INTERDISCIPLINARY CLINICAL MANUAL
Policy & Procedure

TITLE: Care of the Patient with a Pulmonary Artery Catheter – Hemodynamic Monitoring

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THIS IS A POST ENTRY LEVEL COMPETENCY FOR REGISTERED NURSES WHICH REQUIRES EDUCATION AND ASSESSMENT OF COMPETENCY PRIOR TO PERFORMING.

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POLICY

1. The principles of aseptic technique, universal precautions, and sterile technique are to be practiced while caring for the patient with a pulmonary artery (PA) catheter.

2. The anatomy and physiology of PA catheter placement and function must be understood. It is critical that the waveforms associated with each aspect of insertion and monitoring be recognized.

3. The physician is to be alerted to any unexpected findings or complications.

4. The principles of patient and family education are to be ongoing during the period of time that the patient is hemodynamically monitored.

5. All aspects of the procedure is to be documented according to hospital policies and unit protocols/standards.

6. Pulmonary artery systolic (PAS), Pulmonary artery Mean (PAM), Pulmonary artery Diastolic (PAD), and Right Atrium (RA) Pressures are to be documented hourly.

7. PA Catheter waveforms are to be continuously monitored.

8. Professional Nursing responsibilities for Hemodynamic monitoring include:
   8.1. Assisting with insertion
   8.2. Maintenance of the pulmonary artery catheter (PA Catheter)
   8.3. Obtaining pressure readings
   8.4. Measurement of cardiac output (Intermittent)
   8.5. Mixed venous blood sampling
   8.6. Removal of the PA Catheter

9. Patients are to be monitored closely for the following expected or unexpected outcomes, or potential problems:
   - Pneumothorax/Hemothorax
   - Infection
   - Dysrhythmias (Ventricular)
   - Poor Placement
   - Hemorrhage
   - PA Rupture
   - Pericardial or Ventricular Rupture
   - Venous Air Embolus
   - Sepsis
   - Cardiac Tamponade
   - Pulmonary Artery Infarction
   - PA balloon rupture
   - PA Catheter Knotting
   - Valvular Damage
   - Thrombosis

See CC 10-090 Learning Module for Care of the Patient with a Pulmonary Artery Catheter for calculated measurements and their definitions.
GUIDING PRINCIPLES

1. Pulmonary artery catheters (PA catheter) are an invasive type of hemodynamic monitoring useful in the assessment of preload, afterload and contractility. The measurements obtained from a PA catheter may be used to maximize cardiac output, tissue perfusion and fluid balance.

2. Hemodynamic Monitoring is performed to:
   2.1. assess the competency of right ventricular (RV) and left ventricular (LV) function and to provide monitoring in those with cardiac and pulmonary disorders
   2.2. assess and monitor Right Atrial Pressure (RA or RAP), Pulmonary Artery Pressure (PAP), Pulmonary Arterial Wedge pressure (PAWP, Wedge), Pulmonary Occlusive Pressure (POP), and to calculate hemodynamic values
   2.3. evaluate therapeutic interventions which affect hemodynamic status such as vasoactive drugs, fluid replacement, diuretics

3. The PA catheter (Size #7) is inserted through a Percutaneous Introducer (Cordis) size #8.5 and a sterile sleeve. (Refer to: Cordis, SLIC, PICL - Care, Maintenance and Removal of CC 80-030.)

I. ASSISTING WITH INSERTION

EQUIPMENT

- Percutaneous Sheath Introducer Kit
- Disposable PA bifurcated monitoring kit
  (Note: Some units use 2 single transducer monitoring kits)
- Protective sleeve
- 1 Pressure bag
- Transducer cable
  (Note: x 2 for those using two transducer kits)
- Masks
- Sterile gloves
- Gowns
- Transparent dressing (as per policy CC 80-030 - Cordis, SLIC, PICL - Care, Maintenance and Removal of)
- 2% Xylocaine local anaesthetic without epinephrine
- Primed PA tubing
- Primed introducer tubing
- Central line insertion tray
- IV pole with transducer mount
- Chlorhexidine (Solu-Prep)
PROCEDURE

1. Prepare the patient and family prior to procedure.
   
   **Note:** It is the physician’s responsibility to obtain consent.
   
   1.1. Provide the patient/family education booklet that is available (Pulmonary Artery Catheter - IC85-0072)

2. Mount the transducer holder on the IV pole at the approximate level of the phlebostatic axis - 4th intercostal space, mid axillary line (4th ICSMAL).

3. Place a 500 mL bag of preferred solution in a pressure bag.
   
   **Note:** Normal Saline is preferred at CDHA.

4. Prime the PA tubing.

5. Connect the system via the cable to the monitor.

6. Inflate the pressure bag to 300 mmHg.

7. Zero the monitor as per individual monitor specifications.

8. **Priming - Bifurcated Monitoring Kit**
   
   **Note:** Some units use Baxter Pressure Monitoring Kits (x2). The procedure for priming is the same as for an arterial line. Both RA + PA pressures are monitored simultaneously.

<table>
<thead>
<tr>
<th>1st Step:</th>
<th>Remove the kit from the package and slide kit into the pole mount with pigtails <strong>down</strong>. Cables should also be in the down position.</th>
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</thead>
<tbody>
<tr>
<td>Distal: 2nd Step:</td>
<td>Turn the transducer stopcock <strong>off</strong> to the <strong>PA</strong> line (arrow should be pointing to <strong>up</strong>). Remove the white cap from the balance port of the transducer. Using the transducer pigtail, flush the transducer. Replace cap with a dead ender. Turn the transducer stopcock <strong>off</strong> to the balance port.</td>
</tr>
<tr>
<td>Proximal: 3rd Step:</td>
<td>Turn the <strong>PA</strong> stopcock <strong>OFF</strong> to the right atrium <strong>RA bridge</strong>. Remove the white cap from the PA side port (close to the patient end). Using the <strong>transducer</strong> pigtail, flush the <strong>PA</strong> line. Replace the cap with a dead ender. Turn the stopcock <strong>OFF</strong> to the side port. Remove the white cap from the patient end and continue to flush the line. Replace cap with a dead ender. Turn stopcock <strong>OFF</strong> to the flush line until ready to connect to the PA catheter. Turn <strong>PA</strong> stopcock <strong>OFF</strong> to the patient line.</td>
</tr>
<tr>
<td>4th Step:</td>
<td>Using <strong>transducer</strong> pigtail, flush bridge to RA.</td>
</tr>
<tr>
<td>5th Step:</td>
<td>Turn <strong>PA</strong> stopcock <strong>OFF</strong> to bridge.</td>
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</tbody>
</table>
| 6th Step: | Remove white cap from **RA** side port (close to the patient end). Using the **RA** pigtail, flush the **RA** line. Replace the cap with a dead ender. Turn the **
stopcock OFF to the side port. Remove the white cap from the patient end and continue to flush the line. Replace cap with a dead ender. Turn stopcock OFF to the flush line until ready to connect to the PA catheter.

Check entire system for trapped air bubbles. Check to ensure all connections are tight.

**The PA Bifurcated Monitoring Kit-Zero Balancing and Calibrating**

1. To zero balance, align the zero-line on the pole mount with the patients 4th intercostal space on the mid-axillary line (Phlebostatic Axis).
2. Turn the stopcocks, at the patient end of both lines, off to the patient.
3. Turn both the transducer stopcock and the PA stopcock OFF to the patient line (both stopcocks should be pointing to 12 o'clock).
4. Remove the dead ender from the balancing port of the transducer and zero the transducer according to the monitor specifications.
5. Turn the transducer stopcock off to the side port and replace the deadened.
6. Turn the PA stopcock off to the bridge.
7. Reopen stopcocks at patient end of both lines.

9. **Insertion**
   9.1. Open the central line insertion tray, Introducer Kit, gloves and gowns.
   9.2. Pour skin cleansing solution. (Chlorahexidine)
   9.3. Assist the physician to open the Percutaneous introducer set, insertion tray, and supplies as required. (See Cordis, SLIC, PICL - Care, Maintenance and Removal of CC 80-030 for care and maintenance)
   9.4. Assist the physician to draw up 2% Xylocaine local anaesthetic.
   9.5. Place the patient in the preferred position - supine, head turned away from insertion site and in Trendelenberg for introducer insertion.
      
      **Note:** Position may need to be changed dependent upon the patient’s condition.
   9.6. Ensure the introducer is sutured in place.
   9.7. Connect the introducer tubing to the sidearm once the vessel is cannulated and blood is aspirated back; flush blood out of side arm tubing.
   9.8. Open the PA catheter kit and protective sleeve.
   9.9. Level the patient or raise the head slightly as requested by physician.
   9.10. Assist the physician to drape the patient.
   9.11. The physician hands off connection ports at the end of the PA catheter.
   9.12. Connect the appropriate tubing to the RA and PA ports.
9.13. Flush the RA and PA ports with normal saline (500 mL bag).

9.13.1. Ensure the protective sleeve is in place.

9.14. Ensure that an artifact tracing appears on the monitor when the physician wiggles the tip.

Note: Follow manufacturer guidelines for specific instructions on all aspects of PA catheter monitoring and usage

9.15. To confirm the balloon integrity, connect the 3 mL syringe filled with 1.5 mL of air to the balloon inflation port. Inflate the balloon and allow the balloon to passively deflate. Remove the syringe.

9.16. During insertion of the PA catheter:

9.16.1. Monitor the cardiac rhythm.

9.17. Monitor all waveforms during insertion: RA, RV, PA and PCWP.

9.18. Inflate the balloon with maximum of 1.5 mL of air and allow the balloon to passively deflate according to the physician’s request.

Note: The balloon is inflated for insertion and all forward movements of the catheter, and deflated when the catheter is pulled back. Both physician and nurse are monitoring for arrhythmias and waveform changes.

9.19. Secure the catheter, apply a clear transparent dressing and obtain a CXR.

9.19.1. Confirm the X-ray position of the PA catheter prior to performing cardiac output measurements - unless otherwise ordered by physician

9.20. Document the length of catheter insertion as well as the site of the catheter tip (right or left pulmonary artery); both in the Kardex (care plan) and nurses notes (progress notes where applicable). (E.g. 48 cm.)

9.21. Label the tubing with the date and time the system was setup.

II. MAINTENANCE OF PULMONARY ARTERY CATHETER

POLICY
1. Continuous monitoring of PA waveform and cardiac rhythm is necessary.

2. Frequency of dressing and tubing changes are determined by the Central Venous Access Device (CVAD) Umbrella Policy CC 80-021 (sc)

3. Individual unit standards determine the type of flush solution, zeroing and calibration of monitoring equipment.

4. The tubing is to be changed every 96 hours as recommended by the Centre for Disease Control Standards.

5. Inotrope and other drip infusions are to be infused via the percutaneous introducer (Cordis line) or other central line ports unless the only port available is the RA (proximal).
5.1. Use extreme caution if infusing any drug through the RA port.

5.2. Never infuse any solution through the PA port. This port is maintained patent utilizing a flush system only.

6. The PA catheter is never to be flushed when the balloon is wedged.
7. Blood products and albumin should never be infused through a PA catheter.
8. The sterility and integrity of the plastic sleeve is to be maintained.
9. After blood sampling, the system, including stop-cocks, is to be cleared of all traces of blood.

PROCEDURE

1. Using a carpenter level, ensure that the air/fluid interface of transducer is at the level of the phlebostatic axis (4th ICSMAL).
2. Ensure the pressure bag is inflated to 300mmHg.
3. Continuously monitor the PA waveform to ensure catheter position.
4. Troubleshoot waveform abnormalities.
5. Monitor for complications as follows:
   
   **Note:** this list is not all inclusive

   5.1. Dysrhythmias
   
   5.2. PA infarct/rupture
      
      5.2.1. Do not inflate the balloon with more than 1.5cc of air and continually monitor for spontaneous wedging.
      
      5.2.2. If a rupture is suspected, place the patient in the **right** lateral position if the catheter tip is in the **right** pulmonary artery. If a rupture is suspected and the tip is on the **left**, this side would be placed down. If the side of insertion is **unknown**, place assuming the **right** side has been cannulated. If resistance is encountered when the balloon is inflated call the physician.

   5.3. Line related sepsis
      
      5.3.1. Check the site every shift for signs and symptoms of infection.

   5.4. Air embolism
      
      5.4.1. Ensure that all connections are tight.
      
      5.4.2. Ensure that the syringe is not attached to the balloon inflation port when not in use.
      
      5.4.3. Place the patient in the **left** lateral Trendelenberg position, if an air embolism is suspected.

6. Promptly notify physician of any complications.

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III. OBTAINING PRESSURE READINGS

POLICY
1. If balloon integrity is questionable (i.e. air insertion in balloon is effortless; blood is in balloon port), the following actions are to be taken:
   1.1. remove syringe
   1.2. close balloon inflation port
   1.3. label and tape port closed
   1.4. document
   1.5. notify physician
   1.6. Monitor patient for signs and symptoms of air emboli. The PA catheter should be removed.
2. If the catheter spontaneously wedges the physician is to be notified immediately. The patient is to be monitored; coughing encouraged, and position changed to determine the effect of positioning on the wave form.

GUIDING PRINCIPLES
3. Frequency of pressure readings and various calculations are dependent upon unit protocols, physicians’ orders, patient’s condition and titration of vasoactive drugs.
4. Readings are done with air/fluid interface of the transducer level with the phlebostatic axis (4th ICSMAL).
5. Readings are done at end expiration.

PROCEDURE:
1. Place the patient in the preferred position - supine with the head of bed (HOB) 0-60 degrees.
   1.1. Place the patient at the same level each time a reading is taken.
2. Use a carpenter’s level to ensure that the transducer is level with the phlebostatic axis (4th ICSMAL).
3. With the PA stopcock turned off to bridge, obtain the PAS and PAD at end expiration according to monitoring system.
4. Stop any infusion into RA port.
5. Turn the PA stopcock off to PA flush, confirm the RA trace and obtain the RAP at end expiration.
6. Turn the PA stopcock off to bridge, confirm PA trace.
7. Resume infusion into RA port if necessary.
8. Ensure that the balloon inflation valve is in open position. DO NOT LOCK.
9. Connect the 3mL syringe, with 1.5 mL of air, to the balloon inflation port.
10. Slowly inflate the balloon, while monitoring the PA waveform, until the wedge tracing is verified; obtain a PAWP reading.
11. Allow the balloon to passively deflate.
12. Remove the syringe from the inflation port, place in an area where the special 3mL syringe will not be lost.
13. Notify the physician if the wedge tracing is obtained using less than 1.25 mL of air
14. Verify that the PA waveform has returned.

IV. MEASUREMENT OF CARDIAC OUTPUT

GUIDING PRINCIPLES

1. Frequency of procedure is dependent upon unit protocols, physicians’ orders, the patients’ condition, and titration of vasoactive drugs.
2. Individual unit monitoring systems, standards and practice guidelines determines measurement protocols (i.e. volume and temperature of injectate, equipment usage).
   
   **Note:** Some units utilize a CO system that allows for a closed system whereby the tubing and syringe used for CO bolus remain in-line.
3. Greater consistency of CO measurements will be obtained if the procedure is performed during a particular time of the respiratory cycle i.e. inject on expiration.

EQUIPMENT

- 1 bag IV solution 500ml as per unit standard
- CO Cable
- Tubing and syringe–as per unit practice

PROCEDURE (if using in-line system)

1. Remove the foam probe holder from the package and attach to a bag of solution, with foil tape at the top of the bag.
2. Insert the tubing into the bag.
3. Take a syringe and attach to the one-way port.
4. Undo the clamp and prime the tubing and 10cc syringe with injectate.
5. Connect the CO monitor cable to the PA catheter and thermistor or temperature probe; activate the CO mode of the monitoring system.
6. Ensure the correct variables are entered (i.e. catheter size, volume of injectate).
7. Position the patient supine with the H0B 0-30 degrees.(maximum of 60 degrees)
8. Remove the RA side port cap of the RA stopcock, attach another 3-way stopcock and injectate tubing.
   **Note:** The use of the closed D5W CO injectate system is recommended
9. Verify the PA waveform.
10. When the monitor system indicates, “inject”, turn the RA stopcock off to the transducer and smoothly inject the desired volume over 4 seconds or less.
11. Turn the stopcock off to the RA side port and refill the syringe with 10cc of injectate.
12. Repeat the procedure 3-5 times assessing thermodilution curves (sharp steady upstroke and gradual down stroke) and confirming that those measurements are within 10% of each other; delete measurements that do not meet these criteria.
13. Average the CO and enter the relevant data into the monitoring system to generate the Hemodynamic Profile.
14. Ensure the parameters that are automatically entered into the calculation are valid (i.e. MAP will be valid only of arterial line is accurate.)
   14.1. Obtain PA pressures including PAWP immediately prior to measurement of CO.
15. Calculate the hemodynamic parameters according to the unit protocol.

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V. **MIXED VENOUS BLOOD SAMPLING**

**GUIDING PRINCIPLES**

1. Frequency of mixed venous blood sampling and calculation of oxygen consumption and delivery is dependent upon doctors’ orders.

2. Mixed venous blood sampling is usually done immediately following the measurement of CO and simultaneously with the collection of an ABG sample. This practice is unit specific.

**PROCEDURE**

1. Assemble equipment:
   1.1. Two heparinized labelled syringes
   1.2. ice
   1.3. Two 3cc syringes
   1.4. gloves
1.5. 2 x 2 gauze
2. Remove the cap from the side arm of the PA port stopcock and connect a 3cc syringe
3. Turn the stopcock off to the transducer.
4. Withdraw 3cc of solution and blood.
5. Turn the stopcock 45 degrees (turn off all ports).
6. Remove the syringe and connect the Heparinized syringe.
7. Turn the stopcock off to the transducer and slowly withdraw blood sample (1.5 mL).
8. Turn the stopcock 45 degrees and remove the syringe.
   8.1. hold the syringe perpendicular to the floor with the cap end pointing towards the ceiling
   8.2. tap the side of syringe to dislodge any air bubbles
   8.3. slowly push plunger to expel any air from the syringe
9. Cap the syringe, label and immerse into ice.
10. Turn the stopcock off to the sidearm port and flush the lumen of the PA catheter until cleared
    (each flush will not exceed 2 seconds).
11. Replace the “dead ender” cap with a new cap.
12. Verify that the PA waveform has returned.
13. Take the arterial blood gas sample.

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VI. **REMOVAL OF PA CATHETER**

**POLICY**

1. A physician’s order is required prior to:
   1.1. removing the PA Catheter
   1.2. sending the tip of the PA Catheter for C&S
2. The most recent chest x-ray is to be reviewed for evidence of catheter position/looping/ knotting of catheter in R ventricle.

**GUIDING PRINCIPLES**

1. The PA catheter may be removed and the introducer left in place. See policy Cordis, SLIC, PICL - Care, Maintenance and Removal of CC 80-030 for the care and maintenance of the introducer.

**PROCEDURE:**
1. Assemble the equipment:
   1.1. dressing tray
   1.2. sterile gloves (if the tip of the catheter is to be sent for C&S)
   1.3. mask
   1.4. sterile specimen container
   1.5. sterile scissors or blade
   1.6. transparent dressing,
   1.7. incontinent pad
   1.8. Chlorhexidine

2. Obtain baseline vital signs.

3. Open the dressing tray, scissors, 4 x 4, gloves and dressing. Pour the Chlorhexidine solution into the receptacles.

4. Connect a 3cc syringe to the balloon inflation port, ensure that the port is open, and pull back on the plunger to be sure the balloon is deflated.

5. Lock the balloon lumen to ensure the balloon remains deflated.

6. Loosen and remove the catheter dressing.

7. Position the patient supine with the HOB flat if the introducer is to be removed.
   7.1. Have the patient perform the Valsalva manoeuvre or remove on end expiration.
   7.2. Turn the patient’s head away from the insertion site.
   7.3. Position the incontinent pad.

8. Loosen the introducer sleeve.

9. Secure the introducer, while observing the cardiac rhythm and PA waveforms.
   9.1. In one smooth continuous motion gently pull the catheter until it is completely out.
   9.2. If there is any resistance, stop the procedure, notify the physician and await further instructions while continuing to monitor waveforms and cardiac rhythm.

10. Inspect the catheter to ensure that the entire catheter has been removed (obtain tip for C & S, if ordered).

11. Immediately apply an obturator cap to the Percutaneous introducer.

12. Cleanse the insertion sites with Chlorhexidine.

13. If the introducer is to be removed, cut the suture and remove the introducer (PA catheter and introducer may be removed in one continuous step if desired.)

14. If the introducer was removed, apply pressure until bleeding has stopped.
   14.1. Apply a sterile Vaseline gauge and clear transparent dressing (See policy Cordis, SLIC, PICL - Care, Maintenance and Removal of CC 80-030 to insertion site.)
15. If the introducer remains in place, apply a sterile transparent dressing.
16. Monitor the patient for possible complications related to the removal of the PA catheter.


**HISTORICAL DATES**
New (Replaces QEII Hemodynamic Monitoring NC-50-10-100)

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