

Acid Base Introduction

- K pp. 113-115
- C pp. 46-47
- B pp. 290-292
- Paramedic Care vol. 1 p. 191

Objectives

Upon completion of this lecture the learner should be able to:

- Discuss the role of hydrogen ions in normal metabolism.
- Discuss how the arterial blood pH is a reflection of the body's total number of hydrogen ions .
- Discuss the normal buffering and compensatory mechanisms for handling an excess of either a metabolic or a respiratory acid.

Objectives (cont.)

- Define Respiratory Acidosis, Respiratory Alkalosis, Metabolic Acidosis, Metabolic Alkalosis .
- Give clinical examples of uncompensated: Respiratory Acidosis, Respiratory Alkalosis, Metabolic Acidosis, Metabolic Alkalosis .
- Give clinical examples of compensatory buffering mechanisms for handling excess of a metabolic acid and of a respiratory acid.



Treatment Priorities - review

When fluids and electrolytes are altered, these should be corrected in the following order:

- volume
- **pH**
- potassium, calcium, and magnesium
- sodium and chloride



Physiology of Hydrogen Ions

- H^+ origin: a product of normal metabolism
- H^+ excretion:
 - lungs
 - kidney
 - kidneys maintain H^+ concentration by :
 - remove or retain HCO_3^-
 - remove or retain organic acids (e.g., lactic acid)



Buffering of H^+ ions

- Chemical
 - $H^+ + HCO_3^- \rightleftharpoons H_2CO_3 \rightleftharpoons H_2O + CO_2$
- Cellular
 - “soaking up” H^+ ions
- Lungs
 - blow off CO_2
- Kidneys
 - retain HCO_3^-



Buffering of H^+ ions

- Chemical
($H^+ + HCO_3^- \rightleftharpoons H_2CO_3 \rightleftharpoons H_2O + CO_2$)
 - instantaneous
- Cellular
 - seconds
- Lungs
 - minutes
- Kidneys
 - days

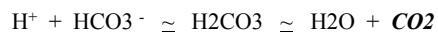


Definitions

- Normal pH
 - 7.35 - 7.45
- Acidosis
 - pH < 7.35
- Alkalosis
 - pH > 7.45



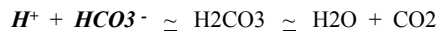
Definitions - Respiratory



- Respiratory (volatile) acid
 - reflected by : pCO_2 level
- Normal
 - pCO_2 : 35 - 45 [40]
- Acidosis
 - $pCO_2 > 45$
- Alkalosis
 - $pCO_2 < 35$



Definitions - Metabolic



Metabolic (nonvolatile) acid

- reflected by : HCO_3^- level

Normal Metabolism

- HCO_3^- : 24 - 28 [25]

Metabolic Acidosis

- HCO_3^- < 24

Metabolic Alkalosis

- HCO_3^- > 28
-
-
-
-
-
-
-



Respiratory Acidosis

- Pathophysiology
 - hypoventilation
 - poor CO_2 exchange
 - CO_2 retention ; O_2 may or may not be adequate
 - Blood gas abnormalities
 - hypoxia (usually, but not always)
 - hypercarbia ($pCO_2 > 40$)
 - if uncompensated : HCO_3^- : “nl” : 25
-
-
-
-
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Respiratory Acidosis

Clinical Presentation

- Sx.:
 - dyspnea
 - hx of WOB +/- ALOC
- Signs:
 - distress (RR, retractions, ...cyanosis)

Clinical Example of Uncompensated Respiratory Acidosis :

- Acute asthma attack
 - pCO_2 : 60 ($pCO_2 > 40$)
 - pH : 7.3
 - HCO_3^- : 25
-
-
-
-
-
-
-



Respiratory Alkalosis

- Pathophysiology
 - hyperventilation
 - excessive CO₂ release
 - poor O₂ exchange may or may not occur
- Blood gas abnormalities
 - pO₂ < 80 [sat. < 93 %] (suggests possible PE,...)
 - hypocarbia (pCO₂ < 40)
 - p H : 7.6
 - if uncompensated : HCO₃ : 25

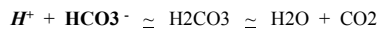


Respiratory Alkalosis

- Clinical Presentation
 - Sx.: dyspnea : hx of WOB +/- ALOC chest pain
 - Signs: increased RR (no cyanosis,...)
- Clinical example of uncompensated Respiratory Alkalosis :
 - Acute hyperventilation attack
 - pCO₂ : 20 (pCO₂ < 40)
 - p H : 7.6
 - HCO₃ : 25



Metabolic Acidosis



- Pathophysiology
 - excess H⁺ ions consume the HCO₃
 - this causes a HCO₃ deficit
 - if uncompensated, then the pCO₂ will be 40
- Blood gas abnormalities
 - HCO₃ : ~ 8 (depletion due to excessive acid)
 - p H : ~ 7.2
 - if uncompensated, then the pCO₂ will be 40



Metabolic Acidosis

- Clinical presentation of *acute* metabolic acidosis
 - Sx.: no dyspnea
 - Signs: If uncompensated : RR unchanged
(If compensated : RR rapid, deep)
- Clinical example of uncompensated **metabolic** acidosis:
 - acute TCA OD
 - HCO_3^- : 8
 - p H : 7.2
 - pCO_2 : 40 (uncompensated)



Metabolic Alkalosis

- $\text{H}^+ + \text{HCO}_3^- \rightleftharpoons \text{H}_2\text{CO}_3 \rightleftharpoons \text{H}_2\text{O} + \text{CO}_2$
- Pathophysiology
 - excessive HCO_3^- ions will consume H^+
 - this causes a “ H^+ deficit ”
 - if uncompensated, then the pCO_2 remains 40
 - Blood gas abnormalities of acute metabolic alkalosis
 - pCO_2 : 40 (no respiratory component)
 - p H : 7.6
 - HCO_3^- : 45

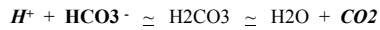


Metabolic Alkalosis

- Clinical Presentation
 - acute metabolic alkalosis is rare.
 - Sx. + “ full arrest, 2 amps of bicarb ;
 - Signs: with ‘adequate ventilations’ ”
- Clinical example of uncompensated or straight metabolic alkalosis :
 - “2 amps of bicarb”
 - HCO_3^- : 45
 - p H : 7.6
 - pCO_2 : 40 (no respiratory component)



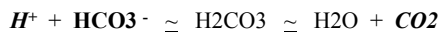
Mixed Acidosis and Alkalosis



- Pathophysiology
 - excess H^+ ions can also be compensated for by blowing off CO_2 and moving the equation to the respiratory side
 - in an uncompensated patient,
 - the pCO_2 is 40
 - but in the *compensated* patient,
 - the pCO_2 will be < 40



Mixed Acidosis and Alkalosis



- Example of blood gas abnormalities of *compensated* DKA
 - pCO_2 : 18
 - pH : 7.33
 - HCO_3^- : 12 (partial depletion due to excessive acid)



Treatment

- $CO_2M_3E\ BI_{NS}G$
- Treatment for acidosis
 - always begins with hyperventilation
- $H^+ + HCO_3^- \rightleftharpoons H_2CO_3 \rightleftharpoons H_2O + CO_2$
- or
- $H^+ + HCO_3^- \rightleftharpoons H_2CO_3 \rightleftharpoons H_2O + CO_2$



Summary

We have discussed :

- Homeostasis of CO_2 and H^+
- Normal buffering and compensatory mechanisms for handling an excess of either a metabolic or a respiratory acid.
- Definitions and clinical examples of some uncompensated Respiratory Acidosis and Metabolic Acidosis and one clinical example of compensation.
