CRITICAL CARE NURSING COURSE
EMERGENCY NURSING COURSE
BROOKE ARMY MEDICAL CENTER
FORT SAM HOUSTON, TEXAS 78234

Blood Gas Interpretation (3 periods)

Objectives

1. Terminal Learning Objectives:

   Interpret blood gas results by applying the concepts of acid-base imbalance in the critical care setting.

2. Enabling Learning Objectives

   a. Given a list, match the components of an arterial blood gas with their normal values IAW Czekaj (1998): Promoting acid-base balance.

   b. Given a list, select the defining characteristics and causes of respiratory acidosis, respiratory alkalosis, metabolic acidosis, metabolic alkalosis, and the three levels of compensation IAW Czekaj (1998): Promoting acid-base balance.

   c. Given a series of arterial blood gas (ABG) results, correctly interpret the data provided IAW Czekaj (1998): Promoting acid-base balance.

   d. Given a patient scenario, identify appropriate treatments and nursing actions pertinent to the particular acid-base disturbance identified IAW Czekaj (1998): Promoting acid-base balance.

NOTES

A. Components of Arterial Blood Gas

1. pH

   a. Measures hydrogen ions (H^+) concentration ($[H^+]$)

   b. Reflects acid-base status of the blood

   c. Relationship between the H^+ concentration and pH is *inverse*:

      (1) A decreased pH signifies an elevated $[H^+]$ and a pH of < 7.35 is considered to be acidic

         (a) Diminishes the force of cardiac contractions

         (b) Decreases normal vascular response to catecholamines

(c) Below 6.8 cell death occurs

(2) An increased pH signifies a decreased [H^+] and a pH of > 7.45 is considered to be alkalotic

(a) Impairs tissue oxygenation and neuromuscular function

(b) Above 7.8 cell death occurs

e. NORMAL RANGE: 7.35 - 7.45

NOTE: These values are for blood only. The pH of other body fluids covers a much wider range. However the enzymatic function of the cells can only take place within a very narrow range.

2. $PaCO_2$

a. Partial pressure of carbon dioxide (CO_2) in the arteries

b. Respiratory component of acid-base regulation

c. Adjusted by changes in rate and depth of pulmonary ventilation

d. Hypercapnia = $PaCO_2$ >45 mm Hg

e. Hypocapnia = $PaCO_2$ <35 mm Hg

f. NORMAL RANGE: 35-45 mm Hg

3. PaO_2

a. Partial pressure of oxygen (O_2) in the arteries

b. No primary role in acid-base regulation *if* it is within normal limits

c. The presence of hypoxemia (PaO_2 <80 mm Hg) and subsequent tissue hypoxia can lead to anaerobic metabolism, resulting in lactic acid production

d. NORMAL RANGE: 80-100 mm Hg

NOTE: Over 60 y/o → PaO_2 is equal to 80 mm Hg minus 1 mm Hg for every year over 60.

4. Base Excess (BE)

   a. Non-respiratory component of acid-base status

   b. Blood normally contains a large buffering capacity that allows significant changes in acid content with little change in free H^+ concentration

      (1) This buffering depends on the plasma bicarbonate concentration and the red blood cell mass (hemoglobin)

      (2) Degree of deviation from normal buffering capacity is expressed as base excess/deficit

   c. Abnormally low values indicate acidosis

   d. Abnormally high values indicate alkalosis

   e. NORMAL RANGE: ($^-2$) – ($^+2$)

5. Serum Bicarbonate (HCO_3-)

   a. Major renal, or non-respiratory component of acid-base regulation

   b. Excreted or generated by the kidneys to maintain normal acid-base

   c. Abnormally low values indicate acidosis

   d. Abnormally high values indicate alkalosis

   e. NORMAL RANGE: 22-26 mEq/L

6. Arterial Oxygen Saturation (SaO_2)

   a. Measures the degree to which hemoglobin is saturated by O_2

   b. Affected by changes in temperature, pH, and $PaCO_2$

   c. When the PaO_2 falls below 60 mm Hg, there is a large drop in saturation

<u>NOTE:</u> Discuss oxyhemoglobin saturation curve handout.

   d. NORMAL RANGE: 95%-99%

7. Gas Exchange

a. Oxygen (O_2)

(1) O_2 transported from the lungs to tissues by way of two routes:

(a) Physically dissolved in plasma

(b) Chemically combined with hemoglobin (oxyhemoglobin)

NOTE: At the tissue level, O_2 dissociates from hemoglobin (Hb) into the plasma and diffuses from the plasma into the tissue cells in order to supply tissue needs. Hb, which has dissociated from O_2 at the tissue level, is called reduced Hb. Reduced Hb is purplish in color and accounts for the bluish color of venous blood.

(c) Each gram of Hb, when fully saturated with O_2, can carry 1.34 ml of O_2

(d) Average Hb concentration is 15 g/100 ml in the adult male

(e) O_2-carrying capacity of Hb is (15g x 1.34 ml) = 20.1 ml of O_2 per 100 ml of blood

(2) A small amount of mixed venous blood from the bronchial circulation is added to the oxygenated blood leaving the pulmonary capillaries, accounting for the fact that only 97% of the blood leaving the lungs is saturated while the remaining 3% is unsaturated

b. Carbon dioxide (CO_2)

(1) CO_2 is transported as plasma HCO_3, combined with Hb as carbaminohemoglobin, and dissolved in plasma

(2) CO_2 when combined with water becomes an acid (carbonic acid)

$$\underset{\text{(lungs)}}{CO_2 + H_2O} = H_2CO_3 = \underset{\text{(kidneys)}}{H^+ + HCO_3}$$

(3) CO_2 and water combine very slowly in plasma

(4) In the red blood cell the presence of an enzyme, carbonic anhydrase, speeds up the reaction

(5) This process is reversible and is known as the bicarbonate-carbonic acid buffer equation

c. Normal Arterial and Mixed Venous Blood Gases

Measurement	**ABG**	**Mixed Venous**
pH	7.35-7.45	7.33-7.43
PCO_2	35-45 mm Hg	41-57 mm Hg
HCO_3	22-26 mEq/L	24-28 mEq/L
BE	(-2) to (+2)	0 - 4
PO_2	80-100 mm Hg	35-40 mm Hg
SaO_2	96-98%	70-75%

B. Classification of Acid-Base Disturbances

1. Acidosis

   a. pH < 7.35

   b. $PaCO_2 > 45$ mm Hg

   c. $HCO_3^- < 22$ mEq/L

2. Alkalosis

   a. pH > 7.45

   b. $PaCO_2 < 35$ mm Hg

   c. $HCO_3^- > 26$ mEq/L

3. Compensation

   a. The body's attempt to return the body's fluid to a normal pH

   b. Compensation occurs at three levels:

      (1) Partially compensated

         (a) Both the $PaCO_2$ and HCO_3 will be abnormal indicating a response to an alteration

         (b) The response is inadequate to return the pH to normal range

      (2) Fully compensated

(a) Both $PaCO_2$ and HCO_3- will be abnormal, indicating a response to an alteration

(b) The response is adequate enough to return the pH to normal

(3) Uncompensated

(a) No response by one system to alterations in the other system

(b) Compensating system will have normal values

c. Buffer

(1) Substances that can readily accept or donate H^+, allowing for relatively large H^- changes to take place with relatively little change in serum free H^+ levels

(2) Exist as pairs - usually a weak acid and its conjugate base

(3) Protect against fluctuations in H^+ levels and attempt to keep the pH normal

(4) Plasma buffering (chemical buffering)

(a) Major one is carbonic acid-bicarbonate system

(b) Reacts instantly

(5) Respiratory buffering

(a) Regulates acid-base balance by increasing or decreasing CO_2 concentration in the blood though hyper- or hypoventilation

(b) Responds within l0 to 30 minutes of onset

(6) Cellular buffering

(a) May occur hand in hand with plasma buffering

(b) Characterized by a shift in the H^+ between intracellular and extracellular fluid

(c) Requires 2 to 4 hours to act

(7) Renal buffering

(a) Regulates acid-base balance by increasing or decreasing HCO_3 concentration

(b) Accomplished through a series of complex reactions that involve H^+ secretion, Na^+ reabsorption, HCO_3 conservation, and NH_3 synthesis for excretion of H^+ in the urine

(c) H^+ secretion out of the serum is regulated by the amount of CO_2 in extracellular fluid

(d) Slow response; takes several hours to days to act

NOTE: The greater the concentration of CO_2, the greater amount of H^+ secretion, making the urine acidic. When H^+ is excreted, HCO_3^- is retained by the kidneys helping to maintain balance between acids and bases. When extracellular fluid is alkalotic, the kidneys conserve H^+ and eliminate HCO_3^-, resulting in alkalotic urine.

C. Arterial Blood Gas Analysis

1. Respiratory acidosis

a. Retention of CO_2 by the lungs

b. Causes an excess of carbonic acid

c. Clinical signs and symptoms

Central Nervous System	**Cardiovascular**	**Neuromuscular**
Apprehension, headache	↓ cardiac contractility	Decreased mentation
Restlessness	Dysrhythmias	Fatigue
Drowsiness		Muscle weakness
Discoordination		Tremors
Disorientation		Diminished reflexes
Coma		

d. Common causes

Neuromuscular disorders	Diaphragmatic injury	Impaired gas exchange
* Guillian-Barre	Chest wall injury	* Pneumonia
* Myasthenia Gravis	Laryngeal edema	* Aspiration
* Poliomyelitis	Airway obstruction	* ↑ pulmonary dead space
Decreased respiratory drive	* Emphysema, asthma	* Interstitial lung disease
Lesions of the medulla	* Foreign body	Kyphoscoliosis
Drugs	* Bronchiectasis	Abdominal distension
Mechanical hypoventilation	Impaired ventilation	Respiratory arrest
Obesity (Pickwickian Syndrome)		

e. ABG values

(1) pH < 7.35

(2) $PaCO_2 > 45$ mm Hg

(3) BE normal ($^-2$ to $^+2$)

(4) HCO_3 normal (22-26 mEq/L)

(5) SaO_2 - with or without hypoxemia

f. Compensatory mechanism = renal: the kidneys conserve HCO_3- (base) while excreting H^+; urine is acidic.

g. Treatment

(1) Physical stimulation of the patient to improve ventilation

(2) Vigorous pulmonary toilet

(3) Mechanical ventilation

(4) Reversal of sedative and narcotic agents

(5) Treatment of infection with antiobiotic agents

(6) Diuretics to correct fluid overload

2. Respiratory alkalosis

a. $PCO_2 < 35$ mm Hg

b. Caused by hyperventilation

c. Clinical signs and symptoms

Peripheral nervous system	Central nervous system	Cardiovascular system
Peripheral paresthesias	Extreme nervousness	Decreased O_2 delivery to tissues
Circumoral paresthesia	Inability to concentrate	Dysrhythmias
Positive Trousseau's sign	Vertigo	Palpitations
Positive Chvostek's sign	Syncope	Hypotension
Carpopedal spasm	Confusion	Coronary vasoconstrictin
Muscle cramps	Anxiety	
Decreased motor function	Seizures	
Tetany		

d. Common causes

Anxiety	**Drugs/hormones**	**Hypoxemia**
Hyperventilation syndrome	Salicylates	Pulmonary disease
Cardiovascular disorders	Theophyllines	Anemia
Acute MI	Catecholamines	LV failure
Chronic heart failure	Progesterone (pregnancy)	High altitude
Pulmonary disorders	Alcohol intoxication	**Other**
Pneumonia	Paraldehyde intoxication	Thyrotoxicosis
Asthma	**CNS disorders**	Gram-negative sepsis
Acute respiratory distress syndrome	Stroke	Excessive mechanical ventilation
Fibrosis	Tumors	Exercise
Pulmonary embolism	Infection	Hepatic insufficiency
	Trauma	

e. ABG values

(1) pH > 7.45

(2) $PaCO_2$ < 35 mm Hg

(3) BE normal ($^-2$ to $^+2$)

(4) HCO_3 normal (22-26 mEq/L)

(5) SaO_2 - with or without hypoxemia

e. Compensatory mechanism = renal: the kidneys excrete HCO_3^- and retain H^+; alkaline urine

f. Treatment

(1) Treat pain or anxiety

(2) Correction of hypoxia, which may include diuretics and mechanical ventilation

(3) Treatment of fever with antipyretics

(4) Treatment of hyperthyroidism

3. Metabolic acidosis

a. Caused by a primary decrease in plasma HCO_3 (HCO_3 of < 22 mEq/L) caused by one of the following mechanisms:

(1) ↑ concentration of H^+

(a) Ketoacidosis associated with diabetes and alcoholism

(b) Lactic acidosis

(2) Loss of alkali

(a) Severe diarrhea, intestinal malabsorption

(b) ↓ acid excretion by the kidneys due to such medical conditions as acute and chronic renal failure

b. Clinical signs and symptoms (may vary, depending on underlying disease state)

Central nervous system	Cardiovascular	Other
Headache	Hypotension	Kussmaul respirations
Drowsiness, decreased mentation	Peripheral vasodilatation	Hyperventilation
Confusion, coma	Hypoxia	Anorexia, N/V/D
Seizures	Dysrhythmias	Hyperkalemia
	Decreasing cardiac contractility	Muscle fatigue
	Blunted response to catecholamines	Muscle twitching

c. Common causes

Increased anion gap	Normal anion gap
Renal failure (uremic met acidosis)	Diarrhea
Ketoacidosis	Biliary/pancreatic fistulas
* Starvation	Intestinal fistulas
* Diabetic ketoacidosis	Renal tubular acidosis
* Alcoholic ketoacidosis	Carbonic anhydrase inhibitors
Lactic acidosis	Ureteral diversion
* Tissue hypoxia	Early renal failure
* Shock	Primary aldosteronism
* Cardiac arrest	Administration of exogenous acid
* Overwhelming sepsis	* Hydrochloric acid
* Hematological malignancy	* Ammonium chloride
Toxins	* Arginine hydrochloride
* Methanol	* Lysine hydrochloride
* Ethylene glycol	* IV hyperalimentation
* Salicylates	Excessive administration of NS
Rhabdomyolosis	
* Massive cell destruction	

d. ABG values

(1) pH < 7.35

(2) $PaCO_2$ normal (35-45 mm Hg)

(3) BE < (-2)

(4) HCO_3 < 22 mEq/L

(5) SaO_2 - with or without hypoxemia

e. Compensatory mechanism = respiratory and renal

(1) Respiratory:

(a) ↓ pH stimulates pulmonary ventilation → lungs blow off CO_2 → ↓ CO_2 available to form carbonic acid (H_2CO_3)

(b) The acid side is decreased

(2) Renal

(a) Kidneys retain base (HCO_3) through preferential excretion of H^+

(b) Urine is acidic

f. Treatment

(1) Rehydrate

(2) Support of respiratory and hemodynamic status

4. Metabolic alkalosis

a. Results in an ↑ serum HCO_3 due to loss of H^+ or intake of an excess of alkaline

b. Clinical signs and symptoms

Dizziness	Agitation	Confusion
Seizures	Paresthesias	Tetany
Hypertonic muscles	Nausea	Vomiting
Diarrhea	Hypokalemia	Cardiac dysrhythmias
Coronary vasospasm	Cardiac ischemia	Hypoventilation

c. Common causes

Acute H^+ Loss	**K^+, Cl^-, &/or H_2O Loss**
Vomiting	K^+- wasting diuretics
Gastric suction	*Thiazides
Addition of Base	*Furosemide
Antacid use	*Ethacrynic acid
Alkaloid ingestion	Mineralcorticoid excess
IV $NaHCO_3$ administration	*Cushing's syndrome
	*1° or 2° hyperaldosteronism
	Diarrhea
	Hypomagnesemia

d. ABG values

(1) pH > 7.45

(2) $PaCO_2$ normal l (35-45 mm Hg)

(3) BE > ($^+$2)

(4) HCO_3^- > 26 mEq/L

(5) SaO_2 - with or without hypoxemia

e. Compensatory mechanism = respiratory and renal

(1) Respiratory

(a) Lungs hold back CO_2 to build up carbonic acid

(b) Breathing may be shallow and irregular

(c) Increase $PaCO_2$ stimulates respiratory drive

(2) Renal

(a) Kidneys excrete HCO_3^- and retain H^+

(b) Urine is alkaline

f. Treatment

(1) Replace KCl losses with NS

(2) Acetazolamide (Diamox)

(3) Monitor neurological status

(4) Implement seizure precautions

5. Summary - Respiratory/Metabolic Disturbances and Compensation

UNCOMPENSATED VERSUS COMPENSATED VALUES

pH	pCO_2	HCO_3^-	Interpretation
Below 7.35	Above 45	Normal	Uncomp. Resp Acidosis
Below 7.35	Above 45	Above 26	Partially Compensated
7.35-7.40	Above 45	Above 26	Fully Compensated
Above 7.45	Below 35	Normal	Uncomp. Resp. Alkalosis
Above 7.45	Below 35	Below 22	Partially Compensated
7.40-7.45	Below 35	Below 22	Fully Compensated
Below 7.35	Normal	Below 22	Uncomp. Metabolic Acidosis
Below 7.35	Below 35	Below 22	Partially Compensated
7.35 - 7.40	Below 35	Below 22	Fully Compensated
Above 7.45	Normal	Above 26	Uncomp. Metabolic Alkalosis
Above 7.45	Above 45	Above 26	Partially Compensated
7.40-7.45	Above 45	Above 26	Fully Compensated

D. Treatment and Nursing Action

1. Acute respiratory acidosis

a. Restoration of normal acid-base balance accomplished by supporting respiratory function

(1) If $PaCO_2$ is > 50-60 mm Hg, PaO_2 is < 50 mm Hg, and patient presents with clinical signs of ventilatory failure, the patient will likely require intubation and mechanical ventilation.

(2) Treatment with $NaHCO_3$ is avoided because of the risk of alkalosis when respiratory disturbance has been corrected.

(3) Although a life threatening pH must be corrected to acceptable level promptly, a normal pH is not the immediate goal

b. Treat the underlying cause *first*

c. Nursing diagnosis, interventions and desired outcomes

(1) Impaired gas exchange

(a) Monitor serial ABG results to assess patient's response to therapy

(b) Continuously assess and document every four hours and as needed the patient's respiratory status, respiratory rate and rhythm, exertional effort, and breath sounds

(c) Assess patient's respiratory effort after every ventilator change

(d) Continuously assess and document every four hours and as needed the patient's level of consciousness

(e) Assess for presence of bowel sounds and monitor for GI distention every four hours and as needed (distention can impede movement of the diaphragm and restrict ventilatory effort)

(2) Outcome: patient has adequate gas exchange as evidenced by a $PaCO_2$ and pH within the normal range

2. Acute respiratory alkalosis

a. Treat underlying disorder

b. Reassurance or sedation - if anxiety is the cause of the decreased $PaCO_2$

c. O_2 therapy if hypoxemia is a causative factor

d. Mechanical ventilator adjustments - ventilator settings are checked and adjustments made to ventilatory parameters in response to ABG results

e. Pharmacotherapy - sedatives and/or tranquilizers may be given for anxiety induced respiratory alkalosis

f. Nursing diagnosis, interventions, and desired outcomes

(1) Ineffective breathing pattern

(a) Encourage patient to breathe slowly and pace breathing as needed

(b) Help to alleviate anxiety and reassure patient as needed

(c) Monitor cardiac rhythm continuously; notify physician if dysrhythmias occur

(d) Administer sedatives or tranquilizers as prescribed

(2) Outcome: patient has normal breathing pattern as evidenced by respiratory rate 12-20 breaths/min; $PaCO_2 > 35$ mm Hg and < 45 mm Hg; and pH < 7.45 and > 7.35

3. Acute metabolic acidosis

a. Sodium bicarbonate ($NaHCO_3$)

(1) Indicated when arterial pH is ≤ 7.2

(2) IV infusion: 2-3 ampules (44.5 mEq/L per ampule) in 1 liter D_5W

(3) Monitor cautiously to avoid metabolic alkalosis

b. Potassium replacement - potassium deficit (< 3.5 mEq/L) must be corrected *before* $NaHCO_3$ is administered

NOTE: When acidosis is corrected, the potassium shifts back to intracellular spaces.

NOTE: Acidosis increases serum potassium by 0.7 mEq/L for every decrease of 0.1 pH unit.

c. Mechanical ventilation may required on the basis of ABG results and clinical signs

d. Treatment of underlying disorder

(1) Diabetic ketoacidosis: insulin and fluids

(2) Alcoholism-related ketoacidosis: glucose and saline

(3) Diarrhea

(4) Acute renal failure: hemodialysis or peritoneal dialysis to maintain an adequate level of plasma HCO_3

(5) Renal tubular acidosis: may require moderate amounts of $NaHCO_3$

(6) Poisoning and drug toxicity: treatment depends on type of drug ingested or infused

(7) Lactic acidosis: correction of underlying disorder

e. Nursing diagnosis, interventions, desired outcomes: specific to the pathophysiology involved

4. Acute metabolic alkalosis

a. Normal saline infusion may correct volume (chloride) deficit in patients with gastric alkalosis because of gastric losses

b. Potassium chloride (KCl) indicated for patients with low potassium

c. Sodium and KCl effective for post-hypercapnic alkalosis

d. Cautious IV administration of isotonic hydrochloride solution or ammonium chloride

e. Nursing diagnosis, interventions, and outcomes: specific to the pathophysiology involved

E. Interpreting ABGs

1. Step-by-step guide

a. **Step 1**: Evaluate the pH

(1) Normal pH = 7.35-7.45

(2) < 7.35 reflects acidemia

(3) > 7.45 reflects alkalemia

(4) If there is an abnormality, determine the primary system involved

b. **Step 2**: Evaluate $PaCO_2$ (respiratory system)

(1) Normal $PaCO_2$ is 35-45 mm Hg

(2) < 35 reflects alkalosis

(3) > 45 reflects acidosis

(4) If it is abnormal, does it correspond with the change in pH?

(a) If pH is high, expect $PaCO_2$ to be low (for every 10 mm Hg ↓ in $PaCO_2$, pH will ↑ by 0.1 unit)

(b) If pH is low, expect $PaCO_2$ to be high (for every 20 mm Hg ↑ in $PaCO_2$, pH will ↓ by 0.1 unit)

c. **Step 3:** Evaluate HCO_3 (metabolic)

(1) Normal HCO_3 is 22-26 mEq/L

(2) Is the value high or low?

(3) Does the change correspond with the change in pH?

(a) If pH ↑ (alkalosis), expect the HCO_3 to be ↑

(b) If pH ↓ (acidosis), expect the HCO3 to be ↓

d. **Step 4**: Determine primary and compensating disorder

(1) Compensation involves the manipulation of opposites.

(2) If the primary component involved is a metabolic acidosis, any compensation will come in the form of respiratory alkalosis

Example: pH: 7.27 (↓ - acidosis) HCO_3: 10 (↓ - acidosis)
$PaCO_2$: 27 (↓ - alkalosis)

(3) The HCO_3 level more closely corresponds with the pH, making the metabolic component the primary problem.

(4) The resultant decrease in the $PaCO_2$ reflects a partial respiratory compensation.

(5) When both the $PaCO_2$ and HCO_3 are abnormal and in the opposite direction, one is primary acid-base disorder, the other is the body's attempt to return the pH to normal.

(6) To decide which is which, check the pH; only a process of acidosis can make the pH acidic; and only a process of alkalosis can make a pH alkaline

(7) May also have both $PaCO_2$ and HCO_3 alterations in the same direction. This is referred to as a "mixed" gas

e. **Step 5**: Evaluate oxygenation

(1) Normal PaO_2 is 80-100 mm Hg

(2) Values between 60-80 mm Hg reflect mild hypoxemia

(3) Values between 40-60 mm HG reflect moderate hypoxemia

(4) Values < 40 mm Hg reflect severe hypoxemia

f. **Step 6:** Interpretation

Disorder	Uncompensated			Compensated		
	pH	**$PaCO_2$**	**HCO_3-**	**pH**	**$PaCO_2$**	**HCO_3-**
Metabolic Acidosis	↓	--	↓↓	↓ (less)	↓	↓↓
(Metabolic Alkalosis	↑	--	↑↑	↑ (less)	↑	↑↑
Respiratory Acidosis	↓	↑↑	--	↓ (less)	↑↑	↑
Respiratory Alkalosis	↑	↓↓	--	↑ (less)	↓↓	↓

<u>NOTE:</u> ↑↑ = primary disorder.

<u>NOTE:</u> One method to help determine interpretation of ABG: "Respiratory opposite, metabolic even" – If the changes in the pH, $PaCO_2$, & HCO_3- are all the same, it is a metabolic problem. If not, it is a respiratory problem.

F. Sample Problems

1.

pH: 7.42	Normal
$PaCO_2$: 37	Normal
PaO_2: 84 mm Hg	Normal
BE: 0.0 mEq/L	Normal
HCO_3: 23.6 mEq/L	Normal
SaO_2: 95.9%	Normal

Interpretation: **Normal ABG with good oxygenation**

2.

pH: 7.22	Acidosis
$PaCO_2$: 65 mm Hg	Acid
PaO_2: 60 mm Hg	Moderate hypoxemia
BE: 4 mEq/L	Alkaline
HCO_3: 27.6 mEq/L	Alkaline (slightly)
SaO_2: 85%	Poor oxygenation

Interpretation: Respiratory acidosis, partial compensated, mild hypoxemia

3.

pH: 7.49	Alkalosis
$PaCO_2$: 48 mm Hg	Acid
PaO_2: 92 mm Hg	Normal
BE: 12 mEq/L	Alkaline
HCO_3: 34.5 mEq/L	Alkaline
SaO_2: 97.2%	Normal

Interpretation: **Metabolic alkalosis, partial compensation, good oxygenation**

4.

pH: 7.50	Alkalosis
$PaCO_2$: 25 mm Hg	Alkaline
PaO_2: 40 mm Hg	Severe hypoxemia
BE: -2.9 mEq/L	Acid
HCO_3: 19.3 mEq/L	Acid
SaO_2: 80%	Low

Interpretation: **Respiratory alkalosis, partially compensated, severe hypoxemia**

5.

pH: 7.37	Normal
$PaCO_2$: 25 mm Hg	Alkalotic
PaO_2 40 mm Hg	Moderate - severe hypoxemia
BE: -2.9 mEq/L	Acidic
HCO3: 19.3 mEq/L	Acidic
SaO2: 80%Low	

Interpretation: **Metabolic acidosis, fully compensated, moderate hypoxemia**

6. pH: 7.37 — Normal
$PaCO_2$: 62 mm Hg — Acidic
PaO_2 : 50 mm Hg — Moderate Hypoxemia
BE: 8.3 mEq/L — Alkalotic
HCO_3: 34.1 mEq/L — Alkalotic
SaO_2: 83% — Low
Interpretation: Fully compensated respiratory acidosis with moderate hypoxemia

7. pH: 7.180 — Acidosis
$PaCO_2$: 20 mm Hg — Alkaline
PaO_2 : 62 mm Hg — Moderate Hypoxemia
BE: -9.3 mEq/L — Acid
HCO_3: 15.0 mEq/L — Acid
SaO_2: 83% — Poor
Interpretation: **Metabolic acidosis, partially compensated, mild hypoxemia**

8. pH: 7.02 — Acidosis
$PaCO_2$: 79 mm Hg — Acid
PaO_2: 39 mm Hg — Severe hypoxemia
BE: -7.0 mEq/L — Acid
HCO_3: 15.6 mq/L — Acid
SaO_2 53.5% — Very poor
Interpretation: **Respiratory acidosis, partially compensated, severe hypoxemia**

9. pH: 7.48 — Alkalosis
$PaCO_2$: 28 mm Hg — Alkalosis
PaO_2: 95 mm Hg — Normal
BE: 1.0 mEq/L — Normal
HCO_3: 22 mEq/L — Normal
SaO_2: 98% — Normal
Interpretation: **Uncompensated respiratory alkalosis with good oxygenation**

10. pH: 7.27 — Acidosis
$PaCO_2$: 49.2 mm Hg — Acid
PaO_2: 100.7 mm Hg — Normal
BE: - 3.1 mEq/L — Alkaline
HCO_3: 20.1 mEq/L — Acid
SaO_2: 96.3% — Adequate
Interpretation: **Mixed acidosis, partial compensation, OK oxygenation**

11. pH: 7.403 — Normal
$PaCO_2$: 31.5 mm Hg — Alkaline
PaO_2: 86.6 mm Hg — Normal
BE: -2.3 mEq/L — Alkaline
HCO_3: 21.1 mEq/L — Acid
SaO_2: 97.1% — Normal
Interpretation: **Respiratory alkalosis, fully compensated, good oxygenation**

12. pH: 7.365 — Normal
$PaCO_2$: 30 mm Hg — Alkaline
PaO_2: 125.5 mm Hg — High
BE: - 4.5 mEq/L — Alkaline
HCO3: 19.6 mEq/L — Acid
SaO_2: 97.1% — Normal
Interpretation: **Metabolic acidosis, fully compensated, adequate oxygenation; turn down O_2**

13. pH: 7.469 — Alkalosis
$PaCO_2$: 31.7 mm Hg — Alkaline
PaO_2: 394.4 mm Hg — High
BE: 0.9 mEq/L — Normal
HCO_3: 23.2 mEq/L — Normal
SaO_2: 98.9% — Normal
Interpretation: **Respiratory alkalosis, good oxygenation, turn down O_2**

14. pH: 7.463 — Alkalotic
$PaCO_2$: 24.4 mm Hg — Alkaline
PaO_2: 208.4 mm Hg — High
BE: 5.6 mEq/L — Alkaline
HCO_3: 30.1 mEq/L — Alkaline
SaO_2: 98.6% — Normal
Interpretation: **Mixed metabolic alkalosis good oxygenation; turn down O_2**

15. pH: 7.543 — Alkaline
$PaCO_2$: 26.7 mm Hg — Alkaline
PaO_2: 246.4 mm Hg — High
BE: - 1.8 mEq/L — Normal
HCO_3: 22.3 mEq/L — Normal
SaO_2: 96.9% — Normal
Interpretation: **Respiratory alkalosis. Good oxygenation; turn down O_2**

16.	pH: 7.58	Alkaline
	$PaCO_2$: 23 mm Hg	Alkaline
	PaO_2: 300 mm Hg	High
	BE: -3.0 mEq/L	Alkaline
	HCO_3: 21.0 mEq/L	Acid
	SaO_2: 60%	Very Poor

Interpretation: **Partially compensated respiratory alkalosis with good oxygenation; turn down O_2**

Critical Care Nursing Course
Emergency Nursing Course
Brooke Army Medical Center

Arterial Blood Gas – Case Study Practical Exercise #1

Case A

T.J. is a 65 y/o male admitted with a decreased level of consciousness. He has a history of chronic bronchitis and heart failure. His vital signs are T 39°C, P104, RR28 and shallow and BP 96/60. ABG results are as follows:

pH:	7.25
PaCO2 :	75 mmHg
PaO2:	38 mEq/L
HCO3-:	32 mmHg
SaO2:	85.9%

1. What is the acid-base disturbance?

2. What is your treatment?

Following a night on the ventilator and the initiation of IV antibiotics, his morning ABG's are:

pH:	7.36
PaCO2 :	62 mmHg
PaO2:	56 mEq/L
HCO3-::	31 mmHg
SaO2:	90%

3. What is the acid-base disturbance?

4. What is your treatment?

Case B

A 22 y/o female is admitted with an acute onset of fever, chills, and RUQ pain. Her vital signs are T39.5°C, P 125, RR 32, BP 108/76. Her ABG results are:

pH:	7.53
PaCO2 :	25 mmHg
PaO2:	82 mEq/L
HCO3-:	20.5 mmHg
SaO2:	92%

1. What is the acid-base disturbance?

2. What is your treatment?

Case C

A.D. is a 45 y/o female admitted with a history of chronic renal failure and diabetes. She is admitted with a temperature of 39°C, P 110, RR 30, BP 90/70. Labs are drawn which reveal a glucose of 780 mg/dl, positive ketones, and the following ABG's:

pH:	7.25
PaCO2 :	32 mmHg
PaO2:	88 mEq/L
HCO3-:	16 mmHg
SaO2:	94%

1. What is the acid-base disturbance?

2. What is your treatment?

Case D

S.D. is a 45 y/o male admitted with a decreased level of consciousness that occurred after he complained of the worst headache of his life. He is lethargic, but can be aroused. He is diagnosed with a subarachnoid hemorrhage and is taken to surgery for an aneurysm clipping. He returns to the unit with a pulmonary catheter in place. His ABG is as follows:

pH:	7.48
PaCO2 :	32 mmHg
PaO2:	92 mEq/L
HCO3-:	25 mmHg
SaO2:	96%

1. What is the acid-base disturbance?

2. What is your treatment?

Case E

A patient is admitted following collapse at home. She has a history of COPD and is on oxygen at home. On admission to the ED, she is wheezing and hypotensive (BP 70/20). Her temperature is normal. Labs and an ABG are drawn. The results are as follows:

pH:	7.29
PaCO2 :	67 mmHg
PaO2:	37 mmHg
HCO3-:	32 mEq/L
SaO2:	65.3 %

1. What is the acid-base disturbance?

2. What is your treatment?

Case F

An 18 y/o was received in the emergency room after suffering a compression fracture of the left ankle. His vital signs are:

BP 128 / 84
HR 108
RR 26

He is complaining of severe pain at the site of the injury.

pH:	7.54
$PaCO_2$:	27 mmHg
PaO_2:	106 mEq/L
HCO_3^-: ·	22 mmHg
BE:	0
SaO_2:	100%

1. What is the acid-base disturbance?

2. What is your treatment?

Case G

A 67 y/o male with a history of moderate COPD is admitted with acute GI bleeding. He is currently receiving FiO_2 of 40% via a Venturi Mask.

pH:	7.30
$PaCO_2$:	50 mmHg
HCO_3^-:	19 mEq/L
PaO_2:	50 mmHg
SaO_2:	82%

1. What is the acid-base disturbance?

2. What is your treatment?

Critical Care Nursing Course
Emergency Nursing Course
Brooke Army Medical Center

Arterial Blood Gas – Case Study Practical Exercise #1

Case A

T.J. is a 65 y/o male admitted with a decreased level of consciousness. He has a history of chronic bronchitis and heart failure. His vital signs are T 39°C, P104, RR28 and shallow and BP 96/60. ABG results are as follows:

pH:	7.25
PaCO2 :	75 mmHg
PaO2:	38 mEq/L
HCO3-:	32 mmHg
SaO2:	85.9%

1. What is the acid-base disturbance?

2. What is your treatment?

Following a night on the ventilator and the initiation of IV antibiotics, his morning ABG's are:

pH:	.7.36
PaCO2 :	62 mmHg
PaO2:	56 mEq/L
HCO3-::	31 mmHg
SaO2:	90%

3. What is the acid-base disturbance?

4. What is your treatment?

Case B

A 22 y/o female is admitted with an acute onset of fever, chills, and RUQ pain. Her vital signs are T39.5°C, P 125, RR 32, BP 108/76. Her ABG results are:

pH:	7.53
$PaCO_2$:	25 mmHg
PaO_2:	82 mEq/L
HCO_3^-:	20.5 mmHg
SaO_2:	92%

1. What is the acid-base disturbance?

2. What is your treatment?

Case C

A.D. is a 45 y/o female admitted with a history of chronic renal failure and diabetes. She is admitted with a temperature of 39°C, P 110, RR 30, BP 90/70. Labs are drawn which reveal a glucose of 780 mg/dl, positive ketones, and the following ABG's:

pH:	7.25
$PaCO_2$:	32 mmHg
PaO_2:	88 mEq/L
HCO_3^-:	16 mmHg
SaO_2:	94%

1. What is the acid-base disturbance?

2. What is your treatment?

Case D

S.D. is a 45 y/o male admitted with a decreased level of consciousness that occurred after he complained of the worst headache of his life. He is lethargic, but can be aroused. He is diagnosed with a subarachnoid hemorrhage and is taken to surgery for an aneurysm clipping. He returns to the unit with a pulmonary catheter in place. His ABG is as follows:

pH:	7.48
PaCO2 :	32 mmHg
PaO2:	92 mEq/L
HCO3-:	25 mmHg
SaO2:	96%

1. What is the acid-base disturbance?

2. What is your treatment?

Case E

A patient is admitted following collapse at home. She has a history of COPD and is on oxygen at home. On admission to the ED, she is wheezing and hypotensive (BP 70/20). Her temperature is normal. Labs and an ABG are drawn. The results are as follows:

pH:	7.29
PaCO2 :	67 mmHg
PaO2:	37 mmHg
HCO3-:	32 mEq/L
SaO2:	65.3 %

1. What is the acid-base disturbance?

2. What is your treatment?

Case F

An 18 y/o was received in the emergency room after suffering a compression fracture of the left ankle. His vital signs are:

BP 128 / 84
HR 108
RR 26

He is complaining of severe pain at the site of the injury.

pH:	7.54
PaCO2 :	27 mmHg
PaO2:	106 mEq/L
HCO3-: ·	22 mmHg
BE:	0
SaO2:	100%

1. What is the acid-base disturbance?

2. What is your treatment?

Case G

A 67 y/o male with a history of moderate COPD is admitted with acute GI bleeding. He is currently receiving FiO2 of 40% via a Venturi Mask.

pH:	7.30
PaCO2 :	50 mmHg
HCO3-:	19 mEq/L
PaO2:	50 mmHg
SaO2:	82%

1. What is the acid-base disturbance?

2. What is your treatment?

CRITICAL CARE NURSING COURSE
EMERGENCY NURSING COURSE
BROOKE ARMY MEDICAL CENTER

Arterial Blood Gas – Case Study Practical Exercise #2

1.
pH: 7.31
$PaCO_2$: 36 mmHg
HCO_3^-: 14 mEq/L
PaO_2: 88 mmHg
SaO_2: 96%
Interpretation:

2.
pH: 7.46
$PaCO_2$: 39 mmHg
HCO_3^-: 30 mEq/L
PaO_2: 69 mmHg
SaO_2: 90%
Interpretation:

3.
pH: 7.29
$PaCO_2$: 60 mmHg
HCO_3^-: 26 mEq/L
PaO_2: 62 mmHg
SaO_2: 89%
Interpretation:

4.
pH: 6.89
$PaCO_2$: 10 mmHg
HCO_3^-: 2 mEq/L
PaO_2: 45 mmHg
SaO_2: 89%
Interpretation:

5.
pH: 7.61
$PaCO_2$: 40 mmHg
HCO_3^-: 35 mEq/L
PaO_2: 89 mmHg
SaO_2: 95%
Interpretation:

6.
pH: 7.48
$PaCO_2$: 32 mmHg
HCO_3^-: 25mEq/L
PaO_2: 56 mmHg
SaO_2: 91%
Interpretation:

7.
pH: 7.32
$PaCO_2$: 41 mmHg
HCO_3^-: 18 mEq/L
PaO_2: 37 mmHg
SaO_2: 84%
Interpretation:

8.
pH: 7.38
$PaCO_2$: 44 mmHg
HCO_3^-: 22 mEq/L
PaO_2: 96 mmHg
SaO_2: 100%
Interpretation:

9.
pH: 7.33
$PaCO_2$: 60 mmHg
HCO_3^-: 30 mEq/L
PaO_2: 78 mmHg
SaO_2: 89%
Interpretation:

10.
pH: 7.6
$PaCO_2$: 40 mmHg
HCO_3^-: 49 mEq/L
PaO_2: 39 mmHg
SaO_2: 97%
Interpretation:

11.
pH: 7.5
$PaCO_2$: 29 mmHg
HCO_3^-: 29 mEq/L
PaO_2: 73 mmHg
SaO_2: 91%
Interpretation:

12.
pH: 7.32
$PaCO_2$: 48 mmHg
HCO_3^-: 26 mEq/L
PaO_2: 90 mmHg
SaO_2: 95%
Interpretation:

13.
pH: 7.5
$PaCO_2$: 50 mmHg
HCO_3^-: 30 mEq/L
PaO_2: 72 mmHg
SaO_2: 90%
Interpretation:

14.
pH: 7.36
$PaCO_2$: 70 mmHg
HCO_3^-: 41 mEq/L
PaO_2: 85 mmHg
SaO_2: 96%
Interpretation:

15.
pH: 7.5
$PaCO_2$: 20 mmHg
HCO_3^-: 15 mEq/L
PaO_2: 66 mmHg
SaO_2: 88%
Interpretation:

16.
pH: 7.3
$PaCO_2$: 51 mmHg
HCO_3^-: 24 mEq/L
PaO_2: 38 mmHg
SaO_2: 85%
Interpretation:

17.
pH: 7.6
$PaCO_2$: 42 mmHg
HCO_3^-: 39 mEq/L
PaO_2: 57 mmHg
SaO_2: 88%
Interpretation:

18.
pH: 7.55
$PaCO_2$: 28 mmHg
HCO_3^-: 24 mEq/L
PaO_2: 79 mmHg
SaO_2: 89%
Interpretation:

19.
pH: 7.33
$PaCO_2$: 33 mmHg
HCO_3^-: 17 mEq/L
PaO_2: 86 mmHg
SaO_2: 95%
Interpretation:

20.
pH: 7.42
$PaCO_2$: 41 mmHg
HCO_3^-: 23 mEq/L
PaO_2: 103 mmHg
SaO_2: 100%
Interpretation:

21.

pH:	7.38
PaCO2:	23 mmHg
HCO3-:	13 mEq/L
PaO2:	81 mmHg
SaO2:	98%
Interpretation:	

22.

pH:	7.2
PaCO2:	54 mmHg
HCO3-:	20 mEq/L
PaO2:	34 mmHg
SaO2:	86%
Interpretation:	