PHYSIOLOGY TEAM 432

LECTURE : 9

Acid Base System

Done By: Najla Al-Rumaih - Omar Al-Zamil
Reviewed By: Khulood Al-Raddadi

OBJECTIVES

At the end of this lecture student should be able to describe:

- Slides
- Important
- What doctor said
- Explanation
- Notes from boy's slides

MIND MAP

Basic of Acid-Base

Importance of acid-base balance:
To keep the optimal work environment for enzymes , electrolytes and hormones.

Blood PH Normal Range :
7.35 – 7.45

PH regulation systems :
(Blood fluid , Respiratory and Kidneys).

✓Acid : **release** hydrogen ions in solutions .
✓bases : **accept** a hydrogen ions in solution .

✓Strong acids & Base: **completely** dissociate.
✓ Weak acid & Base : **partially** dissociate.

What is Acid-base balance

- Acid-base balance is a balance of H+ concentration in ECF.

- To achieve homeostasis , a balance between (the intake or production of hydrogen ions) and the (net removal of hydrogen ions) from the body.

Homeostasis: the intake of H+ = the removal of H+

When the removal of H+ is decreased → ↑ H+ → Acidosis

Precise H+ regulation is essential because the activities of almost all enzyme systems in the body are influenced by H+ concentration. Therefore, changes in H+ concentration alter virtually all cell and body function.

What is Acid-base balance

- About 80 mEq of H^+ ions are ingested daily or produced by metabolic processes ; and without buffering, these would produce large changes in body fluid [H^+] → shifting blood to the acidic side.
- Therefore , to prevent pathological changes , body systems should strive to maintain hydrogen ion homeostasis (keeping [H^+] nearly within controlled limits) = 7.35-7.45
- Why is H^+ homeostasis important ? Because all enzymes are affected by the [H^+], which affects almost all body functions.
- That is why , the blood [H^+] is kept in a tight range around the normal concentration of 0.00004 mEq/liter = 0.00004 mmol/liter.

pH Review

- pH = -log [H+] = - log [0.00000004]

"negative logarithm of hydrogen ion concentration expressed in eq/liter".

Is the mathematical way for calculating pH, but it is not used nowadays. There are pH meters that automatically give the pH when dipped into a solution.

- If [H+] is high, the solution is acidic; pH < 7
- If [H+] is low, the solution is basic or alkaline; pH > 7

The neutral value of pH in the body is 7.4
However, in chemistry and solutions, the neutral value is 7

- pH is inversely related to the H+ concentration
- The higher H+ → the lower pH

table 2.5 Hydrogen Ion Concentrations and pH

Grams of H^+ per Liter	pH	
0.00000000000001	14	↑ Increasingly basic
0.0000000000001	13	
0.000000000001	12	
0.00000000001	11	
0.0000000001	10	
0.000000001	9	
0.00000001	8	
0.0000001	7	Neutral–neither acidic nor basic
0.000001	6	
0.00001	5	
0.0001	4	
0.001	3	
0.01	2	Increasingly acidic
0.1	1	
1.0	0	↓

Normal PH

- 7.4 is the pH for arterial blood.
- Venous blood pH is 7.35, because in venous blood there is more CO_2 to make carbonic acid.
- If the pH falls below 7.4, the person is in acidosis, while if more than 7.4, alkalosis.
- However, the limits of pH that a person can live more than a few hours are 6.8 – 8.0.
- Normal H+ concentration is 40 nEq/L (can be 10-160 nEq/L without causing death.)

An Acid

* Molecules containing hydrogen atoms that can release(donate) hydrogen ions in solutions are referred to as an acid.

- **Strong acids:**

completely dissociate in water (HCL, H_2SO_4)

- HCL is ionized in water to form H+ and CL-
- H_2SO_4 is ionized in water to form H_2O and SO_3

- Weak acid:

partially dissociate (H_2CO_3) (carbonic acid) important for buffering

H_2CO_3 dissociate into H+ and HCO_3

Most acids and bases in ECF that are involved in normal acid-base regulation are weak acid and bases

A Base

- A base is an ion that can **accept** a hydrogen ion.
- An example of a base is bicarbonate ion.
- (HCO_3) is a base because it can combine with H^+ to form H_2CO_3 .

Extra cellular pH

- Extra-cellular PH = **7.4** (7.3 to 7.5) " very narrow range ".
- Homeostasis of pH is important for the function of body enzymes.
- Acid-base balance can also affect electrolytes concentration (Na^+,K^+,Cl^-).
- Can also affect certain hormones.

Blood pH

- Blood pH = 7.35 –7.45
- Blood pH can be calculated by Henderson-Hasselbach equation

- $PH = pKa + \log_{10} \frac{[Base]}{[Acid]} = \left\{ 6.1 + \log \frac{HCO_3^-}{0.03\ X\ PCO_2} \right\}$

pKa: constant

In the case of bicarbonate

- ❑ pKa is a constant
- ❑ Base e.g HCO_3^- (measure the concentration of HCO_3^- in solution)
- ❑ Acid e.g $H_2\ CO_3$ (measure the concentration of $H_2\ CO_3$ in solution)

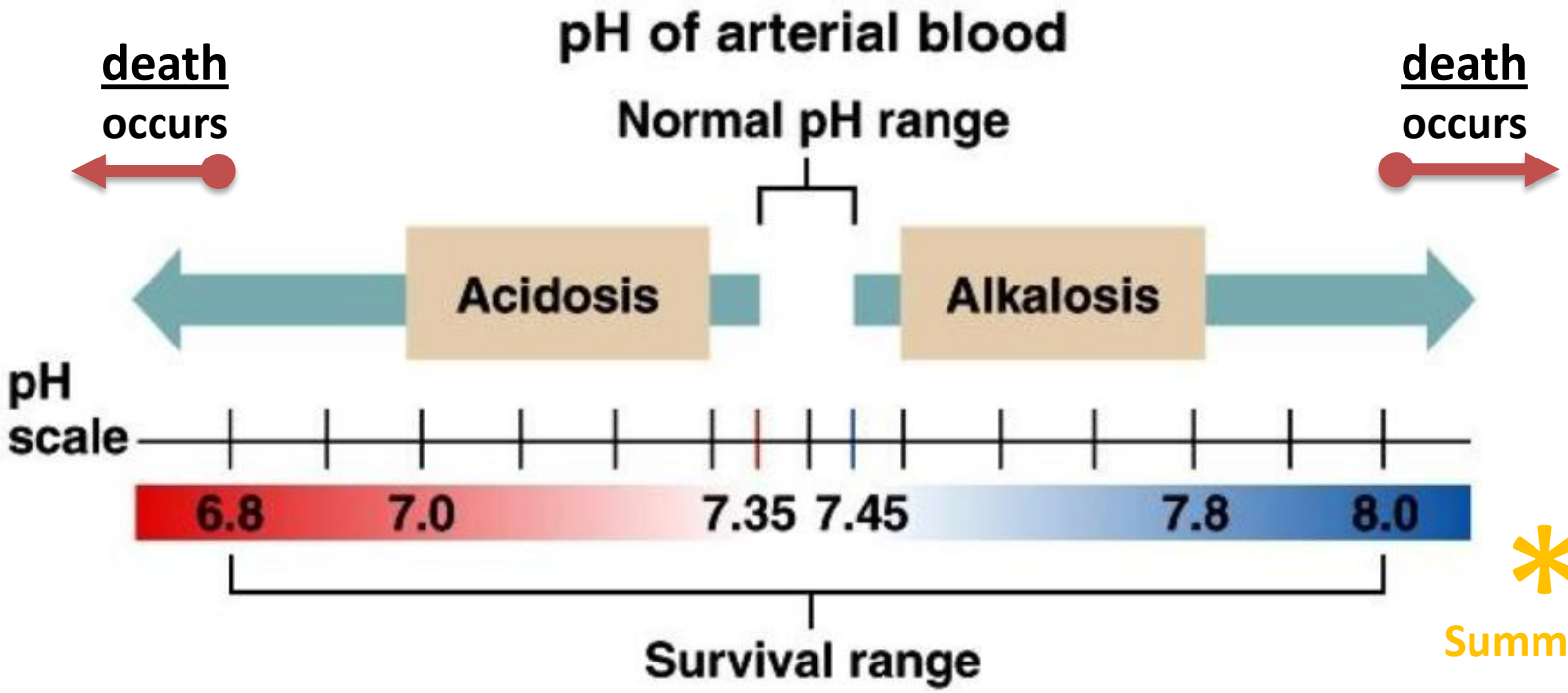
- ❑ Its not important to know it at this point
- ❑ Refer to Guyton page 381-382 for detailed explanation.**

* Acidosis= decrease in arterial pH (< 7.4) due to excess H+

* Alkalosis= an elevation in arterial PH (>7.4) due to excess base

* pH < 6.8 or > 8.0 death occurs (incompatible with life)

- If we say Acidosis or Alkalosis we are talking about blood or ECF.



* Summary

Acid-Base Imbalances

- pH < 7.35 → acidosis
- pH > 7.45 → alkalosis

- The body response to acid-base imbalance is called **compensation**
- Is Completed when pH is brought back within normal limits
- Partial compensation if range is still outside normal

When there is a pH imbalance the body compensate to bring it back to normal regardless of the cause. i.e pH level has the top priority because if there is an imbalance that could effect the cells' function.

Complete compensation : 7.4 the normal value
Partial compensation: 7.35

System Compensation

* If underlying problem is metabolic, hyperventilation or hypoventilation can help : respiratory compensation.

* If problem is respiratory, renal mechanisms can bring about metabolic compensation.

* When disturbances result from a primary change in ECF $[HCO_3^-]$, they are called metabolic disorders.

- ❑ If the pH imbalance was due to metabolic problem then the respiratory system will compensate by (hypo-hyper ventilation)
- ❑ If the problem was essentially respiratory then there would be a metabolic compensation.

- ➢ The main function of respiration is CO_2 either access or low because CO_2 is an a acid , so to get rid of the acid you hypoventilate.

Body produces more acids than bases

Due to metabolism

Sources of Acid :

- ❑ Acids take in with **foods.**
- ❑ Acids produced by **metabolism** of lipids and proteins.
- ❑ **Cellular metabolism** produces CO_2 (volatile acid).

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$$

Carbonic acid

bicarbonate

SUMMARY

- ✓ H+ homeostasis is important and is tightly regulated because all enzymes are affected by the [H+], which affects almost all body functions.

- ✓ Neutral pH is 7 , Extracellular normal PH = 7.4
- ✓ Blood pH is 7.35-7.45
- ✓ pH < 6.8 or > 8.0 → death occurs.
- ✓ Normal H+ concentration is 40 nEq/L

- ✓ pH is inversely proportional to H+
- ✓ ↓intake or ↑removal of H+ → alkalosis
- ✓ ↑intake or ↓removal of H+ → Acidosis

- ✓ Acid releases (donates) H+
- ✓ Base accepts H+
- ✓ Acid-base imbalance → compensation (complete, or partial)

SUMMARY

- ✓ Acid : releases hydrogen ions in solutions.
  - Strong acids: completely dissociate (HCL, H2SO4)
  - Weak acid: partially dissociate (H2CO3)

✓bases : accept a hydrogen ions in solution , e.g. : (HCO3)

✓ Acid-base balance can affect enzymes functions, electrolytes concentration (Na+,K+,Cl-) and it can affect certain hormones.

✓Shifting to the left = more Acidity
✓Shifting to the right = more alkaline *

✓Decreases in [HCO_3^-] are called → metabolic acidosis, while conversely , increase in [HCO_3^-] → metabolic alkalosis.

✓An increase in P_{CO2} is called respiratory acidosis and a decrease P_{CO2} is respiratory alkalosis. (will be discussed in lecture 11)

Questions

1- Which one of these substances can accept a H^+

A- HCO_3^- **B- H_2CO_3** **C- HCl** **D- H_2CO_4**

2- after intense physical exercise, Omar's body pH dropped to 7.32 but after a while the pH rose up to 7.35. what happened to Omar?

A- complete compensation **B-respiratory compensation**

C- renal compensation **D- Partial compensation**

3- cellular metabolism produces :

A- protein **B- CO_2** **C- lipids** **D- O_2**

Question	Answer
1	a
2	d
3	b

THE END

If there are any problems or suggestions
Feel free to contact:

Physiology Team Leaders
Mohammed Jameel & Khulood Al-Raddadi

432100187@student.ksu.edu.sa
432200235@student.ksu.edu.sa

THANK YOU

Actions speak louder than Words