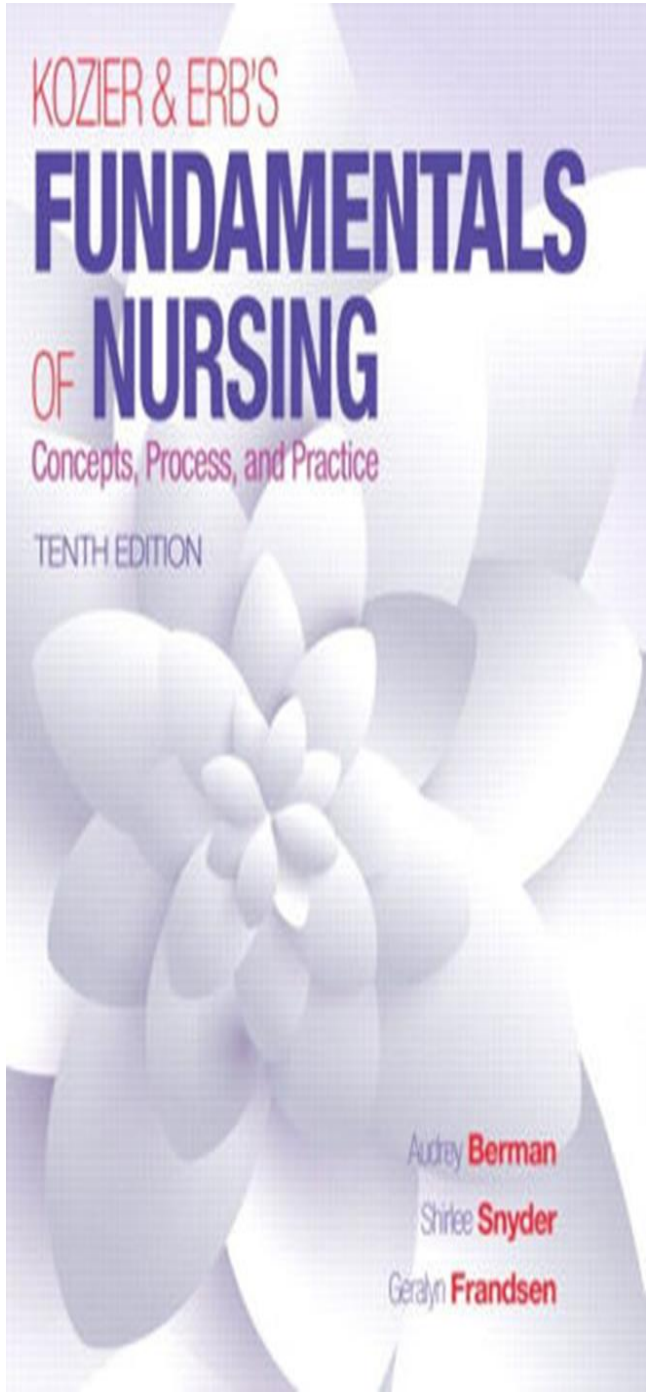
Unit8
Fluid-Electrolytes and Acid-base Balance

Distribution of Body Fluids

- **Composition of Body Fluid**
- **Regulating Body Fluids**
- **Factors affecting body fluid, electrolyte, and acid-base balance**



Distribution of Body Fluids

1- Intracellular fluid (ICF):

- Found within cell of body and constitutes approximately 2/3 of total body fluid in adults.
- Is vital to normal cell functioning.
- It contains solutes such as oxygen, glucose, and electrolytes.
- It provides a medium in which metabolic processes of the cell take place.

2- Extracellular fluid (ECF):

- Found outside cells and accounts for one third of a total body fluid.
- It is the transport system that carriers nutrients to and waste products from the cells.

Extracellular Fluid (ECF)

1-Intravascular fluid or plasma:

✓Found within the vascular system and has a greater quantity of protein.

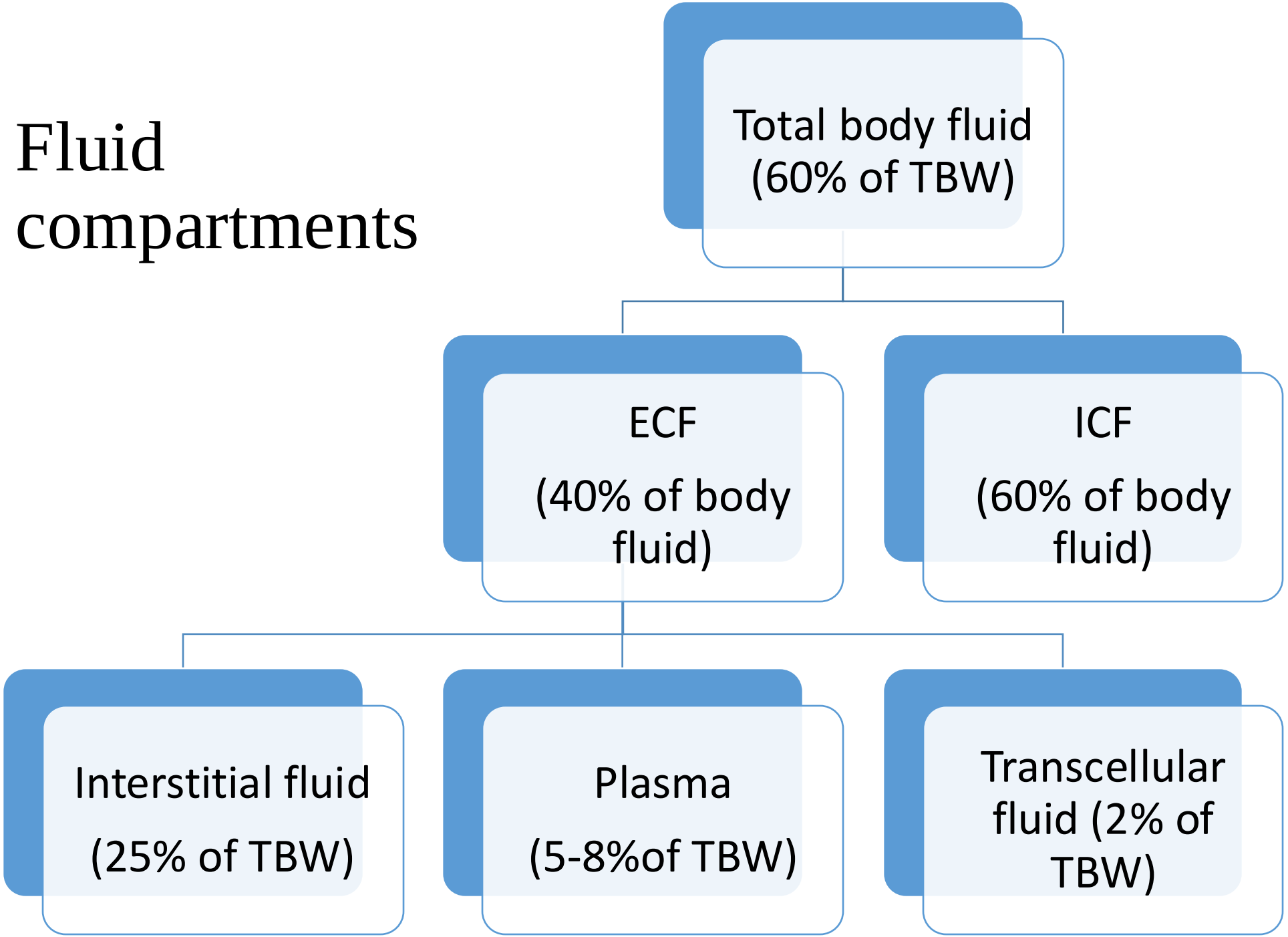
2-Interstitial fluid:

✓Surrounds the cells and include lymph.

3-Transcellular:

✓Considered by some as distinct from intracellular and extracellular fluids, includes cerebrospinal, pleural, peritoneal and synovial fluids

Fluid compartments



Fluid Electrolytes and Acid-Base Balance

Body fluids and electrolytes

- Fluids and electrolytes are necessary to maintain good health,
- Their relative amounts should be maintained within normal range.
- Fluid constitutes about 47% to 55% of average healthy adult’s
- Volume (about 40 liters) of body fluid remains constant.
- The percentage of total body fluids varies according the individual's age, body fat, and sex

Fluid Percentage of Body Weight

Age	Percentage of fluid
Full-term newborn	70 to 80
1 year	64
Puberty to 39 years	52 to 60
40 to 60 years	47 to 55
Over 60 years	46 to 52

Fluid and Body Fat

- Body fat is free of fluid; the less body fat present, the greater proportion of body fluid.
- e.g. a thin man's body may be 70% fluid, whereas an obese man's may be 53%.
- Women have a smaller percentage of fluid in relation to total body weight than do men.
- About 46-60% of the average adult’s weight is water, the primary body fluid.

Functions of Water

1-A medium for metabolic reactions within cells

2-A transporter for nutrients, waste products and other substances

3-A lubricant

4-An insulator and shock absorber

5-Regulating and maintaining body temperature.

Distribution and Composition of Body Fluids and Electrolytes

Electrolytes: are charged ions capable of conducting electricity, and are present in all body fluids and fluid compartments.

- Ions that carry a positive charge are called ***cations***, and ions carrying a negative charge are called ***anions***.

-Examples of cations are sodium (na+), potassium (k+), calcium (ca++), & magnesium (mg++).

-Anions include chloride (cl-), bicarbonate (hco3, phosphate (hpo4--), & sulfate (so4--).

Electrolytes

- Electrolytes are measured in milliequivalents per liter of water (meq/L) or milligrams per 100 milliliters (mg/100 ml).
- Na+ (sodium), cl- (chloride), bicarbonates, k+ (potassium), ca++ (calcium), mg+ (magnesium)

1- Extracellular electrolytes

Major cation is sodium and major anion is chloride.

2- Intracellular electrolytes

Major cation is potassium, mg+ (magnesium) and phosphate and the major anions is sulfate

Regulating Body Fluid (Balance)

Fluid intake

- The average fluid intake for adult is about 1500 ml/day,
- On moderate exercise an additional 1000 ml is needed,

Regulating Body Fluid (Balance)

Thirst Mechanism

- Is the primary regulator of fluid intake.
- Thirst center is located in the brain.
- A number of stimuli trigger this center including:

✓Osmotic pressure of body fluids,

✓Vascular volume and angiotensin ii (hormone released

in response to decrease blood flow to kidneys).

- Increase osmotic pressure stimulates the thirst center, causing the person to experience the sensation of thirst and desire to drink to replace lost fluids.

Regulating Body Fluid (Balance)

-Thirst is normally relieved immediately after drinking a small amount of fluid, even before it is absorbed from the gastrointestinal tract.

-This relief is only temporary, & the thirst returns in about 15 minutes.

-Thirst is again temporarily relieved after the ingested fluid distends the upper GIT.

-These mechanisms protect the individual from drinking too much, because it takes from 30 minutes to 1 hour for the fluid to be absorbed and distributed throughout the body.

Fluid Output

There are four routes of fluid output:

1- Urine : 1400-1500 cc or 30-50 ml/ hour

2- Insensible losses:

-Lungs 350-400 cc

-Skin 350-400 cc

3- Sweat 100 cc

4- Feces 100-200 cc

Fluid Output

- Body systems contribute to this regulation (balance) including:

1-Kidneys: primary regulator of body fluids & electrolyte balance. The kidneys adjust re-absorption of water from plasma filtrate & ultimately the amount excreted as urine.

2- Endocrine system

3-Cardiovascular system

4-Lungs

5-Gastrointestinal system

6-Hormones

-ADH that regulates water excretion from the kidney;

-Renin-angiotensin-aldesterone : promotes sodium wasting and act as a potent diuretic

Functions of Electrolytes

1- Maintain fluid balance

2- Regulate metabolism of enzymes

3- Maintain acid-base balance and osmotic pressure facilitates membrane transfer of essential compounds

4- Maintain nerve and muscular irritability and neuromuscular reactions

5- They are building constituents of body tissue

6- They are involved in growth process.

Factors Affecting Body Fluids, Electrolytes and Acid- Base Balance

1- Age. Fluid intake requirements vary with age.

-Infants lose more fluid through the kidneys because immature kidneys are less efficient than adult kidneys.

2- Gender and body size. Women have more body fat and less body water than men.

3- Climate and environmental temperature. Hot environment increased loss of body fluid and electrolytes

Factors Affecting Body Fluids, Electrolytes and Acid- Base Balance

4- Life-style. Such as diet, exercise, and stress are affecting on this balance.

5- Illness. Severe burns, Cardiac and renal disorders

6- Medical treatments. Gastric & intestinal suctioning.

7- Medications. Diuretics, laxatives, corticosteroids can result in the retention of excessive sodium and water.

8- Surgery. Blood loss or fluid overload due to large volumes of intravenous fluids administered

Fluid Imbalance

1) Isotonic loss of water and electrolytes; on equal proportions.
2) Isotonic gain of water and electrolytes on equal proportions.
3) Osmolar loss of only water
4) Osmolar gain of water only.

1- Fluid Volume Deficit (hypovolemia).

It is related to loss of water and electrolytes from the ECF in similar proportions (isotonic deficit).

Risk factors

1- Excessive losses from: vomiting, diarrhea, excessive sweating, polyuria, fever, nasogastric suction abnormal wound losses.

2- Insufficient fluid intake due to anorexia, nausea, inability to access fluids, impaired swallowing, confusion, depression, and unavailability of fluids.

3- Laboratory values: increased hematocrit, increased hemoglobin, increased blood urea nitrogen (BUN), and decreased central venous pressure (CVP)

Signs and Symptoms of Fluid Volume Deficit

1. Weakness and thirst
2. Weight loss: 2% loss = mild 5% loss = moderate, 8% loss = severe
3. Fluid intake less than fluid output
4. Decreased tissue turgor
5. Dry mucous membranes
6. Sunken eye balls
7. Decreased tearing and salivation
8. Subnormal temperature, weak and rapid pulse, decreased blood pressure
9. Postural hypotension
10. Flat neck veins

2- Fluid Volume Excess (hypervolemia)

-It occurs when body retains both water and electrolytes in ECF in similar proportions.

Risk factors

- Excessive intake of sodium- containing fluids from intravenous therapy
- Excessive ingestion of sodium salts in diet or medication
- Disturbed regulation of fluid balance as in heart failure, renal failure, and liver cirrhosis
- Laboratory values: decreased hematocrit, decreased hemoglobin, decreased BUN, and increased CVP

Signs and Symptoms of Fluid Volume Excess

1.Weight gain : 2% gain = mild, 5% gain = moderate , 8% gain = severe

2.Fluid intake greater than output

3.Moist mucous membranes

4.Increased blood pressure and central venous pressure

5.Full, bounding pulse, tachycardia (increased pulse rate)

6. Distended neck and peripheral veins, slow vein emptying

7.Moist crackles in lungs, dyspnea, shortness of breath

8. Mental confusion

9. Peripheral edema

10. Oliguria and decreased urine gravity less than 1.003

Electrolyte Imbalance

Hyponatremia (Decrease Sodium)
Signs And Symptoms

-Lethargy, confusion

-Muscle twitching

-Abdominal cramps

-Anorexia, nausea, vomiting

-Headache

-Seizures, coma

-Laboratory findings:

✓Serum Na+ below 135 meq/ L,

✓Serum osmolality below 280 mosm/ K.G

Hypernatremia(Increase Sodium)
Signs And Symptoms

-Thirst

-Dry, sticky mucous membranes

-Tongue red, dry, swollen

-Weakness

-Postural hypotension, dyspnea

-Severe hypernatremia: Fatigue, restlessness, decreasing level of consciousness, disorientation, convulsions

-Laboratory findings:

✓Serum Na+ above 145 meq/ L,

✓Serum osmolality above 300 mosm/ K.G

Hypokalemia (Decrease Potassium)
Signs And Symptoms

-Muscle weakness, leg cramps

-Fatigue, lethargy

-Anorexia, nausea, vomiting

-Cardiac dysrhythmias

-Decreased bowel sounds , decreased bowel motility

-Decreased deep tendon reflexes

-Laboratory findings: serum potassium (K+) below 3.5 meq/ L, ABGs may show alkalosis. T wave flattening and ST segment depression on ECG.

Hyperkalemia (Increase Potassium)
Signs And Symptoms

-Gastrointestinal hyperactivity, diarrhea

-Irritability, apathy, confusion

-Cardiac dysrhythmias or arrest

-Muscle weakness, Areflexia (absence of reflexes)

-Parasthesia and numbness in extremities

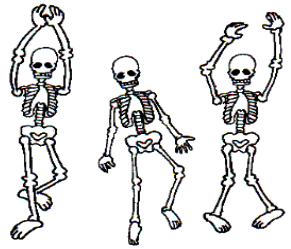
-Laboratory findings: serum potassium (K+) above 5.0 meq/ L. Peaked T wave, widened QRS on ECG

Hypocalcemia (Decrease Calcium)
Signs And Symptoms

-Numbness, tingling of the extremities and around the mouth

-Muscle tremors, cramps, if severe can progress to tetany and convulsions

-cardiac dysrhythmias, decreased cardiac output



-Positive trousseau’s and Chvostek's signs

-Confusion, anxiety, possible psychoses

-Laboratory findings: serum calcium less than 8.5 mg/dl or 4.5 meq/L

Hypercalcemia (Increase Calcium)
Signs And Symptoms

-Lethargy, weakness

-Depressed tendon reflexes

-Anorexia, nausea, vomiting

-Flank pain secondary to urinary calculi-dysrhythmias, possible heart block

-Laboratory findings: serum calcium greater than 10.5 mg/dl or 5.5 meq/L

Hypomagnesemia (Decrease Magnesium)
Signs And Symptoms

-Neuromuscular irritability with tremors

-Increased reflexes, tremors, convulsions

-Positive trousseau’s and Chvostek's signs

-Tachycardia, increased blood pressure, dysrhythmias

-Disorientation and confusion

-vertigo-laboratory findings: serum magnesium below 1.5 meq/ L

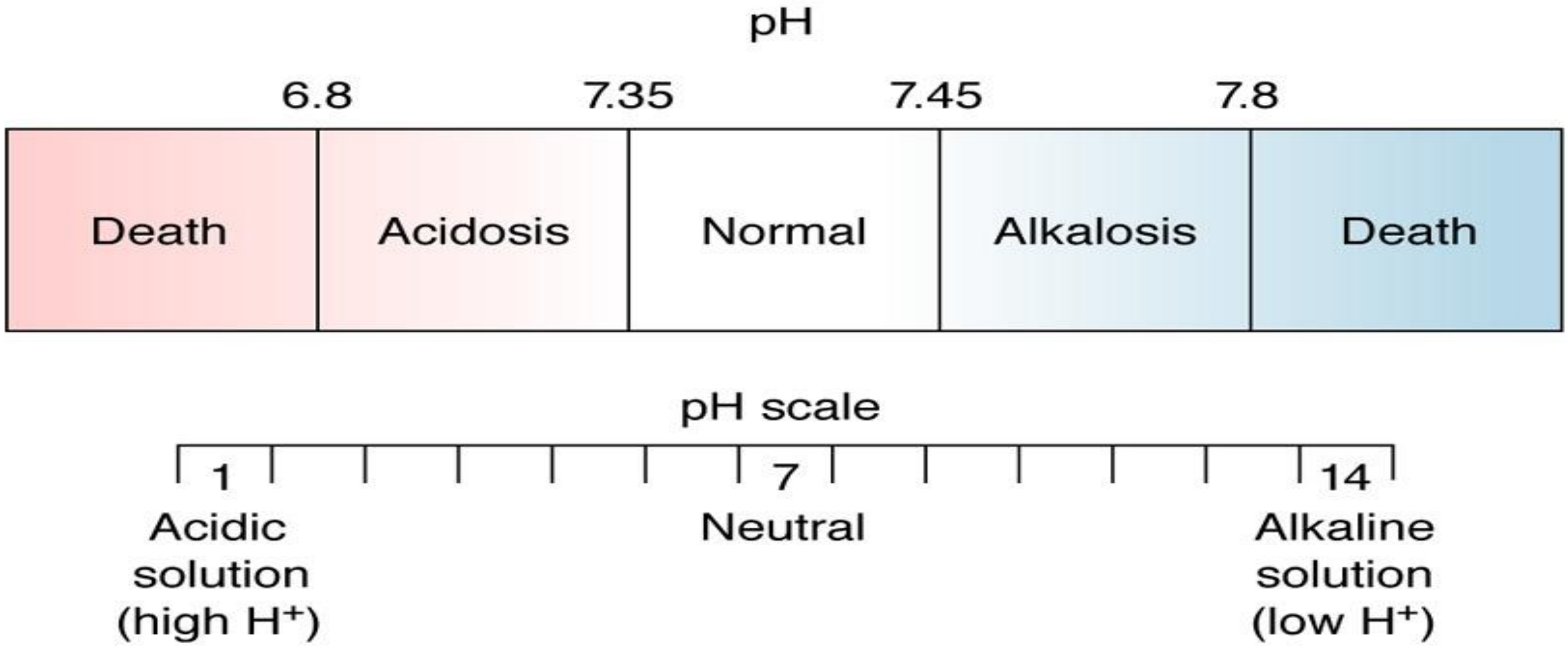
Hypermagnesemia (Increase Magnesium)
Signs And Symptoms

-Peripheral vasodilation flushing
-Nausea and vomiting
-Muscle weakness, paralysis
-Lethargy, drowsiness
-Hypotension, bradycardia
-Depressed deep tendon reflexes
-Respiratory depression, coma
-Respiratory and cardiac arrest if hypermagnesemia is severe-
laboratory findings: serum magnesium above 2.5 meq/ L
-ECG showing a prolonged QT interval & trioventricular (AV) block may occur.

Acid-base Imbalance

- Imbalances in pH can result in either acidosis or alkalosis.
- Acidosis (blood pH below 7.35) occurs with increases in blood carbonic acid or with decreases in blood bicarbonate.
- It is also referred to academia.
- Alkalosis (blood pH above 7.45) occurs with increases in blood bicarbonate or decreases in blood carbonic acid.
- It is also referred to Alkalemia.

Acid –base balance



Acid-base Imbalance

The primary general cause of a pH imbalance is indicated by the terms metabolic or respiratory.

* Metabolic acidosis and metabolic alkalosis are imbalances brought about by changes in bicarbonate levels as a result of metabolic alterations.

*Respiratory acidosis and respiratory alkalosis are imbalances brought about by changes in carbonic acid levels as a result of respiratory alterations

Compensation

Is a corrective body response by both the kidneys and lungs to acid-base imbalances

Arterial Blood Gases

- ABG's determine adequacy of alveolar gas exchange and evaluate ability of lungs and kidneys to maintain acid-base balance of body fluids

✓ Ph: 7.35 to 7.45

✓ Paco2: 35 to 45 mmhg

✓ HCO3-: 22 to 26 meg /L

✓ Pao2: 80 to 100 mmhg

✓ O2 saturation: 95% to 98%

1) Respiratory Acidosis.

- It occurs when exhalation of CO2 is inhibited, creating a carbonic acid excess in the body.

2) Respiratory Alkalosis

- It occurs when exhalation of carbon dioxide is excessive, resulting in a carbonic acid deficit.

3) Metabolic Acidosis.

- It occurs when levels of base bicarbonate are low in relation to carbonic acid blood levels.

4) Metabolic Alkalosis.

-It occurs when the level of base bicarbonate is high.

Normal Electrolyte Values For Adult

-Electrolytes are measured in milliequivalents per liter of water (meq/ L) or milligrams per 100 milliliters (mg/ 100 ml).

The normal values for electrolytes for adults are:

Sodium: 135-145 meq/L

Chloride: 95-105 meq/L

Potassium: 3.5-5 meq/L

Calcium: 4.5-5.5 meq/L

Magnesium: 1.5-2.5 meq/L

Phosphate: 1.8-2.6 meq/L