GENERAL

arterial blood gas interpretation for the acem fellowship exam 25 worked examples

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Mastering Arterial Blood Gas Interpretation for the ACEM Fellowship Exam: 25 Worked Examples

Preparing for the ACEM Fellowship exam demands a deep understanding of arterial blood gas (ABG) interpretation. ABG analysis is a cornerstone of critical care, emergency medicine, and pulmonary practice, and the exam expects candidates to translate laboratory values into clinical decisions swiftly. This comprehensive guide offers more than just a list of normal ranges; it walks you through 25 detailed, worked examples that mirror the complexity and nuance you'll encounter on exam day.

Why ABG Mastery Matters for the ACEM Fellowship Exam

ABGs provide a snapshot of a patient's acid–base status, ventilation, and oxygenation. In the fast paced environment of a fellowship program, clinicians must:

- Identify primary disorders (respiratory or metabolic) and recognize compensatory mechanisms.
- Calculate pH, PaCO ,, PaO ,, HCO ƒ {, and base excess accurately.
- Integrate ABG findings with clinical context (e.g., trauma, sepsis, COPD).
- Choose evidence based interventions (ventilation settings, bicarbonate therapy, diuretics).

Because the ACEM Fellowship exam evaluates both knowledge and application, our 25 worked examples are designed to reinforce the analytical process rather than rote memorization.

Key Concepts to Review Before Diving Into the Examples

1. Normal Ranges (Reference Values)

pH: 7.35–7.45\n**PaCO ,**35–45 mm /Hg\n**PaO ,**80–100 mm /Hg\n**HCO ƒ**22–26 mEq/L\n**Base Excess (BE):**–2 to +2 mEq/L

2. Primary vs. Compensated Disorders

A primary disorder alters either CO , (respiratory) or bicarbonate (metabolic). The body's compensatory response—hypoventilation or metabolic adjustment—shifts the other variable. Recognizing this pattern is crucial for correct interpretation.

3. Calculating Expected Compensation

Use the Winter's formula for metabolic disorders and the Henderson–Hasselbalch equation for quick pH estimation. For example, in metabolic acidosis, the expected drop in PaCO , is ~4.5 mm /Hg per 1 mEq/L decrease in HCO ƒ {.

4. Common Clinical Scenarios

- Acute exacerbation of COPD (respiratory acidosis with hypoxemia).
- Septic shock (metabolic acidosis with hyperventilation).
- Renal tubular acidosis (metabolic acidosis with normal anion gap).
- Diabetic ketoacidosis (metabolic acidosis with high anion gap).

- Pulmonary embolism (respiratory alkalosis).

The 25 Worked Examples

Below are 25 progressively challenging ABG cases. For each, we present the raw values, calculate the key parameters, determine the primary disorder, assess compensation, and suggest a concise management plan.

Example 1: Mild Respiratory Acidosis in COPD Exacerbation

1. ABG Values: pH 7.32, PaCO , 60 mm /Hg, PaO , 58 mm /Hg, HCO ƒ { 28 mEq/L
2. Interpretation: Primary respiratory acidosis (PaCO , >45). HCO ƒ { elevated indicates renal compensation.
3. Compensation Check: Expected HCO ƒ { rise "H 0.35 × (PaCO ,–45) = 0.35 × 15 = 5.25; actual rise 2 (26!’28). Mild compensation.
4. Management: Optimize bronchodilators, consider non invasive ventilation, monitor ABG every 4–6 /h.

Example 2: Severe Metabolic Acidosis – Diabetic Ketoacidosis

1. pH 7.10, PaCO , 18 mm /Hg, PaO , 90 mm /Hg, HCO ƒ { 8 mEq/L
2. Primary metabolic acidosis (HCO ƒ {
3. Base Excess: BE = (HCO ƒ { – 24) = –16 mEq/L.
4. Management: Insulin infusion, fluid resuscitation, electrolyte monitoring, treat precipitating cause.

Example 3: Mixed Respiratory Acidosis and Metabolic Alkalosis – Post operative

1. pH 7.38, PaCO , 55 mm /Hg, PaO , 85 mm /Hg, HCO ƒ { 30 mEq/L
2. Primary respiratory acidosis (PaCO , high) with metabolic alkalosis (HCO ƒ { high).
3. Check: Expected HCO ƒ { rise for respiratory acidosis "H 0.5 × (PaCO ,–45) = 5; actual 6 !’ mild compensation.
4. Management: Address hypoventilation, consider sedation titration, monitor electrolytes.

Example 4: Respiratory Alkalosis – Pulmonary Embolism

1. pH 7.48, PaCO , 30 mm /Hg, PaO , 95 mm /Hg, HCO ƒ { 24 mEq/L
2. Primary respiratory alkalosis (PaCO ,
3. Management: Confirm diagnosis with imaging, initiate anticoagulation, treat hypoxia.

Example 5: Mixed Metabolic Acidosis and Respiratory Acidosis – Sepsis

1. pH 7.25, PaCO , 50 mm /Hg, PaO , 70 mm /Hg, HCO ƒ { 14 mEq/L
2. Primary metabolic acidosis (HCO ƒ { low) with inadequate respiratory compensation (PaCO , high).
3. Base Excess: BE = –10 mEq/L.
4. Management: Broad spectrum antibiotics, source control, consider vasopressors, correct ventilation.

Example 6: Anion Gap Metabolic Acidosis – Lactic Acidosis

1. pH 7.20, PaCO , 32 mm /Hg, PaO , 85 mm /Hg, HCO ƒ { 12 mEq/L
2. Calculate anion gap: AG = Na – (Cl + HCO ƒ {) = 140 – (105 + 12) = 23.
3. Interpretation: High AG metabolic acidosis with appropriate respiratory compensation.
4. Management: Address hypoperfusion, consider vasopressors, monitor lactate trend.

Example 7: Renal Tubular Acidosis – Type 1

1. pH 7.28, PaCO , 38 mm /Hg, PaO , 88 mm /Hg, HCO ƒ { 15 mEq/L
2. Metabolic acidosis with normal anion gap (AG 8). Primary renal cause.
3. Management: Alkali therapy (sodium bicarbonate), monitor potassium.

Example 8: Metabolic Alkalosis – Post operative Hypokalemia

1. pH 7.52, PaCO , 28 mm /Hg, PaO , 92 mm /Hg, HCO ƒ { 32 mEq/L

2. Primary metabolic alkalosis (HCO ƒ { high) with respiratory alkalosis (PaCO , low).
3. Check: Expected PaCO , drop "H 2.5 × (HCO ƒ {–24) = 20; actual 12 !’ inadequate compensation.
4. Management: Replace potassium, consider diuretic review.

Example 9: Hypoxemic Respiratory Failure – ARDS

1. pH 7.40, PaCO , 48 mm /Hg, PaO , 55 mm /Hg, HCO ƒ { 26 mEq/L
2. Respiratory acidosis with hypoxemia. No significant metabolic disturbance.
3. Management: Increase FiO ,, consider prone positioning, evaluate for mechanical ventilation.

Example 10: Mixed Metabolic Acidosis and Respiratory Alkalosis – Hyperventilation with Renal Failure

1. pH 7.30, PaCO , 28 mm /Hg, PaO , 80 mm /Hg, HCO ƒ { 18 mEq/L
2. Metabolic acidosis (HCO ƒ { low) with compensatory hyperventilation (PaCO , low).
3. Management: Treat underlying renal failure, consider bicarbonate infusion if BE

Example 11: Respiratory Acidosis – Severe Asthma Exacerbation

1. pH 7.28, PaCO , 70 mm /Hg, PaO , 60 mm /Hg, HCO ƒ { 32 mEq/L
2. Primary respiratory acidosis with renal compensation.
3. Management: Nebulized bronchodilators, systemic steroids, consider intubation.

Example 12: Metabolic Alkalosis – Vomiting

1. pH 7.50, PaCO , 30 mm /Hg, PaO , 90 mm /Hg, HCO ƒ { 34 mEq/L
2. Primary metabolic alkalosis (HCO ƒ { high) with respiratory compensation.
3. Management: Rehydrate, replace chloride, treat underlying cause.

Example 13: Mixed Respiratory Acidosis and Metabolic Acidosis – Carbon Monoxide Poisoning

1. pH 7.31, PaCO , 55 mm /Hg, PaO , 80 mm /Hg, HCO ƒ { 20 mEq/L
2. Primary respiratory acidosis (PaCO , high) with metabolic acidosis (HCO ƒ { low).
3. Management: Hyperbaric oxygen, monitor ABG trends, treat for hypoxia.

Example 14: Anion Gap Metabolic Acidosis – Methanol Poisoning

1. pH 7.15, PaCO , 28 mm /Hg, PaO , 90 mm /Hg, HCO ƒ { 10 mEq/L
2. AG = 140 – (110 + 10) = 20.
3. Management: Antidote (ethanol or fomepizole), bicarbonate therapy, dialysis if severe.

Example 15: Respiratory Acidosis – COPD with Acute Infection

1. pH 7.30, PaCO , 58 mm /Hg, PaO , 70 mm /Hg, HCO ƒ { 29 mEq/L
2. Primary respiratory acidosis with renal compensation.
3. Management: Optimize antibiotics, bronchodilators, consider non invasive ventilation.

Example 16: Metabolic Acidosis – Salicylate Poisoning

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