Here you will find a simple way to solve all acid-base disturbance Questions, this is a step-wise approach, follow the same sequence exactly so you don't confuse yourself.

At the end there are some Questions to see if you understand, again just go over it step by step and it will be easy :)

Normal values:

- pH = 7.4
- HCO3 = 24 mEq/L
- PCO2 = 40 mm Hg

- First: look at pH (to know acidosis or alkalosis)

If pH <7.35, then it's acidosis.

If pH >7.45, then it's alkalosis.

- Second: look at HCO3 (to know respiratory or metabolic)

Simple rule, does it make sense? then its metabolic!

How?

Q1: Assume pH=7, HCO3=15

so, acidosis

HCO3 is alkaline right? Then it should be lower than normal, like here it makes sense so its Metabolic.

Q2: What if pH=7, HCO3=30?

There is acidosis but Here HCO3 its more than normal and HCO3 is alkaline!!! So, its Respiratory

And the same goes with alkalosis:

Assume pH=8, HCO3=30

alkalosis and HCO3– is elevated, again make sense! so Metabolic alkalosis.

Assume pH=8, HCO3=15

alkalosis and HCO3– is low, HCO3 its lower than normal and HCO3 is alkaline!! then Respiratory alkalosis.

Now after step1&2, we know the disturbance could be:

- Respiratory acidosis
- Metabolic acidosis
- Respiratory alkalosis
- Metabolic alkalosis

Third: Was there compensation?

Respiratory acidosis:

Because kidney compensation is slow, it is important to distinguish between acute (uncompensated) and chronic (compensated) respiratory disturbances.

• If acute, there is a 0.1 mEq/L rise in HCO3 for every 1 mm Hg increase in PaCO2 (1:0.1 ratio).

• If chronic, there is a 0.4 mEq/L rise in HCO3 for every 1 mm Hg rise in PaCO2 (1:0.4 ratio)

For example, a patient has a respiratory acidosis (determined by steps 1 and 2) with PaCO2 60 mm Hg, which is 20 mm Hg greater than the normal of 40 mm Hg.

If acute, then bicarbonate will be 26. (20 × 0.1 = 2; 24 + 2 = 26)

If chronic, then bicarbonate will be 31. (20 × 0.4 =7; 24 + 7 =31)

Metabolic acidosis:

Here to know if there is a compensation, we should calculate the expected patient's PaCO2 if the compensation happened then compare. By: **Winter's equation** don't worry its easy :)

Expected PaCO2 = (1.5 × HCO3) + 8

The patient's PaCO2 should fall to a level that is ±2 mm Hg of this value.

After calculation, we have three possibilities:

• If the patient's PaCO2 is +2 or -2 of the Expected value, then the patient has metabolic acidosis with respiratory compensation.

• higher than 2 of the expected value, then the respiratory response is inadequate, and the patient has metabolic and respiratory acidosis.

• If the patient's PaCO2 is less than 2 of the expected value, then the patient has a metabolic acidosis with a respiratory alkalosis.

For example, a patient has a metabolic acidosis with a HCO3 of 10 mEq/L and a PaCO2 of 23 mm Hg. Expected PaCO2 is (1.5 × 10) + 8 = 23 mm Hg.

so respiratory compensation is adequate.

The anion gap is useful in differentiating the cause of a Metabolic acidosis.

AG = Na+ – (Cl– + HCO3–)

Use the following pneumonics to remember elevated and non-elevated gap metabolic acidosis:

MUD PILES (elevated gap):

M: Methanol

U: Uremia (kidney failure)

D: Diabetic ketoacidosis

P: Paraldehyde

I: Iron; Isoniazid

L: Lactic acidosis

E: Ethylene glycol; ethanol ketoacidosis

S: Salicylates; starvation ketoacidosis; sepsis

HARD UP (non-elevated gap):

H: Hyperchloremia (parental nutrition)

A: Acetazolamide

R: Renal tubular acidosis

D: Diarrhea

U: Ureteral diversion

P: Pancreatic fistula

Respiratory alkalosis:

Again, it is important to distinguish between acute (uncompensated) and chronic (compensated) respiratory disturbances.

• If acute, there is a 0.2 mEq/L fall in HCO3 for every 1 mm Hg decrease in PaCO2 (1:0.2 ratio).

• If chronic, there is a 0.5 mEq/L fall in HCO3 for every 1 mm Hg decrease in PaCO2 (1:0.5 ratio).

For example, a patient has a respiratory alkalosis (determined by steps 1 and 2) with a PaCO2 of 25 mm Hg, which is 15 mm Hg less than the normal of 40 mm Hg.

If acute, then bicarbonate will be about 21. (15 × 0.2 = 3; 24 – 3 = 21)

if chronic it will be around 16. (15 × 0.5 = 7.5; 24 – 7.5 = 16.5)

Metabolic alkalosis:

Here to know if there is a compensation, we should calculate the expected patient's $PaCO_2$ if the compensation happened then compare.

Expected $PaCO_2$ = (0.7 × rise in HCO_3^-) + 40

The patient's $PaCO_2$ should rise to a level that is ± 2 this value.

After calculation, we have three possibilities:

• If the patient's $PaCO_2$ is +2 or -2 of the Expected value, the patient has metabolic alkalosis with respiratory compensation.

• If it is higher than 2, then the patient has metabolic alkalosis and respiratory acidosis.

• If the patient's $PaCO_2$ is too low, then the patient has a metabolic and respiratory alkalosis.

For example, a patient has a metabolic alkalosis with HCO_3^- 34 mEq/L (10 greater than normal) and $PaCO_2$ 47 mm Hg. Expected $PaCO_2$ is (10 × 0.7) + 40 = 47 mm Hg.

So respiratory compensation is adequate.

Test yourself

Follow the sequence and try:

- **First: look at pH (to know acidosis or alkalosis)**
- **Second: look at HCO3 (to know respiratory or metabolic)**
- **Third: Was there compensation?**

Example 1 pH = 7.3 HCO_3^- = 14 mEq/L PCO_2 = 30 mm Hg PO_2 = 95 mm Hg

Example 2 pH = 7.6 HCO_3^- = 20 mEq/L PCO_2 = 20 mm Hg PO_2 = 95 mm Hg

Example 3 pH = 7.2 HCO_3^- = 30 mEq/L PCO_2 = 80 mm Hg PO_2 = 70 mm Hg

Example 4 pH = 7.6 HCO_3^- = 44 mEq/L PCO_2 = 52 mm Hg PO_2 = 70 mm Hg

Answers:

Example 1

acidosis or alkalosis? pH is low, so acidosis.

respiratory or metabolic? HCO_3^- is low, so metabolic acidosis.

Compensation? Use Winter's to compute predicted PCO_2: (14 × 1.5) + 8 = 29.

Patient's is 30, which is within 2, thus this is a metabolic acidosis with respiratory compensation.

Example 2

acidosis or alkalosis? pH is high, so alkalosis

respiratory or metabolic? HCO_3^- is low, so respiratory alkalosis

Compensation? Must determine if acute (uncompensated) or chronic (compensated).

PCO_2 is 20 below normal.

acute: 20 x 0.2 = 4, so HCO_3^- will be around 20 (24 – 4).

If chronic, it would be 20 x 0.5 = 10, so HCO_3^- would be around 14 (24 – 10).

The measured equals the predicted acute, thus this is an acute respiratory alkalosis.

Example 3

acidosis or alkalosis? pH is low, so acidosis.

respiratory or metabolic? HCO_3^- is high, so respiratory acidosis

Compensation? Must determine if acute (uncompensated) or chronic (compensated).

PCO_2 is 40 greater than normal.

if acute, 40 × 0.1 = 4, so HCO_3^- will be around 28 (24 + 4).

If chronic, it will be 40 × 0.35 = 14, so HCO_3^- will be around 38 (24 + 14).

The measured is much closer to the predicted acute, thus this is an acute respiratory acidosis.

Example 4

acidosis or alkalosis? pH is high, so alkalosis.

respiratory or metabolic? HCO_3^- is high, so metabolic alkalosis

Compensation? The respiratory compensation is to reduce ventilation, thereby increasing $PaCO_2$. Thus, we need to compute what $PaCO_2$ should be in a patient with this acid-base disorder.

Calculation: HCO_3^- is 20 greater than normal of 24, 20 x 0.7 = 14, thus $PaCO_2$ should be 14 mm Hg greater than the normal of 40, thus 40 + 14 = 54 (predicted $PaCO_2$).

Patient's is 52, which is within 2, so this is a metabolic alkalosis with respiratory compensation.

Done by: Abdulaziz shaded

Thank you.