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## Monitoring Pulmonary Artery Pressure

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Crit Care Nurse. 2004;24: 67-70

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Published online <http://ccn.aacnjournals.org>

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# Monitoring Pulmonary Artery Pressure

Maureen Keckeisen, RN, MSN, CCRN

**Q**: What is the proper reference point to use when leveling (referencing) and zeroing hemodynamic monitoring systems?

The phlebostatic axis provides an external reference point that approximates the anatomic level of the left and right atria and the pulmonary artery. Leveling (referencing) and zeroing the hemodynamic monitoring system to the tip of the catheter that lies within the pulmonary artery ensures that hemodynamic values obtained with the catheter are accurate.<sup>1</sup> The air-fluid interface (zeroing stopcock), not the transducer, should be used when the hemodynamic monitoring system is being leveled (referenced) to the phlebostatic axis. Recent research with computed tomography has

confirmed that the phlebostatic axis approximates the level of the left atrium at the point midway between the anterior and posterior surfaces of the chest at the fourth intercostal space<sup>2,3</sup> when the patient is supine (Figure 1).

**Q**: What is the best position in which to place the patient to ensure accuracy when monitoring pulmonary artery pressure?

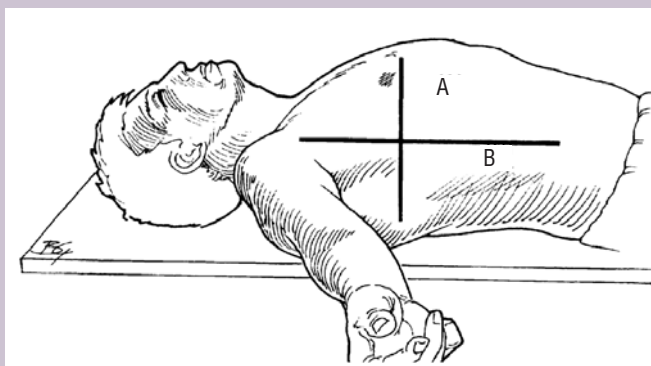
A variety of backrest positions may be used that do not compromise the accuracy of measurements of pulmonary artery pressure. Backrest elevations of 0°, 30°, 45°, and 60° with the patient supine (back flat against bed surface) do not affect the accuracy of measurements of pulmonary artery pressure if the hemodynamic monitoring system has been properly referenced and zeroed.<sup>4-10</sup> As the patient moves from flat to higher levels of backrest elevation, the reference level must remain horizontal to the phlebostatic axis in order for measurements of pulmonary artery pressure to remain accurate (Figure 2).

**Q**: Are pulmonary artery pressures measured in patients who are positioned on the side (lateral or side-lying position) accurate?

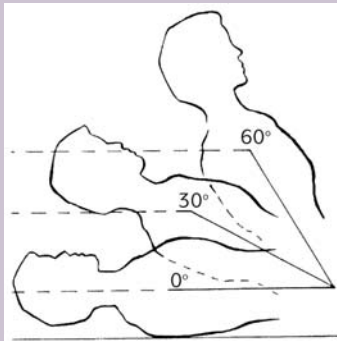
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**Figure 1** Referencing and zeroing the hemodynamic monitoring system in a supine patient. The phlebostatic axis is determined by drawing an imaginary vertical line from the fourth intercostal space at the sternal border to the right side of the chest (A). A secondary imaginary line is drawn horizontally at the level of the midpoint between the anterior and posterior surfaces of the chest (B). The phlebostatic axis is located at the intersection of points A and B.



**Figure 2** The level of the phlebostatic axis as the patient moves from flat to higher levels of backrest. The level of the axis for referencing and zeroing the air-fluid interface rotates on the axis and remains horizontal as the patient moves from flat to increasingly higher backrest positions. For accurate hemodynamic pressure readings at different backrest elevations, the air-fluid interface must be at the level of the phlebostatic axis.

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Monitoring pulmonary artery pressures in patients who are in lateral or side-lying positions (eg, 20°, 30°, 45° to the side) is generally not recommended. Most research results are conflicting and inconclusive because of the lack of a standardized point of reference for leveling and zeroing in patients in side-lying positions.<sup>11-18</sup> The only lateral posi-

tion for which measurements of pulmonary artery pressure seem to be accurate is with patients lying on the side in a 90° lateral position with the backrest flat.<sup>3</sup> The landmarks for leveling and zeroing with patients in the right and left lateral positions areas follows: (a) right lateral position (at 90° with backrest flat)—the intersection of the fourth intercostal space and the midsternum; (b) left lateral position (at 90° with backrest flat)—the intersection of the fourth intercostal space and the left parasternal border. Because most critically ill patients who require monitoring of pulmonary artery pressure are rarely positioned in a 90° side-lying position, until external landmarks for the correct reference location in 20° to 45° side-lying positions are determined by further research, pulmonary artery pressure should not be monitored while patients are lying on the side (Figure 3).

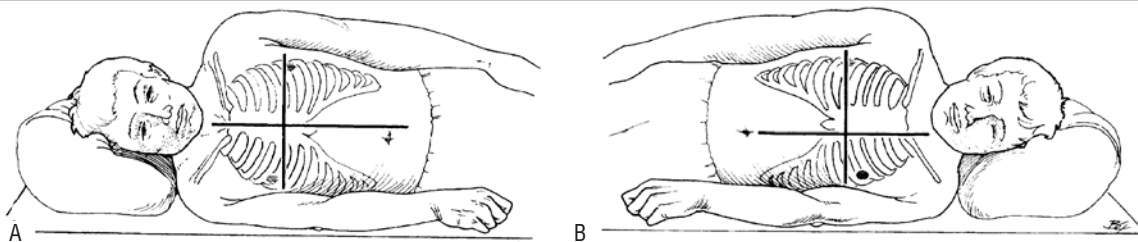
**Q:** Is it normal for measurements of pulmonary artery pressure to fluctuate?

Fluctuations in pulmonary artery pressure are normal in critically ill adults but should be assessed for individual variations

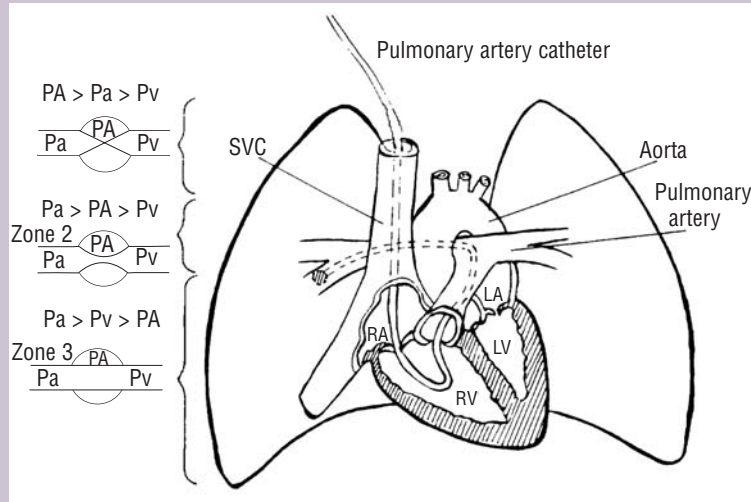
and clinical significance. Limited clinical studies indicate that normal fluctuations in pulmonary artery pressure of 4 mm Hg occur for pulmonary artery diastolic pressure and pulmonary artery wedge pressure (PAWP), and normal fluctuations of 5 mm Hg occur for pulmonary artery systolic pressure.<sup>19</sup>

**Q:** Are measurements of pulmonary artery pressure accurate in patients being treated with positive end-expiratory pressure (PEEP) during mechanical ventilation?

For patients being treated with PEEP of less than 10 cm H<sub>2</sub>O, correlation between the PAWP and left atrial pressure is good, in the absence of hypovolemia. Accuracy also depends upon having the tip of the pulmonary artery catheter below the level of the left atrium or lung zone 3 (dependent blood flow). If the tip of the catheter is in lung zone 1 (upper lung, no blood flow) or lung zone 2 (intermittent blood flow), the PAWP may reflect alveolar airway pressure rather than vascular pressure, resulting in a falsely elevated PAWP<sup>20-25</sup> (Figure 4). For patients being treated with PEEP greater than 10 cm H<sub>2</sub>O, the accuracy of measurements of pulmonary artery



**Figure 3** Referencing and zeroing the hemodynamic monitoring system in a patient in a lateral position. A, For the right lateral position, the reference point is at the intersection of the fourth intercostal space and the midsternum. B, For the left lateral position, the reference point is the intersection of the fourth intercostal space and the left parasternal border.



**Figure 4** Physiologic lung zones. The accuracy of PAWP as a reflection of pressure in the LA depends on having the catheter tip positioned below the level of the LA or in lung zone 3. Zone 1 has no blood flow, and alveolar pressure exceeds arterial pressure (PA > Pa > Pv). In zone 2, blood flow is intermittent, and arterial pressure exceeds alveolar and venous pressure (Pa > PA > Pv). In zone 3, both arterial and venous pressures exceed alveolar pressure (Pa > Pv > PA), and PAWP reflects vascular pressures rather than alveolar pressures.

PA indicates alveolar pressure; Pa, arterial pressure; Pv, venous pressure; SVC, superior vena cava; RA, right atrium; RV, right ventricle; LA, left atrium; LV, left ventricle; PAWP pulmonary artery wedge pressure.

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pressure may be compromised, and data should be interpreted cautiously. PEEP greater than 10 cm H<sub>2</sub>O increases alveolar and intrathoracic pressure, compresses the pulmonary vasculature, and affects the accuracy of PAWP measurement. Graphic recording of the hemodynamic waveform is essential for accurate measurement of PAWP, particularly if respiratory variation is significant and the patient is being treated with high levels of PEEP.<sup>23,24,26-28</sup> The accuracy of measurements of pulmonary artery pressure should be questioned if one of the following occurs:

- Significant respiratory variation with the PAWP waveform
- The PAWP is greater than the

pulmonary artery diastolic pressure

- The gradient between the pulmonary artery diastolic pressure and the PAWP is greater than 4 mm Hg

The following correction calculation can be used to estimate PAWP and correct for high levels of PEEP<sup>27</sup>:

1. Convert the applied PEEP from centimeters of water to millimeters of mercury (1.36 cm H<sub>2</sub>O = 1 mm Hg).

2. Subtract half the applied PEEP in millimeters of mercury from the measured PAWP.

For example, in a patient with a measured PAWP of 24 mm Hg who is receiving 16 cm H<sub>2</sub>O applied PEEP, the correction calculation would be as follows:

- Divide 16 (applied PEEP) by 1.36 = 11.76 mm Hg
- Multiply 11.76 mm Hg by 0.5 = 5.9 mm Hg
- Subtract 5.9 from 24 (measured PAWP) = 18.1 mm Hg (“corrected PAWP”)

Q: Which is the most accurate and reliable method of measuring pulmonary artery pressure, graphic recording or digital data taken directly from the monitor?

Studies have shown that measurements of pulmonary artery pressure are more accurate and reliable when taken from a graphic strip recorder than when based on digital data taken directly from the monitor. Use of graphic strip recordings enhances detection of phases of respiration and makes determination of end-expiration much more accurate. These factors are particularly important if respiratory variation is significant or high PEEP is used in a patient receiving mechanical ventilation. Significant discrepancies in measurements of pulmonary artery pressure can occur, resulting in falsely high measurements in patients receiving mechanical ventilation and falsely low pressures in spontaneously breathing patients when digital data are taken directly from the monitor.<sup>29-31</sup>

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This article is based on the protocol *Pulmonary Artery Pressure Monitoring* by Maureen Keckeisen. It was taken from the *Hemodynamic Monitoring* series of AACN's *Protocols for Practice*. Protocols can be obtained from AACN, 101 Columbia, Aliso Viejo, CA 92656-1491, (800) 899-AACN, (949) 362-2000. \$11, AACN members; \$14, nonmembers.

### Note

This article was first published in *Critical Care Nurse* December 1999.