Acid-base basics

C. Singarajah, M.D, F.C.C.P

Definitions

AN “osis “ means a process
Eg Acidosis.

Alkalaemia means pH > 7.44

Acidaemia means pH < 7.36

Types of Acidosis

- Acidosis
  - Respiratory
  - Metabolic
    - Anion Gap
    - Non Anion Gap

Types of Alkalosis

Alkalosis

Chloride Responsive

Chloride non responsive

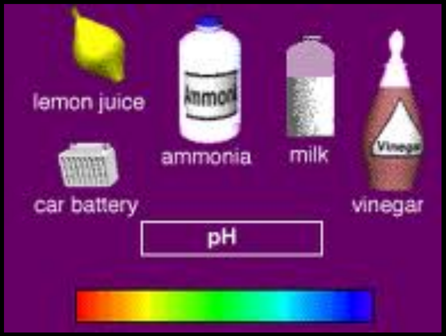
Definitions

- Respiratory means changes in PCO_2 values c.f. to expected/normal.
- Metabolic means changes in serum bicarbonate

Homeostasis

- Various buffers in the body
- HCO_3/CO_2 buffer system is clinically used.
- Other buffers are hemoglobin, bone, proteins

Homeostasis



- Body tries to keep the pH between 7.36-7.44

- Body tries to keep ratio of HCO_3/CO_2 fixed.

Basic disorders

- Metabolic acidosis
  - Decreased bicarbonate
- Metabolic alkalosis
  - Increased bicarbonate

Basic disorders

- Respiratory acidosis
  - Increased PCO_2
- Respiratory alkalosis
  - Decreased PCO_2

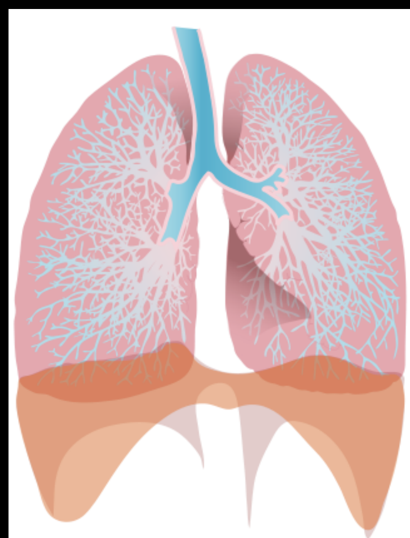
Compensation

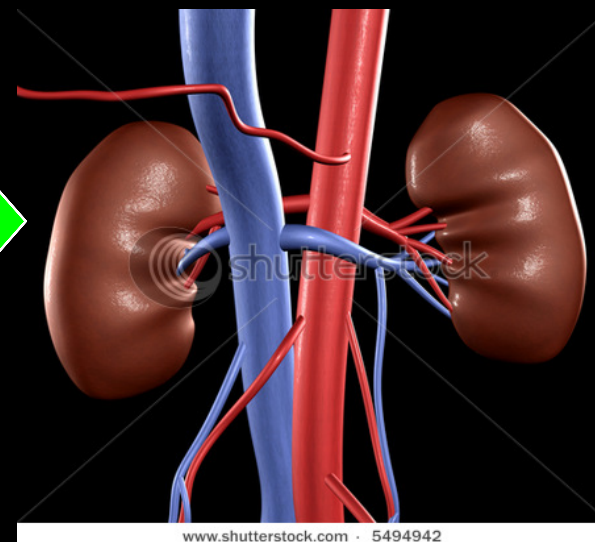
- HCO_3/CO_2 ratio
- Changes in one parameter are compensated by same direction changes in the other:
  - Increased HCO_3 leads to increased CO_2 etc

Compensation

- Lungs compensate for metabolic processes.
  - minutes to hours
- Kidneys compensate for respiratory processes.
  - hours to days

Compensation





Analysis of ABG

- Obtain ABG, chem 7.
- pH - alkalemic or acidaemic ?
- Check P_aCO_2 ; has it changed in direction to explain pH change ?

Analysis

- If P_aCO_2 has changed in appropriate direction, does it account for the whole change?
- Δ P_aCO_2 10 = Δ pH 0.08 acutely
- Δ P_aCO_2 10 = Δ pH 0.04 chronically

Analysis

- If answer is No to either of the previous two questions
- Must be a metabolic acid base problem in addition

pH	PCO2	Interpretation
7.40	40	Normal
7.48	30	Respiratory alkalosis
7.56	20	Respiratory alkalosis
7.32	50	Respiratory acidosis
7.24	60	Respiratory acidosis
7.30	60	Respiratory acidosis + Metabolic alkalosis
7.48	20	Respiratory alkalosis + Metabolic acidosis

Analysis

- Is serum bicarbonate high or low ?
- If low, calculate the anion gap.
  - Na - Chloride - bicarbonate = AG

Analysis of gap acidosis

If there is an anion gap, then check:

- M Methanol
- U Uremia
- D DKA
- P Propylene glycol
- I Iron, infection
- L High lactate
- E Ethanol
- S Salicylate

Correction of AG for low albumin

Low albumin hides a high anion gap

2.5 x (Normal albumin - measured albumin)

+

Measured AG

=

Corrected Anion gap

Analysis of delta gap

- If anion gap present analyze delta gap to look for second acidosis. In effect, correct the bicarbonate for the presence of the anion gap.
- $HCO_{3(c)} = HCO_{3\ (a)}$ + {Actual AG --normal AG}
- E.g. = 8 +{34 -10} = 32

The delta gap.

- Tries to back track in time to when the patient did not have an anion gap that was high.
- Assumes that as AG increases, bicarbonate drops on a 1:1 ratio.

Analysis of delta gap.

- If ***corrected bicarbonate is higher*** than normal : implies ***metabolic alkalosis.***

- If ***corrected bicarbonate is lower*** than normal : implies ***non gap metabolic acidosis***.

Corrected bicarbonate

Anion gap 20
Bicarbonate 5

→ Metabolic gap acidosis

Delta (change) in AG
20-10 = 10

→ Corrected Bicarbonate
5 + 10 =15

Metabolic gap acidosis
+
Metabolic non gap acidosis

Corrected bicarbonate

Anion gap 30
Bicarbonate 10

→ Metabolic gap acidosis

Delta (change) in AG
30-10 = 20

→ Corrected Bicarbonate
10 + 20 =30

Metabolic gap acidosis
+
Metabolic alkalosis

Analysis of respiratory compensation

- Any metabolic acidosis (gap or non gap) - use ***Winter's*** formulae to assess respiratory compensation.

- $P_aCO_{2\ (e)} = \{HCO_3\ x1.5\} + 8 \pm 2$

Bicarbonate	PCO2	Interpretation
24	40	Normal
10	21-25	Metabolic acidosis + appropriate respiratory compensation
10	30	Metabolic acidosis + Respiratory acidosis
10	15	Metabolic acidosis + Respiratory alkalosis

Analysis of respiratory compensation.

- If ***actual P_aCO_2 is higher than*** $P_aCO_{2(e)}$, then there is a ***respiratory acidosis*** (even if <40).

- If ***actual P_aCO_2 is lower than*** $P_aCO_{2(e)}$, then there is a respiratory alkalosis (even if > 40).

Analysis of non gap metabolic acidosis

- Whenever there is a non gap metabolic acidosis, calculate the urinary anion gap.
- UAG = Na + K - Chloride.

- Two types of non gap acidosis
  - Renal and non renal

Analysis of non gap metabolic acidosis

- If UAG is a positive value, implies renal source of non gap acidosis eg RTA.
- If UAG is a negative value, implies non renal source such as diarrhoea

Analysis of metabolic alkalosis

- Either adding bicarbonate and/or losing acid.
- Check urine chloride
- If low : implies chloride responsive
- If high : implies chloride unresponsive

Mixed disorders

- A normal pH may be normal
- A normal pH may be abnormal if
  - combined metabolic and alkalotic process.

Mixed disorders

- No way to have a combined respiratory acidosis and respiratory alkalosis.
- If *bicarbonate and* P_aCO_2 *have changed in opposite directions : a mixed disorder exists*

Mixed disorders

- Up to 3 at a time
  - Metabolic gap acidosis, metabolic alkalosis and respiratory alkalosis
  - Metabolic gap acidosis, metabolic alkalosis and respiratory acidosis
  - Metabolic gap acidosis, metabolic non gap acidosis and respiratory acidosis
  - etc!!!

Some examples

- pH 7. 32, PaC0_2 80
- Acute respiratory acidosis
- Plus metabolic alkalosis

Some examples

- pH 7. 10, $PaCO_2$ 60
- Acute respiratory acidosis
- Plus metabolic acidosis
- Two disorders as pH is lower than a respiratory process could explain

Some examples

- Bicarbonate 10
- AG 30
- Delta gap 20
- Corrected bicarbonate 30
- Metabolic gap acidosis
- Plus metabolic alkalosis

Some examples

- Bicarbonate 5
- AG 18
- Delta gap 8
- Corrected bicarbonate 13
- Metabolic gap acidosis
- Plus metabolic non gap acidosis

Some examples

- Bicarbonate 10
- $PaC0_2$ 25
- Appropriate respiratory compensation

Some examples

- Bicarbonate 10
- $PaC0_2$ 40
- Inappropriate respiratory compensation
- Under compensated
- Respiratory acidosis and metabolic acidosis - May need intubation!!!

Some examples

- Bicarbonate 10
- $PaC0_2$ 40
- Anion gap 40
- Metabolic acidosis gap
- Metabolic alkalosis
- Respiratory acidosis
- A triple disorder

Causes and Rx

- Metabolic gap acidosis
  - Salicylate - dialysis
  - Renal failure - renal Rx
  - Lactic acidosis - resuscitate
  - DKA - insulin, fluids, Rx trigger
  - Methanol OD - dialysis

Causes and Rx

- Metabolic non gap acidosis
  - Diarrhea - Rx the diarrhea
  - Renal tubular acidosis - Rx the cause
  - TPN - change to acetate salts of Na and K

Causes and Rx

- Metabolic alkalosis
  - NG suctioning - replace same fluid or stop suctioning
  - Vomiting - replace with NS

Causes and Rx

- Respiratory alkalosis
  - Head injury
  - Infection
  - Alcohol withdrawal
  - Anxiety
  - Pain

Causes and Rx

- Respiratory acidosis
  - Over sedation
  - COPD
  - Neuromuscular disease