PULMONARY ARTERY/CENTRAL VENOUS PRESSURE MEASUREMENT

Expected Practice:
- Verify the accuracy of the invasive pressure monitoring system by performing a square waveform test at the beginning of each shift and anytime the system is disturbed (e.g., blood draw).
- Position the patient supine, supine position (HOB bed between 0 and 60°), lateral position 20°, 30° or 90° or prone before PAP/PAOP/CVP measurements. Head of the bed (HOB) elevation can be at any angle from 0° (flat) to 60° if the patient is in the supine position.
- Level and reference the transducer air-fluid interface to the phlebostatic axis (supine or prone position) or lateral angle specific reference using a laser or carpenters level before PAP/PAOP/CVP measurements.
- Allow the patient to stabilize for 5-15 minutes after a position change before obtaining PAP/PAOP/CVP measurements.
- Obtain PAP/PAOP/CVP measurements from a graphic (analog) tracing at end-expiration or adjust the measurement point if the patient is receiving airway pressure release ventilation (APRV) or is actively exhaling.
- Use a simultaneous ECG tracing to assist with proper PAP/PAOP/CVP waveform identification.
- PA catheters can be safely withdrawn and removed by competent registered nurses.

Scope and Impact of the Problem:
PAP and CVP aid in differential diagnosis and to guide treatment in critically ill patients who do not respond to standard therapy. Technical aspects of monitoring affect the accuracy and reliability of these measurements.

Supporting Evidence:
- The CVP and PA/PAOP pressures are useful in aiding differential diagnosis (e.g., pulmonary hypertension, cardiogenic vs. noncardiogenic pulmonary edema) and to guide treatment in patients who do not respond to standard therapy (e.g., heart failure, septic shock, severe trauma in elderly patients).
- The CVP may be useful as part of early goal directed therapy for patients with septic shock or acute respiratory distress syndrome.
- The square waveform test, or dynamic response test, determines the ability of the transducer system to correctly reflect invasive pressures. The dynamic response is affected by system problems, such as air bubbles in the tubing, excessive tubing length, loose connections, and catheter patency. Removal of microbubbles during system set up result in an “adequate” or “optimal” system in over 95% of cases. Any of these problems affect the accuracy of PAP/PAOP/CVP measurements and must be corrected prior to pressure measurement. The experts recommend performing the square waveform test: on the initial system setup, at least once each shift, after opening the catheter system (e.g. for rezeroing, drawing blood, or changing tubing), and whenever the PAP/PAOP/CVP waveform appears to be damped or distorted.
- Consider the following changes in PA pressures as clinically significant (i.e., not reflective of the normal variability in PA pressures): △PAS > 4-7 mm Hg; △PAEDP > 4-7 mm Hg; △PAOP > 4 mm Hg.
- Studies in a variety of patient populations found that PAP/PAOP/CVP measurements are accurate when the HOB is elevated to any angle between 0° and 60° or when the patient in a 20°, 30° or 90° lateral position with the HOB flat, as long as the correct angle-specific reference is used. PAP/PAOP/CVP measurements should not be performed in Trendelenburg or if the legs are in a dependent position. There are no studies to support PAP/PAOP/CVP measurements in reverse Trendelenburg. Compared to supine cardiac output (CO) measurements, reliable CO measurements have been obtained only in the supine position with backrest at 20° or 45° and in the prone position. Clinically significant changes in CO may occur in the 20° lateral position, which may limit concurrent PAP/PAOP/CVP and CO measurements. Because there are individual variations in response to a given patient's position, CO should be measured with the patient in the supine position, with the HOB flat at 0° or 15°, placed in reverse Trendelenburg position (HOB at 20° or 45°) or with the patient in the lateral position with the HOB at 30° or 45°.
position, evaluate each patient’s PAP/PAOP/CVP compared to the flat, supine position using a standardized approach.17,39

- The use of position-specific reference is critical to accurate PAP/PAOP/CVP measurement.20,40-44 In the supine position the phlebostatic axis (4th ICS at ¼ the AP diameter of the chest) is the most commonly used reference point.45 In the lateral position the following reference points should be used: 30° lateral (½ distance from surface of bed to the left sternal border). 90° right lateral position (4th ICS/midsternum) and in the 90° left position (4th ICS/left parasternal border).41,42,44 A laser or carpenter’s level (not the eyeball technique) should be used to correctly reference the system.46 Once the correct reference location is identified, a mark should be placed on the chest wall.

- After a position change allow a patient to stabilize before obtaining PAP/PAOP/CVP measurements. Depending on the patient’s left ventricular function, patients may require 5-15 minutes for stabilization.47 No specific recommendations are available for the stabilization period after proning; measurements have been performed 20-30 minutes after repositioning from supine to prone for patients with acute lung injury.35-37 and in patients with ARDS, measurements were performed 20 minutes after stabilization of the SvO₂ (60-90 minutes after proning).34

- Changes in intrathoracic pressure during respiration alter intracardiac pressures. PAP/PAOP/CVP measurements are obtained by convention at end-expiration when pleural pressure is minimal.48 For patients receiving airway pressure release ventilation (APRV), the PAOP should be measured at the end of the positive pressure plateau, which can be observed on the ventilator and is the point immediately before the release of airway pressure and the initiation of inspiration.49 With active exhalation (suspect if respiratory-induced fluctuation in PAOP is greater than 10-15 mm Hg) read the PAOP at the midpoint between the end-expiratory peak and the end-inspiratory nadir.50 The addition of the airway pressure tracing to the analog strip may further improve measurement accuracy.51

- PAP/PAOP/CVP pressures should be read from analog tracings or using the stop cursor method.52-54 Digital readouts should not be used as they reflect pressures obtained throughout respiration and may be significantly different from end expiratory pressures.

- A simultaneous ECG should be used to facilitate correct PAP/PAOP/CVP waveform measurement.55-57

- Registered nurses, who demonstrate competency, can safely withdraw and/or remove PA catheters.58,59 Before incorporating withdrawing and/or removing PA catheters into nursing practice, verify that it is within your state’s scope of practice for registered nurses.

### AACN Evidence Leveling System

- **Level A** Meta-analysis of quantitative studies or metasynthesis of qualitative studies with results that consistently support a specific action, intervention or treatment
- **Level B** Well-designed, controlled studies with results that consistently support a specific action, intervention or treatment
- **Level C** Qualitative studies, descriptive or correlational studies, integrative reviews, systematic reviews, or randomized controlled trials with inconsistent results
- **Level D** Peer-reviewed professional organizational standards with clinical studies to support recommendations
- **Level E** Multiple case reports, theory-based evidence from expert opinions, or peer-reviewed professional organizational standards without clinical studies to support recommendations
- **Level M** Manufacturer’s recommendations only

### Actions for Nursing Practice:

- Always identify and mark the phlebostatic axis or appropriate angle-specific reference, obtain PAP/PAOP/CVP with the patient in the supine position (HOB bed between 0 and 60°), lateral position 20°, 30° or 90° or prone read pressures from an analog recording at end expiration, and perform a square waveform test at appropriate intervals.

- Assure that your critical care unit has written practice documents such as a policy, procedure or standard of care, that include these expected practice alert standards.

- Determine your unit’s rate of compliance with these Practice Alert standards.

- If compliance is < 90%, develop a plan to improve compliance:
  - Consider forming a unit task force to address the need for changes in PAP/PAOP/CVP measurement practices.
  - Educate staff about the inaccuracies which can occur in PAP/PAOP/CVP measurements with improper techniques. Incorporate content into orientation programs, initial and annual competency verifications.
  - Develop various communication strategies to alert and remind staff of the importance of these PAP/PAOP/CVP practices.
  - Create an audit tool for measuring compliance with PAP/PAOP/CVP expected practice standards.
  - Consider creating a team of nurses specially educated to care for patients with PA catheters.

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Need More Information or Help?

- PAP/CVP Practice Alert information at www.aacn.org
  - Test of PA catheter knowledge
  - Square waveform test information
  - Identifying correct PAP/CVP waveforms from simultaneous pressure and ECG tracings
  - Identifying correct phlebotomist axis or angle-specific location for leveling transducers
- Contact a clinical practice specialist for additional information/assistance (www.aacn.org) then select PRN.

References:

40. Bartz B, Maroun C, Underhill S. Differences in midanterior-posterior level and midaxillary level of patients with a range of chest configurations. Heart Lung 1998;17:309.