

## **Fluid and electrolyte balance**

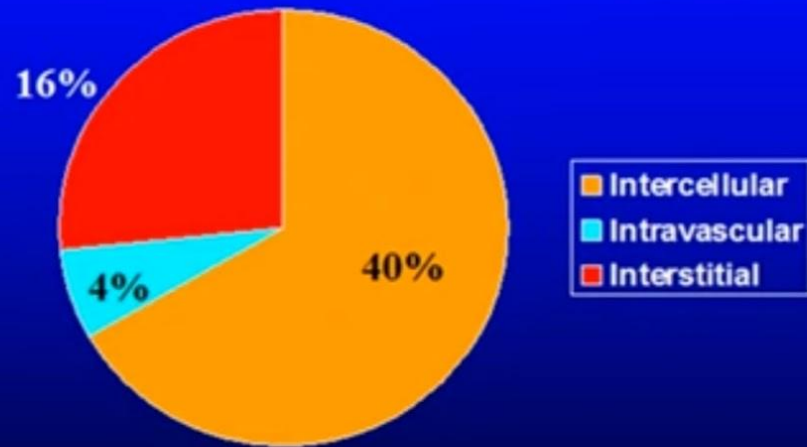
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## Fluid and electrolyte balance

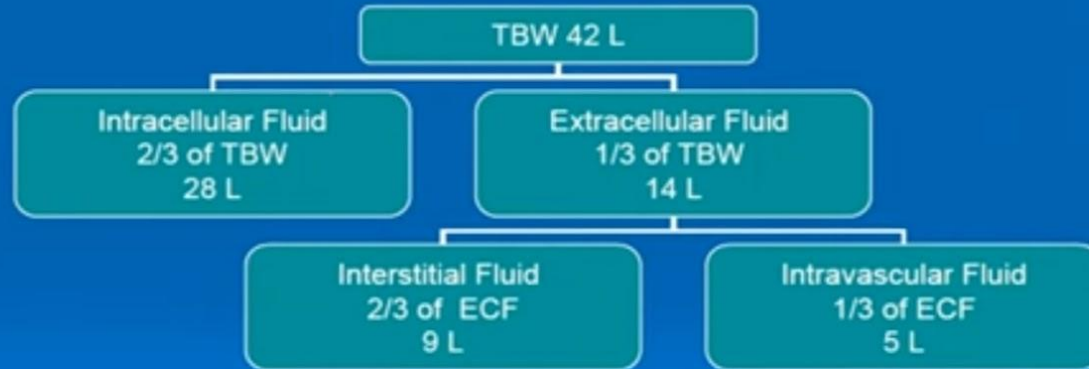
- Total body water is 60% of body weight.
- TBW is 42 liters in 70kg man , 35L in female .
- Intracellular water 2/3 the TBW 28 L.
- Extracellular water 1/3 TBW 14L divided into
  - ◆ Intravascular( plasma) 4.5%
  - ◆ Interstitial fluid 14%
  - ◆ Transcellular fluid 1.5%

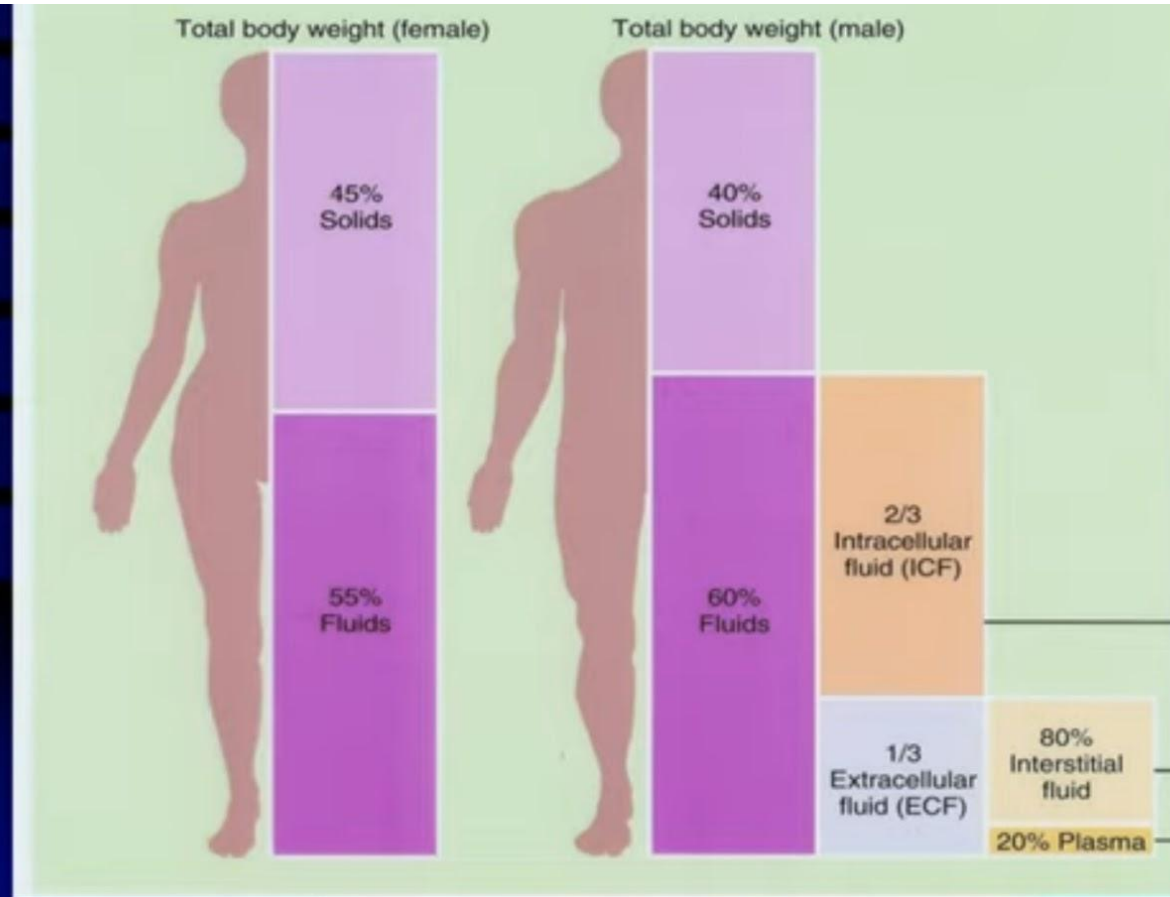
# Body Fluids

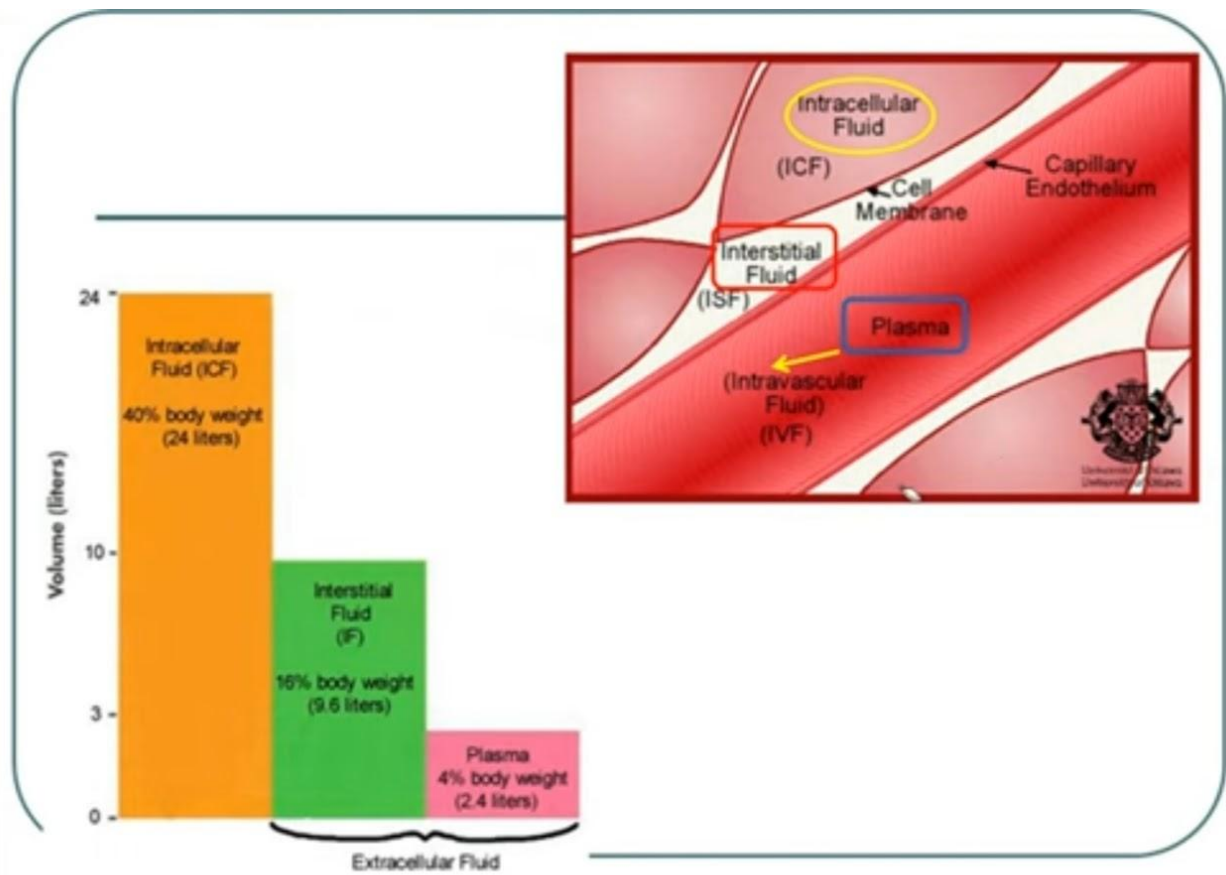


Body Water = 60% of a patient's body weight

# Fluid Compartments

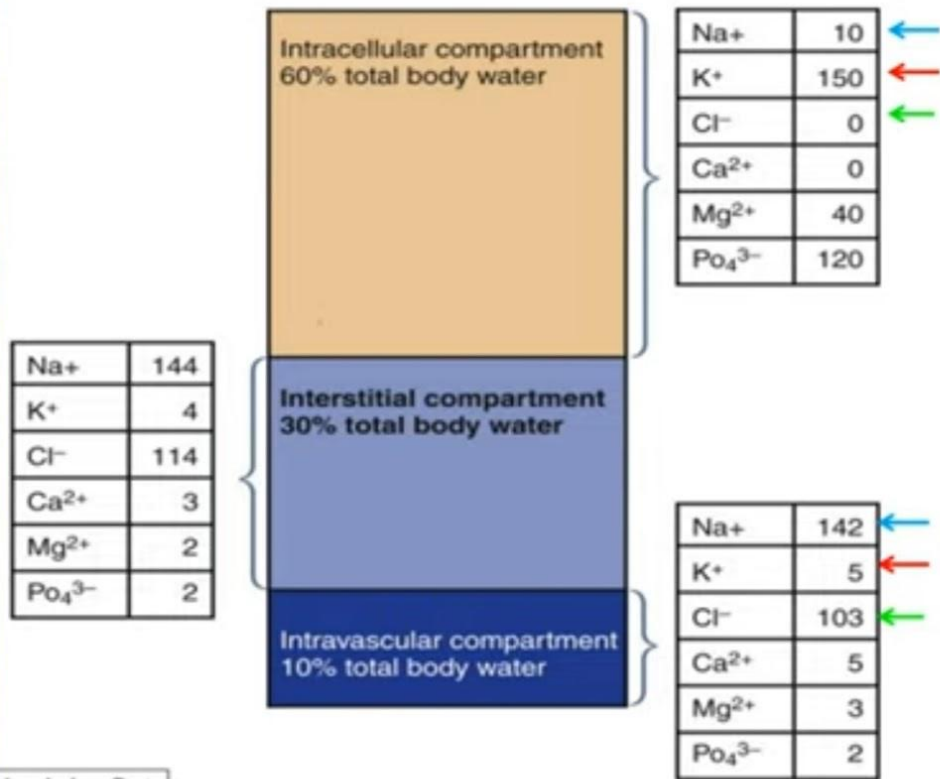


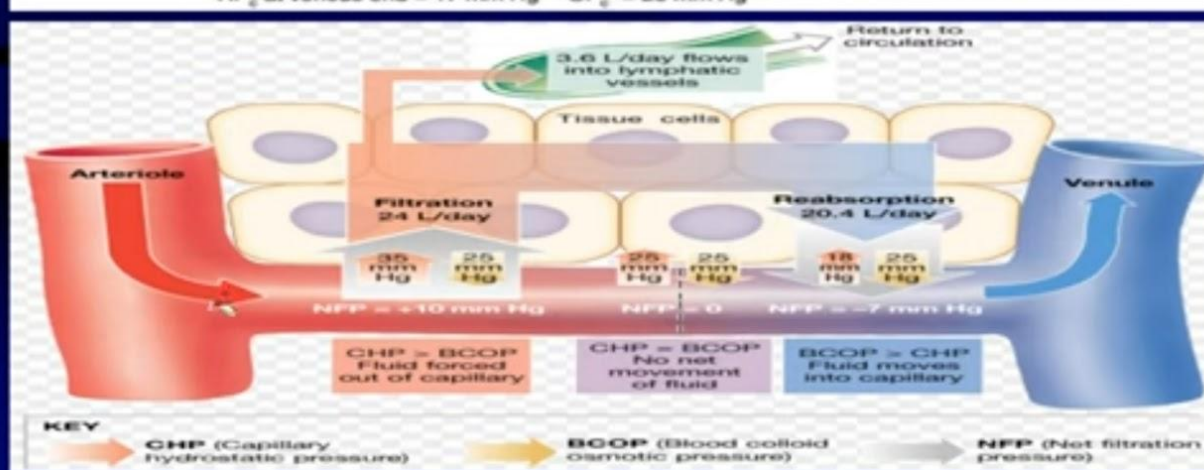
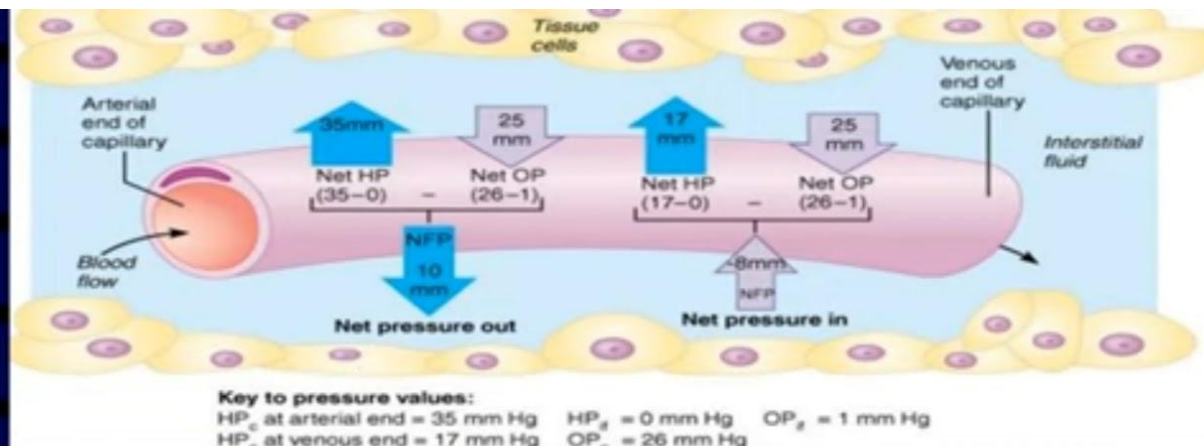




**Total body water in 70 KG MAN**  
**60%**

|                           |                  |               |
|---------------------------|------------------|---------------|
| <b>Plasma</b>             | <b>3.500 ML</b>  | <b>5- 8 %</b> |
| <b>Interstitial fluid</b> | <b>10.500 ML</b> | <b>15 %</b>   |
| <b>Intracellular</b>      | <b>28.000 ML</b> | <b>40%</b>    |





## Chemical composition of body fluids

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

## 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  | 154 | -  | 154 | -    | -  |
| P saline  | 30  | -  | 30  | -    | -  |
| NG tube   | 70  | 10 | 103 | -    | -  |

### Composition of gastrointestinal secretions

| Type of secretion | Volume | Na <sup>+</sup> | K <sup>+</sup> | Cl <sup>-</sup> | Hco <sub>3</sub> |
|-------------------|--------|-----------------|----------------|-----------------|------------------|
| Salivary          | 1000   | 30              | 26             | 70              | 30               |
| Stomach           | 2000   | 80              | 10             | 100             | 0                |
| Small bowel       | 3000   | 140             | 20             | 104             | 0                |
| Bile              | 1000   | 140             | 5              | 100             | 35               |
| Pancreas          | 1000   | 140             | 5              | 70              | 115              |
| R lactate         | 1000   | 130             | 4              | 109             | 28               |

## Maintenance fluid

### ◆ Sensible loss

- Urine 1500 - 2000 ml day.
- Feces 300 ml day.

### ◆ Insensible loss

- Skin 500 ml .
- Lung 300 ml .
- Oxidation of fat + 100 ml .
- 100-200 ml loss per degree rise of temperature, 10 % of insensible loss per °C .
- During laparotomy insensible losses reach 700-1000 ml/H

(10-12 mL/Kg/day)

## 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

- Na : 1-2 mmol /Kg /day
- K : 0.5 -1 mmol/Kg / day
- 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

|                                    | Crystalliod | Colloid         |
|------------------------------------|-------------|-----------------|
| 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

### Symptom and signs of ECF deficit

- CNS: Apathy , confusion, stupor.
- GIT: Nausea ,vomiting, ileus excessive thirst .
- Cardiovascular: Tachycardia , hypotension .
- Tissue: Sunken eyes, decrease skin turgor.
- Metabolic: Hypothermia.
- Biochemical: ↑ Hematocrit , BUN , Creatinine .

## Losses from GIT

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

## Third space loss

### What is third space loss?

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

#### Causes

- ◆ Burns, crush syndrome.
- ◆ Ascites, pleural effusion.
- ◆ Severe soft tissue infections.
- ◆ Intestinal obstruction.
- ◆ Retro- peritoneum.
- ◆ Site of major operative dissection.

## 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 Kcl to each liter .
- In Shock R L is better than NS as it contain less  $\text{Cl}^-$ .
- 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

■ **Hyponatremia** : Na level less than 135 mmol /L.

■ **Hypertonic Hyponatremia**

High glucose, or high BUN.

■ **Hypotonic Hyponatremia.**

Renal, or GIT losses replaced by hypotonic fluids.

■ **Isotonic Hyponatremia**

Hyperproteinemia, hyperlipidemia.

## Hypotonic Hyponatremia

### I. Hypervolemic

### II. Isovolemic (paraneoplastic syndrome)

#### SIADH

- 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.

## Symptoms and signs

- Increased intracranial pressure.
- Muscle twitches, convulsions.
- Hypertension +? Bradycardia.
- Salivation , lacrimation, Diarrhea.
- Oliguria.

# Hyponatremia

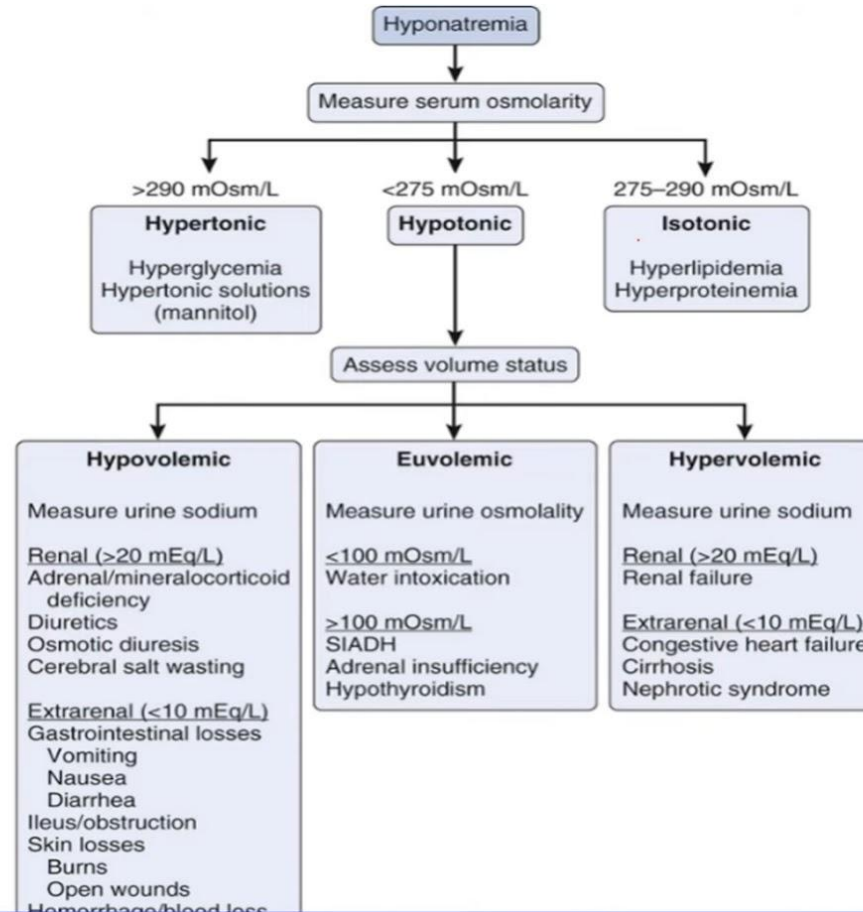
- Hyponatremia is usually associated with hypo osmolality.
- $P_{osm} = 2 \times (Na) + \text{urea} / 2.8 + \text{glucose} / 18$
- Plasma osmolality : 275-290 m O sm/kg H<sub>2</sub>O
- Urine osmolality: 100-1200 m O sm/kg H<sub>2</sub>O
- Urinary Na < 10 mmol / L OR > 20 mmol/L.

## **Treatment of Hyponatremia**

- **Treat underlying causes.**
- **Alleviate symptoms of Hyponatremia.**
- **Avoid correcting Hyponatremia too quick.**

*Continue*

- **Na deficit =  $(140 - \text{patient Na}) \times 0.6 \times \text{weight}$ .**
- **Correct half over 24h .**
- **Don't correct more than 8mmol /day.**
- **Use 3% Na , or normal saline .**



## Hypernatremia

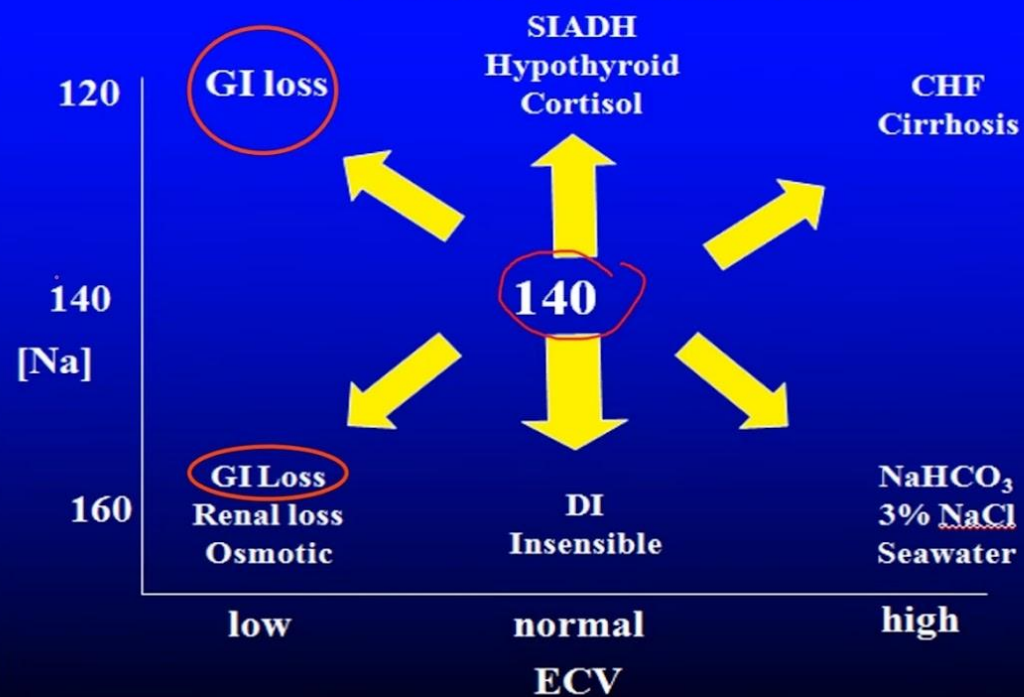
- Na level more than 146 mmol /L.
- Always in Hypertonic State (Hypo, Iso, Hypervolemia)
- Exercise, Sweating.
- NG suction, vomiting, diarrhea.
- Osmotic Diuresis.
- Burns, large open wounds.
- Excess hypertonic fluids.
- Cushing syndrome .
- Peritonitis .

## Hypernatremia

### Symptoms and signs

- Restlessness, weakness.
- Tachycardia, hypotension.
- Dry sticky mucous membranes.
- Oliguria, Decrease Saliva and Tears.
- Fever, red swollen tongue.
- $\text{H}_2\text{O deficit} = 0.6 \times \text{weight} \times (\text{serumNa} - 140) \div 140$
- ✦ Give hypotonic fluids.
- ✦ Don't correct rapidly.

# Fluid Status



## Potassium abnormalities

- $K^+$  requirement is 60 mmol per day.
- 90%  $K^+$  is excreted in urine.
- Kidney can decrease  $K^+$  secretion to 10-20 mmol.
- 98% of  $K^+$  is located intracellularly.
- Acid –base changes affect  $K^+$  levels.
- Hypokalemia leads to hypo magnesemia.

## Hypokalemia

Serum  $K^+$  less than 3.5 mmol /liter.

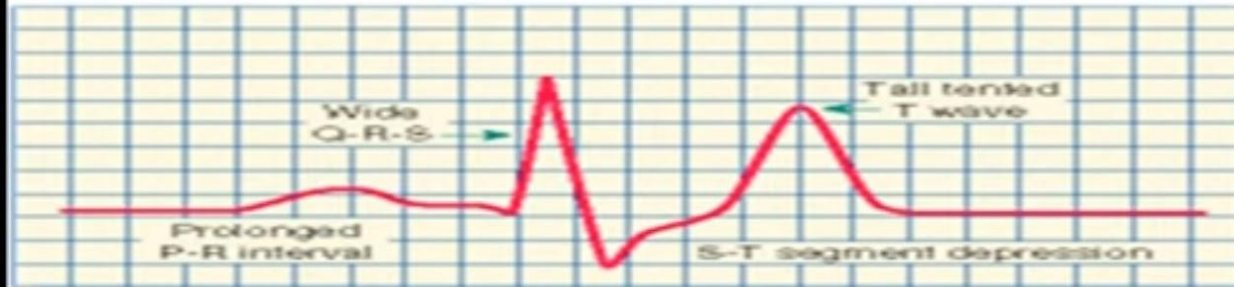
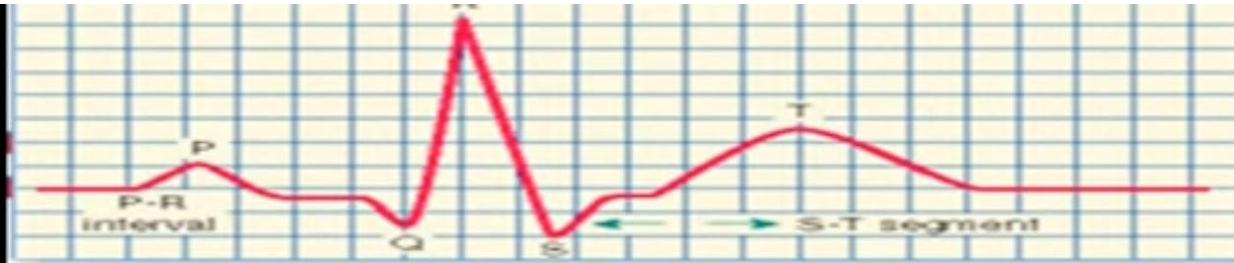
Occur in 20% of hospitalized patients.

### 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.

## 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.



## Treatment

- $K^+$  tablets 20 mmol as chloride, citrate.
- IV  $K^+$  for severe forms.
- Good urine output before  $K^+$  administration.
- *Don't give more than 20 mmol  $K^+$  / hr.*
- Don't give more than 40 mmol  $K^+$  / L in peripheral vein.

## Hyperkalemia

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

### *Causes*

- ◆ Renal failure.
- ◆ Crush syndrome (Rhabdomyolysis).
- ◆ Redistribution in acidosis.
- ◆ Hemolysis , thrombocytosis , leukocytosis.
- ◆ Blood Transfusion.
- ◆ Succinylcholine.
- ◆ 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.**

- **NaHco<sub>3</sub> One ampule 50 mmol over 5 minutes.**