

INVASIVE ARTERIAL MONITORING - CICU - SCH

PRACTICE GUIDELINE[®]

DOCUMENT SUMMARY/KEY POINTS

- The registered nurse caring for a patient with an arterial line in-situ must have successfully completed the required practical assessment as a component of the Clinical Competencies utilised as a minimum standard within CICU.
- All arterial lines must be connected to a pressure transducer and a monitor with an alarm feature to display a clear arterial waveform and accurate blood pressure.
- **ONLY 0.9% SODIUM CHLORIDE WITH ADDED HEPARIN 2 UNITS / ML IS TO BE INFUSED VIA AN ARTERIAL LINE.**
- All arterial lines and infusions must be labelled according to National labelling Standard.
- **FULL PERSONAL PROTECTIVE EQUIPMENT (PPE) INCLUDING GLOVES, FACE SHIELD AND PLASTIC APRON MUST BE UTILISED AT ALL TIMES WHEN HANDLING ARTERIAL LINES OR SAMPLING BLOOD.**
- Infants must be nursed with umbilical catheter entry site exposed at all times – supine or on their side. **They must never be nursed lying on their abdomen.**
- When umbilical arterial line in-situ, feet must be exposed at all times to observe for impairment of circulation.
- Never infuse any drugs via an arterial line.
- Injectable caps or bungs are not to be used thereby eliminating the risk of infusing / injecting any drug.
- All connections must be luer locked.
- The mean alarms are to be set within 10mmHg of the desired pressure for each individual patient and are to be activated at all times.

This document reflects what is currently regarded as safe practice. However, as in any clinical situation, there may be factors which cannot be covered by a single set of guidelines. This document does not replace the need for the application of clinical judgement to each individual presentation.

Approved by:	Director of Clinical Governance	
Date Effective:	1 st March 2017	Review Period: 3 years
Team Leader:	Clinical Nurse Consultant	Area/Dept: CICU - SCH

CHANGE SUMMARY

- Adjustment to include additional safety statements when removal of arterial line to be undertaken

READ ACKNOWLEDGEMENT

- CICU clinical staff are required to read and acknowledge they understand the contents of this document.

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1 Introduction

Invasive arterial monitoring is used to facilitate continuous blood pressure monitoring frequent blood sampling in critically ill patients with a goal of allowing anticipatory management.¹ It is important to remember that pressure does not necessarily equate to flow, cardiac output or oxygen delivery.² The information obtained should be integrated with sequential physical examination to evaluate the effectiveness of interventions and therapeutic decisions.³

It is essential that clinicians caring for patients receiving arterial monitoring understand the indications for its use and are technically competent to care for the patient receiving this management. This requires the ability to be familiar with complications and their prevention and have the ability to interpret the data obtained and make clinical decisions based on that data.

NOTE: utilisation of arterial lines is not to be considered as routine outside CICU

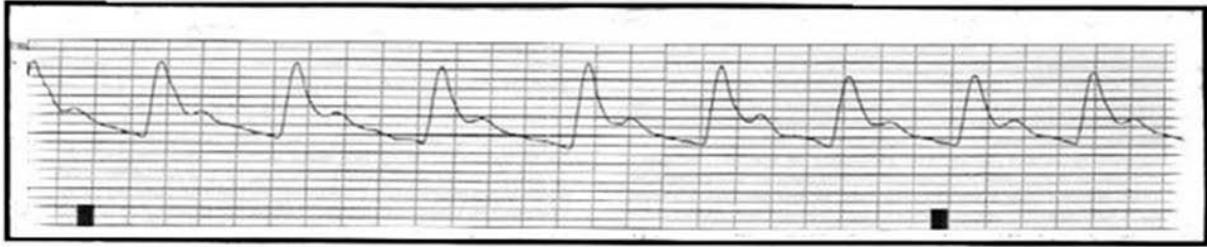
Arterial line management outside CICU may only commence after the Senior Medical Officer has consulted with the CICU Director, Nursing Unit Manager or his/her representative and the Clinical Director - Nursing or after Hours Hospital Co-ordinator and the Chief RMO.

If a patient with an arterial line is to be cared for in any ward other than CICU they must be nursed utilising a nurse: patient ratio of 1: 1 and are never to be left unattended.

General Information

- All procedures undertaken when managing an arterial line are to utilise aseptic non-touch technique except when changing infusion solution for pressure monitoring systems at which time a modified sterile procedure which requires the use of sterile gloves is to occur.
Aseptic technique: a technique that identifies the key parts of therapy and keeps them as free from hospital micro-organisms as possible by ensuring that they are not touched either directly or indirectly.
- Primary delivery system to be utilised within CICU is to be an infusion syringe pump and these must always be utilised for patients < 10 kg
- Externally pressurised infusion bag pumps may be utilised as the delivery system for patients > 10kg or when requested by the CICU consultant
- Always ensure the transducer is positioned correctly by having the three-way tap on the transducer level with the patient's right atrium (Mid axilla at the fourth intercostal space)
- Arterial lines must be zeroed and the transducer level checked at the commencement of every shift or following patient re-positioning and documented on the CICU flow chart.

Waveform



- The normal arterial trace should appear as above.
- The arterial waveform can be divided into systolic and diastolic components.
- The systolic components follow the ECG R wave, consists of a steep pressure upstroke, peak, and decline, and correspond to the period of left ventricular systolic ejection.
- The downslope of the Arterial Blood Pressure (ABP) waveform is interrupted by the dicrotic notch, which reflects aortic valve closure at end-systole.
- The remainder of the ABP occurs during diastole and the ABP reaches its lowest point at end-diastole.
- The presence of all these points is the main criterion to assess the quality of the arterial line.⁴
- Values for systolic and diastolic blood pressure reported by the bedside monitor numeric display are the systolic peak and end-diastolic trough pressure.

Technical considerations

- Invasive pressure monitoring has technical limitations that can make displayed information inaccurate.
- Factors that may affect the quality of measurement include the compliance, resistance and impedance of the system, all of which can result in the alteration of the recorded signal.⁵
- Arterial pressure measurement requires the careful preparation and care of the entire fluid-filled monitoring system (including catheter) and prevention or elimination of any kinks, air, clot and loose connections.⁶
- Invasive pressure measurement systems are indirect and thus require calibration to a reference point; the Right atrium is used for cardiovascular pressures.^{5,6}

2 Securing the Line

1. The patient's limb at the site of the cannula should be splinted to secured stabilisation of cannula.
2. The distal area of the arterial cannula should be observed on a regular basis to ensure that it is well perfused.
3. The arterial line must be securely strapped. The suggested method is to place two sterile 1cm tapes e.g. Steri-strips™ under the body of cannula and folded at 45 degrees over the cannula to secure the body of the cannula to the skin. A further piece of this tape is then to be placed across the hub of the cannula. Do not encircle the limb with strapping as this may lead to venous obstruction.
4. Skin area at cannula tip should be visible and not covered by tape.
5. For added security, the application of a sterile transparent dressing e.g. Op-site™ across the cannula entry site is recommended.
6. To stabilise the cannula site, the limb must be supported by a board that is taped securely in place with 2.5cm elasticised adhesive tape eg Elastoplast™ both proximally and distally from the cannula site, avoiding constriction and subsequent swelling. **The use of non-adherent tape e.g. Coban™ for this practice is not to occur.**
7. The wrist or ankle should be secured in natural alignment as much as possible with only slight extension.
8. The arterial cannula site must always be exposed; ie if femoral line in situ legs must be exposed, if radial line in situ, arm and hand must be exposed.
9. When undertaking dressing changes, a second person must assist to avoid accidental dislodgement.

Special Considerations

Umbilical arterial catheters

- Diagram adjacent indicates how umbilical lines are to be secured in CICU.
- Buttocks, legs and feet must be checked for impairment in circulation a minimum of every 4 hours.
- Cord care should be attended with general cares utilising sterile water and not alcohol based solution (see SCH Standard 9.4 Care of the umbilical cord).
- Do not use topical antibiotic ointment or creams on umbilical catheter insertion sites because of the potential to promote fungal infections and antimicrobial resistance.⁷
- Optimally umbilical arterial catheters should not be left in place > 5days.



3 Priming Transducer Set

- Spike a 500mL 0.9% Sodium Chloride with 1000 units Heparin fluid bag with the transducer giving set.
- Prime the line, paying particular attention to the transducer part of the tubing and the flush port, (the smallest air bubble must be removed).
- If required, draw solution into a leur lock syringe for use with an infusion syringe pump.
- Tighten all tubing connection, whilst maintaining a clean non-touch technique to maintain asepsis. After priming the transducer set, remove all non-injectable caps provided within the set-up by the manufacturer with sterile caps devoid of holes.

4 Zeroing the Arterial Line

- Access the arterial menu on the monitor.
- Turn the tap on the transducer bracket off to the patient.
- Open the transducer to air.
- Press the zero pressure key on the monitor to establish a zero pressure reference value. A perfectly straight line will overlie the zero pressure line on the monitor. It will read as 0/0 on the monitor if correct zeroing has been established and the monitor will register "zero completed".
- Return the tap to the previous position and replace the non-injectable cap.

5 Pressure Monitoring System

- Only disposable transducer assemblies are to be used.
- Minimise the number of manipulations of and entries into pressure monitoring system.⁷
- Keep all components of the pressure monitoring system (including calibration devices and flush solution) sterile.⁷
- Replace all components of the pressure monitoring system (including transducer, tubing, 3-way taps, continuous flush device, flush solution and syringe) at **96 hour** intervals.⁷
- When changing infusion solution for administration through pressure monitoring systems this must be undertaken using a modified sterile technique requiring the use of sterile gloves.⁷
- The transducer is an external, disposable, fluid-air interface which detects changes of pressure in the artery. Air bubbles and blood in the transducer alters this fluid filled column and therefore can lead to inaccurate readings.

- The length of the tubing between the transducer and the cannula has a direct effect upon the accuracy of the values given on the monitor. If tubing is too long or too short, or if the tubing is soft and pliable, the accuracy of the readings will be compromised.
- The patency of the arterial line is paramount and is achieved through the utilisation of an infusion syringe pump or a pressurised flush bag.
- In an attempt to maintain the patency of arterial lines, the minimum infusion rate is to be 1mL/hour unless otherwise requested by the CICU Consultant.
- An externally pressurised infusion bag pump can be attached to the transducer via tubing. This bag is placed under pressure by placing it in a sleeve which when inflated to 300mmHg enables a continuous flow of 3mL/hour or alternately when inflated to 150mmHg (1.5mL/hr).

6 Ongoing care of patients with intra-arterial access and monitoring

- Site checks are to be attended hourly along with perfusion and capillary refill.
- Depending on the line position this may include checking the extremity for colour, warmth, capillary return and movement if the patient is conscious and documenting findings on flow chart.
- The arterial cannula itself must always be on view as an important guard against arterial haemorrhage. With the cannula in the artery there is the potential for a significant haemorrhage should the line become disconnected or the cannula dislodged.
- All administration set tubing must be checked regularly to ensure all connections are secure and no air is present.
- When flushing, the arterial line site should be checked. If the skin blanches it may be arterial spasm. Observe the site, as perfusion should return quickly.
- If perfusion return is delayed, medical staff must be informed, as the line may need to be re-sited. This notification and response of medical officer is to be documented in the patient's progress notes.
- If in use, check pressure bag hourly to ensure accurate pressure for ordered infusion.
- The patient's non-invasive blood pressure (cuff) must be checked at a minimum of once per shift.
- Additionally, when the quality of the trace is questioned or if there is any doubt about the pressure reading non-invasive BP should be checked and frequency guided by findings and clinical condition.
NOTE: Oscillometric instruments do not completely reflect intra-arterial BP and reliance on it may seriously underestimate the severity of hypertension and hypotension potentially leading to under-treatment.³

7 Sampling from Arterial Lines

- **Determine amount of blood required -do not sample any more blood than absolutely necessary.**
- Guidelines for volumes required for particular tests are available in CICU provided by SEALS.

Procedure

1. Calculate volume of blood required based on requested test and collect appropriate specimen containers/ syringes.
2. Basic steps as outlined earlier.
3. Turn alarms off.
4. Turn the 3-way tap closest to the transducer off to the patient, then remove and keep non-injectable cap as sterile as possible as non-injectable caps represent a potential portal of entry for micro-organisms.
5. Clean the sampling port with an alcohol swab.
6. Insert sterile 2 mL syringe into sampling port closest to the transducer.
7. Turn the 3-way tap off to the transducer and gently aspirate blood until it just comes back to the vicinity of the 3-way tap nearest the transducer. (Gentle aspiration prevents spasm or collapse of the artery). **Note: blood should not enter the transducer.**
8. Turn the 3-way tap off 45° (off to all directions) to prevent accidental bleeding or sampling of flushing solution.
9. Insert blood gas syringe into the open sampling port of the 3-way tap closest to the patient ensuring it is free of fluid or blood which may be left from previous sampling.
10. Take note of SaO₂ and if in place the ETCO₂ reading on the monitor and record for later comparison.
11. Turn the 3-way tap off to the transducer and gently aspirate blood. Forceful aspiration may create an excessive vacuum that can lower blood gas results.
12. Turn the 3-way tap off to the sampling port and remove the syringe.
13. Expel air from sampling syringe - air bubbles can alter results on blood gas analysis.
14. Seal blood gas syringe with syringe cap provided.
15. Spin/ roll syringe between hands, then invert syringe and spin/roll again for approximately 30 seconds to mix blood sample and place on clean field.

Notes:

- If done in this manner, there will be ample time to complete all aspects of the sampling procedure before undertaking analysis. The sample can wait up to 10 minutes in ambient air, and up to 40 minutes if placed in a cold slurry (ice / water combination)
- If **more than one blood sample** is to be taken from an arterial line eg blood for gas analysis and blood for pathology, the 3 way tap is to be turned off at 45° (off to all directions), between collections. This prevents the blood samples being diluted with the heparinised saline solution contained in the transducer line.

16. Unless requested by the CICU Consultant (see below), the dead space blood / saline solution (initial aspirate from port closest to transducer) is to be discarded and is not to be returned to the patient.

Note: In certain situations e.g. small infants and patients requiring repeated samples where cumulative blood loss will be clinically significant, blood taken from an intra-arterial line may be re-infused at the discretion of the attending physician.

17. Prior to re-infusing any blood, the integrity of the blood should be examined and if any concerns with clotting etc exist, the blood must not be re-infused.
18. If significant volumes are required (e.g. in neonates), contact the laboratory to determine minimum volumes for samples and discuss with attending medical officer prior to undertaking procedure.
19. When sampling has been completed, ensure both three way taps are turned off to the sampling ports and flush the arterial line. This is accomplished by using the purge button on the infusion syringe pump whilst squeezing the transducer in-line flush intermittently. Gently inject fluid into line to flush the arterial cannula until line is visibly clear of any blood. When using the pressure bag the in-line flush just needs to be gently squeezed. **Note: Ensure air is not flushed into the artery when flushing the line.**
20. As flushing is undertaken, observe the cannula insertion site for blanching. It may occur but should resolve quickly. Observe circulation distal to the insertion site for colour, warmth and perfusion.
21. Clean the ports using an alcohol swab and re-attach the non-injectable cap into the port of the 3-way tap.
22. Ensure all 3 way taps are correctly aligned and recommence IA flush infusion and reactivate alarms.
23. Proceed to undertake blood gas analysis using the Radiometer Blood Gas Analyser as soon as possible.
24. If blood is to be sent to SEALS, place blood in appropriate tube(s), label and dispatch with accompanying request form. If not required for any other pathology, discard withdrawn blood into clinical waste receptacle.
25. Discard equipment and wash hands.
26. Review results of blood gas analysis and show to medical officer and /or team leader.
27. Transcribe results onto relevant documentation.

8 Troubleshooting

- If the trace is dampened check the arterial catheter insertion site and /or limb and if necessary reposition.
- Check the complete system for air bubbles and if found eliminate same.
- Check the complete system for leaks or disconnection and correct problems if found.
- If this is unsuccessful, attempt to aspirate and flush the catheter:
 - i. Attempt to withdraw blood as per sampling procedure.
 - ii. If resistance is felt, reposition extremity and reattempt aspiration.
 - iii. If resistance is still felt, stop and notify medical officer and/or team leader.
- If blood is aspirated then conclude procedure as per sampling procedure.
- If arterial spasm present, action as per instructions in key points.

9 Removal of Arterial Line

ALERT

If a difficult removal is anticipated or the patient is distressed, staff should seek assistance prior to attempting to remove tapes and arterial catheter.

Removal of any arterial line where a second line's security is threatened requires two staff members to perform procedure.

1. Basic hand hygiene
2. Assemble equipment
3. Inform and explain procedure to patient and/or parents
4. Turn off continuous infusion and turn off alarms
5. Aseptic procedural hand hygiene
6. Apply full PPE including eye shield and non-sterile gloves
7. Attach syringe to blood sampling port, turn off stopcock to flush solution and draw back through the tubing enough blood to ensure there is no clot in the catheter
8. Remove tapes and dressing
9. Apply pressure distal to insertion site
10. Pull out catheter using sterile gauze square to cover site as catheter is pulled out
11. Immediately apply firm pressure using sterile gauze
12. Continue to apply pressure for a minimum of 5 minutes for radial or ulnar artery

Note: *Longer period of direct pressure may be needed in patients receiving thrombolytics or those with catheters in large arteries e.g. femoral.*

13. Assess for haemostasis
14. Apply pressure dressing if necessary and observe for ongoing bleeding
15. Discard equipment
16. Basic hand hygiene
17. Document procedure and continue to observe for bleeding

10 Complications

Catheter-related infection and inflammation, mechanical complications and arterial thromboembolism are the most common complications described with arterial cannulation.¹ Incidence of perfusion-related complications associated with femoral artery catheterisation in neonates and infants is directly associated with the duration of catheterization and is lower when 2.5Fr polyethylene catheters are used instead of larger ones.⁸

- **Infection:** inappropriate handling of intra-arterial catheters, 3-way taps and ports and inadequate dressings can lead to contamination of the catheter. Ensuring aseptic technique on insertion, during dressing changes and when withdrawing blood diminishes the risk of infection.
- **Thrombosis:** most frequently reported complication associated with arterial line use is thrombosis at the entry site with distal ischaemia. Thrombosis can develop while an invasive arterial cannula is in-situ, after the cannula is removed or as a consequence of multiple arterial punctures, either to establish invasive monitoring or sample arterial blood.
- **Ischaemia and necrosis:** Neurologic and vascular function of the extremity can be compromised in the extremity with an arterial cannula in-situ. Necrosis of the overlying skin is characterised by skin that blanches during cannula flushing progressing to skin that remains blanched. Assessment of pain, blanched or pale areas beyond the cannula site, pulselessness distal to the cannula, numbness and tingling or motor impairment are essential. Early removal of lines will reduce the risk of ischaemia.
- **Air embolism:** can develop from air in the flush system or when the system is opened to sample blood
- **Exsanguination from catheter disconnection:** accidental dislodgment caused by inadequate line securing or unsecure connections.
- **Vasospasm:** (evidenced by blanching, cyanosis and cool skin or decreased pulse) can occur due to forceful flushing of the line or aspirating for samples of blood too vigorously. Stopping procedure and allowing time for recovery or warming of opposite limb can all elicit reflex vasodilatation. Apply warmth to the area, discuss with medical officer regarding the possibility of removal or replacement and document decision/action.

11 References

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