pH Cases

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Clinical Case #1

15-year-old girl with cystic fibrosis has complained of an increased cough productive of green sputum over the last week. She also complained of being increasingly short of breath, and she is noticeably wheezing on physical examination. Arterial blood was drawn and sampled, revealing the following values:

pH 7.30

pCO2 50 mm Hg

pO2 55 mm Hg

Hemoglobin O2 45%

HCO3 24 meq / liter

**Cystic fibrosis is a genetic disease that causes thick, sticky mucus to build up in the lungs, digestive tract, and other areas of the body. It is one of the most common chronic lung diseases in children and young adults. The thick mucus is difficult to clear from the respiratory tract, and it provides a nutrient-rich breeding ground for bacteria. Individuals with CF are therefore subjected to repeated bouts of lower respiratory tract infections*

Clinical Case #1

15-year-old girl with cystic fibrosis…

How would you classify this girl's acid base status?

Answer: patient has respiratory acidosis, as is evident from her ↓ arterial blood pH, ↑ arterial blood pCO_2, and normal arterial HCO_3^- concentration.

How does cystic fibrosis cause this acid-base imbalance?

Answer: The pooling of excessively thick mucus obstructs the small and large airways. This reduces the patient's minute ventilation, causing hypoventilation. As she hypoventilates, the pCO_2 level rises and the excess CO_2 reacts with H_2O in the bloodstream to produce carbonic acid (H_2CO_3), which dissociates into H^+ ions and HCO_3^- ions, lowering the pH of the blood.

Can you think of other causes of this type of acid-base disturbance?

Answer: Other causes of respiratory acidosis include asthma, chronic bronchitis, emphysema, muscular dystrophy, myasthenia gravis, amyotrophic lateral sclerosis, poliomyelitis, and morphine overdosing.

Clinical Case #2

A 27-year-old woman has been sick with the flu for the past week, vomiting several times every day. She is having a difficult time keeping solids and liquids down, and has become severely dehydrated. After fainting at work, she was taken to a walk-in clinic, where an IV was placed to help rehydrate her. Arterial blood was drawn first, revealing the following:

pH 7.50
pCO2 40 mm Hg
pO2 95 mm Hg
Hemoglobin - O2 97%
HCO3 32 meq / liter

How would you classify the patient's acid base status?

Answer: An ↑ arterial blood pH in combination with a normal arterial pCO2 and ↑ arterial HCO3- concentration suggests that this woman has metabolic alkalosis.

Why might excessive vomiting cause her acid-base imbalance?

Answer: gastric secretions in the stomach are very acidic - pH can be below 1.0. If patient is vomiting a lot, there is a net loss of H+ ions from the stomach lumen and ultimately from the bloodstream. This ↑ her arterial blood pH and causes a metabolic alkalosis.

**** it should be noted that in severe vomiting the loss of alkaline bile and pancreatic secretions into the vomit can actually cause a metabolic acidosis.***

Clinical Case #3

A 76-year-old man at home experienced the ff:

-severe sub-sternal chest pains that radiated the inside of his left arm

- he collapsed on the living room floor
- paramedics found him unresponsive, not breathing, and without a pulse
- CPR and AED shock were required to start his heart beating again
- In ER the man regained consciousness & complained of severe dyspnea and continued chest pain. Vital signs were as follows:

Systemic blood pressure 85 mmHg / 50 mm Hg

HR 175 BPM

Respiratory rate 32 breaths / minute

Temperature 99.2

Arterial blood tests revealed the following:

pH 7.22

pCO2 30 mm Hg

pO2 70 mm Hg

Hemoglobin - O2 88 %

HCO3- 2 meq / liter

What is your diagnosis of the patient?

Answer: heart attack evident by radiating chest pain, sudden collapse, elevated HR etc suggest this diagnosis.

Clinical Case #3

76-year-old man with myo infarction…

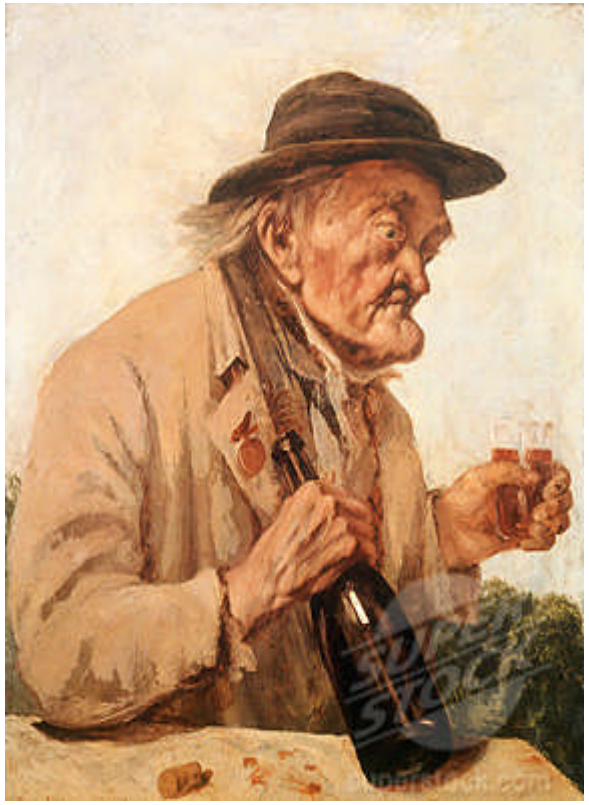
How would you classify his acid-base status? What specifically caused this acid-base disturbance?

Answer: patient has lower-than-normal arterial pH and HCO_3^- levels, in combination with a lower-than-normal arterial pCO_2 level. This indicates that he is in a state of metabolic acidosis. When his heart stopped beating, blood flow to organs stopped. Hence, tissues were forced to continue to work w/o oxygen (anaerobically). A by-product of anaerobic respiration is lactic acid- when lactic acid ↑ in tissues/bloodstream, it ↓ the blood pH, a condition known as lactic acidosis. Even after his heart started beating again, it takes several minutes to hours to flush the excess acid out of the bloodstream.

How has his body started to compensate for this acid-base imbalance?

Answer: patient hyperventilation is driving the arterial pCO_2 downward and causing more production of carbonic acid. This carbonic acid is then converted to CO_2 and H_2O, the former being excreted through the lungs. The net effect of this process is to remove some of the excess H^+ ions from the bloodstream, thus helping to correct the metabolic acidosis.

An 80 year old homeless man presents with nausea, vomiting and poor oral intake 2 days prior to admission. The patient reports a 3 day history of binge drinking prior to symptoms.



Arterial Blood Gas (ABG)

pH = 7.30

PaCO2 = 29

HC03- = 16

P02 = 92

Na+ = 132

Cl- = 104

Acid-Base Disturbance	pH 7.35-7.45	Pco2 35-45mm HG	HCO3- 22-26mEq/L
Respiratory Acidosis	↓	↑	↑ if compensating
Respiratory Alkalosis	↑	↓	↓ if compensating
Metabolic Acidosis	↓	↓ if compensating	↓
Metabolic Alkalosis	↑	↑ if compensating	↑

Arterial Blood Gas (ABG)

pH = 7.30
PCO2 = 29
HC03- = 16
P02 = 92
Na+ = 132
Cl- = 104

Is the patient ACIDEMIC or ALKALEMIC? ↓ACIDEMIC!

Is the PCo2 normal, increased or decreased? ↓DECREASED!

Is the HCo3- normal, increased or decrease ↓DECREASED!

What acid/base order exists in this scenario?

Metabolic Acidosis with respiratory compensation

ANION GAP FORMULA

$$[Na^+] - ([Cl^-]+[HCO_3^-])$$

Normal Anion Gap Range = **10-14**

Arterial Blood Gas (ABG)

pH = 7.30
PaCO2 = 29
HC03- = 16
P02 = 92
Na+ = 132
Cl- = 104

132-(104+16)=**12**

↑ ↑ ↑

Na+ **Cl-** **HCo3-**

=NORMAL AG

Mr. Williams is a 24 year old college student who is complaining of a four day history of bloody-watery diarrhea.

Arterial Blood Gas (ABG)

pH = 7.28

PaCO2 = 43

HC03- = 20

P02 = 88

Na+ = 138

Cl- = 108

Acid-Base Disturbance	pH 7.35-7.45	Pco2 35-45mm HG	HCO3- 22-26mEq/L
Respiratory Acidosis	↓	↑	↑ if compensating
Respiratory Alkalosis	↑	↓	↓ if compensating
Metabolic Acidosis	↓	↓ if compensating	↓
Metabolic Alkalosis	↑	↑ if compensating	↑

Arterial Blood Gas (ABG)

pH = 7.28
PaCO2 = 43
HC03- = 20
P02 = 88
Na+ = 138
Cl- = 108

Is the patient ACIDEMIC or ALKALEMI ↓ACIDEMIC!

Is the PCo2 normal, increased or decrease NORMAL

Is the HCo3- normal, increased or decrease ↓DECREASED!

What acid/base order exists in this scenario?

Metabolic Acidosis

ANION GAP FORMULA

[Na+] – ([Cl-]+[HCO3-])

Normal Anion Gap Range = **10-14**

Arterial Blood Gas (ABG)

pH = 7.28
PaCO2 = 43
HC03- = 20
P02 = 88
Na+ = 138
Cl- = 108

138 - (108 + 20)±**10**

↑ Na+

↑ Cl-

↑ HCo3-

=NORMAL AG

Possible Causes of Metabolic Acidosis

- Severe diarrhea
- Renal Disease
- Untreated diabetes
- Starvation
- Excess alcohol digestion
- High potassium concentration

Acid Base Imbalance

Homeostasis

The human body has many different intricate systems that keep us living, and we have the blood pH

The blood pH is very important measurement of the blood stream, and has a number associated with it from 0-14. It measures the concentration of hydrogen in a solution or substance

If the pH is at 7.0 it's said to be neutral, higher numbers are considered alkali or base and lower numbers are considered acids.

The blood pH is important because it controls the body's biomechanical responses by controlling enzyme activity and the speed of electricity through the body. The higher the pH (alkali) equals more resistance.

Now let's look at what happens numbers constitute an imbalance

Normal Ranges

	Test Normal	↓ Value	↑ Value
pH	7.35-7.45	Acidosis	Alkalosis
pCO2	35-45	Alkalosis	Acidosis
HCO3	22-26	Acidosis	Alkalosis
pO2	80-100	Hypoxemia	O2 Therapy
SaO2	95-100%	Hypoxemia	----------
Anion Gap	10-14	Low	High

pCO2 deals with respiratory

HCO3 deals with (renal) metabolic

Diagnosis

Metabolic acidosis (body builds up too much acid, & kidneys can't remove it fast enough w/ bicarbonate HC03)

Metabolic alkalosis (body builds up too much HCO3, and acid can't neutralize it)

Respiratory acidosis(body builds up too much CO2 in the blood) shallow breaths hypoventilation

Respiratory alkalosis (CO2 is eliminated faster than produced) hyperventilation

Diagnosis

Anion Gap formula $(Na^{+}) - (Cl^{-}) + (HCO_3)$

We use the anion gap any time we diagnose a patient with metabolic acidosis. The anion gap calculation allows us to be differentiate cases of metabolic acidosis.

Also whenever we have a respiratory acidosis or alkalosis we also tend to look at whether or not it is acute or chronic problems

When the body goes through these imbalances it tends to compensate

Mixed

A mixed acid-base disorder is one in which two different primary conditions are acting at the same time. Mixed disorders can be a combination of metabolic and respiratory disorders or a combination of different metabolic disorders.

The expected compensatory response does not occur

Compensatory response occurs, but level of compensation is inadequate or too extreme

pH is normal but PCO_2 or HCO_3^- is abnormal

Case 1

A 26-year-old woman is undergoing treatment for frequent panic attacks. The attacks are accompanied by hyperventilation, a racing heartbeat (tachycardia), dizziness, feelings of “unreality” and tingling in the hands. In one particularly severe attack, when taken to the emergency department, an arterial blood-gas sample was taken, which revealed the following:

pH 7.52

PCO_2 26 mm Hg

HCO_3 22 mEq/L

Answer

The pH of the arterial blood gas identifies it

as alkalemic. Also the numbers indicate the primary disturbance is respiratory, because the PCO2 being lowered primarily. In our case an arterial PCO2 shifted by 0.086 pH for each PCO2 shift of 10 mm. This means that the respiratory disturbance is acute. The renal system compensates bicarbonate ion levels fall as kidneys eliminate more HCO3 because they cant screte it or reclaim.

DIAGNOSIS: Acute Respiratory Alkalosis

from Hyperventilation due to Panic Attack

Case 2

A 31 year old man presents with lethargy, weakness, labored respiration, and confusion. He has had diabetes for 15 years, and has been suffering from the "intestinal flu" so he has been avoiding food to help prevent vomiting. Since he stopped eating, he thought that it would be a good idea to stop taking his insulin. The following arterial blood gas data was obtained:

pH 7.27

PCO2 23 mm Hg

Na+ 132 mEq/L

Cl- 83 mEq/L

HCO3 10 mEq/L

Glucose 345 mg/dL

Answer

The pH is 7.27, which is considerably less than normal (7.35-7.45), so the patient is acidemic.The PCO2 is low, so the respiratory system is not causing the acidosis; rather, the drop in PCO2 must be a compensatory process. The bicarbonate is low, which indicates that a metabolic acidosis is present. The anion gap = [Na+] - [Cl-] - [HCO3] = [132] - [83] - [10] = 39. The anion gap is obviously elevated. This means that the metabolic acidosis is of the elevated anion gap type.

Diagnosis Elevated Anion Gap Metabolic Acidosis

Central Sleep Apnea

Characterized by…

- Periods of absent airflow due to lack of respiratory effort
- Inhibitory input to the respiratory center of the brain exceeds excitatory input

Occurs if…

- Arterial pCO2 is lowered below a highly sensitive apneic threshold

Hyperventilation

- Central sleep apnea can be induced by hyperventilation
  - Hypernea occurs (ex. Hypoxia due to poor lung function)
  - Hypernea leads to hypocapnia (low CO2) which induces central apnea
  - Central apnea causes pCO2 to rise creating a respiratory alkolosis

Central Apnea in Healthy Individuals

- This occurs at the onset of sleep
- During this time pCO_2 levels are at or below apneic threshold
- Once sleep begins wakefulness related excitatory input is lost and a central apnea results

Treatment

- Continuous Positive Airway Pressure
- Supplemental oxygen
- Trials are being done on Acetazolamide, a diuretic which causes a mild metabolic acidosis

Ethylene Glycol Toxicity

- Generally a result of ingesting antifreeze, fairly common poison used
- LETHAL!

Anion Gap

- A profound anion gap occurs with ingestion of ethylene glycol
- There is an accumulation of toxic acid metabolites
- Bicarbonate levels decrease

Symptoms

- Abdominal pain
- Hematuria (RBCs in urine)
- Coma
- Seizures
- Hyperpnea
- Hypotension

Treatment

- Administer sodium bicarbonate
- Inhibit alcohol dehydrogenase
- Hemodialysis

Diabetic Ketoacidosis (DKA)

- Characterized by triad of hyperglycemia, anion gap metabolic acidosis, and ketonemia

Anion Gap

- Reduction in bicarbonate concentration leads to elevated anion gap metabolic acidosis

- A compensatory hyperventilation results to decrease the pCO2

Arterial pH

- pH values in DKA are less then 7.3 and can even be lower then 6.9 in severe cases

Treatment

- Insulin therapy
  - Lowers glucose concentration
  - Diminishes ketone production
- Correction of fluid and electrolyte imbalances
  - Avg fluid loss in DKA is 3-6 liters!
  - Isotonic saline is used as fluid replacement