

# Arterial Blood Gas Interpretation

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# Learning outcomes

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- Interpret arterial blood gas (ABG) values.
- Implement nursing interventions accordingly.



# Why should we care?

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- ABG analysis allows us to:
  - Determine oxygenation status
    - *Used in conjunction with pulse oximetry*
  - Determine acid-base balance
    - *Buffer system*
    - *Respiratory system*
    - *Renal system*



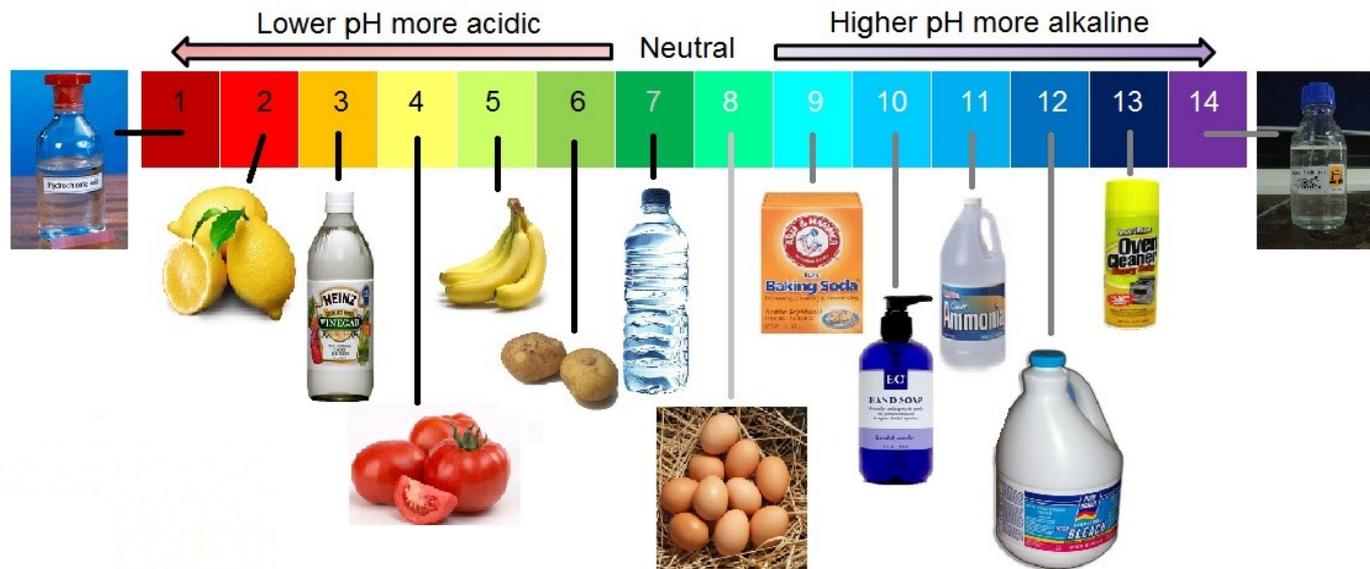
# What do we look at?

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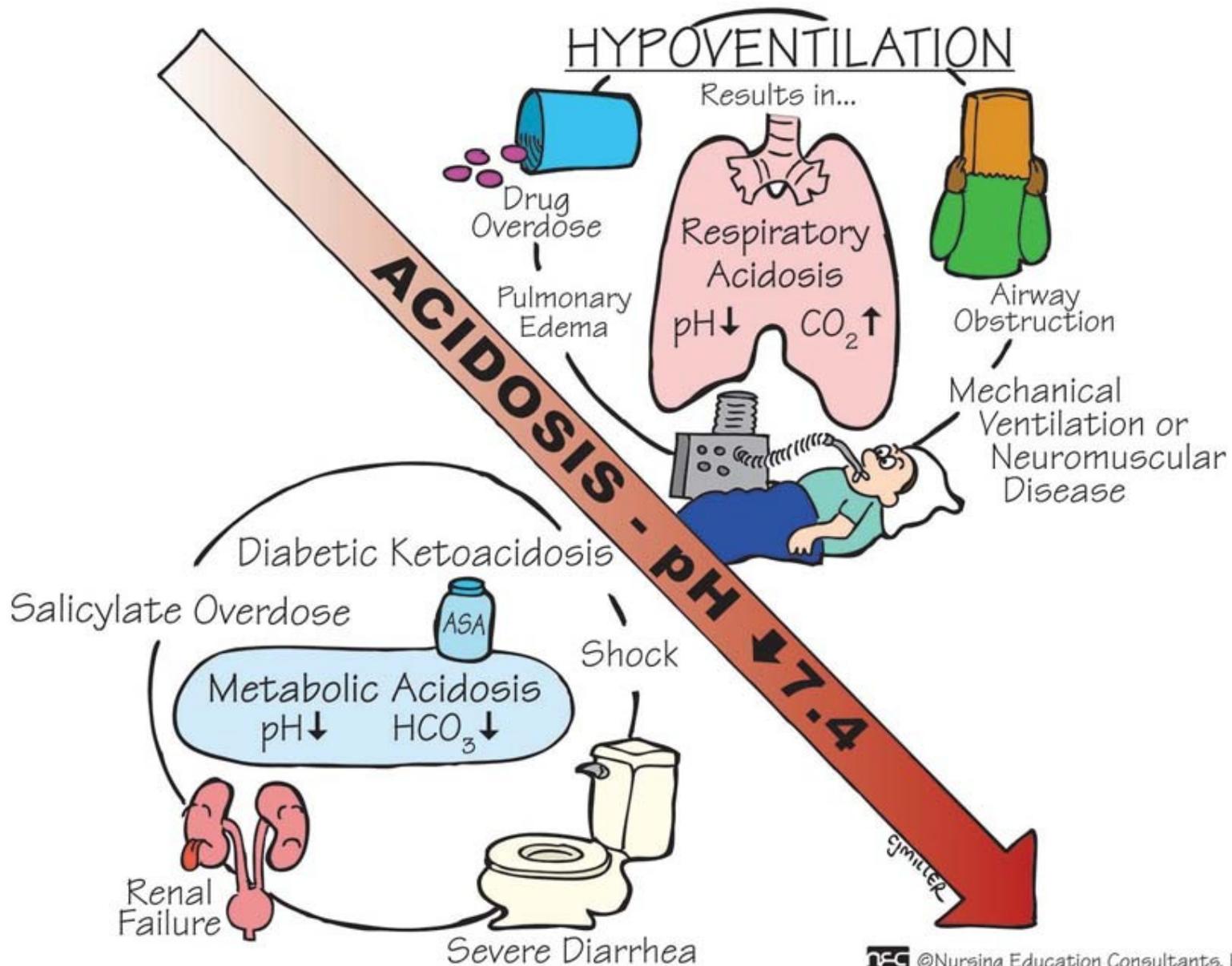
Lab	Value
pH	7.35-7.45
PaO <sub>2</sub>	80-100 mm Hg
SaO <sub>2</sub>	>95%
PaCO <sub>2</sub>	35-45 mm Hg
HCO <sub>3</sub> <sup>-</sup>	22-26 mEq/L (mmol/L)

# Let's talk Ph

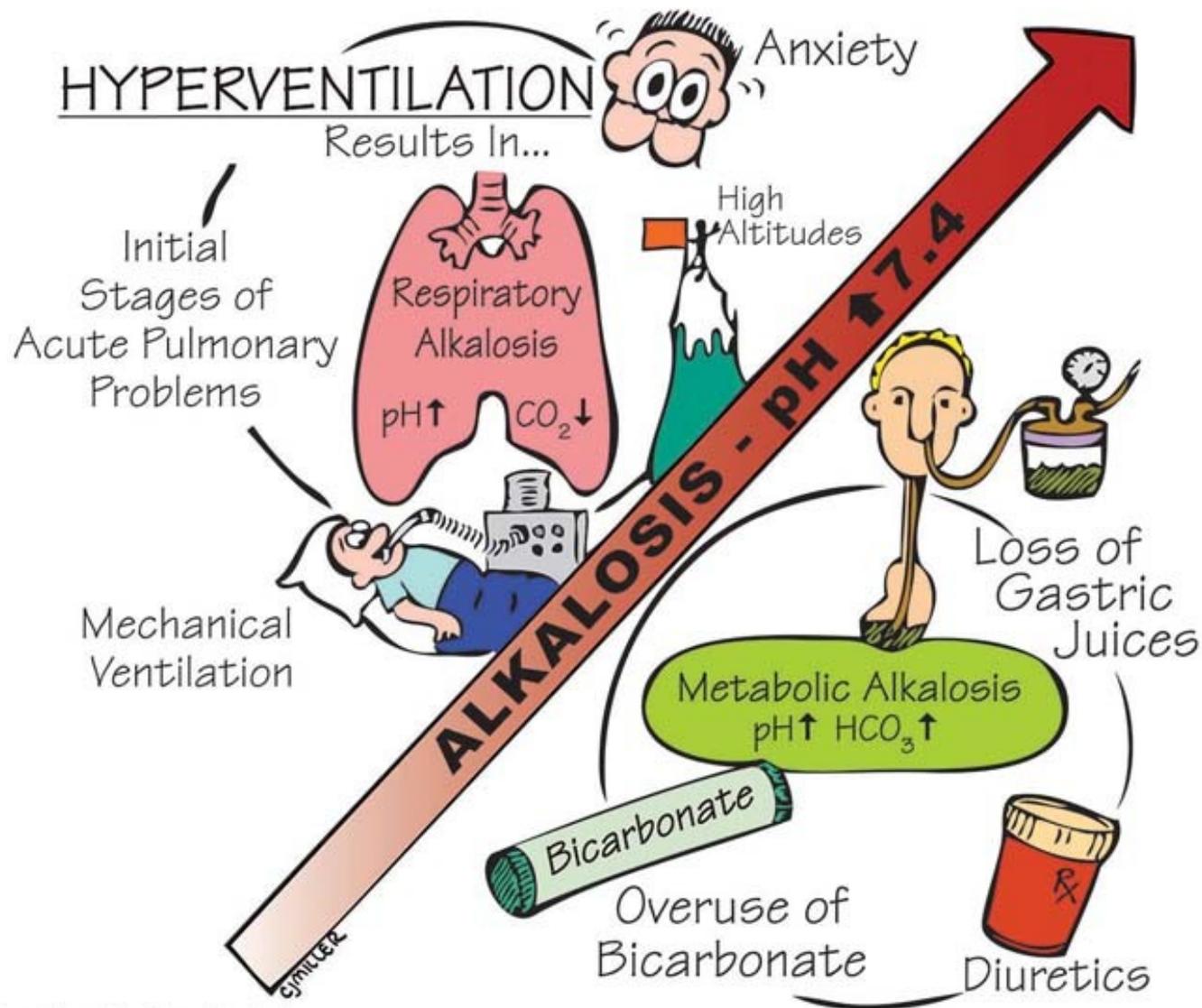
- 7 is neutral
- >7 is alkaline = **Alkalosis**
- <7 is acid = **Acidosis**



# CAUSES OF ACIDOSIS

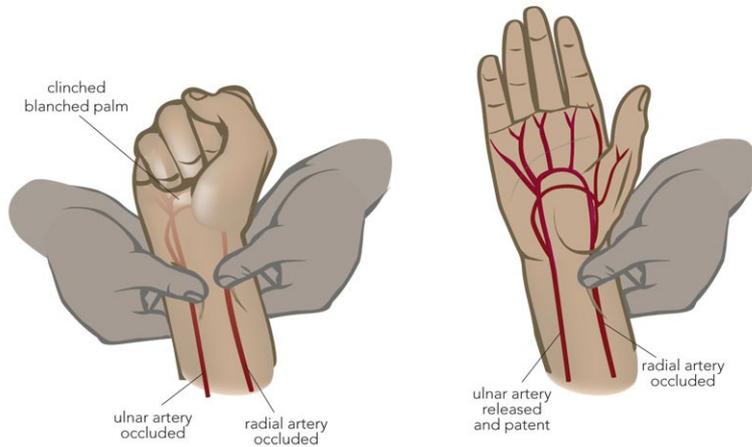


# CAUSES OF ALKALOSIS

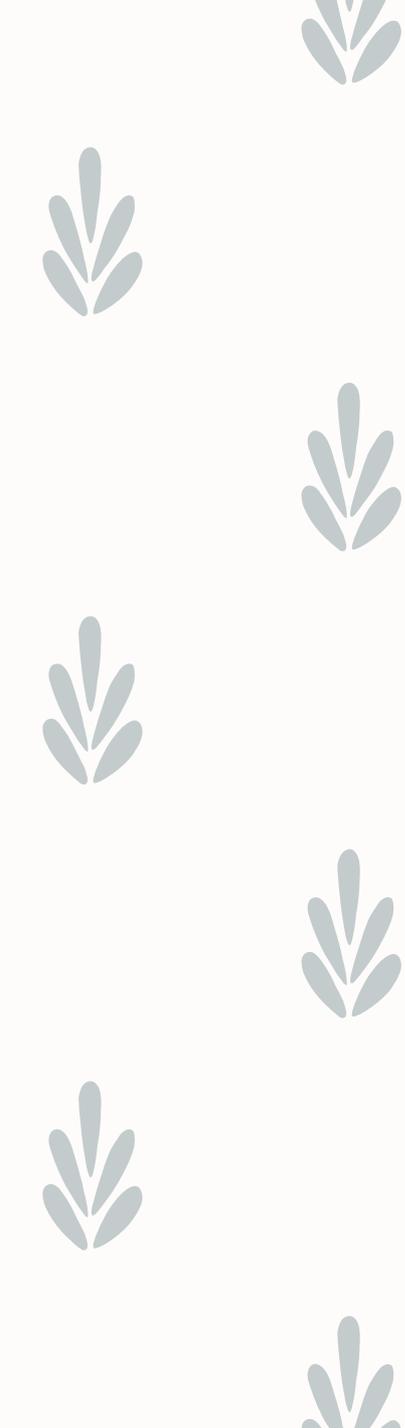


# Allen's Test

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- Compress the radial and ulnar artery while having pt. make a fist
- Relax hand and watch for blanching
- Release ulnar artery and watch for flushing
- Indicates patency of ulnar artery and ability to use radial for ABG



# Allen's Test

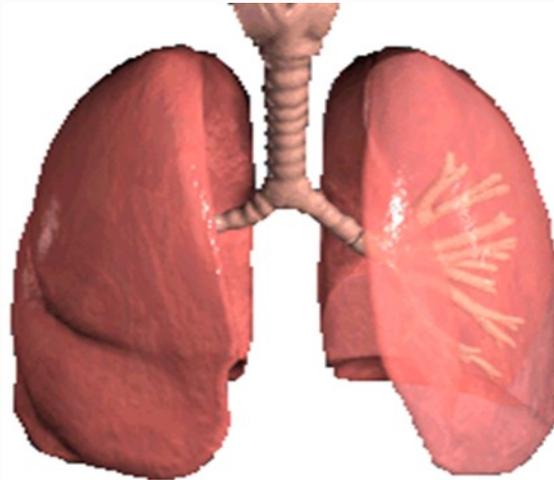
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- <https://www.youtube.com/watch?v=gdgomN6TsuE>

# Let's talk co2

- CO2 is the **ACID** component of our blood gas
  - The body's fastest way of changing our pH
  - Lungs regulate CO2 (**acid**) levels within minutes
- 

**To  
Compensate  
for  
Acidosis**

**\*RR & Depth  
will increase  
\*CO2 will be  
"blown off"**



**To  
Compensate  
for  
Alkalosis**

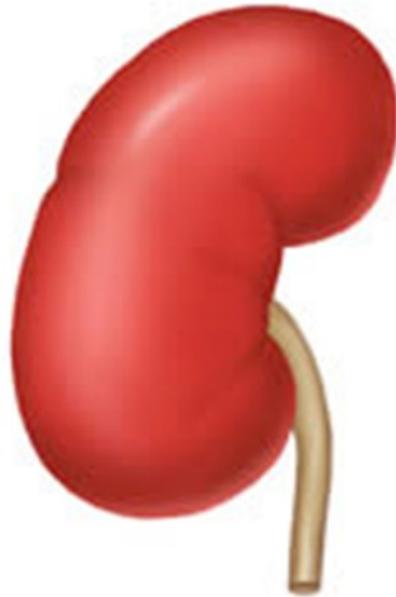
**\*RR & Depth  
will decrease  
\*CO2 will be  
retained**

# Let's talk bicarbonate

- Bicarbonate is the **BASE** component of our blood gas.
  - Kidneys regulate  $\text{HCO}_3^-$  (**base**) levels
  - Slower system, takes hours to days
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**To  
Compensate  
for  
Acidosis**

**\* $\text{H}^+$  ions  
will be  
excreted &  
 $\text{HCO}_3^-$  will  
be retained**



**To  
Compensate  
for  
Alkalosis**

**\* $\text{H}^+$  ions  
will be  
retained &  
 $\text{HCO}_3^-$  will  
be  
excreted**

# Steps to abg analysis

- 
- **Step 1:** Determine if pt. is in Acidosis or Alkalosis using the pH level
  - **Step 2:** Use PaCO<sub>2</sub> to determine respiratory effect on the body
  - **Step 3:** Use HCO<sub>3</sub> to determine metabolic effect on the body
  - **Step 4:** Determine compensation
  - **Step 5:** Determine oxygenation range

# STEP 1: ANALYZE THE PH= ACIDOSIS OR ALKALOSIS

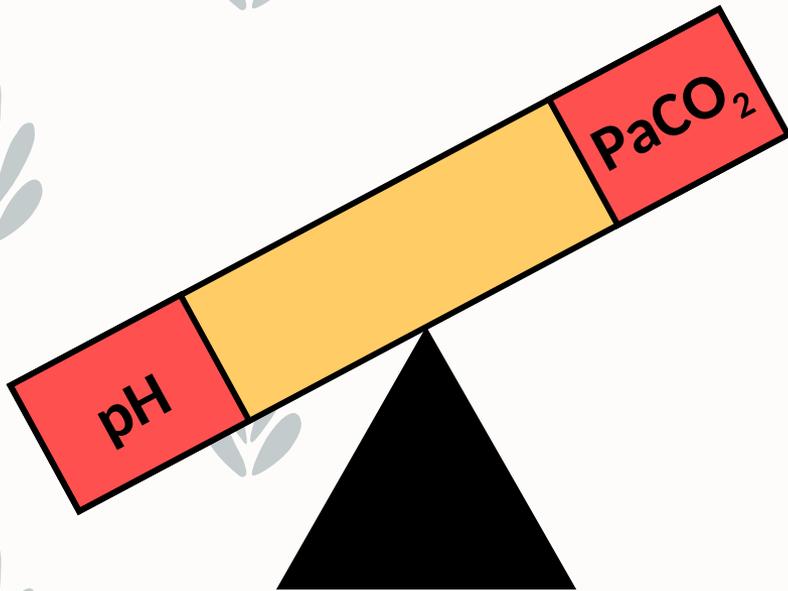
pH		
< 7.35	7.35 - 7.45	> 7.45
Acidosis	Normal or Compensated	Alkalosis

# STEP 2: ANALYZE PaCO<sub>2</sub> TO DETERMINE RESPIRATORY EFFECT

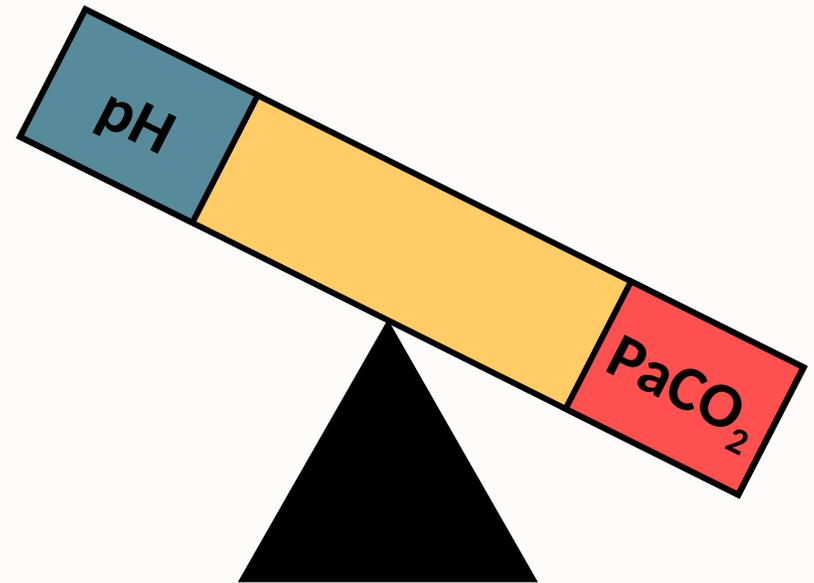
PaCO <sub>2</sub>		
< 35	35 - 45	> 45
Trends Toward Alkalosis	Normal or Compensated	Trends Towards Acidosis

# RESPIRATORY EFFECTS

- The “See-Saw” Effect



Respiratory **Acidosis**



Respiratory **Alkalosis**

# RESPIRATORY ACIDOSIS

- Hypoventilation → Hypoxia

- Rapid, Shallow Respirations

- ↓ BP with Vasodilation

- Dyspnea

- Headache

- Hyperkalemia

- Dysrhythmias (↑K)

I can't catch my breath.

- Drowsiness, Dizziness, Disorientation

- Muscle Weakness, Hyperreflexia

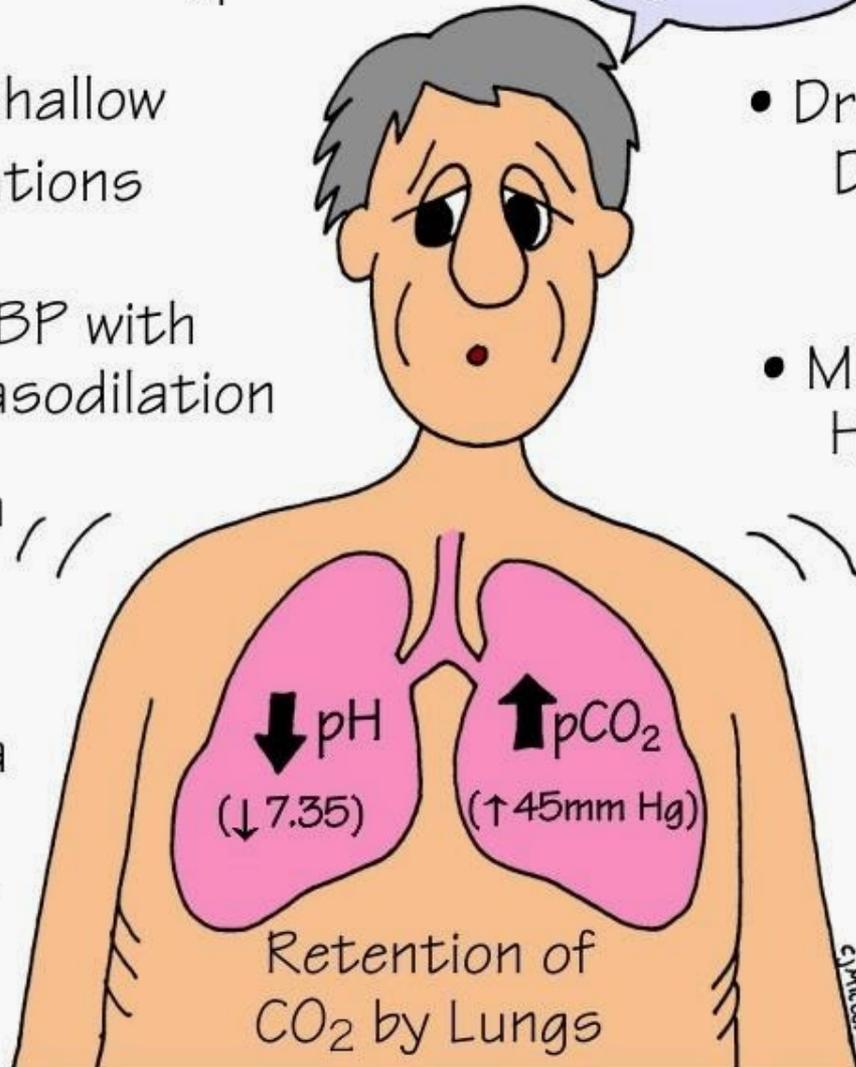
- Causes:

- ↓ Respiratory Stimuli (Anesthesia, Drug Overdose)

- COPD

- Pneumonia

- Atelectasis



# RESPIRATORY ALKALOSIS

- Seizures

- Deep, Rapid Breathing

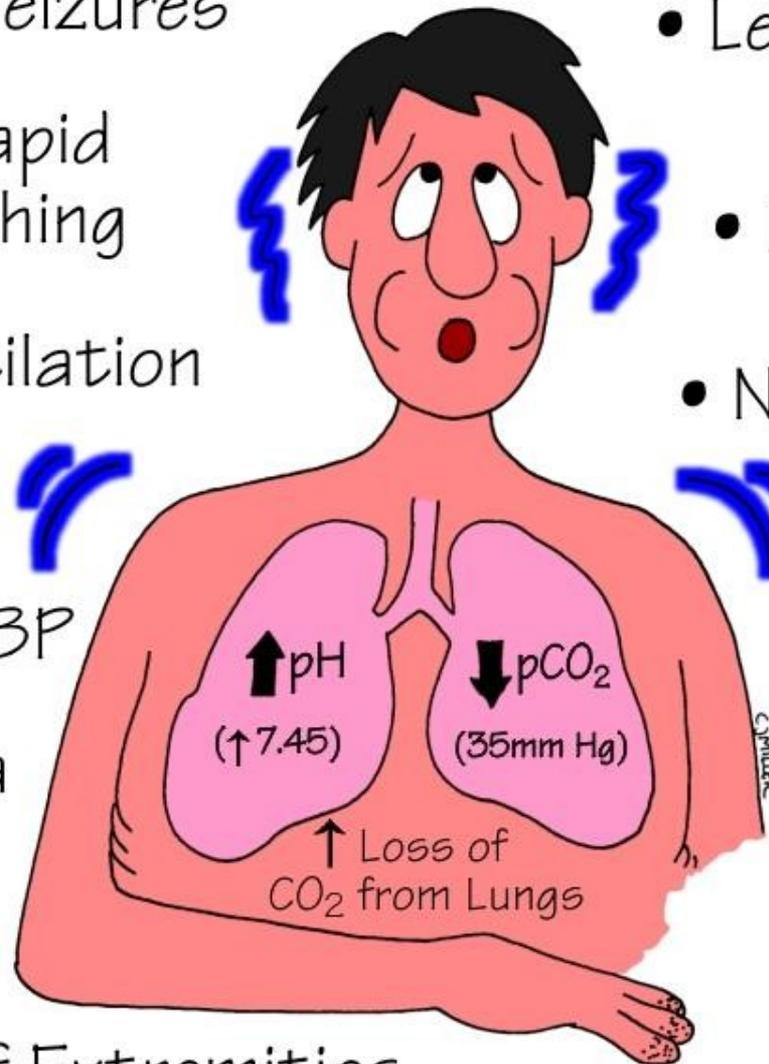
- Hyperventilation

- Tachycardia

- ↓ or Normal BP

- Hypokalemia

- Numbness & Tingling of Extremities



- Lethargy & Confusion

- Light Headedness

- Nausea, Vomiting

- Causes:

Hyperventilation

(Anxiety, PE, Fear)

Mechanical Ventilation

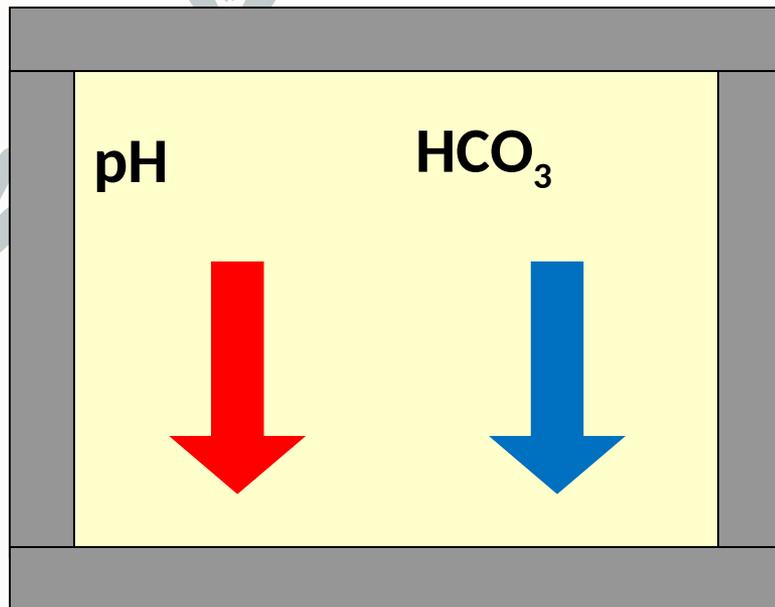
# STEP 3: ANALYZE HCO<sub>3</sub><sup>-</sup> TO DETERMINE METABOLIC EFFECT

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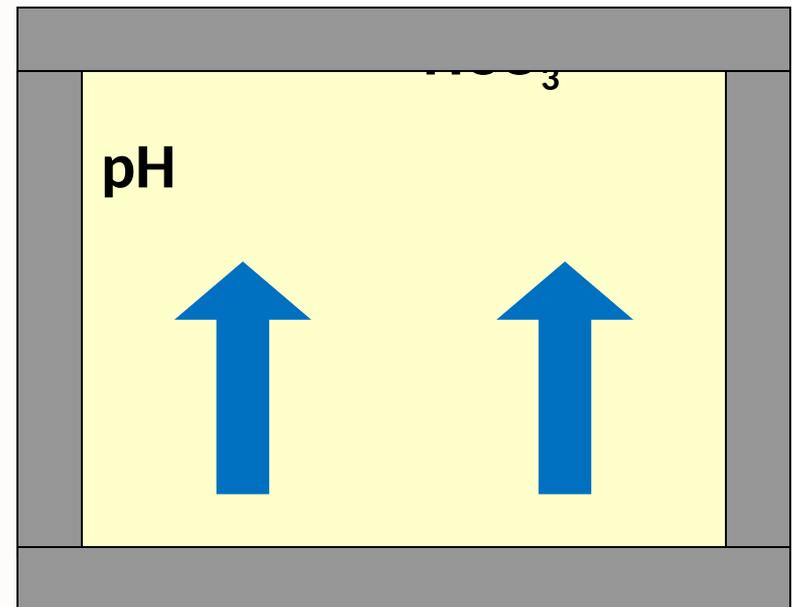
HCO <sub>3</sub> <sup>-</sup>		
< 22	22 - 26	> 26
Trends Towards Acidosis	Normal or Compensated	Trends Towards Alkalosis

# METABOLIC EFFECTS

- The “Elevator” Effect



**Metabolic Acidosis**



**Metabolic Alkalosis**

# METABOLIC ACIDOSIS

- Headache

- ↓BP

- Hyperkalemia

- Muscle Twitching

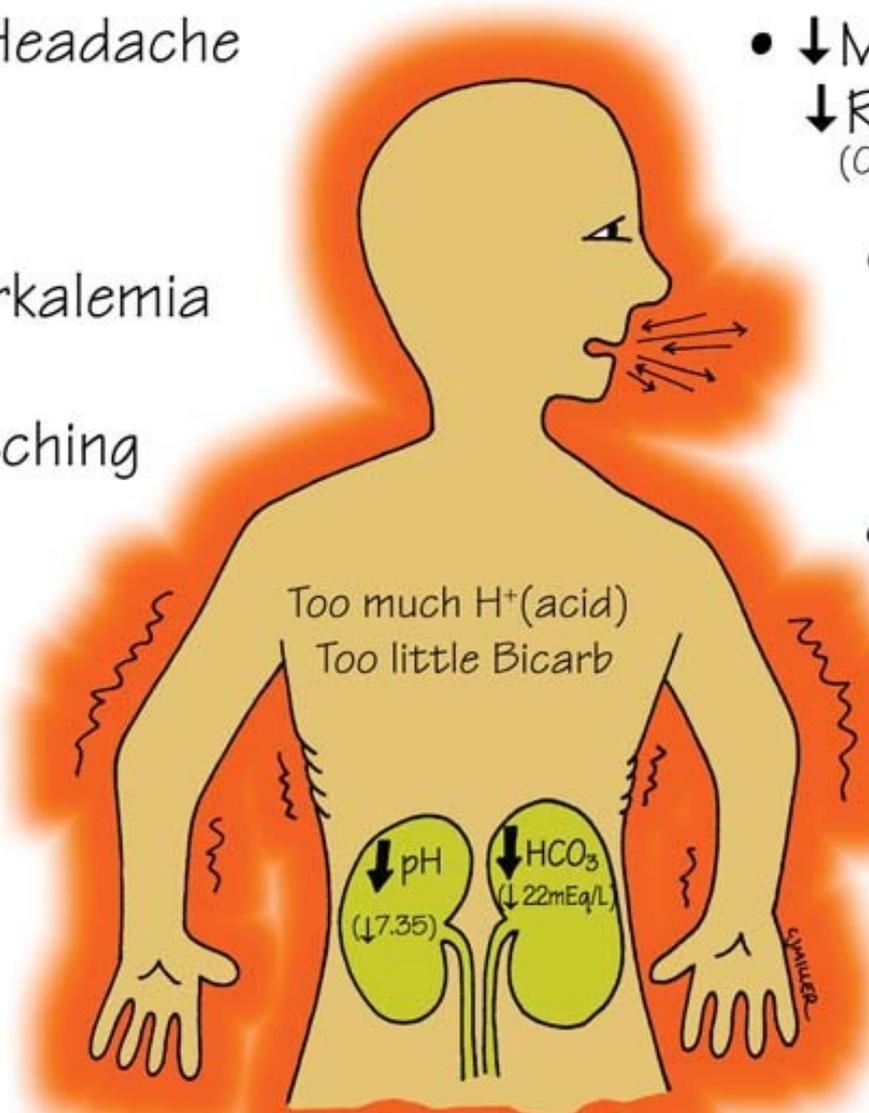
- Warm, Flushed Skin  
(Vasodilation)

- Nausea, Vomiting

- ↓Muscle Tone,  
↓Reflexes  
(Confusion, ↑Drowsiness)

- Kussmaul  
Respirations  
(Compensatory  
Hyperventilation)

- Causes:
  - ↑H<sup>+</sup> Production  
(DKA, hypermetabolism)
  - ↓H<sup>+</sup> Elimination  
(renal failure)
  - ↓HCO<sub>3</sub> Production  
(dehydration, liver failure)
  - ↑HCO<sub>3</sub> Elimination  
(diarrhea, fistulas)



# METABOLIC ALKALOSIS

- Restlessness  
Followed by  
Lethargy

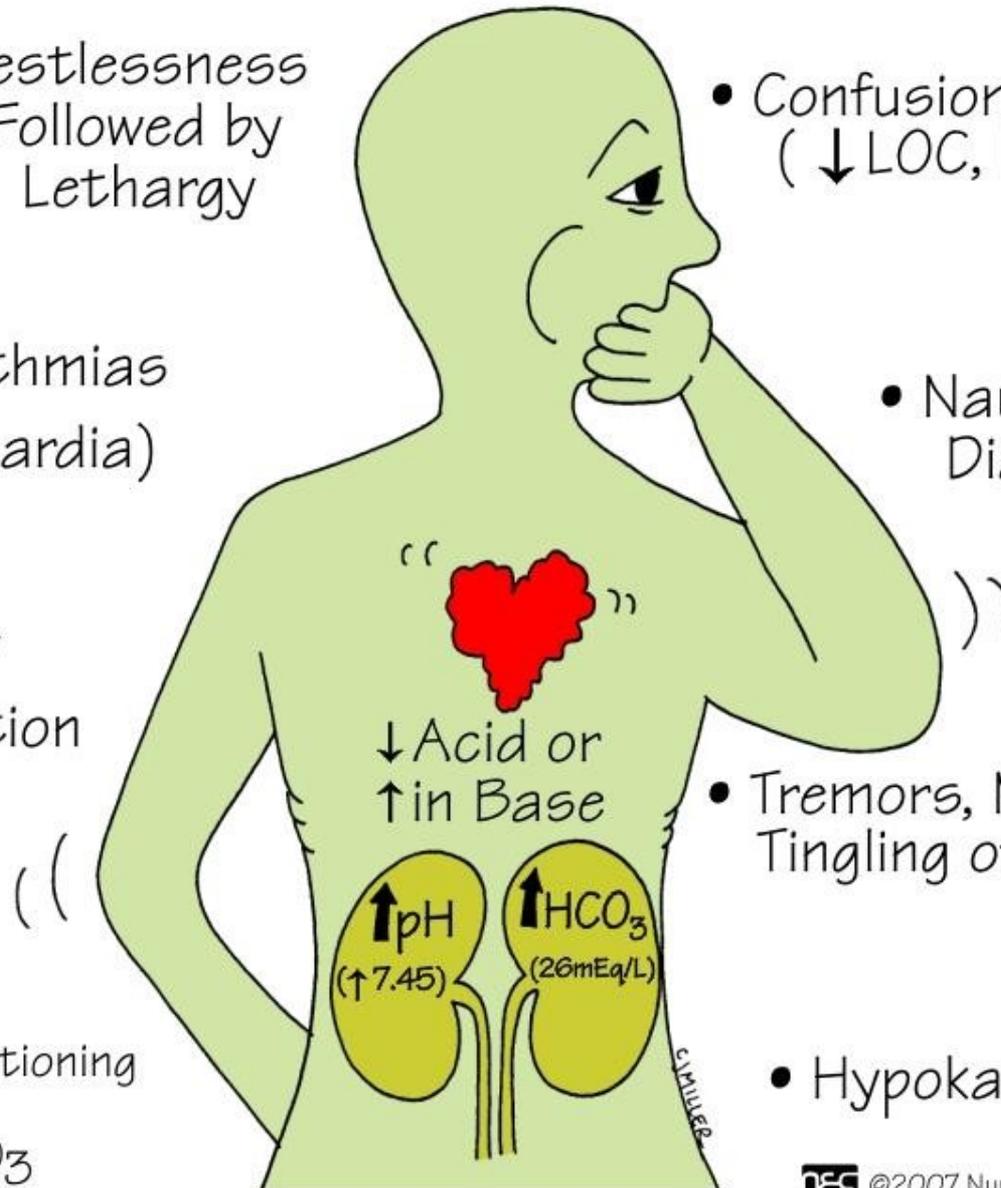
- Confusion  
( ↓LOC, Dizzy, Irritable)

- Dysrhythmias  
(Tachycardia)

- Nausea, Vomiting,  
Diarrhea

- Compensatory  
Hypoventilation

- Causes:  
Severe Vomiting  
Excessive GI Suctioning  
Diuretics  
Excessive  $\text{NaHCO}_3$



- Tremors, Muscle Cramps,  
Tingling of Fingers & Toes

- Hypokalemia

# Tic-tac-toe method

– Mark the grid accordingly:

– pH – 7.26 (A)

– CO<sub>2</sub> – 32 (B)

– HCO<sub>3</sub> – 18 (A)

– Match it up!

– We have metabolic acidosis!

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A	N	B
pH		
HCO <sub>3</sub>		CO <sub>2</sub>

# Step 4: determine compensation

- Compensation present if pH is **NORMAL** with PaCO<sub>2</sub> and/or HCO<sub>3</sub><sup>-</sup> are **ABNORMAL**
- Component going in the **SAME** direction as pH is **PRIMARY**
- Component in the **OPPOSITE** direction of pH is **COMPENSATORY**

System Causing Imbalance	Compensating System
Respiratory (PaCO <sub>2</sub> )	Metabolic (HCO <sub>3</sub> <sup>-</sup> ) *SLOW: 5-7 days
Metabolic (HCO <sub>3</sub> <sup>-</sup> )	Respiratory (PaCO <sub>2</sub> ) *FAST: 12-24 hours

# EXTENT OF COMPENSATION

## - ABSENT:

- Which value does not match the pH? (PaCO<sub>2</sub> or HCO<sub>3</sub>)
- If the value that does **NOT** match pH is **NORMAL**, then **NO** compensation has taken place.

- pH - 7.15 (A)

- PaCO<sub>2</sub> - 40 (N)

- HCO<sub>3</sub> - 8 (A)

- **Metabolic Acidosis**

- No compensation

- PaCO<sub>2</sub> is normal **BUT** pH is abnormal

# Tic-tac-toe

- Mark the grid accordingly:

- pH - 7.15 (A)

- CO<sub>2</sub> - 40 (N)

- HCO<sub>3</sub> - 8 (A)

- Match it up!

- If you have an abnormal pH with either normal CO<sub>2</sub> or HCO<sub>3</sub>, you have *uncompensated*

A	N	B
pH		
HCO <sub>3</sub>	CO <sub>2</sub>	

\*Metabolic acidosis with no compensation

# Extent of compensation

- Partial:

- Which value does not match the pH? (PaCO<sub>2</sub> or HCO<sub>3</sub>)
- If the value that does not match pH is ABNORMAL & pH is ABNORMAL, then PARTIAL compensation exists.

- pH - 7.24 (A)

- PaCO<sub>2</sub> - 90 (A)

- HCO<sub>3</sub> - 38 (B)

- Respiratory Acidosis

- Partial Compensation

- HCO<sub>3</sub><sup>-</sup> & pH are BOTH abnormal.

# Tic-tac-toe method

- Mark the grid accordingly:

- pH - 7.24 (A)

- CO<sub>2</sub> - 90 (A)

- HCO<sub>3</sub> - 38 (B)

- Match it up!

- If your pH is abnormal and both CO<sub>2</sub> and HCO<sub>3</sub> are abnormal, you have *partially compensated*

A	N	B
pH		
CO <sub>2</sub>		HCO <sub>3</sub>

\*Partially compensated respiratory acidosis

# Extent of compensation

- Full:

- What value does not match the pH? (PaCO<sub>2</sub> or HCO<sub>3</sub><sup>-</sup>)
- If the value that does NOT match the pH is ABNORMAL but the pH is NORMAL, then FULL compensation has taken place.

- pH - 7.44 (N)(B)
- PaCO<sub>2</sub> - 30 (B)
- HCO<sub>3</sub> - 21 (A)

- Respiratory Alkalosis

- Full Compensation

- HCO<sub>3</sub><sup>-</sup> is abnormal, BUT the pH is normal.

# Tic-tac-toe

- Mark your grid
  - pH - 7.44
  - CO<sub>2</sub> - 30
  - HCO<sub>3</sub> - 21
- Decide which way your pH is 'leaning'
- Both abnormal CO<sub>2</sub> and HCO<sub>3</sub> indicates *fully compensated*

<b>A</b>	<b>N</b>	<b>B</b>
	pH →	*pH is closer to 'basic'
HCO <sub>3</sub>		CO <sub>2</sub>

\*We have fully compensated respiratory alkalosis

# Step 5: determine oxygenation

- PaO<sub>2</sub> & SaO<sub>2</sub> both assessed

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Normal	80-100 mmHg
Mild Hypoxemia	70-80 mmHg
Moderate Hypoxemia	60-70 mmHg
Severe Hypoxemia	<60 mmHg

# Practice

- A 55 year-old is recovering from an exploratory laparotomy in the PACU. The nurse notices the patient's RR is 7/ minute, demonstrates shallow breathing and has no response to stimuli. The nurse assesses the ABC's and obtains a STAT ABG.

- pH = 7.15
- PaCO<sub>2</sub> = 68
- HCO<sub>3</sub> = 22 mEq/L
- PaO<sub>2</sub> = 68 mmHg

A	N	B
pH		
CO <sub>2</sub>	HCO <sub>3</sub>	

- Uncompensated **Respiratory Acidosis** with Moderate Hypoxemia

# Practice

- A 28 year-old is being prepared for a craniotomy. The patient is very anxious and scared of the impending surgery. He begins to hyperventilate and becomes very dizzy. The patient loses consciousness and STAT ABG's reveal:

- pH = 7.57
- PaCO<sub>2</sub> = 26 mmHg
- HCO<sub>3</sub> = 24 mEq/L
- PaO<sub>2</sub> = 59 mmHg

A	N	B
		pH
	HCO <sub>3</sub>	CO <sub>2</sub>

- Uncompensated  
Respiratory Alkalosis with  
Severe Hypoxemia

# Practice

- A 79 year-old is admitted to the emergency room with nausea, vomiting and abdominal pain that has developed diarrhea after eating a 3 month old sandwich.

- pH= 7.55

- PaCO<sub>2</sub> = 48

- HCO<sub>3</sub> = 47.2

- PaO<sub>2</sub> = 57.7

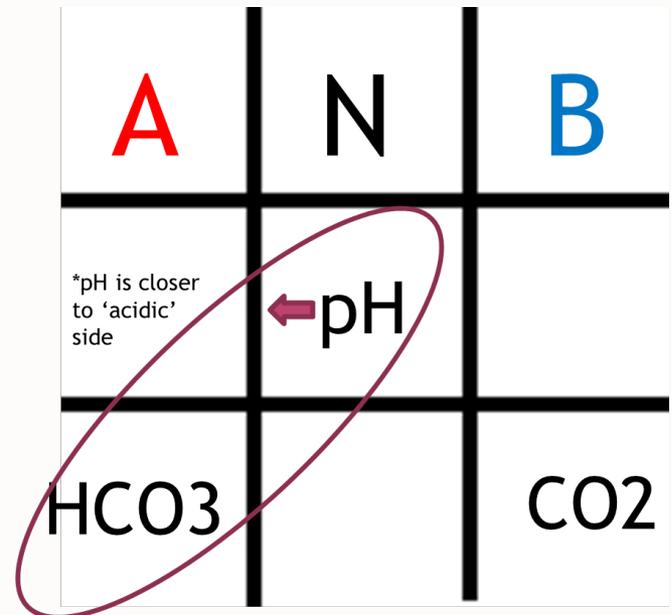
A	N	B
		pH
CO <sub>2</sub>		HCO <sub>3</sub>

- Partially Compensated  
**Metabolic Alkalosis** with  
Severe Hypoxemia

# Practice

- A 65 year-old is admitted to the emergency room with inability to urinate and admits to taking an unknown number of aspirin over the last 24-hour period because of a severe headache. Vital signs are: T=98.5, Pulse= 92, RR=30 and deep. Routine blood test and ABG reveals:

- pH= 7.37
- PaCO<sub>2</sub>= 30
- HCO<sub>3</sub> = 17
- PaO<sub>2</sub> = 80



- Fully Compensated **Metabolic Acidosis** with Normal Oxygenation

