Module
Arterial Blood Gases

Arterial Blood Gases
Medical Education Package

Aims & Objectives

The aim of this learning package is for junior doctors to:

- Know how to collect arterial blood gas samples
- Understand how to interpret the results

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Module Structure

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Overview

BACKGROUND INFORMATION

ABGs (arterial blood gases) are routinely used for

- assessment of PO_2 where pulse oximetry is abnormal and it is presumed there may be changes to acid/base status
- assessment of CO_2 eg hypoventilation, ventilated patients, sepsis
- assessment of acidosis eg sepsis, diabetic ketoacidosis
- rapid assessment of K^+/ COHb
- Rapid Hb

Technique

ARTERIAL BLOOD GAS COLLECTION

Prior To Performing ABGs

1. **Things to note**
   - Check the patient is prepared
   - Is the patient on oxygen?
   - What % or flow rate?
   - Mask or nasal prongs?
   - Are they on room air?
   - If you require test to be performed on room air, then the patient must be off O_2 for 30 minutes prior to test. Notify the nursing staff so they can monitor the patient closely whilst off oxygen.
   - Is the patient on anticoagulants?

2. **Site Selection**

   It is preferable to choose an arterial vessel that
   - has collateral circulation so that if spasm or clotting occurs, the tissue will not be deprived of perfusion
   - is superficial
   - where entry is easiest and minimises pain.

   For this reason, the radial artery is the preferred puncture site.

   If the radial artery is not accessible, the femoral or brachial arteries may be used. However, these arteries are contraindicated in patients with abnormal haemostatic mechanisms because adequate vessel tamponade may not be possible.

   Any vessel that has been reconstructed surgically should not be punctured.

   Please consult your clinical supervisor before performing an ABG collection on a child or infant.

3. **Complications**

   Complications are unusual but can include:
   - local pain
   - haematomas
   - a rare vasovagal episode and
   - extremely rarely, an expanding aneurysm of the radial artery has been reported after frequent punctures

4. **Explain the procedure to the patient (in layman's terms)**
   - It is an arterial puncture and is different to a venipuncture which the patient may have experienced before.
   - It is slightly more uncomfortable that a venipuncture.
   - No tourniquet is required.

- Pressure MUST be applied for at least 5 minutes after the procedure to the puncture site, and longer if the patient is on anticoagulants.

5. Position the patient's hands and perform the Allen's test.

Before puncturing the radial artery, the blood supply to your patient's hand should be assessed. The Allen's test is a simple reliable test used to ensure that in the case of total occulsion of the radial artery, the ulnar artery is able to provide adequate blood flow to perfuse the hand.

- Locate the radial and ulnar arteries and apply **firm** pressure using your middle 2 or 3 fingers

- Observe the hand for pallor or "blanching"

- Remove pressure from the **ulnar artery only** and observe the colour returning to the hand (negative Allen's test)

- If the Allen's test is **negative**, you may proceed with the gases.
- If the Allen's test is **positive** check the other hand.
- The non dominant hand of the patient is the preferred site where possible.
- The best position is to have the patient's arm extended with support under the wrist area (rolled up towel, pillow etc) which allows the hand to be hyper extended to allow for clear access to the arteries.

EQUIPMENT

- Gloves
- Blood gas syringe kit
- Local anaesthetic or emla cream if needed
- 23g/21g needle depending on patient size
- alcohol wipes x3
- sterile cotton wool swap, tape
- small esky/container of crushed ice and water for placing sample after collection
- pressure bandage

ARTERIAL BLOOD GAS COLLECTION

1. Wash hands thoroughly and don gloves/goggles.
2. Prepare equipment.
3. A local anaesthetic or emla cream may be administered at the puncture site if necessary.
4. Cleanse the site over the radial artery using 3 alcowipes (circular motion). If you palpate the site again after cleansing, then it must be recleansed.
5. Palpate the radial artery with your index and middle finger and confirm position.
6. Keeping your fingers in place, insert the needle with the bevel upwards at an angle of 45^{o}-90^{o} using pulsation as a guide. It may help to rest your hand on the patient's during the procedure as this will maintain the extension of the patient's hand and will also steady your hand.

7. When the artery is punctured, there will usually be a flashback of blood in the syringe. You may need to reposition the needle slightly to improve the flow.

THE BLOOD SHOULD FILL THE SYRINGE FAIRLY QUICKLY.

- **The colour of the blood should be bright red, not dark red.**
- **Let the syringe fill by itself- do not pull back on the plunger.**
- **If the syringe does not fill spontaneously, you may have entered a vein and will have to perform the test again using a new syringe and needle.**
- **There should be no air space in the syringe at the completion of collection. If blood flow stops before the syringe is full, then withdraw the needle and expel the air bubble as soon as possible.**

8. After removing the needle from the patient, apply firm pressure with the sterile cotton swab directly over the puncture site. Thumb pressure is the most effective. The patient or nursing staff should hold the swab over the puncture site.
9. Remove the needle from the syringe and discard. Cover the hub of the syringe with the venting stopper, and expel any air bubbles, then apply the transport stopper.
10. Roll syringe between your hands 15-20 times to mix the anticoagulant in the syringe.
11. Label specimen.
12. Transport specimen on crushed ice. The specimen should be cool not frozen.
13. After 5 minutes, check the puncture site for any sign of haematoma or bleeding and if ok, apply the pressure bandage.
14. Recommence O_2 therapy if needed.

Interpretation

REFERENCE RANGES

Normal ABG values have the following ranges:

PO_2	75-100
PCO_2	35-45
pH	7.35-7.45
HCO_3	22-33
Base Excess	+/- 3
O_2 saturation	95-98%

Approach To Interpretation Of Results

1. **Acidemic or Alkalemic**

The pH identifies the disorder as alkalemic or acidemic. The average pH value of arterial blood is 7.4.

Cells are sensitive to changes in pH and normal functions do not occur far outside the normal range. Therefore, it is important to remember that the body does what it can to maintain a normal pH balance, which is referred to as compensation, and may be complete, partial or absent.

A patient may compensate for an underlying disorder by keeping the pH in the normal range. This is complete compensation.

Partial compensation occurs when the body is unable to bring the pH back to normal, but the compensatory PCO_2 or HCO^-_3 values are abnormal.

Compensation is absent when the expected compensatory value is still within the normal range.

2. **Respiratory or Metabolic**

A respiratory disturbance alters the arterial PCO_2.
PCO_2 is the partial pressure of carbon dioxide in the artery and is our best indicator of alveolar ventilation. Carbon dioxide is regulated by the lungs, so an abnormality gives either a respiratory alkalosis or acidosis.

- PCO_2 < 35, respiratory alkalosis
- PCO_2> 45, respiratory acidosis

A metabolic disturbance alters the HCO^-_3.
Bicarbonate is a base that is regulated by the kidneys, and is slower to change than PCO_2. Abnormalities in this value reflect the metabolic component to acid-base balance.

- HCO^-_3 <22, metabolic acidosis is present
- HCO^-_3 >33, metabolic alkalosis is present

3. Respiratory Compensation

The respiratory system responds quickly to metabolic disturbances.

Metabolic Acidosis

If a metabolic acidosis is present, Winter's formula may be used to determine the respiratory response. The change in PCO_2 shows a linear correlation with the change in HCO^-_3.

Winter's Formula:

Expected PCO_2= (1.5 x HCO^-_3) + (8)2)

In the case of a simple metabolic acidosis, the measured PCO_2 will fall within the range determined by the above equation. If a respiratory disturbance is coexisting with the metabolic acidosis, then it is determined by the direction the PCO_2 varies outside the range given by the equation. Therefore, if the measured PCO_2 is below the range, a respiratory alkalosis is also occurring and if the measured PCO_2 is above the range predicted by the equation, a respiratory acidosis is also occurring.

Metabolic Alkalosis

Winter's equation does not predict the respiratory response to a metabolic alkalosis. When present, the respiratory response to metabolic alkalosis is hypoventilation. Generally, there are two (2) points to note for respiratory response to metabolic alkalosis:

- To compensate for metabolic alkalosis, the PCO_2 will increase to >40 but not greater than 50-55
- If the PCO_2 is elevated to compensate for a metabolic alkalosis, the pH will be alkalemic (If the pH is acidemic, then an additional respiratory acidosis is present in the patient)

4. Acid-Base Disorders and Causes

Respiratory Acidosis

Respiratory acidosis occurs with hypoventilation which is manifested by the accumulation of CO_2 in the blood and a drop in blood pH and can be the result of rapid, shallow breathing or decreased respiratory rate. Causes include:

- Pneumothorax
- Foreign Body Obstruction
- Central Nervous System Depression eg sedatives, CNS disease, obesity, obstructive sleep apnoea, opiods
- Musculoskeletal disorders eg Guillain-Barre, Myasthenia Gravis

Respiratory Alkalosis

Respiratory alkalosis occurs with hyperventilation, resulting in excess elimination of CO_2 from the blood and a rise in blood pH. Causes include:

- Anxiety
- Pneumonia
- Pregnancy

- Asthma
- Pulmonary embolism
- Brain injury
- Drugs (salicylates, progesterone)

Metabolic Acidosis

Metabolic acidosis results from an accumulation of acidic metabolites and is characterised by a low bicarbonate levels. Causes include:

- Renal failure
- Ketoacidosis eg diabetic hyperglycaemia, alcohol withdrawal
- Intoxication
- Drugs eg salicylates

Metabolic Alkalosis

Metabolic alkalosis results in an elevation of HCO^-_3. Causes include:

- Vomiting
- Diarrhoea
- Alkali ingestion
- Hypokalemia
- Hyperaldosteronism
- Cushing's Syndrome

5. Oxygenation

Measurement of PO_2 is not necessary to determine if acidosis or alkalosis. Instead, it is a measure of hypoxemia, which is generally a PO_2 <75mmHg. PO_2 is effected by the amount of oxygen in the air we breathe, the depth and rate of breathing, amount of air reaching the alveoli and the amount that can move across the alveolar/capillary barrier. The PO_2 can also give you added information about your patient's underlying disease condition, whether it is COPD, pneumonia or another pulmonary condition. Normal PO_2 levels also decrease with age. Decreased PO_2 is seen with hypoventilation, ventilation/perfusion mismatch, alveolar-capillary block and right to left shunt. Increased PO_2 may be seen in hyperventilation or oxygen therapy.

The PO_2 and O_2 saturation allows the oxyhaemoglobin dissociation curve to be used in the assessment of a patient's ABGs. The curve shows that PO_2 levels above 60mmHg provide saturation levels greater than 90%. There is minimal clinical significance between 90-98% saturation.

When evaluating a patient's oxygenation, it is important to also take into account the haemoglobin level and the patient's cardiac output.

6. Base Excess

Base excess is a measurement reflecting the metabolic component of the acid base balance. It is a positive or negative value, depending on the direction the buffer base has deviated. A positive value indicates that either a base has been added or acid removed and a negative value (base deficit) indicates that acid has been added or removed.

Base excess is decreased in metabolic acidosis and compensated respiratory alkalosis. It is increased in metabolic alkalosis or compensated respiratory acidosis.

Summary Of Interpretation Of Results

		pH	PCO_2	HCO^-_3
METABOLIC	**ACIDOSIS** - Diabetes - Intoxication - Renal Failure	↓	↓	↓/-
	ALKALOSIS - Vomiting - Diarrhoea	↑	↑	↑/-
RESPIRATORY	**ACIDOSIS** - Pneumothorax - Foreign Body Obstruction	↓	↑/-	↑
	ALKALOSIS - Anxiety - Pregnancy - Pulmonary Embolism - Asthma - Pneumonia	↑	↓/-	↓

EXAMPLE

PH 7.37
PCO_2 20
PO_2 94
HCO_3 11

- The pH value of 7.37 falls within the normal range but is on the lower end of the range.
- The CO_2 value of 20 is below the normal range, indicating a respiratory disturbance.
- The HCO_3 value of 11 indicates a metabolic acidosis.
- Winter's Equation predicts a range of 22.5-26.5. This is below the range predicted by the equation indicating a respiratory alkalosis is also occurring.
- The compensating respiratory alkalosis has raised the pH back into the normal range and is therefore complete.

Conclusion: Metabolic acidosis with compensating respiratory alkalosis.

Reflection Exercises

QUESTIONS ASSOCIATED WITH PROCEDURES

Complete these at your leisure. These are the types of questions you may be asked by your assessor.

1. **Describe the steps in performing an Allen's Test and the reason for doing the test.**

2. **List the steps in the collection of arterial blood gases.**

3. **List the causes of a Respiratory Alkalosis**

4. **Interpret the following results**

pH	7.55
PCO_2	28
HCO_3	24

Resources

Allen, A. (1991) *Core Curriculum for Post Anaesthesia Nursing Practice*. Philadelphia: Saunders

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Nairns, R.G. (1980) *Simple and Mixed Acid-Base Disorders: A Practical Approach*. Medicine 59:161-187

Price, S and Wilson, L (1986*) Pathophysiology: Clinical Concepts of Disease Processes* New York: McGraw Hill

Rippe, J. and Irwin, R. et al. (1995) *Procedures and Techniques in Intensive Care Medicine*. USA: Library of Congress Cataloging-in Publication Data

Romanski, S.O. (1990) *Interpreting ABGs in Four Easy Steps* Critical Care Choices 18-22,25

Royal Australian College of Pathologists of Australasia (1997) *Manual of Use and Interpretation on Pathology Tests*. Maryborough, Victoria: Australian Print Group

Illustrated Guide to Diagnostic Tests (1994) P.A. USA: Springhouse Corporation

Clinical Competency Form
Arterial Blood Gases

Achieved **Not Achieved**

- Explains the procedure to the patient
- Correctly performs Allen's Test
- Prepares equipment, including hand washing
- Performs arterial blood gas collection successfully
- Interprets set of results correctly

Date : ___________________ **Achieved** p **REASSESS** p

Assessee Name : _____________________ **Assessee Signature :** ______________

Assessor Name : _____________________ **Assessor Signature :** ______________

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Please detach and return to the Director of Clinical Training for recording of your competency.

Clinical Competency Form
Arterial Blood Gases

Date: ____________________ **Achieved** p **REASSESS** p

Assessee Name: ___________________ **Assessee Signature:** __________________

Assessor Name: ___________________ **Assessor Signature:** __________________

MEC – Medical Received π Date: ___________________