Module 6 - Blood Gas Procurement and Analysis

This module will allow the learner to describe procurement and interpretation of arterial blood gas samples including expected normal values in a variety of patient age groups. A brief look at how respiratory gasses move around the body and how we can measure them will also be included. These fundamental concepts are key to re-entry to practice and will be valuable clinical tools through out your career.

Rationale

Why is it important for you to learn this material?

Blood gas procurement and analysis is a fundamental part of the management of a large array of patients, from the acutely ill patient to trending a disease state or therapeutic response, or in chemically qualifying for home oxygen therapy funding. As such, your skill and understanding of normal physiological function and common responses to disease and therapy are essential in providing the best care possible. Full assessment of the body's ability to carry oxygen to the cell includes the use of indwelling lines for sampling to external pulse oxygen devices. Normal chemical values for a patient population ranging from birth to the aged must be committed to memory for use in therapy decisions. The ability to recognize blood gas abnormalities, their likely cause, and treatment is key to good clinical practice. A therapist must also fully understand the techniques for procuring these samples in a variety of ways in a variety of patient age groups.

Learning Outcome

When you complete this module you will be able to ….

Describe procurement and interpretation of arterial blood gas samples, including expected normal values, in a variety of patient age groups. A brief look at how respiratory gasses move around the body and how we can measure these gasses will also be included. These fundamental concepts are key to re-entry to practice and will be valuable clinical tools throughout your career.

Learning Objectives

Here is what you will be able to do when you complete each objective.

1. Discuss the methods of oxygen and carbon dioxide transport in the blood.
2. Explain the oxyhemoglobin dissociation curve in relation to a variety of factors.
3. Describe systemic manifestations of hypoxemia.
4. Discuss pulse oximetry and co-oximetry.
5. Describe a variety of chemical terms relating to human physiology.
6. Explain the role of the lungs and kidney in chemical terms.
7. Describe normal sea-level values for a variety of chemical variables in adults, children, and neonates.
8. Compare and categorize blood gas analysis results.
9. Describe the methods for obtaining a blood gas sample.
10. Describe and explain the equipment used for procurement, including the use of heparin, and correct handling of a blood gas sample.

Objective 1

When you complete this objective you will be able to…

Discuss the methods of oxygen and carbon dioxide transport in the blood.

Learning Activity

Complete each of the Learning Activities listed below.

Objective Content – Read pages 236 - 246 in Wilkins, R.L., Egan's Fundamentals of Respiratory Care, 8th Edition.

Answer the following questions.

1. How long does it take for oxygen to diffuse across the alveolar-capillary membrane?
2. What factors can affect this rate?
3. Derive the CaO2 using the following variables:
   Hgb = 14.6 g/dL
   Oxygen saturation = 92%
   PaO_2 = 69 mmHg
4. How does a decreased hemoglobin level affect oxygen content?
5. Describe the term dysoxia.
6. How long does it take for CO_2 to diffuse across the alveolar-capillary membrane?
7. What factors can affect CO_2 diffusion at the alveolar-capillary membrane?

Objective 2

When you complete this objective you will be able to…

Explain the oxyhemoglobin dissociation curve in relation to a variety of factors:

- 2,3 DPG
- P_{50}
- Bohr effect
- PCO_2
- Carbon monoxide affinity
- pH
- hemoglobin variants
- temperature
- oxygen affinity

Learning Activity

Complete each of the Learning Activities listed below.

Objective Content – Read pages 124, 125 in Wilkins, R.L., Clinical Assessment in Respiratory Care, 4th Edition, and pages 238 - 243 in Wilkins, R.L., Egan's Fundamentals of Respiratory Care, 8th Edition.

Answer the following questions.

1. Describe the affinity of hemoglobin for oxygen with regards to the location of a single Red Blood Cell (RBC) in the body. If this RBC is in the lung, how is affinity affected? What if the same RBC was now in the capillary bed of the hand?
2. There are specific identified factors that result in changes in the oxyhemoglobin dissociation curve. Create a list or table of these factors and their effects on curve position and affinity for oxygen.
3. Define P50 and relate the clinical value of this.
4. Describe the Haldane effect and the Bohr effect on the dissociation curve. What are the causes for each effect?
5. Saturation is reported as a percent. What are the variables in this calculation?

Objective 3

When you complete this objective you will be able to…

Describe systemic manifestations of hypoxemia.

Learning Activity

Complete each of the Learning Activities listed below.

Objective Content – Read pages 247 - 250 in Wilkins, R.L., Egan's Fundamentals of Respiratory Care, 8th Edition, pages 126 - 127 in Wilkins, R.L., Clinical Assessment in Respiratory Care, 4th Edition.

Answer the following questions.

1. Define hypoxemia in your own words after completing the reading assignment.
2. Describe the most common cause of hypoxemia.
3. Calculate a $P(A\text{-}a)O_2$ gradient given the following values:
   Example 1
   Barometric pressure = 701 mmHg
   FiO_2 = 0.21
   $PaCO_2$ = 46 mmHg
   PaO_2 = 51 mmHg

   And again with these values:
   Example 2
   Barometric pressure = 701 mmHg
   FiO_2 = 0.35
   $PaCO_2$ = 48 mmHg
   PaO_2 = 82 mmHg
4. What signs and symptoms would you expect with the first example?
5. What would be seen with the second example?

Objective 4

When you complete this objective you will be able to…

Discuss pulse oximetry and co-oximetry to the following criteria:

- advantages and disadvantages of pulse oximetry and co-oximetry
- identify appropriate pulse oximetry sites and indications for use
- describe factors that affect accuracy of results
- list alternate means of establishing accuracy

Learning Activity

Complete each of the Learning Activities listed below.

Objective Content – Read pages 377 - 383 and 1084 - 1086 in Wilkins, R.L., Egan's Fundamentals of Respiratory Care, 8th Edition, pages 304 - 309 in Cairo, J.M., Mosby's Respiratory Care Equipment, 7th Edition.

Answer the following questions.

1. When should pulse oximetry be used?
2. What are the limitations of a pulse oximeter at the bedside when compared to co-oximeter analysis of a blood sample?
3. How can you clinically assure that a pulse oximeter probe is functioning? If function is verified yet no waveform is generated, what is the most likely cause?
4. If access to the hands of a patient is not available, in a burn patient for example, list alternative sites that pulse oximeter probes can be placed.
5. Are there any environmental or clinical issues that would make you believe the reported saturation on a pulse oximeter is in error? What are these issues, and can you do anything about them?

Objective 5

When you complete this objective you will be able to…

Describe a variety of chemical terms relating to human physiology including:

- acid, base, pH, [H^+], bicarbonate, buffer
- acidemia, acidosis
- alkalemia, alkalosis, alkali
- dissociation
- covalent bonding, ionic bonding, valence
- electron, neutron, proton, atomic number, atomic weight, mass
- isotope
- anion, cation
- Law of Mass Action
- electrolyte, anion gap
- Avagadro's law
- Suspensions
- colloids, protein
- phosphate

Learning Activity

Complete each of the Learning Activities listed below.

Objective Content – Read Wilkins, R.L., Egan's Fundamentals of Respiratory Care, 8th Edition pages 98, 198, 243, 256, 258 - 263, 273 - 281, 288 - 299, 350 and 1204 - 1205. For chemical term definitions, refer to Davis, F.A., Taber's Cyclopedic Medical Dictionary, 19th Edition, and refer to the Glossary in Wilkins, R.L., Egan's Fundamentals of Respiratory Care, 8th Edition.

Define and explain the clinical significance of the terms in the space provided:

- acid –
- base –
- pH, [H^+] –
- bicarbonate –
- buffer –
- acidemia –
- acidosis –
- alkalemia –
- alkalosis –
- alkali –
- dissociation –

- covalent bonding –
- ionic bonding –
- valence –
- electron –
- neutron –
- proton –
- atomic number –
- atomic weight –
- mass –
- isotope –
- anion –
- cation –
- Law of Mass Action –
- electrolyte –
- anion gap –
- Avagadro's Law –
- suspensions –
- colloids –
- protein --
- phosphate –

Objective 6

When you complete this objective you will be able to…

Explain the role of the lungs and kidney in chemical terms:

- the role of the lung in
- elimination of volatile acid
- relation to H_2CO_3 and alveolar ventilation
- the role of the kidney in terms of
- excretion of H^+ in exchange for Na^+
- acidification of phosphate buffer salts
- role bicarbonate buffer and reabsorption of CO_2 from tubules
- excretion of ammonia ions
- effect of excess H^+
- metabolic compensation for respiratory disorders

Learning Activity

Complete each of the Learning Activities listed below.

Objective Content – Read pages 251 - 262, Des Jardins, T., Cardiopulmonary Anatomy and Physiology, 4th Edition, and pages 271 - 282 in Wilkins, R.L., Egan's Fundamentals of Respiratory Care, 8th Edition.

Answer the following questions.

1. In what percentages and chemical makeup is CO_2 transported in the blood from the tissue to the lung?
2. Write the various chemical reactions that carbon dioxide goes through and where they occur in the renal system. What occurs in the renal tubule cell to ensure these reactions move forward?
3. How does the kidney react in the presence of increased levels of CO_2 in the blood?
4. What is required for the formation of NH4Cl in urine?
5. What is the normal ratio of HCO_3- to H_2CO_3? What is the significance of a 25:1 ratio or a 15:1 ratio?

Objective 7

When you complete this objective you will be able to…

Describe normal sea-level values for a variety of chemical variables in adults, children, and neonates including:

- actual HCO_3-, standard HCO_3-
- $P(A - a)O_2$
- base excess and base deficit
- PaO_2/PAO_2
- buffer base
- $PaCO_2$
- PaO_2
- PaO_2/FiO_2
- CaO_2
- pH, $[H^+]$
- Hb
- SaO_2
- Hb Met
- HbCO
- total CO_2
- HbF
- HbO_2

Learning Activity

Complete each of the Learning Activities listed below.

Objective Content – Read Chapters 4 and 5, pages 3 - 8 and 99 - 101 in Shapiro, Peruzzi, Templin, Clinical Application of Blood Gases, 5th Edition, Chapter 9 in Whitaker, K., Comprehensive Perinatal & Pediatric Respiratory Care, 3rd Edition, and pages 17 - 19 of Appendix D in the occupation profile.

Answer the following questions.

1. Explain the relationship between PH and $PaCO_2$ when interpreting an arterial blood gas sample.
2. Describe the formula to calculate PAO_2 and explain the constants you used.
3. What is the clinical significance of the PaO_2/FiO_2 ratio?
4. Why does the $P(A\text{-}a)O_2$ gradient exist in a normal person? What might make this gradient larger than normal?
5. Name and specify the differences between all of the normal variants of the human hemoglobin molecule.
6. Calculate CaO_2 using the following variables:
   Hb 20g/dL
   PO_2 75 mm Hg
   SO_2 92%

Objective 8

When you complete this objective you will be able to…

Compare and categorize blood gas analysis results:

- Compare
  - respiratory acidemia and alkalemia
  - metabolic acidemia and alkalemia
  - combined respiratory and metabolic acidemia
  - combined respiratory and metabolic alkalemia
  - with regard to etiology, manifestation, pathophysiology, and management
- Categorize
  - acute respiratory acidemia
  - fully compensated states
  - acute respiratory alkalemia
  - combined respiratory and metabolic acidemia
  - partially compensated respiratory acidemia
  - combined respiratory and metabolic alkalemia
  - partially compensated respiratory alkalemia
  - combined primary acidemia and alkalemia
  - partially compensated metabolic acidemia
  - partially compensated metabolic alkalemia
  - hypoxemia, hyperoxemia, normoxemia

Learning Activity

Complete each of the Learning Activities listed below.

Objective Content – Read Chapters 6, 12, 13, and 20 in Shapiro, Peruzzi, Templin, Clinical Application of Blood Gases, 5th Edition, and pages 17 and 18 of Appendix D in the occupational profile.

Answer the following questions.

1. Interpret the following ABGs and name a disorder which may cause each:
   a. $PaCO_2$ 50, pH 7.29, HCO_3^- 16, PaO_2 52
   b. $PaCO_2$ 32, pH 7.49, HCO_3^- 24, PaO_2 58
   c. $PaCO_2$ 35, pH 7.45, HCO_3^- 23, PaO_2 59
   d. $PaCO_2$ 60, pH 7.32 HCO_3^- 27, PaO_2 45
2. Characterize all the different grades of hypoxemia.
3. Explain the difference between an acidosis and an acidemia.
4. What type of acidosis may cause Kussmaul breathing? Also, describe Kussmaul breathing.
5. If a patient suffered a myocardial infarction, what type of blood gas analysis might you expect, if drawn shortly after the emergency, and why?

Objective 9

When you complete this objective you will be able to…

Describe the methods for obtaining a blood gas sample.

Describe using the arterial puncture, indwelling catheters, and the capillary puncture in terms of:

- indications and contraindications
- advantages and disadvantages of puncture sites
- procedure for adult puncture of the radial, brachial, and femoral arteries
- hazards and complications
- modified Allen's test
- sampling procedure

Learning Activity

Complete each of the Learning Activities listed below.

Objective content – Read pages 301 - 309 in Shapiro, Peruzzi, Templin, Clinical Application of Blood Gases, 5th Edition.

Answer the following questions.

1. Specify and compare the contraindications of performing an arterial and capillary puncture.
2. Describe in detail the technique for radial artery puncture.
3. Which areas on the infant are appropriate sites for capillary puncture?
4. Which values from a capillary blood sample do not reflect or show consistent correlation with arterial values, and why is this the case?
5. Explain the importance of assessing collateral circulation before arterial puncture and then describe in point form the modified Allen's test.
6. Describe the justification for arterial cannulation of a patient.

Objective 10

When you complete this objective you will be able to…

Describe and explain the equipment used for procurement, including the use of heparin, and correct handling of a blood gas sample.
Include:

- blood gas analysis sampling kits
- syringes and capillary tubes
- vacuum tubes
- the method of heparinizing: its purpose, advantages, disadvantages, and the effects of excess heparin
- rationale for cooling, mixing, sealing, and labelling of a blood gas sample
- anaerobic handling and the effect of air contamination on results
- identify infection-control techniques for safe procurement, handling, and disposal of blood samples

Learning Activity

Complete each of the Learning Activities listed below.

Objective content – Read pages 291 - 295 in Cairo, J.M., Mosby's Respiratory Care Equipment, 7th Edition, pg 310 in Shapiro, Peruzzi, Templin, Clinical Application of Blood Gases, 5th Edition, and pages 358 - 366 in Wilkins, R.L., Egan's Fundamentals of Respiratory Care, 8th Edition.

Answer the following questions.

1. What is the appropriate quantity and concentration of heparin required when drawing a 2ml blood sample?
2. Describe the procedure for pre-heparinizing a syringe with liquid heparin.
3. Compare the advantages and disadvantages of different types of heparin used in blood gas analysis.
4. Explain the procedure of removing excess air from the syringe after drawing an ABG sample and the consequences of not doing so.
5. Why is it clinically important to mix a blood sample before it is analyzed?