Percutaneous Sheath Introducer Systems Used for Venous Access
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Q Are there guidelines for use of the introducer sheath as a venous access route after the pulmonary artery catheter has been removed? This procedure appears to be common practice, yet no clear guidelines seem to exist for this use. Also, are there any special risks involved in this practice?

A Gloria Oblouk Darovic, RN, CCRN, replies:

The practice of leaving the introducer sheath as a venous access route following removal of the pulmonary artery catheter has been widespread since the 1980s. Unfortunately, this practice is associated with an increased risk for the occurrence of potentially life-threatening complications, particularly if the patient is transferred out of an intensively monitored unit with the sheath in place. Therefore, manufacturers of introducer systems discourage the use of the introducer as a venous access route and instead recommend its removal along with the cardiac catheter or shortly thereafter. A review of the design of the pulmonary artery catheter and introducer system and some its potential risks and complications may help to explain the rationale behind this recommendation.

BACKGROUND

Since the introduction of central circulatory monitoring catheters (central venous and pulmonary artery catheters) into clinical practice, the amount and complexity of accessory equipment and catheter models have increased tremendously. Awareness of associated risks, warnings, and complications has also grown. In fact, the majority of publications relating to pulmonary artery catheters throughout the 1970s and 1980s were related to risks and complications of using these devices.

Percutaneous introducer systems are large bore (typically 8.5 or 9 Fr), relatively short (4 inches) catheters that provide a means to insert and maintain central circulatory catheters. The sites of insertion are typically the subclavian or jugular veins. The tip of the introducer usually lies within the thoracic cavity, where it is subjected to ventilation-induced swings in intrathoracic pressure. In spontaneously breathing patients, a negative inspiratory pressure draws air into and fills the lungs, whereas positive expiratory pressure drives air out of the lungs.

Two types of percutaneous introducer catheters exist. One has a nondetachable hemostasis valve located at the proximal end of the sheath to which a short-length intravenous (IV) tubing is bonded for administration of fluid therapy. This catheter is most aggressively promoted by manufacturers for safety reasons but is least frequently used clinically. The second type of catheter has a detachable hemostasis valve (with the short-length connecting IV tubing side port) that is screwed to the introducer sheath hub with a Luer-lock connector.

In both models, the central venous or pulmonary artery catheter passes through the hemostasis valve and introducer sheath into the jugular or subclavian vein. The hemostasis valve acts as a seal to prevent entry of air into the circulation as well as blood or fluid loss around the indwelling catheter when it is removed from the in situ sheath.
POSSIBLE COMPLICATIONS AND SAFETY MEASURES

The purpose of critical care is to ensure the best possible outcome for the patient and, despite the complexity and risks associated with invasive support and monitoring devices, to do no harm. Consideration of the following possible complications and safety measures is essential to minimize the risk of complications with the use of introducer sheaths.

Air embolism and hemorrhage

Any situation in which there is an open communication (however small) between the central veins and the atmosphere has the potential for 2 major complications: (1) backflow bleeding, which will be more brisk if central venous pressures are elevated, and (2) air entrainment into the central veins and the right side of the heart during inspiration in spontaneously breathing patients. Many possible clinical scenarios can initiate these potentially lethal complications.

Disconnection of the introducer hub from the hemostasis valve/side-port assembly, a possibility in the detachable model, is the first clinical scenario that presents the potential for lethal complications. The introducer hub is secured to the insertion site using the suture tab, which is located on the hub. Tension on the side port IV tubing due to the patient’s movement could accidently un-twist the Luer-lock adapter and disconnect the hemostasis valve.

Accidental disconnection could result in exsanguination within minutes. Similarly, an unobserved, confused patient may unscrew the hub and suffer life-threatening complications. Fracture of the sheath-hub connection can likewise allow entrainment of air into the circulation as well as backflow bleeding. To reduce the risk for air embolism and/or bleeding, securely fix and tape the IV tubing of the side port to the patient’s skin and avoid traction on the IV tubing.

Also, patients in intensive care units should be visible to hospital personnel at all times, preferably with the caregiver at or near the bedside. Introducers should not be left in patients who are transferred out of the critical care environment to areas where they may not be closely monitored. Ideally, the introducer sheath should be removed upon removal of the cardiac catheter and should not be maintained for IV access.

An uncapped stopcock attached to the introducer assembly may also be accidentally opened to air. An unobserved patient in a cardiovascular intensive care unit exsanguinated through an uncapped stopcock that was accidentally opened by the patient’s movement (G.O.D., unpublished data, 2001). Avoid use of stopcocks in the monitoring catheters whenever possible. Unnecessary use of such equipment also reduces the fidelity of the monitoring system. Inspect the site frequently to ensure that the dressings are intact and that stopcocks are in the proper position.

As an additional safety measure, hemostasis valves must be occluded at all times. Manufacturers of introducer catheters warn that the hemostasis devices are not infallible despite having been tested to the highest standards. It is possible for the valve material to take a “set” around an inserted catheter so that when the cardiac catheter is removed, the valve material does not completely close. Manufacturers absolutely recommend immediate use of an obturator cap that is designed to cover and penetrate the hemostatic valve. The obturator acts as a mechanical barrier that must be in place anytime a catheter is not inserted through the hemostasis valve and sheath.

Air can also enter the central venous system during catheter insertion and removal. Several techniques may be used to reduce the risk of air embolism, including the following:

- Cover the valve opening with a sterile gloved thumb until the catheter or obturator is inserted.
- Ask a spontaneously breathing patient to perform a Valsalva maneuver during catheter insertion or removal.
- If the patient is receiving controlled mechanical ventilatory support or cannot cooperate, apply gentle abdominal compression to increase intrathoracic pressure during catheter insertion or removal.
- Place the patient in the Trendelenberg position, if tolerated.

These measures increase intrathoracic pressure, which reduces entrainment of air into the great veins, the right side of the heart, and possibly pulmonary circulation.
Clinicians must also consider that the introducer is a large-bore catheter and that following removal, a skin-to-vessel tunnel may allow entry of air into the central venous circulation during spontaneous inhalation, particularly if the patient’s underlying condition is associated with inspiratory difficulty. The greater the level of inspiratory difficulty and effort, the greater the negative intrathoracic pressure and hence the greater the potential for and the amount of entrained air.

To avoid air entrapment through a skin-to-vessel tunnel immediately after removal of the introducer, cover the site with a gauze dressing to which abundant antiseptic ointment is applied. Rub the ointment-covered dressing over the area of the subcutaneous tract to ensure an airtight seal and use sufficient tape to produce an occlusive dressing.

Phlebitis and Venous Thrombosis

Ideally, the tip of a central venous catheter should be in the proximal superior vena cava where turbulence of blood and rapid venous flow rates quickly dilute and wash out caustic infusates (e.g., concentrated potassium solutions, aminophylline). The insertion length of the introducer sheath is about 4 inches (manufacturer specific within fractions of an inch). A central venous catheter of 6 to 8 inches in length is generally inserted into the right internal or external jugular or right subclavian vein to place the catheter tip in the superior vena cava. In tall persons, the tip of the shorter introducer sheath may not reach into the superior vena cava, but rather may rest in the subclavian or jugular vein, where venous flow rates are relatively slow. Caustic IV solutions in relatively prolonged contact with the vein walls may then result in phlebitis and possible venous thrombosis. Both problems may not be clinically evident and can easily be missed.

When in doubt about the position of the introducer tip, infuse medicated or electrolyte-containing IV solutions into the proximal pulmonary artery ports or central venous pressure catheter. Also, the thrombogenic nature of the intravascular catheter may result in asymptomatic or symptomatic vascular thrombosis without coexisting phlebitis.

Vascular Trauma or Perforation by the Introducer Sheath

Another concern surrounding long-term use of the introducer is that the introducer tip is typically rigid and inflexible. Movement of the catheter within the vessel or malposition of the introducer tip against the vessel wall may result in vascular trauma, erosion, or perforation.6,7 Elderly or debilitated patients with fragile vascular walls are especially vulnerable to vessel perforation.

To prevent vascular trauma and vessel perforation:

□ check chest radiographs for correct introducer position after the catheter is inserted, and on subsequent films, and notify the physician if malposition is noted, so that the sheath can quickly be realigned parallel to the vessel wall; and
□ once proper catheter position is noted, secure the introducer assembly in position with tape to prevent displacement.

Local or Systemic Infection

The septic risk of any vascular catheter increases with the length of indwelling time and the quality of aseptic technique during catheter insertion and maintenance. Although some sheath introducers are impregnated with antimicrobial agents, this does not compensate for poor aseptic technique. Also, the length of time for which antimicrobial action is effective is limited.

Use absolute sterile technique when changing dressings according to institutional protocol, inspect the site for signs of infection, and remove the cardiac catheter and introducer as soon as the patient’s condition no longer requires hemodynamic monitoring.

If the patient begins to show signs of systemic infection without an identifiable cause, all invasive devices should come under immediate suspicion and appropriate actions (catheter removal and blood and catheter cultures) taken.

Introducer Kinking or Collapse

Inaccurate monitoring data, damped or flat waveforms, as well as reduced flow or no flow of IV fluids being administered may be the result of kinking or collapse of the introducer. As dis-
cussed earlier, frequently inspect the catheter insertion site to ensure integrity of dressings and the proper external positioning of the sheath introducer.

Other Complications
Other complications that can occur with prolonged use of cardiac catheter introducer systems include pleural and mediastinal injuries, sheath embolism, pneumothorax, thoracic duct laceration, accidental arterial puncture, and hematoma formation. A more elaborate discussion of complications encountered with central venous pressure and pulmonary artery pressure monitoring is beyond the scope of this article, but can be found in the literature.8

Cardiac catheter introducer systems and invasive catheters are not benign adjuncts to patient care. Although the occurrence of life-threatening complications is relatively rare, when they do occur they may result in death or permanent disability. Moral, ethical, and legal issues mandate strict adherence to safety measures with meticulous adherence to manufacturers’ recommendations during introducer insertion and maintenance as well as removal of the introducer sheath as soon as possible. Short-term use as a venous access site following catheter removal may be life-saving in patients in crisis in whom peripheral vascular access is difficult or impossible. However, as soon as the patient’s condition is reasonably stable, a less risky vascular access site should be established.+

References