

# Emergency and Critical Care



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## Arterial Blood Gases

# Objectives

- Analyze components of arterial blood gas (ABG)
- Describe a method of ABG interpretation
- Discuss the management of acid base abnormalities
- Describe the management of the patient with acid base disorders

# Regulation of Acid-Base Balance

- Normal pH is 7.35 to 7.45
- Regulating hydrogen ion ( $H^+$ )
  - $H^+$  production increases, pH falls
  - $CO_2$  lowers, pH rises
  - Excretion of an acid ( $CO_2$  carbon dioxide) by lungs
  - Excretion of acid or regeneration of base ( $HCO_3^-$  bicarbonate) by kidney

# Acid-Base Regulatory Systems



- Acid-base compensation
  - pH normalized by lungs (within minutes) and kidneys (within hours)
- Acid-base correction
  - Occurs when problem is resolved
- Analysis of arterial blood gases (ABGs)
  - Determines type of imbalance
  - Evaluates degree of compensation
  - Interpreting ABG values

# Analysis of Arterial Blood Gases



- Classify the pH: norm: 7.35 to 7.45
  - Acidemia:  $<7.35$
  - Alkalosis:  $>7.45$
- Assess  $P_{aCO_2}$ : norm: 35 to 45 mm Hg
  - Respiratory acidosis:  $>45$  mm Hg
  - Respiratory alkalosis:  $<35$  mm Hg

- Assess  $\text{HCO}_3^-$ : norm 22 to 26 mEq/L
  - Metabolic acidosis:  $<22$  mEq/L
  - Metabolic alkalosis:  $>26$  mEq/L
- Determine if compensated
  - $\text{CO}_2$  and  $\text{HCO}_3^-$  are abnormal in opposite directions (one is acidic and one is alkalotic)

- Identify primary disorder
  - The acid-base component most consistent with the pH disturbance
- Base Excess (BE): -2 to 2
- Classify degree of compensation
  - Simple compensation
  - Complex compensation

# Disorders of Acid-Base Balance



- Acidosis
  - Pathologic process causing excess acid
- Acidemia
  - Excess acid in the blood
  - Decreased serum pH
- Alkalosis
  - Pathologic process causing excess base
- Alkalemia
  - Excess base in blood
  - Elevated serum pH



# Respiratory Alkalosis

- Etiology
  - Hyperventilatory states
  - CO<sub>2</sub> eliminated
- Some causes
  - Pulmonary disorders (pneumonia, embolism)
  - Acute anxiety
  - Stimulant drugs (epinephrine)
  - Neural disorders (stroke, intracranial lesions)
- Pathophysiology

# Respiratory Alkalosis, cont'd

- Clinical manifestations
  - Hyperventilation
  - Numbness, tingling, lightheadedness, confusion
  - High pH, low  $P_{aCO_2}$ ,  $HCO_3^-$  levels fall with compensation
- Outcome management
  - Treatment of underlying disorder
  - Respiratory support
    - $O_2$  therapy
    - Rebreathing



# Respiratory Acidosis

- Etiology: hypoventilatory states
- Some causes
  - COPD, infections, cardiac diseases, Guillain-Barré syndrome, obesity, inadequate mechanical ventilation
- Pathophysiology
- Clinical manifestations
  - Hypoventilation, hypoxemia
  - Tremors, seizures, lethargy
  - Low pH and high  $P_{aCO_2}$

# Respiratory Acidosis, cont'd

- Outcome management
  - Treat underlying cause
  - Respiratory support: **Improve ventilation**
    - Oxygen
    - Mechanical ventilation
  - Administer
    - Exogenous alkali: Sodium bicarbonate – **USE CAUTION**
    - Bronchodilators

# Metabolic Alkalosis

- Etiology
  - Loss of acid or gain of base ( $\text{HCO}_3$ )
- Some causes
  - Vomiting, long-term gastric suctioning, administration of  $\text{NaHCO}_3$ , overuse of diuretics
- Pathophysiology
- Clinical manifestations
  - Adaptive hypoventilation
  - Lethargy, confusion, seizures
  - High pH and high  $\text{HCO}_3$

# Metabolic Alkalosis, cont'd

- Outcome management
  - Treat the underlying disorder
  - Promote loss of bicarbonate
    - Acetazolamide sodium (Diamox)
  - Consider IV fluids

# Metabolic Acidosis

- Etiology
  - Accumulation of acid or loss of base
- Some causes
  - Lactic acidosis, diabetic ketoacidosis, azotemic renal failure, diarrhea
- Pathophysiology

# Metabolic Acidosis, cont'd

- Clinical manifestations
  - Compensatory hyperventilation
  - Confusion, drowsiness
  - Low pH and low  $\text{HCO}_3$
- Outcome management
  - Treatment of underlying disorder
  - Respiratory support
    - Mechanical ventilation
  - Administration of exogenous alkali
    - Sodium bicarbonate – USE CAUTION



# Complex Acid-Base Disorders

- Etiology
- Suspect when  $\text{PaCO}_2$  value and  $\text{HCO}_3$  levels do not correlate with pH or when ABG evidence of compensation exceeds predicted levels
- Some causes
  - Cardiac arrest
  - Complicated COPD

- Assessment of clients at risk
  - History of diabetes; renal, pulmonary, or cardiac disease,
  - Older adults
  - Vomiting, diarrhea, enteric drainage
  - Burns, fever, sepsis
  - Total parenteral nutrition (TPN) or enteral feedings
  - Mechanical ventilation

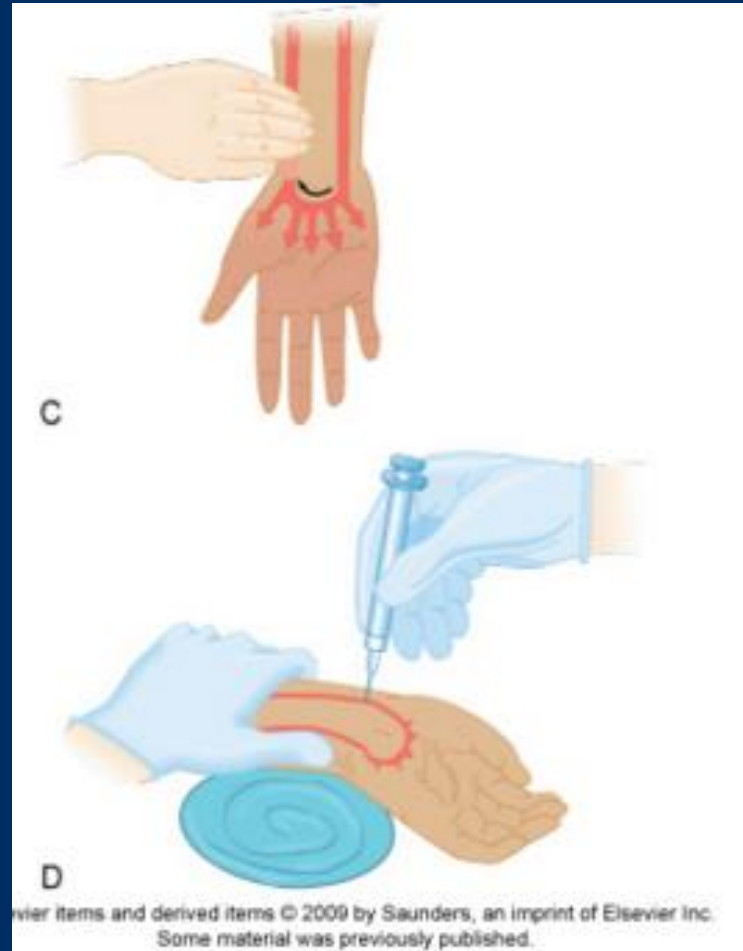
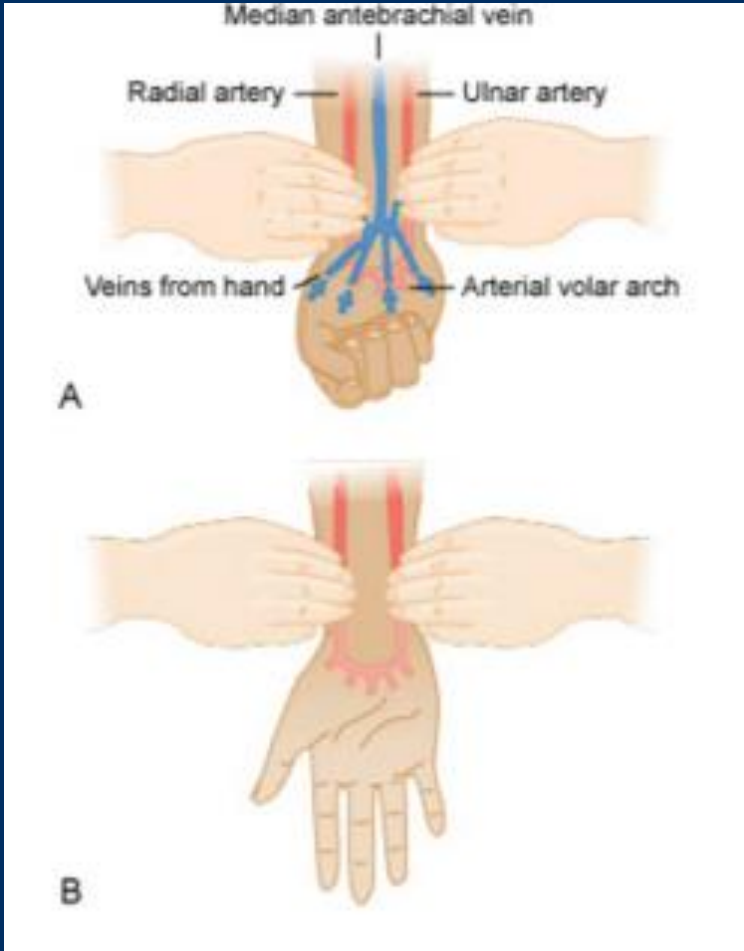
# NC VII: Emergency and Critical Care



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## Arterial Blood Gas Procedure and Interpretation

# Allen Test



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Some material was previously published.

# 6 steps to analyzing an ABG

1. Analyze the pH
2. Analyze the  $\text{PaCO}_2$
3. Analyze the  $\text{HCO}_3$
4. Match either the  $\text{PaCO}_2$  or the  $\text{HCO}_3$  with the pH
5. Determine whether the  $\text{PaCO}_2$  or the  $\text{HCO}_3$  go in the opposite direction of the pH.
6. Analyze the  $\text{PaO}_2$  and the  $\text{SaO}_2$  for hypoxemia

# Assessing Respiratory Alkalosis

- Acute problem

pH 7.6 \_\_\_\_\_

PaCO<sub>2</sub> 25 \_\_\_\_\_

PaO<sub>2</sub> 60 \_\_\_\_\_

HCO<sub>3</sub> 24 \_\_\_\_\_

BE 0 \_\_\_\_\_

SaO<sub>2</sub> 89% \_\_\_\_\_

What is it?  
\_\_\_\_\_

- Why?
- Treatment?

- Chronic problem

pH 7.49 \_\_\_\_\_

PaCO<sub>2</sub> 25 \_\_\_\_\_

PaO<sub>2</sub> 90 \_\_\_\_\_

HCO<sub>3</sub> 19 \_\_\_\_\_

BE -5 \_\_\_\_\_

SaO<sub>2</sub> 95% \_\_\_\_\_

What is it?  
\_\_\_\_\_

- Why?
- Treatment?

# Assessing Respiratory Acidosis

- Acute problem

pH 7.25 \_\_\_\_\_

PaCO<sub>2</sub> 65 \_\_\_\_\_

PaO<sub>2</sub> 50 \_\_\_\_\_

HCO<sub>3</sub> 26 \_\_\_\_\_

BE +2 \_\_\_\_\_

SaO<sub>2</sub> 82% \_\_\_\_\_

What is it?  
\_\_\_\_\_

- Why?
- Treatment?

- Chronic problem

pH 7.34 \_\_\_\_\_

PaCO<sub>2</sub> 64 \_\_\_\_\_

PaO<sub>2</sub> 65 \_\_\_\_\_

HCO<sub>3</sub> 32 \_\_\_\_\_

BE +8 \_\_\_\_\_

SaO<sub>2</sub> 87% \_\_\_\_\_

What is it?  
\_\_\_\_\_

- Why?
- Treatment?

# Assessing Metabolic Alkalosis

- Acute problem

pH 7.51 \_\_\_\_\_

PaCO<sub>2</sub> 40 \_\_\_\_\_

PaO<sub>2</sub> 90 \_\_\_\_\_

HCO<sub>3</sub> 32 \_\_\_\_\_

BE +8 \_\_\_\_\_

SaO<sub>2</sub> 95% \_\_\_\_\_

What is it?  
\_\_\_\_\_

- Why?
- Treatment?

- Chronic problem

pH 7.46 \_\_\_\_\_

PaCO<sub>2</sub> 46 \_\_\_\_\_

PaO<sub>2</sub> 98 \_\_\_\_\_

HCO<sub>3</sub> 32 \_\_\_\_\_

BE +8 \_\_\_\_\_

SaO<sub>2</sub> 99% \_\_\_\_\_

What is it?  
\_\_\_\_\_

- Why?
- Treatment?



# Assessing Metabolic Acidosis

- Acute problem

pH 7.28 \_\_\_\_\_

PaCO<sub>2</sub> 40 \_\_\_\_\_

PaO<sub>2</sub> 78 \_\_\_\_\_

HCO<sub>3</sub> 15 \_\_\_\_\_

BE -9 \_\_\_\_\_

SaO<sub>2</sub> 89% \_\_\_\_\_

What is it?  
\_\_\_\_\_

- Why?
- Treatment?

- Chronic problem

pH 7.34 \_\_\_\_\_

PaCO<sub>2</sub> 30 \_\_\_\_\_

PaO<sub>2</sub> 100 \_\_\_\_\_

HCO<sub>3</sub> 15 \_\_\_\_\_

BE -9 \_\_\_\_\_

SaO<sub>2</sub> 99% \_\_\_\_\_

What is it?  
\_\_\_\_\_

- Why?
- Treatment?

- Woodruff, D.W. (2006). Take these 6 easy steps to ABG analysis. *Nursing Made Incredibly Easy, Jan/Feb, 4-7.*
- Handouts
- Black and Hawks textbook