

Institutional Policy Manual

Policy Title: Pulmonary Artery Catheter Management and Waveform Analysis (Adult)

Policy Summary: It is the policy of *** to safely utilize pulmonary artery catheters (PA) to determine hemodynamic status in certain critically ill patients. Principles of sterile technique must be followed per Care of Patients with a Central Venous Access policy.

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Policies:

1. Pre requisite for insertion: knowledge of normal anatomy of vasculature, technical competence in insertion of central line, understanding the principles of sterile technique, clinical and technical competence in PA catheter insertion and understanding of hemodynamic waveforms
2. Registered nurses in adult ICUs may care for patients with indwelling pulmonary artery catheters after successfully completing Central Line Bundle elearn and Level 1 of PACEP education and/or PA catheter elearn.
3. Patients with pulmonary artery catheters will have continuous cardiac and hemodynamic monitoring.
4. The registered nurse will notify the hemodynamic technician to set up all necessary pressure monitoring lines. The RN is responsible for checking connections, properly connecting the pulmonary artery catheter to the monitoring cables, and setting up the monitor to the appropriate wave forms and scales. Recommend 0-30 scale for central venous pressure (CVP) waveform and 0-60 for PA waveform.
5. During insertion, continuous dual channel recordings of all waveforms coupled with ECG tracings will be obtained and placed in the continuous cardiac monitoring record. Documentation of right atrium (RA), right ventricle (RV), PA, pulmonary capillary wedge pressure (PCWP) pressure and electrocardiograph (ECG) waveforms will be completed and attached to patient progress note. [Of note, the PCWP is also known as the pulmonary artery occlusive pressure (PAOP) and the pulmonary wedge pressure (PWP)].
6. During insertion, cardiac pacing equipment will be available. (A patient with a left bundle branch block may develop a right bundle branch block during P.A. catheter insertion resulting in complete heart block).
7. The health care team will review the line necessity daily.
8. Registered nurses will obtain cardiac output/index, pulmonary vascular resistance (PVR) and systemic vascular resistance (SVR) as prescribed or minimally once in a 24 hour period.
9. The pulmonary diastolic pressure (PDP) can be followed if the PDP is ≥ 4 mm of the PCWP. The PA catheter will not require wedging if the PDP is 4 mm greater than the PCWP.

10. **The Registered Nurse will not wedge the PA catheter.** Privileged Cardiologists/cardiac fellows, cardiothoracic physicians/ physician assistant's/Nurse Practitioner's, and Critical Care physicians/fellows will wedge the PA catheter in a critical care unit.
11. The registered nurse will notify the hemodynamic technician, upon a physician's prescription, to obtain mixed venous sampling.
12. The distal port of the PA catheter is never used for to infuse medications, drawing blood, or administering IV fluids. Blood products should never be infused via PA catheter ports. Vasoactive medications should only be infused via the proximal port as a last resort. A bolus of the medication could occur during the cardiac output measurement procedure.
13. Blood sampling for purposes other than mixed venous sampling may be obtained from the pulmonary artery catheter distal port only in an emergency.
14. Dressing changes are done per Care of Patients with a Central Venous Access policy.
15. Obtain chest x-ray for:
 - placement confirmation (copy of PA catheter placement confirmation from fluoroscopy in the Cath lab is acceptable)
 - o Document PA catheter location (right or left lung)
 - if there is a change in waveform
 - or if Pulmonary Artery catheter is repositioned.

Patient Monitoring and Care

1. The RN will perform a systematic cardiovascular, peripheral, hemodynamic and pain assessment before, during and immediately post insertion of PA catheter, minimally every 4 hours and with change in nurse provider.
2. The RN will document every 12 hours and with change in nurse provider the following :
 1. The transducers have been leveled, zeroed and a square waveform test has been performed.
 2. The insertion length at introducer site in centimeters.
 3. The analysis of dual channel recordings for catheter position
3. Site inspection and care of injection ports according to "Care of Patients with a Central Venous Access" policy.

References:

- Darovic, G. (2002). *Hemodynamic monitoring: Invasive and noninvasive clinical application*. Philadelphia, PA: Saunders.
- Lynn-McHale Wiegand, D.J. 5th edition 2011. In AACN Procedure Manual for Critical Care. Philadelphia, PA: W. B. Saunders.
- Pulmonary Artery Catheter Education Project at <http://pacep.org> as an educational resource.

Appendix A: Pulmonary Artery Catheter Insertion

Procedure for Pulmonary Artery Catheter Insertion:

1. Follow strict aseptic technique for insertion as outlined in central line policy
2. This procedure requires the documentation that a “time out” was performed
3. Mark the phlebostatic axis and level the transducer to the phlebostatic axis. Adjust as necessary.
4. Zero the hemodynamic monitoring system. Check the hemodynamic monitoring system assuring there are no air bubbles in the lines and all connections are tightly secured.
5. If a PA catheter has the capacity to monitor mixed venous oxygenation, the fiber optics need to be calibrated before removal from the package.
6. It is recommended to test the integrity of the balloon by immersing the balloon in a labeled sterile basin filled with sterile water and inflating with < 1.5 ml air, remove the syringe and observe for inflation of balloon.
7. Hand off the ports of the PA catheter to the assistant. The assistant will flush all open lumens in preparation to connect to hemodynamic monitoring system
8. While observing the monitor and the markings on the PA catheter, advance the catheter through the introducer to the right atrium. Observe the changes in the waveform and document the RA pressure.
9. Record a dual channel strip of the ECG and RA waveform.
10. While observing the monitor and the markings on the PA catheter, advance the catheter through the introducer to the right ventricle. Observe the changes in the waveform and document RV systolic and diastolic pressures.
11. Record a dual channel strip of the ECG and RV waveform.
12. While observing the monitor and the markings on the PA catheter, advance the catheter through the introducer to the pulmonary artery. Observe the changes in the waveform and document PA systolic, mean and diastolic pressures. The PA catheter should reach the PA after being advanced to 45-55 cm from internal jugular.
13. Record a dual channel strip of the ECG and the PA waveform.
14. Standard procedure prior to advancing the catheter is to inflate the balloon with 1.5 ml of air and allow to float to the wedge position.
15. Observe the PA waveform and confirm wedge position and pressure. Document PA wedge pressure.
16. Record a dual channel strip of the ECG and PA wedge waveform.
17. Physician allows passive deflation of the balloon by removing the syringe from the inflation port, and leaving the stopcock to open.
18. Standard procedure guides the physician to rewedge the PA catheter to confirm waveform. Extend the sterile sleeve over the catheter and secure in place.
19. Apply Biopatch and clear dressing.
20. Immediately post-insertion, the registered nurse will assess and document the length of catheter insertion in centimeters.
21. Complete the Central Line Insertion Checklist and attach hemodynamic waveform recordings in the shadow chart.
22. After confirmation of PA catheter placement (by chest x-ray and waveform analysis), the Registered Nurse may obtain initial cardiac output/index, PVR and SVR.

Appendix B Pulmonary Artery Catheter: Obtaining & Documenting the PA Pressure Measurements (RA/CVP)

Obtaining & Documenting the PA Pressure Measurements: RA/CVP

1. RA Waveform: Run a dual-channel strip of the ECG and RA waveform.
2. Measure RA pressures at end of expiration.
3. Using the dual-channel recorded strip, draw a vertical line from the beginning of the P wave of one of the ECG complexes down to the RA waveform. Repeat this with the next ECG complex.
4. Align the PR interval with the RA waveform.
5. Identify the “a” wave.
6. Identify the scale of the RA tracing
7. Measure the mean of the “a” wave to obtain the RA pressure (RAP).

PA Systolic and Diastolic Pressures:

1. Run a dual-channel strip of the ECG and PA waveform.
2. Measure the PA pressure at the end of expiration.
3. Identify the QT interval on the ECG strip
4. Align the QT interval with the PA waveform.
5. Identify the scale of the PA tracing
6. Measure the PA systolic pressure at the peak of the systolic waveform on the PA waveform.
7. Align the end of the QRS complex with the PA waveform.
8. Measure the PA diastolic pressure at the point of the intersection of this line.

Appendix C Pulmonary Artery Catheter: Causes and Troubleshooting an Overdamped waveform

Causes of an over damped waveform:

It is important to differentiate between air/blood in the monitoring system and a distally migrated catheter. Air/blood in the monitoring system is benign. The potential that the PA catheter is wedged or over wedged, can lead to complex issues that need to be addressed with the physician.

Report the following clinical situations which may be indicative of catheter movement. These could ALL indicate that the catheter has migrated further into the pulmonary vasculature and potentially require repositioning of PA catheter (withdrawal) by physician and x-ray confirmation of PA catheter position:

1. Unexplained dampening of the waveforms
2. Changes in pressure readings
3. Decline in the volume of air required to wedge catheter
4. Over wedging

Troubleshooting an overdamped waveform:

1. Wash hands and don nonsterile gloves
2. Obtain monitor strip to compare with previous recordings
3. Identify the waveform and evaluate for dampened waveform vs. wedged waveform
 - a. Adjust the scale to 30 (provides more details of waveform)
 - b. Ensure all connections are tight
 - c. Check transducer and pressure tubing for air bubbles, leaks or kinks
 - d. Ensure there is fluid in the flush bag and pressure on the flush bag or device is delivering 300 mm Hg
4. Remove the PA balloon inflation syringe and ensure the gate valve or stopcock is open and that the balloon is deflated. If wave form appears wedged, do NOT ask the patient to cough. Do not attempt to flush or inflate balloon. Immediately notify the physician.
5. Verify location of PA catheter using the waveform and ECG landmarks; frequently the waveform is a dampened PA waveform and not wedged
 - a. Aspirate assessing for blood return; if no blood return, do not flush lumen and notify physician
 - b. If blood return, may gently flush lumen
 - c. Observe waveform on 30 scale (provides more details of waveform)
 - d. Compare current tracing to previous tracings
 - e. Check transducer and pressure tubing for air bubbles, leaks or kinks
 - f. Ensure there is fluid in the flush bag and pressure on the flush bag or device is delivering 300 mm Hg
 - g. Perform square wave test (Dynamic Response Test) by activating the fast flush device and evaluating the corresponding waveform to determine over or under dampening
 - h. Ensure all connections are tight
 - i. Aspirate distal port of PA catheter for blood return
 - i. If positive blood return, fast flush for 15 seconds once blood is cleared from tubing
 - ii. If unable to obtain blood return, PA catheter is either clotted or wedged, notify physician
6. Attempt to have catheter return to PA position spontaneously

- a. Do **NOT** have patient cough or suction the patient as this may cause spontaneous PA rupture
 - b. Reposition the patient
- 7. If catheter remains in wedged position; notify house staff, fellow, physician
- 8. Never flush a wedged catheter, this may lead to pulmonary rupture or hemorrhage.
- 9. If trouble shooting is unsuccessful, notify physician. Immediate repositioning of the catheter is necessary as prolonged wedging can lead to PA infarction. Notify cardiac fellow or attending caring for the patient for repositioning, if that individual is unavailable the RN can withdraw PA catheter under the direction of the eICU physician.

Appendix D Pulmonary Artery Catheter Monitoring: Troubleshooting when the Patient Develops Hemoptysis or Bloody Secretions

Troubleshooting When Patient Develops Hemoptysis or Bloody Secretions during PA Catheter Monitoring:

Procedure:

1. Notify the physician immediately
2. Wash hands and don nonsterile gloves
3. Maintain patency of the airway
4. Prepare for intubation as needed
5. Remain with the patient for monitoring and reassurance
6. The lung where PA catheter is inserted should be positioned down for the patient.
7. Notify and consult the physician and anticipate notifying interventional radiologist for an emergency coil procedure. Prepare patient for radiology procedure as prescribed.
8. Another recommendation for troubleshooting in this instance is a dual lumen endotracheal tube, available in the OR Anesthesia work room, inserted by a privileged Critical Care physician or anesthesia provider
9. Anticipate a blood specimen for type and cross match and coagulation studies as prescribed.

Appendix E: Wedging the Pulmonary Artery Catheter by privileged Cardiologists/cardiac fellows, Critical care Attendings/Fellows, Cardiothoracic Attendings/ Physician assistants.

Registered Nurses do not wedge the PA catheter.

1. Wash hands and don nonsterile gloves
2. Run a dual-channel strip of the ECG and PA waveform.
3. Check the distal pressure waveform before inflation. If waveform appears distorted or dampened do NOT inflate balloon. The catheter may be wedged, check position of catheter. **Never** inflate the balloon when the balloon is wedged in the pulmonary artery.
4. Fill the PA syringe with < 1.5 ml of air.
5. Connect the PA syringe to the gate valve or stopcock of the balloon port of the PA catheter
6. Slowly inflate the balloon with air until the PA waveform changes to a PAW waveform. Use only enough air to convert the PA waveform to a PAW waveform. The entire amount of 1.5 ml of air is not necessarily needed.
7. Inflate the PA balloon for no more than 8 to 15 seconds (two to four respiratory cycles).
8. Passively allow balloon to deflate, close the balloon-inflation valve, and disconnect the syringe from the balloon-inflation port.
9. Observe the monitor as the PCWP waveform changes back to the PA waveform.
10. Expel air from the syringe.
11. Reconnect the syringe to the end of the balloon-inflation valve and open the valve.
12. Align the end of a QRS complex of the ECG strip with the PCWP waveform.
13. Identify the “a” wave.
14. Identify the scale of the PCWP tracing
15. Measure the mean of the “a” wave to obtain the PCWP.
16. Compare the PAD pressure with the PCWP
17. Follow PA diastolic pressure if PAD pressure if PCWP is less than or equal to 4 mm Hg.

Appendix F: Removal of Pulmonary Artery Catheter

Contraindications to RN removal of PA catheter include:

- Prolonged coagulation values
- PA catheter knotted (observed by chest x-ray)
- Presence of permanent pacemaker, ICD or temporary pacemaker

Procedure:

1. Infection Control recommends that the introducer be removed at the time of pulmonary artery catheter removal.
2. Maintain aseptic technique throughout procedure.
3. Explain procedure to patient. Instruct patient that before removing the catheter you will ask him to take a deep breath, hold it until instructed to breathe normally.
4. Wash hands.
5. Place the patient in a supine position in a slight trendelenburg position.
6. Turn the patient's head away from the insertion site so the PA catheter and introducer sheath are readily visible.
7. Transfer or discontinue intravenous solutions and flush solutions.
8. Remove the syringe from the balloon inflation port. Ensure the gate valve is in the open position.
9. Turn all stopcocks off to the patient. Release the sheath from the introducer catheter.
10. Prepare supplies: Open sterile staple or suture removal kit (if appropriate), sterile container for tip culture (if appropriate) and central line dressing change kit.
11. NOTE: If patient is febrile, or demonstrates clinical symptoms often associated with potential line sepsis, request a physician's order for catheter tip culture upon removal.
12. Don mask (in kit) and clean gloves, remove dressing, and assess site for signs of infection, such as redness, swelling, and/or drainage around the catheter.
13. Remove clean gloves and don sterile gloves from central line dressing change kit.
14. Clean the catheter entry site and surrounding skin with chloroprep contained in dressing change kit. Begin at entry site and work in horizontal and vertical motions. Allow to dry.
15. If present, clip suture, securing the catheter.
16. Ask the patient to take in a deep breath in and hold it.
17. While stabilizing the introducer, gently withdraw the PA catheter using a constant steady motion. Monitor the patient's cardiac rate and rhythm during catheter withdrawal. If resistance is felt, do not continue to remove catheter and notify the physician immediately.
18. Temporarily cover the homeostasis valve with a sterile gloved finger.
19. Have the patient exhale once the PA catheter is removed.
20. Examine catheter tip to make sure the tip appears intact and notify physician if catheter is broken or jagged.
21. If the introducer is to be removed, clip the sutures.
22. Ask the patient to take a deep breath in and hold it.
23. Withdraw the introducer pulling parallel to the skin using a steady motion.
24. As the introducer exits the site, apply pressure with a gauze pad.
25. Have the patient exhale once the introducer is removed.
26. Continue to apply firm, direct pressure over the insertion site with gauze until the bleeding has stopped.
27. Apply a sterile occlusive dressing.
28. If physician has ordered a catheter tip culture, continue using aseptic technique and snip the end of catheter into sterile container.

29. Assess the PA catheter site for signs of bleeding:

- Every 15 minutes X2
- Every 30 minutes X 3
- One additional hour.

Documentation:

Patient assessment before and after removal of PA catheter, the date time, response to the procedure and the occurrence of any unexpected outcomes and interventions taken. On catheter removal, document that catheter intact.