Acid Base Analysis

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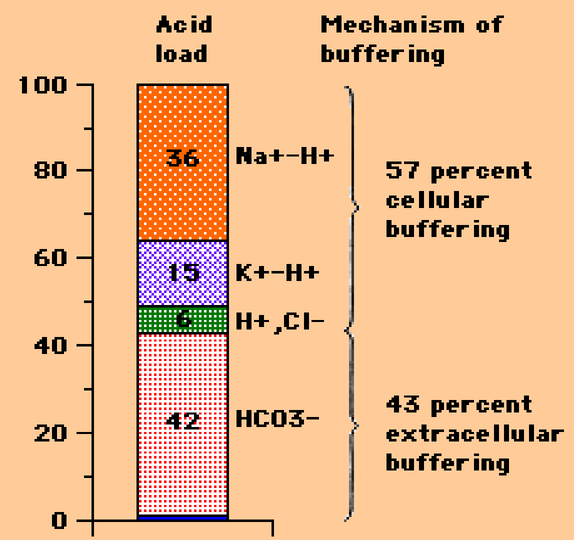
ABG analysis

- Why do we care ?
  - Critical care requires a good understanding
  - Helps in the differential and final diagnosis
  - Helps in determining treatment plan
  - Treating acid/base disorders helps medications work better (i.e. antibiotics, vasopressors, etc.)
  - Helps in ventilator management
  - Severe acid/base disorders may need dialysis
  - Changes in electrolyte levels in acidosis (increased K^+ and Na^+, and decreases in HCO_3)

Acid buffering



Buffering in metabolic acidosis Mechanisms of buffering of strong acid infused intravenously in the dog. Fifty seven percent is mediated by cell buffers, resulting in the movement of sodium (36 percent) or potassium (15 percent) into the extracellular fluid or in the movement of chloride (6 percent) into the cells. Forty three percent of buffering occurs in the extracellular fluid, almost all by bicarbonate. (Data from Pitts, RF, Physiology of the Kidney and Body Fluids, 3d ed, Year Book, Chicago, and from Swan, RC, Pitts, RF, J Clin Invest 1955; 34:205.)

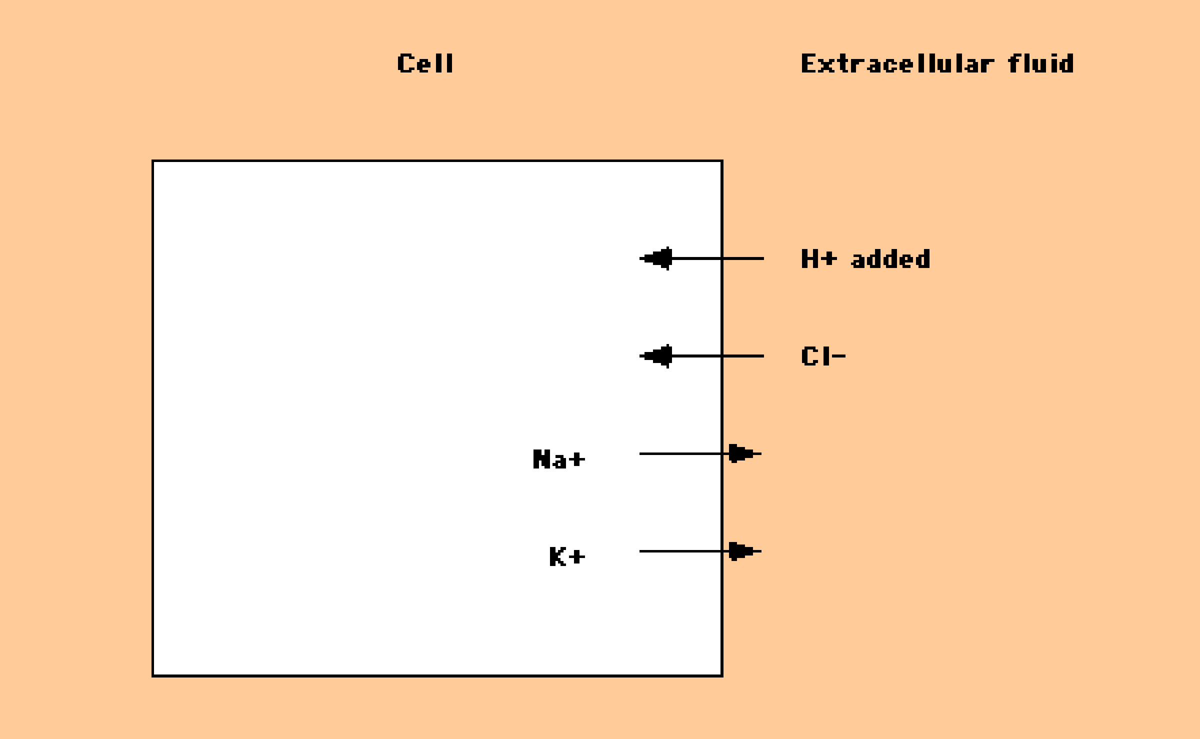
Extracellular vs. Intracellular buffering

- H+ buffering upon entering the extracellular and intracellular fluid
  - Immediate buffering by HCO_3^- extracellularly
  - H+ takes 2-3 hrs to enter the cell
    - Then buffered by intracellular shifts in electrolytes
      - Cl- follows H+ into the cell to maintain electroneutrality
      - Na+ and K+ move out of the cell therefore increasing K+ and Na+ in the extracellular fluid
  - This all occurs to help maintain the PH near 7.4

Extracellular Acid/Base buffering

- $CO_2 \longleftrightarrow CO_2 + H_2O \longleftrightarrow H_2CO_3 \longleftrightarrow H^+ + HCO_3^-$
- gas phase aqueous phase

Intracellular Acid/Base Buffering



Ion redistribution after acid load Effect of an HCl load on the distribution of Cl, Na, and K. As H enters the cells to be buffered, either Cl follows H into the cells or intracellular Na and K leave the cells and move into the extracellular fluid, tending to raise the plasma potassium concentration. These ion shifts are reversed when H ions are removed from the extracellular fluid.

Clinical use of Acid/Base analysis

Acid/Base

- Anion Gap Acidosis
  - Methanol
  - Uremia (renal failure)
  - DKA (ketoacidosis)
  - Paraldahyde
  - Inborn errors of metabolism, idiopathic
  - Lactic acidosis (i.e. sepsis, etc.)
  - Ethanol toxicity
  - Salicilates
  - Rhabdomyolisis

Acid/Base

- Non anion gap acidosis
  - Ureteral diversions
    - Ileal loops
    - Ureteral fistulas
  - Diarrhea
  - Acetazolamide (diamox)
  - Renal tubular acidosis

Acid/Base

- Metabolic alkalosis
  - Removal of gastric secretions
  - Factitious Diarrhea (laxatives)
  - Mineral corticoid excess
  - Diuretics
  - Posthypercapnic alkalosis
  - Milk alkali syndrome

Anion Gap

- Anion gap = Na+ – (Cl- + HCO3-)
  - Difference between cations (+) and anions
  - Normal AG = 8-12
  - Normal AG secondary to unmeasured albumin (anion)
  - Increased AG occurs with decrease in cations (Na+) or more commonly an increase in anions (acids, i.e. sulfates, lactate, ketones)

Arterial Blood Gas (ABG) Analysis

- ABG interpretation

  Follow rules and you will always be right !!

  1) determine PH

     acidemia or alkalemia

  2) calculate the anion gap

  3) determine Co2 compensation (winters formula)

  4) calculate the delta gap (delta HCO3)

ABG analysis

- Arterial Blood Gas (ABG) –interpretation
  - Always evaluate PH first
    - Alkalosis – PH > 7.45
    - Acidosis – PH < 7.35
  - Determine anion gap (AG) – AG = NA – (HCO3+ CL)
    - AG metabolic acidosis
    - Non AG acidosis – determined by delta gap
  - Winters formula
    - Calculates expected PaCO2 for metabolic acidosis
    - PaCO2 = 1.5 x HCO3 + 8

ABG analysis

- Delta gap
  - Delta HCO3 = HCO3 (electrolytes) + change in AG
    - Delta gap < 24 = non AG acidosis
    - Delta gap > 24 = metabolic alkalosis

  - Note: The key to ABG interpretation is following the above steps in order.

ABG analysis

- 33 y/o with DKA presents with the following:
  - Na = 128, Cl = 90, HCO3 = 4, Glucose = 800
  - 7.0/14/90/4/95%
  - PH = acidemia
  - AG = 128 – (90 + 4) = 34
  - Winters formula – 1.5(4) + 8 = 14
  - Delta gap = 4 + (34 – 12) = 26

ABG analysis

- Answer
  - AG acidosis with appropriate respiratory compensation
  - History c/w ketoacidosis secondary to DKA with appropriate respiratory compensation

ABG analysis

- 56 y/o with COPD exacerbation and hypotension and associated diarrhea x 7 days presents with the following ABG:
  - 7.22/30/65/10/90%
    - PH(7.22) = acidemia
    - AG = 139 – (10 + 110) = 19 (nl AG = 8-12)
    - Winters formula
      - PaCO2 = 1.5 (HCO3) + 8 = 1.5 (10) + 8 = 23
    - Delta gap
      - Delta gap = HC03 + change in the AG = 24
      - Delta gap = 10 + (19 – 12) = 10 + 7 = 17
      - Delta gap = 17

139	110	20	120
4.0	10	1.5	

ABG - example

- Triple disorder
  - AG acidosis -
  - Respiratory acidosis
  - Non AG acidosis

- History would suggest AG acidosis is secondary to hypotension with lactic acid build up and the patient is not able to compensate with his COPD therefore there is no respiratory compensation and the non AG acidosis is secondary to diarrhea with associated HCO3 loss.

ABG analysis

- 40 y/o with pneumonia and low BP on dopamine. She has been having N/V over the last three days
- Na = 130, Cl = 90, HCO3 = 10
- ABG = 7.26/15/65/10/90%
- PH = acidemia
- AG = 130 – (90 + 10) = 30
- PCo2 = 1.5(10) + 8 = 23
- Delta HCo3 = 10 + (30 –12) = 28

ABG analysis

- Answer
  - AG acidosis
  - Respiratory alkalosis
  - Metabolic alkalosis

Patient has sepsis causing AG acidosis and respiratory alkalosis. Previous N/V caused baseline metabolic alkalosis

ABG analysis

- 65 y/o with respiratory failure and COPD
  - ABG on vent. 7.60/40/60/30/90%, HCO3 = 30
  - Baseline ABG 7.35/60/55/30/88%, HCO3 = 30
  - Questions:
    - What is wrong with this situation ?
    - What will happen if it is not changed ?
    - How do we fix it ?

ABG analysis

- Vent. ABG = 7.25/35/80/10/95%, HCO_3 =10
  - Questions:
    - What is the acid/base status of the patient ?
    - What equation would you use to determine the changes that need to be made to the ventilator ?
    - What should we do with the ventilator ?

ABG analysis

- Pitfalls
  - Trying to interpret the acid base status without using the prior formulas
  - Using the HCO3 on the ABG which is calculated (must use the HCO3 from lytes)
  - Not drawing the lytes and ABG at the same time
  - Failing to make sure the ABG correlates with patents clinical situation

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