RSPT 2305: Section 7

ARTERIAL BLOOD GAS SAMPLING

I. Obtaining the Sample

A. Rational for using arterial blood
   1. most blood samples from laboratory tests use venous blood
      a. pressures are lower in veins
      b. vessels are abundant
      c. interruption of venous flow is less significant
   2. venous blood reflects the oxygen and carbon dioxide levels after tissue respiration
      a. metabolism is not uniform throughout the body
   3. arterial blood reflects how well the cardiopulmonary system is working as a unit
      a. essentially no gas exchange occurs after the blood leaves the left ventricle until it reaches the capillary beds
      b. arterial blood gives the most accurate account of lung and heart function

B. Criteria for selecting arterial puncture site
   1. site should have collateral blood flow
      a. arterial puncture may cause -
      b. not all sites have collateral circulation
      c. the radial artery and brachial artery usually have good collateral circulation
      d. femoral artery does not have good collateral circulation below the inguinal ligament
   2. superficial arteries have some advantages over deeper ones
      a. easier to palpate, stabilize, and puncture
      b. easier to control bleeding

C. Primary sites for arterial sampling
   1. the radial a. meets most of the criteria for a good site -
   2. brachial artery is the next choice site
   3. femoral artery is usually reserved for emergencies
   4. umbilical artery -
   5. temporal artery -

D. Allen's Test - radial artery
   1. measures collateral circulation in the radial artery
   2. technique
      a. hand is closed tightly forming a fist
      b. pressure is applied to both radial and ulnar arteries
      c. hand is then relaxed -
      d. pressure is removed from ulnar artery -
      e. palm and fingers should become flushed within 15 seconds
   3. negative Allen's test -

E. Technique for drawing arterial samples will be listed in Lab Section 1 and will be demonstrated in the laboratory.

II. Preparing the Sample

A. Glass vs. plastic syringes
   1. the statement that plastic absorbs oxygen to any degree has not been substantiated
   2. glass was considered optimal because:
      a. less friction to move barrel -
      b. seldom requires aspiration of sample -
      c. less problems with air bubbles
      d. in most cases glass is more expensive
   3. plastic syringes have become standard for sampling arterial blood

a. expense has decreased
b. quality has improved
c. many use a preset plunger -

B. Anticoagulants
1. once blood is removed from a vessel, clotting mechanisms are activated
2. blood gases cannot be accurately measured using clotted blood
3. heparin is used to coat the inside surface of the syringe and the barrel of the needle to prevent the blood from clotting
4. excessive amounts of heparin will affect pH -
5. approx. 0.05 ml of heparin will anticoagulate 1 ml of blood
   a. 0.1 ml of heparin does not appear to alter pH, PCO2, or PO2
   b. when a 5 ml syringe is washed with heparin and then emptied, about 0.15 to 0.25 ml of heparin remains in the syringe and needle
   c. 2 - 4 ml of blood would contain about 0.05 ml of heparin per ml of blood
6. types of heparin
   a. sodium heparin -
   b. ammonium heparin -
   c. lithium heparin -

C. Anaerobic sampling
1. room air normally contains no CO2 and a PO2 around 130 torr (Amarillo)
2. air bubbles in a syringe dilute the blood gas values
   a. PaCO2 -
   b. PaO2 -
3. the greater amount of air in the syringe will cause more dilution
4. samples should be discarded if there is a significant amount of air in the syringe
5. any bubbles should be removed as quickly as possible and the syringe should be sealed

D. Delays in running the sample
1. samples not analyzed within 15-20 minutes after being drawn should be placed in an ice slurry mixture -
2. in vitro gas changes - Shapiro

	37°C	**4°C**
pH	0.01 / 10 min.	0.001/ 10 min.
PCO_2	1 mmHg / 10 min.	0.1 mmHg/ 10 min.
PO_2	0.1 vol% / 10 min.	0.01 vol% / 10 min.

3. white blood cells consume oxygen if not chilled
4. if chilled, gases can be run an hour after being drawn with relatively accurate results

III. Quality Control

A. Statistics - three statistical components must be understood to verify internal quality control
1. *Mean* - a fundamental statistic calculated by dividing the sum of all numbers in a group by the number of numeric entries. (syn. - average)
   a. $\bar{x} = \frac{\sum x1}{n} x$
   b. $\bar{x}$ = mean
   c. Σ = sum of
   d. n = number of measurements
2. *Standard deviation* (SD) - is the measurement of variance around the mean

a. describes the difference between mean and normal range
   i) mean - average
   ii) normal range - gives a high and low value within which 95% of the normal population falls
b. the degree of dispersion in a group can be measured by calculating SD
c. $SD = \sqrt{\frac{n\sum x_1^2 - (\sum x_1)^2}{n(n-1)}}$
d. x = each measurement
   Σ = sum of
   n = number of measurements
e. a low SD (minimal dispersion) indicates the values are generally homogenous
f. the SD of $PaCO_2$ in the normal population is approximately 2.5 torr
   i) 1 SD = $PaCO_2$ 40 torr $\pm$ 2.5 torr
   ii) 2 SD = $PaCO_2$ 40 torr $\pm$ 5 torr (35 - 45 torr)
g. the SD of pH in a normal population is approximately 0.025 pH units
   i) 2 SD of pH is 7.4 $\pm$ 0.05 (7.35 – 7.45)
h. 1 SD of oxygen (PaO_2) at sea level is 5 torr (PaO_2 80 to 100 torr)

3. *Coefficient of variation* - compares the degree of variation (dispersion) in two groups of measurement with sharply different means
   a. $CV\% = \left(\frac{SD}{\bar{x}}\right)100$
   b. CV = coefficient of variation
      SD = standard deviation
      $\bar{x}$ = mean

B. Determining Internal Quality Control
1. Controls - are samples run in a blood gas machine to ensure that the machine is operating correctly
   a. controls have their own range of normals, usually ± 3 SD from mean
   b. control limits can be established (requires a min. of 20 measurements)
   c. minimum standards for running controls
      i) after every 25 blood gases
      ii) every 4 hours
      iii) must run high, low, and normals
2. control limits
   a. Levey - Jennings control chart
   b. controls are set at 3 SD
   c. one parameter may exceed 3 SD for one electrode (still be in control)
   d. out of control
      i) any single control outside 4 SD
      ii) two different controls outside 3 SD
3. random error -
4. systemic error - recurrent measurable deviation from mean
   a. trending - example of systematic error
   b. shifting - abrupt movement away from mean
      i) bubbles, change in temperature, contamination of calibration standards

5. Accuracy vs. precision
   a. accuracy is a measure of how closely the measured results reflect the true or actual value
      i) example - an electrode consistently measures 10 torr less than what the PO2 actually is -
      ii) usually related to systematic error
   b. precision is an index of dispersion of repeated measurements
      i) example -
6. all electrodes tend drift electronically
   a. pH and PCO2 exhibit a balance drift -
   b. one point calibration is usually necessary between blood samples
   c. PO2 is adjusted by slope control
7. two point calibrations are used to maintain the greatest accuracy but are not needed between samples

B. External controls
1. gases
   a. require certified gases to measure
   b. electrodes may act differently to partial pressure in a gas mixture when compared to the partial pressure of a gas in a liquid
2. aqueous buffers -
   a. very similar to blood but does not contain protein
   b. respond differently than blood with temperature variations
3. tonometered liquids - may require 30 minutes or longer to reach equilibration
   a. aqueous buffers -
   b. whole blood -
   c. emulsions -
4. commercial preparations - basically two kinds
   a. ampules with a solution of predetermined pH, PCO2, PO2
   b. ampules of human serum with predetermined pH and PCO2 values
   c. may demonstrate errors not seen with calibration
5. aqueous controls -
6. fluorocarbon emulsions -
7. quality control is a must when critical decisions concerning a patient's life hinge on the blood gas analysis

A few words of **CAUTION!!!!!!!**

1. Blood may contain infectious organisms, ALWAYS use **Universal Precautions**. Avoid accidents, especially those with penetrating injuries. ALWAYS report accidents.
2. When possible, ABG's should be drawn before anticoagulant therapy.
3. NEVER use excessive pressure to force a blood sample into an analyzer.
4. NEVER instill any solution into an ABG sampling chamber unless you are sure of its function.
5. NEVER pivot a needle in tissue, ALWAYS withdraw the needle to just below the surface of the skin and reinsert at the desired angle.
6. ALWAYS apply pressure to a sampling site for a MINIMUM of 3 minutes after a sample is drawn. Report any signs of circulation changes to the nurse in charge or the physician.
7. Remember Murphy's law!!!