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Review Article

Interpretation of Gasometrias: New Solutions Before Old Paradigms

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Abstract

A correct approach to acid-base disorders can be fundamental to identify an unsuspected causal process. Classically, we used the Henderson-Hasselbalch method, currently supplemented with the base (B) to assess the magnitude of the metabolic abnormality and the anion gap (BA) to perform a differential diagnosis. A correct interpretation of blood gas is a skill that every doctor must master. Trying to interpret "all at once" and in a poorly organized manner is the most common mistake. Then the secret to developing this ability lies in the "order", so we suggest you use only 3 steps and only 3 formulas. The diagnostic approach of acid-base disorders with the traditional method of Henderson-Hasselbalch does not explain all the disorders, but in combination with the Base (B) described by Siggaard-Andersen, the diagnostic sensitivity improves remarkably, besides that this combination is simple, rigorous and practical.

Keywords: *Henderson-Hasselbalch; Base; The Anion Gap*

Introduction

A major obstacle for which solid epidemiological data are lacking on the different types of acid-base balance disorders are the various definitions or classifications used to describe them. The absence of a uniform classification system and the different designs used in the studies limit our ability to fully appreciate the real incidence. In the intensive care unit (ICU) alterations of the acid-base balance and hydroelectrolytic disorders are common, although as we discussed, the real epidemiology remains uncertain. In general, most cases are mild and self-limiting, but some can have fatal consequences. Acid-base balance disorders may have a primary character, but usually occur as a complication of a pre-existing condition. A correct approach to the acid-base disorder can be fundamental to identify an unsuspected causal process [1]. Classically, we used the Henderson-Hasselbalch method to classify disorders of the acid-base balance in either respiratory (abnormal CO_2) and/or metabolic (HCO_3- abnormal) problems and also define compensatory changes. Currently, we complement the Henderson-Hasselbalch method with the base (B) to assess the magnitude of the metabolic abnormality and the anion gap (BA) to perform a differential diagnosis [2,3]. Different methods to address acid-base disorders over time have appeared, each and every one of them with advantages and limitations which is essential for the doctor to know for a more precise diagnosis and treatment [4]. Today, the Henderson-Hasselbalch method is the most widely used for the interpretation of acid-base balance alterations, increasing its diagnostic sensitivity when complemented with B and BA.

Physiopathological Aspects

Traditional Method: Henderson Hasselbalch

Hydrogen ions (H^+) are one of the most important parameters in the equilibrium of the acid-base state and their concentration depends on the interaction between the carbon dioxide arterial pressure ($PaCO_2$), the plasma concentration of the bicarbonate ions (HCO_3^-) and the constant dissociation of carbonic acid (H_2CO_3) as determined by the Henderson and Hasselbalch equation which defines the pH in its non-logarithmic variant as $[H^+] = 24 \times pCO_2/HCO_3^-$. Acidosis can then occur with a decrease in the more negative HCO_3^- or B (metabolic acidosis) or by an increase in $PaCO_2$ (respiratory acidosis) and alkalosis due to a more positive increase in HCO_3^- or B (metabolic alkalosis) or a decrease in $PaCO_2$ (respiratory alkalosis) [1,5].

Abnormal			Abnormal
Acidemia	**pH**		**Alcalemia**
< 7.35	7.35	7.45	> 7.45
	$PaCO_2$ (mmHg)		
<3 5	35	45	> 45
	Base (mEq/L)		
< -2	-2	+2	> +2
	HCO_3^- (mEq/L)		
< 22	22	26	> 26

Table 1: *Reference values.*

pH: Potential of Hydrogen; $PaCO_2$: Blood Pressure of Carbon Dioxide; HCO_3^- : Bicarbonate, B: Base

Complementary Method: Base and Anion Gap

The traditional method can be complemented with the Base (B) described by Siggaard-Andersen in 1977, when using it the diagnostic results are improved. It is routinely used in clinical practice and today the vast majority of gas analyzers include it within their results. HCO_3- a dependent variable whose values are determined exclusively by three independent variables Carbon Dioxide Blood Pressure ($PaCO_2$), Weak Acids (ATOT) and Strong Ion Difference (DIF). Therefore, it is advisable to use B to assess the metabolic disorder. The Anionic Gap (BA) described by Emmett and Narins in 1977 is based on the principle of "electroneutrality", it is an additional contribution to the diagnosis, representing the first form of detection of unmeasured ions. It should always be corrected with albumin. Both are available tools that we add daily to the traditional method for the interpretation of acid-base alterations [1,5].

Base (B): We use it to assess the magnitude of the strictly metabolic abnormality. It represents the number of additional milliequivalents of acid or base that must be added to a liter of blood to normalize the pH to a temperature of 37°C. In the gasometry we can find it as Base Excess (BE) and Excess of Standard Base (SBE), the difference is explained because the gas machine calculates SBE estimating a hemoglobin of 5 g/dl of the extracellular fluid. The B can be calculated with the following formulas: (HCO_3- + 10 (pH - 7.40) - 24) or (0.9287 x HCO_3- - 24.4 + 14.83 x pH - 7.4). The reference ranges are: -2 to +2 mEq/L [5-7].

The B has limitations being the most important that cannot determine the cause of metabolic acidosis or differentiate what is its main component. It only tells us that a metabolic disorder is present. The compensatory relationship that exists between $PaCO_2$ and B varies in relation to time and the type of acid-base disorder. B will not change with acute hypercapnia, but may increase with chronic hypercapnia as a result of compensation, with retention of HCO_3-; then the acute problems can be hidden when they coexist with chronic problems if we only infer an aggregate disorder so it is advisable to apply the correct formula that evaluated the compensation [6,8].

Anionic Gap (BA): The difference between anions and plasma cations that are usually not measured (proteins, sulfates, inorganic phosphates, lactate, calcium (Ca^+) and magnesium (Mg^+). in the plasma we find them in relatively low concentrations, so their variations in the pathological range are small. The ions of highest concentration and therefore we use to calculate BA are Sodium (Na^+), Chlorine (Cl^-) and Bicarbonate (HCO_3^-) although they are not the only "Unmeasured Ions". The reason for using BA is justified in making a differential diagnosis of metabolic acidosis, which will present high BA due to accumulation, gain or lack of acid elimination, Normal BA due to the loss of HCO_3^- and low BA due to an increase in cations (Na^+, K^+, Ca^+, Mg^+), presence of lithium or alterations in proteins BA can be calculated with the following formula: (Na^+) - (Cl^+ + HCO_3^-) The reference ranges are: 8 to 12 or 12 to 16 mEq/L if we add potassium to the formula [9,10].

As when we talk about B, the BA also has limitations because it does not take into account all the available information, for example, cations such as K^+, Ca^+ or Mg^+ are not considered. It assumes normal concentrations of albumin and phosphate, a condition that does not always apply in the critically ill patient. The BA must be corrected with the following formula: (Na^+) - (Cl^- + HCO_3^-) + 2.5 (4.5 - albumin in g/dL) or ([Na^++ K^+] - [Cl- + HCO_3^-]) - (2.5 [albumin in g/dL) + 0.5 [phosphate in mg/dL]) [5,6,8]. The greater the BA, the greater the possibility of making a specific diagnosis of the cause that causes metabolic acidosis. A BA > 20 mEq/L indicates metabolic acidosis as the main diagnosis. (eleven)

It is useful to calculate BA because it is possible to establish a differential diagnosis of metabolic acidosis [12] (Figure 1). In the presence of elevated BA metabolic acidosis, the BA Delta (DBA) will be calculated comparing the change in BA with respect to the change in HCO_3^- (1:1) concentration and it helps us to determine the presence of another concomitant acid-base disorder. You get: (BA Measure - 12)/(24 - HCO_3^-). When the result is < 1 (1:2) then there is metabolic acidosis of normal added BA or less loss of HCO_3^- with respect to BA. If the result is > 1 (2:1) there will be added metabolic alkalosis or a greater increase of the BA with respect to HCO_3^-. In turn, the Hiatal Osmolar (HO) can help determine the presence of toxins (methanol, ethanol, ethylene glycol) and obtain: (Osmolarity Measurement - Calculated Osmolarity). The normal value in adults will be between -2 and +10 mOsm/L and values above this number suggest the ingestion of some toxic alcohol. The presence of HO less than 10 does not exclude the ingestion of a toxic alcohol. The longer the time between ingestion and the less reliable HO measurement will be. When there is normal BA metabolic acidosis, the Urinary Gap (BU) should be determined: (urinary sodium + urinary potassium) - (urine chlorine), this will identify the possible cause of acidosis. The BU can be positive (disorder in the acidification of the urine) or negative (without disorder in the acidification of the urine) and this can be conditioned by renal or gastrointestinal alterations respectively [13,14].

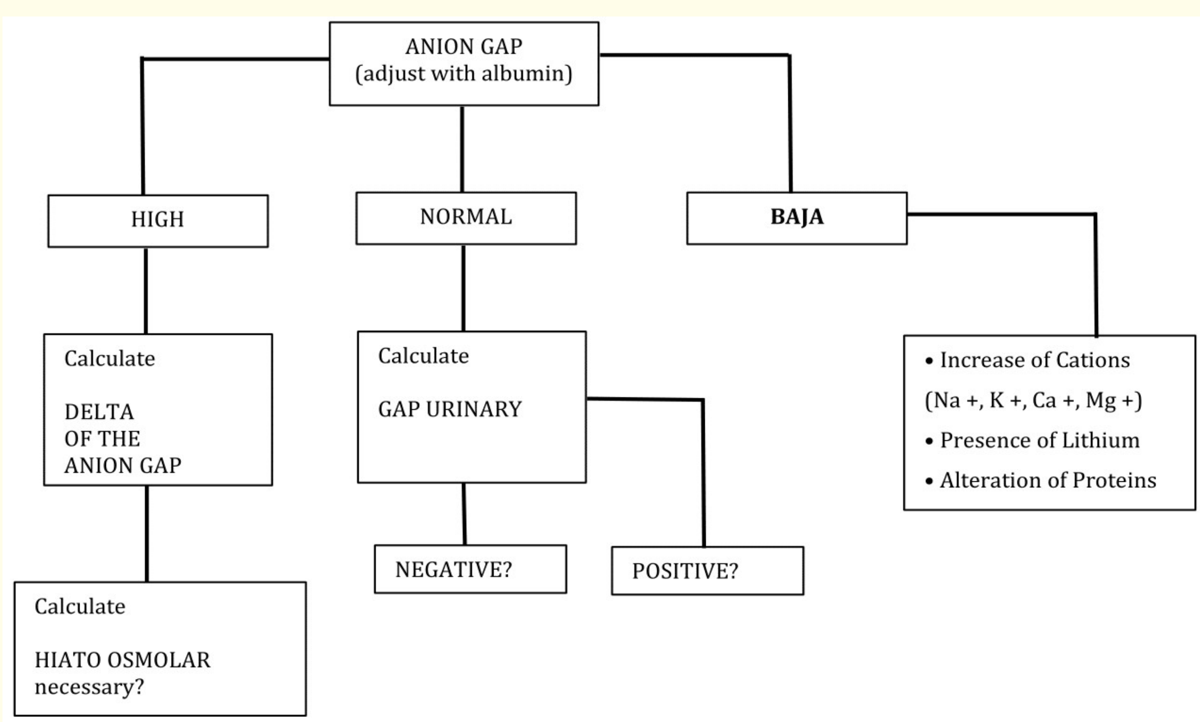

Figure 1: *Anionic Gap.*
Na+: Sodium, K+: Potassium, Ca+: Calcium, Mg+: Magnesium

Compensation to the acid-base alterations

Maintaining the H^+ concentration of the extracellular fluid within normal limits is the purpose of the compensatory mechanisms. The pH compatible with life normally ranges between 6.80 - 7.80. Physiologically, a large amount of acids are generated which are neutralized and this helps us to maintain a constant pH. Acute changes in blood pH carry regulatory effects on the structure and function of proteins and enzymes, this conditions changes in cellular functions (glycolysis, gluconeogenesis, mitosis, DNA synthesis, etc). It is essential to understand the concurrence of the elements that govern the pH stability in physiological limits, such as: HCO_3^-, H^+, phosphates, albumin, hemoglobin, NH_4^+, Na^+, K^+, Cl^-, lactate, CO_2 among others because these allow the acid-base balance is preserved. All disorders of the acid-base balance will present a compensatory response (renal in respiratory and respiratory disorder in metabolic disorder) [1].

Disorder	pH	Change	Compensator Change
Respiratory Acidosis		PCO_2	HCO_3^- Base
Respiratory Alcalosis		PCO_2	HCO_3^- Base
Metabolic Acidosis		HCO_3^- Base	PCO_2
Metabolic Alcalosis		HCO_3^- Base	PCO_2

Table 2: *Expected Compensation.*

pH: Potential for Hydrogen; PCO_2: Carbon Dioxide Pressure; HCO_3^-: Bicarbonate

Shock Absorber Systems

We should know that kidney compensation will be slower, but in the end more successful, than respiratory compensation. Respiratory compensation is the first to respond, but it will fully develop up to 12 to 36 hours after its start. The kidney responds more effectively, but compensation is fully achieved in 2 to 5 days. In conclusion, renal function dominates the long-term maintenance of the acid-base balance [1,10,11,15].

The bicarbonate buffer system (HCO_3^-)/carbonic acid (H_2CO_3) is considered one of the most important but not the only one. By adding an acid this can release many H^+ which would reflect a decrease in pH, but in the presence of a buffer this will not happen because the H^+ will combine with the HCO_3- resulting in H_2CO_3 which in turn will unfold to H_2O and CO_2 being eliminated through alveolar ventilation. To maintain the pH at 7.40, there must be a ratio between HCO_3-/$PaCO_2$ (0.03 x $PaCO_2$) of approximately 20:1. There are other types of buffers which are considered intracellular and extracellular, here include proteins such as albumin and hemoglobin, phosphates and carbonates of bone [16,17] (Figure 2).

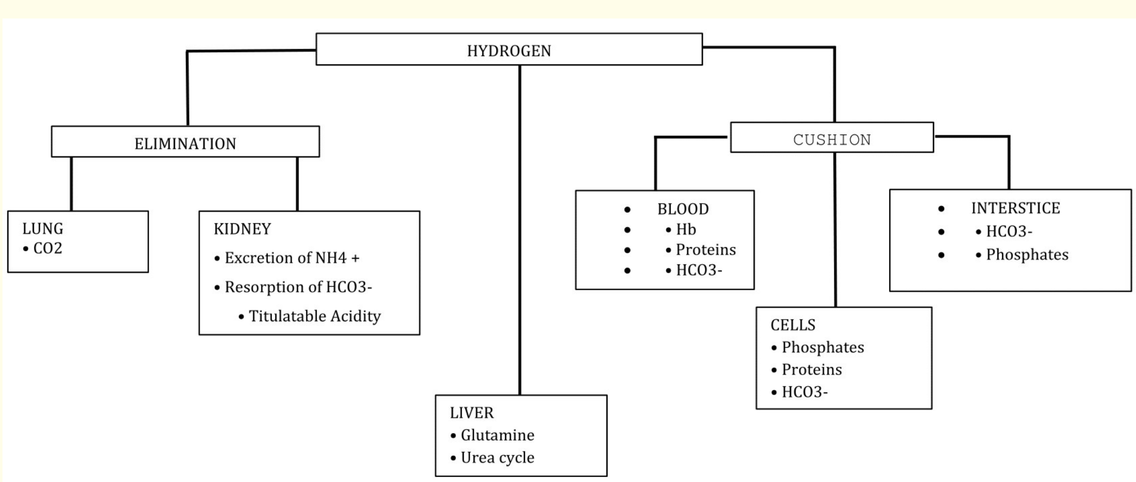

Figure 2: *Regulation Of The Acid-Base Equilibrium.*

Hb: Hemoglobin, CO_2: Carbon Dioxide, HCO_3-: Bicarbonate, NH_4+: Ammonium

Rules of Compensation [1,10,15]

Once the first disorder is diagnosed, verify that formula (Table 3) of compensation corresponds and calculate the compensation expected for each disorder.

3 Steps	3 Formulas
pH Step 1: Analyze the pH The normal pH values range between 7.35 and 7.45. If the pH decreases (< 7.35) it implies acidemia whereas if the pH increases (> 7.45) it implies alcalemia. Remember that to calculate (formulate) the compensation these values are not used, but the expected ones.	Metabolic Acidosis Expected $PaCO_2 = (1.5 \times HCO_3^-) + 8 \pm 2$
$PaCO_2$ Step 2: Analyze $PaCO_2$ Normal levels of $PaCO_2$ range between 35 mmHg and 45 mmHg (sea level). Below 35 mmHg is alkalosis and above 45 mmHg is acidosis. Remember that to calculate (formulate) the compensation these values are not used, but the expected ones.	Metabolic Alcalosis Expected $PaCO_2 = (0.7 \times HCO_3^-) + 21 \pm 2$
Base Step 3: Analyze the Base Normal base levels range from -2 to + 2 mEq/L. Below - 2 mEq/L is acidosis and above + 2 mEq/L is alkalosis. Remember that to calculate (formulate) the compensation these values are not used, but the expected ones.	Acute respiratory disorders do not modify the base (do not apply formula) Chronic Respiratory Acidosis Expected Base: $(PaCO_2\text{-}40) \times 0.4$ Chronic Respiratory Alcalosis Expected Base: $(PaCO_2\text{-}40) \times 0.4$

Table 3: *Steps and formulas for the interpretation of a gasometry.*

Metabolic Acidosis

Metabolic acidosis modifies the $PaCO_2$ according to the change in the base:

- If $PaCO_2$ is the same as expected, the disorder is pure.
- If $PaCO_2$ is greater than expected, there is an added respiratory acidosis.
- If $PaCO_2$ is lower than expected, there is respiratory alkalosis added (Figure 3).

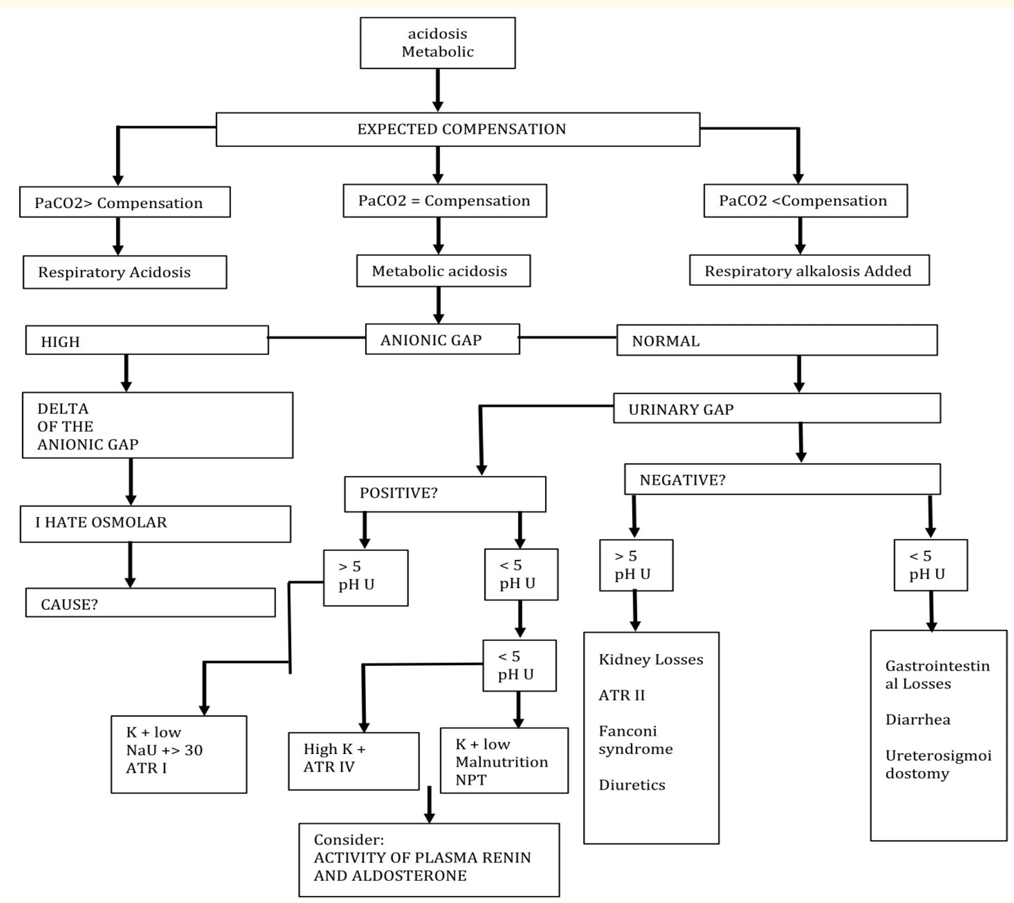

Figure 3: *Metabolic Acidosis.*

Metabolic Alcalosis

Metabolic alkalosis modifies $PaCO_2$ according to the change in the base:

- If $PaCO_2$ is the same as expected, the disorder is pure.
- If the $PaCO_2$ is higher than expected, an aggregate respiratory acidosis is diagnosed.
- If $PaCO_2$ is lower than expected, an aggregate respiratory alkalosis is diagnosed (Figure 4).

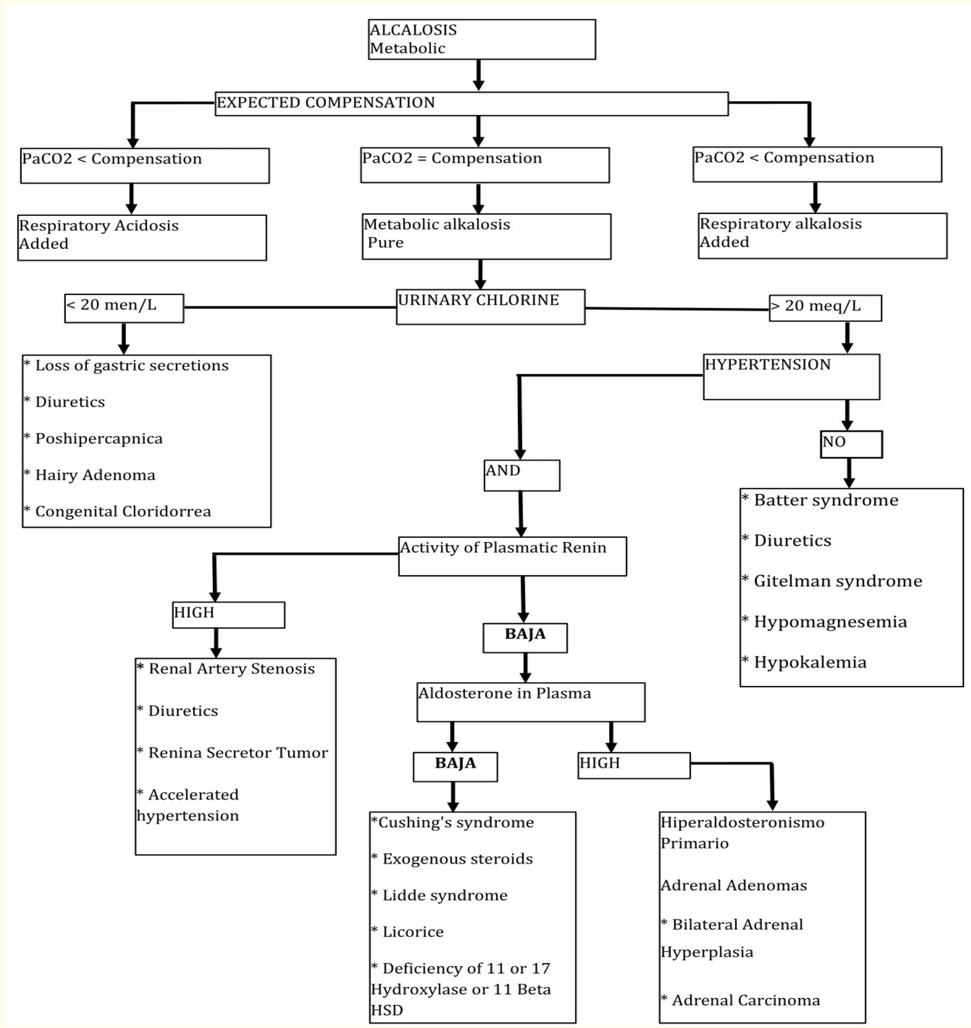

Figure 3: *Metabolic Alcalosis..*

Acute respiratory disorders (< 24 hours) do not modify the base, so it will not be necessary to calculate expected compensation. Chronic respiratory acidosis (> 24 hours) modifies the base in relation to $PaCO_2$:

- If the base is the same as expected, it is pure chronic respiratory acidosis.
- If the base is higher than expected, aggregated metabolic alkalosis is diagnosed.
- If the base is lower than expected, added metabolic acidosis is diagnosed (Figure 5).

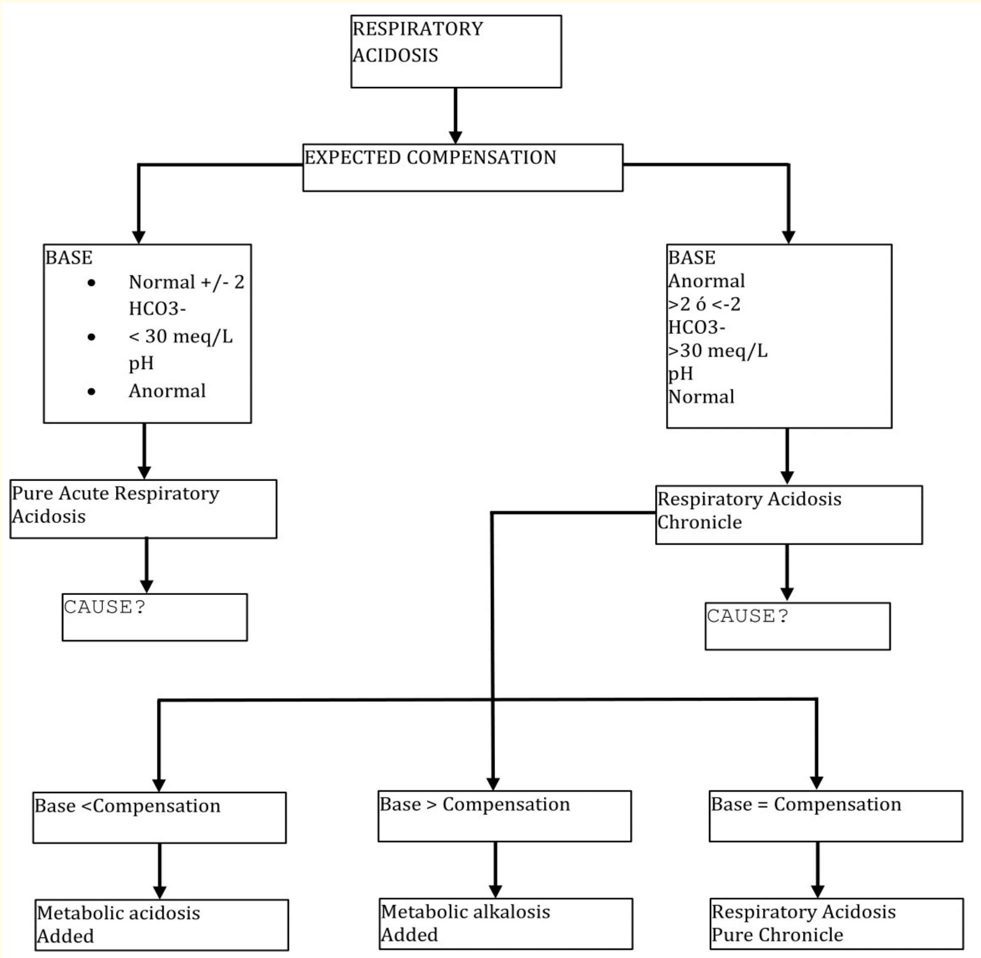

Figure 5: *Respiratory Acidosis.*

Respiratory Alcalosis

Acute respiratory disorders (< 24 hours) do not modify the base, so it will not be necessary to calculate expected compensation. Chronic respiratory alkalosis (> 24 hours) modifies the base in relation to $PaCO_2$:

- If the base is the same as expected, it is pure chronic respiratory alkalosis.
- If the base is higher than expected, aggregated metabolic alkalosis is diagnosed.
- If the base is lower than expected, an added respiratory acidosis is diagnosed (Figure 6).

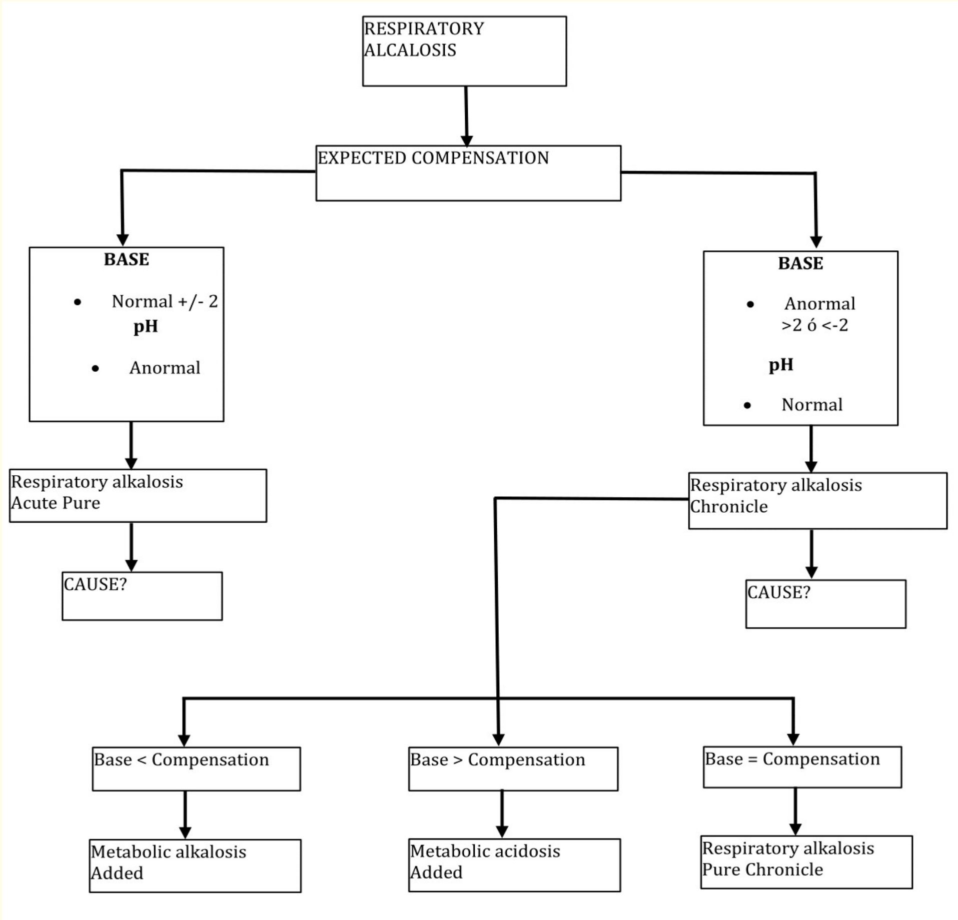

Figure 6: *Respiratory Alkalosis.*

Diagnostic implications of acid-base disorders

The analysis and diagnosis of acid-base disorders should be based on the patient's clinical picture and arterial blood gases, from which we will obtain the pH values, pCO_2, base and HCO_3^-, these are reliable as long as we avoid technical errors as, for example: excessive amount of heparin, presence of air bubbles, extreme variations of the temperature in the sample and excessive time between extraction and analysis. Observe the pH which will determine if there is alkalemia or acidemia, we will determine the cause either respiratory (altered pCO_2) or metabolic (base or altered HCO_3-), we will analyze if there is a compensatory response, if it is the expected one (simple disorder) or if it is outside compensation range (mixed disorder). The value of plasma sodium, chlorine and potassium are essential for the calculation of BA. The deficit or excess of base can be obtained through the gasometry or otherwise it can be calculated by means of the formula [18].

how to analyze a gasometry?

A correct interpretation of blood gas is a skill that every doctor must master. Trying to interpret "all at once" and in a poorly organized manner is the most common mistake. Then the secret to developing this ability lies in the "order", so we suggest you use only 3 steps and only 3 formulas [19].

The 3 steps in order of frequency that should be used to interpret gasometry are: pH (step 1), $PaCO_2$ (step 2) and Base (step 3). The 3 formulas that should be used to calculate the expected compensation after identifying the first disorder (metabolic or respiratory) are: $PaCO_2$ expected = (1.5 x HCO_3^-) +8 ± 2 (metabolic acidosis), $PaCO_2$ expected = (0.7 x HCO_3^-) +21 ± 2 (metabolic alkalosis) and Expected Basis: ($PaCO_2$-40) x 0.4 (acidosis and chronic respiratory alkalosis). Remember that acute respiratory disorders (< 24 hours) do not modify the base, so it will not be necessary to calculate expected compensation [19]. The above is easy to understand when we systematically evaluate the pH, $PaCO_2$ and Base in an orderly manner (Table 3). In this chapter, we use the Henderson-Hasselbalch method (based on pH, $PaCO_2$ and HCO_3^-) in combination with the Base (B) described by Siggaard-Andersen, a combination that we consider to be the most useful for the interpretation of gasometry. simple, rigorous and practical to classify and treat in a systematic way the alterations of the acid-base balance. The reason for using (B) and not HCO_3^- is that the latter is a dependent variable whose values are determined exclusively by three independent variables $PaCO_2$, ATOT and DIF [16,19]. Another important point to consider is the estimated values of blood gases ($PaCO_2$ and PaO_2), which can be useful in different places, at different heights. However, they may differ from those measured due to geographical, atmospheric and biological conditions, which is why they should adjust to the height, barometric pressure and acute exposure of the local area [21]. The above, and following this order: pH, $PaCO_2$ and Base will allow us to recognize the type of acid-base disorder.

Example 1: Metabolic acidosis (N: Normal, A: Abnormal).

1A		**Arterial**	**1B**		**Arterial**	**1C**		**Arterial**
pH	1	7.40^N	pH	1	7.34^A	pH	1	7.40^N
$PaCO_2$	2	41 mmHg^N	$PaCO_2$	2	34 mmHg^A	$PaCO_2$	2	45 mmHg^N
HCO_3-	3	22 mmol/L	HCO_3^-		22 mmol/L	HCO_3		22 mmol/L
EB		-4 mmol/L^A	EB	3	-4 mmol/L^A	EB	3	-4 mmol/L^A
$Pa0_2$		99 mmHg	$Pa0_2$		99 mmHg	$Pa0_2$		99 mmHg
Lact		2 mmol/L	Lact		2 mmol/L	Lact		2 mmol/L
SO_2		> 96%	SO_2		> 96%	SO_2		> 96%
Metabolic acidosis			Metabolic Acidosis + Respiratory alkalosis			Metabolic Acidosis + Respiratory Acidosis		

1A	**1B**	**1C**
The pH is Normal (Step 1) Evaluate PaCO2: Normal (Step2) Evaluate the Base: Altered (Step 3) • Present Metabolic Problem (metabolic acidosis) Algorithm 3 • Determine respiratory compensation: $PaCO_2$ expected • Use the formula: Expected $PaCO_2$ = (1.5 x HCO3-) + 8 ± 2 • $PaCO_2$ = Compensation Pure Metabolic Acidosis Algorithm 3	The pH is Abnormal (Step 1) Evaluate $PaCO_2$: Abnormal (Step2) Evaluate the Base: Altered (Step 3) • Present Metabolic Problem (metabolic acidosis) Algorithm 3 • Determine respiratory compensation: $PaCO_2$ expected • Use the formula: Expected $PaCO_2$ = (1.5 x HCO3-) + 8 ± 2 • $PaCO_2$ <Compensation Alkalosis Respiratory Aggregate Algorithm 6	The pH is Normal (Step 1) Evaluate $PaCO_2$: Normal (Step2) Evaluate the Base: Altered (Step 3) • Present Metabolic Problem (metabolic acidosis) Algorithm 3 • Determine respiratory compensation: $PaCO_2$ expected • Use the formula: Expected $PaCO_2$ = (1.5 x HCO3-) + 8 ± 2 • $PaCO_2$> Compensation Respiratory Acidosis Aggregate Algorithm 5

Example 2: Metabolic slcalosis (N: Normal, A: Abnormal).

2A		Arterial	2B		Arterial	2C		Arterial
pH	1	7.43^{N}	pH	1	7.47^{A}	pH	1	7.43^{N}
$PaCO_2$	2	40 mmHg^{N}	$PaCO_2$	2	36 mmHg^{N}	$PaCO_2$	2	44 mmHg^{N}
HCO_3-	3	26 mmol/L	HCO_3^-		26 mmol/L	HCO_3		26 mmol/L
EB		4 mmol/L^{A}	EB	3	4 mmol/L^{A}	EB	3	4 mmol/L^{A}
$Pa0_2$		99 mmHg	$Pa0_2$		99 mmHg	$Pa0_2$		99 mmHg
Lact		1.5 mmol/L	Lact		1.5 mmol/L	Lact		1.5 mmol/L
SO_2		> 96%	SO_2		> 96%	SO_2		> 96%
Metabolic acidosis			Metabolic Acidosis + Respiratory alkalosis			Metabolic Acidosis + Respiratory Acidosis		

2A	2B	2C
The pH is Normal (STEP 1) Evaluate $PaCO_2$: Normal (STEP2) Evaluate the Base: Altered (STEP 3) • Present Metabolic Problem (metabolic alkalosis) ALGORITHM 4 • Determine respiratory compensation: $PaCO_2$ expected • Use the formula: Expected $PaCO_2$ = (0.7 x HCO_3-) + 21 ± 2 • $PaCO_2$ = Compensation Pure Metabolic Alkalosis ALGORITHM 4	The pH is Abnormal (STEP 1) Evaluate $PaCO_2$: Normal (STEP2) Evaluate the Base: Altered (STEP 3) • Present Metabolic Problem (metabolic alkalosis) ALGORITHM 4 • Determine respiratory compensation: $PaCO_2$ expected • Use the formula: Expected $PaCO_2$ = (0.7 x HCO_3-) + 21 ± 2 • $PaCO_2$ <Compensation Alkalosis Respiratory Aggregate ALGORITHM 6	The pH is Normal (STEP 1) Evaluate $PaCO_2$: Normal (STEP2) Evaluate the Base: Altered (STEP 3) • Present Metabolic Problem (metabolic alkalosis) ALGORITHM 4 • Determine respiratory compensation: PaCO2 expected • Use the formula: Expected $PaCO_2$ = (0.7 x HCO_3-) + 21 ± 2 • $PaCO_2$> Compensation Respiratory Acidosis Aggregate ALGORITHM 5

Example 3: Acute respiratory acidosis (N: Normal, A: Abnormal).

3A		Arterial
pH	1	7.30^{A}
$PaCO_2$	2	55 mmHg^{A}
HCO_3-	3	25 mmol/L
EB		1.5 mmol/L^{N}
$Pa0_2$		99 mmHg
Lact		1.5 mmol/L
SO_2		> 96%
Acute Respiratory Acidosis		

3A

The pH is Abnormal (Step 1)

Evaluate $PaCO_2$: Abnormal (Step2)

• Present Respiratory Problem

(respiratory acidosis) Algorithm 5

Evaluate the Base: Normal (Step 3)

• Acute Respiratory Problem

Acute respiratory disorders (<24 hours) do not modify the base, so it will not be necessary to calculate expected compensation.

Acute Respiratory Acidosis Algorithm 5

Example 4: Chronic respiratory acidosis (N: Normal, A: Abnormal).

4A		Arterial	4B		Arterial	4C		Arterial
pH	1	7.325^{A}	pH	1	7.330^{A}	pH	1	7.300^{A}
$PaCO_2$	2	65 mmHg^{A}	$PaCO_2$	2	65 mmHg^{A}	$PaCO_2$	2	65 mmHg^{A}
HCO_3-	3	34 mmol/L	HCO_3^-		36 mmol/L	HCO_3		27 mmol/L
EB		10 mmol/L^{A}	EB	3	11 mmol/L^{A}	EB	3	3 mmol/L^{A}
$Pa0_2$		99 mmHg	$Pa0_2$		99 mmHg	$Pa0_2$		99 mmHg
Lact		1.5 mmol/L	Lact		1.5 mmol/L	Lact		1.5 mmol/L
SO_2		> 96%	SO_2		> 96%	SO_2		> 96%
Chronic Respiratory Acidosis			Chronic Respiratory Acidosis + Metabolic alkalosis			Chronic Respiratory Acidosis +Metabolic acidosis		

4A	4B	4C
The pH is Abnormal (Step 1)	The pH is Abnormal (Step 1)	The pH is Abnormal (Step 1)
Evaluate $PaCO_2$: Abnormal (Step2)	Evaluate $PaCO_2$: Abnormal (Step2)	Evaluate $PaCO_2$: Abnormal (Step2)
• Present Respiratory Problem	• Present Respiratory Problem	• Present Respiratory Problem
(respiratory acidosis) Algorithm 5	(respiratory acidosis) Algorithm 5	(respiratory acidosis) Algorithm 5
Evaluate the Base: Altered (Step 3)	Evaluate the Base: Altered (STEP 3)	Evaluate the Base: Altered (Step 3)
• Chronic Respiratory Problem	• Chronic Respiratory Problem	• Chronic Respiratory Problem
(chronic respiratory acidosis)	(chronic respiratory acidosis)	(chronic respiratory acidosis)
• Determine the metabolic compensation:	• Determine the metabolic compensation:	• Determine the metabolic compensation:
Expected base	Expected base	Expected base
• Use the formula:	• Use the formula:	• Use the formula:
Expected base = ($PaCO_2$-40) x 0.4	Expected base = ($PaCO_2$-40) x 0.4	Expected base = ($PaCO_2$-40) x 0.4
• Base = Compensation	• Base> Compensation	• Base <Compensation
Pure Chronic Respiratory Acidosis Algorithm 5	Added Metabolic Alkalosis Algorithm 4	Added Metabolic Acidosis Algorithm 3

Example 5: Acute respiratory alkalosis (N: Normal, A: Abnormal).

5A		Arterial
pH	1	7.50 [A]
$PaCO_2$	2	28 mmHg [A]
HCO_3-	3	25 mmol/L
EB		2 mmol/L [n]
$Pa0_2$		99 mmHg
Lact		1.5 mmol/L
SO_2		> 96%
Acute Respiratory Alkalosis		

5A

The pH is Abnormal (Step 1)

Evaluate $PaCO_2$: Abnormal (Step2)

• Present Respiratory Problem

(respiratory alkalosis) Algorithm 6

Evaluate the Base: Normal (Step 3)

• Acute Respiratory Problem

Acute respiratory disorders (< 24 hours) do not modify the base, so it will not be necessary to calculate expected compensation.

Acute Respiratory Alkalosis Algorithm 6

Example 6: Chronic respiratory alkalosis (N: Normal, A: Abnormal).

6A		Arterial	6B		Arterial	6C		Arterial
pH	1	7.46	pH	1	7.50	pH	1	7.346 [A]
$PaCO_2$	2	20 mmHg	$PaCO_2$	2	20 mmHg	$PaCO_2$	2	19 mmHg [A]
HCO_3-	3	14 mmol/L	HCO_3^-		22 mmol/L	HCO_3		12 mmol/L
EB		-8 mmol/L [A]	EB	3	-2.5 mmol/L [A]	EB	3	-10 mmol/L [A]
$Pa0_2$		99 mmHg	$Pa0_2$		99 mmHg	$Pa0_2$		99 mmHg
Lact		1.5 mmol/L	Lact		1.5 mmol/L	Lact		1.5 mmol/L
SO_2		> 96%	SO_2		> 96%	SO_2		> 96%
Chronic Respiratory Alkalosis			Chronic Respiratory Alkalosis + Metabolic Alkalosis			Chronic Respiratory Alkalosis+ Metabolic acidosis		

6A	6B	6C
The pH is Abnormal (Step 1)	The pH is Abnormal (Step 1)	The pH is Abnormal (Step 1)
Evaluate $PaCO_2$: Abnormal (Step2)	Evaluate $PaCO_2$: Abnormal (Step2)	Evaluate $PaCO_2$: Abnormal (Step2)
• Present Respiratory Problem	• Present Respiratory Problem	• Present Respiratory Problem
(respiratory alkalosis) Algorithm 6	(respiratory alkalosis) Algorithm 6	(respiratory alkalosis) Algorithm 6
Evaluate the Base: Altered (Step 3)	Evaluate the Base: Altered (Step 3)	Evaluate the Base: Altered (Step 3)
• Chronic Respiratory Problem	• Chronic Respiratory Problem	• Chronic Respiratory Problem
(chronic respiratory alkalosis)	(chronic respiratory alkalosis)	(chronic respiratory alkalosis)
• Determine the metabolic compensation:	• Determine the metabolic compensation:	• Determine the metabolic compensation:
Expected base	Expected base	Expected base
• Use the formula:	• Use the formula:	• Use the formula:
Expected base = ($PaCO_2$-40) x 0.4	Expected base = ($PaCO_2$-40) x 0.4	Expected base = ($PaCO_2$-40) x 0.4
• Base = Compensation	• Base < Compensation	• Base > Compensation
Alloysis Respiratory Chronic Pure Algorithm 6	Added Metabolic Alkalosis Algorithm 4	Added Metabolic Acidosis Algorithm 3

Conclusion

The diagnostic approach of acid-base disorders with the traditional method of Henderson-Hasselbalch does not explain all the disorders, but in combination with the Base (B) described by Siggaard-Andersen, the diagnostic sensitivity improves remarkably, besides that this combination is simple, rigorous and practical. The absence of "order" limits the understanding of acid-base disorders. The geographical, atmospheric and biological conditions influence the blood gases, so they must adjust to the height, barometric pressure and acute exposure of the local area.

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Volume 4 Issue 5 May 2018