GIPPSLAND HEALTH SERVICES CONSORTIUM

ARTERIAL CATHETERISATION, INVASIVE BLOOD PRESSURE MONITORING & BLOOD GAS INTERPRETATION

Self-directed Learning Package

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CPD Points
4: SDLP
1: Competency Assessment
Total: 5 points

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Contents

INTRODUCTION

Welcome to the arterial catheterisation & invasive blood pressure monitoring self-directed learning package.

Arterial line insertion and invasive blood pressure monitoring is a common occurrence in high acuity patients or patients who are critically ill. This package has been created to provide nurses with the fundamentals of arterial line management and the skills and knowledge to assist with the insertion and management of an arterial line.

Arterial line insertion is an invasive procedure which involves risk, therefore nurses working within the critical care/high acuity environment must be knowledgeable and competent to help ensure safe and effective use of this valuable monitoring tool.

Arterial line insertion and system management will be discussed in detail with both theoretical and practical information included. Assessment within the package includes both short answer and multiple-choice questions which can be submitted to the Education Department for marking. The registered nurse will be required to complete a competency skills-based assessment. This can be done either in the workplace or as a Simulation session with a Clinical Educator/Clinical Development Nurse.

Please read this package in conjunction with relevant policy/procedure and guidelines at your local health service.

OBJECTIVES

The registered nurse, upon completion of this package, should be able to:

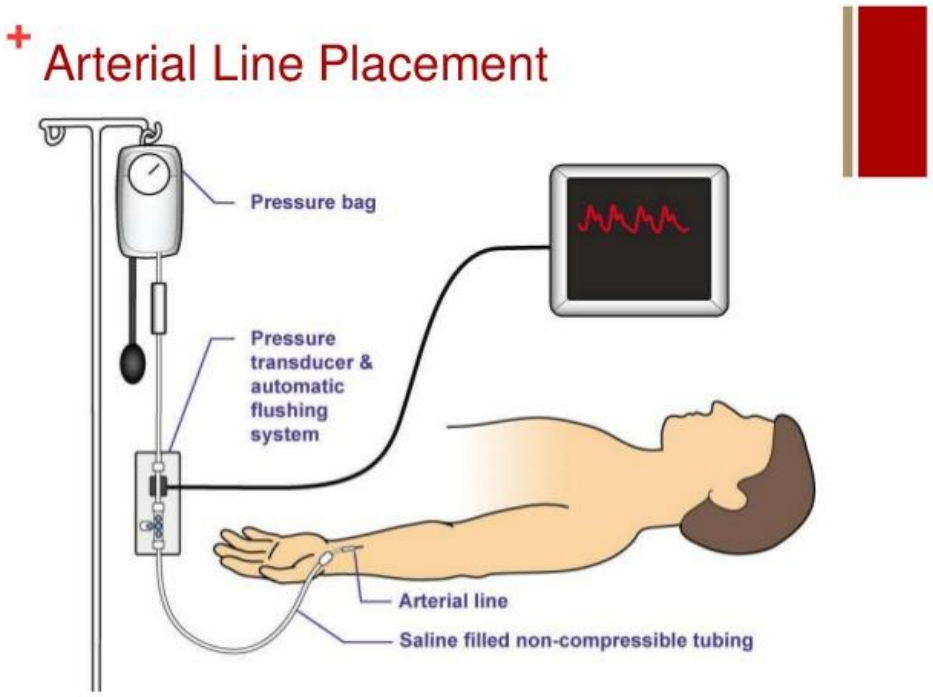
1. Describe indications and contraindications for insertion of an arterial line.
2. Safely and competently prepare for and assist the medical officer with the insertion of an arterial line whilst maintaining the principles of ANTT.
3. Explain actual and potential complications of arterial line insertion and monitoring.
4. Identify components of an arterial waveform and demonstrate an understanding of over/under dampened wave forms.
5. Demonstrate trouble shooting of an arterial line to ensure safety and accuracy of trace & readings.
6. Outline specific nursing care and responsibilities when managing a patient with arterial monitoring including infection control and safety principles (escalation of care).
7. Identify normal and abnormal blood gas values, accurately interpret disturbances to these values and identify potential causes.

Arterial (invasive) Blood Pressure Monitoring

Critically unwell patients require constant observation to enable early identification and management of deterioration. Arterial line insertion enables continual (beat to beat) monitoring of blood pressure.

Arterial blood pressure monitoring (invasive blood pressure monitoring) involves the insertion of a catheter into an artery which is in turn connected to a transducer set which connects to a monitor. The transducer is primed with fluid and attached to a pressurised bag. An arterial line reflects changes in the systemic pressure from the insertion site. Arterial pulsations travel along the fluid to the transducer where it is converted to an electrical signal that is displayed as a wave form and a numerical value on the monitor. This allows for continuous measurement of systolic, diastolic and mean arterial blood pressure (MAP).

The tubing containing fluid is made to a specific compliance being stiffer and less compressible than usual IV tubing to produce an optimal waveform unaltered from inadvertent external pressure. Fluid is pressurized using a pressure bag to 300mmHg; this causes a continuous infusion of fluid at a rate of 3ml/hour which helps to prevent clot formation and waveform dampening. The pressure in the bag (300mmHg) is higher than the patient's blood pressure which prevents back flow into the line, while also allowing a manual flushing mechanism which enables clearing of the line post blood sampling Advantageously arterial lines enable frequent drawing of blood for pathology testing including blood gases whilst preventing repetitive venepuncture or arterial punctures.



INSERTION

Arterial line insertion is an invasive procedure requiring ongoing observation and care to maintain patient safety & accuracy of arterial monitoring. Insertion of an arterial line is a procedure done by a Medical Officer with the required training however it is a nursing responsibility to set up, assist with insertion and manage the line once inserted. Arterial lines are generally inserted in the departments where high acuity/critically ill patients are being cared for. Please refer to your local health service guidelines regarding this.

Indications for insertion:

- Critically ill patient with haemodynamic instability or potential for
- Acute acid/base disturbances
- Patients requiring inotropic or vasopressor support
- Major surgical cases or high acuity surgical patients
- Mechanically ventilated patients
- Patients requiring frequent blood gas analysis or blood sampling (Clermont et al, 2024)

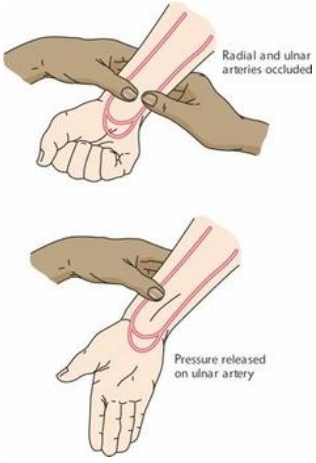
Contraindications:

- Limbs where an 'Allen's test' shows poor ulnar artery circulation (see explanation further down the page: Allen's test)
- A patient's coagulation status should also be considered prior to insertion as haemorrhage can occur, haematoma formation can lead to distal ischemia
- A limb or insertion site where there is active infection or ischemia
- A limb with a surgical shunt (Haemodialysis fistula) (Monash Health, 2020)

The most common insertion site is in the radial artery; however, a femoral or brachial artery may also be used. The radial artery is the preferred site as it is easily accessible, superficial, easily palpable, and can be easily inspected for complications. The radial artery is preferred due to the tissues having collateral circulation via the ulnar artery helping to reduce the risk of ischemia should arterial occlusion occur due to haematoma formation. An 'Allen's test' should always be performed by a medical officer prior to insertion to assess collateral circulation to the hand (Nutbeam et al, 2010).

Allen's Test:

- Ask the patient to present their hand palm side up
- Occlude the patient's radial and ulnar arteries simultaneously by direct pressure using both thumbs
- Elevate the patient's hand and ask them to make a fist before opening the hand again to reveal blanching to the palm, in the unconscious patient their hand can be gently squeezed until it blanches
- Lower the hand
- With the hand open release, the ulnar artery whilst maintaining direct pressure over the radial artery
- Observe hand for return in colour – this should occur in than 5-15 seconds to indicate **adequate** ulnar blood supply: positive Allen's test (World health Organisation, 2010).



- If this does not occur the ulnar circulation is **inadequate** negative Allen's test and the radial artery should not be used (Cameron et al, 2020).

Arterial line insertion is conducted using surgical aseptic non-touch technique and requires the use of a critical aseptic field (NHMRC 2019). Care should be taken throughout preparation of the equipment to ensure that asepsis is maintained in accordance to the principles of aseptic non-touch technique (ANTT) (NHMRC 2019). The transducer, fluid bag and pressure bag should be assembled prior to insertion of the arterial line using ANTT protecting key sites and key parts (NHMRC 2019). It should be prepared and primed ready for connection immediately after insertion of the arterial catheter. This helps to prevent contamination and ensures the line is primed and free from air bubbles prior to contact with the patient.

Equipment:

- Sterile dressing pack, drapes, sterile gloves & PPE
- Chlorhexidine 2% in 70% alcohol
- Local anaesthetic (MO's preference)
- Transparent occlusive dressing
- Arterial cannula of choice set. This will also be dependent on-site selection
- Transducer set & labels
- 500ml bag 0.9% Sodium Chloride, monitor cable & pressure bag
- Arm board/splint
- Suture set and suture or securement device e.g. stat lock

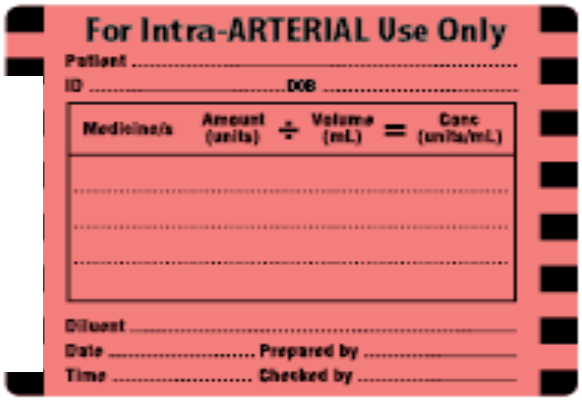
Procedure:

- Ensure hand hygiene throughout & DON PPE (Medical Officer & RN setting up equipment)
- Open transducer and check connections
- Check, label and date 0.9% sodium chloride (500ml bag)
- Complete & attach labels
- Prime transducer line carefully ensuring that any air bubbles are expelled. Flush as much as needed to ensure it is primed entirely with fluid (use fast flush device)
- Remove access cap and replace with non-vented cap (found in transducer pack)
- Place bag of 500ml 0.9% sodium chloride into pressure bag and inflate to 300mmHg
- Connect monitor cable to monitor and transducer. Level transducer & zero (maybe done when attached to patient check your local guideline). Information on zeroing & levelling the transducer is in the next section of the SDLP
- Open all equipment, on to the critical aseptic field applying principles of ANTT
- Open sterile gloves on separate aseptic field
- Medical Officer to insert arterial line, attach transducer line, suture or secure with securement device and cover with dressing
- RN to pass transducer line over palm (patient) and pass between thumb and index finger; passing back to run up forearm and secure with tape/hyperfix.
- Using an arm board secure the patients wrist in a slightly extended position
- Ensure limb & lines exposed for observation

Labelling of Arterial Lines:

Please ensure that all arterial lines have labelling applied which complies with the standards set out by Australian Commission on Safety and Quality in Healthcare (ACSQHC, 2015)
Arterial line labels must be red:

- Include the route (arterial)
- Date and time of commencement
- A label must be placed near the port on the patient side



Depending on local guideline date & time on fluid bag

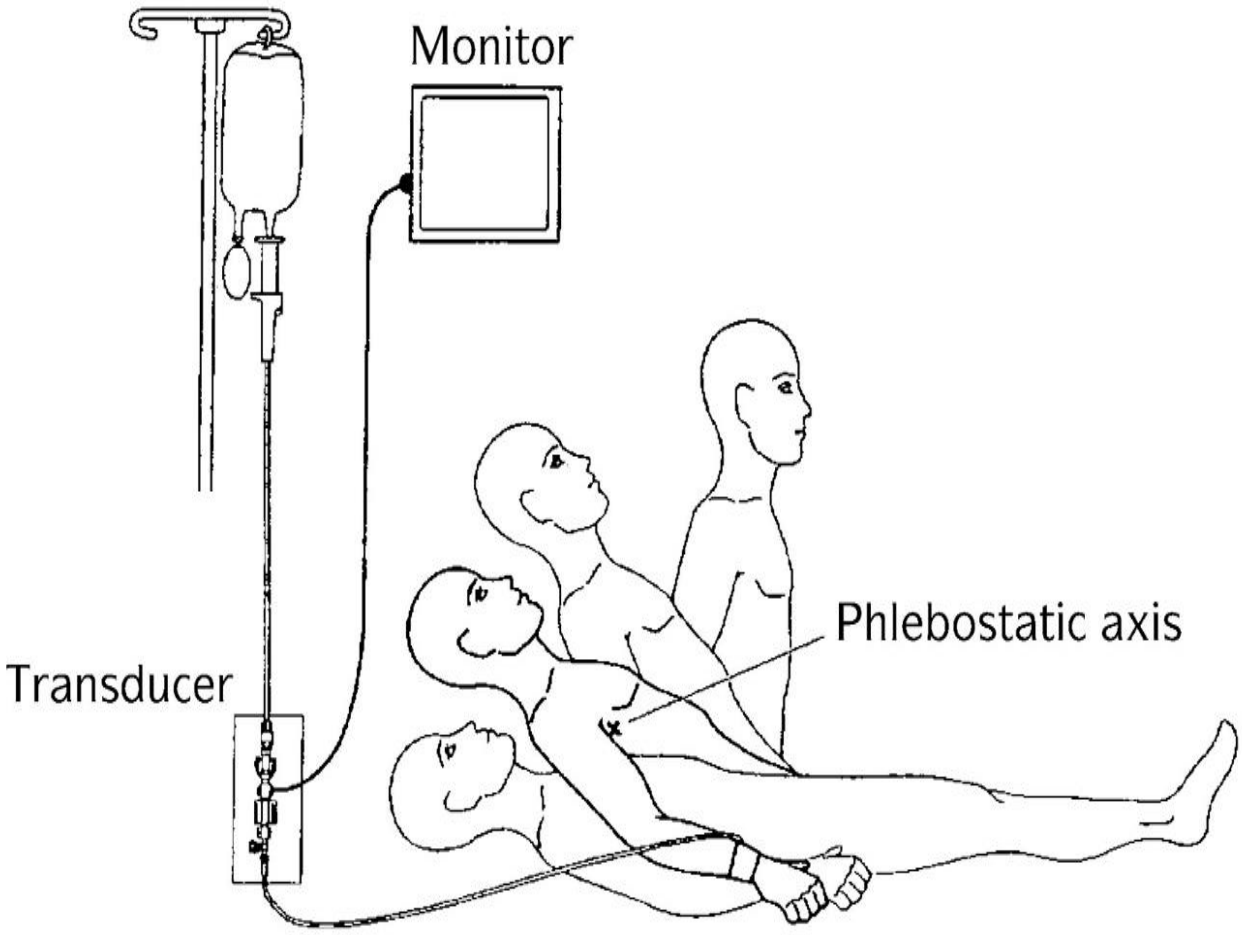
https://www.safetyandquality.gov.au/publications/national-standard-for-user-applied-labelling/

LEVELLING & ZEROING THE TRANSDUCER

Levelling against phlebostatic axis and zeroing are essential components of set up and ongoing care to ensure accuracy of blood pressure readings and trace.
A description of each will be discussed in this section.

Levelling:

Levelling the transducer at the phlebostatic axis eliminates the influence of hydrostatic pressure on the transducer and subsequently readings.
In a supine patient with the head of the bed at less than 60° the phlebostaic axis is located external to the right atrium at the fourth intercostal space, mid axilla line.
The phlebostatic axis provides a reference point for zeroing and helps ensure accuracy of readings. A transducer positioned above the axis (patient's heart) will produce falsely low BP pressure readings, conversely if positioned below the heart falsely high-pressure BP readings. (Iversen, 2021)
Zeroing of the device without levelling of the transducer can cause inaccurate readings and may result in mismanagement of a patient. (Iversen, 2021)



Zeroing:

Zeroing the transducer on the patient monitor eliminates the effect of atmospheric pressure on measured haemodynamic values. (London Health Sciences Centre, 2015)

The transducer should be zeroed following set up of lines and connection to monitor and

- At the commencement of a new shift
- After change in patient position
- Following interruption to or change to any component of the system
- As a troubleshooting technique.

Zeroing Procedure:

- Inform staff/patients that you are zeroing the arterial line as monitors may alarm and may need to be silenced for a short time
- Ensure transducer is located in alignment with the level of the phlebostatic axis (as outlined on previous page)
- Turn the tap on the transducer "off" to the patient
- "Open to air" by removing the non-vented cap on the access port
- Access ART in the monitor and select 'zero'
- Check that the wave form flattens and the monitor reads 'zero'
- Turn tap 'off to air'
- Replace cap with new non-vented cap
- Open tap to patient

Example of an arterial transducer set

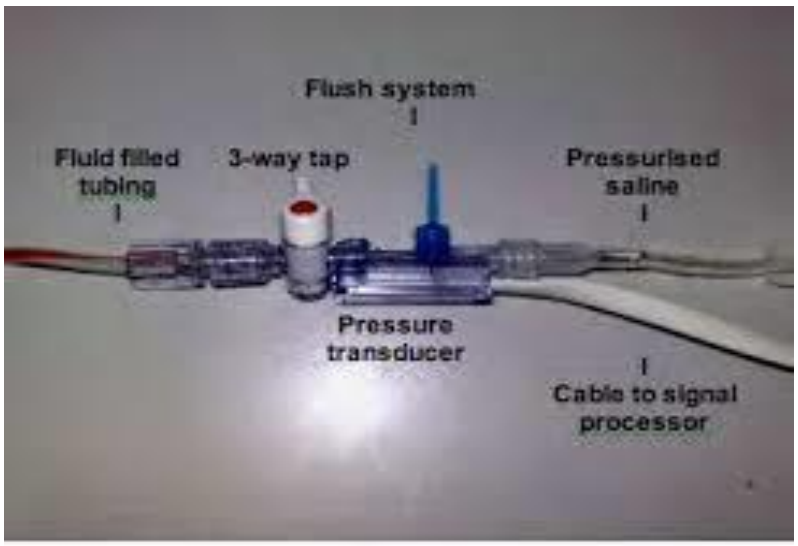


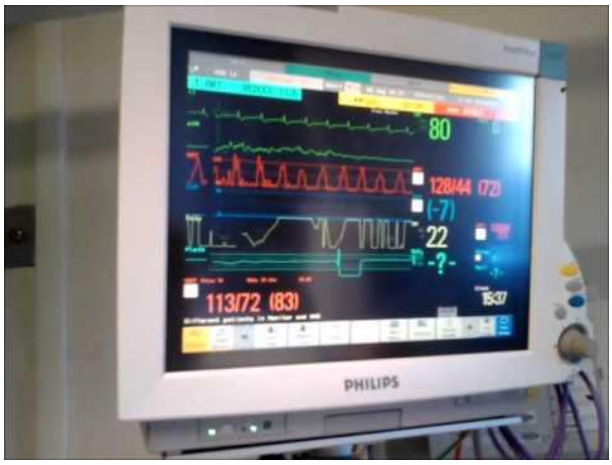
Fig 1. A typical IABP measuring system

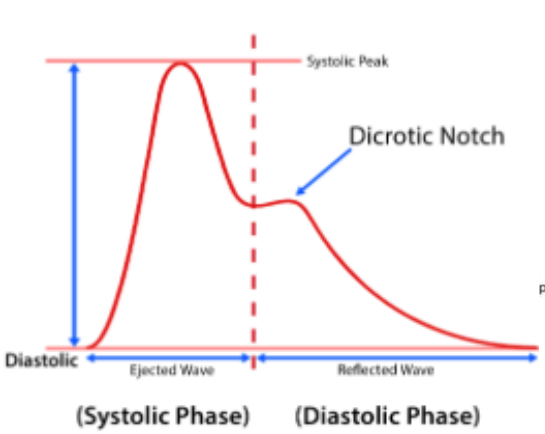
ARTERIAL WAVEFORM & NUMERICAL READINGS

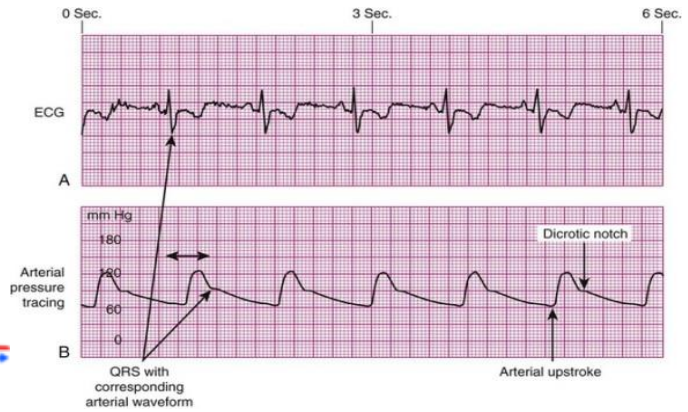
The clinical usefulness of arterial blood pressure monitoring is dependent on the accuracy of the information provided. The registered nurse caring for a patient must be able to manage the system safely, interpret waveforms & readings and be able to troubleshoot problems.

Arterial Blood Pressure Waveform:

An arterial waveform should correlate with an ECG waveform however the ECG ventricular complex will occur just prior to the atrial waveform which reflects the time it takes for the pressure changes to reach the peripheral transducer. The upstroke of the wave form represents the ejection of blood from the left ventricle into the aorta, the top of the wave form represents the systolic pressure and the bottom of the waveform is diastolic pressure. A 'notch' (a secondary upstroke in the descending part of a pulse tracing) can be noted on the wave form after the systolic pressure prior to the diastolic pressure, described as the 'dicrotic notch' caused by transient increase in aortic pressure upon closure of the aortic valve (Nutbeam et al, 2010).

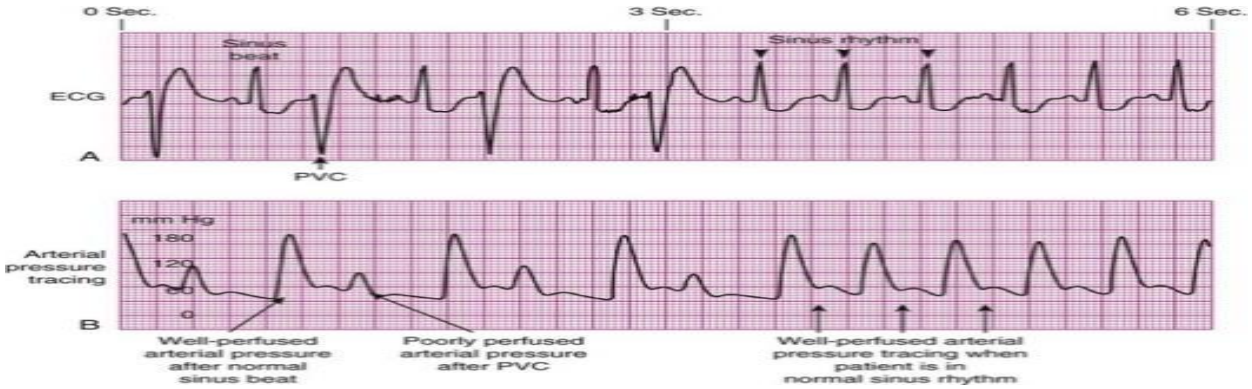




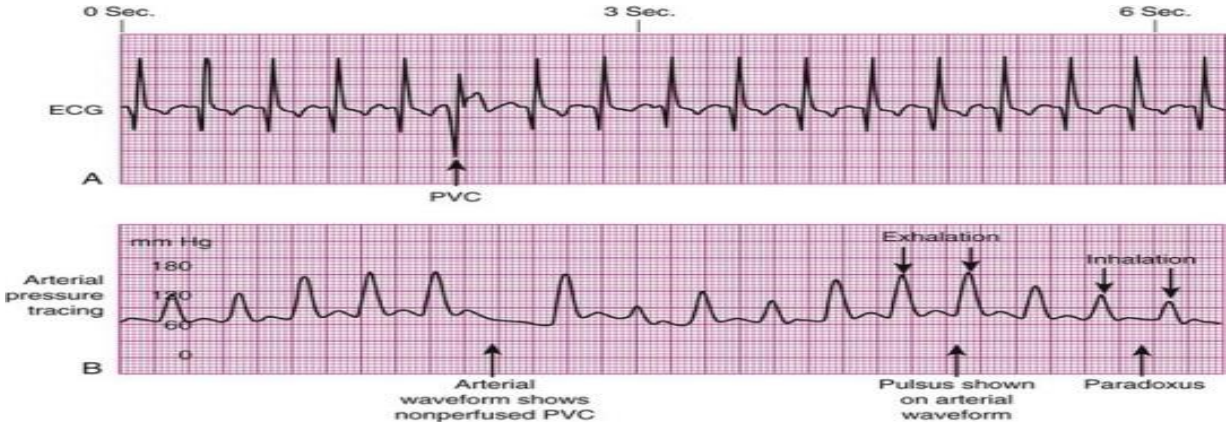


Disease processes can cause altered waveforms in an arterial line due to changes in stroke volume and cardiac output. Some examples are outlined below;

Premature ventricular complex – Due to the early ejection of the ventricles decreased output can be noted for that beat by decreased arterial pressures.



Pulsus paradoxus- is described as a decrease in systolic pressure greater than 10mmHg during inhalation. Pulsus paradox occurs due to decreased cardiac output resulting from a fluctuation in intrathoracic pressure and may be caused by cardiac tamponade, pleural effusion or pericarditis.



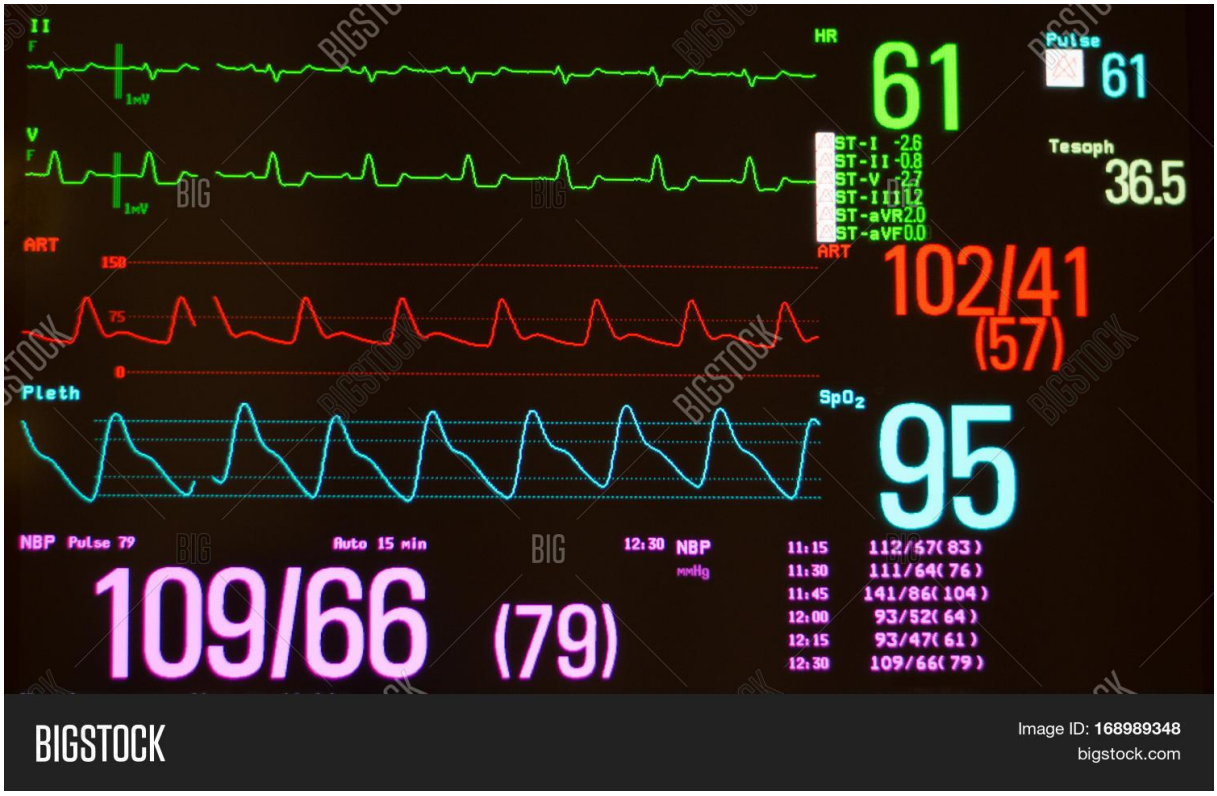
ECG tracing showing adequate waveform e.g. sinus rhythm with arterial waveform showing flat line doesn't necessarily mean you have lost a connection or have a fault with arterial line – a patient in PEA / EMD will have an ECG tracing with a flat line in arterial line due to no pressure (cardiac output).

Numerical Arterial BP Readings

Assess the quality of the waveform prior to interpretation of numerical readings.
Systolic, diastolic and mean arterial pressure (MAP) are all displayed numerically.
The MAP is the average arterial pressure during the cardiac cycle and provides the best indicator of organ and tissue perfusion. For this reason, it is often used to guide patient management.
MAP is automatically calculated by the monitor but can also be calculated using the following equation.

$$\text{MAP} = \frac{\text{Systolic BP} + (\text{Diastolic BP} \times 2)}{3}$$

(Cameron,2020)



NURSING CARE

The nursing care of a patient with an arterial line is critical to ensure accuracy of the observational data and to prevent/minimise risks and complications.
The nurse caring for a patient with an arterial line must understand the components of the arterial waveform and be able to interpret data on the monitor and troubleshoot where required.
The nurse needs to be conversant with the risks/complications, recognise these and escalate care appropriately according to the hospital escalation protocol.

- Patient consent & education
- Procedural preparation – aseptic field preparation, priming of line and pressure bag inflation
- Levelling and zeroing
- Patient observation & monitoring (check your local hospital guideline)
    - BP trends & all other relevant observational data related to the patient's condition
    - Characteristics of the arterial waveform
    - Dressing & insertion site
    - Integrity of lines & equipment
    - Set appropriate alarm parameters
- Neurovascular observations of the limb distal to the insertion site: 15 minutely for first hour then 1 hourly (check your local hospital guideline)
- Ensure limb visible at all times, well positioned, lines secured and limb splinted
- Ensure lines are clearly labelled
- Pressure bag to remain inflated at 300mmHg, adequate volume of fluid in pressure bag (2/3 full)
- Components of the system are changed in accordance with hospital guideline i.e. transducer line & continuous flush bag
- Level and zero transducer each shift and with patient positioning or if troubleshooting is required.
- Ensure aseptic technique implemented when accessing or changing line.
- Check for correlation regularly between arterial BP and NIBP
- Removal of arterial catheter as soon as clinically indicated
- DO NOT INJECT any medication or other substances via the arterial line
- Document all care & interventions

ERRORS AND TROUBLESHOOTING:

Sources of errors

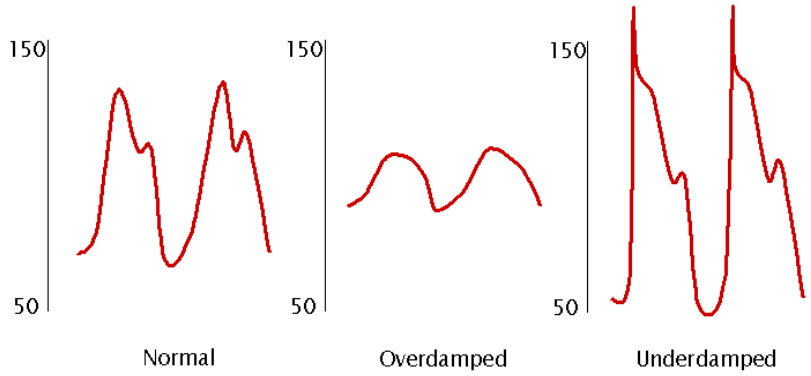
- Failure of any one component of the system
- Incorrect transducer positioning – too low will cause a falsely high blood pressure readings and too high will give a falsely low blood pressure readings
- Transducer not zeroed to atmospheric pressure
- An under or over damped trace

Damping of trace:

"The damping coefficient is a measure of how quickly an oscillating system comes to rest" (Clermont & Theodore, 2024)

- Inadequate amount of damping will result in excessive resonance in the system and an overestimate of systolic pressure. An underdamped trace is often characterised by a high initial spike in the waveform.
- The opposite occurs with over damping.

Causes of under & overdamping are listed in the next table under trouble shooting techniques.



Nutbeam et al (2010),

Trouble shooting techniques

Problem	Cause	Troubleshoot
Over damped waveform	• Air bubbles • Thrombus • Kinked cannula • Loose connections • Empty flush bag • Patient position • Under inflated pressure bag	• Ensure line is primed carefully and **all air bubbles** are expelled prior to procedure • **Aspirate** air bubbles then **flush thoroughly** • Check and tighten connections • Replace flush bag and ensure pressure bag is inflated to 300mmHg • Check roller clamp and tap ensuring 'open' to patient • Secure patient's wrist in extended position with an arm board. • Slight traction on line can help move from the vessel wall • Check NIBP – an over damped line can underestimate systolic pressures.
Under damped waveform	Non-complaint tubing Excessive lengths of tubing	• Remove any excess tubing • Ensure use of approved transducer and tubing only • Ensure transducer and tubing is within date • Level and Zero • Fast flush line • Check NIBP – an under damped line can over estimate systolic pressures
Unable to aspirate blood	• Clotted or kinked cannula • Tap incorrectly positioned • Cannula against vessel wall • Patient position • Vasospasm	• Check cannula and line for kinks, loose connections and ensure tap is 'open to patient, off to bag' • Ensure wrist is in a slightly extended position • Slight traction on the line can help to move the line off the vessel wall.

		• Aspirate **slowly**
Problem	**Cause**	**Troubleshoot**
Normal waveform with abnormal blood pressures	• Transducer is not positioned at the phlebostatic axis • Patient related – pain/anxiety/sedated • - Medication related	• Confirm blood pressures with manual blood pressure • Position patient and transducer to ensure it is positioned at the level of the phlebostatic axis • Check all connections and cables • Assess patient and treat accordingly (analgesia, sedation, repositioning, reassurance) • Consider medication – accidental bolus, error, disconnection of infusion • - Consider possible side effects of medications
Loss of waveform	• Patient in cardiac arrest • Loose connections • Cable not connected • Tap 'off to patient' • Monitor parameter not set correctly • Clot • Pressure bag deflated • Cannula against vessel wall	• Check patient • Check all connections • Check for any kinks in the line, check tap is 'open to patient' and that roller clamp is open • Ensure pressure bag is inflated to 300mmHg • Gentle traction can be used to move cannula off the vessel wall

Monash Health (2020), Nutbeam et al., (2010).

POTENTIAL COMPLICATIONS

In order to optimise patient care and prevent adverse outcome it is essential for nursing staff caring for patients with an arterial line to be conversant with factors which affect the accuracy and safety of arterial monitoring.

Major complications of arterial catheters occur rarely but patient safety is critical, prevention, early recognition, treatment & escalation of care according to hospital escalation protocol will help reduce the incidence of these & minimise adverse outcomes.

Complication	Prevention/interventions
Thrombosis/Embolism including air embolus Clots can form both in and around the cannula which can break off and travel to any of the body including the brain, heart, lungs and limbs. If a large clot forms it may occlude the artery causing distal ischemia.	• Regular neurovascular observations should be conducted distal to the insertion site (see local hospital protocol or guideline for frequency of these observations) • Keep pressure bag inflated 300mmHg to ensure 3-5ml flush per hour • Ensure pressure bag is at least 2/3 full • Use fast flush to clear line after sampling • Ensure security & integrity of lines • Notify MO & escalate care according to hospital escalation protocol if abnormalities detected • Ensure limb containing arterial line is visible
Infection: Insertion is an invasive procedure which exposes the patient to infection. The presence of an invasive device for a period of time further exposes the patient to the likelihood of infection particularly if frequent interventions or manipulations are required.	• Patient observation for any signs of infection • Insertion sites should be assessed for localised signs of infection including redness, swelling and increasing pain • Use appropriate Aseptic Technique on insertion and any interventions/manipulations to line. • Apply key principles of ANTT using correct aseptic fields protecting key sites & key parts • Change lines & pressure bag according to hospital protocol • Remove arterial catheter as soon as clinically indicated • Escalate care if infection suspected

Complication	Prevention/interventions
Inadvertent Medication administration: As arterial lines have an access point which increases risk of intra-arterial medication administration.	• Ensure that arterial lines are labelled clearly & correctly in line with the standards set out by Australian Commission on Safety and Quality in Healthcare • Do not add any additional lines connectors with access points
Extravasation/infiltration: Fluid and blood can collect into the tissues surrounding the insertion site.	• Regular observations for increased swelling and or pain should be done.
Vasospasm: The walls of an artery are smooth muscle meaning that they can constrict	• To help mitigate the risk of vasospasm ensure that lines are well positioned and secured and with draw blood samples slowly.
Fistula and aneurysm: Artery damage during the process of insertion can result in false aneurysms and fistula formation during healing.	
Haemorrhage Loose connections Accidental dislodgement Arterial oozing at site	• Tighten all connections prior to insertion • Use transparent occlusive dressing to secure arterial cannula, hyperfix can be used to secure lines and edge of dressing. • Use arm board to minimize movement of the wrist and accidental dislodgement • Keep arterial site in view – do not cover with arm board crepe bandage • Support line when moving patient to prevent inadvertent traction • Ensure tap is 'off to access point' unless taking blood samples. • If oozing from site continues a small absorbent dressing can be cut and placed around insertion site with a new transparent occlusive dressing on top. • If accidental removal occurs; using gauze place firm pressure over the site for at least 5 minutes then cover with an occlusive dressing.

Arterial Blood Sampling

INDICATIONS FOR ARTERIAL BLOOD SAMPLING:

The sampling of arterial blood provides “end-effect” data on oxygenation and CO2 elimination and is a common practice in Emergency departments and intensive care units in order to assist medical staff in the diagnosis of respiratory insufficiency, hypoxaemia or metabolic disorders.

Arterial blood gas analysis also allows medical staff to assess the affinity state of haemoglobin, as reflected by the percentage of saturation by oxygen and by the levels of carboxyhemoglobin and methemoglobin. Because results obtained will identify changes in pH and PaCO2 clinicians are able to initiate required therapies rapidly, and monitor the patient’s response to therapy.

CONTRAINDICATIONS / CONCERNS FOR ARTERIAL PUNCTURE:

Contraindications are relative and should be considered in relation to situational context and presenting compliant of the patient.

- Vascular surgery in the area to which an arterial sample is to be taken. E.g., dacron grafts increase the risk of contamination and bleeding problems. It is also difficult to apply pressure in such areas
- A fractured wrist as the circulation to the hand maybe compromised
- A coagulopathy or medium-to-high dose anticoagulation therapy (e.g., heparin or warfarin, streptokinase, and tissue plasminogen activator but not necessarily aspirin) may be a relative contraindication for arterial puncture
- History of a clotting disorder (haemophilia)
- History of arterial spasms following previous punctures
- Severe peripheral vascular disease
- The presence of an AV fistula shunt for haemodialysis
- Cellulitis or other infection over the arteries
- Absence of palpable pulse
- Negative (abnormal) Allen’s test – indicative of inadequate collateral blood supply to the hand and suggest the need to select another extremity as the site of puncture

POTENTIAL COMPLICATIONS OF ARTERIAL PUNCTURES:

COMPLICATION	CAUSE	ACTION
Arteriospasm	May occur secondary to pain or anxiety.	Reassure patient; explain procedure and purpose.

Haematoma	Leakage of blood into tissue due to lack of sufficient elastic tissue to seal puncture site, especially in elderly.	Ensure using small diameter needle. Ensure proper technique in holding site 5 to 10 minutes post-puncture.
Haemorrhage	Patient receiving anticoagulant therapy or patients with known blood coagulation disorders.	After taking an ABG pressure should be applied immediately for no less than five full minutes. Apply pressure for ten full minutes if the patient is fully heparinised or has had thrombolytic therapy within the past 24hrs. Two minutes after this pressure is released inspect site for bleeding oozing or seepage of blood; continue pressure until bleeding ceases. A longer compression time is necessary.
Infection of Health Care Provider	Contact with virus, infections contained in blood of infected patients.	Universal blood & body fluid precautions should be implemented. All blood samples from all patients must be treated with full precautions.
Nosocomial Bacteraemia	Inadequate cleansing prior to puncture.	Ensure appropriate cleansing technique.
Distal ischemia	No collateral circulation.	Do Not proceed with puncture after patient has a negative (abnormal) Allen's Test / plethysmography.
Numbness of hand	Nerve damage.	Ensure proper technique. Palpate artery, do not redirect when needle lies deep within tissue.
Sepsis	Infection / inflammation adjacent to puncture site.	Avoid sites indicating presence of infection or inflammation.

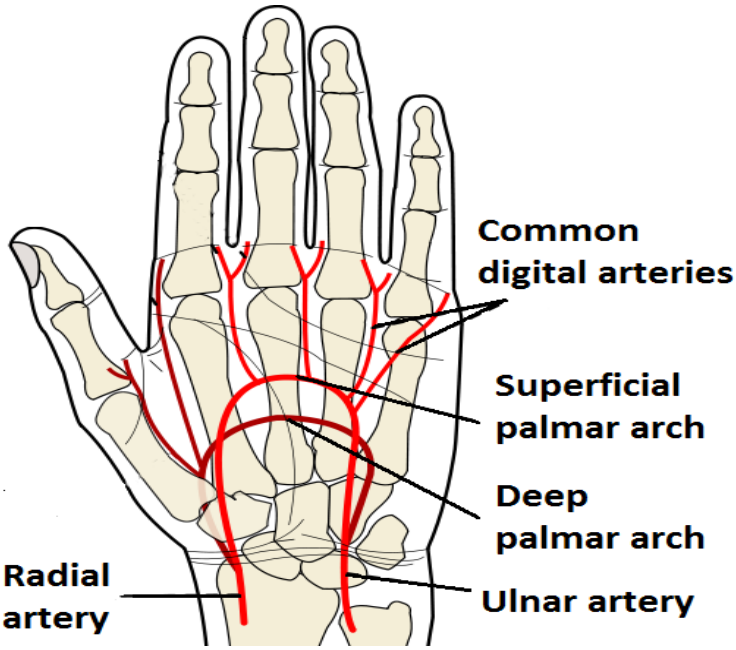
SITE SELECTION:

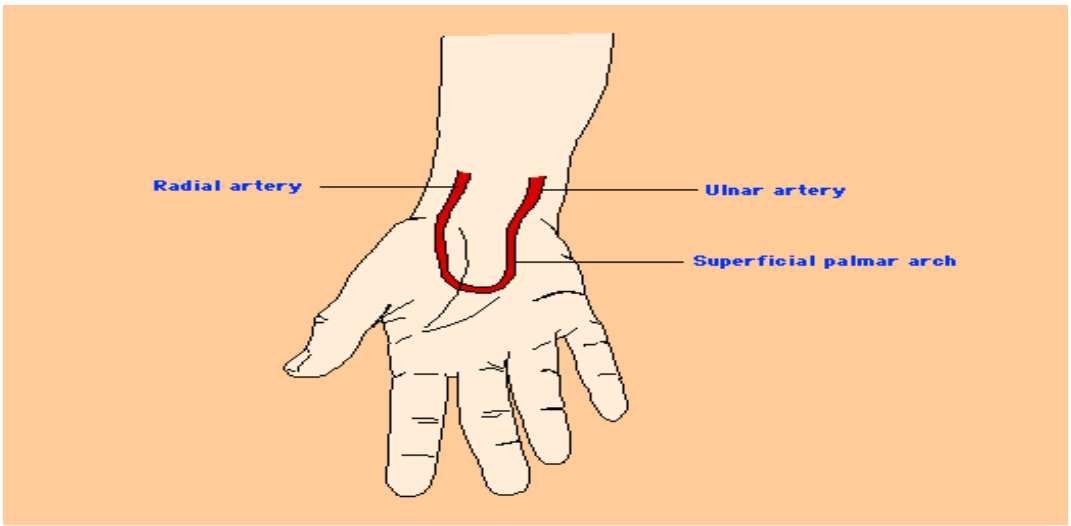
Arterial blood is usually obtained by percutaneous needle puncture of a palpable artery. The most commonly accessed sites for this include the radial, brachial, and femoral arteries. Other potential sites include the posterior tibial and dorsalis pedis arteries (primarily accessed in paediatrics) and the umbilical artery (frequently cannulated in neonates).

The approach and anatomic landmarks for the various sites are described below

RADIAL ARTERY ANATOMY:

The anatomy of the radial artery is shown below. The radial artery is palpable between the distal radius and the tendon of the flexor carpi radialis and usually can be more easily accessed with the wrist extended. The modified Allen test or plethysmography with pulse oximetry (POX) should be used to demonstrate collateral flow through the superficial palmar arch prior to cannulation. The incidence of thrombosis of the radial artery is high (up to 50 per cent), but the incidence of actual ischemic complications is low.

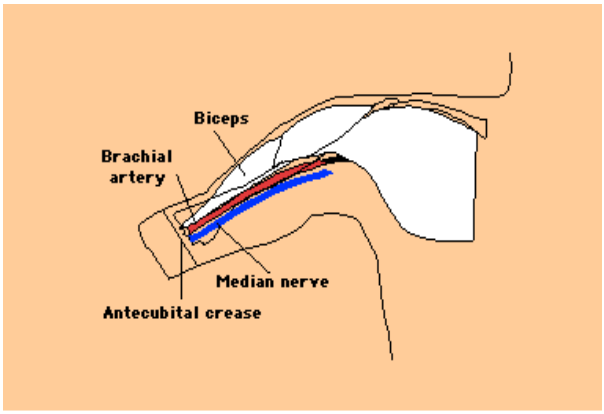




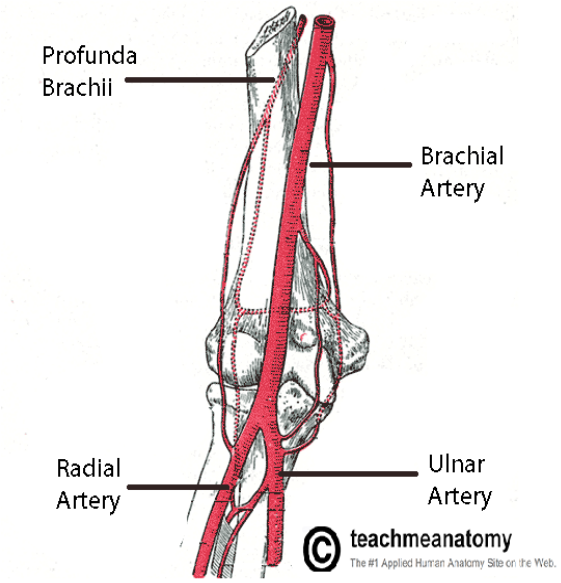
Anatomy of the radial artery Schematic representation of the arterial supply to the ventral surface of the hand. Collateral circulation to the radial artery is provided by the ulnar artery through the deep and superficial volar arterial arches. (Redrawn from American Heart Association. Textbook of Advanced Cardiac Life Support, 1994.)

BRACHIAL ARTERY ANATOMY:

The brachial artery is palpable in the antecubital fossa just medial to the biceps tendon. Although some collateral flow into the lower arm occurs, thrombosis of the brachial artery is a complication associated with this site choice which can result in the loss of limb. It is for this reason that other sites of catheter placement are preferable.



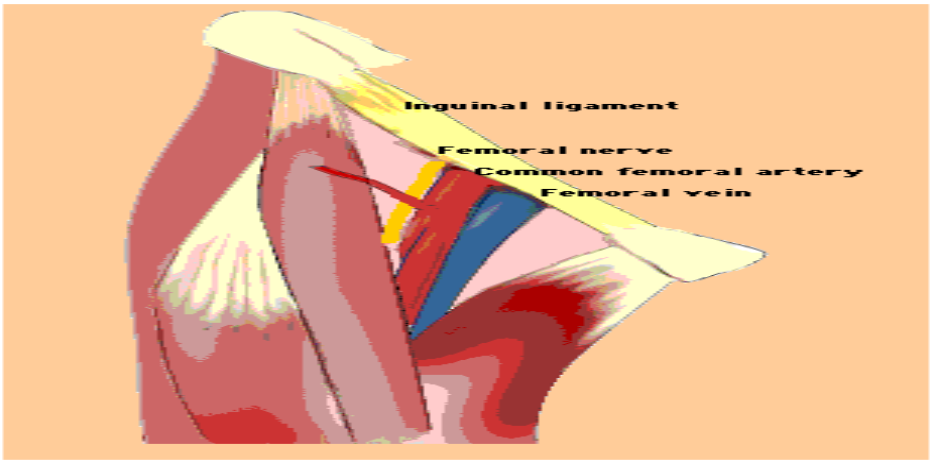
Brachial artery anatomy Schematic representation of the relationship of the brachial artery to the antecubital crease and the median nerve. The artery should be entered just above the antecubital crease.



Femoral Artery Anatomy:

The femoral artery can be palpated just below the midpoint of the inguinal ligament.

The needle should be inserted just below the inguinal ligament, at a 90º angle toward the pulsation. Arterial catheterization via the femoral route may lead to thrombosis and distal embolization to the foot and should be accompanied by close monitoring of distal pulses.



Femoral artery anatomy Schematic representation of the relationship of the common femoral artery to the femoral vein and femoral nerve.

PERFORMING A PERIPHERAL ARTERIAL PUNCTURE:

Prior to undertaking an arterial puncture medical staff need to explain the procedure to the patient ensuring that adequate explanations are provided regarding the reasons for obtaining an arterial blood sample and the method that you are going to use to obtain the sample. During this explanation there should be an emphasis placed on the importance of remaining still and calm in order to prevent complications and hyperventilation which may provide an inaccurate result.

Ensure that you have assessed the patients for any contraindications for arterial blood gas sampling and that effective collateral circulation has been assessed.

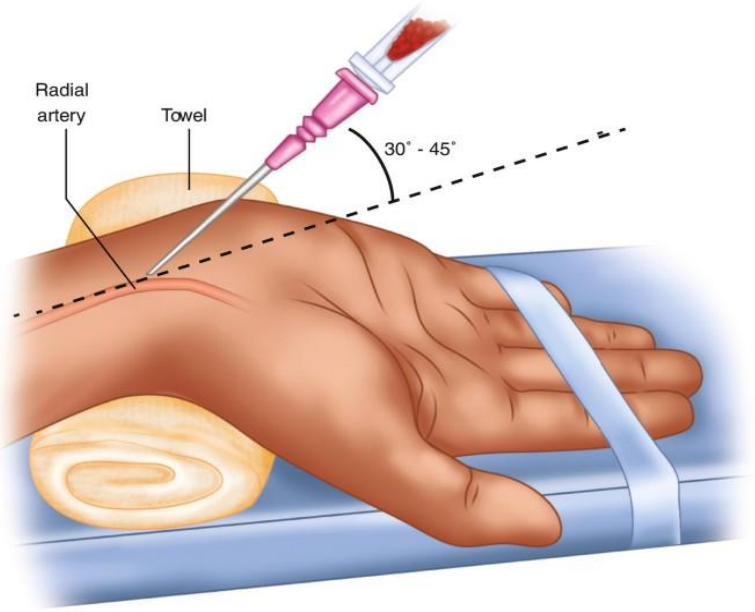
Equipment:

- PPE – googles & gloves
- Cotton swabs
- Alcohol swab
- 23-gauge needle
- Ice pack (if sending to pathology)
- Patient label
- Pre-heparinised blood gas syringe
- Absorbent sheet
- Request slip
- Air-tight cap for syringe

Procedure:

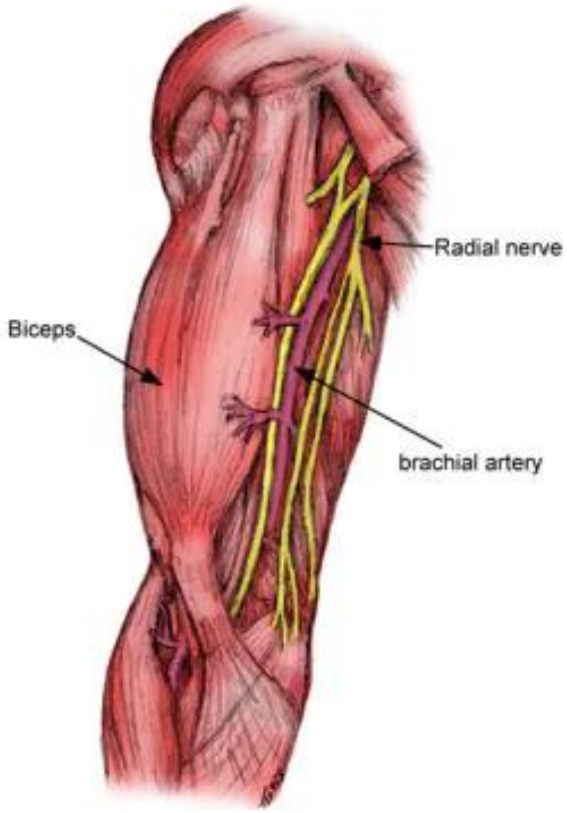
- Wash hands prior to preparing equipment, gloving and putting on glasses.
- Select arterial site to be used and locate pulse. Take into consideration all contraindications when choosing puncture site. (See 'contraindications'). Avoid using the same sample site on consecutive punctures to prevent infection.
- If the patient is ventilated, and has been suctioned recently, changes to ventilator settings, or given a nebuliser, ABG's should be avoided for 20 minutes as this will interfere with true results. If patient is requiring oxygen therapy, consideration should be given to taking arterial blood gas on room air. In this situation, oxygen supplement should be turned off for 20 minutes prior to the arterial blood gas sampling.
- If the radial artery is chosen for an arterial puncture, the Allen's test or POX must be performed to test collateral circulation. The Allen's test or POX can only be performed on the radial artery.
  (See 'Testing collateral circulation')
- Position client supine with arm at side, palm up. Before stab you may use a small towel rolled under wrist to hyperextend wrist.
- Clean the skin thoroughly using an alcohol swab, remembering to use gloves and glasses at all times. Allow approximately 40 seconds for the alcohol to evaporate.

For Radial artery puncture palpate pulse with two fingers and insert the needle at a 30 –40^{o} angle to wrist, pointing towards the elbow.



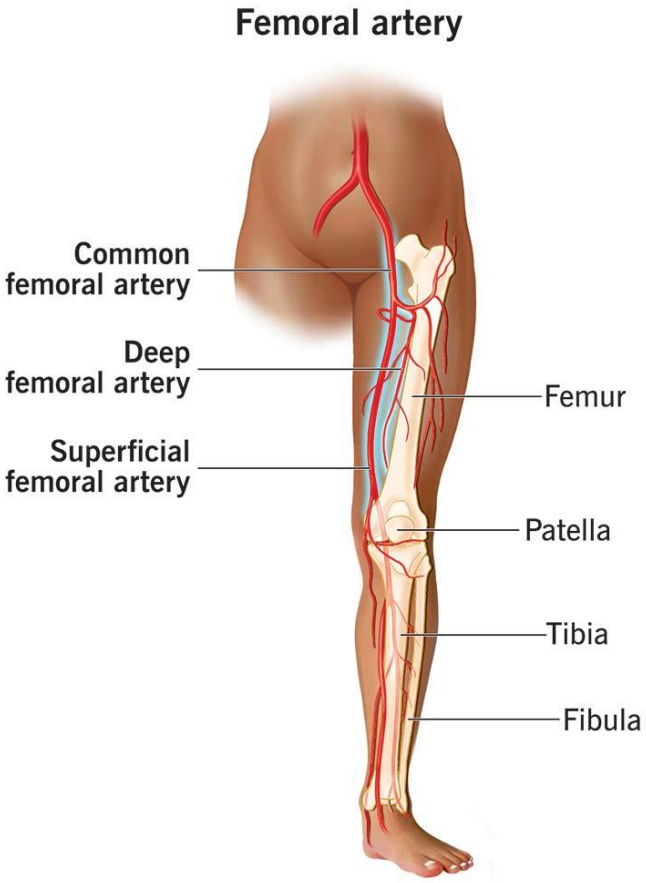
ABG_Picture.jpg (720×480)

For **Brachial** artery puncture insert needle closer to a 60° angle: ensure arm is extended and palm is up. The needle should enter just above the elbow crease.



November 2024

For Femoral artery puncture insert needle at a 90-degree angle



- When blood appears in the syringe allow the pressure of the artery to fill the syringe. 1.0 –2.0ml of blood is a sufficient amount.
- Withdraw needle and apply pressure immediately for no less than five full minutes. Apply pressure for ten full minutes if the patient is fully heparinised or has had thrombolytic therapy within the past 24hrs. Do not bandage site. Bandaging only compresses venous or capillary ooze. Therefore, it is unnecessary to apply after an arterial stab and conceals the site. Bandaging is not to be used in place of digital pressure to the site. It is important that the site is visualised and assessed for no visible signs of bleeding ensuring haemostasis has occurred.
- Remove and discard sharps into container.
- Expel air from tip of syringe and push blood into the cap of the ABG syringe in order to create an airtight seal – air bubbles may introduce error leading to an artificially high arterial PaO2 (see picture below).

- Label the sample with the patient's name. Store blood syringe in ice pack till delivered to pathology for analysis or analyse immediately via Blood Gas Machine.

An arterial blood sample held at room temperature has to be analysed within 15 minutes of obtaining the sample

An arterial blood sample packed in ice has to be analysed within 2 hours of obtaining the sample

- The patients' temperature and FiO2 are important to document as it assists in determining how much oxygen is bound to the patients' haemoglobin molecules and is being delivered to the tissues
    - it is important to realize that some health facilities require FiO2 and temperature to be recorded on the label when sent for testing and some don't – Please check with your facility
    - it is important to record these on the chart at the time the sample is taken
- Ensure you dispose of sharps appropriately

BLOOD SAMPLING – Arterial Line Collection

Blood gas sampling from an arterial line is a simple and pain free procedure but requires care to prevent potential complications such as air embolism, clotting of the line and infection. Correct aseptic technique must be employed

Equipment:

- PPE – gloves & googles
- Alcohol wipes
- 1 x 5ml syringe for discard
- Blood gas syringe, 1 x 10ml syringe or vacutainer barrel with multi sample luer adaptor for sampling
- Replacement non-vented cap
- Extra syringe to be used when fast flushing to clear line
- Pathology request slip and transport bag

Procedure:

1. Patient education, gain consent & check patient identification
2. Ensure all equipment ready and accessible
3. Complete hand hygiene and DON PPE
4. Remove access port cap, swab aspirate port and allow to dry
5. Insert 5ml syringe or vacutainer barrel & firmly apply
6. Turn 3 way tap ***off to pressure bag, open to patient and sample port***
7. Gently aspirate 5ml blood (discard first sample unless collecting for blood cultures then do not discard) N.B. Only one set of cultures to be taken from an arterial catheter further cultures must be taken from venepuncture.
8. Turn 3 way tap ***45 degrees back towards sample port*** remove & discard syringe
9. Attach 10ml or blood tubes in order of draw to vacutainer, turn 3 way tap off to pressure bag gently aspirate required blood
10. Repeat process for blood gas syringe
11. Turn 3 way ***tap off to sample port*** & remove syringe
12. Attach a further syringe to the aspiration port
13. Turn tap ***off to patient*** & use fast flush to flush line and aspiration port
14. Swab aspiration port and seal with new occlusive non vented cap
15. Turn tap ***off to sample port open to patient & pressure bag***
16. Fast flush to clear line back to patient
17. Label and send pathology – An ABG should be placed on ice and transported to pathology urgently.

(Monash Health, 2020)

Arterial Blood Gas Result Analysis

As discussed earlier arterial blood gases are a quick and useful diagnostic test that is often indicated for critically ill patients such as those with severe respiratory, renal or metabolic impairment as well as for monitoring and titrating mechanical ventilation or respiratory support. Now that we have discussed the process of blood gas sampling it is important to be able to identify and interpret blood gas results in order to appropriately alter patient care.

NORMAL VALUES

To maintain homeostasis in the human body the plasma pH must be kept within a narrow set of limits. To be able to understand and interpret blood gases you must firstly be familiar yourself what each component of an arterial blood gas is (Ph, PaCO2, PaO2, HCO3, SaO2, BE) and in particular what their normal parameters are.

Components of Blood Gases

There are six main components which make up an arterial blood gas result these are:

- Ph
- PaCO2
- PaO2
- HCO3
- SaO2
- Base Excess (BE)

In order to fully understand the implications for the patient in relation to ABG analysis it is important to understand what each element of an ABG is a direct reflection both individually and as a whole.

pH

This refers to the concentration of hydrogen ions in the blood. The term pH is an indication of whether a person's acid base balance is normal, acidic or alkalotic.
Because pH is expressed as a negative logarithm an increase in hydrogen ions results in a drop in the pH and a decrease in hydrogen ions results in an increase in the pH.
For the purpose of ABG analysis acidosis refers to a lower pH (↓7.35) and alkalosis refers to a higher pH (↑7.45)

PaCO2

Carbon dioxide (CO2) is produced in vast amounts by normal cellular metabolism and is excreted by the lungs.
PaCO2 is the respiratory component of blood gases and is defined as the partial pressure of CO2 being carried around the blood stream for the lungs to excrete (blow off).
While in the blood stream CO2 is mainly in the form of carbonic acid (H2CO3) this is then converted back to CO2 and H2O in the lungs. As CO2 is carried as an acid, elevated level of CO2 results in a respiratory acidosis (↑ 45) while decreased levels of CO2 cause a respiratory alkalosis (↓35).
Conditions resulting in hypoventilation such as a decreased conscious state will in turn result in elevated levels of CO2 as the patient is unable to blow off excess carbon dioxide, whilst conditions that result in hyperventilation such as anxiety result in decreased levels of CO2 as the patients elevated respiratory rate results in excess blow off of CO2.

HCO3

This represents the amount of bicarbonate present in the patients' blood and forms the metabolic component of an ABG.
The kidneys are responsible for the reabsorption, excretion and formation of HCO3.

Bicarbonate is a base or buffer used to assist in correcting acidosis or alkalosis. Increased levels of HCO3 in conjunction with an elevated pH of greater than 7.45 is known as metabolic alkalosis.
A patient with decreased levels of HCO3 in the context of a decreased pH (less than 7.35) is deemed to have a metabolic acidosis.

Base Excess

This refers to the total amount of bases or alkalis. It is affected by metabolic process and drops ($\Downarrow$ -2) in the setting of a metabolic acidosis and increases ($\uparrow$ +2) in the setting of a metabolic alkalosis.

PaO_2

Represents the partial pressure of oxygen dissolved in the blood. While it only represents 2-3% of oxygen in the body it is an important indicator of tissue oxygenation. This is because PaO_2 is the oxygen that is dissolved in the blood and readily available for use by the tissues and cells.
An elevated PaO2 can be a clinical indicator of hyper oxygenation and indicates the need for staff to decrease a patient's FiO2 before complications such as oxygen toxicity can occur.

SaO_2

Represents the percentage of O_2 occupied binding sites on haemoglobin. There are four binding sites on each haemoglobin molecule and each one can carry one molecule of O_2.
It is important to note that anaemic patients can and often do have a high SaO_2 because although they lack haemoglobin, the haemoglobin they do have is completely occupied with O_2 molecules.

Normal ABG Parameters

Below is a table of normal reference ranges for ABG analysis

PH	*7.35-7.45*
PaCO2	*35-45*
PaO2	*85-100*
HCO3	*22-26*
SaO2	*95-100%*
Bases excess	*+2- -2*

Interpreting Blood gases

Hypoxemia (refers to low arterial PaO_2)

In order to determine if the patient is hypoxemic you examine the PaO_2.
If it is below 85 then the patient is hypoxemic and you will need to administer supplemental O_2 or increase the patients current FiO2 unless the patient has a history of COPD.

Acidotic or Alkalotic

To determine if a patient is acidotic or alkalotic you need to examine their pH
<u>If the pH is below 7.35 then the patient is acidotic</u>

If it is above 7.45 then the patient is alkalotic

Is the cause respiratory or metabolic?

In order to determine if the cause is respiratory or metabolic you need to assess the PaCo2 and HCO3 in conjunction with what is the contributing to the problem.

Is the problem respiratory in origin?

As previously mentioned the CO_2 is the primary respiratory component of an ABG. If the alteration in pH is due to a respiratory cause then there will be a derangement in the patients $PaCO_2$ level.

If the patients CO_2 is above 45mmHg and their pH is below 7.35 this is known as respiratory acidosis.

If the CO_2 is below 35 mmHg and their pH is above 7.45 this is known as respiratory alkalosis.

results.

A HCO_3 level below 22 mmols/L in conjunction with a pH of less than 7.35 will cause a metabolic acidosis you would expect a base excess below -2

A HCO_3 level of above 28 mmols/L in conjunction with a pH of greater than 7.45 will cause a metabolic alkalosis you would also expect a base excess above +2

Respiratory acidosis

Respiratory acidosis is primarily caused by conditions that either result in increased CO2 production or decreased CO2 removal such as:

- Central nervous system depression
- Pneumothorax
- Respiratory failure
- COPD
- Lung disease
- Musculoskeletal disorders

Respiratory Alkalosis

Respiratory alkalosis results from conditions that result in hyperventilation. This results in excessive elimination of CO2 from the blood and causes a rise in the pH.

Some potential causes of respiratory alkalosis include:

- CNS haemorrhage
- Drug overdoses such as salicylates and progesterone

- Pregnancy
- Decreased lung compliance, i.e. interstitial lung disease
- Liver cirrhosis
- Anxiety

Metabolic Acidosis

Metabolic acidosis is caused by conditions that result from a loss of bicarbonate or increased production/ retention of acid ions.
Some such causes of metabolic acidosis are:

- Vomiting
- Renal tubular necrosis
- Ketoacidosis
- Lactic acidosis
- Renal failure

Metabolic alkalosis

Results from gaining bicarbonate or excessive loss of acid ions.
Some conditions which can result in metabolic alkalosis include:

- Cystic fibrosis
- Vomiting
- Diarrhoea
- Diuretics
- Renal artery stenosis
- Renin secreting tumours
- Cushing syndrome

Compensation

As we have already mentioned there are 2 main systems that regulate pH in the body. When one system is failing the other system attempts to fix the situation and return the pH to normal limits (7.35-7.45).

For example, when a patient has a metabolic acidosis due to diabetic ketoacidosis normally their respiratory rate becomes rapid in an attempt to blow off excess CO2 and return the pH to its normal parameters. The gases for such a patient would look something like this.
PH 7.16
PCO2 30
HCO3 19
PaO2 108
O2 sat 98%
BE –4
We can see that this patient has an acidosis. The low bicarbonate level would be causing the acidosis but a low carbon dioxide would be helping to reverse the acidosis. The interpretation for this blood gas would be a metabolic acidosis with partial respiratory compensation.

Compensation would only be complete if the pH had returned to its normal parameters. When interpreting blood gases with compensation we need to work out what is causing the problem and then identify if the other system is trying to rectify the acid base balance and then finally, determine if the compensation is complete or partial.

If the compensation is complete it can be difficult to work out, if you have a metabolic acidosis with respiratory compensation or a respiratory alkalosis with metabolic compensation. It is usually from the patient's history and presentation that you will be able to determine what the cause is.
Respiratory compensation can occur immediately while metabolic compensation takes days to be effective.

Mixed respiratory and metabolic disturbances

Unfortunately, in some situations patients can have a failure in both systems (respiratory and metabolic) which contributes to either an acidosis or an alkalosis. An example of this may be a patient that has both renal failure and COPD. In these cases, we will find that both the CO2 and the HCO3 are contributing to the problem. The following is a set of ABG results which indicates a mixed respiratory and metabolic disturbance.

PH 7.13	
CO2 50	
PaO2 85	
HCO3 19	
BE -3	

REMOVAL OF AN ARTERIAL LINE

Equipment:

- PPE – gloves & goggles
- Gauze
- Occlusive dressing
- Contaminated waste bin
- Stitch cutter
- Sharps container

Procedure:

1. Removal to be ordered by Medical Officer
2. Check patient identity (3 identifiers) explain procedure and obtain consent
3. DON PPE
4. Perform hand hygiene
5. Apply ANTT
6. Deflate pressure bag and turn roller clamp on pressure line off
7. Remove dressing carefully
8. Remove sutures if they are present
9. Place gauze over cannula
10. Gently remove cannula from patient wrist
11. Apply firm pressure over wound for minimum 5 minutes
12. Inspect tip of cannula checking integrity
13. If bleeding ceased apply occlusive dressing
14. Document removal
15. Continue to monitor site

(Monash Health, 2020)

KEY NURSING RESPONSIBILITIES

- Infection control & ANTT
    - This is an invasive procedure and requires adherence to aseptic principles both during insertion and all ongoing care & manipulations

- Medication safety
    - Remember your labels!
    - Watch for accidental medication administration

- Observations & escalation of care
    - Patient observation according to hospital guidelines
    - Interpret data on monitor & have understanding of the components of the arterial waveform
    - Profuse bleeding can occur if dislodged so ensure always visible and well secured
    - Neurovascular observations on limb should be conducted hourly to assess for complications
    - Escalate care according to your hospital escalation protocol

- Communication & patient education
    - Informed consent when able
    - Patient & family education
    - ISBAR
    - Documentation

- Care & Maintenance of Equipment
    - Levelling to phlebostatic axis, zeroing and maintaining 300mmHg of pressure on fluid bag are vital to accuracy
    - Don’t forget damping of trace & trouble shooting techniques

KNOWLEDGE ASSESSMENT - Arterial Lines & Blood Gas Interpretation

Name: _____

1. List 3 common indications for insertion of an arterial line.
   1) _____
   2) _____
   3) _____

2. Where is the phlebostatic axis located?

_____
_____
_____
_____

3. What is an Allen's Test and why is it required?

_____
_____
_____
_____

4. What is the difference between an Allen's test and the plethysmography with pulse oximetry test?

_____
_____
_____
_____

5. Why is a pressure bag required for arterial monitoring?

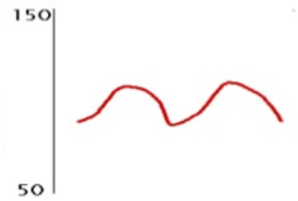
_____
_____

6. Normally an arterial line infuses_____ per hour

7. Select the correct pressure that a pressure bag should be maintained at:
   a. 100mmHg
   b. 150mmHg
   c. 250mmHg
   d. 300mmHg

8. List 4 potential complications of an arterial line?
   1) _____
   2) _____
   3) _____
   4) _____

9. What does this wave form indicate?



_____
_____

10. Identify two potential causes of arterial waveform damping?
    1) _____
    2) _____

11. What are some potential nursing interventions you could make to troubleshoot this problem?

_____
_____
_____
_____

12. What does Zeroing an Arterial line do?

_____
_____
_____
_____

13. What does the dicrotic notch represent?

_____
_____
_____

14. What type of aseptic technique is required when inserting an arterial line?
    a. Standard aseptic technique
    b. Surgical aseptic technique

15. What are the 3 sites for peripheral ABG sampling?
    a.
    b.
    c.
    d.

16. Name 3 complications associated with arterial blood gas sampling?
    1) _____
    2) _____
    3) _____

17. What equipment is required for a peripheral arterial blood gas puncture?

_____
_____
_____
_____

18. If a patient is on warfirin or clexane what additional care needs to be taken following a peripheral arterial puncture?

_____
_____
_____

19. What are the normal parameters for the following:

pH	
PaCO2	
PaO2	
SaO2	
HCO3	
BE	

20. If a patient was acidotic what would you expect their pH to be?
    a. 7.36
    b. 7.38
    c. 7.14
    d. 7.44
21. If a person was alkalotic what would you expect their pH to be?
    a. 7.35
    b. 7.39
    c. 7.68
    d. 7.31

22. What do these blood gas results indicate?
    a.

Results	Interpretation
pH = 7.15	
PaCO2 = 50	
PaO2 = 75	
HCO3 = 22	
B.E. = -2	

    b.

Results	Interpretation
pH = 7.23	
PaCO2 = 50	
PaO2 = 95	
HCO3 = 24	
B.E. = +1	

c.

Results	Interpretation
pH = 7.60	
PaCO2 = 36	
PaO2 = 90	
HCO3 = 34	
B.E. = +5	

d.

Results	Interpretation
pH = 7.14	
PaCO2 = 22	
PaO2 = 95	
HCO3 = 16	
B.E. = -4	

23. A patient with an ABG indicating respiratory acidosis could show what signs and symptoms?

_____
_____
_____
_____

SKILLS ASSESSMENT – Arterial Punctures & Arterial Line Sampling- please contact Emma O'Neill Gippsland Regional Education Coordinator: emma.oneill@lrh.com.au

November 2024

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