Department of Anesthesia Techniques

Arterial BLOOD GASES II

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Acids and bases

The body maintain a balance between acids and bases. Without that balance, cells can't function properly.

As cells use nutrient to produce the energy, two by-products are formed H+ & CO_2.

acid-base balance depends on the regulation of the free hydrogen ions

Even slight imbalance can affect metabolism and essential body functions.

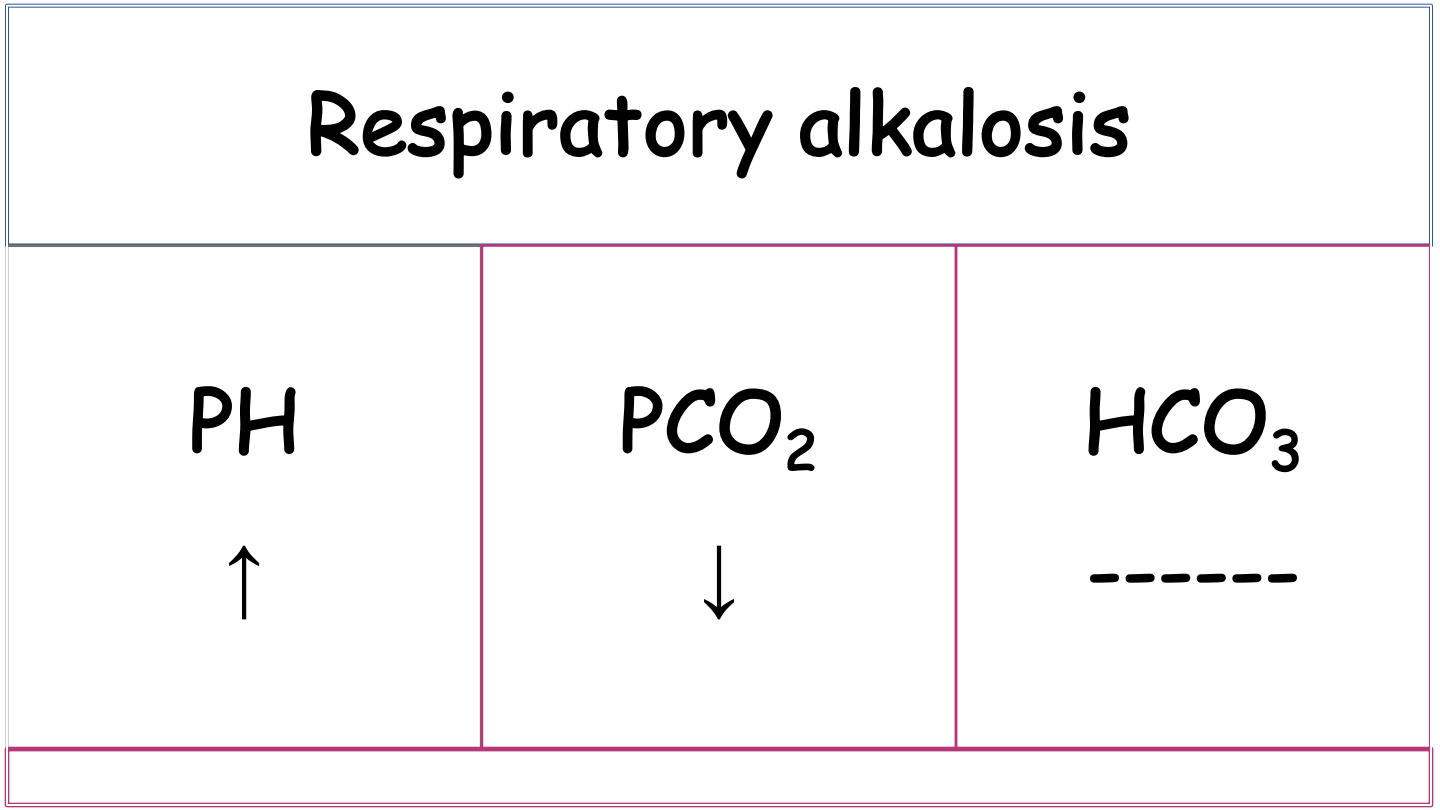
Several conditions as infection or trauma and medications can affect acid-base balance

Steps for ABG interpretation

- Step1: Look at Pao_2 (hypoxemia)
- Step2: **look at pH** (acid or alkaline)
- Step 3: **look at $Paco_2$** (resp. acidosis, alkalosis or normal)
- Step4: **look at Hco_3** (metabolic acidosis, alkalosis, or normal)
- Step5: **look back at pH** (compensated or uncompensated)

Acid base disorders

Respiratory acidosis	
PH	PCO_2
↓	↑


Respiratory alkalosis
PH
↑
PCO_2
↓
HCO_3

Metabolic acidosis

PH	PCO_2	HCO_3
↓	------	↓

Metabolic alkalosis

PH	PCO_2	HCO_3
↑	------	↑

Disorder	Primary pH	Primary	Compensated response
Metabolic acidosis	↓	↓ [HCO3-]	↓ Pco2
Metabolic alkalosis	↑	↑ [HCO3-]	↑ Pco2
Respiratory acidosis	↓	↑ Pco2	↑ [HCO3-]
Respiratory alkalosis	↑	↓ Pco2	↓ [HCO3-]

Interpretation of ABG results

Respiratory acidosis

PH	**7.30**	**acidemia**
$PaCO_2$	**55 mmhg**	**increased (respiratory cause)**
HCO_3	**25 meq/l**	**normal**
PaO_2	**80 mmhg**	**normal**

Metabolic alkalosis

PH	**7.49**	**alkalemia**
$PaCO_2$	**40 mmhg**	**normal**
HCO_3	**29 meq/l**	**increased (metabolic cause)**
PaO_2	**85 mmhg**	**normal**

Compensation

The respiratory and metabolic system works together to keep the body's acid-base balance within normal limits.

The respiratory system compensation :

1- metabolic acidosis: ↑ respiratory rate and depth (↓$PaCO_2$)

2- metabolic alkalosis: ↓ respiratory rate and depth (↑$PaCO_2$)

The metabolic system compensation for respiratory imbalances:

1-Respiratory acidosis: ↑ HCO3 reabsorption

2-Respiratory alkalosis: ↓HCO3 reabsorption

a. Respiratory acidosis

Phase	PH	PaCO2	HCO3
UNCOMPENSATED	↓	↑	------

Because there is no response from the kidneys yet to acidosis the HCO3 will remain normal

Phase	PH	PaCO2	HCO3
PARTIAL COMPENSATED	↓	↑	↑

The kidneys start to respond to the acidosis by increasing the amount of circulating HCO3

Phase	PH	PaCO2	HCO3
FULL COMPENSATED	N	↑	↑

PH return to normal PaCO2 & HCO3 levels are still high to correct acidosis

B. Respiratory alkalosis

Phase	PH	PaCO2	HCO3
UNCOMPENSATED	↑	↓	------

Because there is no response from the kidneys yet to acidosis the HCO3 will remain normal

Phase	PH	PaCO2	HCO3
PARTIAL COMPENSATED	↑	↓	↓

The kidneys start to respond to the alkalosis by decreasing the amount of circulating HCO3

Phase	PH	PaCO2	HCO3
FULL COMPENSATED	N	↓	↓

PH return to normal PaCO2 & HCO3 levels are still low to correct alkalosis

C. Metabolic acidosis

Phase	PH	PaCO2	HCO3
UNCOMPENSATED	↓	-------	↓

Because there is no response from the lungs yet to acidosis the PaCO2 will remain normal

Phase	PH	PaCO2	HCO3
PARTIAL COMPENSATED	↓	↓	↓

The lungs start to respond to the acidosis by decreasing the amount of circulating PaCO2

Phase	PH	PaCO2	HCO3
FULL COMPENSATED	N	↓	↓

PH return to normal PaCO2 & HCO3 levels are still low to correct acidosis

D. Metabolic alkalosis

Phase	PH	PaCO2	HCO3
UNCOMPENSATED	↑	-------	↑

Because there is no response from the lungs yet to alkalosis the PaCO2 will remain normal

Phase	PH	PaCO2	HCO3
PARTIAL COMPENSATED	↑	↑	↑

The lungs start to respond to the alkalosis by increasing the amount of circulating PaCO2

Phase	PH	PaCO2	HCO3
FULL COMPENSATED	N	↑	↑

PH return to normal PaCO2 & HCO3 levels are still high to correct alkalosis

Example 1

Layla is a 45-year-old female admitted to the nursing unit with a severe asthma attack. She has been experiencing increasing shortness of breath since admission three hours ago. Her arterial blood gas result is as follows

Clinical Laboratory:

pH 7.22

PaCO2 55

HCO3 25

Follow the steps:

1. Assess the pH. It is low therefore, we have acidosis.

2. Assess the PaCO2. It is high and in the opposite direction of the pH.

3. Assess the HCO3. It has remained within the normal range (22-26).

Acidosis is present (decreased pH) with the PaCO2being increased, reflecting a primary respiratory problem. For this patient, we need to improve the ventilation status by providing oxygen therapy, mechanical ventilation or by administering bronchodilators.

Example 2

Qassim is a 55-year-old male admitted with a recurring bowel obstruction. He has been experiencing intractable vomiting for the last several hours, Here is his arterial blood gas result:

Clinical Laboratory:

pH 7.50

PaCO2 42

HCO3 33

Follow the steps again:

1. Assess the pH. It is high (normal 7.35-7.45), therefore, indicating alkalosis.

2. Assess the PaCO2. It is within the normal range (normal 35-45).

3. Assess the HCO3. It is high (normal 22-26) and moving in the same direction as the pH.

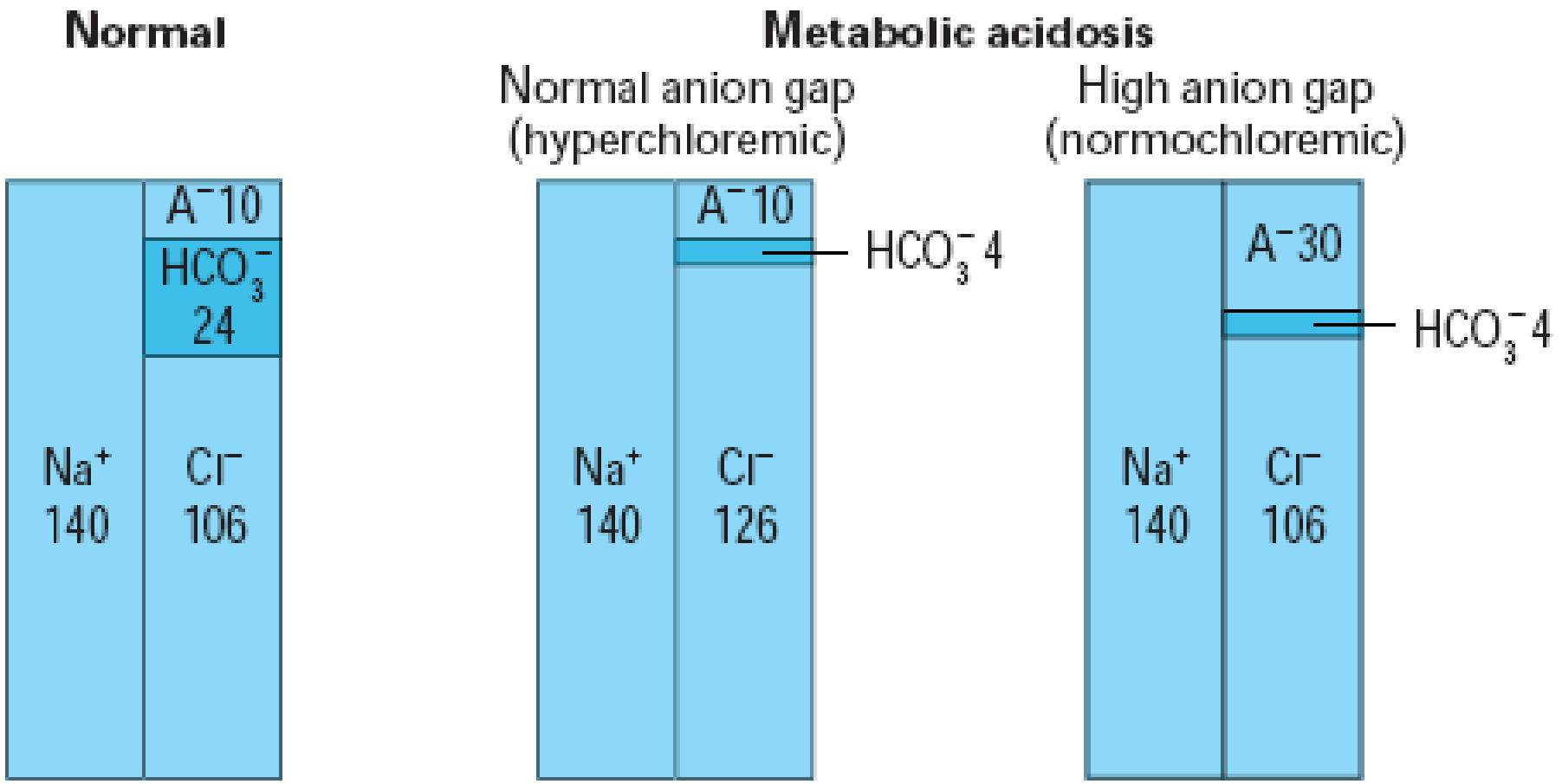
Alkalosis is present (increased pH) with the HCO3 increased, reflecting

a primary metabolic problem.

Anion gap

- The anion gap is a calculation of the difference between the amounts of negatively charged electrolytes (such as chloride and bicarbonate) and the amount of positively charged electrolytes (such as sodium) blood.
- normal anion gap (12 ± 4)

Metabolic acidosis - anion gap



Is the metabolic acidosis associated with an increased anion gap?

- Na^+ 135 mmol/L; $HCO3^-$ 12 mmol/L; Cl^- 99 mmol/L
- 135^- [99 + 12] = 24.
- AG is elevated compared to a normal anion gap (12 ± 4)

Normal anion-gap acidosis

- GI bicarbonate ($HCO3^-$) losses (diarrhea, ileostomy, colostomy)
- Renal tubular acidosis (RTA)
- Interstitial renal disease
- Ingestion of ammonium chloride, chole-styramine, calcium chloride or magnesium chloride.
- Small bowel or biliary or pancreatic drainage or fistula

Increased anion-gap acidosis

- Ingestion of:
  - Methanol, ethanol, ethylene glycol, aspirin, paraldehyde, salicylates, cyanide
- Uremia or renal failure
- Lactic acidosis
- Alcoholic ketoacidosis or diabetic ketoacidosis

- a 54-year-old widower with a history of COPD in emergency department with shortness of breath, pyrexia, and a productive cough . his sons , says he has been unwell for three days.
- Upon examination, crackles and wheezes can be heard in the lower lobes; he has tachycardia and a bounding pulse.
- Measurement of arterial blood gas shows
- **pH 7.3**
- **PaCO2 68 mm Hg**
- **HCO3 28 mmol/L**
- **PaO2 60 mm Hg.** How would you interpret this?
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- A. Respiratory Acidosis, Uncompensated
- B. Respiratory Acidosis, Partially Compensated
- C. Metabolic Alkalosis, Uncompensated
- D. Metabolic Acidosis, Partially Compensated

- Women brought to the emergency department of a hospital after she fell into the ground and hurt her left leg. She is noted to be tachycardic and tachypneic. Suddenly, she started complaining that she is still in pain and now experiencing muscle cramps, tingling, and paraesthesia. Measurement of arterial blood gas reveals
- **pH 7.6**
- **PaO2 120 mm Hg**
- **PaCO2 31 mm Hg**
- **HCO3 25 mmol/L.** What does this mean?
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- A. Respiratory Alkalosis, Uncompensated
- B. Respiratory Acidosis, Partially Compensated
- C. Metabolic Alkalosis, Uncompensated
- D. Metabolic Alkalosis, Partially Compensated

- Old man underwent post-abdominal surgery, has a nasogastric tube. The nurse on duty notes that the nasogastric tube (NGT) is draining a large amount (900 cc in 2 hours) of coffee ground secretions. The patient is not oriented to person, place, or time.
- the ABGs show
- **pH 7.57**
- **PaCO2 37 mmHg**
- **HCO3 30 mEq/L.** What is your assessment?

- A. Metabolic Acidosis, Uncompensated
- B. Metabolic Alkalosis, Uncompensated
- C. Respiratory Alkalosis, Uncompensated
- D. Metabolic Alkalosis, Partially Compensated

- 20 t patient admitted to the hospital and is to undergo brain surgery. The client is very anxious and scared of the upcoming surgery. He begins to hyperventilate and becomes very dizzy. He loses consciousness and the ABGs reveal
- **pH 7.61**
- **PaCO2 22 mmHg**
- **HCO3 25 mEq/L.** What is the ABG interpretation based on the findings?
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- A. Metabolic Acidosis, Uncompensated
- B. Respiratory Alkalosis, Partially Compensated
- C. Respiratory Alkalosis, Uncompensated
- D. Metabolic Alkalosis, Partially Compensated
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