Contents

- Significance
- Introduction
- Functional components of body fluids
- Composition of body fluids
- Homeostasis
- Disorders due to disturbance in volume

i. Hypovolaemia
ii. Hypervolaemia

- Disturbance in concentration

Sodium

- Disturbance in composition

a. Acid base imbalances
b. Potassium
c. Calcium
d. Chloride
e. Magnesium

- Fluid therapy

FLUID AND ELECTROLYTES

DR PRATIK SHAPARIA

Significance

The ever expanding specialty of oral and maxillofacial surgery has made it obligatory for the surgeons to be aware of the basic principles of fluid management and to possess a sound strategy for blood product usage in order to enhance and optimize comprehensive patient care.

The water in the body contains dissolved minerals called electrolytes. They include sodium,

Introduction

Daily we consume 2250 ml of water but….

- Why do we need to drink water…
- Where does all this water go…
- Why we drink only this much of water…

We need to drink water because..

1	All chemical reactions occur in liquid medium.
2	It is crucial in regulating chemical and bioelectrical distributions within cells.
3	Transports substances such as hormones and nutrients.
4	O_2 transport from lungs to body cells.
5	CO_2 transport in the opposite direction.
6	Dilutes toxic substances and waste products and transports them to the kidneys and the liver.
7	Distributes heat around the body

Where does all this water go…

- Water constitutes an average 50 to 70% of the total body weight

  Young males - 60% of total body weight
  Older males – 52%

  Young females – 50% of total body weight
  Older females – 47%

- Variation of ±15% in both groups is normal

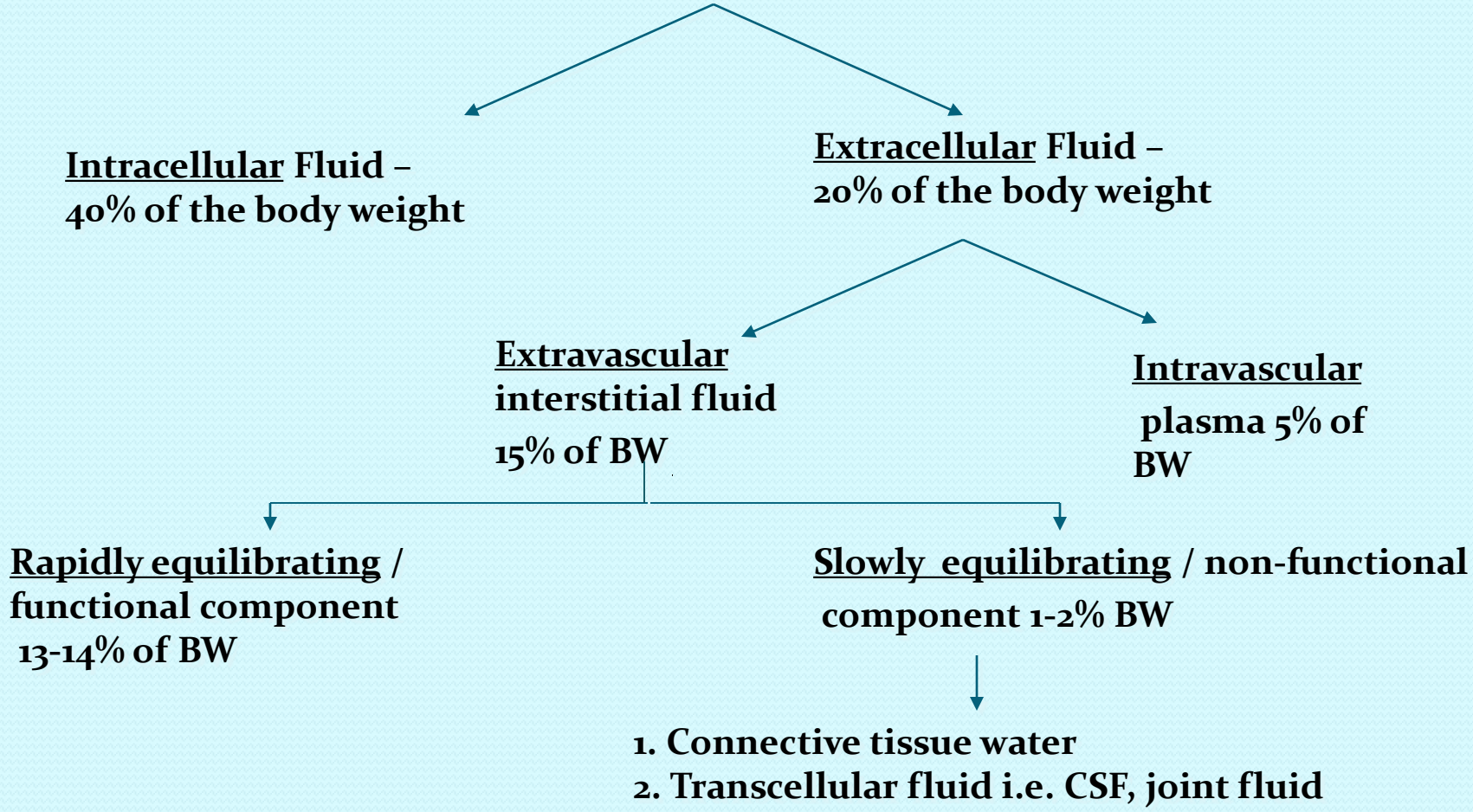
- Obese have 25 to 30% less body water than lean people.

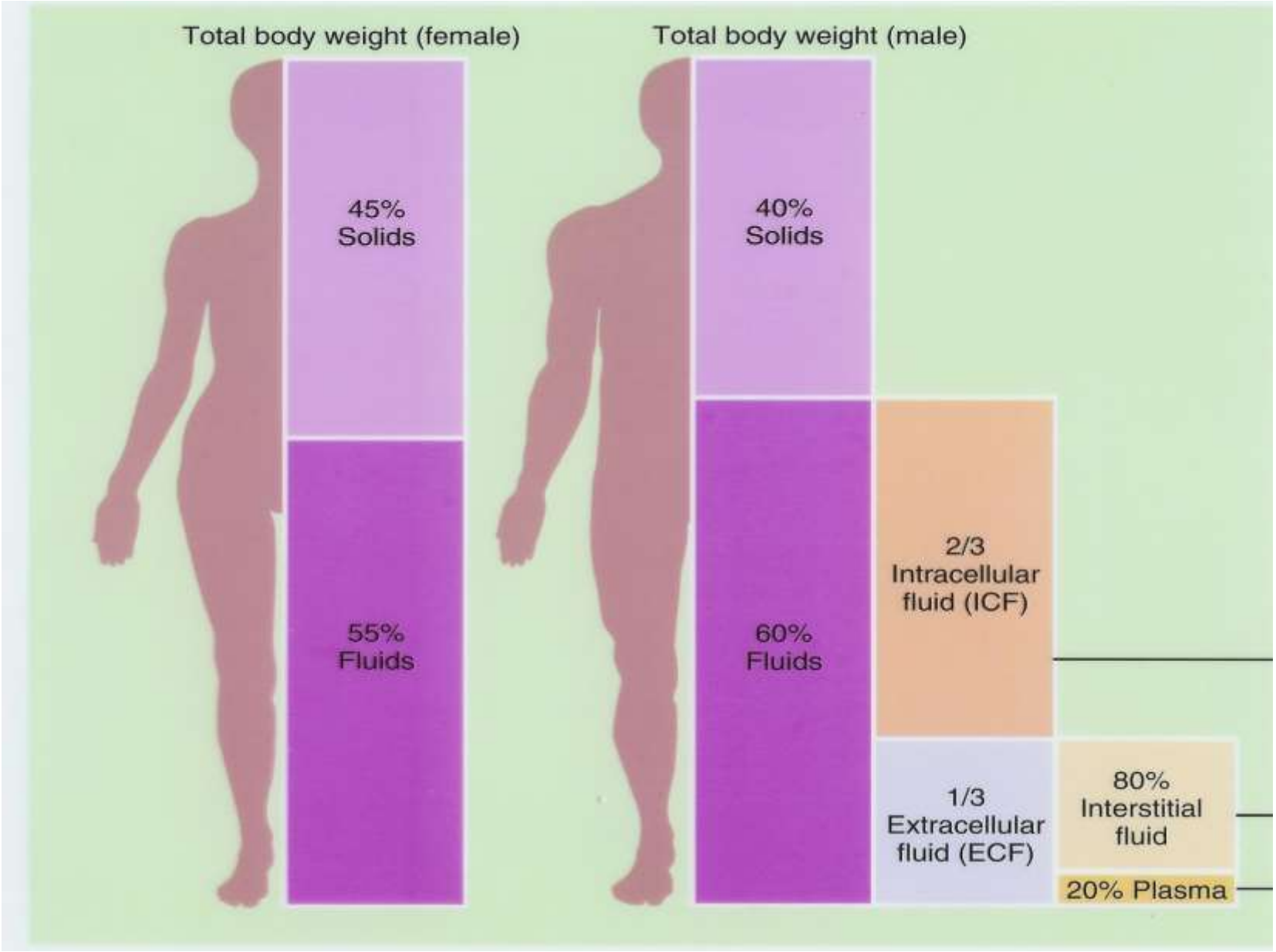
- Infants 75 to 80%
  - gradual physiological loss of body water
  - 65% at one year of age

Components of body fluids

Functional Components of the Body Fluid

The water of the body is divided into 3 functional components (TBW – 60%):

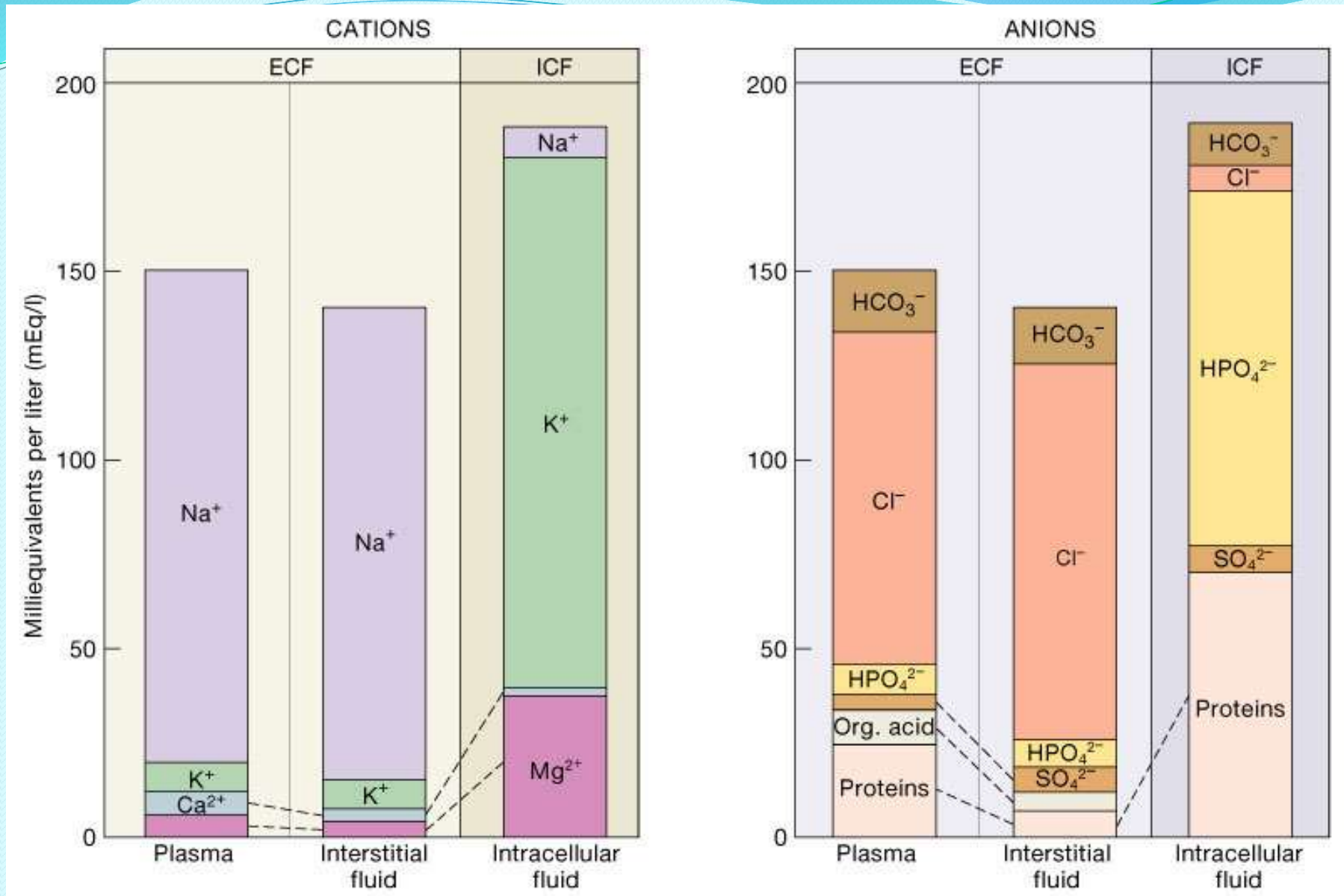


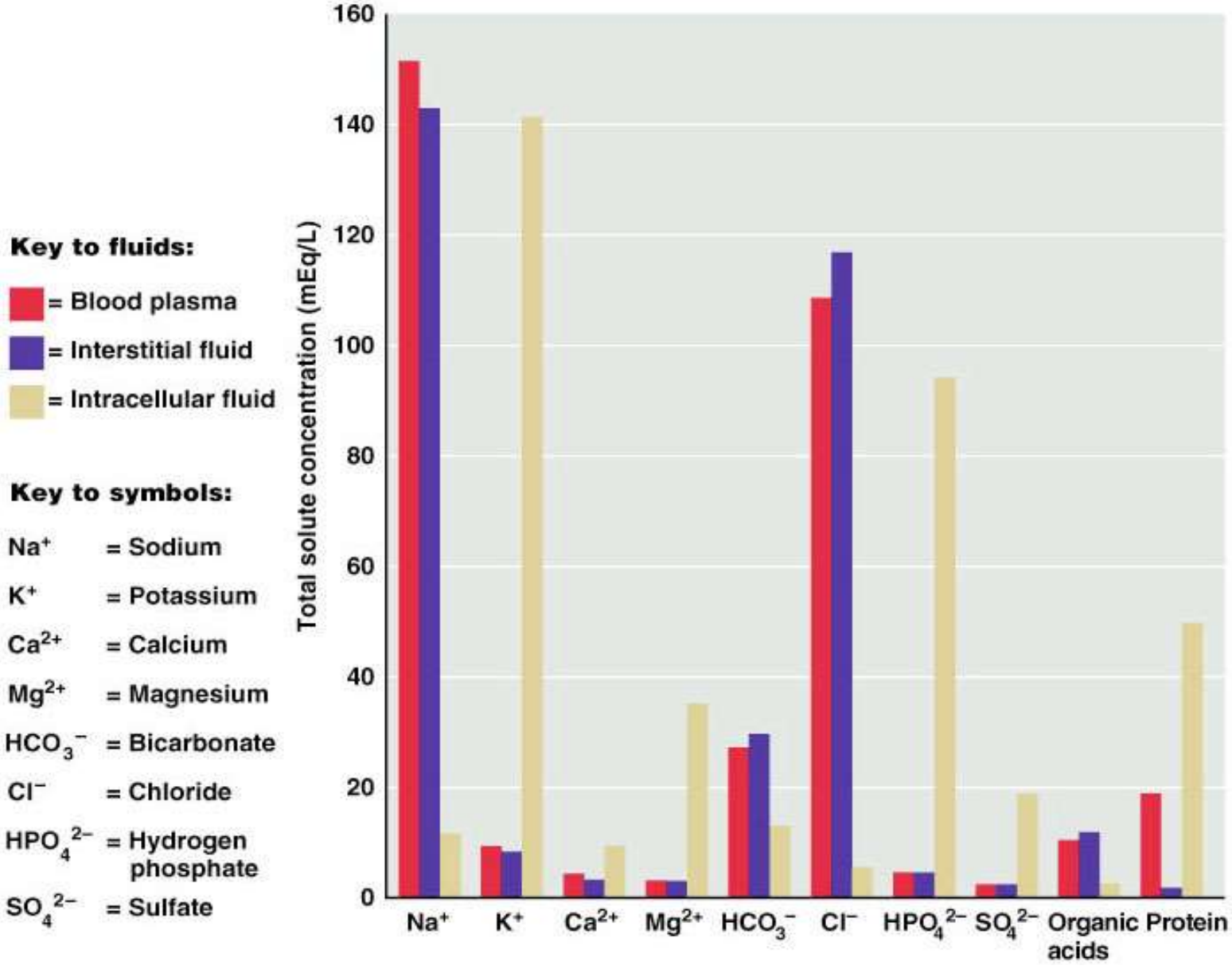

Total body weight (female)
45%
Solids
55%
Fluids
Total body weight (male)
40%
Solids
60%
Fluids
2/3
Intracellular
fluid (ICF)
1/3
Extracellular
fluid (ECF)
80%
Interstitial
fluid
20% Plasma

Composition of Body Fluids

- Water is the universal solvent
- Solutes
  - **Electrolytes** – Inorganic salts, all acids and bases, and some proteins.
  - **Non-electrolytes** –Most non electrolytes are organic molecules – glucose, lipids, creatinine and urea

- Electrolytes have greater osmotic power than non electrolytes
- Water moves according to osmotic gradients


CATIONS
ECF
ICF
200
150
100
50
0
Milliequivalents per liter (mEq/l)
Na+
K+
Ca2+
Mg2+
Plasma
Interstitial fluid
Intracellular fluid
ANIONS
HCO3−
Cl−
HPO4 2−
SO4 2−
Org. acid
Proteins


Key to fluids:
= Blood plasma
= Interstitial fluid
= Intracellular fluid
Key to symbols:
Na+ = Sodium
K+ = Potassium
Ca2+ = Calcium
Mg2+ = Magnesium
HCO3− = Bicarbonate
Cl− = Chloride
HPO4 2− = Hydrogen phosphate
SO4 2− = Sulfate
Total solute concentration (mEq/L)
160
140
120
100
80
60
40
20
0
Na+
K+
Ca2+
Mg2+
HCO3−
Cl−
HPO4 2−
SO4 2−
Organic acids
Protein

Solute Overview
Intracellular v/s Extracellular

- **Ionic composition** very different
- **Total ionic concentration** very similar
- **Total osmotic concentrations** virtually identical

Osmolarity is identical in all body fluid compartments

Principles of Body Water Distribution

- Body control systems regulate ingestion and excretion:
  - constant total body water
  - constant total body osmolarity
- Homeostatic mechanisms respond to changes in ECF
- No receptors directly monitor fluid or electrolyte balance
  - Respond to changes in plasma volume or osmotic concentrations

Fluid Movement Among Compartments

- Compartmental exchange is regulated by osmotic and hydrostatic pressures.
- Net leakage of fluid from the blood is picked up by lymphatic vessels and returned to the bloodstream.
- Exchanges between interstitial and intracellular fluids are complex due to the selective permeability of the cellular membranes.
- Two-way water flow is substantial.
- Ion fluxes are restricted and move selectively by active transport.
- Nutrients, respiratory gases, and wastes move unidirectionally.
- Plasma is the only fluid that circulates throughout the body and links external and internal environments.
- Osmolalities of all body fluids are equal; changes in solute concentrations are quickly followed by osmotic changes.

Homeostasis

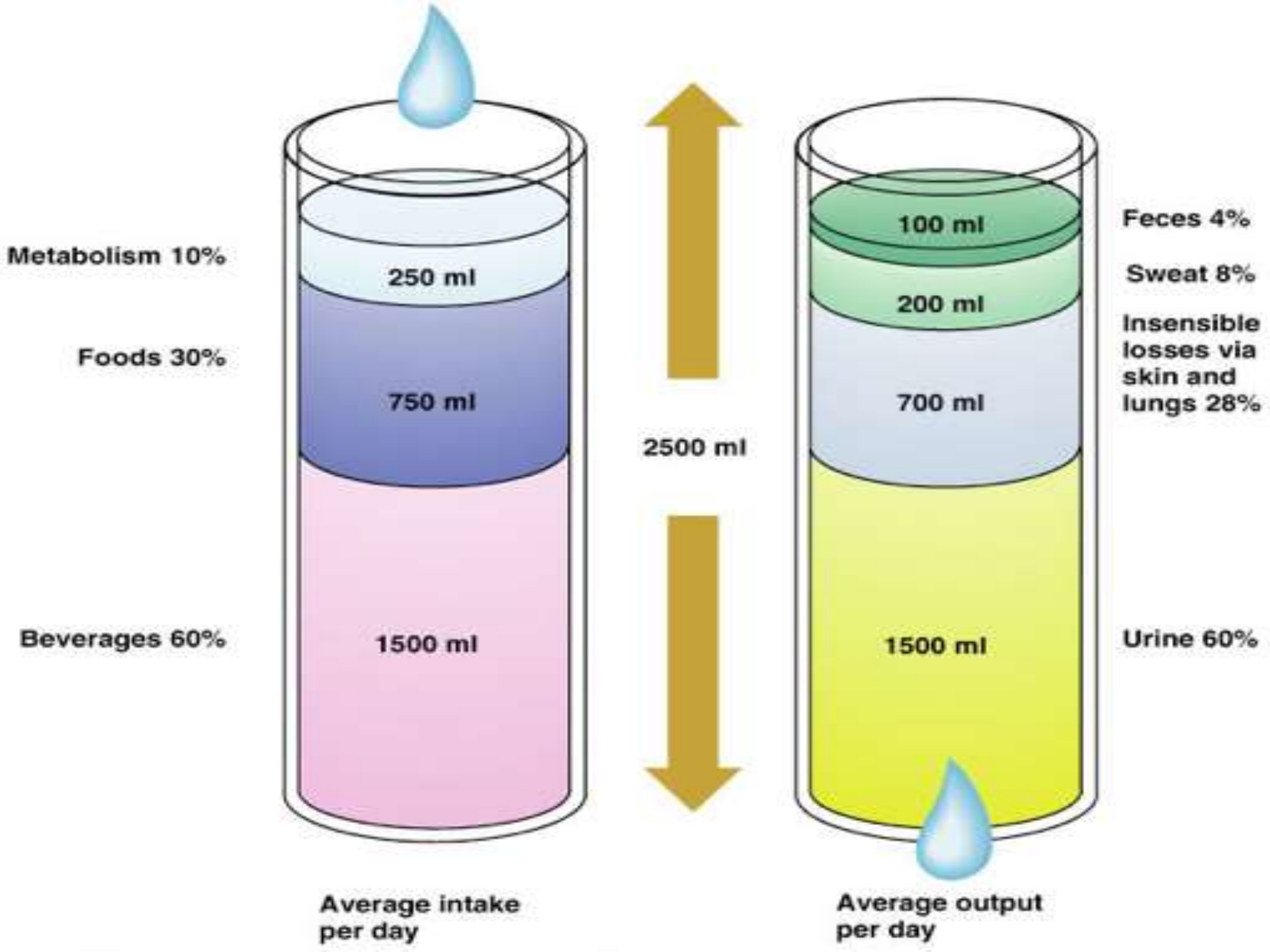
Homeostasis means the constancy of the internal environment by the coordinated activities of all the systems of the body.

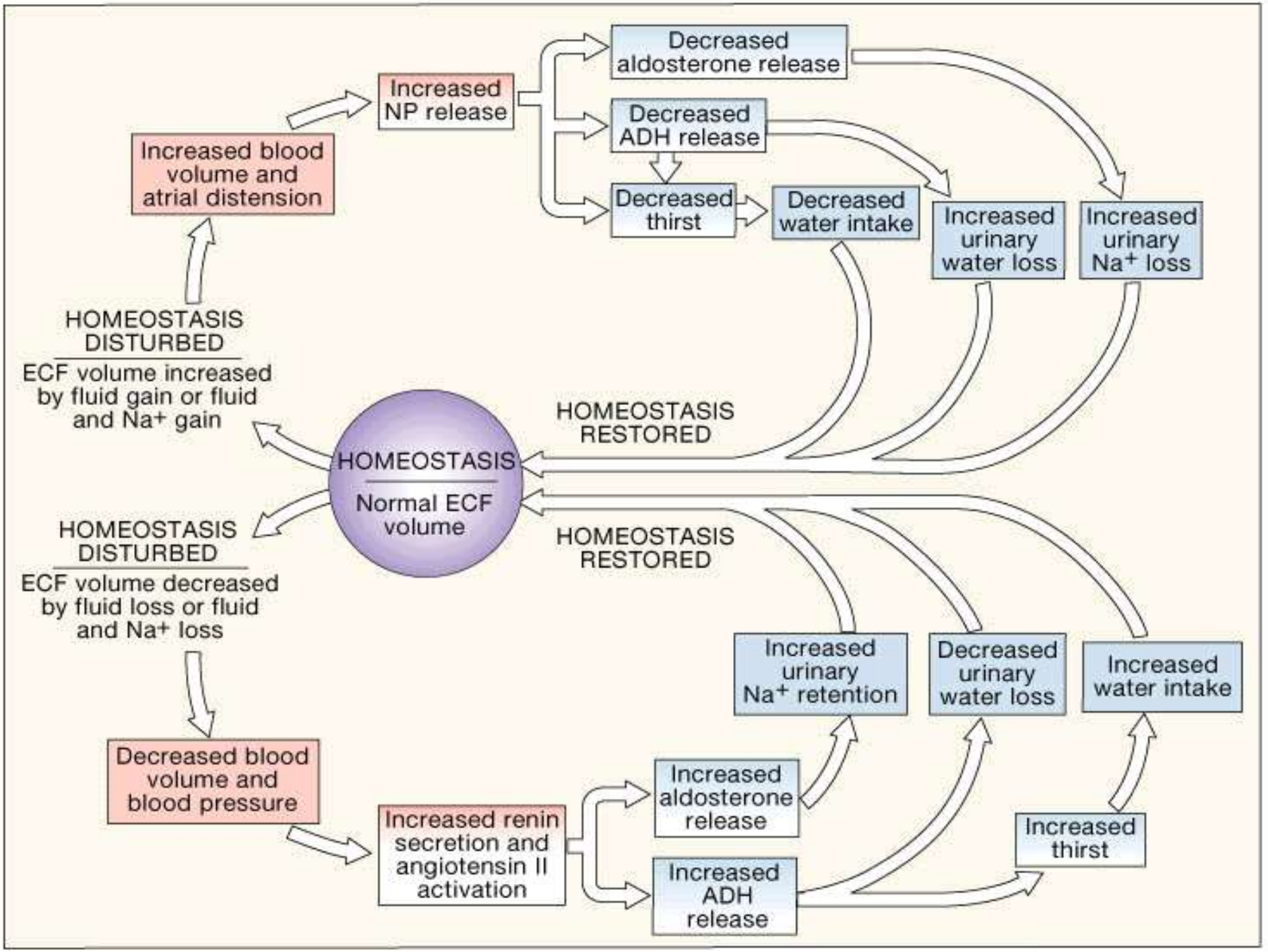
The working systems include

1. Respiratory system
2. Excretory system
3. Digestive system
4. Circulatory system
5. Nervous and endocrine systems

The amount of water we drink is regulated by homeostasis

1. Output = Intake
2. Thirst & Satiety
3. Hormonal regulation


Metabolism 10%
250 ml
Foods 30%
750 ml
Beverages 60%
1500 ml
2500 ml
100 ml
Feces 4%
Sweat 8%
200 ml
Insensible losses via skin and lungs 28%
700 ml
1500 ml
Urine 60%
Average intake per day
Average output per day


Increased blood volume and atrial distension
Increased NP release
Decreased aldosterone release
Decreased ADH release
Decreased thirst
Decreased water intake
Increased urinary water loss
Increased urinary Na+ loss
HOMEOSTASIS DISTURBED
ECF volume increased by fluid gain or fluid and Na+ gain
HOMEOSTASIS RESTORED
HOMEOSTASIS
Normal ECF volume
HOMEOSTASIS DISTURBED
ECF volume decreased by fluid loss or fluid and Na+ loss
HOMEOSTASIS RESTORED
Increased urinary Na+ retention
Decreased urinary water loss
Increased water intake
Decreased blood volume and blood pressure
Increased renin secretion and angiotensin II activation
Increased aldosterone release
Increased ADH release
Increased thirst

Fluid and electrolyte imbalances

1. Due to disturbances in volume:
   a. Hypervolaemia
   b. Hypovolaemia
2. Disturbances in concentration:
   a. Hypernatraemia
   b. Hyponatraemia
3. Due to disturbances in composition
   a. Acid-base balances
   b. Changes in concentrations of calcium, magnesium and potassium

Common laboratory tests to evaluate fluid disturbances due to volume

Hypervolaemia

- Serum electrolytes
- Serum Urea Nitrogen/CR
- Hematocrit
- Urine electrolytes
- Specific gravity
- Serum albumin
- 24 hour urine for Cr clearance

Hypovolaemia

- Serum electrolytes
- Urine – specific gravity
- Total protein
- LFT
- Creatinine clearance

Causes

Hypervolaemia causes

- Excessive infusion of intravenous fluids
- Retention of water in abnormal conditions such as cardiac, renal and hepatic failure
- Absorption of water as during transurethral resection of prostrate using distilled water.

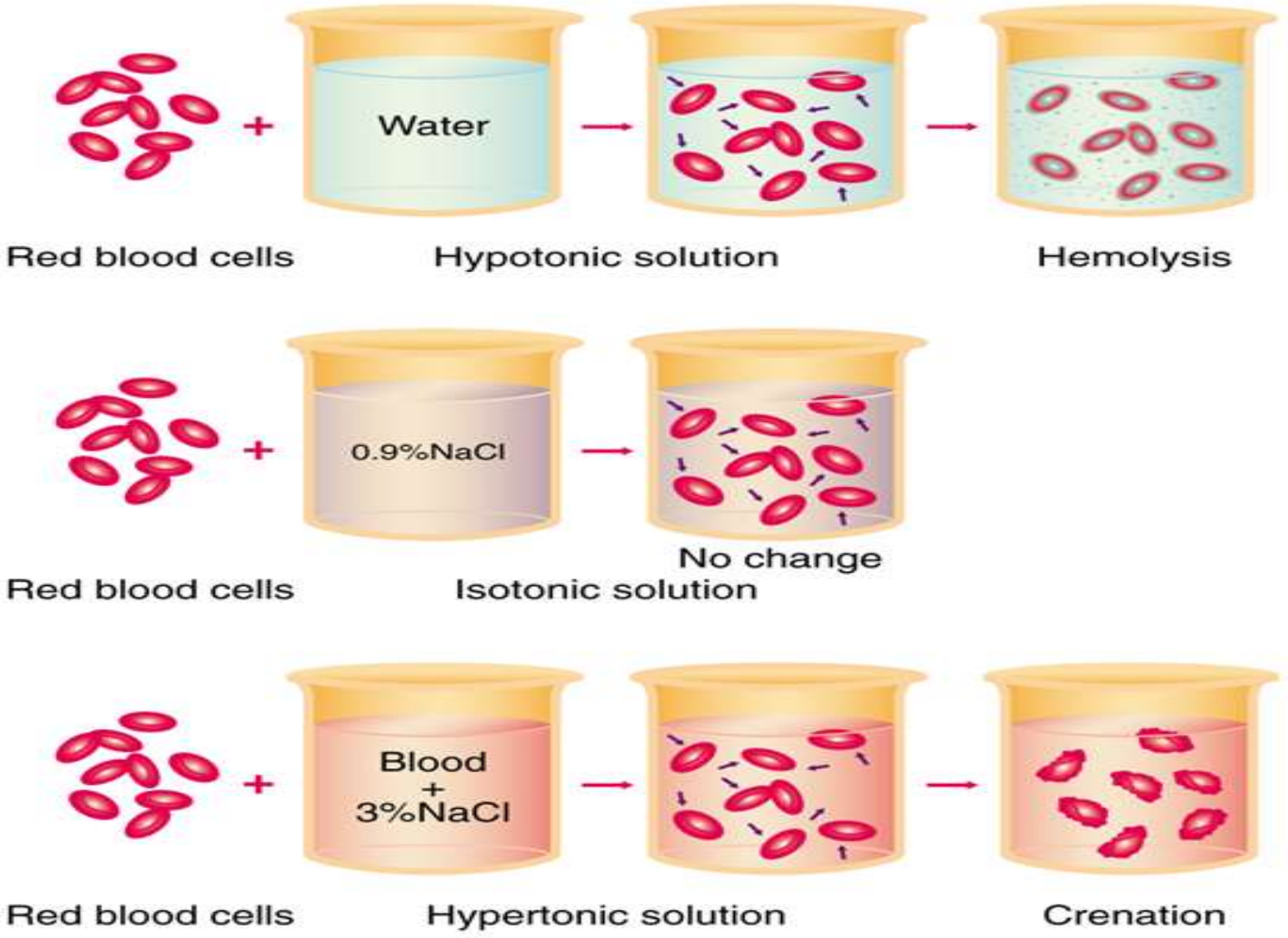
Hypovolaemia causes

- Vomitting, diarrhoea,fistulae
- When the patient is febrile: fluid loss increases by 12% with every centigrade rise in temperature
- Sequestration of fluid in third space/ interstitial space
- Burns
- Haemorrhage

Degree of dehydration	Loss of body weight (%)	Clinical features
Mild	5	Skin turgor, sunken eyes, dry mucous membranes
Moderates	10	Oliguria, hypotension tachychardia in addition to above
Severe	15	Profound symptoms

Manangement:

1. Treat the cause
2. Regulation of water and salt
3. Diuretics or dialysis: to remove excess of water in case of hypervolaemia


Water
Red blood cells
Hypotonic solution
Hemolysis
0.9%NaCl
No change
Red blood cells
Isotonic solution
Blood
+
3%NaCl
Red blood cells
Hypertonic solution
Crenation

Signs and symptoms of Hypernatraemia	Signs and symptoms of Hyponatraemia
Confusion	Confusion
Lethargy	Lethargy
Coma	Stupor
Seizures	Coma
Hyperflexia	Nausea
	Vomiting
	Head ache
	Muscle twitching
	Seizures

Etiology and management of hypernatremia

Hypernatremia	Etiology	Treatment
Hypervolemic	Administration of hypertonic sodium-containing solutions, mineralocorticoid excess	Diuretics
Isovolemic	Insensible skin and respiratory loss, diabetes insipidus	Water replacement[a]
Hypovolemic	Renal losses, gastrointestinal losses, respiratory losses, profuse sweating, adrenal deficiencies	Isotonic NaCl, then hypotonic saline

Imbalance of composition:

- Acid-balance imbalance
- Imbalance of potassium
- Imbalance of calcium
- Imbalances of chloride
- Imbalances of magnesium

Alkalosis

Respiratory Alkalosis

Deficit

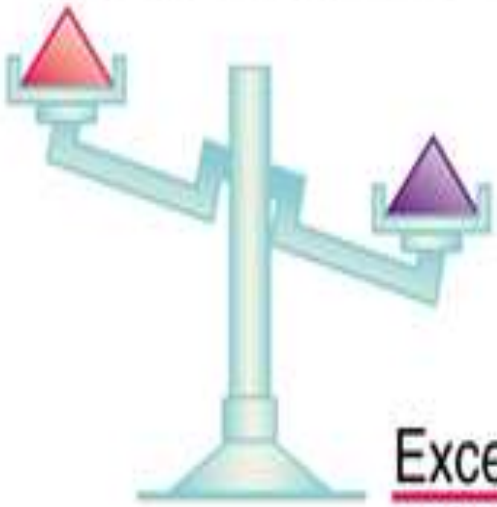
H_2CO_3

(Acid)

pH ↑

$PaCO_2$ ↓

Metabolic Alkalosis



Excess

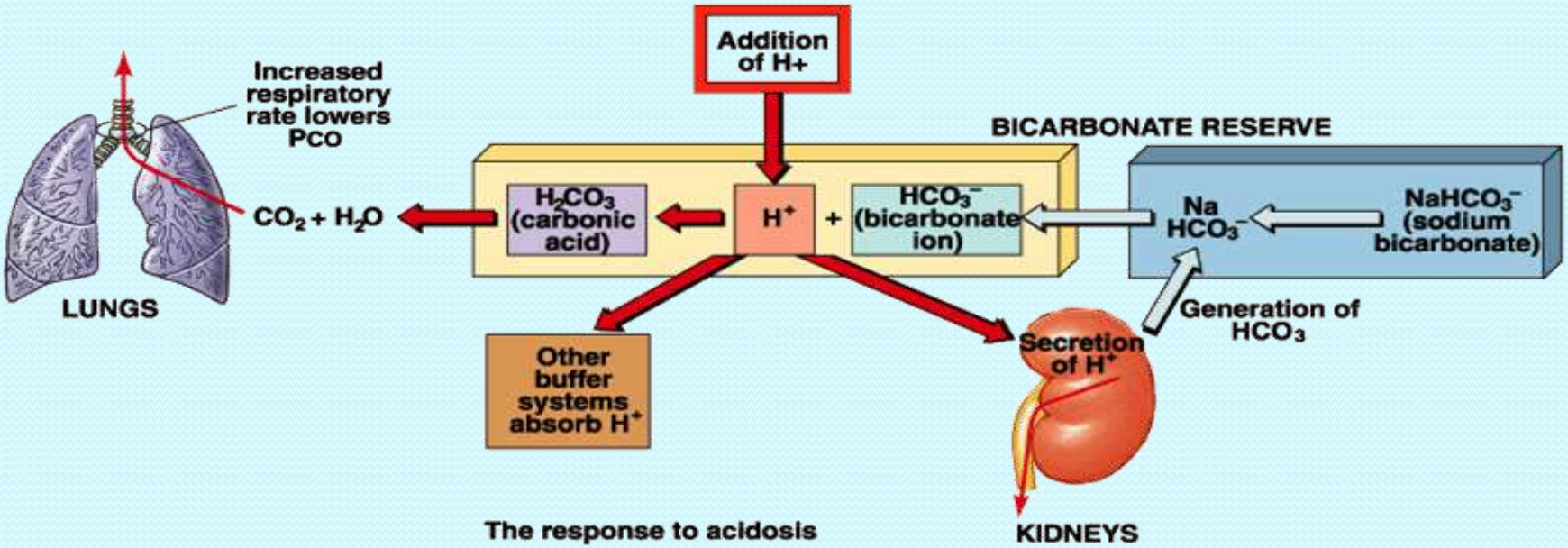
HCO_3^-

(Bicarbonate)

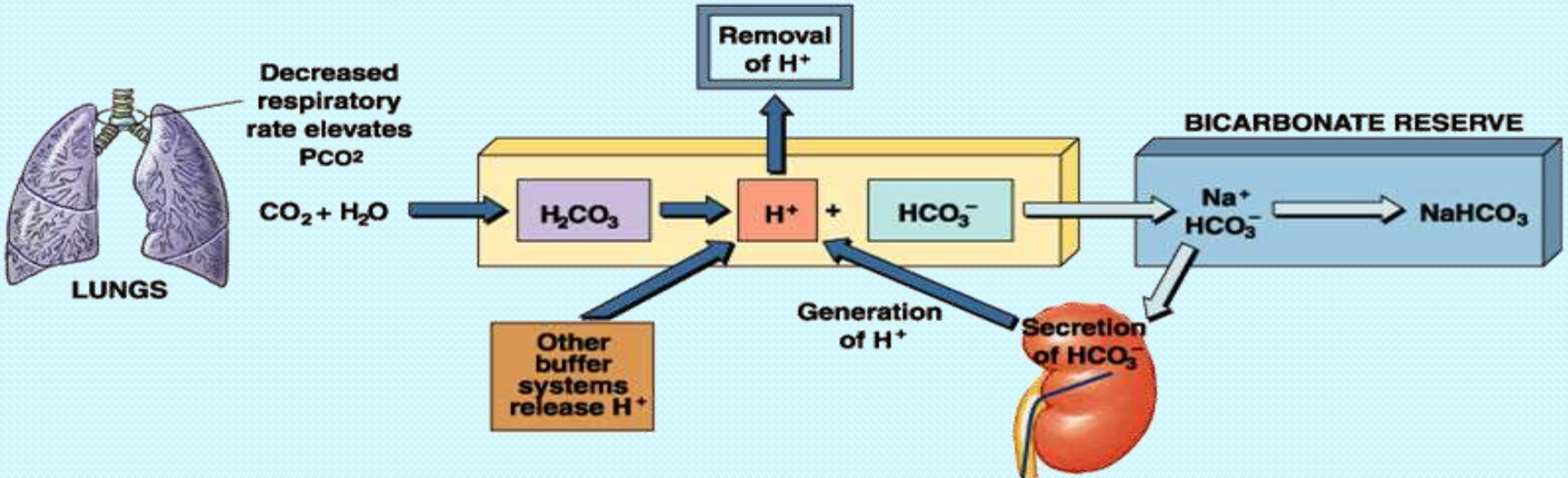
pH ↑

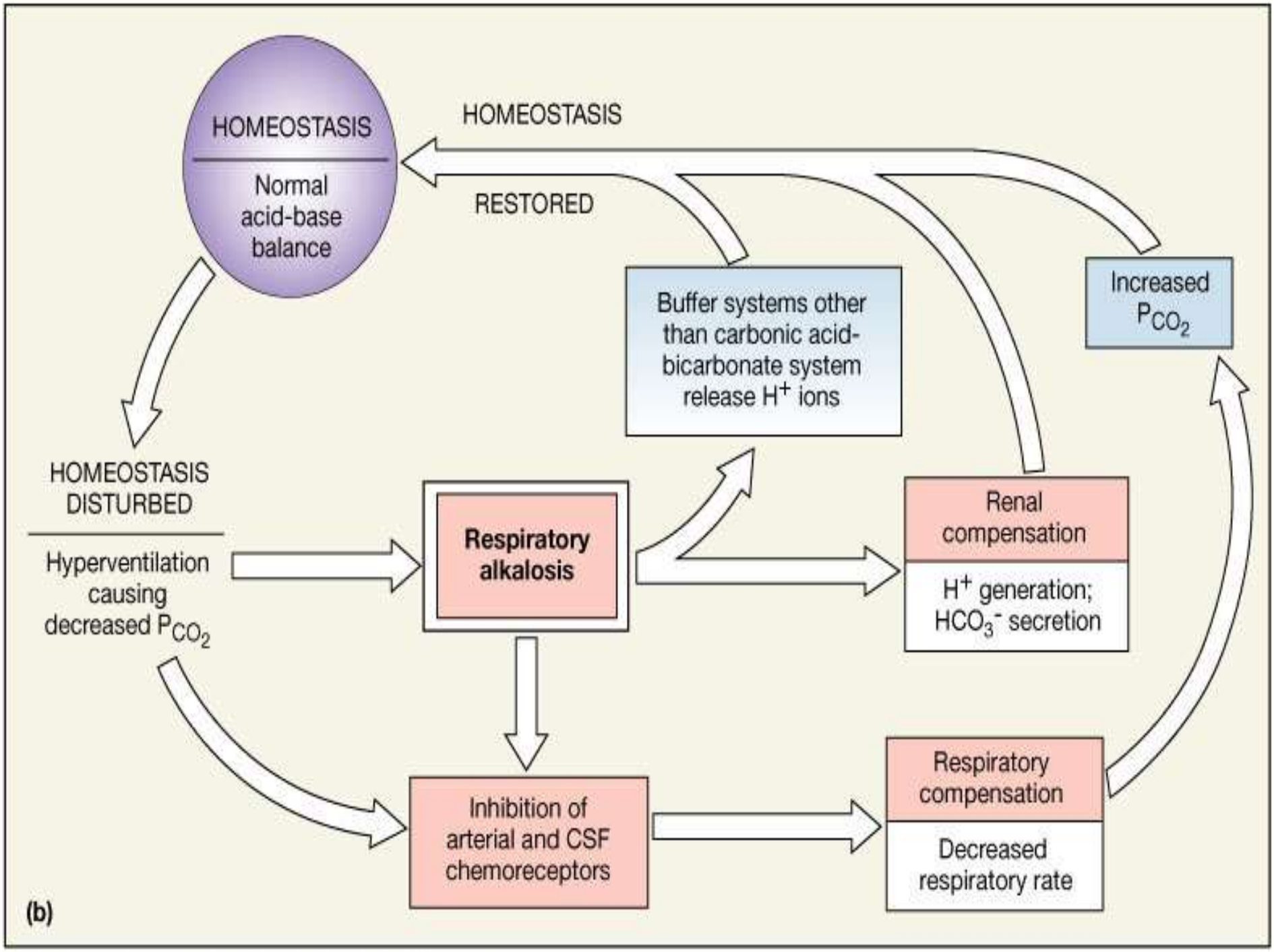
HCO_3^- ↑

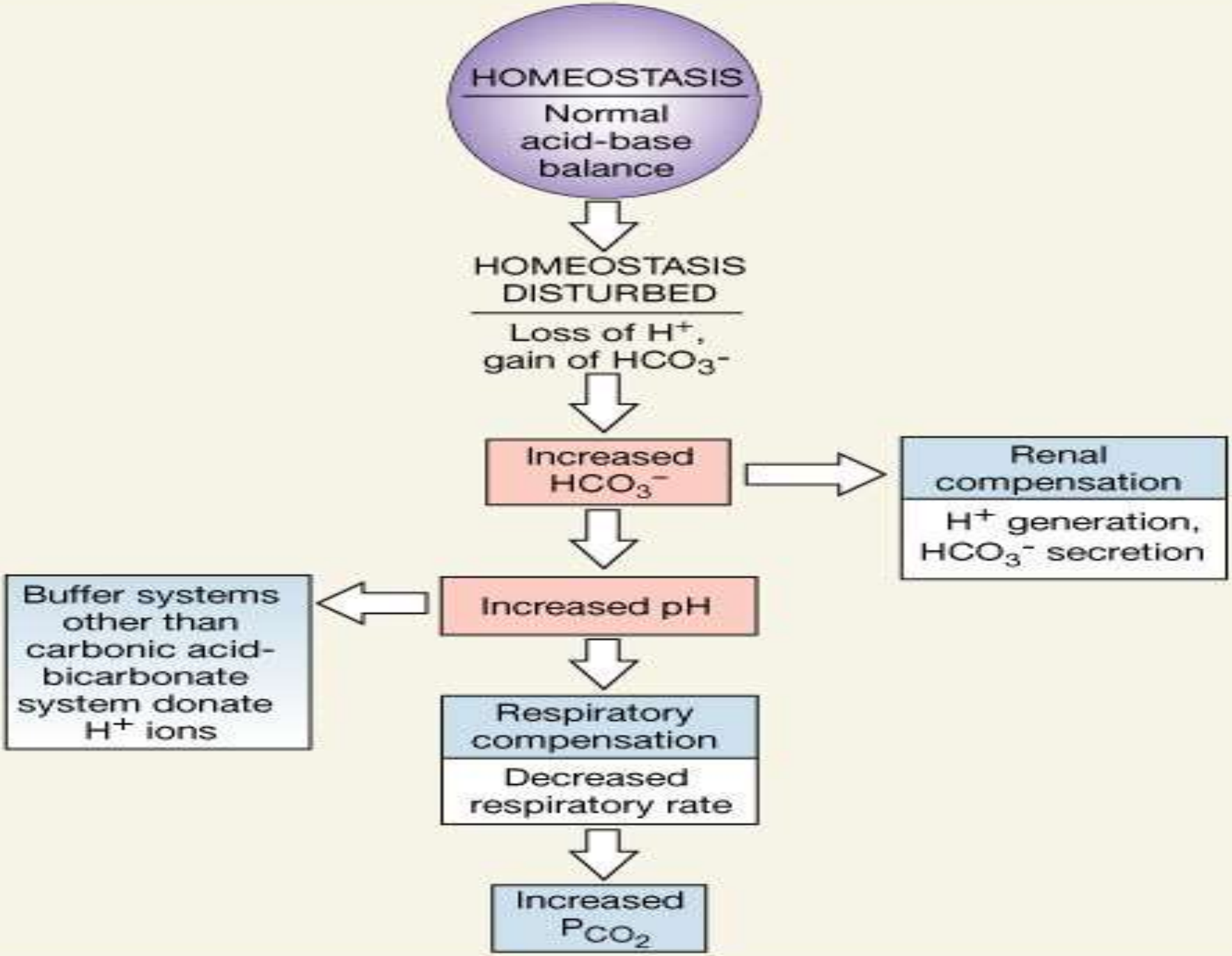
Serum CO_2 ↑



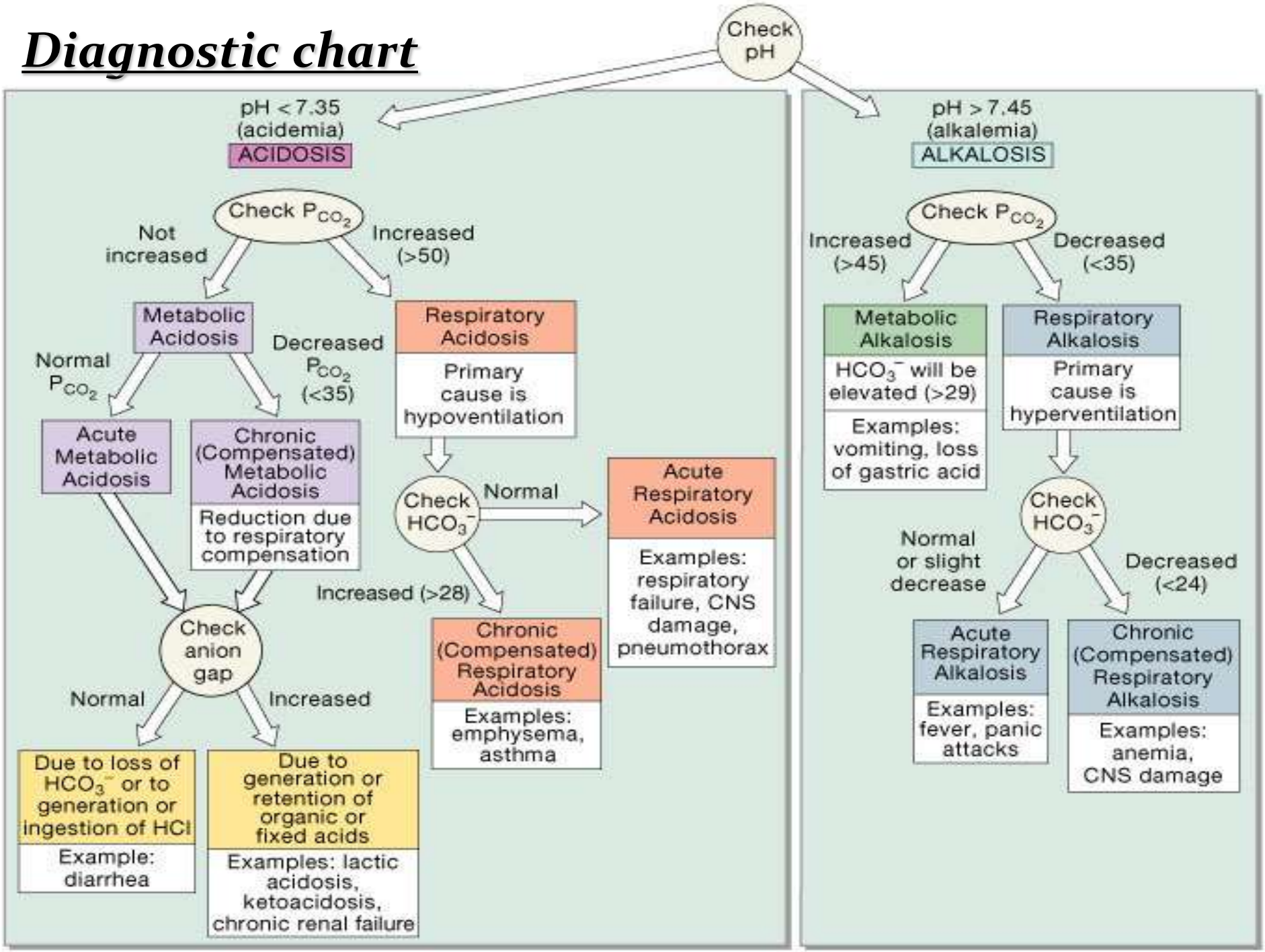
The response to acidosis




HOMEOSTASIS
Normal acid-base balance
HOMEOSTASIS
RESTORED
Buffer systems other than carbonic acid-bicarbonate system release H^+ ions
Increased P_{CO_2}
HOMEOSTASIS DISTURBED
Hyperventilation causing decreased P_{CO_2}
Respiratory alkalosis
Renal compensation
H^+ generation; HCO_3^- secretion
Inhibition of arterial and CSF chemoreceptors
Respiratory compensation
Decreased respiratory rate
(b)


HOMEOSTASIS
Normal acid-base balance
HOMEOSTASIS DISTURBED
Loss of H^+, gain of HCO_3^-
Increased HCO_3^-
Renal compensation
H^+ generation, HCO_3^- secretion
Increased pH
Buffer systems other than carbonic acid-bicarbonate system donate H^+ ions
Respiratory compensation
Decreased respiratory rate
Increased P_{CO_2}

Diagnostic chart

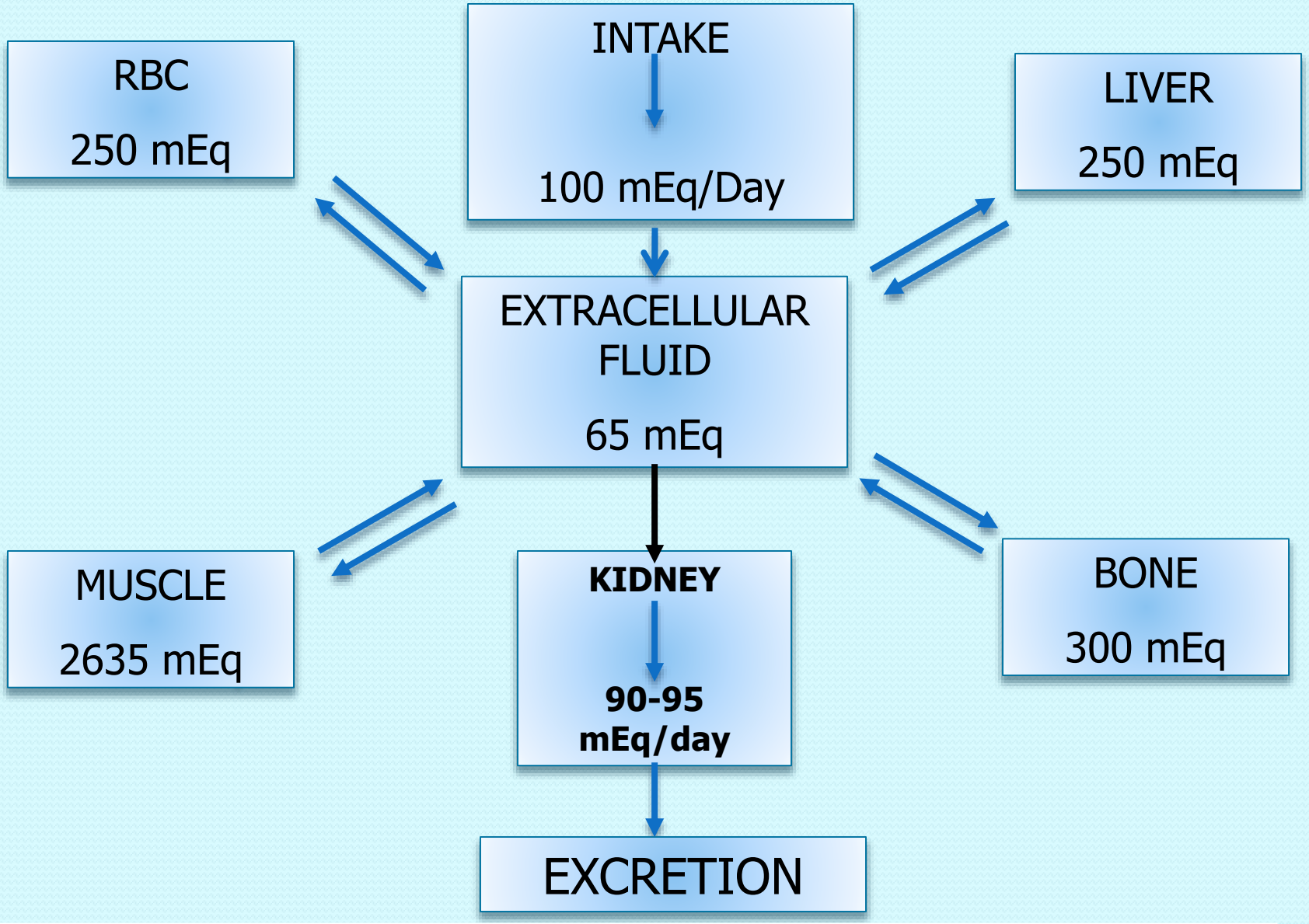


Imbalances in levels of potassium

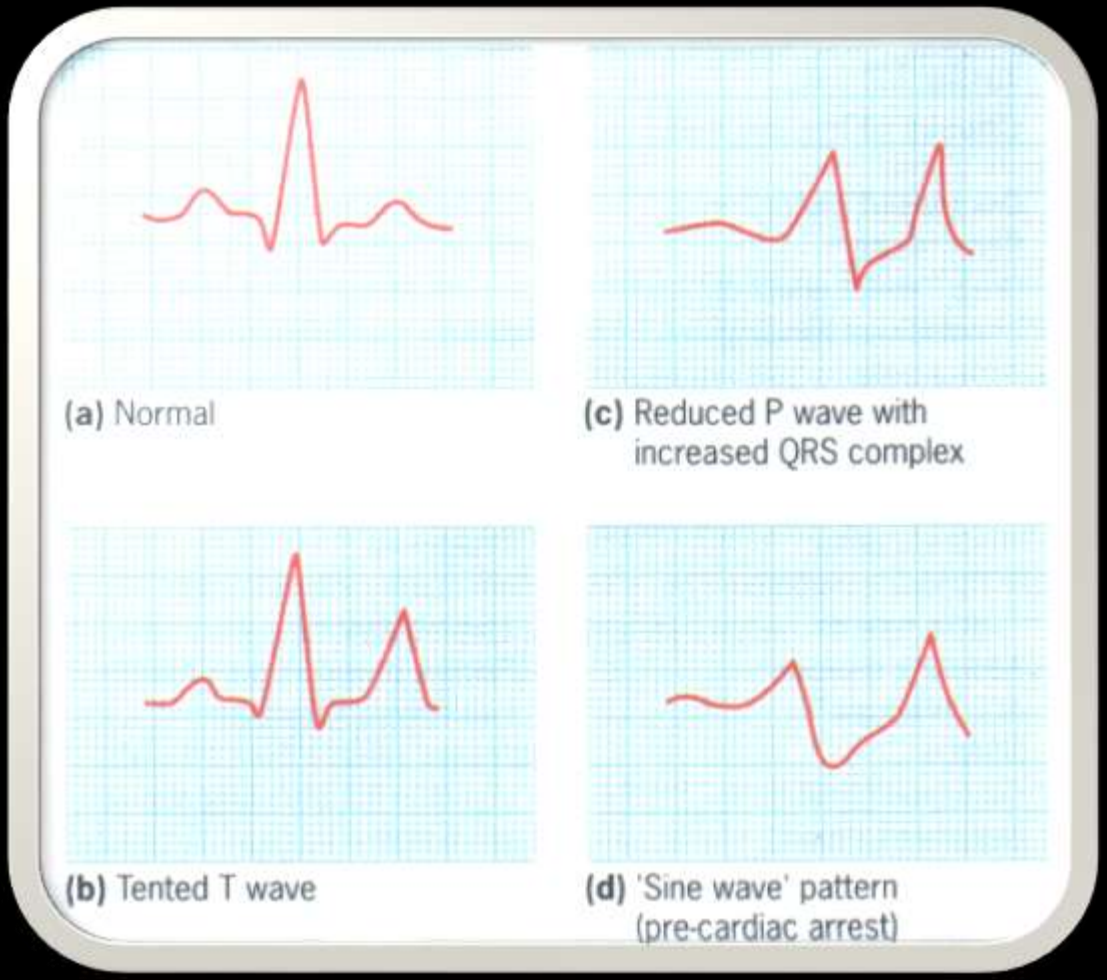
- **Major cation in intracellular compartments**
  - Regulates metabolic activities, necessary for glycogen deposits in liver and skeletal muscle, transmission and conduction of nerve impulses, normal cardiac conduction and skeletal and smooth muscle contraction
  - Regulated by dietary intake and renal excretion
  - Normal level – 3.5 - 5.1 mEq/L
    - Body conserves potassium poorly
      - Increased urine output decreases serum K^+

- *For every 3 k^+ ions going out 2 Na^+ ions and 1 H^+ enter the cell resulting in intracellular acidosis and extracellular alkalosis*

DISTRIBUTION OF POTASSIUM



Signs and symptoms in hypokalaemia	Signs and symptoms in hyperkalaemia
NEUROMUSCULAR ❖ Muscle weakness ❖ Hypo reflexia ❖Paralysis	NEUROMUSCULAR ❖ Muscle weakness ❖Paralysis
GASTROINTESTINAL ❖Paralytic ileus	CARDIAC ❖T- wave peak, flattened P-waves, prolonged PR, widened QRS complex ❖ST segment depression ❖Cardiac arrest ❖Ventricular fibrillation
RENAL ❖Polydipsia ❖Polyurea	
CARDIAC ❖T- wave inversion of flattening ❖ST segment depression	


(a) Normal
(c) Reduced P wave with increased QRS complex
(b) Tented T wave
(d) 'Sine wave' pattern (pre-cardiac arrest)

Treatment

Hypokalaemia

- Correction of alkalosis/acidosis, Volume deficits
- Other electrolyte disturbances.
- Replace GI fluids upto upper limits of loss if person has normal renal function.
- Oral supplements like fresh fruits and vegetables or potassium supplements of 20 to 40 mmol daily.
- Patients with high renal use potassium sparing diuretics Eg. Spironolactone.

Hyperkalaemia

- Identify and treat cause
- Specially check renal function
- 10 – 20 mL intravenous 10% Calcium Chloride/ Calcium Gluconate over 10 min in patients with ECG abnormalities: helps in membrane stabilization.
- Sodium bicarbonate 50 mEq/l shift k+ into cells
- 50 mL 50% dextrose plus 10 units short acting insulin over 2-3min: shifts k+ into cells.
- Monitor plasma glucose and K+ over next (30-60 min)
- Regular Salbutomol nebulizers
- Consider oral or rectal Ca^{+2}
- Resonium (ion exchange resin)
- Haemodialysis for persistent hyperkale
- Potassium binding resin
  Kayexalate – Na polystyrene sulfonate

  K Bind – Calcium polystyrene sulfonate
  - 15 - 30 gms orally in sorbitol (3ml/gm) every 6 hours [1 gm/kg / dose]
    - 1 gm binds 1meq of K
  - Can be given per rectally but takes long time for action and cumbersome

Points to Remember in Hypokalaemia

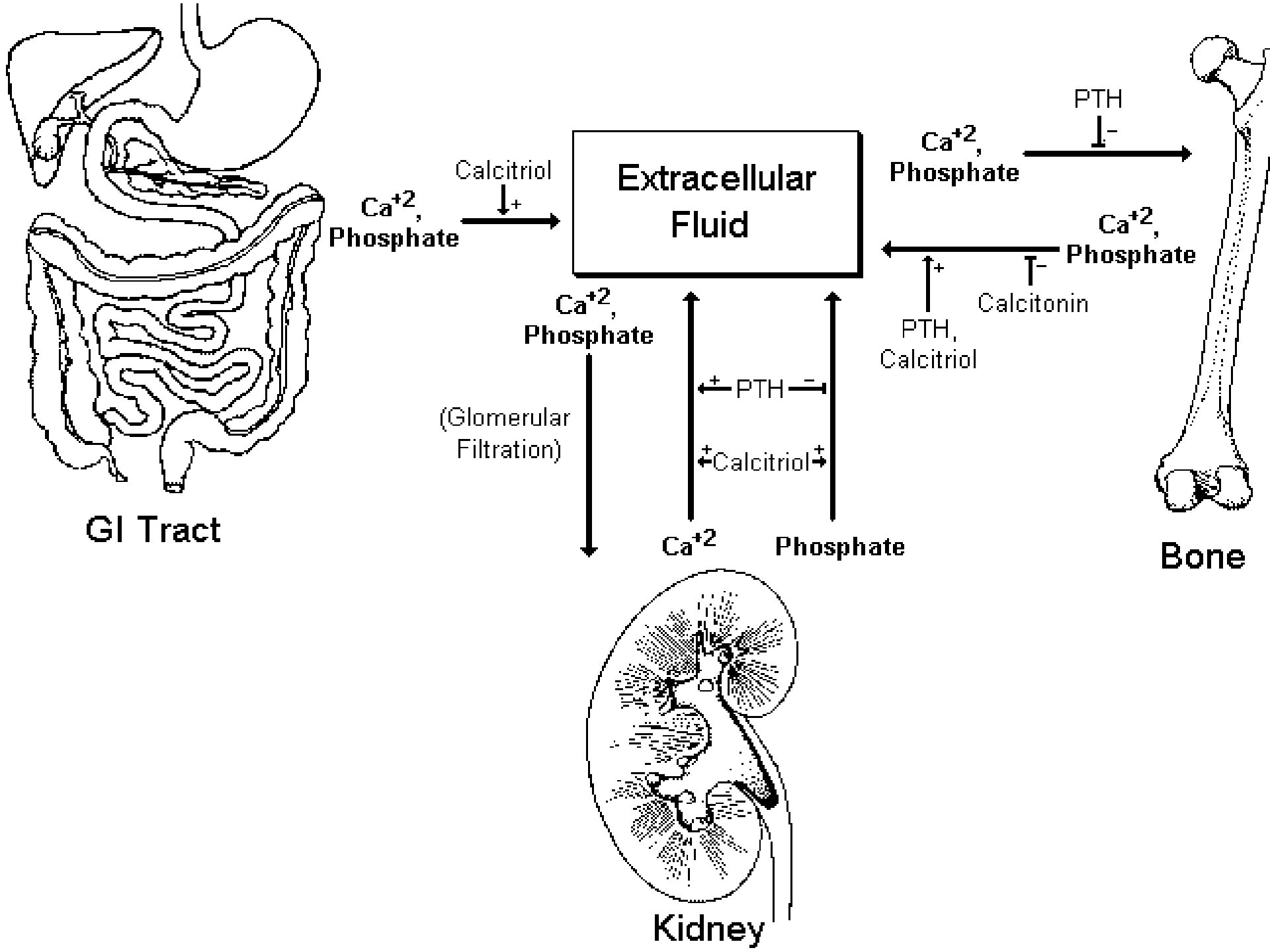
- In emergency situation 20-40mEq / hr of potassium can be given with frequent monitoring of cardiac status and serum potassium levels.
- In non-emergency situations 10mEq of potassium / hr
- Use glucose free solutions as glucose drives potassium intracellularly.
- In the absence of specific indications potassium should not be given
    1. To oliguric patients
    2. During the first 24 hours following severe surgical stress or trauma.

Imbalances in levels of Calcium

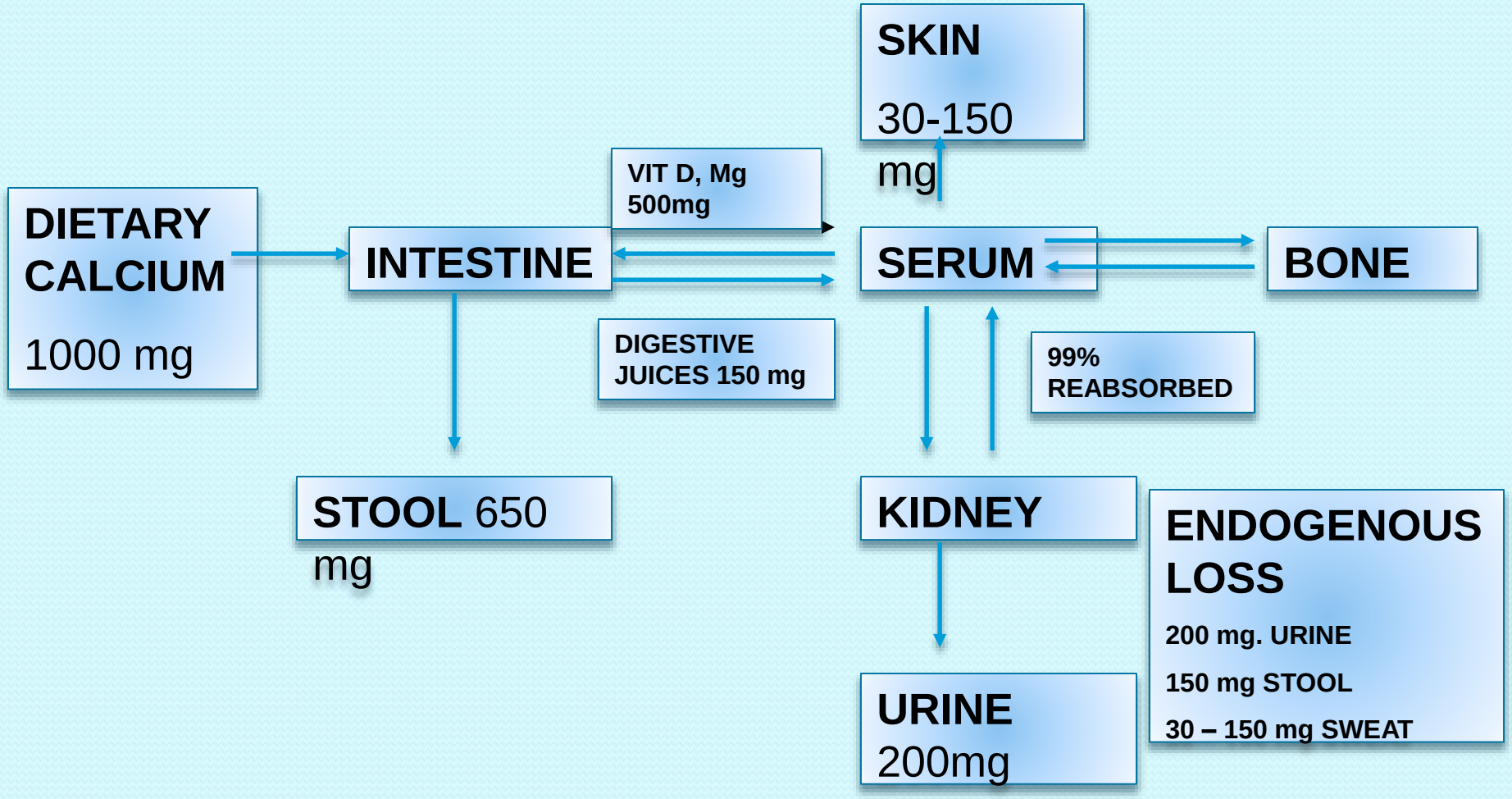
Stored in bone, plasma and body cells

- 90% in bones
- 1% in ECF
  - In plasma, binds with albumin
- Necessary for bone and teeth formation, blood clotting, hormone secretion, cell membrane integrity, cardiac conduction, transmission of nerve impulses, and muscle contraction

- Calcium concentrations must be interpreted with respect to the serum albumin, because 40% to 60% of total serum calcium is bound to albumin
  - Normal level – 4.5-5.5 mEq/L or 8 – 11 mg%
  - Regulated by
    - Calitonin
    - Paratharmone
    - Calcitriol


GI Tract
Ca+2, Phosphate
Calcitriol
+
Extracellular Fluid
Ca+2, Phosphate
PTH
−
Bone
Ca+2, Phosphate
+
PTH, Calcitriol
−
Calcitonin
Ca+2, Phosphate
(Glomerular Filtration)
+
PTH
−
+
Calcitriol
+
Ca+2
Phosphate
Kidney

CALCIUM TRANSFER AND EXCRETION



Causes

Hypercalcemia (Ca^{+2} > 5mEq/L or > 11mg %)

- Hyperparathyroidism
- Malignant neoplastic disease
- Paget's disease
- Osteoporosis
- prolonged immobilization
- Acidosis

Hypocalcemia (Ca^{+2} < 4.0mEq/L or < 8mg%)

- severe illness
- Hypoalbuminemia
- Hypoparathyroidism
- Vitamin D deficiency
- Blood transfusion with citrate
- Alkalosis

Signs and symptoms

Hypercalcemia (Ca^{+2} > 5mEq/L or > 11mg %)

- Anorexia
- nausea
- Vomiting
- Weakness
- kidney stones

Hypocalcemia (Ca^{+2} < 4.0mEq/L or < 8mg%)

- Numbness and tingling
- Hyperactive reflexes
- Pathological fracture
- Muscle cramps
- Tetany

Neuromuscular signs

- Chvostek's sign
- Trousseau's sign
- Erb's sign
- Laryngmus stridor leading to production of characteristic crowing sound

Phosphate imbalance

Hypophosphatemia less than 2.5 mg/dl

Etiologies

- Decreased GI Absorption
  - Decreased dietary intake (rare in isolation)
  - Diarrhea / Malabsorption
  - Phosphate binders (calcium acetate, Al & Mg containing antacids)
- Decreased Bone Resorption / Increased Bone Mineralization
  - Vitamin D deficiency / low calcitriol
  - Hungry bones syndrome
  - Osteoblastic metastases
- Increased Urinary Excretion
  - Elevated PTH (as in primary hyperparathyroidism)
  - Vitamin D deficiency / low calcitriol
  - Fanconi syndrome

Hypophosphatemia more than 5.0 mg/dl

Etiologies

- Increased GI Intake
  - Phospho-Soda
- Decreased Urinary Excretion
  - Renal Failure
  - Low PTH (hypoparathyroidism)
- Cell Lysis
  - Rhabdomyolysis
  - Tumor lysis syndrome

Clinical features and treatment

Hypophosphatemia less than 2.5 mg/dl

- Lethargy
- Hypotension
- Cardiac arrythmias
- Skeletal demineralization

Hyperphosphatemia more than 5.0 mg/dl

- pruritis

Treatment

Mild	Moderate	severe
2.0-3.0	1.5-2.0	Less than 1.5 mg/dl
0.16mm/kg over 4-6 hours dissolved in 100 ml	0.32 mm/kg over 4-6 hours dissolved in 50 ml	0.64 mm/kg over 8-12 hours dissolved in 100 ml

Treatment

1. Phosphate intake restriction
2. Hydration to promote excretion
3. Phosphate binders like calcium acetate or carbonate
4. Insulin infusion or D50% infusion

Chloride Balance

- Major anion in ECF
  - Normal level – 95-108mEq/L
    - Follows sodium
  - Regulated by dietary intake and the kidneys
- Disturbance usually seen with acid-base imbalance
  - Hyperchloremia (Na >145, Bicarb <22)
    - Serum bicarbonate values fall or sodium rises
  - Hypochloremia (pH > 7.45)
    - Excess vomiting or N/G drainage; loop diuretics because of sodium excretion
      - Leads to metabolic alkalosis due to reabsorption of bicarbonate to maintain electrical neutrality .

Magnesium Balance

- Normal conc. 1.5 – 2.4 mg%
- Essential for proper functioning of enzyme systems
- Depletion characterised by neuromuscular & CNS hyperactivity.

↓ Mg^{+2}

Chvostek & Trousseau sign

↑PR & QT interval with cardiac arrythmias

Treatment

if < 1.5mg% = 1 mEq/ Kg

if 1.5 – 1.8mg% = o.5mEq/ kg

↓Mg^{+2}

Respiratory Depression

↓BP, Cardiac arrest, Hyporeflexia

Treatment

-Calcium Infusion

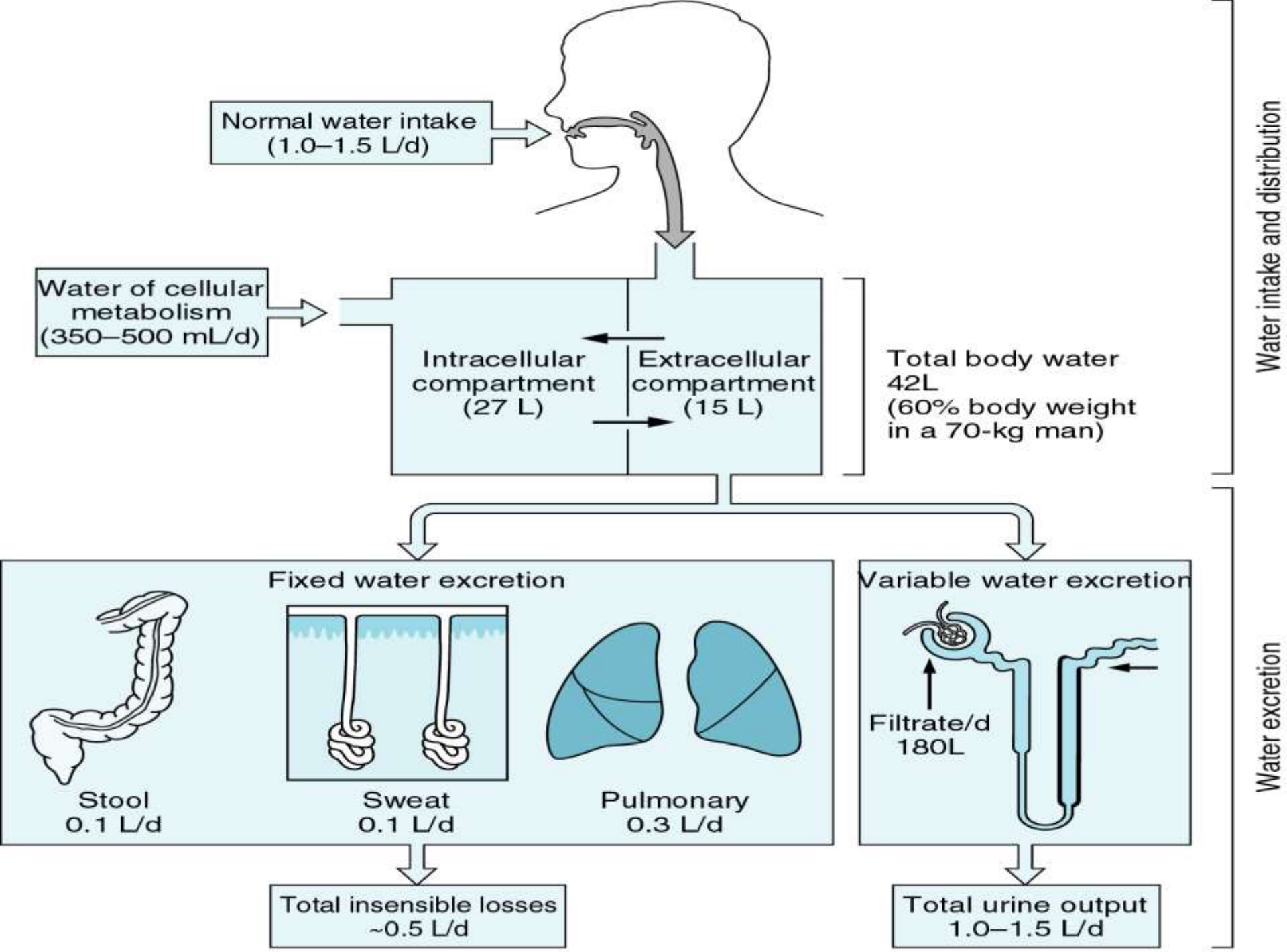
-Loop diuretics with NS

-$MgCl_2$ / $MgSo_4$

Principles of Fluid Therapy

Whenever fluid therapy is contemplated in a patient, the following basic questions must be considered….

1. Does the patient need fluid..?
2. Which fluid would be most suitable..?
3. How much fluid is needed..?
4. At what rate..?
5. Which route is to be used..?
6. What are the likely complications..?


Normal water intake
(1.0–1.5 L/d)
Water of cellular metabolism
(350–500 mL/d)
Intracellular compartment
(27 L)
Extracellular compartment
(15 L)
Total body water
42L
(60% body weight
in a 70-kg man)
Water intake and distribution
Fixed water excretion
Variable water excretion
Stool
0.1 L/d
Sweat
0.1 L/d
Pulmonary
0.3 L/d
Filtrate/d
180L
Total insensible losses
~0.5 L/d
Total urine output
1.0–1.5 L/d
Water excretion

Clinical Evaluation

Changes in body weight should be recorded accurately and repeatedly on a day to day basis....

Weight loss > 300 to 500gms per day indicate dehydration secondary to decreased fluid intake and / or increased water losses.

Water loss	Degree of Dehydration
4% of body wt	Mild
6% " "	Moderate
8% " "	Severe

Detecting Dehydration

- Skin pinch test
  - falls back instantly - normal
  - 2 - 4 sec - moderate
  - 4 -6 sec - severe
- Capillary refill
  - press finger on gums above an upper tooth
    - if it takes longer than 2 seconds for blood to return - dehydration

Does the Patient Need Fluids..

- **Pre-existing disease processes**
  - **Cancer, cardiovascular, renal, GI**
- **Age**
  - **Infants have higher % water- loss felt faster**
  - **Elderly –kidneys decreased filtration rate, less functioning nephrons, don't excrete mediations as fast**
- **Acute illness**
  - **Surgery, burns, respiratory disorders, head injury**
- **Environmental**
  - **Vigorous exercise, temperature extremes**
- **Diet**
  - **Fluids and electrolytes gained through diet**
- **Medications**
  - **Side-effects may cause fluid and/or electrolyte imbalances**

Medications Likely to Cause F&E Imbalances

- **Diuretics**
  - Metabolic alkalosis, hyperkalemia, hypokalemia
- **Steroids**
  - Metabolic alkalosis
- **Potassium supplements**
  - GI disturbances
- **Respiratory center depressants** (narcotic analgesics)
  - Respiratory acidosis
- **Antibiotics**
  - Nephrotoxicity, hyperkalemia, hypernatremia
- **Calcium carbonate**
  - Metabolic alkalosis
- **Magnesium hydroxide** (Milk of Mag)
  - hypokalemia

Diagnostics

- Hematocrit

normal value in males – 44 -52%

females – 39 -47%

  - If no anemia, can indicate hydration status
- Blood creatinine
  - Measure kidney function
    - Excreted at constant level if no kidney disease
- Blood urea nitrogen
  - Indicates kidney function
    - May be affected by cell destruction or steroid therapy
      - Decrease may indicate malnutrition or hepatic damage
      - Increases with decrease in ECF volume
- Serum and urinary electrolyte levels
- Urine specific gravity

Assessment of Intravascular Depletion

- **5%** — **thirst, dry mucous membranes, UO 1-2 ml/kg/hr**
- **10%** — **tachycardia, oliguria, UO 0.5-1 ml/kg/hr**
- **15%-20%** — **tachycardia, hypotension, severe oliguria, UO < 0.5 ml/kg/hr**

OSMOLALITY

- **Measure of solution's ability to create osmotic pressure & thus affect movement of water**
- Number of osmotically active particles per kilogram of water
- Plasma osmolality is 280-**300*** mOsm/ kg
- ECF osmolality is determined by sodium
- MEASURE used in clinical practice to evaluate serum & urine

Osmolality In Clinical Practice

- Serum 280-300mOsm/kg; Urine 50-1400mOsm/kg
- Serum osmolality can be estimated by doubling serum sodium
- Urine specific gravity measures the kidneys' ability to excrete or conserve water
- Nl range 1.010 to 1.025 (compared to weight of distilled water with sp g of 1.000)

What Fluids to Give..

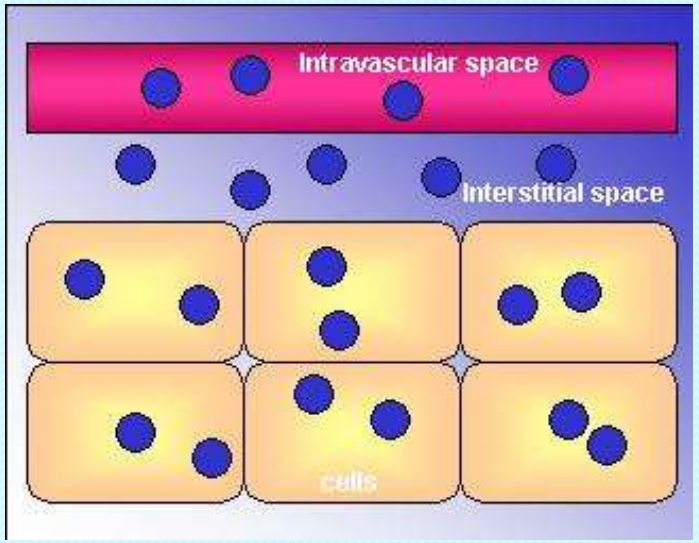
- Choice of a particular fluid depends on
  - Volume status
  - Concentration abnormality
  - Compositional abnormality

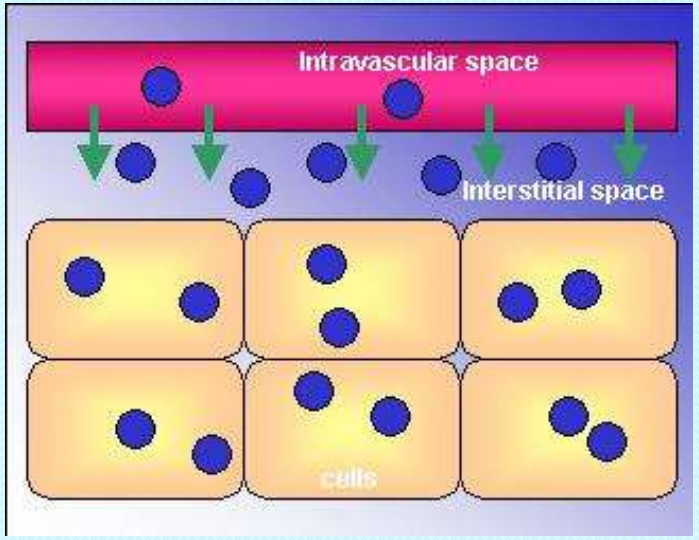
- **Crystalloids:**

  - contain Na as the main osmotically active particle
  - useful for volume expansion (mainly interstitial space)
  - for maintenance infusion
  - correction of electrolyte abnormality

Crystalloids

- **Isotonic crystalloids**
  - Lactated Ringer's, 0.9% NaCl
  - only 25% remain intravascularly
- **Hypertonic saline solutions**
  - 3% NaCl
  - 7% NaCl
- **Hypotonic solutions**
  - 0.45% NaCl
  - less than 10% remain intra-vascularly, inadequate for fluid resuscitation

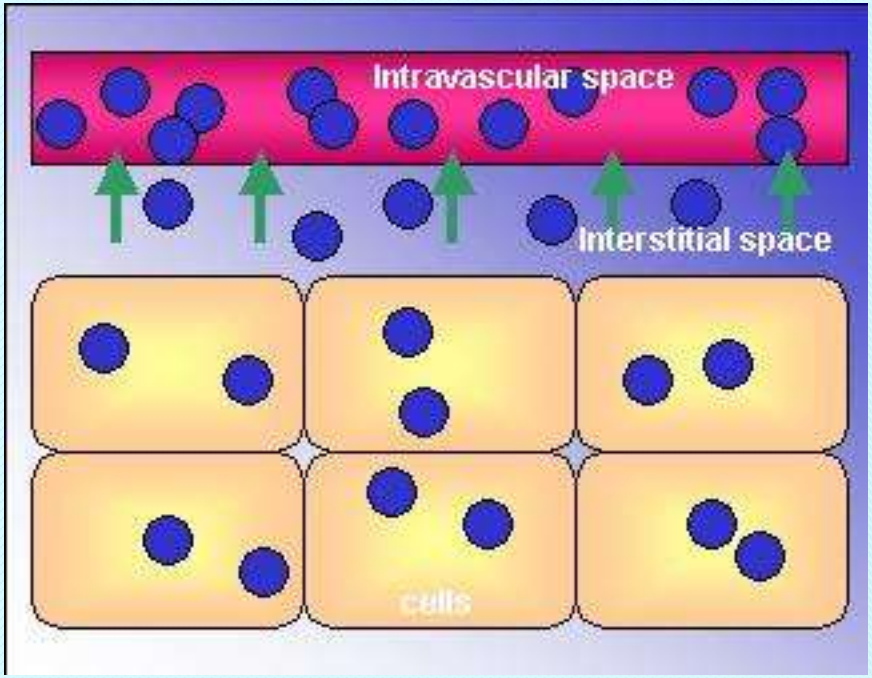




Colloid Solutions

- Contain high molecular weight substances→do not readily migrate across capillary walls

- Preparations
  - Albumin: 5%, 25%
  - Dextran
  - Gelifundol
  - Hetastarch



Colloids

A colloid solution contains suspended substances that do not settle out of the solution. Most of the suspended substances are plasma proteins, which include albumin, globulins, and fibrinogen.

Types include:

1. Fresh frozen plama and albumin
2. Plasmanate- fluid with albumin, globulins and fibrinogen
3. Dextran – higly concentrated glucose solution
4. Hespan – heta starch in synthetic plasma

	Crystalliod	Colloid
Intravascular persistance	Poor	Good but with risk of CHF and pulmonary edema
Haemodynamic stabilisation	Transient $t_{1/2}$ ~ 30 mins	Prolonged $t_{1/2}$ ~ 90 mins
Required infusion volume	Large Ratio 3:1 to loss	Moderate Ratio 1:1 to loss
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

What solution to give…

- *Oral electrolyte solution:*

  This solution is isotonic and provides a rich source of Na^+, K^+, Cl^- and dextrose. The sodium citrate tends to correct any acidosis.

- *IV fluids*:

  0.9% Sodium Chloride

  - iso osmolar with plasma
  - serves a good replacement solution for ECF volume
  - chloride content - higher than that of plasma infusion → too much of normal saline may produce hyperchloraemic acidosis
  - indication : ECF def in the presence of hypernatremia, hypochloremia & metabolic alkalosis…

Dextrose 5% in Water

- It provides 50gms of dextrose / L.
- slightly hypertonic to plasma
- after infusion dextrose is metabolized→ water is left in the ECF…
- too much of 5% dextrose may cause dilution and hypotonicity of ECF and water loading, if kidneys are not functioning normally.

Dextrose 5% with 0.9% Saline.

- Its twice as hypertonic as plasma…
- However within a few hours glucose is used and there is no significant change in the plasma tonicity…

Lactated Ringers Solution.

- This is slightly hypo osmolar compared to plasma
- Minimum effect on pH & normal body fluid composition
- Replaces both G.I. & ECF losses
- Used in correcting metabolic acidosis….
- Should not be given in patients with liver diseases and in presence of lactic acidosis.

***Ringers Acetate Solution*.**

- slightly hypo osmolar to plasma…
- main use is as a replacement for ECF deficits in patients with damaged liver or lactic acidosis..
- helps in correction of mild to moderate metabolic acidosis.

0.45% Sodium Chloride in 5% Dextrose Solution

- It is used as maintenance fluid in postoperative period.
- Provides sodium for renal adjustment
- Potassium may be added to be used for maintenance requirements in uncomplicated pt requiring only a short period of parenteral fluids.

7.2-7.5 % Sodium Chloride

- Studies have shown that even with 50% blood loss, a small volume of 7.2-7.5% NaCl restores the cardiac output and blood pressure within one minute.
- This saline is given through a peripheral vein very fast over 2 to 5 mins. And this results in rise in the plasma sodium level and plasma osmolality causing a shift of body water in the vascular tree

Hetastarch

- Mixture of derivatized amylopectin of various mol. Wt.
- Derivatization increases resistance to enzymatic hydrolysis
- Vol. expansion ~ 100 – 172 % of infused volume
  - seen for 24 – 36 hrs.

Dextran

- It's a polysaccharide in 0.9% NaCl / 5% Dextrose
- Two types
  - 40 – lasts for 6 hrs
  - 70 – lasts for 24 hrs
- Facilitates agglutination of RBC. Thus interferes with susequent cross matching of blood

Human Plasma

- Used for resuscitation of shock patient and for maintenance of I.V. fluid therapy
- It has a composition and osmolality similar to ECF.

Human Albumin

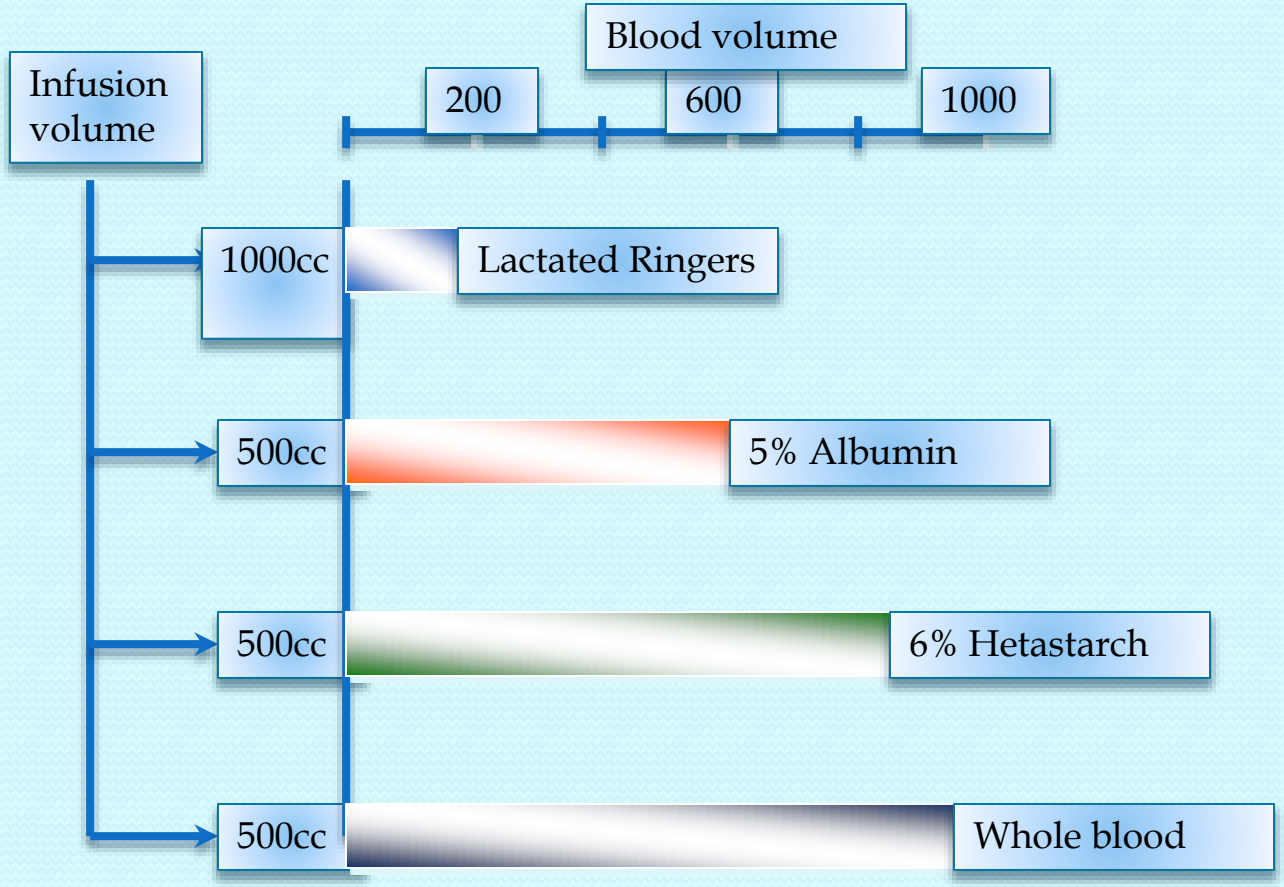
- 20% purified human albumin is commercially available. Its volume expansion capacity is 400 per cent.
- Rarely, anaphylactoid reaction has been reported with albumin and may cause post resuscitation hypotension.

Composition of Parental Fluids (Electrolytes Content, mEq/L)

	Cations				Anions		
Solutions	*Na*	*K*	*Ca*	*Mg*	*Cl*	*HCO_3*	*Osmolality, mO*
Extracellular fluid	142	4	5	3	103	27	280–310
Lactated Ringer's	130	4	3	—	109	28*	273
0.9% sodium chloride	154	—	—	—	154	—	308
D_5 45% sodium chloride	77	—	—	—	77	—	407
D_5W	—	—	—	—	—	—	253
M/6 sodium lactate	167	—	—	—	—	167*	334
3% sodium chloride	513	—	—	—	513	—	1026

*Present in solution as lactate that is converted to bicarbonate.

The Influence of Colloid & Crystalloid on Blood Volume



What Route to be Used..

- As in normal health - oral Route.

- However when rapid correction of hypovolaemia and other electrolyte abnormalities indicated i.v. route provides a quick access to circulation.

- Other routes of parenteral therapy include
  - Subcutaneous
  - Per Rectal

What Rate to be Used..

- Standard recommendation for calculation of Hourly maintenance of Fluid Replacement are :

0 – 10 Kg	4 ml / kg
11 – 20 Kg	2 ml / Kg
> 20 kg	1 ml / kg

So in a 70 Kg person

(4×10) + (2 ×10) + (1× 50) = 110 ml/ hr

Fluid Regulation in Young

- Fluid balance in young is dicey because…
- In neonates most significant source of water loss is insensible water loss through skin ~ 7ml / kg / hr
- Under normal renal function
  - Infants & neonates – 2 ml / kg
  - Toddlers & school age – 1 ml / kg
- Daily K^+ req. = 2mEq/ kg
  Na^+ req. = 3 mEq/ kg
- Replacement by isotonic sol. with osmolality of ~ 285
- Maintenance fluid rate
  - 0 – 10 kg - 4 ml / kg / hr
  - 10 – 20 kg - 40 ml + 2 ml / kg / hr
  - > 20 kg - 60 ml + 1 ml / kg / hr

Fluid Balance in Pre Op. Period

1. Correct 3rd space losses
2. Correct Na^+ balance
3. K^+ to be corrected only when adequate urine output maintained
4. Check if blood replacement is required
5. Calculate Allowable Blood Loss
6. Prevention of volume depletion

Third Space Losses

- Isotonic transfer of ECF from ***functional*** body fluid compartments to ***non-functional*** compartments.
- Depends on location and duration of surgical procedure, amount of tissue trauma, ambient temperature, room ventilation
- Replacement of 3rd space losses
  - Minimum trauma : 3 – 4 ml / kg / hr
  - Moderate trauma : 5- 6 ml / kg /hr
  - Severe trauma : 7 – 8 ml / kg / hr
- Surgeon must remember that by 72 hours post op., this 3rd space loss becomes mobilised which results in increased intravascular volume

Allowable Blood Loss

$$\text{Allowable Blood Loss} = \text{estimated blood vol.} \times \frac{(Hi - Hf)}{Hi}$$

Estimated blood vol. = Wt (kg) × Avg. blood vol.

In a 75 kg male with Hi of 45 %

$$ABL = \frac{\{4.95 \times (45 - 31.5)\}}{45} = 1.4$$

In obese patients the formula is

$$ABL = \frac{ABW \times ABV \times (Hi - Hf)}{Hi}$$

Volume deficit calculated by multiplyin
Estimated blood volume by percentage
Blood loss

Body fluid and blood volumes

Fluid	Men	Women
Total body fluid	600 mL/kg	500 mL/kg
Whole blood	66 mL/kg	60 mL/kg
Plasma	40 mL/kg	36 mL/kg
Erythrocytes	26 mL/kg	24 mL/kg

End Parameters for Fluid Replacement Therapy

- Monitoring urine output, heart rate, BP on repeated basis and comparing them to measure fluid intake assists in determining fluid requirement ….
- Normal urinary output

  Adult 0.5-1 ml / kg / hr

  Child 2 ml / kg / hr

  adequate oxygen saturation

Box 11. Goals of volume resuscitation

1. Central venous pressure = 15 mm Hg
2. Pulmonary capillary wedge pressure = 10 to 12 mm Hg
3. Cardiac index > 3 L/min/m^2
4. Oxygen uptake (Vo_2) > 100 mL/min/m^2
5. Blood lactate < 4 mmol/L
6. Base deficit −3 to +3 mmol/L

Intra Op. Fluid Management

- If pre-op. volume deficit not addressed --- hypotension
- 3rd space losses to be addressed because of
  - Tissue Trauma
  - Extensive Dissection
  - May vary from min. to 3 Lt.
- But no lab methods to exactly quantify fluid loss
- So, clinically useful guidelines are
  1. Replacement of ECF should begin intra op.
  2. Blood should be replaced to maintain an acceptable RBC mass irrespective of any additional fluid/ electrolyte therapy
  3. Balanced salt sol. needed intra op. ~ 0.5 – 1 Lt/ hr.

     Only max. of 3 Lt. req. during 4 hr major surgery

Post Op. Fluid Management

0 – 24 hrs.

- Increased secretion of aldosterone & ADH
  - Na^+ & water retention
- If blood loss is there, replace it
- Replace fluid deficit
  - DNS or RL
- Should not administer K^+ unless definitive deficiency present

24 – 48 hrs.

- Replace insensible losses which may vary from 900 – 1500 ml/ hr because of
  - Hyper Ventilation
  - Fever
  - Tracheostomy – upto 1200 ml/ day
- Loss replaced by DNS since kidneys conserve Na^+ even at this stage .

48 – 72 hrs.

- Replace insensible losses
- Better to give isotonic DNS & RL

Importance of I/O charts

Output = urine + vomitus + aspiration
+ 1000 ml insensible losses
+ 500 – 1000 ml sweating loss

Total this has to be replaced

Post Op. Urine Output

- Oliguria is common in immediate post op. period because
  1. Surgical stress – affects Adrenal Cortex
     - increase ADH & Aldosterone
  2. Insufficient post op. analgesia – sympathetic activity increased
  3. General anesthetics decrease glomerular blood flow & thus GFR
- Persistent oliguria
  - < 20 ml / hr in adults
  - < 1 ml / hr / kg in children

  } Hypervolemia

- If urine output < 0.5 ml / hr / kg for 3 or more hrs.– indicative of Acute Renal Failure.

Practical Crystalloid Therapy

- **If you infuse NaCl 0.9% 1000ml, all the Na^+ will remain in the ECF**
- **As NaCl is isotonic there is no change in ECF osmolality and no water exchange occurs across the cell membrane**
- **NaCl expands ECF only**
- **Intravascular volume will be increased by 250ml**

Practical Crystalloid Therapy

- **If you infuse glucose 5% 1000ml, the glucose will enter the cell and be metabolised**
- **The water expands both ECF and ICF in proportion to their volumes**
- **The ECF volume will increase by 333ml**
- **Intravascular volume will only increase by approximately 100ml**

Complications associated with blood product usage

Complication	Sign/symptoms	Treatment/prevention
Transfusion reaction		
Febrile	Fever, chills, headache myalgias, nausea, nonproductive cough	Antipyretics
Allergic	Urticaria, pruritus, facial swelling	Intravenous antihistamines
Hemolytic	Fever, chills, chest pain, chest pain, nausea, flushing dyspnea, hypotension, hemoglobinuria	Stop transfusion Lactated Ringer's/ mannitol/furosemide
Coagulation disorder		
Dilutional Thrombocytopenia	Lack of blood-clotting ability	Platelets
Factor V and VIII deficiency	Prolonged PT/PTT	FFP
Disseminated intravascular coagulation	Prolonged PT/PTT, increased fibrin split products, decreased serum fibrinogen	Platelets/FFP
Metabolic abnormality		
Hyperkalemia	Weakness, paresthesias, flaccid paralysis, elevated T wave	Calcium gluconate, calcium chloride, insulin-dextrose, loop diuretics, hemodialysis
Hypocalcemia	Hypotension, narrow pulse pressure, hyperreflexia, prolonged QT interval, tetany, shortened PR interval	Calcium gluconate, Calcium chloride
Metabolic alkalosis	Muscle cramps, weakness, hypoxia, arrhythmias	None required Usually self-correcting
Hypothermia	Cardiac irritability, shivering, increased myocardial oxygen demand	Warm blood to 38° Prior to Tx
Acute lung injury	Noncardiogenic pulmonary edema, dyspnea, hypoxemia	Supportive
Microaggregates	Vascular obstruction, fever	Micropore filters

Conclusion

- Surgical management & medical management of oral and maxillofacial surgery patients are intertwined intimately.
- The management of fluids & electrolytes & the usage of blood products are governed by basic principles outlined in this seminar.
- A favourable surgical outcome is predicated on optimal comprehensive care.