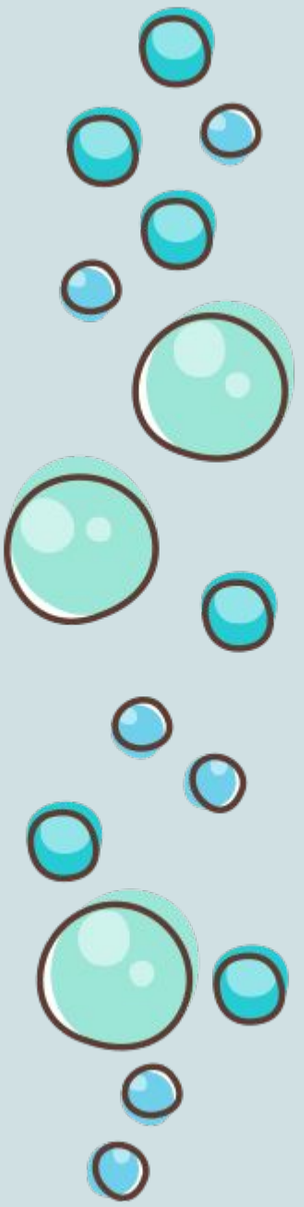
Acid Base Disorders



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بفضلٍ من الله

شكرًا، كقصر حروفها كانت الرحلة، وكعمقِ معناها كانت هي في غناها من كل جانب، فشكرًا لكل يد وروح ساهمت في إنجاز هذا العمل، شَكرًا لكم من القلب ...

أعضاء فريق علم السموم

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جواهر أبانمي	عبدالله الطويرقي
ريان القرني	مؤيد أحمد
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غيداء السعيد	ندى الدخيل

سندس الحوامدة

وكيف لنا أن ننسى من شكرنا، أولئك العظيمين الذين ساهموا في نجاح ليس فقط عمل هذا الفريق وإنما أعمال الدفعة كاملة، شكرًا كحجم السماء لقادتنا الأكاديميين...!

شكرًا يارا الدعيجي

شكرًا باسل المفلح

لن ينتهي هذا الشكر بل سيستمر من خلال دعواتنا لكم بالتوفيق والنجاح (: !

قادة فريق علم السموم

خالد العيدان

أسيل بادخن

Objectives

1. To provide a simple, systematic approach to interpreting arterial blood gas (ABG) samples. (It has been so long since we had one >_<)

Last lecture)': May Allah grant you success!

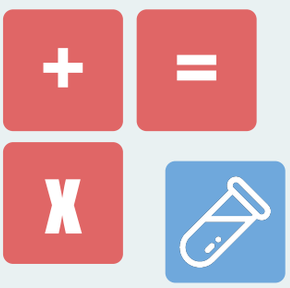
NOTES EXTRA BOOK IMPORTANT GOLDEN NOTES

Introduction

- Multiple formulas and rules exist to help guide us through the forest of diagnoses and complex problems
- All that is needed is a little clinical information obtained from:

A history and physical examination | A few readily available laboratory tests | The knowledge of 5 simple steps

-It is important for doctors to recognize if the metabolic disorder is compensated or not because metabolic disorders could be life-threatening.
-In respiratory disorders, we need to know if it is acute or chronic for management.



Getting in the routine of performing these steps on each patient in which an ABG and electrolytes are performed will help decrease the rate of missed complex acid-base disturbances and hopefully improve patient care

-In osis, you can have mix disorders and pH will be normal so that's why calculating anon gap is important.
-Chronic patient has history of either **smoking** or **COPD**
-Acute on chronic respiratory disorder means when your patient is chronic but the calculated **result is lower than the excepted**
-Worst acid-base disorders are in order:
1-Metabolic Acidosis
2-Respiratory Acidosis
3-Metabolic alkalosis
4-Respiratory alkalosis (Patient can live with it)

Five Steps of Acid-Base Analysis 1-5

1

Acidemia (pH <7.38) or alkalemia (pH >7.42)? Any emia should have osis with it , Any osis not necessarily to have emia with it. Emia is the change in the blood.

2

Primary respiratory or metabolic disturbance? (Look at PCO2 on ABG or HCO3 on metabolic panel.)
PCO2 baseline is 40, HCO3 is 24. If both of Pco2 and HCO3 are increased or decreased it's metabolic, if one of them is increased and other is decreased it's respiratory. Metabolic (Acidosis both are decreased, alkalosis both are increased), Respiratory(Acidosis pH is low and PCO2 is high, alkalosis pH is high, PCO2 is low)

3

Is there appropriate compensation for the primary disorder?
-Metabolic acidosis: PCO2 = [1.5 x (serum HCO3)] + 8 (±2) is the process to induce acidemia (Osis)
-Metabolic alkalosis: ↑PCO2 = 0.6 x ↑HCO3 (±2)
-Respiratory acidosis: ↑PCO2 10 ↑ HCO3 by 1 (acute) or 4 (chronic) (e.g. if PCO2 was 70, the increase from baseline is 30 (10x3) so HCO3 will increase by 3 [1x3] "acute", 12 [4x3] "chronic")
-Respiratory alkalosis: ↓PCO2 10 ↓ HCO3 by 2 (acute) or 5 (chronic)
-If patient's PCO2 is lower/higher than calculated PCO2 in metabolic acidosis, then no appropriate compensation (another primary disorder) but if both results are equal then there is compensation.

4

Is there an anion gap metabolic acidosis (AGMA)? STEP 4 is essential, even if step 1-3 are normal, numbers can cheat you; step 4 can confirm if your pt has disorder or not.
-AG = Na - (HCO3 + Cl).
-If > 12, an AGMA is present.

5

If metabolic acidosis, is there another concomitant metabolic disturbance? Depends on step 4, if it is AGMA then proceed to this step but if you have NAGMA then don't do it.
-If AGMA then calculate:
ΔGap = ΔAG-ΔHCO3 =(AG-12) - (24-HCO3)

Interpretation of result: (If the result is between 6 and -6 it means that you have **ONLY** AGMA but no additional disorders)
-If the Gap is > 6 there is a combined AGMA and metabolic alkalosis.
-If the Gap is < -6, there is a combined AGMA and NAGMA*.
-If NAGMA, for every 1 mEq/L ↑Cl there should be a 1 mEq/L ↓ HCO3 (±5).
-If HCO3 decrease is less than predicted, then NAGMA and metabolic alkalosis.

*Non-anion Gap Metabolic Acidosis

Acidosis

1-Metabolic Acidosis

Most common cause of HAGMA:
1-DKA (diabetic ketoacidosis)
2-Lactic acidosis
3-Renal failure
-Aspirin overdose causes **metabolic acidosis** and **respiratory alkalosis**

In the presence of a pH < 7.38, metabolic acidosis is diagnosed as a primary condition when the pCO2 is < 40 mmHg or the bicarbonate is < 24 mEq/L.

Metabolic acidosis can be further classified based on the presence of an anion gap. Into 2 types:

AGMA | NAGMA

➔ Anion Gap:

The anion gap reflects the balance between positively and negatively charged particles in the blood.

Sodium is the only significant positively charged particle that is measured

While

The measured anions are chloride and bicarbonate

HCO3- Cl- Na+

Therefore, the anion gap is calculated by the formula:

Na-(Cl + HCO3)

Low Albumin:

- One potential pitfall in the measurement of the anion gap is patients with low albumin.
- Albumin has several negative charges on it and therefore, in a patient with a low albumin level, their "normal" anion gap might be much lower than 12.

For every 1 gram drop in serum albumin level, the anion gap decreases by 2.5.

A patient with a calculated anion gap of 10 and a 2 gram drop in their albumin may actually have an anion gap metabolic acidosis (recalculated AG 15).

➔ Classifications of Metabolic Acidosis:

Anion Gap Metabolic Acidosis — A G M A

Detection of an AGMA is important because only a few conditions commonly cause it.

In addition, in mixed acid-base disorders, an elevation in the anion gap may be the only signal that a metabolic acidosis is present.

The causes of an AGMA are divided into four main categories:

Renal failure	Ketoacidosis
Toxins	Lactic acidosis

In any patient with an AGMA, calculate an osmol gap.

Osmol gaps are a clue to a potentially life-threatening toxic alcohol ingestion (ie. ethylene glycol and methanol).

The osmol gap is determined by subtracting the calculated osmolality from the measured osmolality.

Calculated Osmolality = 2(Na) + Glc/18 + BUN/2.4 + ETOH/4.6

A CAT MUDPILES

A	Analgesics (massive NSAID, acetaminophen)
C	Cyanide, Carbon monoxide
A	Arsenic, Alcoholic ketoacidosis
T	Toluene
M	Methanol, Metformin
U	Uremia
D	Diabetic ketoacidosis
P	Paraldehyde, Phenformin
I	Iron, Isoniazid
L	Lactic acidosis
E	Ethylene glycol
S	Salicylates (aspirin)

Acidosis

1-Metabolic Acidosis

➔ Classifications of Metabolic Acidosis:

Non-Anion Gap Metabolic Acidosis

N A G M A

A NAGMA is due to either GI or renal losses of bicarbonate.

If desired, GI mediated and renally mediated losses can be distinguished by:

The most common cause of normal anion gap acidosis is **diarrhea with a renal tubular acidosis**

Calculating the urine anion gap

Obtaining urine electrolytes (ie. Na,K, and Cl)

The urine anion gap: Na + K - Cl

If an excess of negatively charged ions is present, the acidemia is due to the kidney

The urine anion gap is the difference between the spot urine positive ions and spot urine negative ions.

2-Respiratory Acidosis

Respiratory acidosis is characterized by: An elevation in the pCO2 + A decrease in blood pH

It results from conditions that decrease the ability of the lungs to excrete carbon dioxide at a rate to keep up with the body's production. = Due most commonly to Hypoventilation

Renal Compensation:

The kidney compensates for primary respiratory acidosis by retaining bicarbonate.

This compensation occurs over hours to days and is generally at a maximum within four days.
The rate of onset of respiratory acidosis can be determined by the degree of renal compensation (increase in HCO3) as listed above in step 3.

Alternatively, the chronicity of the respiratory acidosis can be predicted by the change in the pH.

Acute Chronic

In acute respiratory acidosis, the pH decreases by **0.08** units for each increase of 10 mmHg in the pCO2 from its baseline of 40 mmHg.

Chronic respiratory acidosis is marked by a decrease in the pH of **0.03** units for every increase of 10 mmHg in the pCO2.

Differentiating acute from chronic respiratory conditions can have important clinical implications that may alert the clinician to a patient that is rapidly spiraling downward and might require emergent intubation, from a patient who has chronic disease, but is in less danger of imminent decompensation

Differential Diagnosis

CNS depression	Sedatives, CNS disease, Sleep apnea
Pleural disease	Large pneumothorax or Pleural effusion
Lung disease	ARDS, COPD, pulmonary edema, severe pneumonia
Acute Airway Obstruction	Laryngospasm, sleep apnea
Neuromuscular Disorders	GBS*, Myasthenia Gravis, Botulism
Thoracic Cage Injury	Flail Chest
Ventilator Dysfunction	-

*Guillain-Barré Syndrome

Acidosis

Practice Cases:

1

32 year old man with depression and alcohol abuse presents with altered mental status.
ABG: pH 6.9, pCO2 29, pO2 100
Metabolic panel: Na 140, Cl 101, HCO3 5

Answer:

Step 1: Acidosis

Step 2: Metabolic

Step 3: pCO2 = 1.5(HCO3) + 8 = 15 but the patient's pCO2 is higher than 15. Therefore, a respiratory acidosis is also present, possibly secondary to CNS depression.

Step 4: AG = 140 (101 + 5) = 34

Step 5: Delta gap = (34-12) (24-5) = 3. No additional metabolic disorders other than AGMA.

Anion gap metabolic acidosis and respiratory acidosis.The patient had an osmol gap of 174 and a methanol level of 510 mg/dL.

2

A 68 year old man who recently took antibiotics for a skin infection presents with 10 episodes of watery diarrhea per day for the last 5 days.
ABG: pH 7.34, pCO2 34, pO2 80
Metabolic panel: Na 135, Cl 108, HCO3 18

Answer:

Step 1: Acidosis

Step 2: Metabolic

Step 3: pCO2 = 1.5(HCO3) + 8 = 35

Step 4: AG = 135 (108 + 18) = 9

Step 5: Cl ↑ by 8 and HCO3 ↓ by 6; therefore there is no metabolic alkalosis.

NAGMA due to diarrhea.

3

A 70 year-old smoker presents with an acute onset of shortness of breath.
ABG: pH 7.30, pCO2 = 60 mmHg, pO2 60 mmHg
Metabolic panel: Na 135, Cl 100, HCO3 30

Answer:

Step 1:Acidosis

Step 2:Respiratory

Step 3:Acute on chronic. pCO2 increased by 20, therefore the HCO3 should increase by 2 if acute and 8 if chronic. Because the HCO3 increased from 24 to 30 (6), an acute on chronic respiratory acidosis is present.

Step 4: AG = 135-(100+26) = 9. No anion gap metabolic acidosis

Step 5: XX

Acute on chronic respiratory acidosis due to COPD exacerbation

Alkalosis

1-Metabolic Alkalosis

$\uparrow HCO_3$

Metabolic alkalosis is characterized by an increase in the serum bicarbonate concentration.

Causes of Metabolic Alkalosis:

- **Volume Contraction** (Vomiting, NG suction, Loop or thiazide diuretics)
- **Excess glucocorticoids or mineralocorticoids** (E.g. Cushing's Syndrome)
- Hypokalemia
- Bartter's Syndrome
- Alkali Ingestion/Infusion
- Post-hypercapnic

To differentiate the most common cause of metabolic alkalosis which is volume depletion from other causes you need to measure urine chloride.

- If urine chloride less than 10,this due to volume depletion (Saline responsive) ✓
- If urine chloride more than 10, this due to other causes (Saline resistance) ✗

2-Respiratory Alkalosis

PCO_2

Respiratory alkalosis is characterized by a decrease in the pCO2 and an elevation in the blood pH.

The pO2 can be used to distinguish between disease of the lungs and other causes of hyperpnea (eg, fever)

PO_2

"The causes of a primary respiratory alkalosis include:

- CNS disease (CVA)
- Toxins (Salicylates)
- High altitude
- Severe anemia
- Pregnancy

- Lung disease/hypoxia (asthma, pneumonia, PE, pulmonary edema, pulmonary fibrosis)
- Anxiety
- Cirrhosis of the liver
- Fever (Sepsis)
- Ventilator dysfunction

Alkalosis

Practice Cases:

1

A 20 year old student presents with excessive vomiting after binge drinking.
ABG: pH 7.50, pCO2 44, pO2 100
Metabolic panel: Na 138, Cl 100, HCO3 30

Answer:

Step 1:Alkalosis

Step 2:Metabolic

Step 3:Increase in pCO2 should equal 0.6 multiplied by the elevation of the HCO3 ±2. The increase of the pCO2 of 4 is within two of 6(0.6) or 3.6; therefore there is appropriate compensation.

Step 4: AG = 138 (100 + 30) = 8

Step 5: XX

Metabolic alkalosis secondary to vomiting.

2

A 22 year-old woman presents with 4 hours of numbness in both hands typical of previous episodes of anxiety.
ABG: pH 7.48, pCO2 30 mmHg, pO2 86 mmHg
Metabolic panel: Na 140, Cl 110, HCO3 22

Answer:

Step 1:Alkalosis

Step 2:Respiratory

Step 3:Acute. Drop in the pCO2 by 10 corresponds to a drop in the HCO3 by 2 if acute and 5 if chronic. 24-22 = 2 and therefore, as would be expected by the clinical history, an acute disorder is diagnosed.

Step 4: AG 140-(110+22) = 8

Step 5: XX

Acute respiratory alkalosis secondary to a panic attack.

How Toxic is your knowledge

1-A 22-year-old female is admitted to the hospital with severe asthma attack. She has been experiencing increasing shortness of breath since admission five hours ago. Her arterial blood gas result is as follows:
PH= 7.47, CO2= 25, HCO3= 28

Which one of the following is the acid base disorder?
A. Metabolic acidosis
B. Respiratory acidosis
C. Respiratory alkalosis
D. Metabolic alkalosis

2-A 45 years old male, came to the ER with his wife, complaining of anuria and confusion for three days. His arterial blood gas result is as follows:
PH= 7.25, PO2= 75, PCO2= 35, HCO3= 12

What is the type of abnormality in this analysis?
A.Metabolic alkalosis
B.Respiratory alkalosis
C.Respiratory acidosis
D.Metabolic acidosis

3-A 50 years old female known to have COPD presented to the emergency department with complaint of shortness of breath. Her blood gas analysis is as follows:
PH= 7.29 CO2= 65 HCO3= 34

What is the type of abnormality in this result?
A. Respiratory acidosis
B. Metabolic acidosis
C. Respiratory alkalosis
D. Metabolic alkalosis

4-A depressed 52 years old man who is a known alcoholic presented to the ER with altered mental status. As part of his investigations an arterial blood gas was performed and the result is as follows:
PH 6.9, PCO2 28, pO2 100.

The metabolic panel results are as follows:
Na 140 mEq/L, HCO3 6 mEq/L.

Based on these results what is the primary acid base disorder of this patient?
A.Metabolic alkalosis
B.Respiratory acidosis
C.Metabolic acidosis
D.Respiratory alkalosis

5-A man with arthritis presents with confusion, shortness of breath, and diaphoresis. Patient is having aspirin overdose. His laboratory investigations show a
PH of 7.30, Pco2 of 18 mmHg, Na 147 mEq/L, Cl 108 mEq/L and HCO3 16 mEq/L.

What is the acid base disorder for this patient with aspirin overdose?
A.Metabolic alkalosis and respiratory acidosis
B.Respiratory alkalosis
C.Respiratory acidosis
D.Metabolic acidosis and respiratory alkalosis

6-A diabetic patient present with diarrhea and cough. His Chest X-ray reveals bilateral pulmonary infiltrates. He has a
pH of 7.31; Pco2 of 10 mmHg.

His electrolytes panel is as follows:
Na 123 mEqL/L; Cl 99 mEq/L; HCO3 5 mEq/L

What is the calculated anion gap for this patient?
A.9
B.19
C.29
D.39

7-A 70-year-old smoker presents with an acute onset of shortness of breath. His investigation results are as follows:
Arterial Blood Gas:
PH 7.29, 60mmHg, Po2 60mmHg.

His electrolytes panel:
Na 135mEq/L, Cl 100mEq/L Hco3 30mEq/L.

What is the primary acid base disorder for this patient?
A.Respiratory acidosis
B.Metabolic acidosis
C.Respiratory alkalosis
D.Metabolic alkalosis

1-C
2-D
3-A
4-C
5-D
6-B
7-A

How Toxic is your knowledge

1-A diabetic presents with diarrhea and cough. CXR reveals an infiltrate.
pH 7.31; pCO2 10
Na 123; Cl 99; HCO3 5

Answer:
Primary AGMA (DKA), respiratory alkalosis (pneumonia), NAGMA (diarrhea)

2-An alcoholic presents with vomiting.
pH 7.20; pCO2 25
Na 130; Cl 80; HCO3 10

Answer:
Primary AGMA (alcoholic ketoacidosis), metabolic alkalosis (vomiting)

3-A man with arthritis presents with confusion, shortness of breath, and diaphoresis.
pH 7.30; pCO2 18
Na 147; Cl 108; HCO3 16

Answer:
Primary AGMA and respiratory alkalosis (Salicylate toxicity—107 mg/dl)

4-A patient with COPD presents with shortness of breath.
pH 7.18; pCO2 80
Na 135; Cl 93; HCO3 30

Answer:
Primary respiratory acidosis—acute-on-chronic (COPD exacerbation)

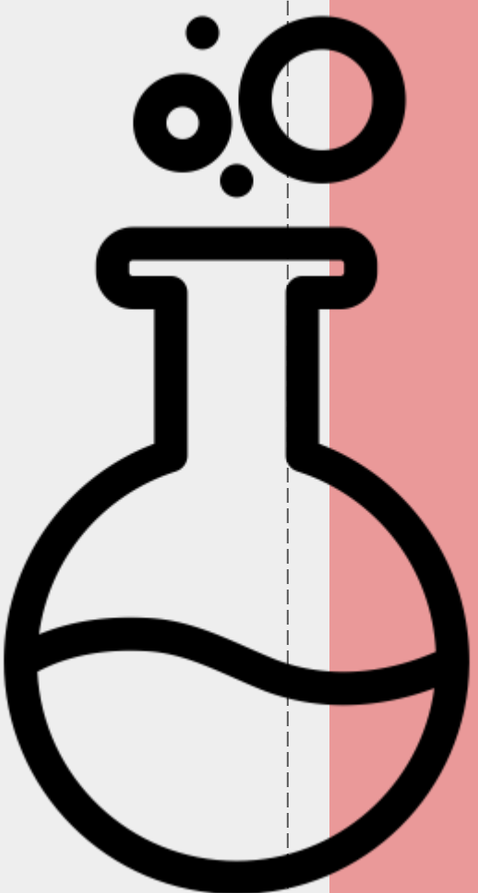
5-A woman with Crohn's disease presents with fever, vomiting, and diarrhea.
pH 7.36; pCO2 22
Na 147; Cl 121; HCO3 14

Answer:
Primary NAGMA (diarrhea), respiratory alkalosis (fever), metabolic alkalosis (vomiting)

6-A noncompliant patient with diabetes and cirrhosis presents with vomiting.
pH 7.46; pCO2 17
Na 133; Cl 84; HCO3 15

Answer:
Primary chronic respiratory alkalosis (cirrhosis), AGMA (DKA), metabolic alkalosis

Thank you and good luck!



Very Toxic but you are gonna do it!

A+ is yours (:

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