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
  – $H^+ + HCO_3^- \simeq H_2CO_3 \simeq H_2O + CO_2$
- Cellular
  – "soaking up" H^+ ions
- Lungs
  – blow off CO_2
- Kidneys
  – retain HCO_3^-

Buffering of H^+ ions

- Chemical
  ($H^+ + HCO3^- \simeq H2CO3 \simeq H2O + CO2$)
  - instantaneous
- Cellular
  - seconds
- Lungs
  - minutes
- Kidneys
  - days

Definitions

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

Definitions - Respiratory

$H^+ + HCO3^- \simeq H2CO3 \simeq H2O + \boldsymbol{CO2}$

- Respiratory (volatile) acid
  - reflected by : $pCO2$ level
- Normal
  - $pCO2$: 35 - 45 [40]
- Acidosis
  - $pCO2 > 45$
- Alkalosis
  - $pCO2 < 35$

Definitions - Metabolic

$H^+ + HCO3^- \simeq H2CO3 \simeq H2O + CO2$

Metabolic (nonvolatile) acid
- reflected by : $HCO3^-$ level

Normal Metabolism
- $HCO3^-$: 24 - 28 [25]

Metabolic Acidosis
- $HCO3^-$ < 24

Metabolic Alkalosis
- $HCO3^-$ > 28

Respiratory Acidosis

- Pathophysiology
  - hypoventilation
    - poor CO2 exchange
    - CO2 retention ; O2 may or may not be adequate
- Blood gas abnormalities
  - hypoxia (usually, but not always)
  - hypercarbia (pCO2 > 40)
  - if uncompensated : HCO3: "nl" : 25

Respiratory Acidosis

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

Clinical Example of Uncompensated Respiratory Acidosis :
- Acute asthma attack
  - pCO2 : 60 (pCO2 > 40)
  - p H : 7.3
  - HCO3 : 25

Respiratory Alkalosis

- Pathophysiology
  - hyperventilation
    - excessive CO_2 release
    - poor O_2 exchange may or may not occur
- Blood gas abnormalities
  - $pO_2 < 80$ [sat. < 93 %] (suggests possible PE,…)
  - hypocarbia ($pCO_2 < 40$)
  - p H : 7.6
  - if uncompensated : HCO_3 : 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

$H^+ + HCO3^- \simeq H2CO3 \simeq H2O + CO2$

- 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
    - HCO3 : 8
    - p H : 7.2
    - pCO2 : 40 (uncompensated)

Metabolic Alkalosis

$H^+ + HCO3^- \simeq H2CO3 \simeq H2O + CO2$

- Pathophysiology
  - excessive HCO3 ions will consume H^+
  - this causes a " H^+ deficit "
  - if uncompensated, then the pCO2 remains 40
- Blood gas abnormalities of acute metabolic alkalosis
  - pCO2 : 40 (no respiratory component)
  - p H : 7.6
  - HCO3 : 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"
    - HCO3 : 45
    - p H : 7.6
    - pCO2 : 40 (no respiratory component)

Mixed Acidosis and Alkalosis

$H^+ + HCO3^- \simeq H2CO3 \simeq H2O + CO2$

- Pathophysiology
  - excess H^+ ions can also be compensated for by blowing off CO2 the and moving the equation to the respiratory side
  - in an uncompensated patient,
    - the pCO2 is 40
  - but in the ***compensated*** patient,
    - the pCO2 will be < < 40

Mixed Acidosis and Alkalosis

$H^+ + HCO3^- \simeq H2CO3 \simeq H2O + CO2$

- Example of blood gas abnormalities of ***compensated*** DKA
  - pCO2 : 18
  - p H : 7**.** 33
  - HCO3 : 12 (partial depletion due to excessive acid)

Treatment

- $CO_2M_3E\ BI_{NS}G$
- Treatment for acidosis
- always begins with hyperventilation
- $H^+ + HCO3^- \simeq H2CO3 \simeq H2O +$ ***CO2***
- *or*
- ***H***$^+ + HCO3^- \simeq H2CO3 \simeq H2O +$ *CO2*

Summary

We have discussed :

- Homeostasis of CO2 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.