K to cell *(Alkalosis)* .**
- **Decrease K administration , Insulin administration .**
- **Diuretics ,TPN.**
- **Increase catecholamine.**
- **Hypo-Magnesemia .**

(lead to hypokalemia and hypoproteinemia

↳ in lower 1/3 of rectum

↳ the SB content has : 20 mmol/L K^+

to prevent loss it in urine...

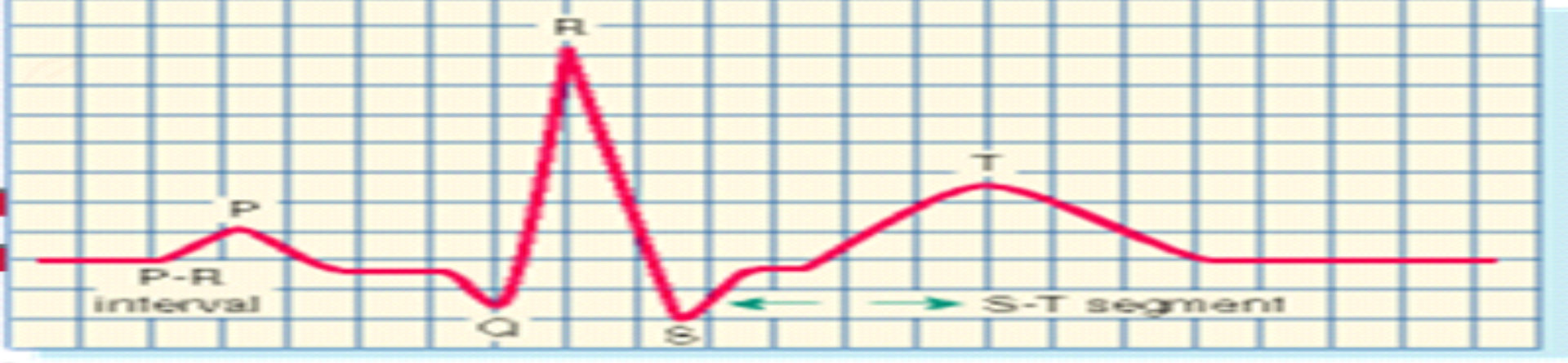
↳ No H^+ in ECF so lead to move the H^+ outside and K^+ inside the cells

(so when we give laxics we should give with it K^+)

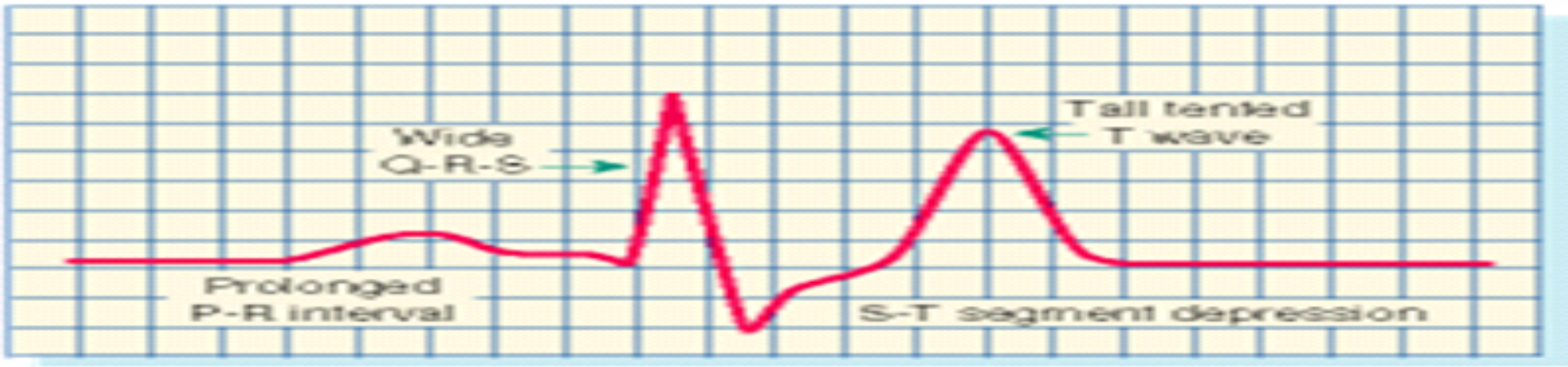
Continue

- Renal excretion occur in *Alkalosis.*
- Hypokalemia produce Alkalosis.
- *It cause muscle weakness, myalgia Absent tendon reflexes ,Paralytic Ileus.*
- ECG changes, Absent T wave, U Wave, Depressed ST segment, prolonged QT interval, Atrial arrhythmias.

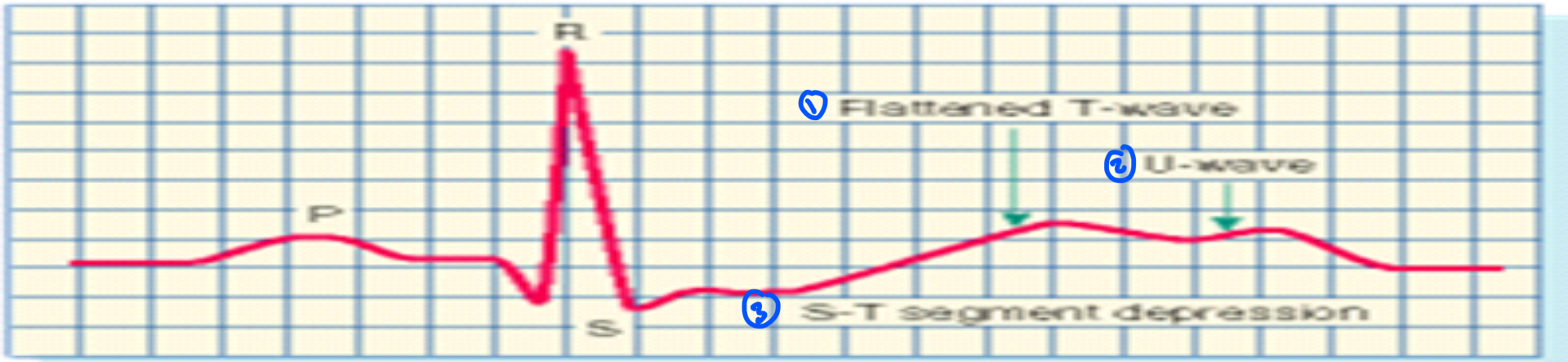
*The Hyperkalemia changes in the ECG → Peaked [tall] T wave [early]...
Prolonged QRS complex...


R
P
T
P-R
interval
Q
S
S-T segment

A


Wide
Q-R-S
Tall tented
T wave
Prolonged
P-R interval
S-T segment depression

B


R
1 Flattened T-wave
2 U-wave
P
3 S-T segment depression
S

Treatment

- K^+ tablets 20 mmol as chloride, citrate.
- IV K^+ for severe forms.
  ↳ infusion.
- Good urine output before K^+ administration.
- ***Don't give more than 20 mmol K^+ / hr.***

20 mmol/Hr ممكن نعطي ICU فقط بال
10 mmol/H وكلش في الضغط وصابيح وتعطي اكثر منه

[So max we can give 20 mmol/day K^+]...
in each L has 40 mmol K^+

- ***Don't give*** more than 40 mmol K^+ / L in peripheral vein.

to prevent the thrombophibitis and vein occlusion...
[if we want to give more than 120 mmol/day we should put central line]...
peripheral بيعطي

Hyperkalemia

Serum K^+ level more than 5.5 mmol /L .

Causes

- Renal failure.
- Crush syndrome (Rhabdomyolysis). (the cell destroyed and the K^+ go out...)
- Redistribution in acidosis.
- Hemolysis , thrombocytosis , leukocytosis.
- Blood Transfusion. (plt > 600000 or 700000 lead to ↑ K^+) (WBC > 100000 → ↑ K^+) (especially if it old Blood so we preferred the fresh Blood → fresh Blood unit has 3.5 mmol/L but old unit [before 28 day for ex] has 30 mmol/L K^+...)
- Succinylcholine. (muscle relaxant)
- Reperfusion injury.
- Pseudo hyperkalemia.

CONTINUE

- ECG changes tall peaked T wave, wide QRS, depressed ST segment Shortened QT interval.
- Ventricular arrhythmias.
- GIT symptoms nausea and vomiting, diarrhea.

Treatment

- Ca gluconate 10 ml 10% over 10 minutes

Act immediate last 15 minutes

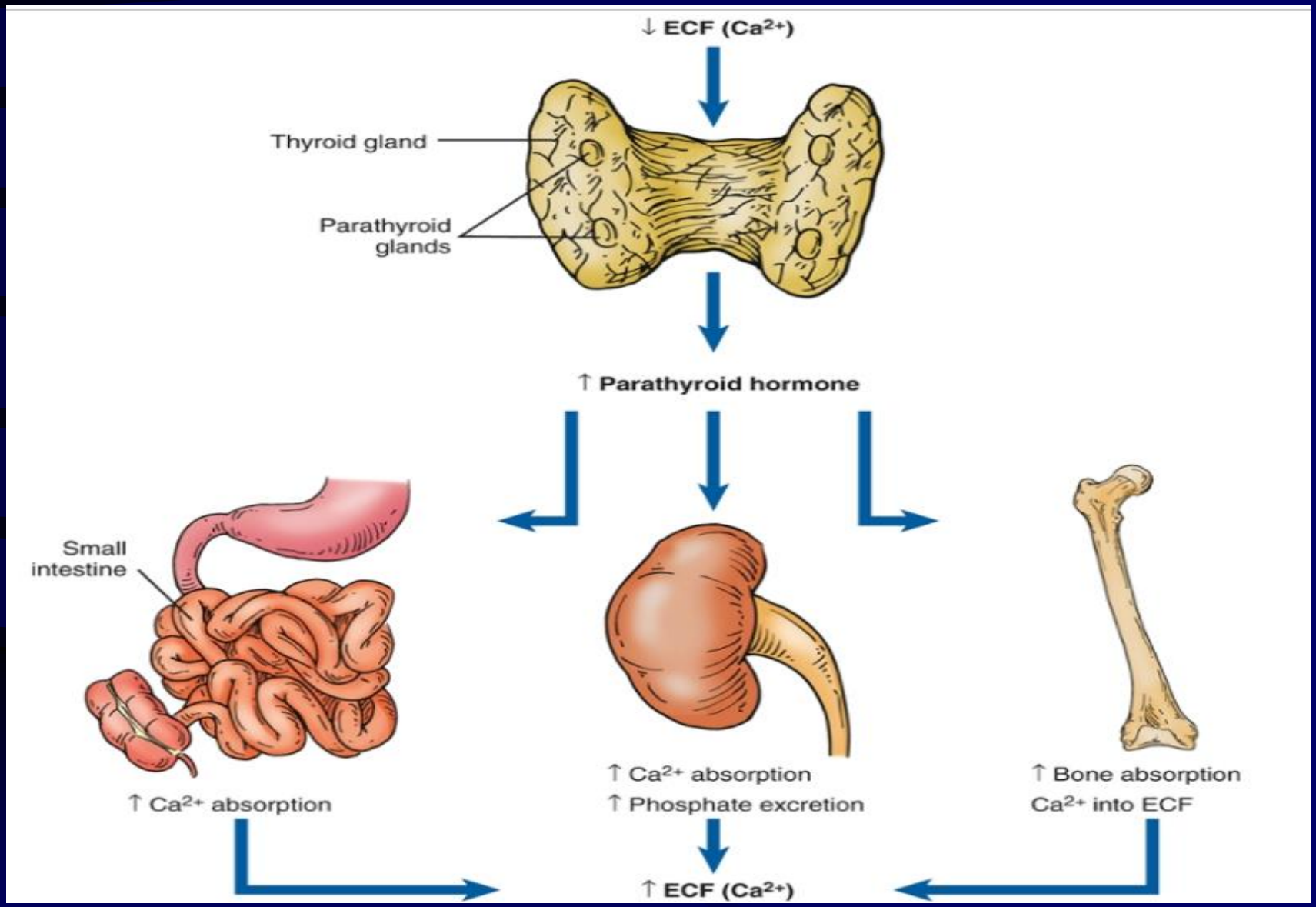
- Glucose 50 gm+10 unit regular insulin

Acts in 10-20 minutes last 2-3 hours

- Kayexalate (Na-K exchange resin) 40gm,orally, or 100 gm enema.
- Loop diuretics furosemide , ethacrynic acid.
- NaHco3 0ne ampule 50 mmol over 5 minutes.

Calcium balance

- **99% of calcium is present in bone, 1% ECF.**
- **Ca^{++} metabolism need *Bone , Bowel and , kidney.* regulations, and PTH and vitamin D.**
- **Ca^{++} is 40% protein bound ,45% ionized form, 15% complex form (phosphate and citrate).**


↓ ECF (Ca^{2+})
Thyroid gland
Parathyroid glands
↑ Parathyroid hormone
Small intestine
↑ Ca^{2+} absorption
↑ Ca^{2+} absorption
↑ Phosphate excretion
↑ Bone absorption
Ca^{2+} into ECF
↑ ECF (Ca^{2+})

Hypocalcemia

Definition

Serum Ca^{++} less than 8.4mg/dl.

Ionized form less than 4.5ml/dl.

Corrected Ca^{++} = Measured Ca^{++} + 0.8(4 -albumin)

Causes of hypocalcemia

- ***Impaired PTH secretion or action.***

Thyroid and parathyroid surgery

- ***Impaired vitamin D synthesis or action***

Liver disease, malabsorption syndrome

- **Ca chelating agents.**
- **Acute pancreatitis, burns and sepsis.**
- **End stage renal failure.**
- **Hypomagnesaemia , hyperphosphatemia.**
- **Massive blood transfusion, and large volume of resuscitation fluids.**

Symptoms and signs

- Acral , perioral numbness, and Paresthesia
- Muscle cramps , seizures , laryngeal spasm , tetany.
- Carpo-pedal spasm (Trousseau's sign).
- Facial twitches (Chvostek's sign).
- ECG changes long QT interval arrhythmias.
- Bradycardia and hypotension.



Chvostek sign



Trousseau sign

Treatment

- Treatment of underlying cause.
- Calcium and vitamin D replacement.
- Treat Hypomagnesaemia , hyperphosphatemia.
- Ca gluconate 10% 10ml IV or, Ca chloride Iv slowly as bolus over 10 minutes, followed by 1mg/kg/hour.
- Oral elemental Ca carbonate 500-1000mg tds, with meals
- Vitamin D3, 0.25-0.5ug Bid.
- Ca chloride contain three times more Ca gluconate.
- Ca chloride lead to thrombophlebitis and skin necrosis.

Hypercalcaemia

- ***Definition***
- **Serum Ca more than10.4 mg/dl**
- **Ionized calcium more than 5.6mg/dl**
- ***Causes***
- **Metastatic bone tumors**
- **Hyperparathyroidism(adenoma , hyperplasia)**
- **Hyper-vitaminosis D**
- **Drugs.**
- **Milk alkali syndrome, hyperthyroidism.**
- **Prolonged Immobilization in bed.**

Symptoms and signs

- Weakness , fatigue , lethargy , psychosis.
- Nausea , vomiting , constipation
- Renal stones , nephron-calcinosis
- Polyuria
- PUD.
- Pancreatitis
- ECG changes short QT interval , arrhythmias

Hypercalcemia / Hyperparathyroidism Signs

Mnemonic: "Bones, Stones, Groans, Moans"

knowmedge

Painful Bones	Painful bone condition (Classically osteitis fibrosa cystica)
Renal Stones	Kidney Stones (Can ultimately lead to Renal failure)
Abdominal Groans	GI symptoms: Nausea, Vomiting, Constipation, Indigestion
Psychiatric Moans	Effects on nervous system: lethargy, fatigue, memory loss, psychosis, depression

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Treatment

- **Treatment of underlying cause.**
- **Expanding the intravascular volume by *normal saline*, reduce Ca by 30%.**
- ***Furosemide (lasix)* to increase renal excretion**
- ***Bisphosphonates* decrease osteoclastic activity**

Acts after 48 h for 1-2 weeks

- ***Calcitonin* reduce bone resorbtion, decrease ca reabsorption by tubules, acts within 6-9 h , for one w**
- ***Glucocorticoids* inhibit action of vitamin D**

Magnesium balance

- Normal range 1.5mEq/l .
- 2nd most common intracellular cation after K.
- Found in bone and muscle.
- Extracellular mg is 1%.
- Important for Ca , K homeostasis.
- Essential for protein synthesis, neuromuscular excitability and many enzymatic reactions energy metabolism.

Hypomagnesaemia

Less than 1.6 mg/dl

Causes

- Prolonged IV fluid therapy.
- TPN
- Prolonged GIT,and renal losses.
- Acute pancreatitis.
- Redistribution
- Diuretics
- Alcoholics

Symptoms and signs

- Muscle weakness, paresthesia ,spasm, seizures.
- Anorexia nausea and vomiting , dysphagia.
- Hyperactive tendon reflexes.
- Cardiac arrhythmias
- Delirium, coma.
- $^{+}$Ve Chvosteks', and Trousseaus' signs.

Treatment

- Treat underlying cause.
- Correct hypovolemic first.
- Correct associated Hypokalemia *(Common Together).*
- ***Mg sulphate*** 0.5mEq/kg/ day continuous infusion .
- Don't exceed 16 mEq/hour,1gm = 8mEq.
- Maintenance 10-20 mEq/day of 50% mg sulphate
- In emergency 2gm in 5 minutes

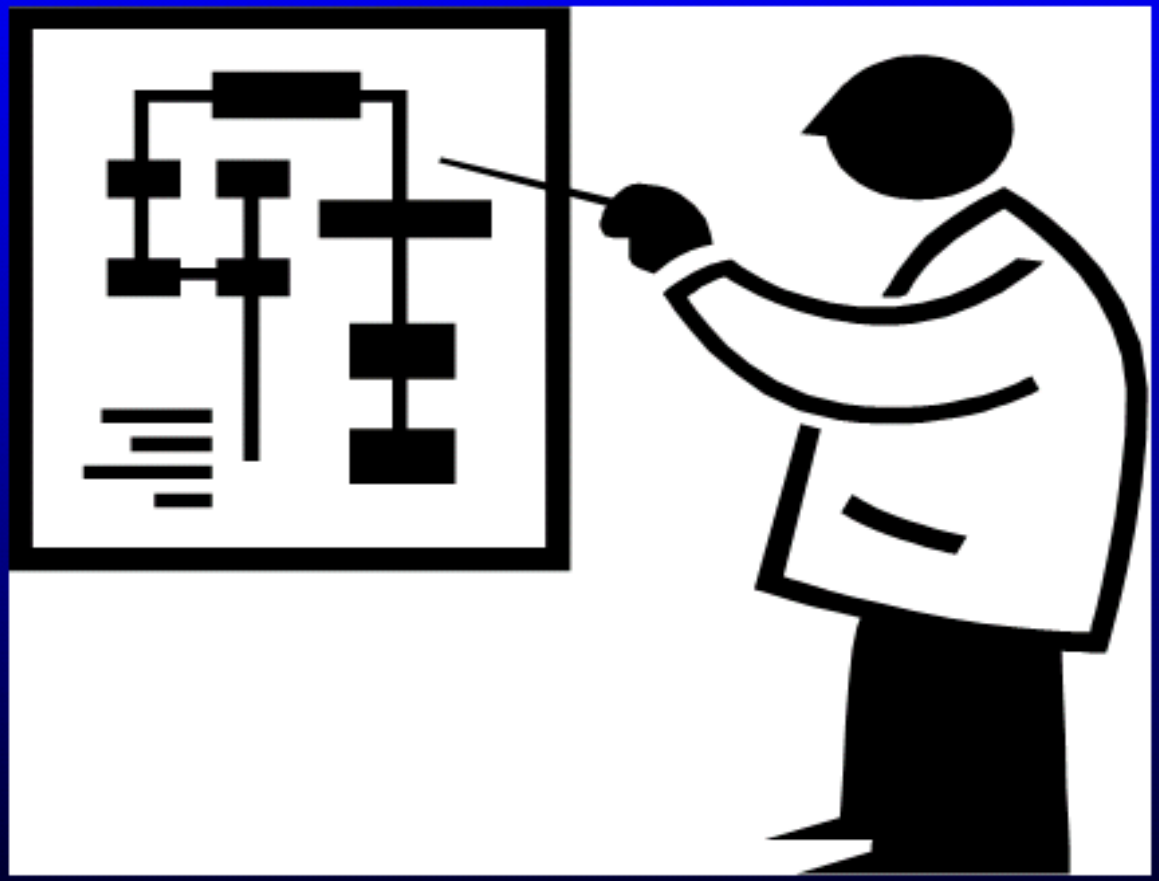
Hypermagnesiemia

- Serum level above 2.5 mg/dl
- Mainly in renal failure,rhabdomyolysis.
- Excessive antiacids,laxatives.
- Lethargy, facial paresthesia,nausea.
- Weakness, loss of tendon reflexes, hypotension
- ECG changes, prolonged PR interval
- Hydration normal saline
- Ca gluconate , Loop diuretics

Questions?



Case Studies



"Found Down"

- 45 yo WM, found down, presumed to be assaulted, hypertensive,bradycardia
- CT head - hygromas, small ICH
- labs:
  - Na = 118
  - K = 2.4
  - Cl = 74

What do you think? What do you do?

Severe Hyponatremia

- Correct sodium to above 120 mEq/dl
  - NaCl + 40 mEq/L KCl
  - 3% Saline
  - furosemide diuresis (euvolemic)
  - serial electrolytes
  - be prepared to handle seizures
- Replace potassium
- Cl should correct itself

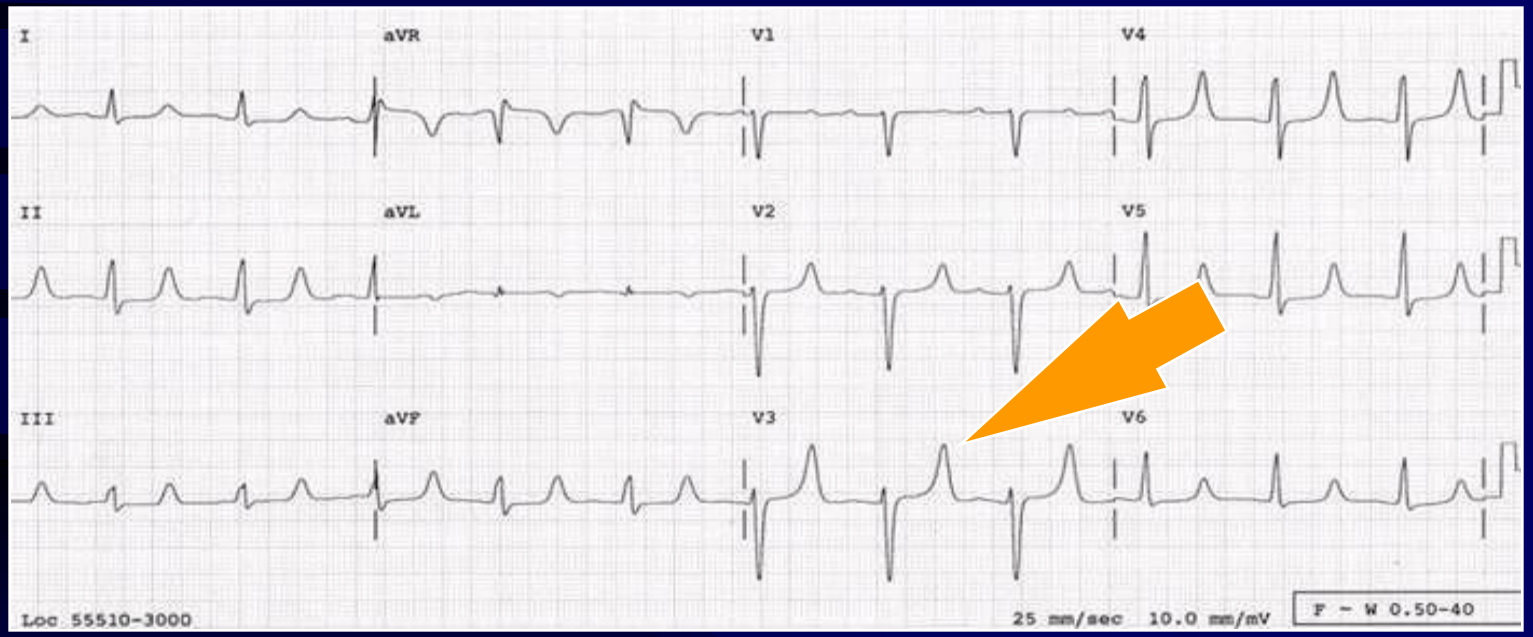
HDU Code

A Code Blue is called in the HDU.

65 yo male with ESRD has "arrested" awaiting his dialysis treatment. CPR and BVM resuscitation are in progress and an IV has been established.

What do you think? What do you do?

Pre-Arrest Rhythm Strip



HYPERKALEMIA

Treatment

- $CaCl_2$ 10% - 1 ampule
- Sodium Bicarbonate - 1 ampule
- D_{50} & Insulin 10 U
- β_2 - agonist nebulizer- cellular K ↑
- Kayexalate

Post op patient

- **42 year old female admitted to the ICU post op after undergoing a thyroidectomy for thyroid cancer.**

- **She is complaining of peri-oral numbness and tingling. Her DTRs are hyperactive and her ECG has a prolonged QT interval.**

What do you think? What do you do?

HYPOCALCEMIA

- **Treatment**
  - monitor ECG
  - IV calcium
  - follow up labs
  - oral calcium supplements
    - normal is 1 gram/day

ACUTE ADRENAL INSUFFICIENCY

- fluid and vasopressor support
- treat precipitating conditions
- draw baseline Cortisol level
- administer dexamethasone
- ACTH stimulation test
- hydrocortisone 100 mg IV q 8°

Diarrhea Dysrhythmia

- **68 yo female on digoxin for chronic CHF, presents to the SIU for colitis as evidenced by copious diarrhea.**

- **The patient is weak and lethargic and ectopic beats are noted on her ECG.**

What do you think? What do you do?

Hypokalemia

- **Deficits**
  - **Serum K =**
    - **3-4 is a 100-200 mEq deficit**
    - **2-3 is a 200-400 mEq deficit**
  - **replacement 10 mEq/hr via peripheral IV**
  - **10 mEq α 0.1 mEq/L increase in serum K**
  - **Remember to check the Mg level too**

Cancer

- **72 yo female with stage 4, metastatic breast cancer.**
- **Patient is confused, cachetic, and nauseated**
- **Na^{+}= 147, Ca^{+2} = 14mg/dl**

What do you think? What do you do?

HYPERCALCEMIA

- Cancers associated
- with hypercalcemia
  - bone
  - breast
  - kidney
  - lung
  - thyroid
  - multiple melanoma
  - prostate

- Treatment
  - hydration
  - diuretics-lasix
  - mithramycin
  - corticosteroids
  - calcitonin-osteoclast resorption
  - phosphate