University of Colorado Hospital Policy and Procedure
Arterial Line Placement, Management, and Arterial Blood Gas Sampling

Related Policies and Procedures:
Central Venous Lines
Pain Management
Pressure Line Management
Specimen Integrity
Hang Hygiene-Outside the Surgical Setting
Respiratory Care Protocol
Procedural Safety and Timeout

Approved by: Professional Practice Policy & Procedure Committee
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Description:
This policy and procedure describes the insertion and management of continuous arterial pressure monitoring catheters. Arterial lines are used for the management of patients with hypotension, titration of vasoactive drugs, acute hypertension and/or for patients requiring frequent arterial blood sampling. Arterial catheters may be placed in the radial, brachial, femoral, or pedal artery. The radial artery is the preferred location for both indwelling catheter placement and direct arterial needle sticks. This policy and procedure also provides guidelines for obtaining arterial blood gas (ABG) samples from a direct arterial puncture in the radial or brachial artery. Arterial blood samples may also be obtained from an indwelling arterial catheter. The sampling of arterial blood by means of a needle puncture or via indwelling catheter allows the sample to be analyzed for blood acid base balance (PH; respiratory: PaCO2; metabolic: HCO3); evaluate ventilation (PaCO2), oxygenation (PaO2, SaO2), and to quantitate patient response to therapeutic interventions and/or diagnostic evaluation. This arterial blood sample may also assist in monitoring the severity and progression of documented disease processes.

Accountability:
Arterial lines are inserted by a physician. If the physician is unable to perform the procedure, a competency verified respiratory therapist (RT) can insert radial arterial lines only. The RN is responsible for the continuous monitoring of arterial pressure lines, arterial site care, assessment of the quality of the waveform, trouble shooting if indicated, and documentation. All arterial lines may be discontinued by a physician or an RN. A Respiratory Therapist (RT), Registered Nurse (RN), or MD who has demonstrated proficiency in obtaining an arterial puncture may perform the procedure, and a competency verified Respiratory therapist (RT) or Registered Nurse (RN) may draw a blood sample from an indwelling arterial catheter. Only a physician may perform femoral puncture. Competency verified RT’s and RN’s may draw radial abgs via arterial puncture or through the SAFESET® blood sampling device and with a physician’s order, following protocol, may draw a specimen from the brachial or pedal artery sites.
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Definitions:

**Arterial Catheter:** A flexible indwelling catheter that continuously monitors blood pressure and provides access to arterial blood samples.

**Arterial puncture:** The puncture of an artery by means of a needle to obtain an arterial blood sample for analyzing blood acid base balance (PH; respiratory: PaCO2; metabolic: HCO3); evaluate ventilation (PaCO2), and oxygenation (PaO2, SaO2)

**Allen Test:** Manual test used to determine adequate collateral circulation to a hand to obtain an arterial blood gas

**Clinically verified:** Respiratory therapist (RT) or Registered Nurse (RN) that has completed education and clinical competencies within scope of care regarding arterial lines and arterial puncture at UCH.

**Collateral Circulation:** When an area of tissue or an organ has a number of different pathways for blood to reach it. This is often as a result of anastamoses branches formed between adjacent blood vessels.

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Policies and Procedures:

I. Arterial Line Insertion and Management

A. The patient must be located in a clinical area in which hemodynamic monitoring is available.

B. Insertion of arterial catheter:
   1. Gather equipment:
      a. Arterial catheterization set
      b. Lidocaine 1% without epinephrine
      c. 3 ml syringe with 25-gauge needle
      d. 2-0 Silk suture, needle holder, and scissors
      e. Sterile towels
      f. Sterile gloves and goggles
      g. Non-sterile gloves
      h. Chloraprep applicator
      i. Transparent dressing
      j. Tape
      k. Arm board with rolled Kerlex (for radial site)
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1. Pressure module and cable
   m. Disposable transducer monitoring kit
   n. Pressure bag
   o. Flush solution—500 ml bag of 0.9% normal saline solution
   p. SAFESET blood sampling device (preferred method for drawing blood samples to conserve patient’s blood and minimize healthcare exposure).

2. Prepare the pressure transducer system (refer to policy “Pressure Line Management”).

3. Attach optional SAFESET® blood sampling device:
   a. Using aseptic technique, remove the stopcock of the pressure transducer system that is closest to the patient. Replace the stopcock with the SAFESET® system, with the sampling port end closest to the patient and the syringe reservoir further away from the patient.
   b. Unlock the plunger of the syringe reservoir by pinching the ridged areas on plunger clip. Pull plunger back to 2ml mark.
   c. Hold syringe reservoir upright (one-way stopcock at the top) and flush the SAFESET tubing. Check for removal of any air bubbles at the tip of the reservoir by pushing the plunger clip back into locked position.
   d. Continue to flush tubing until all air is cleared from the system.

4. Explain procedure to patient and MD should obtain consent if not emergent and explain the procedure to the patient.

5. An Allen’s test should be performed by the physician/RT prior to insertion of a radial arterial catheter. Healthcare provider performing/prescribing arterial stick will review coag studies (PT, PTT, INR) prior to the procedure.

6. The physician or competency verified RT will perform hand hygiene, prepare area and patient for procedure accordingly, wear protective eyewear, don sterile gloves and disposable gown before placing catheter.

7. Using aseptic technique, the physician/RT will cleanse the site with Chloraprep. Prior to cannulation of artery, the physician may choose to inject Lidocaine 1% (without epinephrine) for anesthetic purposes.

8. The RN will don gloves and connect the primed pressure tubing to the catheter hub while physician/RT holds it secure.

9. The physician/RT and RN will evaluate the waveform obtained on the pressure monitor. The waveform should be pulsatile with a sharp ascent during systole and a gradual descent during diastole. The downstroke to diastole will contain a dicrotic notch representing closure of the aortic valve. However, the more distal the cannula is from the aorta, the less defined the dicrotic notch.

10. Set pressure wave form display scale to appropriate hemodynamic level (0-120 for most patients).

11. The physician/RT will stabilize the catheter at the insertion site with suture.

12. Keep sterile all components of the pressure monitoring circuit sterile.

13. Record a pain assessment prior to, during, and post procedure as appropriate. Provide pain relief measure as needed and document patient response.

C. Post-insertion care of arterial catheter for continuous arterial monitoring:
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1. Clean all blood from the site and cover with a transparent dressing, while maintaining aseptic field. Do not place gauze under the transparent dressing. Tape and secure pressure tubing in a manner that prevents tension on the catheter and maintains skin integrity. Label the dressing with date, time, and your initials. Date pressure tubing according to “Pressure Line Management” policy.

2. If radial the artery is used, immobilize the extremity with an arm board. Maintain the wrist in a relaxed, neutral position. Do not allow the patient to flex the wrist as this can damage the catheter. Do not leave the wrist hyperextended as this can cause neuromuscular damage.

3. Level and zero-calibrate the transducer stopcock at the level of the phlebostatic axis (fourth intercostal space, mid-axillary line or mid-thoracic line with barrel chest physiology). Leveling should be done with the head of bed elevated to the position that it will be during patient care; optimally at 30° or higher.

4. Always provide continuous monitoring of the arterial line tracing with appropriate alarms on due to risk of exsanguination if the arterial line is accidentally disconnected or pulled out.

II. Arterial Line Management

A. Nursing management:
   1. Check every shift and PRN, to ensure that there is an adequate amount of flush solution remaining in bag. Air bubbles in the flush solution of an arterial catheter can embolize and cause ischemic damage to organs.

   2. The pressure bag is to be inflated to 300 mmHg at all times to maintain forward flow of flush solution.

   3. Zero and calibrate transducer every 12 hours, and whenever the transducer is disconnected from the pressure cable to assure accurate readings. Level the transducer to phlebostatic axis at beginning of shift and prn with position changes.

   4. Check accuracy of the arterial waveform hemodynamics by performing the square wave test every 12 hours and prn for questionable waveforms and/or hemodynamic data. If the square wave tracing is suboptimal (over or underdamped), troubleshoot the transducer, tubing, and catheter to obtain an accurate reading. If the artery no longer supports an adequate dynamic response, advocate for removal of the arterial line.

   5. **Square wave test (Measuring Optimal Dynamic Response):**
      a. Activate snap or pull tab on flush device and flush arterial line for 1-3 seconds.
      b. Observe square wave generated on the bedside monitor.
      c. Count oscillations or ringing after square wave.
      d. Observe distance between the oscillations.
      e. **Optimally Damped:** 1-2 oscillations before quickly returning to arterial waveform baseline. Values obtained are hemodynamically accurate.
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f. **Underdampend**: greater than 2 oscillations. Overestimated systolic pressure, diastolic pressures may be underestimated.

g. **Overdampend**: less than 1 ½ oscillations and rounded in appearance. Underestimation of systolic pressures, diastolic may not be affected.

h. Mean arterial pressures (MAP’s) are less affected by over/under damped systems and therefore should be utilized as hemodynamic end points.

i. **Trouble shooting**: Check for the presence of blood clots or air bubbles in the tubing and eliminate by turning the stopcock away from patient and disconnecting the tubing (while keeping ends sterile), allowing you to flush the line clear, ensure that there are no kinks in the tubing, and utilize one pre-packaged pressure tubing and one SAFESET® containment extension—do not add more pressure tubing to this standard set up.

j. Identify with the patient’s name and medical record number, print off and post the arterial line square wave tests in the medical record every shift and PRN.

k. A manual noninvasive BP may be utilized to determine differences between pressures (NIBP vs. Art Line) If significant differences are noted, this may require treatment decisions as to the accuracy of the arterial pressure. Avoid placing a manual cuff on the same arm as the radial arterial line due to increasing pressure during manual cuff measurements. Advocate to discontinue a non-functioning arterial line as soon as possible.

l. Assess the cannulated extremity for signs of impaired circulation such as post arterial line tissue pallor, coolness, nail bed pallor, pain, hematoma or hemorrhage, infiltration, and signs of infection every four hours and PRN. Notify the physician of any changes at or distal to the arterial line site.
   i) Assess the arterial site for pain/discomfort every four hours and PRN. Provide pain relief measures as needed.
   ii) Check the security of all connections. Keep stopcocks and tubing free of bubbles, blood, and kinks. Place sterile occlusive caps on all stopcock ports.
   iii) Arterial line catheters are not routinely changed. Monitor with physicians the length of time of the arterial line presence and the potential for blood stream infections.
   iv) Transducer, pressure tubing, and flush bag are to be changed every 96 hours (4 days).

m. Change the dressing every 4 days with tubing change and prn according to "Central Venous Lines" policy (Biopatch does not need to be used for this dressing).

n. Minimize the number of manipulations and entries into the pressure monitoring system.
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o. No medications may be given through the arterial line at any time.

III. Arterial Line Blood Sampling

1. Blood sampling from arterial line using In-Line Reservoir system (SAFESET) ®: Should be performed by clinically verified RT or RN.
   A. Gather equipment:
      i) Non-sterile gloves
      ii) Alcohol wipes
      iii) Vacutainer with needleless cannula, or appropriate size syringe(s) with “Shielded Blunt Cannula” and needle safe blood transfer device
      iv) Blood tubes and lab labels
   B. Perform hand hygiene and explain the procedure to the patient.
   C. Silence the arterial pressure alarm.
   D. Don on non-sterile gloves.
   E. Pinch the ridged areas on the plunger clip to release the locking mechanism. Pull back on the plunger to fill the syringe reservoir. Fill the reservoir at a rate no faster than 1 ml/second to avoid occlusion of the catheter.
   F. Once the syringe reservoir is filled, turn the one-way stopcock connected to the reservoir “off” by turning it perpendicular to the tubing.
   G. Scrub the sample site port with an alcohol wipe for 15 seconds and let dry.
   H. Insert a syringe or vacutainer into the sample site port (do NOT use blunt tip needle to access system). Withdraw the amount of blood needed.
   I. Turn the one-way stopcock between the sampling port and the patient “off” by turning it perpendicular to the tubing.
   J. Aspirate slightly while removing the blood collection device from the sampling port.
   K. Return both one-way stopcocks back to the “on” position, parallel to the tubing.
   L. Return the volume in the reservoir to the patient by pushing the plunger back into its locked position. Return the reservoir volume at a rate of 1 ml/second.
   M. Flush intermittently for 2-second intervals with the fast flush device until the tubing is clear of blood. Avoid vigorous, large volume flushing.
   N. Scrub sampling port with alcohol wipe to remove any excess blood.
   O. Ensure that the arterial alarm is no longer silenced and assess the quality of the wave form has returned to baseline.
   P. If a syringe is used, transfer blood to tubes using a needle safe blood transfer device. Do not utilize actual needles to pierce vacutainers for blood transfer from a syringe.
   Q. Label blood tubes appropriately at the patient’s bedside and place in a plastic biohazard bag.

2. Blood Sampling from arterial line using stopcock system:
   A. Gather equipment:
      i) Non-sterile gloves
      ii) Alcohol wipes
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iii) 5 ml syringe for “waste”
iv) Appropriate size syringe(s) and needle safe blood transfer device; or vacutainer if preferred
v) Sterile 2x2 gauze
vi) Blood tubes and lab labels

B. Wash hands and explain the procedure to the patient.
C. Silence the arterial pressure alarm.
D. Don non-sterile gloves.
E. Remove the sterile protective cap from the distal stopcock.
F. Cleanse the stopcock port with an alcohol wipe for 15 seconds and let dry.
G. Attach a sterile “waste” syringe to the stopcock for discard.
H. Turn the stopcock off to the flush solution. Aspirate slowly until blood enters the syringe. Stop aspiration and note the volume in the syringe, which is the dead space volume. Continue to aspirate until a total of 3 times the dead space volume has been withdrawn. For example, if the dead space volume is 0.5 ml, aspirate 1.5 ml. When prothrombin time or partial thromboplastin time values are to be determined, aspirate until 6 times the dead space volume has been withdrawn (the dead space is the volume of the space from the tip of the catheter to the sampling port of the stopcock).
I. Turn the stopcock to the half-closed position and remove the “waste” syringe. Discard appropriately.
J. Attach sampling syringe(s) to the stopcock. Turn the stopcock off to the flush solution. Withdraw the amount of blood needed for lab tests.
K. Close the stopcock and remove the syringe containing blood sample.
L. Intermittently activate the fast-flush device for 2 second intervals to clear the arterial line. Avoid vigorous, large volume flushing. Turn the stopcock off to the patient and fast-flush side port of the stopcock into sterile gauze until all blood is cleared from the stopcock.
M. Close the stopcock and cleanse the port with alcohol wipe to remove any residual blood. Replace sterile protective cap.
N. Transfer blood to lab tubes using a needle safe blood transfer device.
O. Label blood tubes appropriately at the patient’s bedside and place in a biohazard bag.
P. Ensure the arterial pressure alarm is no longer silenced and assess the quality of the wave form has returned to baseline.

IV. Discontinuing arterial catheter

1. The physician writes an order to discontinue the arterial catheter.
2. Healthcare provider performing/prescribing arterial stick will review coag studies (PT, PTT, and INR) prior to procedure, and prior to removal of an arterial catheter. Also be aware if the patient is on any anticoagulation medications i.e. heparin or coumadin. These factors may prolong time needed to stop bleeding at site once catheter is removed.
A. Obtain the following supplies:
   i) Tape
   ii) Suture removal kit
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iii) Container of 4x4 gauze
iv) 2x2 dressing
v) Non-sterile gloves
B. Explain the procedure to the patient.
C. Wash hands and don gloves.
D. Remove the dressing and sutures. Hold 4x4 gauze 1-2 finger widths proximal from the insertion site. Apply firm pressure with the 4x4 gauze as the catheter is being removed.
E. Assess the integrity of catheter on removal. Notify the physician if catheter tip is not intact.
F. Maintain pressure to the site for 5-10 minutes. Apply a dry, sterile, occlusive pressure dressing once bleeding has stopped.
G. Change the dressing and assess the site every 24 hours until site has epithelialized.
H. Documentation:
   i. Documentation is to be done in the electronic health record (EHR) and should include:
      a. Name of physician/RT who inserted arterial catheter.
      b. Patient response to procedure.
      c. Date, time, and location of insertion.
      d. Assessment of arterial site every 4 hours and prn.
      e. Quality of peripheral pulse and any signs of impaired circulation to involved extremity every 4 hours and prn.
      f. Pain assessment, medications, and response to pain relief measures every 4 hours and prn.
      g. Zeroing and leveling of transducer every 12 hours and prn. Trend NIBP and arterial line pressure every shift.
      h. Quality of arterial wave form with square wave test every 12 hours and prn. Place recorded strip of square wave test and arterial pressure wave form in the chart every 12 hours and prn.
      i. Tubing and dressing changes every 4 days and prn.
      j. When arterial line is discontinued, how long pressure is held, application of pressure dressing, site assessment, and status of catheter tip.

V. Arterial Blood Gas Sampling
   Technique for obtaining arterial blood gas by puncture of skin.

1. Explain procedure to patient. Obtain a physician’s order.
2. Gather equipment: one pair nonsterile gloves, a Chloraprep (2% Chlorhexidine with 70% Isopropyl alcohol) applicator, one alcohol swipe, one sterile 2x2, tape, arterial blood gas kit.
3. Perform the Modified Allen test to assess for collateral circulation. Elevate patient’s hand and instruct the patient to open and close his or her fist several times. With the patient’s hand clenched, simultaneously occlude the radial and ulnar arteries. Observe for pallor in the patient’s hand. Release ulnar artery pressure; patient’s hand should then flush (return of color) within 10 seconds. If the hand does not flush within 10 seconds, do not use this radial artery and document the rationale.
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4. Select an arterial sampling site. A clinically verified RN or RT may perform a radial arterial puncture. An RN or RT may perform a brachial or dorsalis pedis arterial puncture with a MD order only and clinical verification, giving serious consideration to the quality of circulation when performing a pedal stick.

5. Prepare the pre-heparinized syringe by setting plunger to desired sample (1.5cc-2cc).

6. Palpate and localize the artery between the index and middle finger.

7. Clean the site with ChloraPrep using repeated back and forth strokes, completely wetting treatment area with antiseptic; allow ChloraPrep to dry for approximately 30 seconds. Do not blot or wipe away.

8. Don nonsterile gloves. Keeping index or middle finger on the puncture site to mark area and stabilized the artery, hold the syringe like a pencil with the bevel up. Take note of SpO2 on monitor.

9. Puncture the radial artery at a recommended angle of 30-45 degrees. Puncture the brachial artery at a recommended angle of 60 degrees. For Pedal arterial punctures a recommended angle is 30-45 degrees.

10. Advance the needle into the chosen artery. Allow the syringe to fill completely (1.5-2ml). Remove the syringe and apply pressure to the site. Hold pressure on site for 5 minutes, or longer if needed for bleeding to stop. Cover the site with clean gauze and secure with tape once homeostasis is achieved.

11. Engage the needle protection system immediately after withdrawing the syringe from artery, using one-handed technique before removing needle from syringe.

12. Ensure that the needle is shielded before touching capped needle. Remove capped needle. Dispose of needle properly. Seal the syringe with cap included in kit. Expel air/ bubbles from syringe with the syringe tip upright and cap held in place.

13. Immediately roll syringe gently (for approximately 10 seconds) to ensure heparin mixing.

14. Label specimen according to lab policy. Transport to lab immediately. If greater than 30 minutes, put on ice. Do not send syringe to lab with needle attached.

15. Document the procedure, including Allen test and site used in EHR

16. Record a pain assessment prior to, during and post procedure as appropriate. Provide pain relief measures as needed and document patient response.

17. Patient Care Considerations:
   A. No suctioning or adjustments in FIO2 or ventilator settings should be done 20 minutes prior to arterial blood gas sampling. Patients with an obstructive defect may require 30 minutes before an accurate blood gas may be obtained
   B. Observe arterial puncture site for delayed hematoma formation and impaired circulation to extremity.
   C. Instruct patient to expect some discomfort and to avoid sudden movements of the arm during procedure.
   D. When performing radial puncture, dorsiflexion of the wrist moves the artery closer to the skin surface making the artery easier to palpate.
   E. Care should be exercised to use alternate sites for patients requiring frequent arterial specimens, in these patients an indwelling arterial catheter may be warranted for these patients and should be discussed with the MD.
   F. Universal precautions must be applied in all circumstances involving blood or blood contaminated collection devices, and all sharps need to be disposed of appropriately.
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VI. Contraindications

1. An abnormal modified Allen’s test suggests using an alternate limb/site for arterial punctures. Notify MD if unable to use radial site due to poor collateral circulation. These sites are at increased risk of ischemic complications, these sites should be carefully scrutinized before arterial puncture is attempted.
2. Arterial puncture should not be performed on/through any surgical shunt (dialysis fistula), or if there is evidence of infection or peripheral vascular disease involving selected limb.
3. A coagulopathic patient may also be a relative contraindication for arterial puncture and should be discussed with MD.

VII. References