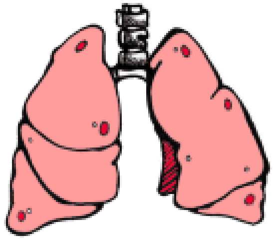

University Health Network
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ABG Interpretation: A Respirologist's approach

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November 2016

Outline

- A quick review of acid-base physiology
- The 8 steps to ABG interpretation
- Discuss the causes of hypoxemia and hypercapnea

CO2 and Carbonic Acid

Carbonic Anhydrase

$$CO_2 + H_20 \Leftrightarrow H_2CO_3 \Leftrightarrow H^+ + HCO_3^-$$

Carbonic Acid

Bicarbonate

- These reactions are very fast, so consider them to always be in equilibrium

$$CO_2 + H_20 \Leftrightarrow H^+ + HCO_3^-$$

Acid

Hydrogen ion

Bicarbinate (base)

What use is an ABG?

- Assess acid-base balance
- Assess adequacy of ventilation
- Assess oxygenation

Acid-Base Disturbances

- Acidosis = process that makes the blood acidic
- Alkalosis = process that makes the blood alkaline
  - This is a diagnosis
  - Mutliple disorders can exist simultaneously

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Two kinds of pH disorders

1. “Respiratory” = 1º abnormality in ventilation (CO2)
2. “Metabolic” = 1º abnormality in any other acid or base

Acid-Base Disturbances

- When acidosis or alkalosis occurs, the body tries to normalize pH by “compensating” using buffers
  - If the primary process is metabolic,
    - We use lungs to increase or decrease ventilation to alter p_aCO2
    - This “respiratory compensation” takes minutes
  - If the primary process is respiratory,
    - We use kidneys to excrete either acid (NH4) or base (NaHCO3)
    - This “metabolic compensation” takes hours or days

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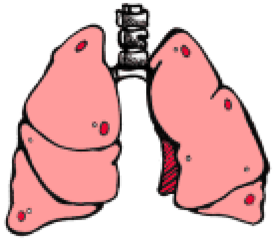
    - We use kidneys to excrete either acid (NH4) or base (NaHCO3)
    - This "metabolic compensation" takes hours or days
- Compensation is always in the same direction as the primary problem
  - If p_aCO2 rises, appropriate compensation increases HCO3-
  - If p_aCO2 falls, appropriate compensation decreases HCO3-
  - If HCO3- rises, appropriate compensation increases p_aCO2
  - If HCO3- falls, apppropriate compensation decreases p_aCO2

Alveolar Ventilation



- CO_2 is normally tightly regulated
  - Small changes to CO_2 alter ventilation
- Carotid body is essential to this regulation
  - This is a cluster of chemoerceptors in the carotid artery
  - Detects levels of [O_2], [CO_2] and [H^+]
  - Sends signals to the brain
  - Alters ventilation in response to [CO_2] and [H^+]

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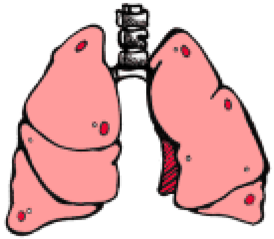

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- Carotid body response:
  - When patient has acidemia (low pH)
    - Carotid body makes you more sensitive to $[CO_2]$ = ↑ ventilation
  - When patient has alkalemia (high pH)
    - Carotid body makes you less sensitive to $[CO_2]$ = ↓ ventilation

Respiratory Acidosis

$$CO_2 + H_20 \Leftrightarrow H^+ + HCO_3^-$$

$$[H+] = \frac{24 \times p_aCO2}{[HCO3]}$$

Respiratory Acidosis

$$CO_2 + H_2 0 \Leftrightarrow H^+ + HCO_3^-$$

- Hypoventilation

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Respiratory Acidosis

$$\uparrow \mathbf{CO_2} + H_20 \Leftrightarrow H^+ + HCO_3^-$$

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- Hypoventilation causes rise in p_aCO2, shifts equilibrium to the right.
  - Acutely (10:1)
    - For each 10 mm Hg rise in p_aCO2, HCO3 should increase by 1 mEq/L
    - This is due to equilibrium shift (buffering)

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  - Common causes
    - Lung disease
    - Neuromuscular disease
    - Sedative drugs
    - Adaptation to extreme obesity and sleep apnea

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Respiratory Alkalosis

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Respiratory Alkalosis

$$\downarrow CO_2 + H_2 0 \Leftrightarrow H^+ + HCO_3^-$$

- Hyperventilation causes p_aCO2 to fall,

$$[H+] = \frac{24 \times p_aCO2}{[HCO3]}$$

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  - Common causes
    - Anxiety / panic (including panic attacks)
    - Pregnancy
    - Early sepsis
    - Drugs (one component of ASA toxicity)
    - Mechanical ventilation at excessive rate or volumes

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Metabolic Alkalosis

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- Compensation (1:0.7)
  - For every 1 mEq rise in HCO3-, p_aCO2 increases by 0.7 mmHg

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- Causes
  - Volume depletion ("contraction alkalosis")
  - Nasogastric suction
  - Diuretics
  - Hyperaldosteronism

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Metabolic Acidosis

- Two possible mechanisms of onset
  - Loss of HCO_3^-
  - Gain of H^+
- Mechanisms of compensation are a bit more complex

Metabolic Acidosis – Bicarb Loss

$$CO_2 + H_20 \Leftrightarrow H^+ + HCO_3^-$$

- Loss of bicarbinate (ie. diarrhea) creates an acidemia (a relative increase in [H+])

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Metabolic Acidosis – Acid Gain

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- Some acid gets added to the body (ie. excercising muscle makes lactate)

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- Compensation
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- Examples of metabolic acidosis
  - Diarrhea/GI losses (loss of HCO3)
  - lactic acidosis (lactic acid)
  - renal failure (metabolic acids and loss of HCO3)
  - diabetic ketoacidosis (acetic acid)
  - ASA (acetylsalicylic acid)

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ABG Interpretation

“ABG’s in 8 steps”

A Case

- You get a call from a your clinical clerk…
  - “I need your input on Ms. K. She is a 65 year old woman who is here for a small bowel obstruction. Med consults is following her for long standing back pain and they are working her up for possible cancer.”

- ABG (pH / PaCO2 / PaO2 / HCO3-)

7.30 / 80 / 45 / 38

3.6

140 | 3.9 /

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Please interpret this ABG

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Step 1

- **Step 1: Obtain ABG and electrolytes**
  - If you don’t perform the test, you’ll never know what is going on with the patient
  - An ABG and a lactate are the 2 best tests to help you get a sick patient to the ICU

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Step 2

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•7.30 / 80 / 45 / 38

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- **Step 2: Determine the primary process:**
  – Is it an acidosis or an alkalosis?
  – Is the primary problem respiratory or metabolic?

•7.30 / 80 / 45 / 38

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A. Look at the pH.
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   - If concordant, the primary problem is respiratory
     - Low pH and high p_aCO_2 indicates respiratory acidosis
     - High pH and low p_aCO_2 indicates respiratory alkalosis

   - If not concordant, the primary problem is metabolic
     - Low pH and low p_aCO_2 indicates metabolic acidosis
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  - Has it changed by the expected amount?
    - It doesn't have to be "perfect"
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    - Whether multiple disorders are present

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	Δ p_aCO2	Δ HCO3-
Acute Respiratory Acidosis		
Acute Respiratory Alkalosis		
Chronic Respiratory Acidosis		
Chronic Respiratory Alkalosis		
Metabolic Alkalosis		
Metabolic Acidosis		

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	Δ p_aCO2	Δ HCO3-
Acute Respiratory Acidosis	↑ 10	↑ 1
Acute Respiratory Alkalosis	↓ 10	↓ 2
Chronic Respiratory Acidosis	↑ 10	↑ 3
Chronic Respiratory Alkalosis	↓ 10	↓ 4
Metabolic Alkalosis	↑ 0.7	↑ 1
Metabolic Acidosis	↓ 1	↓ 1

- 7.30 / 80 / 45 / 38

Step 3: What is the compensation?

- If compensation is "right", there is one process
- If compensation doesn't "fit", there may be more than one process going on

	Δ p_aCO2	Δ HCO3-
Acute Respiratory Acidosis	↑ 10	↑ 1
Acute Respiratory Alkalosis	↓ 10	↓ 2
Chronic Respiratory Acidosis	↑ 10	↑ 3
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Metabolic Alkalosis	↑ 0.7	↑ 1
Metabolic Acidosis	↓ 1	↓ 1

- 7.30 / 80 / 45 / 38

Step 4:

Step 4: Determine the Anion Gap

3.6

140 | /

100 | 35 \

85

•7.30 / 80 / 45 / 38

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3.6

140 | /

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Anion Gap = $Na^+ - Cl^- - HCO3^-$

= 140 – 100 – 35

= 5 (normal is < 12)

•7.30 / 80 / 45 / 38

Anion Gap

- What is the anion gap?

Anion Gap

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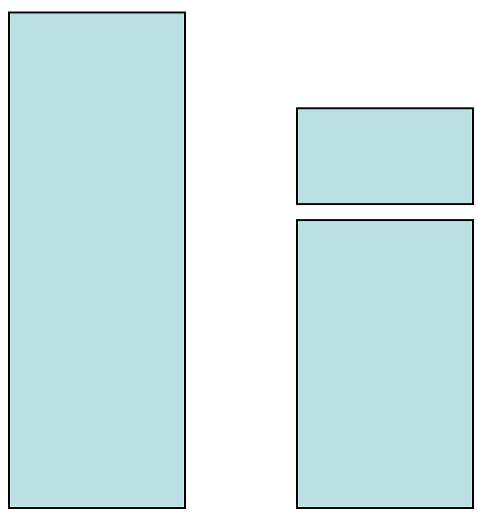
All the cations in the body

(Na+)



\+ -

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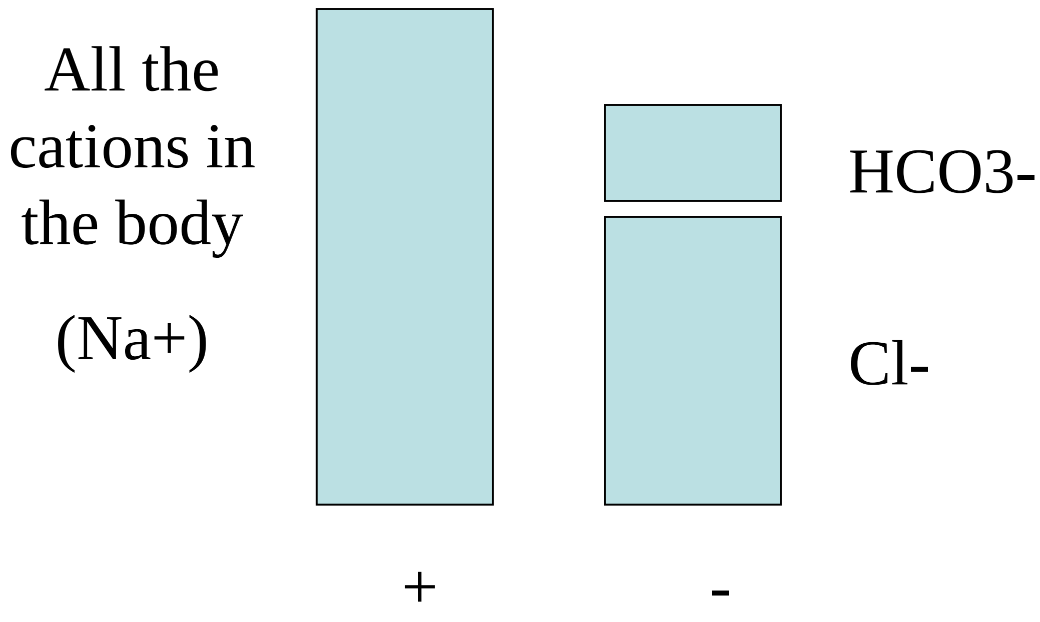

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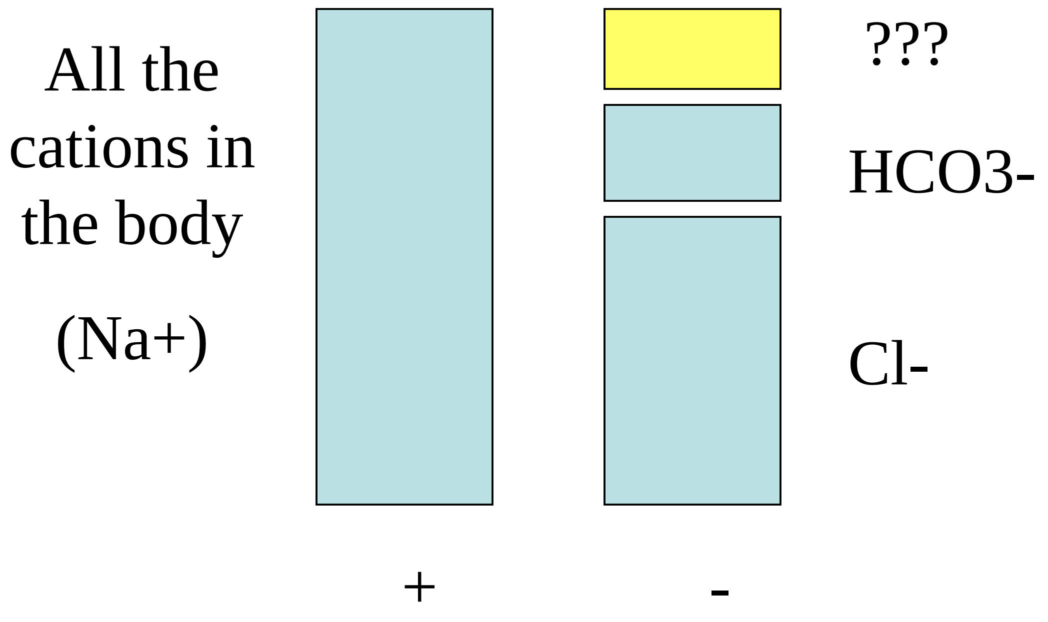

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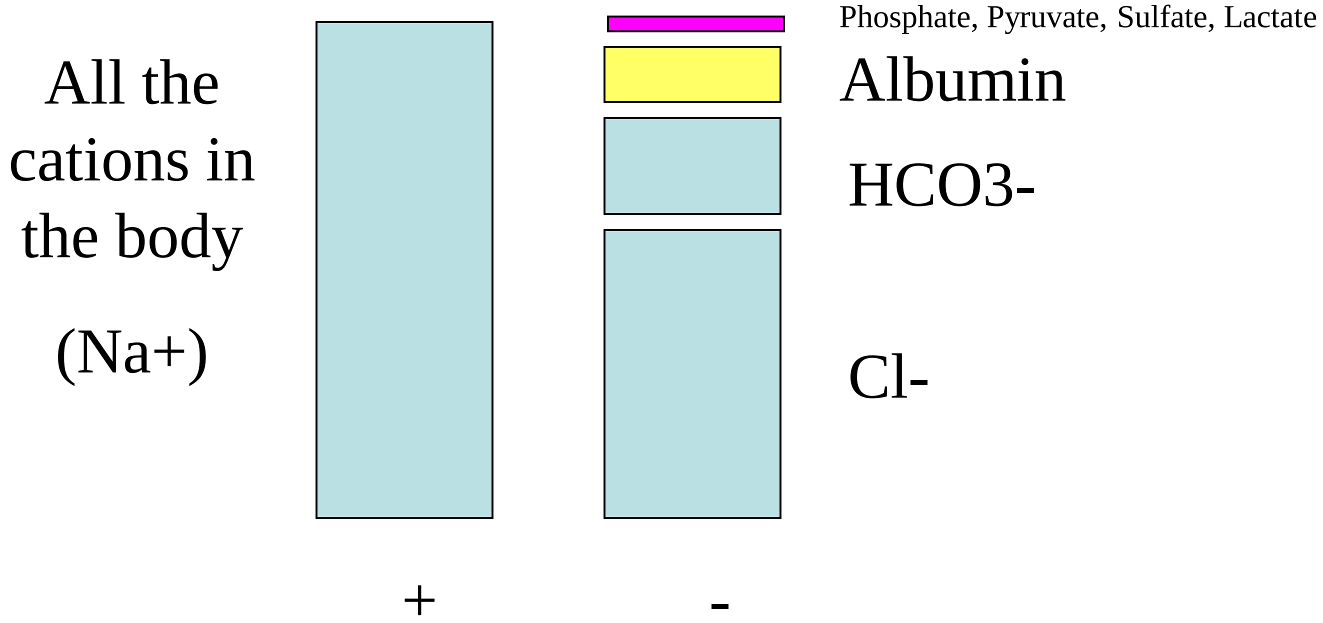
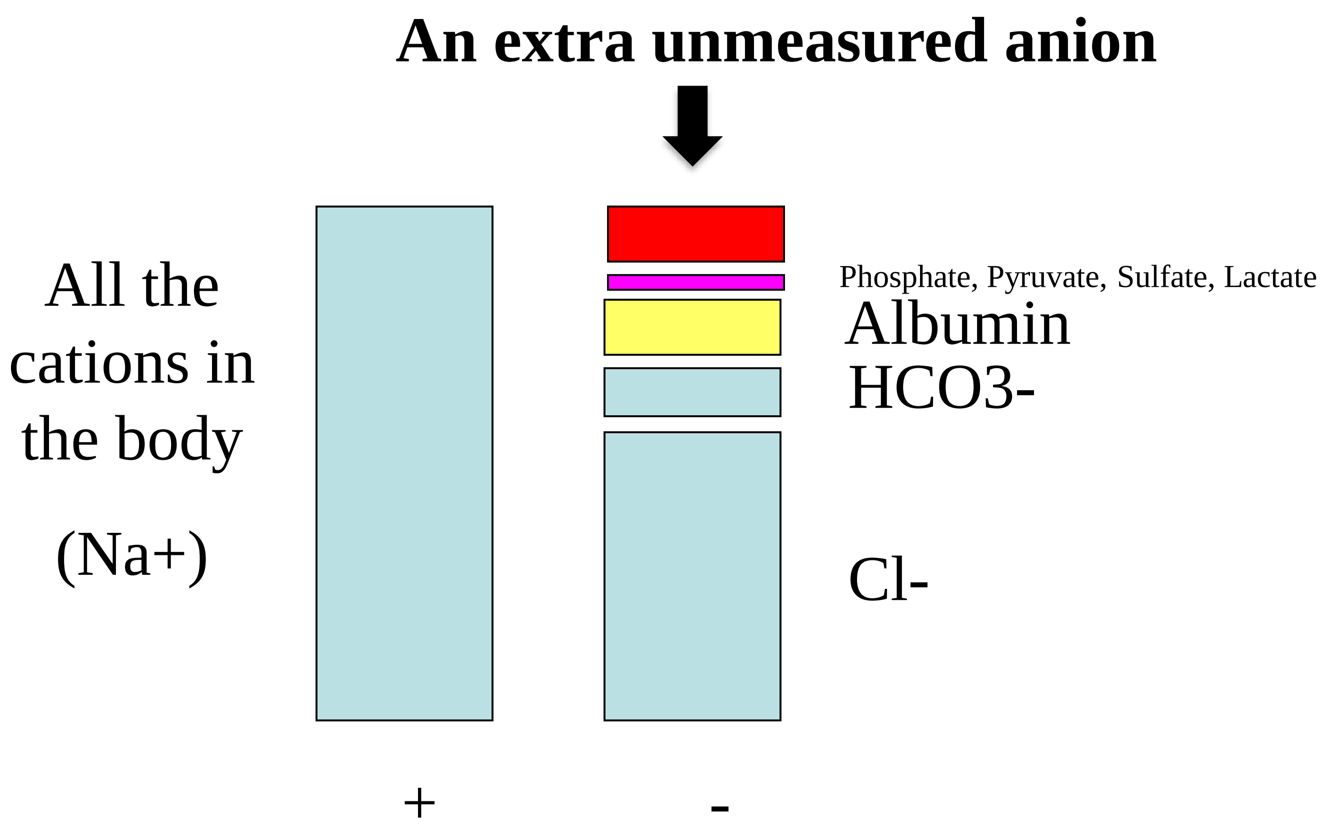


Anion Gap

- What causes an increased anion gap?



Anion Gap – DDx

- Medical student answer
  - MUDPILES
- Real life answer…

Anion Gap – DDx

- Medical student answer
  - MUDPILES
- Real life answer…
  - Lactic acidosis
  - Ketosis (DKA, starvation, alcohol)
  - Renal failure
  - Poison (alcohols, ASA, cyanide)

Step 5

- Step 1: Get the ABG
- Step 2: Determine primary abnormality
- Step 3: What is the compensation
- Step 4: Assess the anion gap
- Step 5:

- 7.30 / 80 / 45 / 38

Step 5: <u>If</u> an Anion Gap is present, is it the only process?

- How do you determine if AG is the only process?

•7.30 / 80 / 45 / 38

Step 5: <u>If</u> an Anion Gap is present, is it the only process?

- Each molecule of unmeasured anion (ie. Lactate) donates a H+ which binds to HCO3-
- $H^+ + HCO3^- \rightarrow$ H20 and CO2

Step 5: <u>If</u> an Anion Gap is present, is it the only process?

- Each molecule of unmeasured anion (ie. Lactate) donates a H+ which binds to HCO3-
- H^{+} + $HCO3^{-}$ → H20 and CO2
- Therefore, if there is only one process,
  - Amount of added acid **=** the increase in H+ **=** the fall in HCO3-
  - The amount of added acid is measured using the anion gap
  - So, the <u>**change**</u> in Anion Gap should equal the <u>**change**</u> in HCO3-

Step 5: <u>If</u> an Anion Gap is present, is it the only process?

- Calculate ΔAG/ΔHCO_3^- ratio

ΔAG = measured AG – 12

Δ HCO_3^- = 24 – measured HCO_3^-

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Step 5: <u>If</u> an Anion Gap is present, is it the only process?

- Calculate ΔAG/ΔHCO3- ratio

- If ΔAG/ΔHCO3- ratio = 1 → no other process

  - Ratio > 1, HCO3 is too low → concomitant non-AG acidosis

  - Ratio < 1, HCO3 is too high → concomitant alkalosis

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Step 6

- Step 1: Get the ABG
- Step 2: Determine primary abnormality
- Step 3: What is the compensation
- Step 4: Assess the anion gap
- Step 5: Is the anion gap the only process
- Step 6:

Step 6: Determine the Osmolar (OSM) Gap

- How do you calculate the osmolar gap?

Step 6: Determine the Osmolar (OSM) Gap

- OSM gap = measured OSM - calculated OSM
  - Measured OSM: given by the lab
  - Calculated OSM = (2 x Na^+) + BG + BUN
    - “Two salts and a sugar bun.”
- Normal Osmolar gap < 10

Step 6: Determine the Osmolar (OSM) Gap

- DDx of a high osmolar gap
  - Methanol*
  - Ethylene glycol*
  - Ethanol
  - Mannitol
  - Acetone
  - Isopropyl alcohol
  - Others…

* Anion gap AND osmolar gap

Step 7

- Step 1: Get the ABG
- Step 2: Determine primary abnormality
- Step 3: What is the compensation
- Step 4: Assess the anion gap
- Step 5: Is the anion gap the only process
- Step 6: Calculate the osmolar gap
- Step 7:

Step 7: Calculate the A-a gradient

- Calculate the A-a gradient in this patient

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Step 7: Calculate the A-a gradient

- A-a gradient = PAO2 – PaO2

- PAO2 = [(Pbar – PH20) x FiO2] – [PaCO2/RQ]
  = [(760 - 47) x FiO2] – [PaCO2/RQ]
  = [(713) x FiO2] – [PaCO2/RQ]

- PaO2 = measured with ABG

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Step 7: Calculate the A-a gradient

- PAO2 = [(Pbar – PH20) x FiO2] – [PaCO2/RQ]

- A-a = PAO2 – PaO2
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•7.30 / 80 / 45 / 38

Step 7: Calculate the A-a gradient

- PAO2 = [(Pbar – PH20) x FiO2] – [PaCO2/RQ]

- A-a = PAO2 – PaO2
- A-a = **[(Pbar – PH20) x FiO2] – [PaCO2/RQ]** – PaO2
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•7.30 / 80 / 45 / 38

Step 7: Calculate the A-a gradient

- PAO2 = [(Pbar – PH20) x FiO2] – [PaCO2/RQ]

- A-a = PAO2 – PaO2
- A-a = [(Pbar – PH20) x FiO2] – [PaCO2/RQ] – PaO2
- A-a = [(**760 – 47**) x **0.21**] – [PaCO2 **/ 0.8**] – PaO2
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•7.30 / 80 / 45 / 38

Step 7: Calculate the A-a gradient

- PAO2 = [(Pbar – PH20) x FiO2] – [PaCO2/RQ]

- A-a = PAO2 – PaO2
- A-a = [(Pbar – PH20) x FiO2] – [PaCO2/RQ] – PaO2
- A-a = [(760 – 47) x 0.21] – [PaCO2 / 0.8] – PaO2
- A-a = [(760 – 47) x 0.21] – [**1.25 x PaCO2**] – PaO2
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•7.30 / 80 / 45 / 38

Step 7: Calculate the A-a gradient

- PAO2 = [(Pbar – PH20) x FiO2] – [PaCO2/RQ]

- A-a = PAO2 – PaO2
- A-a = [(Pbar – PH20) x FiO2] – [PaCO2/RQ] – PaO2
- A-a = [(760 – 47) x 0.21] – [PaCO2 / 0.8] – PaO2
- A-a = [(760 – 47) x 0.21] – [1.25 x PaCO2] – PaO2
- A-a = [(**713**) x 0.21] – [1.25 x PaCO2] – PaO2
- -
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•7.30 / 80 / 45 / 38

Step 7: Calculate the A-a gradient

- PAO2 = [(Pbar – PH20) x FiO2] – [PaCO2/RQ]

- A-a = PAO2 – PaO2
- A-a = [(Pbar – PH20) x FiO2] – [PaCO2/RQ] – PaO2
- A-a = [(760 – 47) x 0.21] – [PaCO2 / 0.8] – PaO2
- A-a = [(760 – 47) x 0.21] – [1.25 x PaCO2] – PaO2
- A-a = [(713) x 0.21] – [1.25 x PaCO2] – PaO2
- A-a = [**150**] – [1.25 x PaCO2] – PaO2
- -
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- -

•7.30 / 80 / 45 / 38

Step 7: Calculate the A-a gradient

- PAO2 = [(Pbar – PH20) x FiO2] – [PaCO2/RQ]

- A-a = PAO2 – PaO2
- A-a = [(Pbar – PH20) x FiO2] – [PaCO2/RQ] – PaO2
- A-a = [(760 – 47) x 0.21] – [PaCO2 / 0.8] – PaO2
- A-a = [(760 – 47) x 0.21] – [1.25 x PaCO2] – PaO2
- A-a = [(713) x 0.21] – [1.25 x PaCO2] – PaO2
- **A-a = [150] – [1.25 x PaCO2] – PaO2 - Simplified version for pt on R/A**
- -
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•7.30 / 80 / 45 / 38

Step 7: Calculate the A-a gradient

- PAO2 = [(Pbar – PH20) x FiO2] – [PaCO2/RQ]

- A-a = PAO2 – PaO2
- A-a = [(Pbar – PH20) x FiO2] – [PaCO2/RQ] – PaO2
- A-a = [(760 – 47) x 0.21] – [PaCO2 / 0.8] – PaO2
- A-a = [(760 – 47) x 0.21] – [1.25 x PaCO2] – PaO2
- A-a = [(713) x 0.21] – [1.25 x PaCO2] – PaO2
- A-a = [**150**] – [1.25 x PaCO2] – PaO2
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- -
- -

•7.30 / 80 / 45 / 38

Step 7: Calculate the A-a gradient

- PAO2 = [(Pbar – PH20) x FiO2] – [PaCO2/RQ]

- A-a = PAO2 – PaO2
- A-a = [(Pbar – PH20) x FiO2] – [PaCO2/RQ] – PaO2
- A-a = [(760 – 47) x 0.21] – [PaCO2 / 0.8] – PaO2
- A-a = [(760 – 47) x 0.21] – [1.25 x PaCO2] – PaO2
- A-a = [(713) x 0.21] – [1.25 x PaCO2] – PaO2
- A-a = [150] – [1.25 x PaCO2] – PaO2
- A-a = [150] – [**1.25 x 80**] – PaO2
- -
- -
- -
- -

•7.30 / 80 / 45 / 38

Step 7: Calculate the A-a gradient

- PAO2 = [(Pbar – PH20) x FiO2] – [PaCO2/RQ]

- A-a = PAO2 – PaO2
- A-a = [(Pbar – PH20) x FiO2] – [PaCO2/RQ] – PaO2
- A-a = [(760 – 47) x 0.21] – [PaCO2 / 0.8] – PaO2
- A-a = [(760 – 47) x 0.21] – [1.25 x PaCO2] – PaO2
- A-a = [(713) x 0.21] – [1.25 x PaCO2] – PaO2
- A-a = [150] – [1.25 x PaCO2] – PaO2
- A-a = [150] – [1.25 x 80] – PaO2
- A-a = [150] – [**100**] – PaO2
- -
- -
- -

•7.30 / 80 / 45 / 38

Step 7: Calculate the A-a gradient

- PAO2 = [(Pbar – PH20) x FiO2] – [PaCO2/RQ]

- A-a = PAO2 – PaO2
- A-a = [(Pbar – PH20) x FiO2] – [PaCO2/RQ] – PaO2
- A-a = [(760 – 47) x 0.21] – [PaCO2 / 0.8] – PaO2
- A-a = [(760 – 47) x 0.21] – [1.25 x PaCO2] – PaO2
- A-a = [(713) x 0.21] – [1.25 x PaCO2] – PaO2
- A-a = [150] – [1.25 x PaCO2] – PaO2
- A-a = [150] – [1.25 x 80] – PaO2
- A-a = [150] – [100] – PaO2
- A-a = **50** – PaO2
- -
- -

•7.30 / 80 / 45 / 38

Step 7: Calculate the A-a gradient

- PAO2 = [(Pbar – PH20) x FiO2] – [PaCO2/RQ]

- A-a = PAO2 – PaO2
- A-a = [(Pbar – PH20) x FiO2] – [PaCO2/RQ] – PaO2
- A-a = [(760 – 47) x 0.21] – [PaCO2 / 0.8] – PaO2
- A-a = [(760 – 47) x 0.21] – [1.25 x PaCO2] – PaO2
- A-a = [(713) x 0.21] – [1.25 x PaCO2] – PaO2
- A-a = [150] – [1.25 x PaCO2] – PaO2
- A-a = [150] – [1.25 x 80] – PaO2
- A-a = [150] – [100] – PaO2
- A-a = 50 – PaO2
- A-a = 50 – **45**
- -

•7.30 / 80 / 45 / 38

Step 7: Calculate the A-a gradient

- PAO2 = [(Pbar – PH20) x FiO2] – [PaCO2/RQ]

- A-a = PAO2 – PaO2
- A-a = [(Pbar – PH20) x FiO2] – [PaCO2/RQ] – PaO2
- A-a = [(760 – 47) x 0.21] – [PaCO2 / 0.8] – PaO2
- A-a = [(760 – 47) x 0.21] – [1.25 x PaCO2] – PaO2
- A-a = [(713) x 0.21] – [1.25 x PaCO2] – PaO2
- A-a = [150] – [1.25 x PaCO2] – PaO2
- A-a = [150] – [1.25 x 80] – PaO2
- A-a = [150] – [100] – PaO2
- A-a = 50 – PaO2
- A-a = 50 – 45
- A-a = **5**

•7.30 / 80 / 45 / 38

Step 7: Calculate the A-a gradient

- What is a normal A-a gradient?

Step 7: Calculate the A-a gradient

- Normal A-a gradient
  - A-a gradient < 10 is normal
  - A-a gradient is higher in elderly (up to 20)

Step 8: Causes of hypoxemia

- List the 5 major causes of hypoxemia
- Which have a normal A-a gradient?
- Which have a high A-a gradient?

Step 8: Causes of hypoxemia

1. Low inspired O2 content (low FiO2 or low PiO2)
2. Hypoventilation

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3. V/Q mismatch
   - Asthma, COPD, Alveolar filling (fluid, blood, pus), pHTN
4. Shunt
   - Physiologic shunt
   - Intra-cardiac (ASD, PFO or VSD)
   - Intra-pulmonary
     - With normal capillaries: atelectasis or consolidation
     - With abnormal capillaries: pAVM's or HPS
5. Diffusion abnormality
   - Severe ILD, severe COPD, etc…

Summarize this ABG

- Step 1: Get the ABG
- Step 2: Determine primary abnormality
- Step 3: What is the compensation
- Step 4: Assess the anion gap
- Step 5: Is the anion gap the only process
- Step 6: Calculate the osmolar gap
- Step 7: Calculate the A-a gradient
- Step 8: Cause of hypoxemia

7.30 / 80 / 45 / 38

140 | ___ / 3.6

100 | 35 \ 85

Summarize this ABG

- Step 1: done
- Step 2: chronic respiratory acidosis
- Step 3: compensated appropriately (10:3.5)
- Step 4: anion gap = 5 (normal)
- Step 5: no anion gap present
- Step 6: osmolar gap (can't do)
- Step 7: A-a gradient = 5 (normal)
- Step 8: hypoxemia due to hypoV

7.30 / 80 / 45 / 38

140 | ___ / 3.6

100 | 35 \ 85

Causes of Hypercapnia

- What are the determinants of $PaCO_2$?

Causes of Hypercapnia

- What are the determinants of $PaCO_2$?
- $PaCO_2 = (VCO_2) / RR (V_t - V_d) \times K$
  - CO_2 production
  - Respiratory rate
  - Tidal volume
  - Dead space volume

Causes of Hypercapnia

$$PaCO2 = (VCO2) / RR (Vt-Vd) \times K$$

- **High VCO2**

Causes of Hypercapnia

$$PaCO_2 = (VCO_2) / RR (Vt - Vd) \times K$$

- **High VCO_2**
  - fever, sepsis, seizures

Causes of Hypercapnia

$$PaCO_2 = (VCO_2) / RR\,(V_t - V_d) \times K$$

- **High VCO2**
  - fever, sepsis, seizures

- **Low RR**

Causes of Hypercapnia

$$PaCO_2 = (VCO_2) / RR (V_t - V_d) \times K$$

- **High VCO_2**
  - fever, sepsis, seizures
- **Low RR**
  - drugs, brainstem lesions, hypothyroid

Causes of Hypercapnia

$$PaCO_2 = (VCO_2) / RR (V_t - V_d) \times K$$

- **High VCO_2**
  - fever, sepsis, seizures
- **Low RR**
  - drugs, brainstem lesions, hypothyroid
- **Low Vt**

Causes of Hypercapnia

$PaCO_2 = (VCO_2) / RR (Vt-Vd) \times K$

- **High VCO_2**
  - fever, sepsis, seizures
- **Low RR**
  - drugs, brainstem lesions, hypothyroid
- **Low Vt**
  - muscle weakness (rapid shallow breathing pattern), neuromuscular disease, low chest wall compliance

Causes of Hypercapnia

$PaCO_2 = (VCO_2) / RR (Vt - Vd) \times K$

- **High VCO_2**
  - fever, sepsis, seizures
- **Low RR**
  - drugs, brainstem lesions, hypothyroid
- **Low Vt**
  - muscle weakness (rapid shallow breathing pattern), neuromuscular disease, low chest wall compliance
- **High Vd**

Causes of Hypercapnia

$$PaCO_2 = (VCO_2) / RR (Vt-Vd) \times K$$

- **High VCO_2**
  - fever, sepsis, seizures
- **Low RR**
  - drugs, brainstem lesions, hypothyroid
- **Low Vt**
  - muscle weakness (rapid shallow breathing pattern), neuromuscular disease, low chest wall compliance
- **High Vd**
  - ARDS, PE, COPD

Back to the case

- You get a call from a your clinical clerk…
  - “I need your input on Ms. K. She is a 65 year old woman who is here for a small bowel obstruction. Med consults is following her for long standing back pain and they are working her up for possible cancer.”

- ABG (pH/$PaCO_2$/PaO_2/HCO_3^-)

7.30 / 80 / 45 / 38

Back to the case

- You get a call from a your clinical clerk…
  - “I need your input on Ms. K. She is a 65 year old woman who is here for a small bowel obstruction. Med consults is following her for long standing back pain and they are working her up for possible cancer.”

- ABG (pH/PaCO2/PaO2/HCO3-)

  7.30 / 80 / 45 / 38

- You diagnose a chronic respiratory acidosis with a normal A-a gradient due to hypoventilation
  - You remove the fentanyl patch from her arm
  - You transfer her to the ICU

Back to the case

- 15 minutes later
  - Patient arrives in ICU
  - RT feels patient is worse

- ABG: 7.30 / 80 / 30 / 38
  - What happened?

Baseline ABG:
7.30 / 80 / 45 / 38

Back to the case

- ABG: 7.30 / 80 / 30 / 38
  - Acid base status unchanged
  - PaO_2 fell from 45 → 30

- A-a gradient has increased
  - A-a = PAO_2 – PaO_2
  - A-a = [150 – (1.25 x $PaCO_2$)] – PaO_2
  - A-a = [150 – (1.25 x 80)] – 30
  - A-a = [150 – 100] – 30
  - A-a = 20

- DDx?

Baseline ABG:
7.30 / 80 / 45 / 38

Back to the case: Causes of hypoxemia

1. Low inspired O2 content (low FiO2 or low PiO2)
2. Hypoventilation

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3. V/Q mismatch
   - **Asthma, COPD, Alveolar filling (fluid, blood, pus), pHTN**

4. Shunt
   - **Physiologic shunt**
   - **Intra-cardiac (ASD, PFO or VSD)**
   - **Intra-pulmonary**
     - **With normal capillaries: atelectasis or consolidation**
     - **With abnormal capillaries: pAVM's or HPS**

5. Diffusion abnormality
   - **Severe ILD, severe COPD, etc…**

Back to the case:
DDx of acute rise in A-a gradient

- V/Q mismatch
  - Aspiration pneumomitis
  - Flash pulmonary edema
  - Mucous plug
  - Pneumothorax
  - PE
  - (ARDS)

Review:
ABG interpretation in 8 steps

- Step 1: Get the ABG
- Step 2: Determine primary abnormality
- Step 3: What is the compensation
- Step 4: Assess the anion gap
- Step 5: Is the anion gap the only process
- Step 6: Calculate the osmolar gap
- Step 7: Calculate the A-a gradient
- Step 8: Causes of hypoxemia

Questions?