Clinical Skills

Arterial Puncture (PDF version)

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Clinical Skills and Simulation Team

Clinical Skills + Simulation Centre
Aims & Outcomes

The aim of this module is to facilitate learning regarding the purpose and procedure of Arterial Puncture.

Learning Outcomes

At the end of the session the student should be able to:

- Define the reasons why obtaining an arterial blood sample may be necessary.
- Understand the need for asepsis and analgesia with arterial puncture.
- State the common risk factors that may arise as a result of the procedure being carried out.
- Discuss the reason why obtaining an arterial blood sample may be contraindicated.
- List the information required for the completion of patient care plan documentation.
- Demonstrate, to a level expected of the students stage of training, a degree of competence in the interpretation of arterial blood gas results.
- Evaluate own learning and recognise how improvements can be made.
**Introduction**

For most blood tests, venous blood is adequate, but for blood bases and pH, an arterial sample of blood is required. This is usually required in patients with respiratory disease, where an arterial measurement of oxygen and carbon dioxide partial pressures and pH are more useful measurements than the venous equivalent. Along with these measurements, bicarbonate levels and a derived value (base excess) are also reported. These readings can be particularly important in illnesses that may lead to metabolic acidosis. Such illnesses include: liver failure, renal failure, diabetic ketoacidosis and multi-organ failure.

<table>
<thead>
<tr>
<th>NORMAL VALUES:</th>
<th></th>
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<tbody>
<tr>
<td>pH</td>
<td>7.35 – 7.45</td>
</tr>
<tr>
<td>$pO_2$</td>
<td>11 – 13 kPa</td>
</tr>
<tr>
<td>$pCO_2$</td>
<td>4.7 – 6.0 kPa</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>22 – 26 mmol/l</td>
</tr>
<tr>
<td>Base</td>
<td>0 +/- 2</td>
</tr>
<tr>
<td>Saturation</td>
<td>94 – 100%</td>
</tr>
</tbody>
</table>

The partial pressure of oxygen ($pO_2$) and carbon dioxide ($pCO_2$) are reported in both millimetres of mercury (mmHg) and kilopascals (kPa) in the UK. Plasma acidity may be reported as the hydrogen ion concentration [H+] or the negative logarithmic value, the pH. The most commonly used dimensions will be used for the rest of this article.
Introduction

As a rule of thumb, a low pO₂ generally indicates the need for oxygen to be administered because of a problem with lung diffusing capacity. The pCO₂ may also reflect this, but more commonly reflects alveolar ventilation in the lungs. A low pCO₂ suggests hyperventilation, a high pCO₂ respiratory failure or hypoventilation. A low pH indicates an acidaemia, which may be respiratory or metabolic in origin. The base excess is a calculation based on both the pH and the pCO₂, with a negative value suggesting a metabolic acidosis and a positive value indicating a metabolic alkalosis.

When arterial samples are required on a regular basis, an arterial catheter is commonly used. This is a small bore plastic catheter similar to an intravenous catheter. Because of the extremely serious consequences of a drug being mistakenly injected into an intra-arterial catheter, this technique tends to be used only where direct supervision of staff is possible (such as in an operating theatre or on a critical care unit). In these circumstances, direct blood pressure measurement is the main reason for arterial catheter insertion.

For arterial blood sampling, the radial artery at the wrist is most commonly used. It is superficial, easy to palpate and almost always present in the same location. There is usually a good collateral circulation to the hand (from the ulnar artery) in the event that the radial artery is damaged by the procedure.
**Allen’s Test**

This is a test used to assess the collateral circulation of the hand prior to performing arterial puncture. The arterial blood supply to the hand is supplied by both the radial and the ulnar arteries. If either the radial or the ulnar artery is patent, an adequate blood supply will flow to the hand. If both blood supplies are impaired, ischaemia may develop. It is a good idea, therefore to assess the ulnar blood supply before radial arterial puncture. If the ulnar blood supply is inadequate, assess the other hand. If the blood supply to both hands is poor, consider first of all whether the test is necessary. If it is, then other arteries such as the dorsalis pedis artery in the foot or the femoral artery may be more suitable.

The value of Allen's test is disputed, but it seems sensible to assess collateral circulation of the hand prior to a procedure that could, in principle damage the radial artery. The modified test uses a pulse oximeter on a finger to assess the return.

*Fig 1. Anatomy of the collateral arterial supply to the hand.*
Performing the Allen’s Test

- Identify both the radial and ulnar artery pulses in the patient's arm
- Ask the patient to clench their fist as tightly as possible.
- Press hard over both ulnar and radial arteries

- Ask the patient to unclench their hand. The hand should be exsanguinated (appear white)

- Release the pressure on the ulnar artery. If colour returns to the hand within 2 seconds, the collateral blood supply from the ulnar artery is adequate.

The modified Allen’s test uses a pulse oximeter on a finger to assess the return of circulation more objectively than simple visual appearance of the hand.
Arterial blood sampling syringes need to contain an anticoagulant such as heparin to prevent the blood clotting, since fluid blood is required for this test. Commercial syringes are usually available, containing heparin in tablet form within the syringe. If this is not available, use an aspirating needle to draw up approximately 0.1ml amount of 1:1000 heparin from an ampoule (in the fridge) into a 2ml syringe. Remove the needle safely, replace with fresh blue needle, and squirt out all except the small amount that will remain in the needle hub. This is an adequate amount to prevent the blood coagulating. Larger amounts will dilute the specimen and should be avoided.

The pressure of arterial blood is usually adequate to push the barrel of the syringe out when obtaining the sample. If this does not occur, avoid excessive suction when obtaining the sample. This will reduce the gas content in the sample, giving an inaccurately low reading. For this reason, vacutainers cannot be used for sampling arterial blood.
Complications

Failure to obtain a sample of blood is the most common complication. Another common complication is haemorrhage or haematoma, and is most likely to occur if inadequate pressure is applied to the artery following puncture.

Other complications are far more rare. The arterial wall may become aneurysmal due to damage, most likely following multiple attempts in the same area. Thrombosis may also occur under these circumstances. Intra-arterial infection is rare following simple puncture, but is far more likely following long-term cannulation. However, if a large haematoma is present, this could impair arterial blood supply by both direct pressure and potential infection. Under these circumstances, intra-arterial thrombosis is again more likely to occur.
Complications

It is possible to mistakenly puncture both veins and nerves in attempts at arterial puncture. Venous puncture will produce dark blood, reluctantly flowing back into the syringe in a non-pulsatile manner. Shooting pains ("like an electric shock") may be reported if a nerve is being damaged. In both these situations, the landmarks should be re-evaluated and another attempt made at a different site.

Following puncture (or attempted puncture), the artery will almost certainly go into spasm and the pulse will become impalpable. This is not harmful, and the normal pulsation should return after a few minutes. If there is evidence of ischaemia to the hand that does not resolve after a few minutes, senior advice should be sought.
### Indications
- Measurement of blood oxygen tension
- Measurement of blood carbon dioxide tension
- Measurement of acidaemia / alkalaemia (pH)
- Measurement of bicarbonate and base excess

### Contra-Indications
- Local infection around predicted puncture site
- Lack of consent
- Negative Allen’s Test

### Risks
- Pain
- Failure to gain arterial sample: go to another site or ask for help
- The sample obtained is in fact venous
- Bleeding
- Haematoma Formation
- Infection at puncture site
- Ischaemia of hand or fingers due to emboli, spasm, aneurysm formation or thrombosis
Arterial Puncture
Procedure

Procedure

☑ Check that the patient details are correct from questioning and the wrist band. Explain the procedure to the patient (indicating why the procedure is required) and any discomfort that may be anticipated. Ask whether the patient is right or left-handed.

☑ On the non-dominant hand, assess the collateral circulation using Allen's Test. If this is OK, prepare the hand.

Obtaining an arterial blood sample is an uncomplicated invasive procedure. Therefore, a standard aseptic technique is required, utilising specific care of the ‘key parts’ and ‘key parts’

If you are unsure of this technique revisit the Aseptic Technique E-Tutorial
Arterial Puncture
Procedure (1)

Procedure

 ✓ Extend the hand over a rolled-up cloth or bag of fluid. Palpate the radial artery about 2-3cm proximal to the wrist where it is most superficial. If necessary, mark the spot with a pen.
Put on some gloves and clean the area with an alcohol swab. Wait for it to dry before needle insertion. This usually takes approximately 30 seconds.
Local Anaesthetic

Local anaesthetic can be offered to patients particularly anxious about the procedure however is not always used.

If administering local anaesthetic:

- After warning the patient, infiltrate the skin immediately over the artery with about 1 ml of 1% lidocaine.
Types of Syringes

**Pre-filled syringes with liquid heparin** – need to have the liquid expelled out of the syringe through needle which will be used to obtain the blood sample. No heparin should remain in the syringe as this affects the results. These syringes will easily self-fill and do not require any aspiration.

**Syringe with heparinised paper** – need to be primed. Move the plunger base to the level you want to fill to (0.5 - 2 ml), when needle inserted into artery no aspiration required as will fill the air space only.

**Syringes requiring pre-heparinisation** – Prepare a 2ml syringe and blue (23G) needle draw up approximately 0.1ml of 1:1000 heparin from an ampoule (in the fridge) into the syringe. Remove the needle safely, replace with a fresh blue needle, and expel all heparin except the small amount that will remain in the needle hub.
Tell the patient that a “sharp scratch” is on the way, then slowly insert the needle through the skin toward the point of maximal pulsation.
Top Tip – Angle of the Needle

When taking a sample of blood from an artery, there are two schools of thought in regards to the angle at which the needle should be inserted.

Some recommend approaching the artery at a 30 degree angle, while others recommend a 90 degree angle.

You should use whichever approach works best for you.
Allow the syringe to fill in accordance with the type of syringe used until a volume of between 0.5 – 2 ml of blood is obtained.

Never aspirate whilst in the artery as this causes pressure and could lead to the artery going into spasm or further damage being caused.
Press on the puncture site with a gauze swab for five minutes until bleeding from the site has stopped.

Avoid allowing the patient to complete this step as they are unlikely to apply the required pressure.

Observe the site for up to 5 minutes for evidence of haematomas or localised swelling.
Remove excess air from the syringe and cap the end. Some syringes have filter caps to enable removal of air with the cap in place.
Procedure

✓ Dispose of needles and gloves in an appropriate manner. Label the syringe with the patient's name, date of birth and hospital number. Fill in the blood form with the same details as well as clinical information required. Ensure that the patient details match the information on the patient's wrist band. Record in the patient notes that an arterial sample of blood has been taken.

✓ Alert the laboratory that the arterial blood sample is on the way. The quality of arterial blood samples deteriorate rapidly, so the test needs to be performed as soon as possible. In some hospitals a near-patient device may be available for performing arterial blood gas estimations. Only a trained person should use these machines, so check the local hospital procedures.

✓ After a few minutes, when pressure on the puncture site has been removed, check the site for bleeding or haematoma formation. More pressure may be required if either are present.

✓ Check the puncture site for haematoma and the hand for ischaemia. If ischaemia is present the hand will be white in appearance and will not blanch with digital pressure. If this is persistent, senior advice is required.
**Tips**

- Some operators use a 90 degree angle for needle insertion, others use a more shallow angle as in venous catheterisation. There is little evidence to suggest that one technique is better than the other - whatever works consistently for you is good.

- If the needle has entered the skin to an appropriate depth and no blood has been obtained, then there are two usual reasons for this. Either the artery has been missed or the needle has penetrated both walls of the artery without flash-back. If this occurs, slowly withdraw the needle, applying a small amount of suction till arterial blood flows freely into the syringe.

- If the artery has been penetrated without obtaining blood, it will go into spasm for a few minutes, making further attempts futile during this time. The other radial artery may need to be used. Repeated attempts will increase the chances of complications, so after each failed attempt, balance the risk of complications against the benefit of obtaining a sample. A more experienced operator may be required in difficult cases.
Interpreting Arterial Blood Gas Results

A systematic approach is important when interpreting ABG results, by not doing so important information could be overlooked.

The Resuscitation Council UK have provided a 5-step approach to arterial blood gas interpretation:

**Step 1: How is the patient?**
This will provide valuable clues to help with interpretation of the results. Try and predict the effect on the blood gases of the pathological process.

**Step 2: Assess oxygenation**
Is the patient hypoxaemic?
The PaO\textsubscript{2} should be > 10kPa (75mmHg) on air and about 10kPa less than the % inspired concentration.

**Step 3: Determine the pH or H\textsuperscript{+} concentration**
Is the patient acidaemic; pH < 7.35 (H\textsuperscript{+} > 45 nmol l\textsuperscript{-1})
Is the patient alkalaemic; pH > 7.45 (H\textsuperscript{+} < 35 nmol l\textsuperscript{-1})
The Resuscitation Council UK’s 5-Step Approach to Arterial Blood Gas Interpretation

**Step 4: Determine the respiratory component**

- **PaCO2** > 6.0 kPa (45 mmHg) – respiratory acidosis (or respiratory compensation for a metabolic alkalosis)
- **PaCO2** < 4.7 kPa (35 mmHg) – respiratory alkalosis (or respiratory compensation for a metabolic acidosis)

**Step 5: Determine the metabolic component**

- **HCO3⁻** < 22 mmol l⁻¹ – metabolic acidosis (or renal compensation for a respiratory alkalosis)
- **HCO3⁻** > 26 mmol l⁻¹ – metabolic alkalosis (or renal compensation for a respiratory acidosis)

Some clinicians prefer to use the base excess / deficit instead of the bicarbonate. The changes in these values tend to mirror each other and therefore makes no significant difference to the interpretation of the clinical condition.

Draw all of the information together to produce a final diagnosis of the primary disturbance, any degree of compensation and any indication of disturbance of oxygenation.
Case Study
Consider the following case example and use the 5-Step Approach to Arterial Blood Gas Interpretation to determine the diagnosis.

Initial Information
A 23-year-old male is thrown from his horse at a national event. On the way to the hospital he becomes increasingly drowsy and the paramedics have inserted an oropharyngeal airway and given high flow oxygen via a face-mask.

An arterial blood gas sample has been taken

Arterial Blood Bas Analysis Reveals: 40% (FiO₂ 0.4)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Normal Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>PaO₂</td>
<td>18.8 kPa</td>
<td>&gt; 10 kPa (75 mmHg) on air</td>
</tr>
<tr>
<td>pH</td>
<td>7.19</td>
<td>7.35 – 7.45</td>
</tr>
<tr>
<td>PaCO₂</td>
<td>10.2 kPa</td>
<td>4.7 – 6.0 kPa</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>23.6 mmol l⁻¹</td>
<td>22 – 26 mmol l⁻¹</td>
</tr>
<tr>
<td>Base Excess</td>
<td>-2.4 mmol l⁻¹</td>
<td>+/- 2 mmol l⁻¹</td>
</tr>
</tbody>
</table>
**Case Study - Interpretation**

**Step 1: How is the patient?**

The reduced level of consciousness and obstructed airway will impair oxygenation and ventilation, causing an increased PaCO₂, a respiratory acidosis. There is unlikely to be much compensation (change in bicarbonate) because of the acuteness of the situation.

**Step 2: Assess oxygenation**

The PaO₂ should be about 10 kPa less than the % inspired concentration. In this patient the gradient is increased suggesting impaired oxygenation.

**Step 3: Determine the pH or H+ concentration**

The patient is acidaemic; pH < 7.35

**Step 4: Determine the respiratory component**

The pH < 7.35, and the PaCO₂ > 6.0 kPa (45 mmHg) indicating a respiratory acidosis

**Step 5: Determine the metabolic component**

The pH < 7.35, but the HCO₃⁻ is within normal limits, indicating no metabolic disturbance or compensation
Case Study – Summary and Treatment

**In Summary:**
An acute respiratory acidosis with impaired oxygenation

**Treatment will include:**
Improving the airway and ventilation to reduce the PaCO2, particularly as the patient may have a significant head injury.
Arterial Puncture
Checklist (1)

- Wash hands
- Explain to the patient why you need to take blood
- Ascertain patient’s ‘handedness’
- Inspect and palpate radial artery on the non-dominant side
- Put on gloves
- Clean skin over artery using an appropriate skin disinfectant and allow to dry
- Take a 2ml syringe and draw up small volume of heparin. Discard needle safely and attach new needle (blue), and expel Heparin **OR** use a pre-heparinised syringe.
- Palpate artery with non-dominant hand
- Hold syringe in dominant hand
- Insert needle through skin towards artery
- Apply gentle traction on plunger as you advance needle
- On arterial puncture, allow syringe to fill
- Remove needle from artery
Apply pressure to the puncture site for 5 minutes
Discard needle in sharps bin
Remove excess air from syringe
Apply cap to syringe
Label syringe with patient's details
Complete the request form giving patient details
Send immediately to the laboratory
Check puncture site and apply a suitable dressing
Discard gloves in appropriate container
Students should now be able to:

- Define the reasons why obtaining an arterial blood sample may be necessary.
- Understand the need for asepsis and analgesia with arterial puncture.
- State the common risk factors that may arise as a result of the procedure being carried out.
- Discuss the reason why obtaining an arterial blood sample may be contraindicated.
- List the information required for the completion of patient care plan documentation.
- Demonstrate, to a level expected of the students stage of training, a degree of competence in the interpretation of arterial blood gas results.
- Evaluate own learning and recognise how improvements can be made.
Arterial Puncture

References


E-tutorial review completed by RT August 2015
Web Resources

http://www.resus.org.uk/

Aseptic Non Touch Technique. The Association for Safe Aseptic Practice
www.ant.org