Measuring Central Venous Pressure With a Triple-Lumen Catheter

What port should be used to measure central venous pressure with a triple-lumen catheter?

Kristine J. Peterson, RN, MS, CCRN, CCNS, replies:

Central catheters are common in acute and critical care areas. Because of the complexity of the care for these patients, many central catheters have multiple lumens. Typically, the distal lumen opens at the tip of the catheter, while the other lumen(s) open slightly proximal to this on the sides of the catheter. Is a central venous pressure (CVP) measurement obtained from any one of the 2, 3, or 4 lumens of these catheters different from the measurement obtained from any of the other lumens? Very little direct evidence is available to guide us on this question. What little we know comes from studies on different types of catheter placement. Only 1 study specifically addressed the influence of port site on CVP measurements.

In a laboratory study from 1985, Ikeda and Schweiss1 examined the effect of rapid infusion of saline or blood in 1 lumen on the CVP measurements from other lumens of multilumen catheters. Their results indicated that CVP accuracy was unaffected by rapid infusion into other lumens of the catheter with or without pressure infusion. That study was done on anesthetized dogs; however, the results indicate that what is going on in one lumen does not affect pressure readings from a different lumen. They did not specify which ports were used for what purpose.

Another area of interest has been whether CVP readings are altered by insertion site. Chait et al2 reported a study of 33 pediatric cardiac surgical patients. All patients had intraoperative placement of a double-lumen femoral venous catheter and a transthoracic right atrial catheter. The femoral venous catheters were 8 cm and were positioned in the inferior vena cava. The paired measurements were taken simultaneously, at end expiration, with the bedside monitor’s algorithm used to calculate CVP. Measurements were taken both in patients receiving mechanical ventilation and in spontaneously breathing patients. The results of that study indicated that, although the measurements were not statistically identical, the differences between measurements from the femoral site and the right atrium were not clinically significant. Chait et al concluded that the femoral site was a reliable alternative to the superior vena cava for cannulation in pediatric patients.

Murdoch et al3 reported results from a similar study in 1994. Again in children, they found no differences between CVP measurements taken from the superior vena cava, the right atrium, and the inferior vena cava via a femoral insertion. In a third study of pediatric critical care patients, Fernandez et al4 examined CVP measurements via internal jugular, subclavian, and common femoral veins, as well as direct right atrial catheterization. Lower inferior vena caval pressure
correlated well with CVP ($r^2 = 0.995$, $P < .001$). They concluded that the CVP measurements from the lower part of the inferior vena cava were clinically reliable.

Similar results have been reported from studies in adults. Joynt et al compared CVP measurements taken from a standard intrathoracic central catheter with CVP measurements from femoral catheters and concluded that femoral CVP readings were clinically reliable. In this study, the femoral catheters were advanced to the inferior vena cava close to the right atrium.

Black et al compared peripherally inserted catheters (PICCs) with centrally inserted catheters. They completed 77 paired measurements on each of 12 adult critical care patients, all recorded at end expiration. The CVP measurements from the PICCs correlated well with the measurement from the centrally inserted catheters ($r^2 = 0.99$). Differences were not clinically significant. The only caveat the authors noted was that the PICC measurement required a pressure infusion device to overcome the natural resistance of the longer PICC catheter.

Blot and Laplanche compared CVP readings from totally implanted ports, tunneled central venous catheters, and multilumen centrally inserted catheters with direct measurements of right atrial pressure measured via a pulmonary artery catheter. The data were obtained prospectively via 56 paired measurements in 35 patients who had both a pulmonary artery catheter and one of the comparison catheters. Again, measurements from the different sites were strongly correlated ($r^2 = 0.94$, $P < .01$). They concluded that CVP can be measured accurately with any of the studied catheters.

Because PICCs are increasingly common, a number of researchers have investigated whether CVP can be reliably measured via a PICC. Latham et al in a laboratory study, compared CVP measurements from both 5F and 6F PICCs with CVP measurements from a standard triple-lumen catheter. They designed a device to create controlled pressures via a column of water that could be measured simultaneously via both catheters. A standard pressure infusion device was connected to each catheter. The correlation coefficient for both the 5F and 6F catheters with the standard catheter was 1.0 ($P < .001$). They concluded that their results indicated that CVP measurements from PICCs are accurate and that these results needed to be confirmed in a clinical study. The same group published another report comparing CVP measurements via PICCs and centrally inserted catheters in 2012.

That study consisted of 70 paired measurements in 10 critically ill patients. The results confirmed previous reports. CVP measurements from both catheters were equivalent ($r^2 = 0.99$; $P < .001$). Yun et al compared CVP measurements obtained via PICCs with CVP measurements made via an internal jugular catheter in liver transplant patients. Again, the measurements were deemed clinically accurate ($r^2 = 0.97$; $P < .001$).

In contrast to these results, Groombridge et al compared CVP measured via catheters whose tip ended in the superior vena cava with measurements taken via femoral catheters. They found poor agreement between these measurements.

prospective study differed from other studies in that only 1 paired measure was taken from each patient. In addition, their findings suggested that intra-abdominal pressure had a significant effect on the femoral CVP measurement ($P < .01$). They concluded that the 2 sites could not be used interchangeably.

Only 1 study was found that directly compared CVP measurements from each lumen of a triple-lumen catheter. In that study, Scott et al obtained measurements of CVP from each of the 3 ports of a triple-lumen catheter in 48 adult patients in an intensive care unit. Catheters were placed via either the internal jugular vein or the subclavian vein and were connected to a standard continuous pressure system. A repeated-measures analysis of variance indicated that the measurements from each lumen were significantly different ($P < .001$). Further analysis determined that the difference between the distal port and either the proximal or medial port explained the differences in the measurements between the ports. They found that the mean difference was either 1.12 mm Hg or 1.28 mm Hg, which was statistically significant, but was not clinically significant. Further analysis, however, indicated that the differences between the distal and medial ports were clinically significant in 12.5% of measurements and the differences between the measurements made via the distal and proximal ports were clinically significant for 14.6% of the subjects. These results led the investigators to conclude that the port choice might affect the CVP measurement. An additional group makes a recommendation
that CVP monitoring take place via the proximal port as a safety measure. If the catheter migrates out of the central vein, the CVP waveform will be lost. No data support this recommendation.

Several studies in both pediatric and adult patients indicate that CVP measurements taken from a centrally inserted catheter are not clinically different from CVP measurements taken from a catheter placed in the abdominal inferior vena cava. Taken logically, we could conclude that if those measures, with the relatively large physical distance between the sites, are equivalent, then the measurements from different ports on a single triple-lumen catheter would also be equivalent. However, these studies are small studies with differing methods. In addition, in at least 1 study, researchers found significant differences between CVP measurements in a central catheter and a femoral vein catheter, and in another study, researchers found differences in measurements from different ports on the same multilumen catheter.

From these results, we can conclude that the evidence is insufficient to determine reliably whether or not the choice of port in a multilumen catheter will influence the result. There are some clinical implications. First, considering that we cannot be certain that the CVP will be clinically equivalent in each lumen, it might be wise for a patient care area to decide on a single port to use for CVP measurements and make that standard for all patients. Alternatively, one could make note of the specific port being used for CVP measurements in each patient and ensure that all measurements for that patient are taken from the same port. Second, a CVP measurement cannot be used in isolation. It must be used in the context of the assessment of the whole patient as well as the trends of the CVP measurements. And, third, bear in mind the limits of the CVP measurement and what information that measurement will be able to provide when making treatment decisions for patients.

**References**


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