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AARC Clinical Practice Guideline

Sampling for Arterial Blood Gas Analysis

ABS 1.0 PROCEDURE:

Sampling for arterial blood gas analysis

ABS 2.0 DESCRIPTION:

Blood is drawn anaerobically from a peripheral artery (radial, brachial, femoral, or dorsalis pedis) via a single percutaneous needle puncture, or from an indwelling arterial cannula or catheter for multiple samples. (1-8)

Either method provides a blood specimen for direct measurement of partial pressures of carbon dioxide ($PaCO_2$) and oxygen (PaO_2), hydrogen ion activity (pH), total hemoglobin (Hbtotal), oxyhemoglobin saturation (HbO_2), and the dyshemoglobins carboxyhemoglobin (COHb) and methemoglobin (MetHb).

ABS 3.0 SETTING:

Sampling may be performed by trained health care personnel(6-8) in a variety of settings including (but not limited to) hospitals, clinics, physician offices, extended care facilities, and the home.

ABS 4.0 INDICATIONS:

4.1 The need to evaluate the adequacy of ventilatory ($PacO_2$) acid-base (pH and $PaCO_2$), and oxygenation (PaO_2 and SaO_2) status, and the oxygen-carrying capacity of blood (PaO_2, HbO_2, Hbtotal, and dyshemoglobins)(1,2,7,8)

4.2 The need to quantitate the patient's response to therapeutic intervention(1,2,5) and/or diagnostic evaluation (eg, oxygen therapy, exercise testing)(2)

4.3 The need to monitor severity and progression of a documented disease process.(1,2)

ABS 5.0 CONTRAINDICATIONS:

Contraindications are absolute unless specified otherwise.

5.1 Negative results of a modified Allen test (collateral circulation test) are indicative of inadequate blood supply to the hand' and suggest the need to select another extremity as the site for puncture.

5.2 Arterial puncture should not be pertormed through a lesion or through or distal to a surgical shunt (eg, as in a dialysis patient). If there is evidence of infection or peripheral vascular disease involving the selected limb, an alternate site should be selected.
5.3 Agreement is lacking regarding the puncture sites associated with a lesser likelihood of complications; however, because of the need for monitoring the femoral puncture site for an extended period, femoral punctures should not be performed outside the hospital.
5.4 A coagulopathy or medium-to-high-dose anticoagulation therapy (eg, heparin or coumadin, streptokinase, and tissue plasminogen activator but not necessarily aspirin) may be a relative contraindication for arterial puncture.

ABS 6.0 HAZARDS/COMPLICATIONS:

6.1 Hematoma(1,2,7,8)
6.2 Arteriospasm(1,7,8)
6.3 Air or clotted-blood emboli(1-3,7,8)
6.4 Anaphylaxis from local anesthestic(7,8)
6.5 Introduction of contagion at sampling site and consequent infection in patient; introduction of contagion to sampler by inadvertent needle 'stick.' (1-3,7,8)
6.6 Hemorrhage(2,3)
6.7 Trauma to the vessell(1,3)
6.8 Arterial occlusion(2)
6.9 Vasovagal response
6.10 Pain

ABS 7.0 LIMITATIONS OF METHOD/VALIDATION OF RESULTS:

7.1 Limitations:
7.1.1 Artery may be inaccessible due to periarterial tissues (overlying muscle, connective tissue, or fat).(1)
7.1.2 Pulse may not be palpable.(7,8)
7.1.3 Arteriospasm may preclude collection despite successful introduction of needle into the artery.(7-8)
7.1.4 Arterial blood specimens withdrawn from the body only reflect the physiologic condition at the moment of sampling (eg, pain from the puncture itself may lead to hyperventilation with consequent changes in values).
7.1.5 Specimens drawn at peak exercise best reflect response to exercise; however, specimens drawn within 15 seconds or less of termination of exercise may be acceptable (otherwise results do not reflect ventilatory status during dynamic activities and may yield false-negatives for hypoxemic events).(9-10)
7.1.6 Specimens from mechanically ventilated patients with minimal

pulmonary pathology adequately reflect the effects of oxygen concentration change 10 minutes after the change.(7,8,11) In spontaneously breathing patients, at least 20-30 minutes should elapse following oxygen concentration change (patients with obstructive defects and increased residual volumes may require the full 30 minutes or longer).

7.1.7 Specimens held at room temperature must be analyzed within 10-15 minutes of drawing; iced samples should be analyzed within 1 hour.' The PaO2 of samples drawn from subjects with elevated white cell counts may decrease very rapidly. Immediate chilling is necessary.(12-13) Some dual-purpose electrolyte/blood gas analyzers stipulate immediate analysis without chilling because of possible elevations in potassium from chilling;(14) however, the accuracy of the blood gas results should not be affected by the chilling.

7.2 Validation of results:

7.2.1 Sample must be obtained anaerobically and anticoagulated, with immediate expulsion of air bubbles. Sample should be immediately chilled or analyzed within 10-15 minutes if left at room temperature.(15)

7.2.2 When a sample is obtained, date, time, patient's body temperature, position, activity level, respiratory rate, sample site, results of Allen test, inspired oxygen concentration(4,6-8) or supplemental oxygen flow, and mode of supported ventilation4 should be documented in the patient' s medical record with the results of blood gas analysis.

7.2.3 Appropriate sample size depends on (1) the anticoagulant used, (2) the requirements of the specific analyzers to be used, and (3) the presence of a need for other assays.

7.2.3.1 If liquid heparin (sodium or lithium, 1,000 units/mL of blood) is used, excess heparin (all except that filling the dead space of the syringe and needle) should be expelled and a blood sample of 2-4 mL be drawn (liquid heparin dilutes the specimen and changes PCO2 and PO2 in direct relationship to the heparin volume).(16)

7.2.3.2 If lyophilized heparin is used, the minimum volume drawn depends on the design of the analyzers and the need for other assays.

7.2.3.3 If other assays are required (eg, electrolyte determination), the choice of anticoagulant and the volume of the blood sample should be guided by the analyzer manufacturer's recommendations.

ABS 8.0 ASSESSMENT OF NEED:

The following findings may assist the clinician in deciding whether arterial blood sampling is indicated:

8.1 History and physical indicators (eg, positive smoking history, recent onset of difficulty in breathing independent of activity level,

trauma)(2)
8.2 Presence of other abnormal diagnostic tests or indices (ice abnormal pulse oximetry reading, chest x-ray)(2)
8.3 Initiation of, administration of, or change in therapeutic modalities (eg, initiation, titration or discontinuance of supplemental oxygen or initiatiort of, changes in, or discontinuance of mechanical ventilation)(1,2,4,5)
8.4 Projected surgical interventions for patients at risks(5,17)
8.5 Projected enrolment in a pulmonary rehabilitation program

ABS 9.0 ASSESSMENT OF TEST QUALITY:

9.1 Sampling of arterial blood for any of the indications listed will be useful for patient management only if the sampling procedure is carried out according to an established, proven protocol. The validity of test results can be voided if any of the following occur:(1,6-8)
9.1.1 The sample is contaminated by air, improper anticoagulant or inappropriate anticoagulant concentration, flush solution (if sample is drawn from an indwelling catheter), or venous blood.(1,2,4,6-8)
9.1.2 The sample clots because of improper anticoagulation of the collection device, improper mixing, or exposure to air.(1,2,6)
9.1.3 Analysis is delayed (> l5 minutes for samples held at room temperature or > 60 minutes for samples held at 4°C).(2,4,6-8)

ABS 10.0 RESOURCES:

10.1 Recommended equipment:
10.1.1 Single puncture: Appropriate anticoagulant, sterile glass or plastic (low diffusibility) syringe with needle, patient label,(6) 70% isopropyl alcohol or other suitable antiseptic solution,(1,7,8) gauze squares or similar material, well-fitting latex or vinyl gloves, puncture-resistant container, syringe cap, 'cork' and device to remove needle from syringe.
10.1.1.1 The term cork describes any device designed to allow insertion of the sample needle point after withdrawal from the artery. The purpose of the cork is to reduce exposure time of the sampler to the contaminated needle and remind the sampler not to resheath the needle-thus reducing the potential for inadvertent needle stick. The cork should provide some resistance to insertion and should not allow the needle to completely traverse it. Devices that allow single-hand recapping are preferred.
10.1.1.2 Local anesthetic is not generally considered necessary for single punctures.
10.1.2 Indwelling catheter: Sterile glass or plastic (low diffusibility) syringe that has been appropriately anticoagulated, 'waste' syringe,(1,7,8) syringe cap, protective eyewear and outerwear (in the

anticipation of splashing), well-fitting latex or vinyl gloves, and patient labels(6-8) (local anesthetic is recommended for arterial line insertion)
10.1.3 Container of ice and water (to immerse syringe barrel if specimen will not be analysed within l5 min)
10.1.4 A detailed institutional protocol incorporating current OSHA (Occupational Health and Safety Administration) and CDC (Centers for Disease Control) guidelines should be in place
10.2 Personnel:
Arterial blood sampling should be performed under the direction of a physician specifically trained in laboratory medicine, pulmonary medicine, anesthesia, or critical care. Two levels of training and experience are recognized for the actual sampling.

In addition, as one aspect of a quality assurance monitoring program, individuals performing arterial puncture should undergo periodic reevaluation relative to Universal Precautions, proper syringe preparation, site determination, puncture technique, sample acquisition, storage and disposal of blood specimens, and postsampling care of puncture site. Individuals who do not meet acceptable indicator thresholds should not continue to perform punctures independently until they have received remedial instruction and been re-evaluated. (Please note that failure to obtain a sample from a single arterial puncture does not indicate failure as long as all other aspects of the indicator are acceptable.)

10.2.1 Level I: Persons designated as Level I should have a high school education plus specific training in sampling arterial blood, oxygen delivery devices and related equipment, recordkeeping, and the associated hazards and sources of specimen and sampler contamination. Additionally, a strong background in mathematics, with one or more years of college courses in the physical and biologic sciences is preferred.(18) Performance of blood sampling should be supervised by a Level-II individual.(18)
10.2.2 Level II: The Level-II person is a health care professional trained in patient assessment, acid-base, and oxygenation disorders, and diagnostic and therapeutic alternatives-an associate or higher degree in the sciences or respiratory therapy or subtantial experience in pulmonary function technology is preferred. Two years of college with courses in the biologic sciences and mathematics plus 2 years of training and experience may be substituted for personnel supervising arterial blood sampling. Level-II personnel both sample and supervise Level-I personnel during sampling.(8) A recognized credential (MD, DO, CRTT, RRT, RN, RPFT, CPFT, MT, MLT, RCVT, or equivalent) is strongly recommended.

ABS 11.0 MONITORING:

The following should be monitored as part of arterial blood sampling:
11.1 FIO2 (analyzed) or prescribed flowrate(1,2,7,8)
11.2 Proper application of patient device (eg, mask or cannula)(1,2,7,8)
11.3 Mode of supported ventilation and relevant ventilator settings(7,8)
11.4 Pulsatile blood return(1,6,8)
11.5 Presence or absence of air bubbles or clots in syringe or sample(1,2,6-8)
11.6 Patient's respiratory rate(7,8)
11.7 Patient'stemperature(7,8)
11.8 Position and/or level of activity (if other than resting)
11.9 Patient's clinical appearance
11.10 Ease of (or difficulty with) blood sampling(1,7,8)
11.11 Appearance of puncture site after direct pressure has been applied and before application of pressure dressing for potential hematoma formation(1,6-8) (a detailed protocol for postsampling management should be in place)

ABS 12.0 FREQUENCY:

The frequency with which sampling is repeated should depend on the clinical status of the patient and the indication for performing the procedure(2,5) and not on an arbitrarily designated time or frequency.
12.1 Repeated puncture of a single site increases the likelihood of hematoma, scarring, or laceration of the artery. Care should be exercised to use alternate sites for patients requiring multiple punctures.
12.2 An indwelling catheter may be indicated when multiple sampling is anticipated.

ABS 13.0 INFECTION CONTROL:

13.1 Universal Precautions as published by the Centers for Disease Control(19) and directives issued by the Department of Labor concerning occupational exposure to blood-borne pathogens(20) must be applied in all circumstances involving blood or bloodcontaminated collection devices in the immediate area.
13.2 Aseptic technique must be employed whenever blood is sampled from an indwelling arterial catheter.(1)
13.3 Prior to a single puncture, the site should be cleaned.(1,7,8)
13.4 Blood specimens, contaminated needles, and syringes must be disposed of in appropriate containers.
13.5 Needle sticks are the most frequent source of transmission of

blood-borne diseases in health care workers.(19-20)
13.5.1 Needles used for blood sampling should be resheathed only with a technique that utilizes a one-hand device or by careful insertion into a cork, rubber plug, or similar device that prevents the sharp point from being accessible.
13.5.2 The needle should removed from the syringe and the syringe capped.
13.5.3 Gloves provide little protection from needle punctures but should be worn to prevent splashing of blood on sores or other skin breaks.
13.5.4 Specimen sampling devices in which the needle retracts after use are recommended when the design does not interfere with obtaining the sample.

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REFERENCES

1. Shapiro BA, Harrison RA, Cane RD, Templin R. Clinical application of blood gases, 4th ed. St Louis: Year Book Medical Publishers Inc. 1989.
2. Raffin TA. Indications for arterial blood gas analysis. Ann Intern Med 1986;105:390-398.
3. Weibley RE, Riggs CD. Evaluation of an improved sampling method for blood gas analysis from indwelling arterial catheters. Crit Care Med 1989; 17(8):803-805.
4. Thorson SH, Marini JJ, Pierson DJ, Hudson LD. Variability of arterial blood gas values in stable patients in the ICU. Chest 1983;84(1): 14-18.
5. Browning JA, Kaiser DL, Durbin CG. The effect of guidelines on the appropriate use of arterial blood gas analysis in the intensive care unit. Respir Care 1989; 34:269-276.
6. Moran RF, Van Kessel A. Blood gas quality assurance. NSCPT Analyzer 1981;11(I): 18-26.
7. Bruck E, Eichhorn JH, Ray-Meredith S. Shanahan JK, Slockbower JM. Percutaneous collection of arterial blood for laboratory analysis. National Committee for Clinical Laboratory Standards 1985;H11A;5(3):39-59.
8. National Committee for Clinical Laboratory Standards. Procedures for the collection of diagnostic blood specimens by

skin puncture, 3rd ed. Villanova PA: NCCLS, 1992.
9. Frye M, DiBenedetto R. Lain D, Morgan K. Single arterial puncture vs arterial cannula for arterial gas analysis after exercise. Chest 1986;93:294-298.
10. Ries, AL, Fedullo PF, Clausen JL. Rapid changes in arterial blood gas levels after exercise in pulmonary patients. Chest 1983;83:454-456.
11. Hess D, Good C, Didyoung R. Agarwal NN, Rexrode WO. The validity of assessing arterial blood gases 10 minutes after an Flo2 change in mechanically ventilated patients without chronic pulmonary disease. Respir Care 1985;30:1037-1041.
12. Fox MJ, Brody JS, Weintraub LR. Leukocyte larceny: a cause of spurious hypoxemia. Am J Med 1979;67:742-746.
13. Matchuny JK. Unexplained hypoxemia in a leukemia patient (blood gas corner). Respir Care 1988;33:971-973.
14. Fleisher M, et al. Two whole-blood multi-analyte analyzers evaluated. Clin Chem 1989;35: 1532- 1535.
15. Harsten A, Berg B. Inerot S. Muth L. Importance of correct handling of samples for the results of blood gas analysis. Acta Anaesthesiol Scand 1988;32:365-368.
16. Hansen JE, Simmons DH. A systematic error in the determination of blood PCO2- Am Rev Respir Dis 1977; 115:1061-1063.
17. Zibrak JD, O'Donnel1 CR, Marton K. Indications for pulmonary tunction testing. Ann Intern Med 1990;112: 763-771.
18. Gardner RM, Clausen JL, Epler G. Hankinson JL, Permutt S. Plummer AL. Pulmonary function laboratory personnel qualifications. American Thoracic Society Position Paper, ATS News, November 1982.
19. Centers for Disease Control and Prevention. Update: Universal Precautions for prevention of transmission of human immunodeficiency virus, hepatitis B virus, and other blood-borne pathogens in health care settings. MMWR 1988; 37:377-388.
20. Department of Labor, Occupational Safety and Health Administration. Occupational exposure to bloodborne pathogens. 29 CFRR Part 1910.1030. Federal Register, Friday December 06, 1991.

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