PHYSIOLOGY TEAM 432

LECTURE : 10

Buffer Systems

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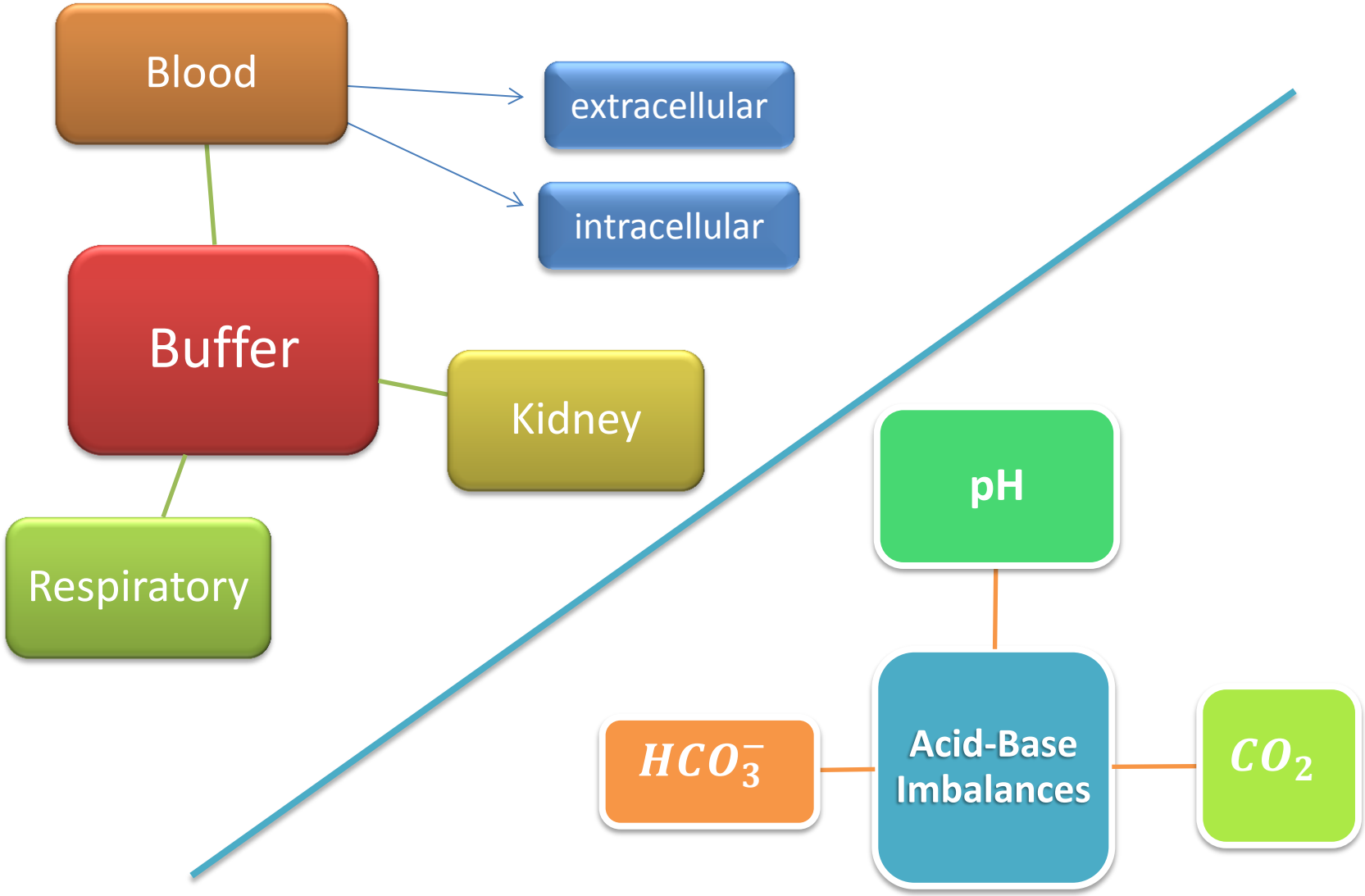
OBJECTIVES

To Identify the body systems that control against Acid-Base Imbalance

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

MIND MAP


Blood
extracellular
intracellular
Buffer
Kidney
Respiratory
pH
HCO_3^-
Acid-Base Imbalances
CO_2

Buffers

Means balanced or not changed

- Buffers are substances that neutralize acids or bases. these substances manly found in blood
- Chemical reactions which reduce the effect of adding acid or base to a solution PH.

- If I have 1L of water and I add 1 or 2 drops of acid to it → pH will drop [7.4→4]
- If I have 1L of HCO_3^- and I add 1 or 2 drops of acid to it → pH will drop [7.4→7.35]
- Because HCO_3^- is a buffer, so it will prevent the severe drop of pH.

How the Body defends against fluctuations in pH

- **Buffers in the blood** "First Line"
- **Breathing through the lungs** " second Line "
- **Excretion by the kidneys** " Severe Changes "

Perfect but it takes time

Blood Buffer

These buffer systems serve as a first line of defense against changes in the acid-base balance.

1- Bicarbonate Buffer

- Important extra cellular buffer
- HCO3=24-28 meq/ml
- Present in larger quantities
- Can be regulated by respiratory and renal
  - If I need more HCO_3^- , I can either hypoventilate or ↑ reabsorption
  - If I want to lower HCO_3^- , I can either hyperventilate or ↓ reabsorption)
- Consist of: Weak acid H_2CO_3 - Bicarbonate salt $NaHCO_3$

- HCO_3^- : H2CO3 Maintain at a ratio of 20:1 (Bicarbonate is more)
- pH = 6.1 + log $\frac{HCO_3^-}{0.03 \times PCO_2}$ ⟶ (solubility of CO_2 in H_2O "0.03" X PCO_2 = $[H_2CO_3]$

- If Acid is added → $H^+ + HCO_3^- \leftrightarrow H_2CO_3 \leftrightarrow CO_2 + H_2O$

Note : if I add H^+ to a buffer, bicarbonate (base) will take the H^+ and give carbonic acid which will dissociate into water and CO_2. H^+ will go to water and not affect the pH and vise versa.

- If Base is added → $NaOH + H_2CO_3 \leftrightarrow NaHCO_3 + H_2O$

Note : if I add $NaOH$ to a buffer, it will work with the acid "H_2CO_3" and gives a salt "$NaHCO_3$" and water . OH will be converted to water and not affect the pH

2- Phosphate

3- Protein and Hemoglobin

Blood Buffer

These buffer systems serve as a first line of defense against changes in the acid-base balance.

1- Bicarbonate Buffer	2- Phosphate	3- Protein and Hemoglobin
	❑ Phosphate is an intra and extracellular buffer ❑ Minor role compare to HCO3 or HB (low quantities) ❑ Intra cellular buffers (proteins & phosphate) are needed because H does not cross PM (plasma membrane) ❑ Intracellular pH is more acidic (7.2) Because of High cellular metabolism not like the extracellular which is 7.4	❑ Protein Includes hemoglobin and plasma protein ❑ Acidic (positive) and basic (Negative) amino acids in plasma and cell protein act as buffers : ➢ Carboxyl group gives up H^+ (acid) ➢ Amino Group accepts H^+ (base) ❑ Side chains that can buffer H^+ are present on 27 amino acids. ❑ Cannot be regulated physiological (as a disadvantage. So, I can't immediately add, remove or change the level of proteins)

Respiratory regulation of pH

- Role: Maintain normal ECF pH by changing the rate and depth of breathing to maintain constant PCO2 (volatile acid)
- Controlled by chemoreceptors.
- Respiratory doesn't affect fixed acids like lactic acid (but affect HCO_3^-).
- ↑ in PCO_2 → ↓ pH (↑ PCO_2 → Acidosis , ↓PCO_2 → Alkalosis)

Very important

Kidney excretion

Two main roles

- Can eliminate large amounts of acid by tubular secretion of H^+
- Can also excrete base by adjusting tubular reabsorption of HCO_3^-
- Can conserve and produce bicarbonate ions
- Kidney is the most effective regulator of pH (because the kidney can bring the pH back to normal but it takes time around a week)
- If kidneys fail, pH balance fails (Renal Failure Patient have Acidosis)

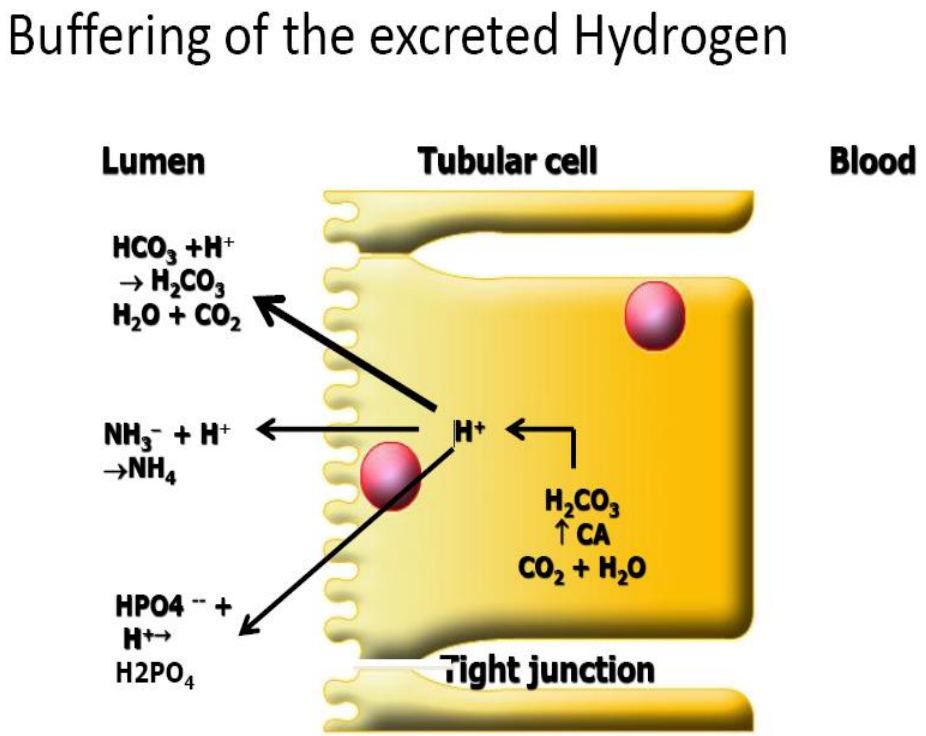
H^+ ion will be secreted from the cell to the tubular fluid to go out with urine, but the problem is that the H^+ is very acidic and we can't execrate it in the urine (pH=4-5) as such. We should do buffering for the secreted H^+in urine so that the nephrons don't get destroyed. If the H^+pass through the nephrons without buffering, nephrons will be destructed.

How this will happened?

H^+ is secreted in exchange with Na then will take one of these 3 ways:

1. combined with filtered **bicarbonate** HCO_3^- and gives us carbonic acid $H_2\,CO_3$ which will dissociate to CO_2 + H_2O , as we mentioned before, water doesn't affect the pH.
2. combined with filtered **Ammonia** NH_3^- and give us Ammonium NH_4 .
3. combined with filtered **hydrophosphate** $HPO_4^{-2}$and give us dihydrophosphate $H_2\,PO_4$

"For further details see Guyton 388-389"



By Dr. *Sitelbanat*

Diagnosis of Acid-Base Imbalances

By 3 parameters:

1. **pH low (acidosis) or high (alkalosis)**
2. **If pCO2, is abnormal the problem is respiratory.**
3. **If HCO3- is abnormal the problem is metabolic.**

If pH= 7.3, PCO_2= 60 and HCO_3^-= 24 → **Respiratory Acidosis**

If pH is within the normal range, there is full compensation. If it is outside the normal range, the body is partially compensating for the problem.

"Sometimes we find pH is normal or around normal but the PCO_2 is abnormal, this indicates an abnormality in the compensation or regulation mechanism.

System Compensation

By bringing of the pH to normal range

If underlying problem is metabolic, hyperventilation or hypoventilation can help (Respiratory compensation)

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

Acid-Base Imbalances

- pH < 7.35 acidosis
- pH > 7.45 alkalosis

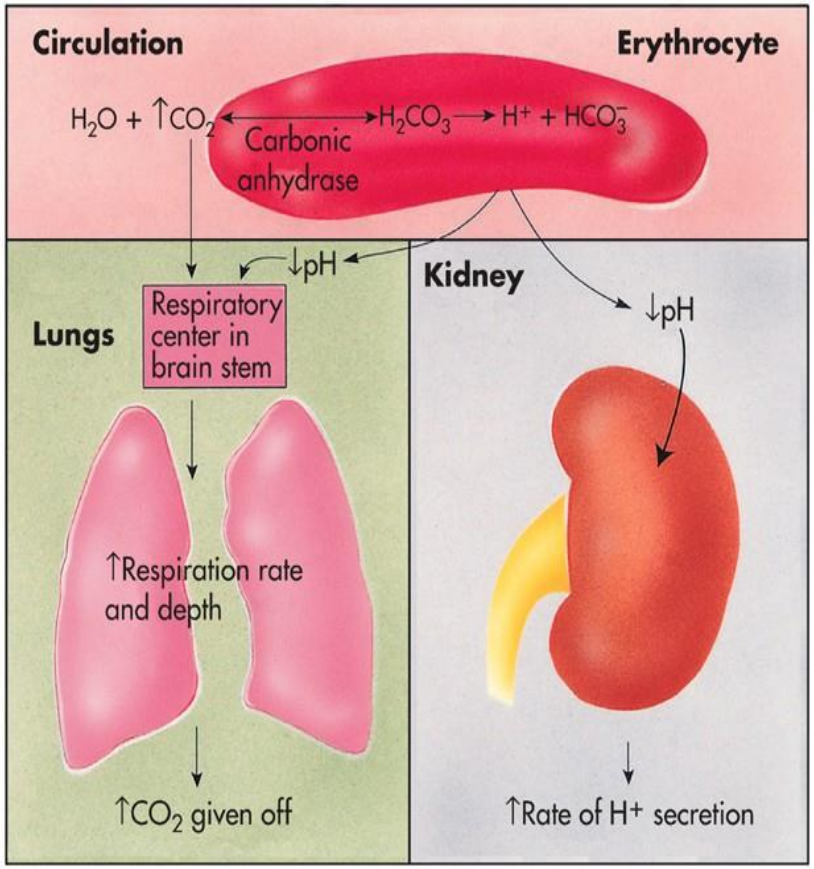
} The difference is very low because the blood has many buffers.

- The body response to acid-base imbalance is called compensation.
- May be complete compensation if brought back within normal limits.
- Partial compensation if range is still outside normal limits.

Rates of correction

- Buffers function almost instantaneously (immediately)
- Respiratory mechanisms take several minutes to hours
- Renal mechanisms may take several hours to days " to make new bicarbonate but its correction is 100% "

SUMMARY



Three systems are working together

Blood

First line of defense against pH shift — Chemical buffer system
- Bicarbonate buffer system
- Phosphate buffer system
- Protein buffer system

Second line of defense against pH shift — Physiological buffers
- Respiratory mechanism (CO_2 excretion)
- Renal mechanism (H^+ excretion)

SUMMARY

- Blood buffer system serve as a first line of defense against changes in the acid-base balance.
- Bicarbonate Buffer important extra cellular buffer .
- Phosphate is an intra and extracellular buffer .
- Acidic and basic amino acids in plasma and cell act as a Buffer, but it Cannot be regulated physiological .
- Respiration Maintain normal ECF pH by changing the rate and depth of breathing to maintain constant PCO2.
- Kidney eliminate large amounts of acid by tubular secretion of H+ and excrete base by adjusting tubular reabsorption of HCO3
- Buffering of execrated hydrogen by combined with filtered bicarbonate , Ammonia, and hydrophosphate .
- Diagnosis of Acid-Base Imbalances is done by 3 parameters: pH, PCO_2, and HCO_3^-
- Buffers function almost instantaneously (immediately) .
- Respiratory mechanisms take several minutes to hours .
- Renal mechanisms may take several hours to days .
- The body response to acid-base imbalance is called compensation
- May be complete if brought back within normal limits
- Partial compensation if range is still outside norms.

Questions

1- Which of these buffers is only extracellular ?

a) Bicarbonate Buffer
b) phosphate
c) Protein and hemoglobin
d) all

2- The most effective way to control changing in PH is via :

a) Respiratory system
b) renal system
c) Blood
d) bicarbonate

3- Which of these acids can't be affected by the respiratory system:

a) Carbonic acid
b) Lactic acid
c) CO_2
d) non

Question	Answer
1	A
2	B
3	B

THE END

If there are any problems or suggestions
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THANK YOU

Actions speak louder than Words