Intravenous Fluids in Pediatrics

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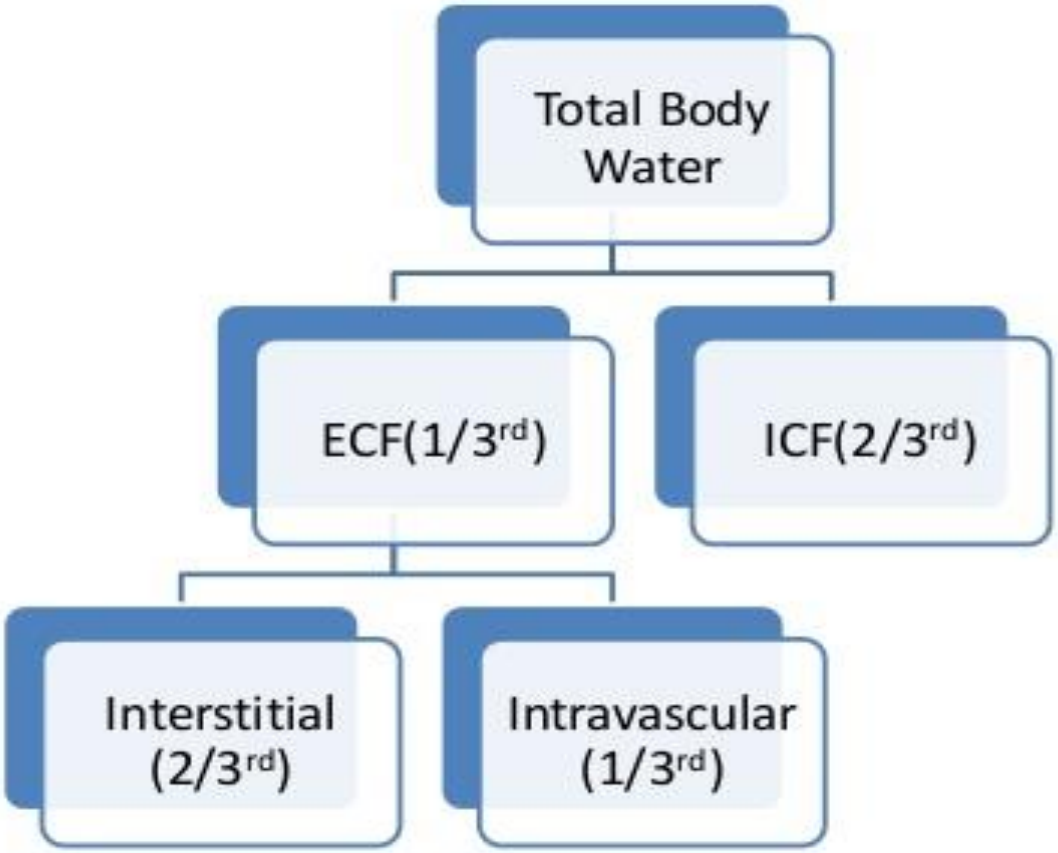
Intravenous Fluids in Pediatrics

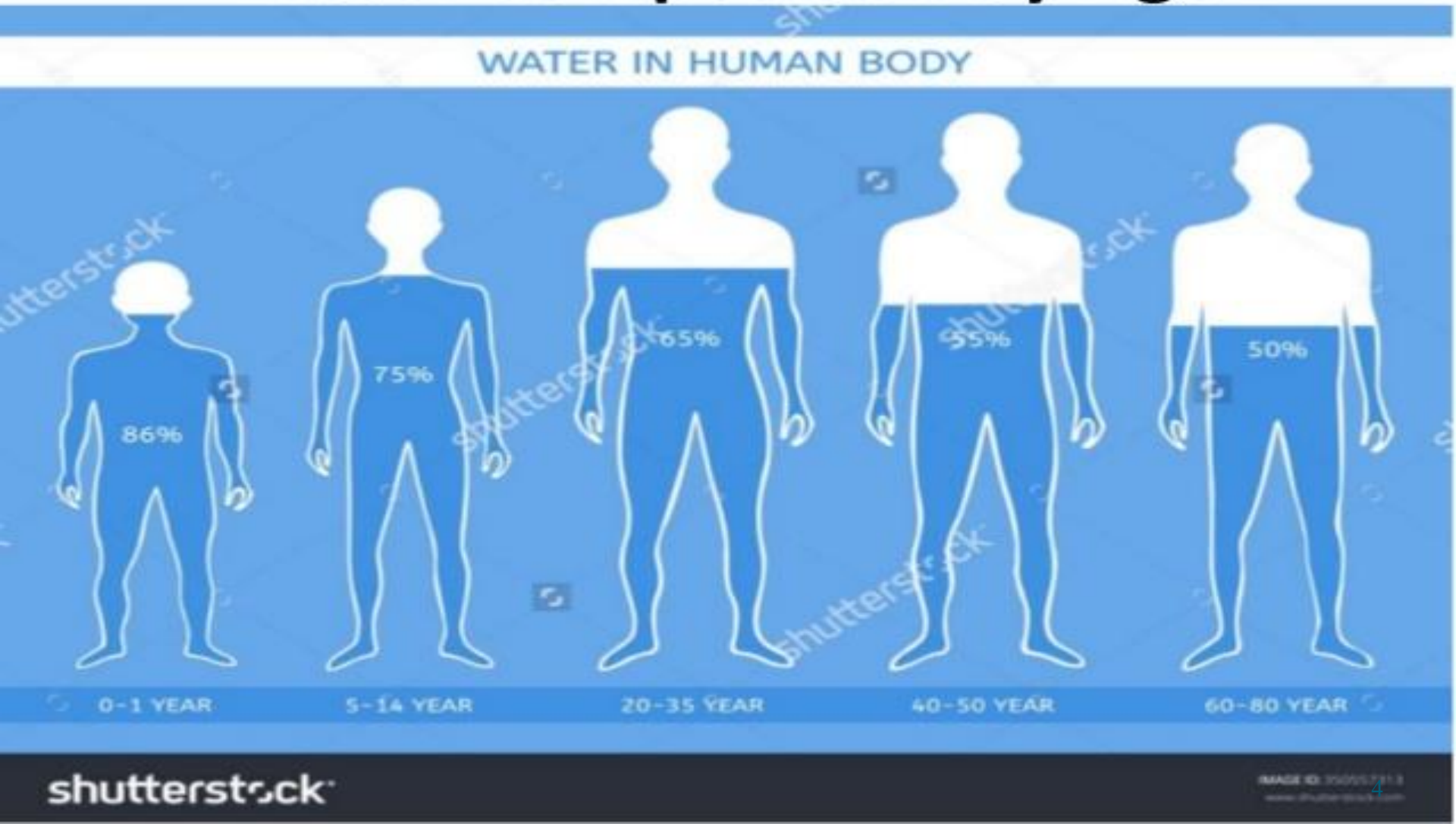
- **Objectives**

- Physiology of fluid distribution
- Distribution of IV fluids in body compartments
- Maintenance fluid calculation
- Special circumstances
- Electrolyte maintenance
- Electrolyte disturbances

Distribution of Fluid in Body



Water Composition by Age



Types Of Fluids

CRYSTALLOIDS:

- Contain Na as major osmotically active particle
- Will cross a semi-permeable membrane
- E.g. Normal Saline, Ringer Lactate

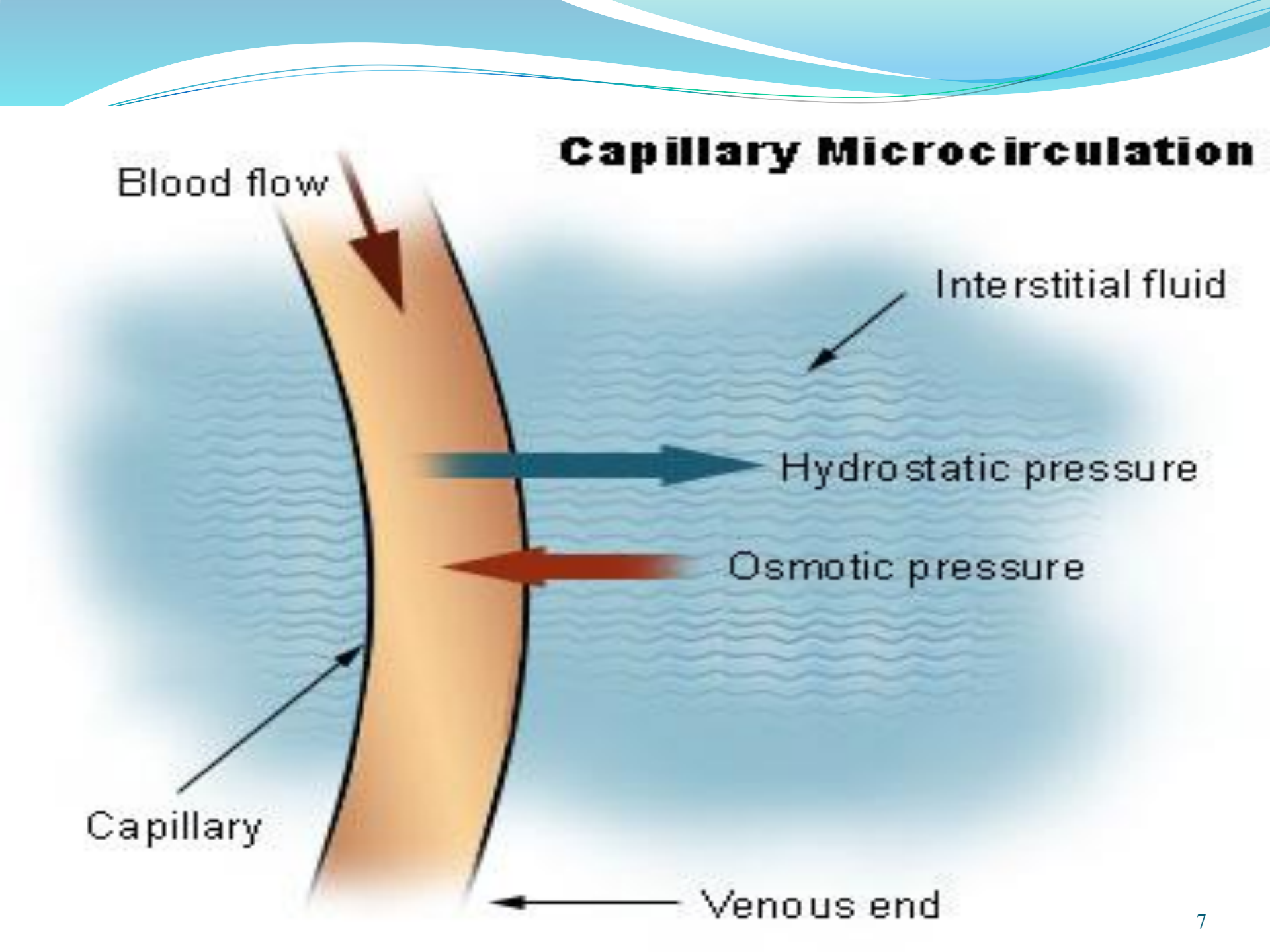
COLLOIDS:

- Contain high molecular weight substancces
- Are largely unable to cross a semi-permeable membrane
- Albumin, Dextran, Gelatin

Physiology of fluid compartments

Capillary membrane

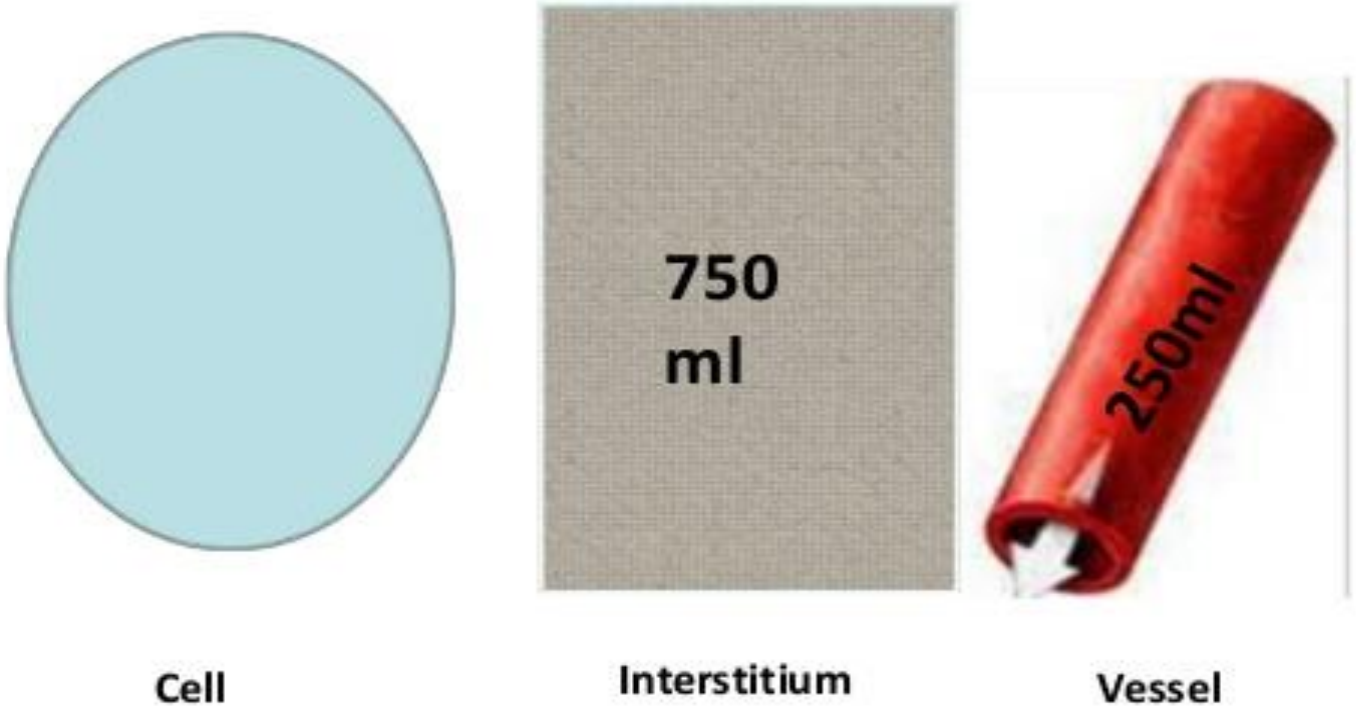
- Between plasma and interstitium
- Allows free passage of electrolytes
- Restricts passage of protein molecules
- Colloid osmotic pressure draws fluid in capillary
- Hydrostatic fluid pushes fluid out


Capillary Microcirculation
Blood flow
Interstitial fluid
Hydrostatic pressure
Osmotic pressure
Capillary
Venous end

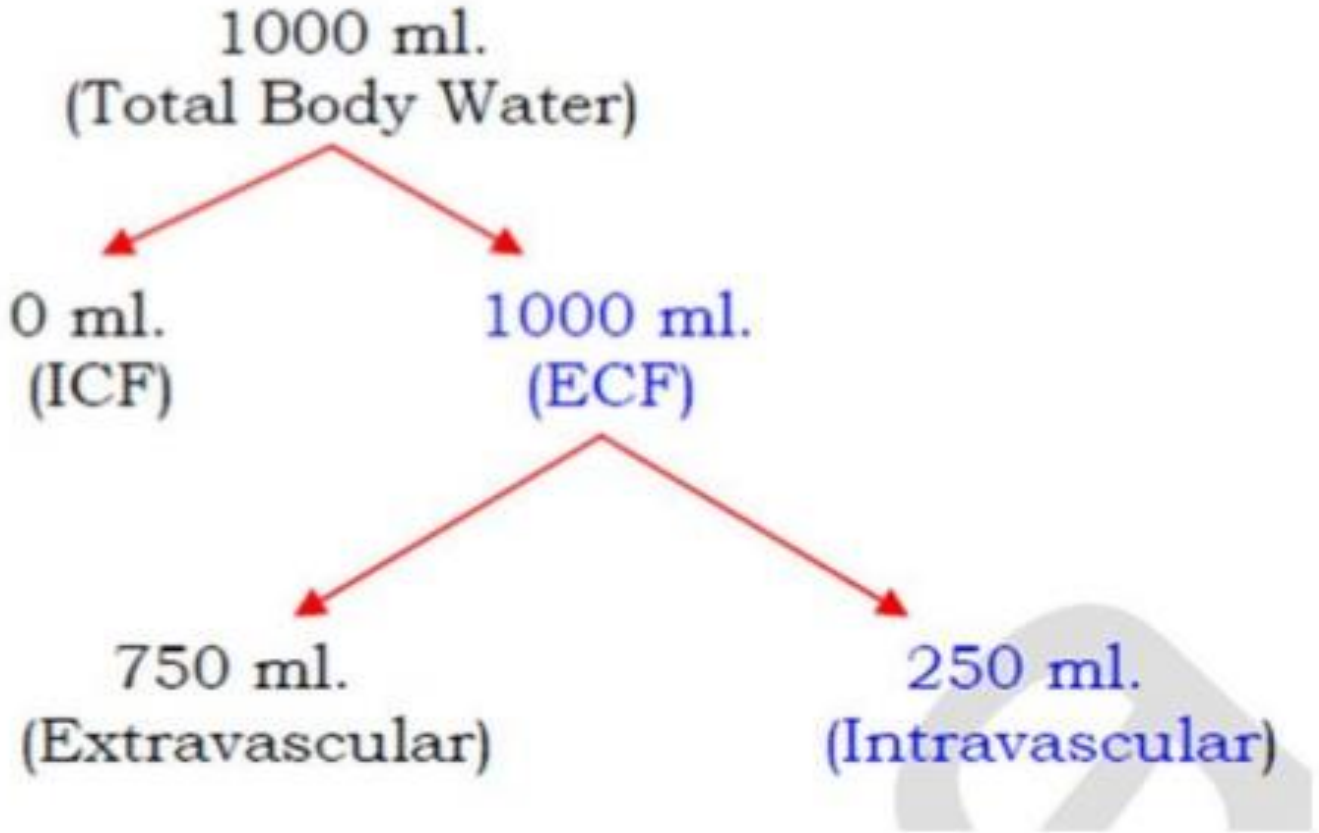
Diff. In ICF & ECF

Component	ECF	ICF
Sodium	142	14
Potassium	4.2	140
Chloride	108	4
Bicarbonate	24	10
Magnesium	0.8	
Nutrient	O2, Amino acid, Fatty acid	Proteins

Distribution of N/S & R/L



Distribution of N/S & R/L



0.9% Normal Saline

('Salt and water')

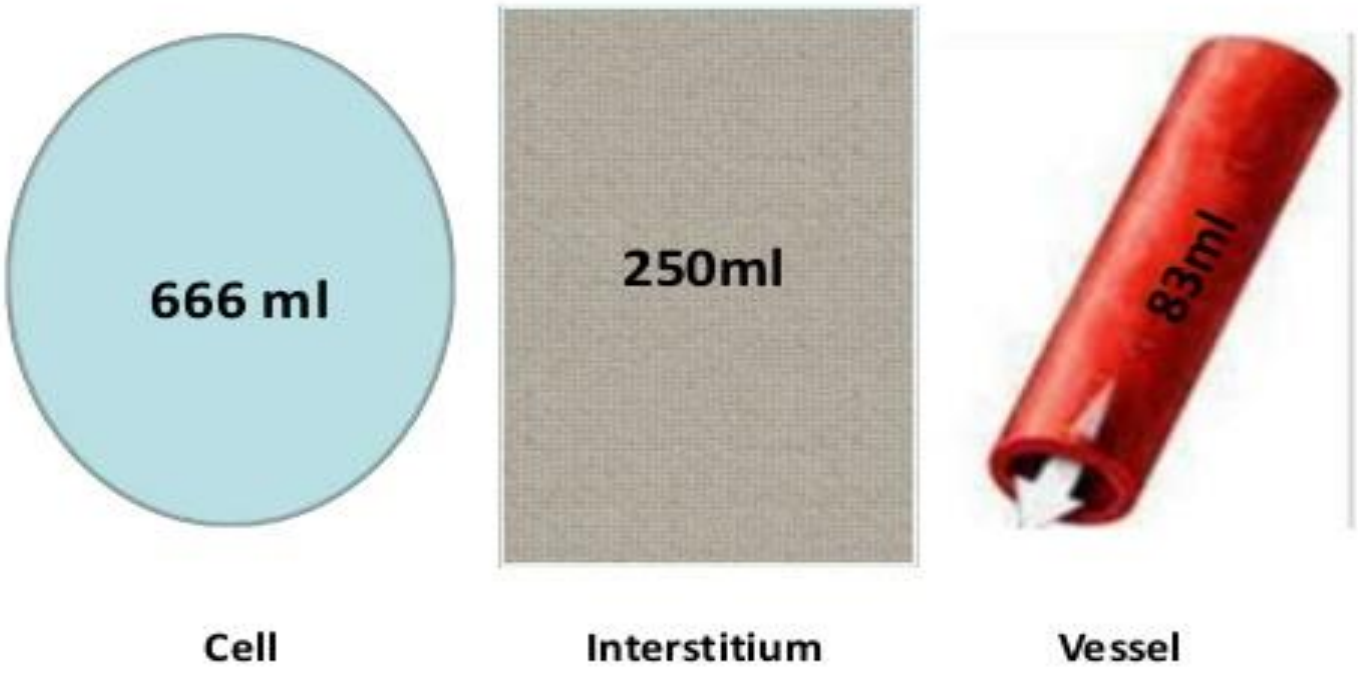
- Iso-osmolar (compared to normal plasma)
- Contains: 154 mmol/l of sodium and chloride
- Stays almost entirely in the extracellular space,

  so for 100ml blood loss – need to give 400ml normal saline (only 25% remains intravascular)
- Principal fluid used for intravascular resuscitation and replacement of salt loss e.g diarrhoea and vomiting

Composition of Different Fluids

FLUIDS	Na (mmol /L)	K (mmo l/L)	Ca (mmol/L)	Cl (mmol/L)	OTHERS	pH	OSMOLARITY mosm/L
N/S	154			154		5	308
PAED"s Solution	30			30	DEXTROSE 40g	4	300
DEXTROSC 5%					D.50g	4	252
HART MANN"s Solution	131	5	2	111	LACTATE 29	6.5	273
HAEMACCEL	145	5	625	145	GELATIN 35g	7.4	
GELOFUSINE	154	<.4	<.4	125	GELATIN 40g	7.4	
PENTA STARCH	154 (9g)			154	STARCH 60g	5	309
ALBUMIN 4.5%	<160	<2		<136	ALBUMIN 40-50g	7.4	309

Distribution of Dextrose Water



5% Dextrose (D5W)

"Sugar and Water"

- Commonly used 'maintenance' fluid in conjuction with normal saline
- Provides some calories (approximately 20% of daily requirements)
- Regarded as 'electrolyte free'
- Distribution: <10% Intravascular; > 66% intracellular
- When infused is rapidly redistributed into the intracellular space; Less than 10% stays in the intravascular space therefore it is of limited use in fluid resuscitation.
- For every 100ml blood loss – need 1000ml dextrose replacement [10% retained in intravascular space

Albumin

- natural protein
- t1/2 = 20 days in the body but t1/2 = 1.6 hours in plasma
- 10% leaves the vascular space within 2 hours, 95% within 2 days
- causes 80-90% of our natural oncotic pressure
- stays within the intravascular space unless the capillary permeability is abnormal

Types of Fluid Replacement

- **Maintenance:** Normal ongoing losses of fluids and electrolytes

- **Deficit:** Losses of fluids and electrolytes resulting from an illness

- **On-going Losses:** Requirement of fluids and electrolytes to replace ongoing losses

GOALS OF MAINTENANCE FLUIDS

- Prevent dehydration
- Prevent electrolyte disorders
- Prevent ketoacidosis
- Prevent protein degradation

Maintenance Fluid Replacement

Holliday-Segar Method

	cc/kg/day	cc/kg/hr.
First 10 kg (wt. 10 kg or less)	100	4
Next 10 kg (wt. 10-20 kg)	50	2
More than 20 kg (wt. >20 kg)	20	1

Example:
A 30-kg child would require (100 × 10) + (50 × 10) + (20 × 10) = 1,700 cc/day
or (4 × 10) + (2 × 10) + (1 × 10) = 70 cc/h

Table 8-4. Normal Water Losses for Infants and Children

Cause of Loss	Volume of Loss (mL/100 kcal)
Output	
Urine	70
Insensible loss	
Skin	30
Respiratory tract	15
"Hidden intake" (from burning 100 calories)	15
Total	100

Maintenance Electrolyte Requirements

- **Na: 2-3** mEq/100ml water /day
  OR 2-3 mEq/kg/day
- **K: 1-2** mEq/100ml of water/day
  OR 1-2mEq/kg/day
- **Chloride**:
  2 mEq/100ml of water /day

I.V fluid therapy:-

Indications:-

1-severe dehydration

2-mild to moderate dehydration if there is:-

*diarrhea >100 cc/hr

*abdominal distension due to paralytic ilius or gastric distention.

*comatose patient.

*repeated vomiting.

*patient refused oral route.

Fluid therapy

There are two components to fluid therapy:

Maintenance therapy

Replacement therapy

Maintenance therapy:-

replaces the ongoing losses of water and electrolytes under normal physiologic conditions via urine, sweat, respiration, and stool.

Measured according to body weight;

Body weight(kg)	Volume per day	Hourly rate
0-10	100ml/kg	4 ml/kg/hr
11-20	1000 ml+50 ml/kg for each 1kg >10 kg	40 ml/hr +2 ml/kg/hr*(wt-10)
>20	1500 ml +20 ml/kg for each 1 kg >20kg	60 ml/hr+1 ml /kg/hr *(wt-20)

The glucose in maintenance fluids provides approximately 20% of the normal caloric needs of the patient.

This percentage is enough

to prevent the development of starvation ketoacidosis and

diminishes the protein degradation that would occur if the patient received no calories.

avoiding the administration of hypotonic fluids, which may cause hemolysis


0.9% w/v Sodium Chloride
Intravenous Infusion B.P. 500 ml
Pharmaceutical Solutions Industry Ltd.
In cooperation with Fresenius Kabi, Germany
Normal Saline
DOSAGE :
STERILE & NON-PYROGENIC
Do not use if bottle is leaking, solution cloudy
or contains particles. Single dose container
0.9% w/v Sodium Chloride
Intravenous Infusion B.P.
B.N.: MG102608
Mfg.: 10 07 06
Exp.: 09 07 11


5% w/v Dextrose
intravenous Infusion B.P. 500 ml
5%
DOSAGE
STERILE & NON-PYROGENIC
Do not use if bottle is leaking, solution
cloudy or contains particles.
5% w/v Dextrose
Intravenous Infusion B.P.
B.N.: MK112606
Mfg.: 11 10 06
Exp.: 10 10 11

Heat stress:-

Fever leads to a predictable increase in insensible losses, causing a 10% to 15% increase in maintenance water needs for each 1°C increase in temperature greater than 38°C.

e.g:-12 kg ,39c

=1100+(1100*10%)

=1100+110

=1210 ml

Requirement increased in:

Skin	Radiant warmer
	Phototherapy
	Fever
	Sweat
	Burns
Lungs	Tachypnea
	Tracheostomy
Gastrointestinal	Diarrhea
	Emesis
	Nasogastric suction
Renal	Polyuria
Miscellaneous	Surgical drain
	Third space losses

Conditions that decrease requirment by 30-45 % include:-

- Anuria or extreme oliguria
- Excessive ADH release(meningitis)
- Congestive heart failure
- But hypothyroidism decrease requirement by 10-20 %

Hyponatremia: Na<130 mEq/L

Hyponatremia usually associated with hyposomolality.

Types of hyponatremia

- Pseudohyponatremia(lab artifact)
- Hyperosmolality(hyperglycemia,mannitol)
- Hypovolemic(extrarenal,renal)
- Euvolemic(SIADH, hypothyroidism, water intoxication)
- Hypervolemic(CHF,cirrhosis,nephrotic syndrome, RF,hypoalbominemia)

CAUSES OF HYPERNATREMIA

Excessive Sodium / Hypernatremia

Improperly mixed formula

Excess sodium bicarbonate

Ingestion of sea water **(Drowning)** or sodium chloride

Intentional salt poisoning

Intravenous hypertonic saline

Hyperaldosteronism

WATER DEFICIT/ Hypernatremia

Nephro. Diabetes insipidus:

- Acquired
- X-linked
- Autosomal recessive
- Autosomal dominant

Central diabetes insipidus:

- Acquired
- Autosomal recessive
- Autosomal dominant
- Wolfram syndrome

Hypokalemia: K < 3.0 mEq/L

Clinical manifestations:

ileus, muscle weakness, polyuria, polydipsia, areflexic paralysis.

ECG changes include:

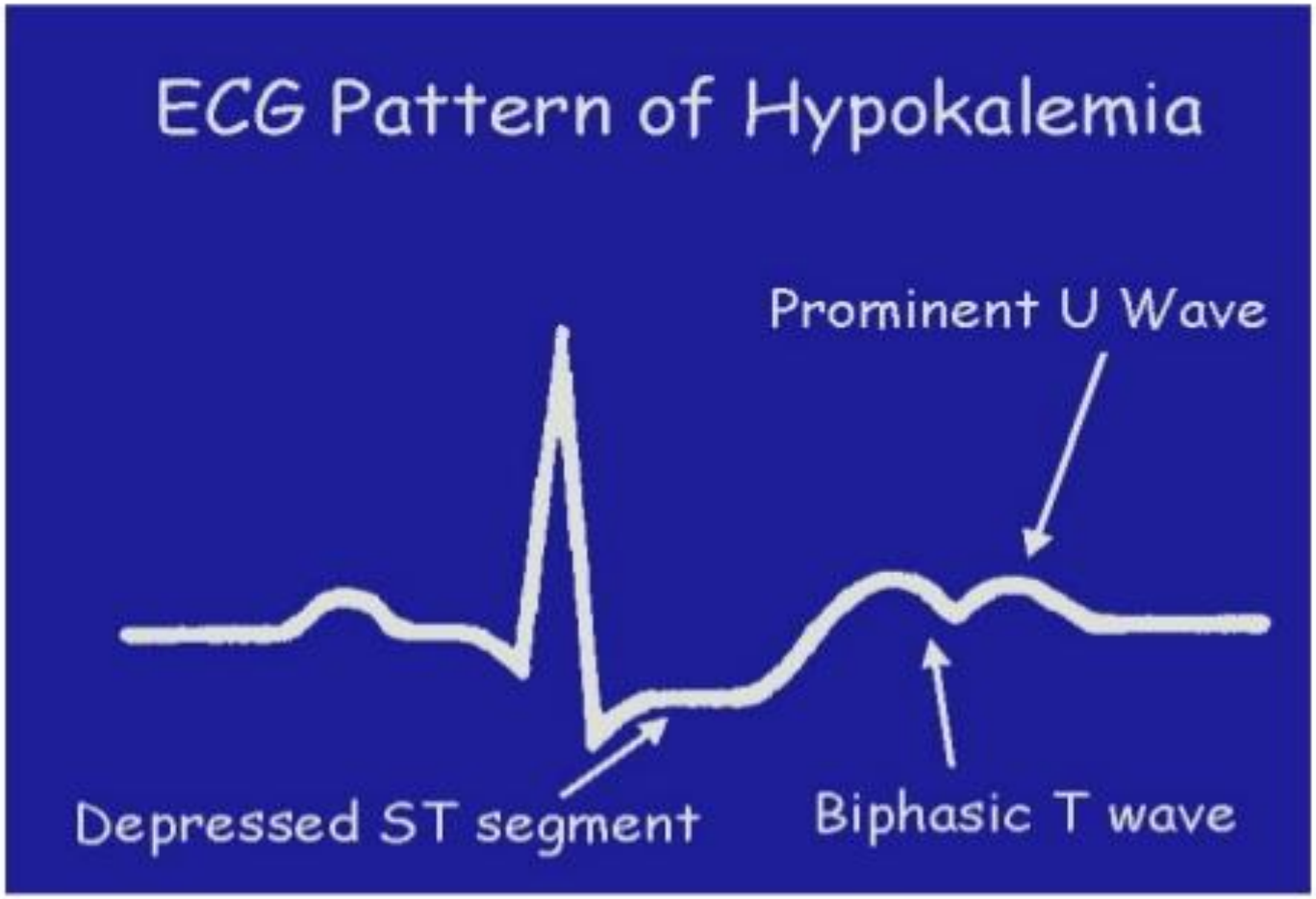
ST depression

T wave reduction

Presence of U wave

Causes

- Renal Excessive diuretic therapy
- Gastrointestinal Vomiting and diarrhoea
- Metabolic Diabetes mellitus, metabolic alkalosis
- Drugs b-2-Adrenergic agonists, xanthenes, steroids
- Rare Cushing syndrome, liver cirrhosis


ECG Pattern of Hypokalemia
Prominent U Wave
Depressed ST segment
Biphasic T wave

Treatment:

Gastrointestinal or renal causes → KCl

Does of 0.5-1 mEq/kg given over 1 hr

The adult maximum dose is 40 mEq.

Hyperkalemia: K >5.5 mEq/l

Clinical manifestations

paresthesia ,weakness ,flaccid paralysis ,cardiac arrhythmia.

ECG changes

(5.5-7 mEq/l)peaked or tented T-wave.

(7-8 mEq/l)prolonged PR, ST depression, initial widening of the QRS complex.

(>8mEq/l)flat P wave, wide QRS.

no treatment lead to asystole or ventricular fibrilation

Causes Hyperkalemia

- Pseudohyperkalaemia Blood sample **hemolysis**
- Metabolic acidosis, insulin deficiency
- Potassium replacement therapy, blood transfusion
- Decreased renal excretion
- Hypoaldosteronism, drugs (amiloride, triamterene, spironolactone, NSAIDs, ACE- inhibitors,angiotensin-receptor antagonists)

Treatment

Rapidly decrease the risk of life-threatening arrhythmias

- Shift potassium intracellularly

  Sodium bicarbonate administration (IV)

  Insulin + glucose (IV) Glucose (0.5 g/kg insulin 0.1 U/kg IV over 30 minutes)

  β-Agonist

- Cardiac membrane stabilization

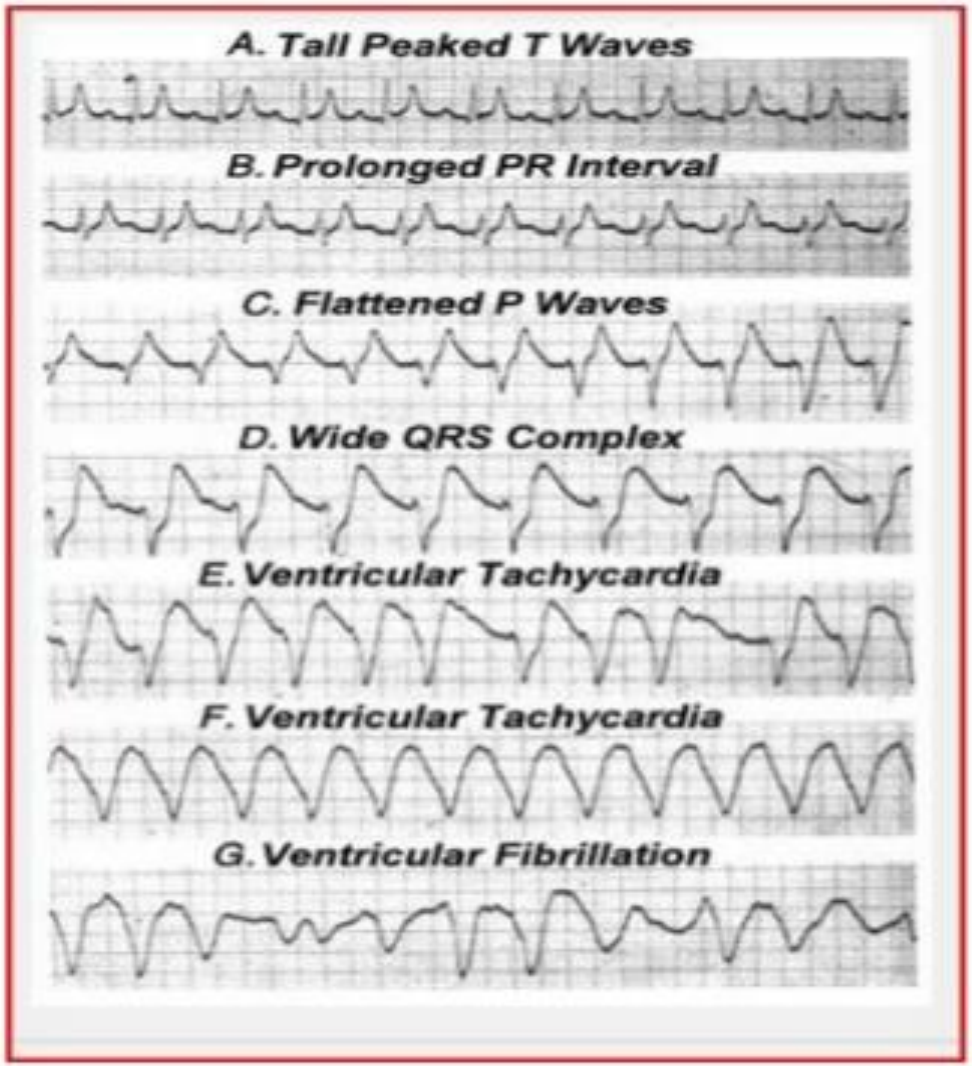
  IV calcium gluconate 1 mL/kg of 10% solution IV over 3-5 minutes

Remove potassium from the body

Loop diuretic (IV or PO)

Sodium polystyrene (PO or rectal)

Dialysis


A. Tall Peaked T Waves
B. Prolonged PR Interval
C. Flattened P Waves
D. Wide QRS Complex
E. Ventricular Tachycardia
F. Ventricular Tachycardia
G. Ventricular Fibrillation

AGENT	MECHANISM	DOSE	PRECAUTIONS/COMPLICATIONS
Kayexalate	Exchange K^+ across colonic mucosa	1-2 g/kg oraly or PR	Hypernatremia, constipation
Glucose and insulin	Cell uptake	Glucose 0.5 g/kg insulin 0.1 U/kg IV over 30 minutes	Hypoglycemia, hypophosphatemia
Sodium bicarbonate	Cell uptake	0.5 meq/Kg IV over 10-15 minutes	Hypernatremia, alkalosis, hypocalcemia, tetany
Calcium gluconate	Stabilizes membrane irritability	1 mL/kg of 10% solution IV over 3-5 minutes	Bradycardia, hypercalcemia

hypocalcemia

Clinical manifestations

Increase neuromuscular irritability: muscle cramps, carpopedal spasm(tetany), weakness, paresthesia, laryngospasm.

Seizure like activity

Chvostek sign

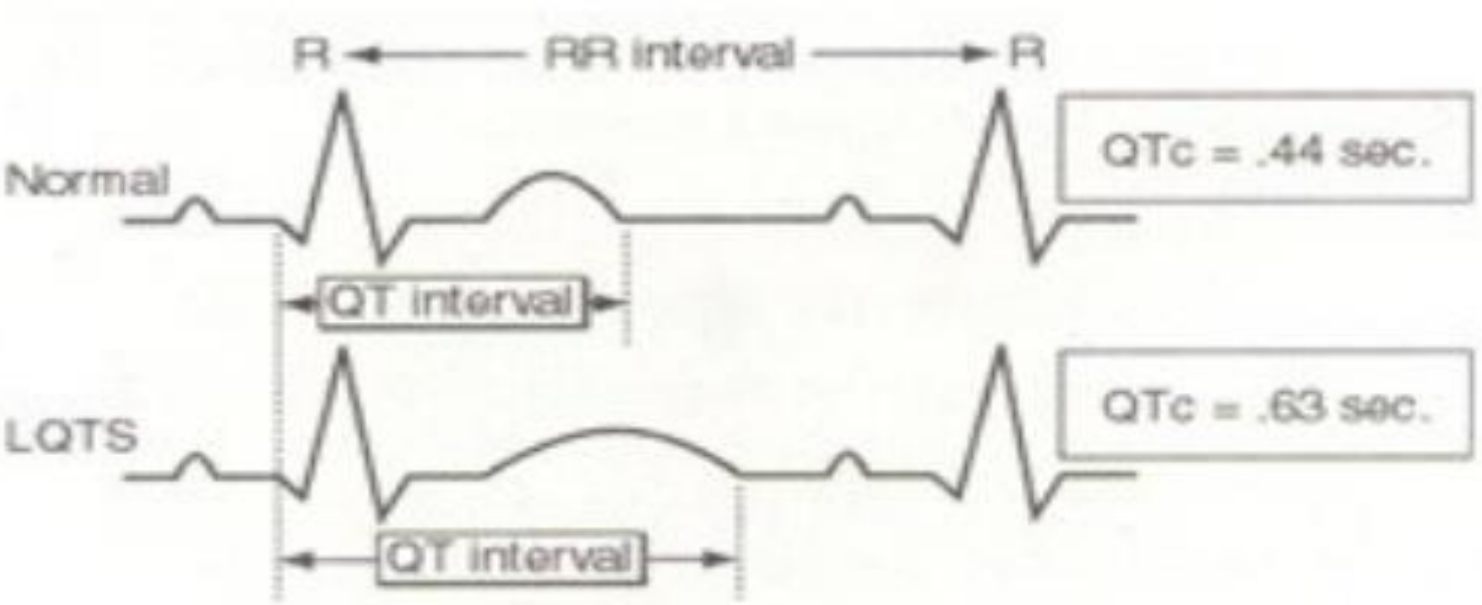
Trousseau sign

Hypocalcaemia, causes

- Hypoalbuminemia.
- Hypoparathyroidism
- Rickets
- Hyperventilation
-
- Excessive citrated red blood cell transfusion;
- Hyperphosphatemia
- Acute renal injury
- Tumor lysis syndrome

ECG-characteristics of hypocalcemia

Prolongation of the QT-interval



treatment:-

Severe tetany treated with I.V calcium gluconate 2ml/kg of 10% solution, given slowly over 10 min while cardiac status is monitored for bradycardia.

Keep serum calcium in the lower half of the normal range to avoid episodes of hypercalcemia

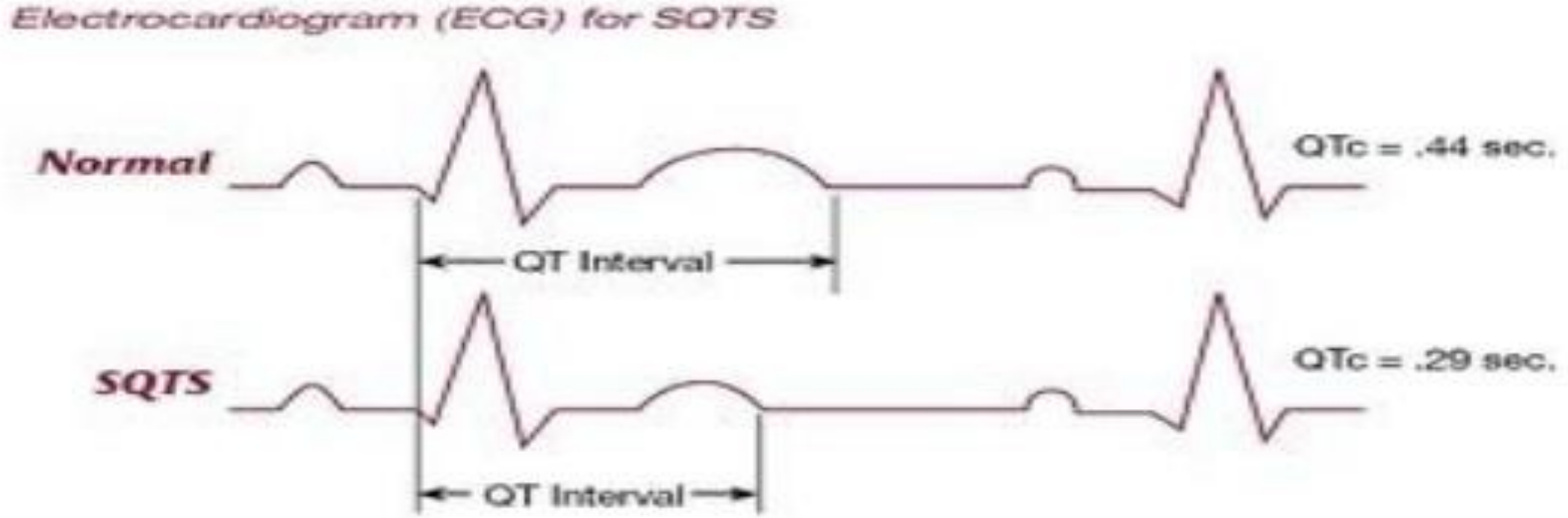
hypercalcemia

Clinical manifestations

mental disturbances, anorexia, constipation, lethergy, vomiting, weakness and polyuria

ECG changes:

short QT interval and a widened T wave suggest hypercalcaemia



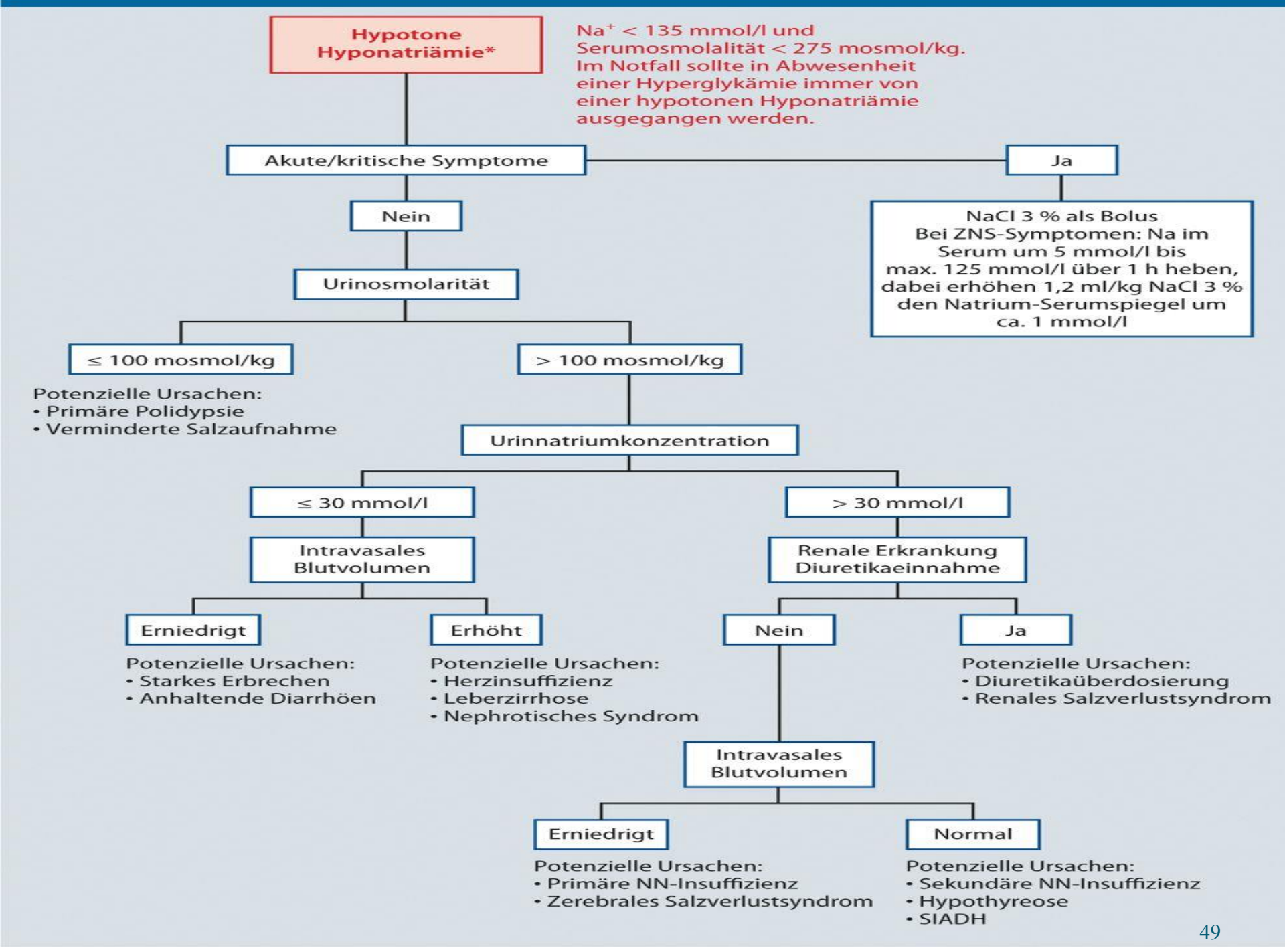
Treatment:-

Aggressive therapy with normal saline because the child is usually dehydrated

Loop diuretics enhance Ca excretion,started after rehydration.

Furosemide (Lasix) (0.5-1mg/kg, Max **Dose** 10mg/kg/day)

Monitor serum sodium, potassium, bicarbonate and magnesium.


Hypotone Hyponatriämie*
Na+ < 135 mmol/l und Serumosmolalität < 275 mosmol/kg. Im Notfall sollte in Abwesenheit einer Hyperglykämie immer von einer hypotonen Hyponatriämie ausgegangen werden.
Akute/kritische Symptome
Ja
NaCl 3 % als Bolus Bei ZNS-Symptomen: Na im Serum um 5 mmol/l bis max. 125 mmol/l über 1 h heben, dabei erhöhen 1,2 ml/kg NaCl 3 % den Natrium-Serumspiegel um ca. 1 mmol/l
Nein
Urinosmolarität
≤ 100 mosmol/kg
Potenzielle Ursachen:
• Primäre Polidypsie
• Verminderte Salzaufnahme
> 100 mosmol/kg
Urinnatriumkonzentration
≤ 30 mmol/l
Intravasales Blutvolumen
Erniedrigt
Potenzielle Ursachen:
• Starkes Erbrechen
• Anhaltende Diarrhöen
Erhöht
Potenzielle Ursachen:
• Herzinsuffizienz
• Leberzirrhose
• Nephrotisches Syndrom
> 30 mmol/l
Renale Erkrankung Diuretikaeinnahme
Nein
Intravasales Blutvolumen
Erniedrigt
Potenzielle Ursachen:
• Primäre NN-Insuffizienz
• Zerebrales Salzverlustsyndrom
Normal
Potenzielle Ursachen:
• Sekundäre NN-Insuffizienz
• Hypothyreose
• SIADH
Ja
Potenzielle Ursachen:
• Diuretikaüberdosierung
• Renales Salzverlustsyndrom