Peripherally Inserted Central Catheters

Guideline for Practice, 2nd Edition

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Preface

Peripherally inserted central catheters (PICCs) are being placed with increasing frequency in infants to enhance the delivery of care for this vulnerable population. Guidelines for PICC use are needed to support nursing practice and promote infant safety. This guideline defines criteria for educational competencies for nurses inserting and maintaining PICCs and discusses infant selection criteria, techniques for catheter insertion, identification and management of complications, and strategies for daily maintenance.

This is the only guideline specific to infants with PICCs. Nurses also should be aware of the *Infusion Nursing Standards of Practice* by the Infusion Nurses Society (INS; 2006), the *Position Statement* related to catheter tip location from the National Association of Vascular Access Networks (formerly NAVAN, now the Association for Vascular Access or AVA; 1998), *Guidelines for Prevention of Intravascular Catheter Related Infections* from the Centers for Disease Control and Prevention (CDC; 2002b), guidelines specific to particular patient populations, and state and federal statutes.

This guideline is designed as a description of practices currently accepted and documented by experts in the field of neonatal care. It also identifies gaps in existing scientific knowledge. This guideline does not preclude the use of manufacturers' recommendations or other safe and acceptable methods for inserting and maintaining PICCs. It provides a foundation for the specific nursing protocols, policies, and procedures developed by individual institutions.

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Introduction

The survival of an increasing number of very-low-birthweight and critically ill neonates heightens the need for parenteral nutrition to support growth, as well as reliable vascular access for administration of additional intravenous fluids and medications. As a result, caregivers are continually being challenged to improve the methods by which they provide safe and consistent vascular access to this vulnerable population.

Peripheral intravenous (PIV) and umbilical catheters have commonly been employed for these purposes, but they have a limited dwell time (i.e., the life of an inserted vascular access device). In addition, the PIV has an increased complication profile and infusate limit compared with other central venous catheters. Surgically inserted, tunneled central venous catheters (e.g., Broviac®) have been successfully placed in neonates and infants for more than 2 decades and have proven to be a reliable but more costly means of providing long-term access. In 1973, Shaw described a novel technique for inserting a silicone catheter into the central veins of neonates. Since then, the practice of inserting PICCs has been streamlined because of improvements in catheter technology and insertion devices. Registered nurses (RNs) are inserting PICCs with increasing frequency, presenting a cost-effective approach to providing vascular access while yielding similar outcomes as physicians (Fong, Holtzman, Bettmann, & Bettis, 2001).

Definitions

Peripherally inserted central catheter

A peripherally inserted central catheter (PICC) is a device inserted into a peripheral vein and threaded into the central venous circulation. Although PICC is the preferred term for this device, neonatal care providers have historically referred to these catheters as percutaneous central venous catheters (PCVCs), perc lines, and long lines. According to the U.S. Food and Drug Administration (FDA) and other entities, the tip of the PICC should reside in the superior vena cava (lower $^1/_2$ to $^1/_3$) for upper-body insertions and the thoracic inferior vena cava for lower-extremity insertions (National Association for Vascular Access Networks [NAVAN], 1998; FDA, 1989; Infusion Nurses Society [INS], 2006).

Midline catheter

A midline catheter is a vascular device inserted into a peripheral vein and threaded to an area of greater blood flow in the proximal portion of the extremity, or it can be inserted into a scalp vein and threaded into the external jugular vein (INS, 2006; Wyckoff, 1999). These catheters may be appropriate for the infusion of fluids or medications with osmolalities <600 mOsm/kg, a pH ranging from 5 to 9, and the noncontinuous infusion of irritant or vesicant properties (similar to those that can safely be administered through a PIV) (Dawson, 2002; Gazitua, Wilson, Bistrian, & Blackburn, 1979; INS, 2006; Lesser, Chhabra, Brion, & Suresh, 1996; Pettit, 2003b; Wyckoff).

Vascular Access Device Comparisons

It is important to assess the infant early during the hospital stay and to determine the most appropriate vascular access device for meeting the infant's ongoing needs. This device will allow for uninterrupted therapy, preserve the peripheral vasculature, reduce the cost of delivering therapy, and protect the infant from pain associated with multiple PIV restarts (Janes, Kalyn, Pinelli, & Paes, 2000; Pettit, 2002). The selection criteria for vascular devices include length and type of anticipated therapies, age and weight of the infant, diagnoses, condition of the vasculature, and current clinical condition of the infant (INS, 2006). One device will not meet the needs of every infant and some will need a few devices throughout their hospital stay. Some infants may need more than one PICC for infusion or withdrawal of laboratory specimens.

Peripheral IVs

PIVs have been indispensable for providing therapies to infants who require intensive care. Although historically PIVs have served as the vehicle for infusing most IV solutions and medications, the potential for temporary or permanent damage to the peripheral veins has not been sufficiently considered. A patient's length of therapy and type of therapy distinguishes whether he or she is well-suited for peripheral or central catheter placement. Although PIVs remain common, the risk of complications is high (Franck, Hummel, Connell, Quinn, & Montgomery, 2001). Nonelective removal of a PIV due to complications occurs in up to 78% of insertions and can lead to premature removal of up to 95% of devices, though variations in reporting make accurate rates difficult to detect (Franck et al.). Inserting and maintaining PIVs in premature infants, especially those weighing <1,000 g, can be difficult due to the small size of their veins and the depletion of available sites from repeated puncture. It is not unusual for an infant to undergo multiple attempts at IV placement before successful cannulation, which has been shown to increase the risk of infection (Franck et al.; Grant et al., 1997). PICC insertion has demonstrated a reduction in painful PIV insertion attempts by 50% in infants weighing

<1,250 g (Janes et al., 2000). PICCs prevent damage to the peripheral veins (caused by the properties of many IV solutions and medications) and protect infants from the pain and stress of frequent PIV restarts (Pettit, 2002, 2003b).

Umbilical catheters

For critically ill neonates and those weighing <1,000 g at birth, an umbilical catheter often is required. If ongoing vascular access is necessary, a PICC is placed before removing the umbilical device to avoid repeated attempts at PIV access and the accompanying risk of infection. Infants who weigh >1,000 g and do not require umbilical venous access should be evaluated for a midline catheter or PICC as the initial vascular access device, based on diagnosis, vascular assessment, and therapeutic and nutritional needs.

Midline catheters

Midline catheters offer an alternative for those infants who do not require a PICC, but who need several days of IV therapy. Mean dwell times for midline catheters have been reported to be between 6 and 10 days and up to four times as long as those of PIVs (Dawson, 2002; Leick-Rude & Haney, 2006; Lesser et al., 1996; Wyckoff, 1999). Fewer PIV restarts and a longer life span make midlines an attractive option for vascular access in select infants (Dawson; Leick-Rude & Haney; Lesser et al.; Wyckoff). Currently, no data exist to support a limit to the dwell time of a properly functioning midline catheter.

Tunneled catheters

Tunneled central venous catheters (CVCs) (e.g., Broviac®) historically have been associated with a higher rate of infection when compared with the reported infection rate of PICCs (Chathas, Paton, & Fisher, 1990; Hruszkewycz et al., 1991; Oellrich, Murphy, Goldberg, & Aggarwal, 1991; Pandit, Pandit, Govan, & O'Brien, 1999). More recent data support equal infectious risks when comparing PICCs to tunneled CVCs (Foo, Fujii, Harris, LaMorte, & Moulton, 2001). The risks of pneumothorax and hemothorax, as well as increased insertion-related costs, use of anesthesia, and invasiveness of the insertion procedure are additional disadvantages of the tunneled catheter.

Recommendations for Peripherally Inserted Central Catheter

Although many infants will benefit from central venous access achieved using a PICC, the CDC recommends that patients who require more than 6 days of therapy should be considered for more than a PIV (CDC, 2002b). The placement of preemptive PICCs has been shown to be safe and effective in infants with anticipated postoperative hospital stays of 4–7 days (Schwengel et al., 2004). PICCs offer neonates numerous advantages over other vascular access devices and provide a safe, effective alternative for providing required therapies. When a PICC is used appropriately, the risk of complications is low.

Infusate Considerations for Vascular Access Device Selection

Placement of the PICC with the tip residing in the superior or inferior vena cava provides increased blood flow with resultant increased hemodilution of infusates (INS, 2006; NAVAN, 1998; Racadio, Doellman, Johnson, Bean, & Jacobs, 2001). This allows the safe delivery of more concentrated parenteral nutrition, increased dextrose-containing solution with higher caloric density, and medications (e.g., vancomycin, phenobarbital) known to damage the peripheral veins with repeated use.

Many substances infused into peripheral veins can cause venous damage, including chemical phlebitis, thrombosis, and infiltration or extravasation injuries (Camara, 2001; Gazitua et al., 1979; Irving, Simone, Hicks, & Verger, 2000; Kearns, Coleman, & Wehner, 1996; Kuwahara, Asanami, Tamura, & Kaneda, 1998; Racadio et al., 2001). Trauma to the vein, as well as potential decrease in dwell time leading to the development of chemical phlebitis, is related to the composition of the infusate (i.e., osmolality, pH, chemical properties) (Wermeling, Rapp, DeLuca, & Piecoro, 1985). Chemical phlebitis presents clinically with the appearance of erythema within hours of infusing an offending agent. Development of venous thrombosis often accompanies phlebitis. Infiltration and extravastion injuries may present with ecchymosis, blistering, and skin sloughing. Intervention and removal of the peripheral device is required to facilitate vein healing and possible recovery. It may be necessary to infuse medications or solutions that are known to cause venous damage into a peripheral vein. Although this may be tolerated for short periods of time, it is important to ensure that the vein is large enough to enhance hemodilution and decrease the risk of severe damage to the vessel. For repeated administration of these substances, central venous access should be obtained (INS, 2006; Pettit, 2002).

The following factors should be considered when determining the appropriate route for infusing an IV solution or medication.

Osmolality factors

Medications and IV solutions with an osmolality <450 mOsm/kg rarely cause chemical phlebitis, whereas those with an osmolality between 450 and 600 mOsm/kg run a moderate risk of developing chemical phlebitis. Medications and IV solutions with an osmolality >600 mOsm/kg almost always lead to chemical phlebitis, resulting in a decreased PIV dwell time (Gazitua et al., 1979). Peripheral veins have been shown to tolerate higher osmolar solutions for shorter periods of time before developing complications (Kuwahara et al., 1998). Hyperosmolar solutions routinely given to neonates include dextrose concentrations ≥10%, parenteral nutrition, ampicillin, cefotaxime, sodium bicarbonate, and phenobarbital (Irving et al., 2000; Santeiro, Sagraves, & Allen, 1990; Trissel, 2006). Central venous access is recommended for the infusion of solutions with an osmolality >600 mOsm/kg (INS, 2006; Ryder, 1995).

pH factors

If the pH of the medications or solutions is <5 or >9, vein damage can occur when the infusate enters a small vein without adequate hemodilution (Fonkalsrud, Murphy, & Smith, 1968; Roberts et al., 1994). Gentamicin and vancomycin are examples of acidic drugs and ampicillin and phenobarbital are alkaline drugs routinely given to infants (Hadaway & Chamallas, 2003; Trissel, 2006). Adults often describe pain when these medications are infused into the peripheral vein; unfortunately, neonates are unable to verbalize their feelings of discomfort and crying may be related to multiple factors.

Chemical/irritant factors

The chemical properties of some medications irritate the veins, possibly leading to phlebitis and thrombosis. Amphotericin B, vasopressin, resuscitation medications, dopamine, and calcium are examples of chemical irritants that can promote venous damage, particularly if there is inadequate hemodilution.

Cost considerations for vascular access device selection

No significant difference was found in the cost per day of a PICC or a PIV in premature infants (Nakamura, Sato, & Erenberg, 1990). The cost of a midline catheter is equivalent to that of a PIV after 3–4 days of therapy. The cost of inserting a PICC has been favorably compared to that of surgical placement of a CVC (Horattas et al., 2001). The latter procedure may require using an operating room, a skilled surgeon and, often, general anesthesia, all of which increase the cost of the procedure. Most PICC insertions require less time (i.e., 15 minutes–1 hour). Identifying the need for the PICC early in the course of treatment is financially prudent.

Candidate Selection and Contraindications

Candidates for PICC insertion may include the following:

- premature infants, particularly those who weigh <1,500 g because of a delay in establishing maintenance quantities of enteral nutrition
- infants requiring more than 6 days of intravenous therapy (CDC, 2002b), which may include infants with
  - infections requiring intravenous antimicrobial therapy
  - gastrointestinal disorders, such as necrotizing enterocolitis, omphalocele, gastroschisis, and those requiring multivisceral transplants
  - respiratory insufficiency
  - congenital cardiac disorders
- limb anomalies, which may limit the number of vascular access sites
- infants requiring the infusion of fluids or medications with hyperosmolar (>600 mOsm/kg), nonphysiologic pH (<5 or >9), or irritating properties (INS, 2006)
- infants with inadequate peripheral venous access; PICC insertion should be considered before the problem occurs (INS, 2006; Oellrich et al., 1991)
- infants whose medical providers or parents prefer the use of a PICC over other vascular access devices.

Infants should be assessed individually, with attention to the risks and benefits of the procedure. There are few absolute clinical contraindications to the insertion of a PICC (i.e., lack of suitable peripheral veins or need for vascular access). Ultrasound, transillumination, and infrared vein visualization technologies may enhance venous access in situations where suitable veins are not visible.

However, the existence of any of the following conditions affects the assessment and warrants additional consideration:

- uncontrolled bacteremia or fungemia (A PICC could become colonized with organisms, which would impede or prevent adequate treatment. Some recommend antimicrobial treatment for 24–48 hours before an elective PICC placement. However, the infant may require reliable vascular access, and a PICC may be the most appropriate delivery device for antimicrobial treatment.)
- thrombocytopenia or coagulopathy (Delayed clotting mechanisms increase the risk of prolonged bleeding at the PICC insertion site.)
- fracture (The condition of the veins surrounding the fractured bone is uncertain and the presence of the fracture can hinder assessment for PICC-related complications.)

- decreased venous return (Edema that presents due to decreased venous return related to a nerve palsy or other etiology may be difficult to distinguish from edema resulting from a PICC-related complication. Use of another extremity or the scalp is preferable.)
- cardiac malformations requiring operative procedures (Consult with a surgeon regarding the use of a PICC and the preferred catheter tip location.).

Educational Competency for Nurse Inserters and Caregivers

RNs assuming responsibility for the placement of PICCs should consult with their respective State Board of Registered Nursing to determine whether the procedure is within the scope of nursing practice. PICC placement may be considered an advanced nursing practice and therefore require development of a standardized procedure requiring approval from an interdisciplinary practice committee. Practice restrictions, such as limitations of veins that can be cannulated, vary among states and hospitals.

PICC insertion requires specialized training in order to improve patient outcomes by reducing device-related complications and decrease the cost of care. (CDC, 2002b; FDA, 1989). A two-pronged approach to training consists of a didactic and a clinical component. An expert in the field of neonatal vascular access who possesses current expertise in PICC placement in infants should provide the didactic content. Curriculum designed to prepare professionals for placing and maintaining PICCs should be formalized and minimally include (INS, 2006)

- indications and contraindications for placement
- risks-benefit analysis of the procedure
- applicable legal issues
- knowledge of guidelines and standards of infusion therapy published by professional organizations and governmental agencies
- knowledge of the anatomy and physiology of the venous and arterial systems
- application of sterile technique
- patient preparation
- pain management
- use of equipment and supplies for PICC insertion
- insertion technique (traditional and modified Seldinger technique [MST], where appropriate)
- assessment and management of complications
- routine catheter care and maintenance (including troubleshooting)
- institutional quality improvement process for PICCs
- documentation of the procedure, assessment findings, and complications.

Each facility is responsible for establishing written criteria for qualifying employees to perform the procedure and defining guidelines for obtaining competence (FDA, 1989; INS, 2006; Masoorli, 2005). A healthcare professional who is experienced in PICC insertion must observe an employee to verify and assess clinical competency. A minimum of three supervised successful insertions is required for independent practice.

Maintaining competency

Each facility is responsible for establishing criteria for maintaining clinical competence (INS, 1997b, 2006). The successful insertion of a minimum of five PICCs per year should be required to maintain privileges. In addition, a review of recent PICC-related literature, NICU procedures for PICC insertion and maintenance, and outcomes of insertions by each clinician performing the procedure support team improvement efforts and should be performed at least annually (INS, 1997b; Linck, Donze, & Hamvas, 2007; Sharpe, 2006).

One of the strongest predictors of long-term success with PICC use identified more than 20 years ago continues to be staff education regarding all aspects of PICC care, management, and surveillance (Chathas, 1986; Linck et al., 2007; Sharpe, 2006). An increase in knowledge and self-efficacy has been demonstrated following targeted educational programs, along with a significant decline in the rate of PICC occlusion (Ngo & Murphy, 2005). Knowledgeable staff members are able to intervene earlier to identify problems (Chathas, 1986). Every RN caring for a patient with a PICC must demonstrate knowledge of potential complications and care and maintenance strategies (Pettit, 2002). Only RNs with verified competency should perform dressing changes, treat catheter occlusions, repair catheters, and discontinue catheters due to the higher risk associated with these procedures.

Vascular Access Teams

Specially trained IV teams have demonstrated effectiveness in reducing catheter-related complications, particularly infections, and have proven to be cost-effective (CDC, 2002b; Golombek, Rohan, Parvez, Salice, & LaGamma, 2002; Schelonka, Scruggs, Nichols, Dimmitt, & Carlo, 2006; Sherrod, Warner, & Altimier, 2005). Using dedicated PICC teams has significantly improved patient safety and reduced costs. The use of a consistent team decreases multiple insertion attempts, improves outcomes, and decreases infection rates (Burns, 2005; Hornsby, Matter, Beets, Casey, & Kokotis, 2005; Santolucito, 2001). Early vascular access assessments are a multidisciplinary effort and can be facilitated by the nursing team for identification and initiation. The majority of physicians may be unaware of the multitude of venous punctures infants will experience. Early assessment through a team concept may well decrease the pain and suffering caused by short-term peripheral venous access. Notification of the ordering of hyperosmolar medications or other medications or solutions irritating to the vein should be incorporated as part of the pharmacy communication with the PICC team to facilitate early assessment (Santolucito, 2001; Sharpe, 2006).

These teams may perform all PICC insertions, conduct daily surveillance of each catheter and dressing, perform dressing changes, troubleshoot catheter problems, provide formal and informal staff education, and conduct outcome monitoring. A team concept further minimizes the use of inappropriate device selection and inappropriate catheter tip location.

Facilities may choose to have one team responsible for PICC insertion and another educated team designated for insertion, care, and maintenance, following standardized protocols that have minimized complications (Golombek et al., 2002; Linck et al., 2007; Rourke & Higgins, 1998). Advancing the team concept to include full responsibility for the PICC program is the ultimate goal. The creation of PICC, stick, and run teams significantly diminishes the safety of PICC use. These teams are not cost-effective and increase the risk of infection and decrease positive outcomes. Their only goal is PICC placement; these teams neglect to follow through on quality assurance and care and maintenance (Burns, 2005; Hornsby et al., 2005; Sharpe, 2006). Providing staff education and competency validation, ensuring adequate staff scheduling to perform PICC insertion, and financially supporting the PICC program are responsibilities of the healthcare institution that elects to develop and support a PICC team (Sharpe). Empowering and expanding nursing practice to advance the health of infants by incorporating a PICC team will decrease complications and improve the vascular access health of neonates.

Outcome monitoring

Quality improvement programs are an integral component of a hospital's PICC program (Chathas & Paton, 1996; INS, 2006; Linck et al., 2007; McMahon, 2002). Data gathered through this process guide decision making to positively affect patient care (Linck et al.; McMahon). Targeted data collection for outcome monitoring (procedural documentation requires additional information) for each PICC placed should at a minimum include

- patient's weight at the time of catheter insertion
- indication for placement
- catheter specifics (brand, composition, size, number of lumens)
- complications occurring during insertion, dwell, or removal
- length of catheter dwell
- reason for removal.

Data from each inserter and the team as a whole are reviewed on a regular basis to identify trends in usage and outcome measures. Data should be reported per 1,000 catheter days to allow for benchmarking against other hospitals.

To arrive at this number, perform the following calculation:

$$\frac{\text{Total number of complications}}{\text{Number of catheter days}} \times 1{,}000 = \text{rate of complications per catheter day}$$

Equipment and Supplies for PICC Insertion Procedure

Table 1, beginning on page 12, outlines each step in the process of PICC insertion in an infant.

Potential Insertion-Related Difficulties

A number of problems can occur related to catheter insertion. Those most common are addressed in this section.

Inability to thread the catheter through the introducer

Once the vein is cannulated, blood return is typically, but not always, evident. Although the catheter usually is easily advanced into the vein, obstructions can be encountered. Strategies to facilitate catheter passage include

- Ensuring that the introducer and the entire bevel are in the vein. If you are unsure, redirect the device into the vessel.
- Checking the angle of the introducer in the vein and realigning or straightening it; move it either up or down to prevent the catheter from contacting the vein wall.
- Removing the tourniquet after the catheter has passed into the vein lumen.
- Tightening the tourniquet or reapplying it to distend the vein and allow the catheter to pass. The larger vein diameter may increase ease of catheter passage.
- Visualizing the location of the catheter using ultrasound or other imaging technologies. Using ultrasound to visualize the catheter in the subclavian or internal jugular veins will provide further information to

evaluate whether the catheter is malpositioned in an upward position toward the head.
- Removing the introducer and catheter if these measures fail to correct the problem.

Inability to thread the catheter to the premeasured distance

Vasospasm, venous valves, bifurcation of the vein, scarring or sclerosis of veins, venous anatomy, and patient positioning have all been linked to difficulty in threading catheters. In addition, the catheter may be taking an aberrant route. If the catheter cannot be threaded more than 2–3 cm beyond the tip of the introducer, the catheter may not be within the vein. Establish where the catheter is located by determining the length of the catheter in the patient, then follow the appropriate strategies.

Inability to insert the catheter through the peripheral circulation

1. Remove the introducer (if needle style) to prevent catheter damage and withdraw the catheter a few centimeters (depending upon the distance it is inserted).
2. Rotate or twist the catheter and reinsert. This maneuver, which can be done two or three times, can help the catheter to pass valves.
3. If the catheter fails to advance, place a tourniquet high on the extremity above the catheter tip. Venous engorgement may help the catheter advance.
4. If a stylet is present, it can be withdrawn a few centimeters. Partial withdrawal of the stylet adds more flexibility to the catheter tip and can facilitate catheter advancement. The stylet can be completely removed if the catheter still will not thread.
5. Gentle flushing while threading can help the catheter pass valves or an obstruction.
6. Other strategies:
   - Massaging over the length of the vein has been described as helpful in catheter passage (Rastogi, Bhutada, Sahni, Berfon, & Wung, 1998).
   - Application of warm packs to promote dilatation.
   - Waiting several minutes to allow the vein to relax.
7. If the catheter cannot be advanced, it should be removed.

Inability to thread the catheter from the peripheral into the central circulation

If the catheter is entering the trunk of the body, the following should be considered:

1. Ensure that the patient is correctly positioned. For upper-extremity insertions, the arm should be at a 90° angle and the head turned toward the arm of insertion.
2. Remove the needle-style introducer.
3. Partially withdraw the catheter and reinsert it following the instructions outlined below.
   a. For insertion in the arm, elevating the shoulder or moving the arm in different locations may allow the catheter to pass the obstruction (Puntis, 1986).
   b. For insertion in the leg, elevating the pelvis may help a catheter that is stuck at the groin to advance. Abducting or manipulating the leg are other measures that can be tried (Puntis, 1986).
   c. Difficulty in threading catheters from the scalp to the jugular vein may be overcome by gently pulling the skin on the neck down toward the body if the catheter is stuck anterior to the ear. If the catheter is stuck at the neck, rotate the patient's shoulders or gently move the head to midline, extend or flex the neck (Puntis, 1986).
4. Massaging over the vein or rolling a sterile cotton swab over a portion of the vein where the catheter is stuck has been described anecdotally as beneficial (Rastogi et al., 1998).
5. If the catheter has been preflushed, gently flushing with 0.5–1 ml of flush solution while attempting to advance can be helpful.
6. If you are still unable to thread the catheter, repeat step 3.
7. If the catheter is successfully inserted to the premeasured depth, attempt to aspirate for a blood return. If a blood return is not obtained, an X ray can help determine the position of the catheter tip.
8. If the catheter remains outside the superior vena cava (typically in the brachiocephalic or subclavian vein) despite attempts to place it within the vena cava, it may be in an acceptable position to infuse therapies that can safely be given through a PIV, if doing so will meet the infant's needs or as a temporary measure until a CVC can be placed. Blood return must be present and the catheter should flush easily. This is not considered a central catheter tip position because there is an increased risk of thrombosis when catheter tips reside in the brachiocephalic and subclavian veins compared with those that are located in the superior vena cava (Brown-Smith, Stoner, & Barley, 1990; INS, 2006; Kearns et al., 1996; Racadio et al., 2001).
9. Catheter tips that remain in the peripheral circulation are referred to as midline catheters.
   a. Catheters placed in the arm should have the tip located opposite the axillary fold, not entering the torso and away from areas of flexion (Wyckoff, 1999).
   b. Catheters inserted in leg veins should remain below the inguinal crease and away from areas of flexion.
   c. Catheters placed in the scalp should reside in the jugular vein above the clavicle and out of the torso.

Table 1. Procedure for PICC Insertion in an Infant

Step	*Considerations*	*Precautions/Comments*
1. **Determine need for a PICC and obtain an order.**	The nurse inserter should evaluate patients individually to verify the need, risks and benefits, and presence of a suitable vein. Not all infants are appropriate candidates.	If a suitable vein is not identified, the infant may be a better candidate for another vascular access device.
Verify patient identification.	Follow hospital procedure to ensure compliance with patient identification procedures as outlined in the Patient Safety Goals by the Joint Commission (Join Commission, 2007).	
2. **Reviewthe procedure with parents and obtain informed consent** (per hospital protocol and by appropriate personnel, according to state and federal statutes). Many facilities consider PICC insertion a routine procedure for the NICU and do not require a separate signed consent.	Information should include a description of the procedure, indications, risks, benefits, and the alternatives to the procedure (Zonderman, 2000). Sample consent forms and information for parents about the procedure are included in the Appendix.	The nurse performing the procedure is responsible for ensuring that informed consent has been obtained (if required and per hospital protocol).
3. **Select the vein to be used for the procedure. Figure 1** shows the major veins that can be used for PICC insertion in neonates.	The vein needs to be of sufficient caliber to accommodate the large size of the catheter and introducer.	Avoid using previously damaged or sclerotic veins because of the increased risk of complications (i.e., difficulty threading catheter, phlebitis, infection).
Some hospitals and states specify the veins that RNs are allowed to cannulate for a PICC. Only a highly skilled inserter should cannulate the external jugular, femoral, and axillary veins.	If the vein is difficult to locate, consider use of a transilluminator or other imaging devices, application of warm packs, or application of double tourniquets. The use of "blind" technology utilizing anatomical landmarks and palpable veins to insert PICC catheters is rapidly becoming obsolete. Recommendations from Agency for Healthcare Research and Quality (AHRQ) and Society of Critical Care Medicine (SCCM) have moved forward with instituting the use of ultrasound technology for the insertion of PICC catheters. These newer technological advancements provide bedside imaging during the placement of PICC catheters. The advantages incorporate exact vessel location and avoidance of arterial puncture. Ultrasound technology further improves the success rate and decreases the complication rate, while diminishing pain for the patient by minimizing attempts (Rothschild, 2007).	Use of ultrasound requires additional training to achieve proficiency.

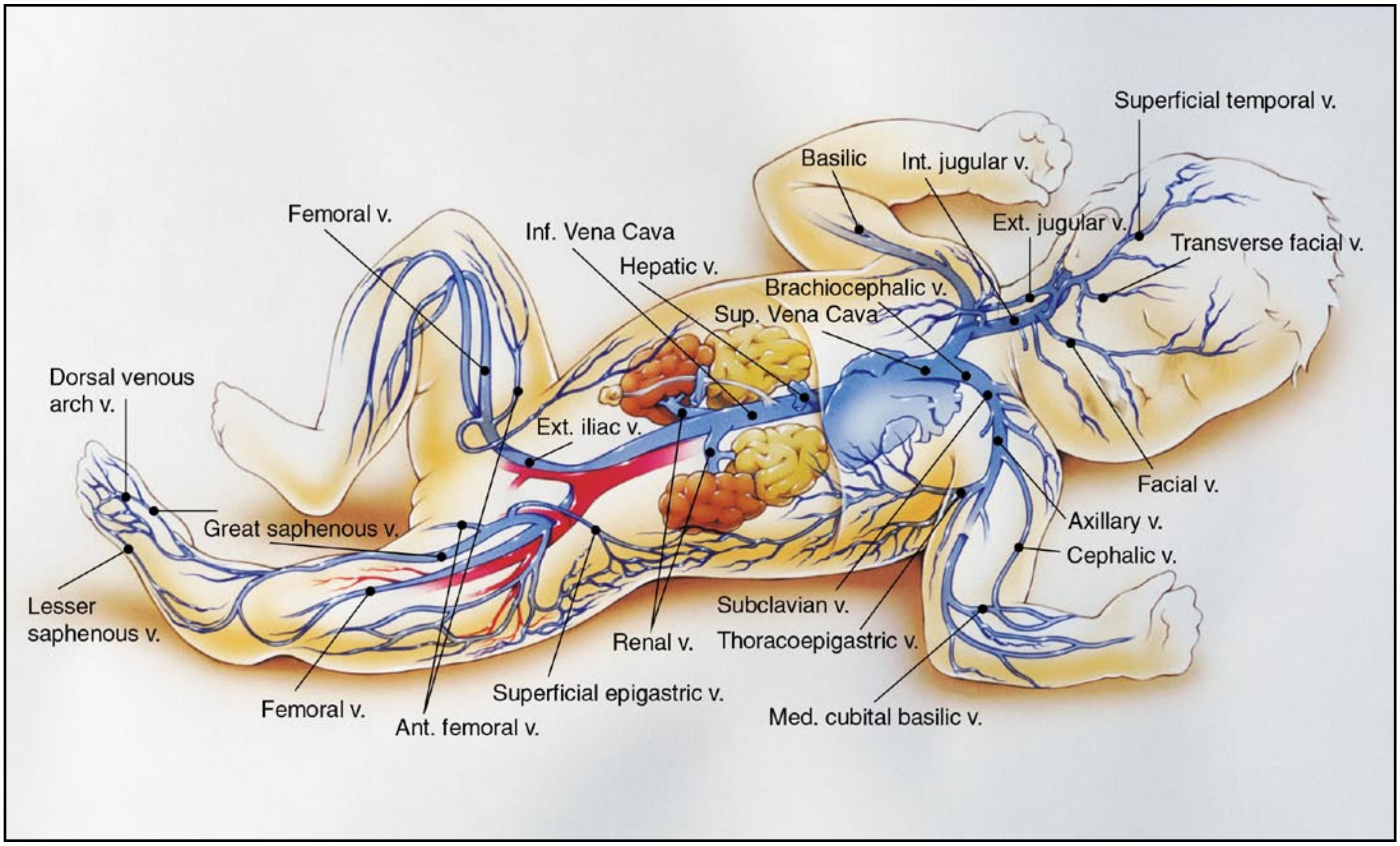

Figure 1. *The major veins that may be used for PICC placement in young infants*

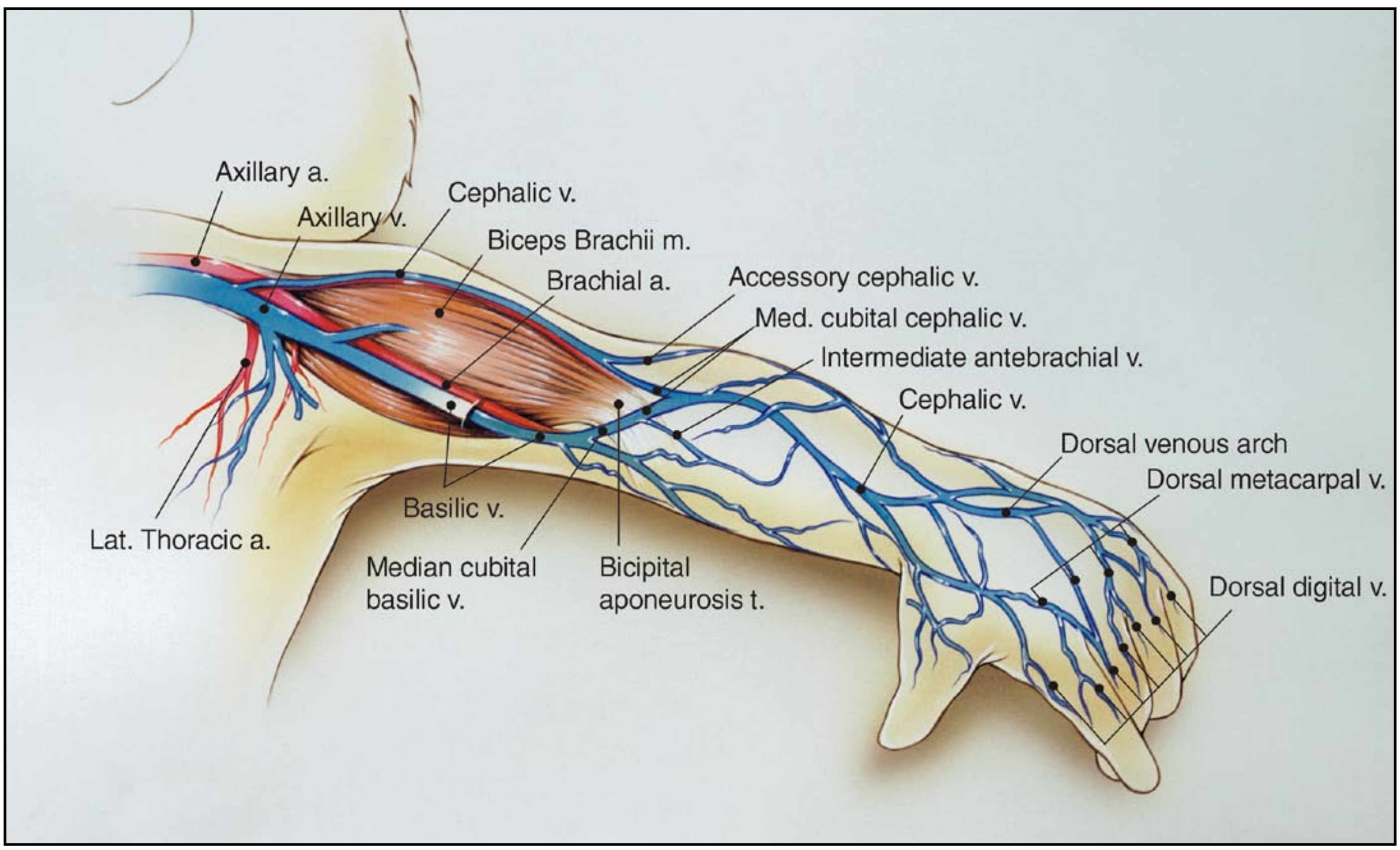

Figure 2. *The major veins of the arm*

Table 1. Procedure for PICC Insertion in an Infant *(continued)*

Step	***Considerations***	***Precautions/Comments***
The following veins are used for PICC insertion in neonates (Evans & Lentsch, 1999; Pettit, 2002; Racadio, Johnson, & Doellman, 1999)		
Veins of the arm		
• Basilic and median cubital basilic vein (See **Figure 2**.)	The basilic vein is a large vein in the arm that is straighter and less tortuous than the cephalic vein in the arm. It is easily accessible, is easy to thread the catheter through, requires less time for insertion, and allows a secure dressing to be placed. It has a low incidence (4.7%) of reported phlebitis (Nakamura et al., 1990; Neubauer, 1995).	Disadvantages of using the basilic vein include its close proximity to the brachial artery and risk of inadvertent arterial puncture, as well as possible previous venipuncture for lab draws. These factors make the vein a less satisfactory candidate. The most common site of malposition is the jugular vein (Lum & Soski, 1989).
• Cephalic and median cubital cephalic vein (See Figure 2.)	The cephalic vein is smaller than the basilic and has a sharp angle where it joins the axillary vein. It may bifurcate, with one portion joining the external jugular vein and the other the axillary vein (Lum & Soski, 1989).	The cephalic vein narrows and may be tortuous as it ascends the arm leading to an increased risk of mechanical phlebitis. It may be difficult to thread the catheter past the shoulder, and the catheter may become malpositioned into the axillary vein.
• Axillary vein (See Figure 2.)	Benefits of using the axillary vein include its large size, which makes it easy to cannulate and thread the catheter through. The size of this vein allows use of larger-size and dual-lumen catheters in many infants (Metz, Lucking, Chaten, Williams, & Mickell, 1990; Oriot & Defawe, 1988).	The axillary vein may be difficult to visualize in larger infants due to subcutaneous fat. Its close proximity to the axillary artery poses the risk of arterial cannulation. Ensure the introducer remains out of the thorax.

Table 1. Procedure for PICC Insertion in an Infant *(continued)*

Step	*Considerations*	*Precautions/Comments*
Veinsof the scalp and neck (A right-sided approach is preferred because it provides a near straight entry into the superior vena cava (SVC). A neck roll can facilitate catheter entry into the subclavian vein.)		
• External jugular vein (See **Figure 3**.)	The external jugular is a large, superficial vein that is easily palpable and visible. The vessel usually has not been cannulated for other purposes. To facilitate entry, place a towel roll under the shoulders to slightly hyperextend the neck, and turn the head to the side (Abdulla, Dietrich, & Pramanik, 1990; Dolcourt & Bose, 1982; Oellrich et al., 1991).	Positioning patients for catheter placement and stabilizing the catheter after insertion can be difficult. There also can be increased risk of catheter dislodgment, and it is difficult to maintain a dry, intact dressing. Leaving a few centimeters of catheter external and bringing the hub onto the upper chest for securement keeps the catheter away from formula and secretions and allows for easier access into the catheter.
• Temporal vein (See Figure 3.)	The branch of the temporal vein just in front of the ear is large and easily visualized (Racadio et al., 1999).	Carefully distinguish the temporal vein from the adjacent temporal artery. Resistance to threading can occur where the catheter traverses the area in front of the ear and where it enters the subclavian vein.
• Posterior auricular vein (See Figure 3.)	The posterior auricular vein is best cannulated behind the ear.	The posterior auricular vein is variable in size and may be tortuous. Resistance to threading can occur where the catheter enters the subclavian vein.
Veins of the Legs		
• Femoral vein (See **Figure 4**.)	Catheterization of the femoral vein can be accomplished by inserting the needle at a 30° angle 1 cm below the inguinal ligament and 5 mm medial to the femoral pulse (Abdulla et al., 1990). A larger or dual-lumen catheter can be placed into this vein due to its large size. Imaging technology is recommended while cannulating the femoral vein (Rothschild, 2007).	The close proximity to the femoral artery poses the risk of arterial puncture. The femoral vein may be needed for cardiac catheterization, so it may not be an appropriate choice. Preventing the insertion site from becoming contaminated with excrement may be difficult. The risk of leg swelling has been reported to be as high as 15.6% (Foo et al., 2001).

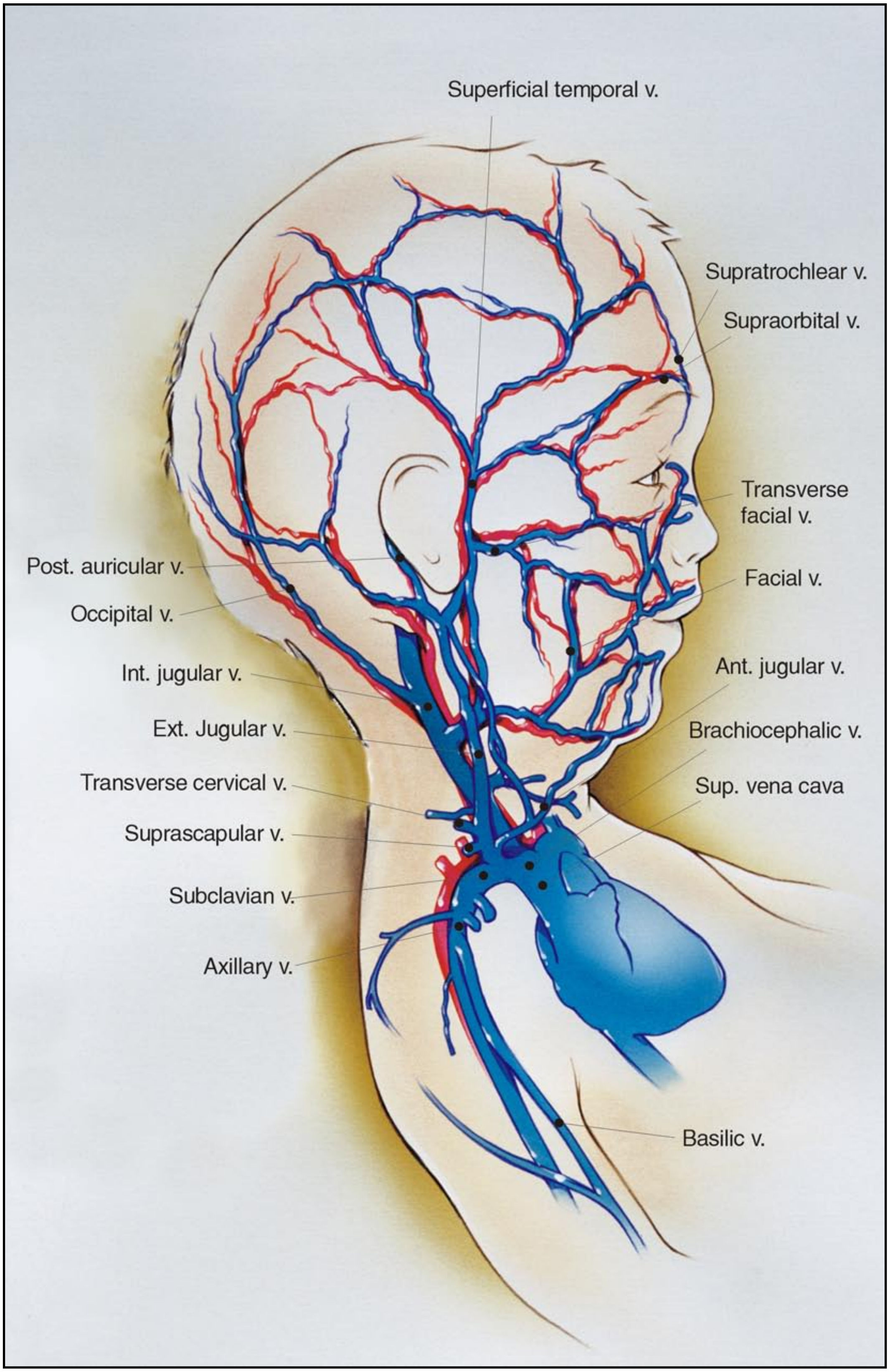

Figure 3. *The path from the temporal and posterior auricular and external jugular veins into the central circulation*

Table 1. Procedure for PICC Insertion in an Infant *(continued)*

Step	*Considerations*	*Precautions/Comments*
• Greater saphenous vein (See Figure 4.)	The greater saphenous vein is a large, easily visible vein on the medial aspect of the leg beginning near the ankle and extending up the leg. Cannulation may be performed at multiple sites along the vein. Some report a higher incidence (9%) of phlebitis (Neubauer, 1995).	The greater saphenous vein is the longest vein in the body, containing 7–15 valves that must be transversed. It is not an appropriate choice for infants requiring cardiac catheterization via the femoral vein. Edema of the leg may occur due to placement of the PICC. The edema is usually mild, and the circulation to the leg is not compromised.
• Lesser saphenous vein (See Figure 4.)	The lesser saphenous vein is a small, tortuous vein best reached from the lateral aspect of the leg.	Positioning the infant may be awkward. This vein joins the popliteal vein at the back of the knee. The lesser saphenous vein is not an appropriate choice for infants requiring cardiac catheterization via the femoral vein.
• Popliteal vein (See Figure 4.)	The popliteal vein is easily visualized in the premature infant, but it is less so in full-term infants.	Access may be difficult with the increase in muscle tone seen with advancing gestational age. Stabilizing the catheter after insertion may be difficult. The popliteal vein is not an appropriate choice for infants requiring cardiac catheterization via the femoral vein.
4. **Measure the length of the catheter to be inserted.** For upper-body insertion, measure from the insertion site along the course of the vein, to the right of the sternal border, to the third intercostal space. If insertion is through an arm vein, extend the arm at a 90° angle for measuring. For lower-extremity insertion, measure from the insertion site along the course of the vein, to the right of the umbilicus and up to the xiphoid (Serrao, Jean-Louis, Godoy, & Prado, 1996).	Inserting the catheter to a premeasured depth helps to ensure the desired placement within the SVC or inferior vena cava (IVC) and prevents complications associated with malpositioning of the catheter.	There is variability in venous pathways among individuals and measurement will not exactly predict internal placement (James, Bledsoe, & Hadaway, 1993).

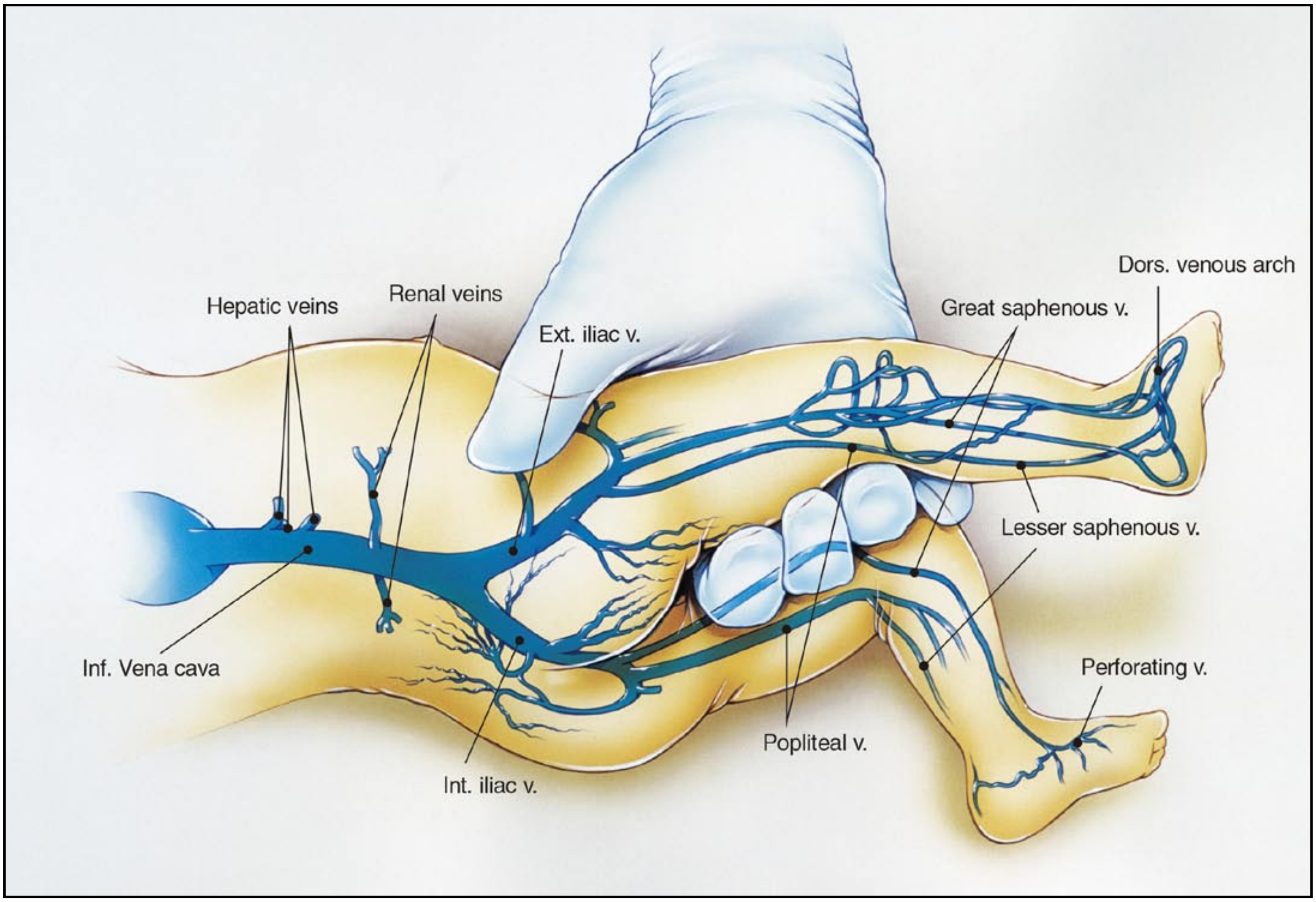

Figure 4. *Access sites for entering the leg veins and venous pathway into the central circulation*

Figure 4 ©BD Medical Systems. Used with permission.

Table 1. Procedure for PICC Insertion in an Infant		*(continued)*
Step	***Considerations***	***Precautions/Comments***
5. **Assemblethe following equipment and supplies before the procedure.** Many of the supplies are available packaged as commercially prepared kits. General equipment and supplies • Sterile gown • Hair cover • Face mask • Protective eyewear • Sterile gloves (two pairs), powder and latex-free • Restraints or swaddling device (optional) • Limb board and tape (optional) • Imaging devices, such as a transilluminator, infrared technology, or ultrasound and sterile sleeve or glove (if applicable) Catheter equipment and supplies • 1.1 to 2 F (28- to 23-gauge) catheter, with sufficient length to achieve appropriate catheter tip placement for infants weighing < 2,500 g • 1.9 to 3 F (26- to 20-gauge) catheter, with sufficient length to achieve appropriate catheter tip placement for infants weighing ≥ 2,500 g • Introducer needle or cannula, in a size appropriate for the catheter, utilize safety-engineered introducers, if available (INS, 2006) Modified Seldinger technique (MST) supplies (if applicable) in addition to the previously listed supplies • 24-gauge peripheral intravenous device • Flexible guidewire, size 0.12–0.15, approximately 15 cm in length • #11 surgical blade • Sheath dilator	Efforts should be made to provide latex-free and di-(2-ethylhexyl) phthalate (DEHP)-free products to minimize the risk to healthcare providers of an allergic reaction and the risk of such an allergy developing in infants.	

Table 1. Procedure for PICC Insertion in an Infant		*(continued)*
Step	***Considerations***	***Precautions/Comments***
These items may be available in a manufacturer-supplied kit • Tape measure • Sterile tourniquet • Antiseptic solution (e.g., chlorhexidine gluconate or povidone iodine) • Sterile water or saline pads • Three sterile 4"x 4", lint-free gauze sponges • Sterile tape measure for trimming catheter (optional) • Sterile tape or skin-closure tape strips • Semipermeable transparent dressing or 2"x 2"gauze and non-occlusive tape • Two or three surgical drapes (one may be fenestrated) • Flush solution, which may include a heparinized saline solution, concentration per unit protocol (usually 0.5–1.0 units heparin/ml) or sodium chloride. (Throughout the document, "flush solution" is the term used to indicate either solution.) • One or two 5–10-ml syringes (per manufacturer's recommendation) • Needles or needleless supplies for drawing flush solution into syringes or prefilled syringes that are sterile on the outer surface and labeled. • Nontoothed forceps • Scissors • Catheter-trimming device (optional, per manufacturer's recommendations) • Extension set (T-connector, straight connector, or multilumen device) with luer-lock and closed-end adapter. The extension set should be lipid resistant and free of DEHP. Some catheters are manufactured with an integrated extension set and do not require a separate extension set. • Water-soluble radiocontrast media (optional; may be needed for small catheters, catheters containing lower amounts of radiopacity, or when infants have extensive cardiopulmonary disease and when the catheter cannot be visualized radiographically)		

Table 1. Procedure for PICC Insertion in an Infant *(continued)*

Step	*Considerations*	*Precautions/Comments*
6. **Select catheter.**	Some infants require a double-lumen catheter or more than one PICC at a time. One may have the tip located in the SVC and the other in the IVC.	Catheters with tip terminations within the same vessel can become entangled and be difficult to remove.
	The catheter should be selected that meets the infant's therapeutic needs.	
	Catheter material	
	• PICCs are currently made of silicone or polyurethane. • The smallest catheters (28-gauge) are only made of polyurethane. • Catheters made of both materials have been successfully used in infants. • The choice of catheter material is personal because little current data support the superiority of either.	Both materials have been used successfully for many years, and both are biocompatible. Catheter materials are judged by their structural integrity, resistance to kinking, structural rigidity for easy insertion, low thrombogenicity, low bacterial adhesion, long-term stability, inertness to surrounding cells and tissues, and chemical inertness to infusate and mechanical irrtitation (DiFiore, 2005). The major significant difference lies in the tensile strength of the catheter material. Polyurethane has high tensile strength allowing thinner catheter walls and a larger internal lumen, whereas silicone (Silastic) requires thicker walls with resultant smaller inner diameter (DiFiore, 2005).
	Number of lumens • Single- or dual-lumen devices are available. • A dual-lumen device is appropriate for an infant receiving total parenteral nutrition, multiple medications, or volume resuscitation. Size • Determining factors include the infant's weight, the size of the vein, the type of fluids to be infused, rate of infusion, and the need for blood sampling or administration. • Place the smallest size catheter that will meet the infant's needs (INS, 2006).	A meta-analysis of 15 published studies concluded that multilumen central venous catheters may be associated with a slightly higher risk of infection when compared with single-lumen catheters; however, this relationship diminishes when only high-quality studies that control for patient differences are considered. The slight increase in infectious risk when using multilumen catheters is likely offset by their improved convenience, thereby justifying the continued use of multilumen vascular catheters (Dezfulian, Lavelle, Nallamothu, Kaufman, & Saint, 2003).

Table 1. Procedure for PICC Insertion in an Infant *(continued)*

Step	***Considerations***	***Precautions/Comments***
	Presence of stylet • Stylets provide additional body to the catheter to facilitate insertion. • Stylets are increasingly available in polyurethane and silicone catheters (DiFiore, 2005; Tingey, 2000).	Stylets have been used in neonatal PICCs for more than 20 years and are standard in pediatric and adult PICCs without substantiated risk of an increase in morbidity or mortality (Catudal, 1999; Loughran, Edwards, & McClure, 1992).
7. **Select the preferred style of introducer.** Some manufacturers offer a choice for use with their catheters. Current choices from manufacturers include peel-away cannulas, break-away needles, or butterfly needle. Safety-engineered introducers should be used to prevent needle-stick injuries and exposure to blood-borne pathogens if offered by the manufacturer (INS, 2006)	Break-away needles may be smaller than cannula-style devices and may facilitate entry into smaller vessels with less trauma.	The insertion technique for a break-away needle is similar to that for a butterfly needle. There is a risk of catheter damage if this device is used inappropriately. A peel-away cannula is more like a traditional IV catheter, and nurses are comfortable with the insertion technique. There may be less risk of catheter shearing with this device.
8. **Manage pain.** Provide developmentally supportive care throughout the procedure. Use swaddling, pacifiers, and visual stimulation as appropriate (Walden, 2001). Consider premedicating the infant with an analgesic. Topical anesthesia (e.g., EMLA or LMX4 creams) may be appropriate for some infants (Walden, 2001).	PICC insertion causes pain. Infants requiring a PICC often are unstable and easily agitated. Movement of the infant during the cannulation procedure can lead to unsuccessful venipuncture or catheter damage. The infant needs to remain quiet when using the modified Seldinger technique to prevent catheter and vein damage. Parents or a caregiver may soothe the infant during the procedure.	Medication should be administered and its effectiveness ensured before the procedure begins. Monitor for respiratory depression and other side effects. Document procedural sedation per hospital policy. Topical anesthetics can cause vasoconstriction in a small percentage of patients.
9. **Apply hair covering and mask.**		
10. **Perform hand hygiene, using an alcohol-based waterless cleanser or antimicrobial soap and water.**		
11. **Open equipment and prepare a sterile field**.	Creating a large sterile field reduces the risk of contamination of supplies and allows the inserter adequate space to work.	Restrict traffic near the sterile field to reduce the risk of contamination.

Table 1. Procedure for PICC Insertion in an Infant *(continued)*

Step	*Considerations*	*Precautions/Comments*
12. **Perform hand hygiene, then don sterile gown and gloves.**	Maximal sterile barrier precautions, including the use of hair covering, face mask, sterile gown and gloves, and large sterile drapes have been shown to reduce the risk of infection by six to seven times over the use of sterile gloves and drapes alone (CDC, 2002a; Maki, 1994; Raad et al., 1994).	It is preferable to use powder-free gloves to reduce the potential for reactions. Rinsing powder-containing gloves is not acceptable due to clumping of residual powder. Latex-containing gloves may lead to latex reactions in infants (NANN, 2003).
Consider using goggles.	Standard precautions protect the caregiver against infectious exposure from the patient.	There is minimal splashing of blood when breaking the insertion device in the small catheters.
13. **Prepare the catheter.**		
Flush catheter. • Attach a 5–10-ml syringe, per the manufacturer's recommendation, to the catheter and flush. • Flushing is required for catheters containing a hydrophilic-coated stylet in order to retract and remove the stylet. • This step cannot be performed with all catheters, depending on their configuration.	This step removes air from the internal lumen before insertion.	
Trim catheter • Excess catheter length can be trimmed to the measured insertion length if allowed by manufacturer. • Follow manufacturer's directions for trimming, including use of scissors, scalpel, or cutting blade.	Theoretic benefits of trimming excess catheter include the following: • facilitating assessment of the external portion of catheter to ensure the same amount is present as was left external upon insertion • decreasing the risk of catheter migration • decreasing resistance to flow within the catheter • decreasing potential damage to the external portion of the catheter • creating a smoother catheter tip on some catheters, dependent upon method	FDA (1994) guidelines state that the trimmed tip should be squarely (not bevel) cut and should closely approximate the original tip. Manufacturers fashion the catheter tip by cutting with a blade. This may result in a straight or slightly irregular cut surface (Pettit, 2006)
	Potential risks of trimming the catheter include • trimming too short • creating an irregular catheter tip depending upon catheter and trimming method • presence of fragments remaining on trimmed end (Trotter, 2004)	Whereas the method of trimming (scissors, scalpel blade, or cutting tool) may alter the smoothness of catheter tip, data linking this to a patient complication, such as phlebitis or thrombosis, are lacking (Parvez, Parmar, & Chan, 2004; Pettit, 2006; Trotter, 2004)

Table 1. Procedure for PICC Insertion in an Infant *(continued)*

Step	*Considerations*	*Precautions/Comments*
Stylet management • If a stylet is used, it should be retracted 0.5–1 cm from the catheter tip and secured to ensure that it remains within the lumen of the catheter. • Stylets should never be trimmed or allowed to extend beyond the catheter tip.	Flexible stylets facilitate threading of the catheter; can increase success in threading into the vena cava; and reduce the risk of coiling, reversing direction, or catheter shearing with a break-away needle (Catudal, 1999).	The concern that stylets may increase the risk of phlebitis or vascular perforation is not supported by available data (Catudal, 1999; Loughran et al., 1992). If the stylet has been trimmed in error, catheter damage can occur and a new catheter should be used.
14. **Position the patient and restrain as needed.** Arm insertion: Abduct the arm to a 90° angle, with the patient's head turned toward the arm. Axillary vein insertion: Abduct the arm 100°–130° or place the infant's hand by the head and puncture parallel and inferior to the artery. Femoral vein insertion: Position the infant "frog legged"; insert the introducer at a 30° angle 1 cm below the inguinal ligament and 5 mm medial to the femoral pulse (Abdulla et al., 1990).	Abducting the arm makes the venous course straighter and facilitates entry into the axillary and subclavian veins. Turning the head narrows the angle between the jugular and subclavian veins, making it difficult for the catheter to enter the jugular vein.	
15. **Tape the extremity, as needed, to a limb board to prevent excessive movement during the insertion.**	Fixing the extremity to a limb board can help stabilize the vessel and decrease patient movement.	Prestabilizing the extremity can make adequate prepping difficult and increase the risk of infection.
16. **Prep the insertion site and surrounding skin with chlorhexidine gluconate (CHG) or povidone iodine (PI) per facility prococol** (CDC, 2002b; Clark et al., 2004; Linder et al., 2004).	A large prepped area reduces the risk of contamination. The hand or foot may be wrapped in sterile gauze or glove and a large portion of the extremity prepped. This method of prepping provides access to a larger portion of the extremity, reducing the incidence of contamination, and allows entry into alternate sites without reprepping if the original insertion attempt is unsuccessful.	PI and CHG have been shown to cause local skin reactions in some neonates and PI has been linked to systemic effects (Branemark & Ekholm, 1967; Lineaweaver et al., 1985). CHG (alcoholic and aqueous formulations) should be used with caution in very-low-birth-weight infants due to reports of skin erythema and breakdown (Andersen, Hart, Vemgal, & Harrison, 2005).
Povidone Iodine Begin at the insertion site and prep in a circular motion for 30 seconds and allow to dry at least 2 minutes.		PI should be removed from the skin after the procedure to prevent tissue damage, absorption, and thyroid suppression (AWHONN & NANN, 2001; Linder et al., 1997; Parravicini et al., 1996).

Table 1. Procedure for PICC Insertion in an Infant *(continued)*

Step	*Considerations*	*Precautions/Comments*
Chlorhexidine Gluconate Apply the solution by moving the applicator using a back-and-forth and side-to-side motion for 30 seconds and allow to dry (at least 30 seconds) (Medi-Flex, 2007). Change gloves if contamination occurs.	There are many products containing CHG available with aqueous or alcohol bases and containing different concentrations of CHG. One neonatal study compared 0.5% CHG in 70% alcohol to 10% PI on peripheral intravenous sites and noted less skin colonization with use of CHG (Garland et al., 1995).	There is no evidence of sustained toxicity with CHG remaining on the skin, although the aqueous formulation needs to be removed due to its soapy consistency to allow the dressing to adhere (AWHONN & NANN, 2001; Malathi, Miller, Leeming, Hedges, & Marlow, 1993; Mullany, Darmstadt, & Tielsch, 2006). Trace serum levels have been detected following bathing and umbilical cord care with 1% or 2% chlorhexidine, particularly in preterm newborns. Potential for absorption may be reduced with aqueous formulation (Mullany et al., 2006). Studies have utilized a variety of concentrations for multiple interventions and tens of thousands of neonates worldwide have received CHG for umbilical cord care, bathing, and maternal vaginal lavage prior to birth without reported adverse effects (Mullany et al., 2006).
17. **Place a sterile drape underneath and above the insertion area.** Cover as much of the infant as can be safely done while ensuring the ability of adequate observation.	This step provides a large sterile field to prevent the catheter or supplies from becoming contaminated and is a component of maximum sterile barrier precautions (CDC, 2002b)	
18. **Applya sterile tourniquet (for an extremity insertion).** For insertion into a scalp or axillary vein, apply digital pressure proximal to the insertion site.	This step is performed to dilate the vessel to enhance insertion. Large veins may not require a tourniquet for insertion.	If the tourniquet is placed on an unprepped area of the extremity, apply a new pair of sterile gloves. Monitor the extremity to prevent arterial occlusion from a restrictive tourniquet.

Table 1. Procedure for PICC Insertion in an Infant *(continued)*

Step	*Considerations*	*Precautions/Comments*
19. **Insert the introducer bevel up at a 15°–30° angle into the skin a few millimeters before anticipated entry into the vein.** Hold the skin taut below the level of insertion to prevent the vein from rolling. A 30° angle is recommended for insertion into the femoral vein (Abdulla et al., 1990).	Blood return may not be visible with some introducers. If you think you have cannulated the vein, try advancing the catheter.	
20. **Observe for blood return.** When the vessel is cannulated, a blood return may be observed or a "pop" may be felt. When the blood returns, lower the introducer until it is parallel with the skin, and gently insert it a few millimeters farther to ensure that the entire bevel is within the vein.	A blood return usually is obtained due to the large size of the introducer, but it may be absent in some infants and in low perfusion states. Sometimes it is not evident until the catheter is advanced.	A vein can be cannulated without blood return. Observe the color, speed of flow, and pulsation of blood to detect arterial cannulation. If in doubt, obtaining a blood gas through the catheter may be helpful. Additionally, contrast injection or ultrasound may be definitive.
21. **Removethe tourniquet after the introducer is well within the vein and blood return is evident.**	Tourniquets distend the vein and when removed the vein contracts. If the introducer tip is not entirely within the lumen or close to the wall it may retract with tourniquet removal leading to extravascular placement.	Removal of the tourniquet may cause some infants to move and may cause the introducer and catheter to become dislodged.
22. **Using nontoothed forceps, thread the catheter through the introducer needle in 0.5–1-cm increments to the premeasured length.**	Slow, controlled insertion can prevent venous irritation and the development of phlebitis (Hadaway, 1998). It also allows the catheter to float into the central circulation with the flow of blood. To minimize trauma to the vessel, threading the catheter should take at least 30–60 seconds.	
23. **To facilitate insertion, flush with saline or heparinized saline while threading the catheter if obstruction is realized.**	Flushing may help the catheter advance past obstructions and valves in veins. It can be attempted when the catheter is within the vein and appears to be stuck.	There is little benefit to flushing a catheter containing a stylet because only minimal flow can be achieved.
24. **Remove the introducer.** Apply digital pressure to the vein of insertion a few centimeters above the tip of the introducer to hold the catheter in position, and slowly remove the introducer until it is outside the skin several centimeters. Alternatively, hold the catheter in place with forceps while withdrawing the introducer. Initially, hold behind the introducer and then switch to close the skin as soon as the introducer is removed.	Digital pressure over the vein prevents the catheter from being withdrawn with the introducer. The introducer needs to be away from the insertion site to be removed from the catheter.	Applying pressure too close to the tip of the introducer may cause catheter damage. Keep the introducer parallel to the catheter to prevent catheter damage.

Table 1. Procedure for PICC Insertion in an Infant *(continued)*

Step	*Considerations*	*Precautions/Comments*
25. **Releasethe break-away needle or peel-away cannula per the manufacturer's guidelines.**	This step removes the introducer from the catheter and allows the required length of catheter to be inserted.	Prevent catheter damage by keeping the introducer and catheter parallel.
26. **Applypressure to the puncture site until the bleeding stops.**	Bleeding can persist for several minutes due to the large size of the insertion device and the smaller size of the catheter.	Persistent, difficult-to-control bleeding is unusual. In such cases, coagulopathy or arterial puncture should be considered.
27. **Ensurethat the catheter is at the premeasured length.** Adjust as necessary.	The catheter may slip out slightly during removal of the introducer. Reinsert it as needed.	
28. **If a stylet is present, remove it slowly over a period of 30–60 seconds.** If the stylet cannot be removed (possibly due to a curve in the vein), the catheter can be pulled back 1 cm and removal attempted. If a hydrophilic-coated stylet is in place, the catheter must be flushed to activate the lubricant before the stylet is removed.	Rapid removal can lead to catheter damage.	If the catheter bunches or ripples near the insertion site, it is necessary to slow down.
29. **Aspiratefor a blood return and flush the catheter.** If blood return is not present, withdraw the catheter slightly and aspirate. Continue this maneuver until a blood return is present or the catheter is pulled back to the extremity or scalp. Attempt to reinsert the catheter to the premeasured depth.	Blood return indicates vascular placement. Lack of blood return or inability to flush may indicate malposition.	Radiographic verification may assist in identifying tip location, which may provide guidance to repositioning efforts.
30. **Attachthe luer-lock extension set, if an integrated extension set is not part of the catheter design.**	Extension sets applied at the time of insertion may be considered part of the catheter and not routinely changed (CDC, 2002b).	All connections should contain luer locks to prevent inadvertent disconnection, with the potential for embolus, hemorrhage, or occlusion. Extension sets prevent stress to the catheter hub from repeated disconnection or IV tubing changes.
31. **Temporarilysecure the catheter to the skin with sterile tape or skin-closure tape.**	The catheter is lightly secured until radiographic verification of the tip position. Temporary taping prevents having to remove the dressing (and risking skin damage) to reposition the catheter if necessary. Allowing tape or skin-closure tape to remain on the catheter over time has been linked to catheter damage (Frey, 1999). The infant and the catheter should be carefully monitored until the catheter is dressed.	Maintain the sterile field while waiting for verification of tip location. If an X ray cannot be performed in a timely fashion, consider applying the dressing.

Table 1. Procedure for PICC Insertion in an Infant *(continued)*

Step	*Considerations*	*Precautions/Comments*
32. **Keepthe catheter patent by flushing it intermittently with 0.5 ml flush solution in a 5–10-ml syringe;** or attach a positive or neutral displacement device until the position is verified. Flush using a pulsatile (short bursts or start-stop) technique.	Catheters with small internal lumens (27 and 28 gauge) are more prone to clot without frequent flushing or use of a positive or neutral displacement device prior to the infusion of fluids. Refer to the manufacturer's recommendations for minimum syringe size that can be safely used.	Maintain sterility during flushing. Pulsatile flushing has been anecdotally described as a method of enhancing catheter patency.
33. **Verify the location of the catheter tip with a chest radiograph.** If the insertion site is in the arm, include a portion of the upper arm and neck. If it is in a lower extremity, include the abdomen. For scalp insertion, include the skull. The catheter tip must be adequately visualized before the catheter is used.	Radiographic or another imaging modality is required for verification of the catheter-tip location (FDA, 1989; NAVAN, 1998). Tips for enhancing tip visualization • Positioning the infant for a lateral oblique view of the chest (right side elevated at a 10°–15° angle) can enhance visualization of the catheter because the PICC is not superimposed over the mediastinal structures. This technique has been credited with enhancing agreement among physicians on catheter tip location when compared to the anterior-posterior view in adults (Harako, Nguyen, & Cohen, 2004) • Overpenetrating the radiograph can allow better visualization of the catheter. If using computed radiography, adjust the contrast or use the invert feature. • To determine whether the catheter has coiled within the peripheral or central veins, the part of the vein near the insertion site can be included in the radiographic assessment. • A lateral X ray may be beneficial in locating the catheter tip, particularly if malpositioning is suspected based on the AP view or clinical findings (Coit & Kamitsuka, 2005; Royer, 2001; Stark, Brasch, & Gooding, 1984).	Positioning the infant for the insertion and subsequent X rays to verify catheter tip location should be consistent to prevent misinterpretation of catheter migration due to positioning. There is little data to suggest the optimal position to place the infant in for the X ray. Suggestions for infant and catheter tip positiong include • Positioning the infant in a manner that would make the catheter at its deepest location or placing the infant in the position that is most likely to be maintained during the infant's day (Nadroo, Glass, Lin, Green, & Holzman, 2002). • Positioning the infant for the post insertion X ray to allow maximal inward movement of the catheter (Nadroo et al., 2002). • Maintaining the catheter tip 1 cm outside the cardiac reflection in a premature infant and 2 cm in a term infant has been suggested (Nowlen, Rosenthal, Johnson, Tom, & Vargo, 2002).

Table 1. Procedure for PICC Insertion in an Infant *(continued)*

Step	*Considerations*	*Precautions/Comments*
PICC catheters are radiopaque, but some, depending on manufacturer and size, may be difficult to see on radiograph and require the instillation of additional contrast (Odd, Page, Battin, & Harding, 2004). Catheters are difficult to visualize in infants with opacified lungs. Water-soluble, nonionic contrast media may be used to enhance catheter visualization.	Many catheters contain enough barium or bismuth for visualization without additional contrast enhancement. Contrast media can be instilled if the catheter tip cannot be adequately visualized without them. Certain water-soluble, nonionic contrast solutions may not cause tissue damage if the catheter tip is extravascular. However, some contrast solutions do, and they should be checked carefully before instillation.	The contrast medium should be injected slowly, instilling enough to slightly overfill the catheter. The X ray can be taken after 3–5 seconds. This allows time for the bloodstream to wash excess contrast away from the catheter tip so that the tip can be accurately identified. Withdraw the contrast after the X ray. Suggestions supporting routine use of contrast to visualize the catheter tip focused on lack of visibility and were brand specific and cannot be applied to all catheters due to individualized radiopaque properties (Cartwright, 2004; Odd et al., 2004; Reece, Ubhi, Craig, & Newell, 2001). There is a lack of agreement to support the use of contrast as a routine measure and the use of contrast does not guarantee precise localization of a catheter tip in all situations (Bagchi, Nycyk, & Bodicoat, 2002; Odd et al., 2004).
34. **Placethe catheter tip in the SVC or thoracic IVC** (FDA, 1989; INS, 1997a, 2006; NAVAN, 1998). This position has been described as the T3–T5 level, but it varies depending on radiographic technique and infant anatomy. Both the INS and AVA recommend the lower ½–⅓ of the SVC as the ideal tip location for upper body insertions. Difficulty in defining this location and the risk of the complications related to the catheter migrating in the right atrium in infants have led to the more general SVC location. The appropriate IVC tip placement is not well defined, but current data suggest a tip location between the right atrium and the diaphragm, described as T8–T10 (Racadio et al., 2001; Serrao et al., 1996). The catheter should lie parallel to the vessel wall.	A catheter tip in the lower ⅓ of the SVC lies parallel to the vessel wall, so the risk of thrombosis and infection is reduced (NAVAN, 1998). The SVC is much shorter in neonates than in adults, so identifying the lower ⅓ is challenging. Outside the vena cava, the catheter tip is subjected to smaller diameter vessels, curvature of the vein, and venous valves; these increase the likelihood of the catheter's contacting and damaging the vessel wall. Chemical irritation (caused by the infused fluid or medication) is more likely in these smaller diameter veins. Exposure of the subendothelial layer of the vein due to mechanical or chemical irritation can lead to thrombosis, thrombophlebitis, and infection (Hadaway, 1998; Kearns et al., 1996; Racadio et al., 2001). A 60% rate of subclinical thrombosis of the axillary, subclavian, and brachiocephalic veins has been seen with catheter tips residing in these veins in adults (Kearns et al.). In a small study of pediatric patients, Stringer and colleagues (1992) found a slightly shorter survival time and a 15% incidence of thrombophlebitis when catheter tips were in the brachiocephalic and subclavian veins rather than the vena cava. They recommended elective replacement of these catheters after 10 days.	Placement in the right atrium is against manufacturers' recommendations for use. The FDA (1989) states that only pulmonary artery catheters should be left in the heart due to the risk of dysrhythmias, perforation, tamponade, and death. Catheter tip locations in the brachiocephalic and subclavian veins are not considered central, due to the decreased diameter and lack of laminar blood flow in these veins and increased risk of complications (INS, 1997a; NAVAN, 1998; Racadio et al., 2001).
35. **Reposition the catheter, if necessary.**	If a sterile technique has been maintained and repositioning can be accomplished in an efficient manner, the catheter can be advanced if necessary. Otherwise, the catheter may only be withdrawn to reposition it.	Verify the new catheter tip location by radiographic means after all repositioning efforts.

Table 1. Procedure for PICC Insertion in an Infant *(continued)*

Step	*Considerations*	*Precautions/Comments*
36. **RemovePI and aqueous CHG skin prep with sterile water or saline** (AWHONN & NANN, 2001).	PI can be absorbed through the skin, leading to elevation of iodine levels and hypothyroidism (Linder et al., 1997; Parravicini et al., 1996). The formulation of aqueous CHG prevents adherence of dressings if not removed. There is currently no data to support removal of CHG contained in an alcohol base.	
37. **Securethe catheter to the skin.** A slight curve should be placed in the catheter as it exits the skin to prevent applied tension from causing outward migration or allowing inward migration with movement.	The dressing is intended to secure the catheter to the skin and reduce the potential for infection. One study in neonates supported the use of semipermeable transparent dressings for this purpose (Zenk et al., 1993).	Attempt to stop bleeding prior to dressing to decrease blood remaining on the skin, which serves as a medium for bacterial growth. Dress in a manner that promotes visualization of the catheter and insertion site to facilitate assessment and promote catheter security. Some manufacturers have specific recommendations for securing their catheter. Tape or skin-closure tape applied directly on the catheter tubing have been reported to cause catheter damage (Frey, 1999).
Secure to allow visualization of amount of catheter external to infant and the insertion site (Pettit, 2002).		
If several centimeters of catheter are external, place the curve as directed above and coil catheter while preventing kinks or bends in the catheter.		
Securement devices are available for some PICCs.		
Sterile skin barriers made of hydrocolloid can be placed under the catheter hub to prevent skin breakdown from contact with a rigid catheter hub or T-connector.	Prevention of skin damage is critical to prevention of infection.	
The catheter hub should be secured to the infant using the method described by the manufacturer. If not specified, adhere hub or disk to the skin with sterile tape or skin-closure strips.	Catheter securement depends on adequate fixation of the device to the patient.	
Extension sets (i.e., T-connector) should be attached to the skin with tape to prevent catheter dislodgement.		

Table 1. Procedure for PICC Insertion in an Infant *(continued)*

Step	*Considerations*	*Precautions/Comments*
Apply the dressing to the catheter and hub. The choice of dressings includes transparent semipermeable or gauze and tape. The dressing should cover the insertion site, catheter, and hub of the extension set, if this is a separate device.	There are a variety of transparent dressings. Those shown to be superior have the ability to keep the skin drier by allowing more moisture vapor to pass. They are more comfortable and allow visualization of the insertion site. Gauze or impermeable tape placed under or on top of this dressing creates a gauze-and-tape dressing. Although preferred by some, they are bulky, prevent visualization of the insertion site and catheter, and may require more frequent manipulation of the dressing to check the insertion site and require routine changing. Antimicrobial ointments should not be applied to the insertion site (CDC, 2002b).	The dressing should not be completely wrapped around the extremity, as this may lead to venous stasis and edema. Accumulation of moisture or blood on the skin may increase colonization of microorganisms. Infants who have oozing of tissue fluid or persistent bleeding are at risk for catheter migration. For persistent bleeding, a topical hemostatic agent (e.g., Surgicel®, Gelfoam®) may be placed under the dressing. Hydrocolloid or karaya wafers may be placed under the dressing of infants who have oozing from the skin, and the catheter and dressing placed on top.
38. **Documentthe procedure on the medical record.** The following should be recorded: • indication • consent and parent education • patient identification • skin prep solution • vein of insertion • brand, type, size, number of lumens, and lot number • initial length of catheter (i.e., length trimmed, inserted, and external) • style and size of introducer • presence of stylet • radiographic location of catheter tip • type of dressing used • infant's tolerance of procedure • number of attempts at cannulation • complications encountered • procedural medications administered with therapeutic response • MST specifics • Imaging technology used for insertion • Catheter tip location verified radiographically • Name of clinician performing procedure	A formal procedure note should be prepared. The bedside caregivers should have immediate access to this information to allow assessment of catheter tip placement and monitoring for complications.	Initiation of a data collection tool for outcome monitoring is recommended following each insertion. Responsibility should be assigned for ongoing monitoring of each PICC at least daily for the need to remain indwelling. Each shift the catheter should be evaluated for signs of malfunction and the integrity of the dressing and cleanliness of the site.

Use of modified Seldinger technique (MST) and poor peripheral venous access

Some infants have veins that are difficult to cannulate, making the traditional methods of insertion challenging. Although alternative techniques have been used in older patient populations, they are relatively new in the NICU. Using the following technique requires training and practice protocols, and in some states it requires approval of the facility and state boards of nursing.

Using an MST (also referred to as micropuncture) allows a smaller introducer to be used (Frey, 2002). A small gauge, short PIV catheter is initiated following strict sterile technique as set up for the PICC placement. Following cannulation, the needle is removed and a short guidewire is inserted a few centimeters beyond the tip of the PIV while remaining in the peripheral circulation. The peripheral catheter is removed over the wire.

After the skin is anesthetized, a small nick is made to allow the introducer to be inserted. The PICC introducer or a larger sheath or sheath dilator is inserted over the guidewire. Once in place, the guidewire and dilator (if used) are removed. The PICC is placed through the introducer/sheath and advanced into the proper position. The introducer/sheath is separated and removed (Frey, 2002; Pettit, 2007; Stephenson & Khan, 1993; Valk, Liem, & Geven, 1995). Using ultrasound technology in combination with the MST can improve the chances of achieving venous access in patients and decreasing pain and should be considered.

Malposition of catheter

When the PICC does not terminate in the appropriate location within the vena cava it is considered to be malpositioned.

Etiology

- vein used for catheter insertion
- insertion technique, particularly rapid threading of the catheter
- venous anatomy

Location of malposition

- Catheters inserted into the basilic vein most commonly are malpositioned into the internal jugular vein.
- Catheters inserted into the cephalic vein most commonly are malpositioned into the axillary and basilic veins.
- Catheters inserted through the saphenous or other leg veins (particularly on the left side) may enter the ascending lumbar vein (Clarke, Wadhawan, Smyth, & Emmerson, 2003; De & Imam, 2005).
- Catheters inserted into the scalp can enter intracranial veins or tissue and thoracic veins (Anderson, Graupman, Hall, Sweeny, & Lam, 2004).

Identification

Suspect a malposition if

- the catheter is difficult to thread or won't thread to the premeasured depth (Aladangady, Roy, & Costeloe, 2005; Baker & Imong, 2002)
- a blood return is not easily obtained
- the catheter flushes with resistance
- the stylet is difficult to remove or is bent upon removal.

An X ray may provide definitive evidence that a catheter is malpositioned.

Management

Techniques for successfully repositioning a malpositioned catheter include the following:

- Repositioning or partially withdrawing the catheter and attempting to reinsert it (done only at the time of insertion and requires sterile technique to have been maintained). To prevent catheter shearing, the catheter must not be withdrawn until the needle introducer is removed.
- Using the MST to incorporate a guidewire exchange and facilitate appropriate positioning. Alternatively, a catheter exchange procedure through a cannula-style introducer has been described (Pettit, 2007).
- Using patient repositioning maneuvers (Nadroo et al., 2002)
  - For basilic vein insertions with the catheter tip in the jugular vein, abduct the arm at the shoulder and extend the elbow as far as possible to pull the catheter into a more peripheral location. Follow these maneuvers by adducting the arm and flexing the elbow to reinsert the catheter.
  - For cephalic vein insertions with the catheter tip in the axillary vein, adduct the arm and extend the elbow as far as possible to withdraw the catheter into a more peripheral location. Abducting the arm and flexing the elbow will reinsert the catheter.
- Repositioning the patient to allow gravity and blood flow to help the catheter travel to the superior vena cava (James et al., 1993)
  - Raise the head of the bed (if the catheter is in the internal jugular vein) (Lum & Soski, 1989).
  - Place the infant on the ipsilateral side with the head of the bed elevated (if the catheter has entered the contralateral brachiocephalic vein) (Lum & Soski, 1989).

– Catheters that are curled back into the axillary vein can flow to the superior vena cava if the infant is placed on the contralateral side with the head of the bed elevated (Lum & Soski, 1989).

- If the PICC is looped back on itself and is in a deep vein (e.g., subclavian, jugular), or is in a large vein such as the internal jugular vein, it can enter the superior vena cava with fluid infusion, gravity, and the aid of venous return to the heart (Frey, 1995; Lum & Soski, 1989; Tawil, Eldemerdash, Hathlol, & Laimoun, 2006).
- Gentle flushing through the catheter has been anecdotally described as facilitating repositioning.

Further considerations may include

- repeating X rays within 24 hours to assess catheter position.
- infusing the line with fluids that can be given in a PIV or heparin locked until it is properly positioned to avoid vascular injury. Achieving maintenance rate to the infusion may be beneficial in catheter repositioning (Tawil et al., 2006).
- discontinuing using the catheter if its position is not appropriate (Tawil et al., 2006).

Prevention

- Select a vein for insertion knowing risks of malposition.
- Position the infant to facilitate successful insertion. (Refer to positioning the infant in "Insertion Procedure.")
- Insert the PICC slowly, allowing the blood returning to the heart to carry the catheter with it to the vena cava.

Bleeding

Oozing from the insertion site is common during the 24 hours after insertion because of the large size of the insertion device.

- Apply pressure on the puncture site for at least 5 minutes following insertion and until bleeding has stopped.
- A sterile piece of gauze can be applied under the dressing to the side of the catheter to wick blood away from the site. Placing gauze under the dressing can contribute to moisture accumulation and therefore requires a dressing change within 48 hours (INS, 2006).
- If there is persistent oozing, a hemostatic agent (e.g., Surgicel®, Gelfoam®) can be applied under the dressing to promote adherence and to prevent catheter migration.

Prevention

- Use the smallest introducer available to minimize the size of the insertion hole.
- Excessive bleeding can be caused by an inadvertent arterial puncture. Differentiate the vein from the artery before attempting the insertion.
- If oozing or bleeding persists, investigate the cause (i.e., vigorous movement of extremity, coagulopathy).

Postinsertion Complications

The incidence of major complications associated with PICC use is low. The majority of catheters are removed electively at the conclusion of therapy (Cartwright, 2004; Evans & Lentsch, 1999; Linck et al., 2007). A variety of complications have been associated with PICCs and there is an increased risk of complications in units where the procedure is performed infrequently (Garden & Laussen, 2004). A reduction in complications was noted when the procedures for insertion and catheter care were standardized and nurses became more experienced in inserting and maintaining the catheters (Rourke & Higgins, 1998; Sherrod et al., 2005). Compliance with central line policy and care regimen was positively linked to a specialized education program (East & Jacoby, 2005).

Although most complications are minor and easily treated, some can be life threatening and require prompt action. Mechanical problems, including occlusion, leaking, and dislodgment, along with infection are the most commonly identified complications. Many case reports of infection, however, do not distinguish the catheter as the source of the infection (Trotter, 1996). Complications can be related to insertion technique, routine care and maintenance procedures, or patient-specific problems (Pettit, 2002, 2003a). Serious complications often are related to improper catheter tip location (Cartwright, 2004; De & Imam, 2005; Nowlen et al., 2002). The complications encountered most commonly or associated with serious sequelae are addressed here.

Catheter-related bloodstream infection or catheter-associated bloodstream infection

A *catheter-related bloodstream infection (CRBSI)* is defined as "bacteremia or fungemia in a patient who has an intravascular device and ≥1 positive result of culture of blood samples obtained from the peripheral vein, clinical manifestations of infection (e.g., fever, chills, hypotension), and no apparent source for bloodstream infection (with the exception of the catheter). One of the following should be present: a positive result of semiquantitative (≥15 cfu per catheter segment) or quantitative (≥10^2 cfu per catheter segment) catheter culture, whereby the same organism (species and antibiogram) is isolated from a catheter segment and a peripheral blood sample; simultaneous quantitative cultures of blood samples with a ratio of greater than 5:1 (CVC versus peripheral); differential time to positivity (i.e., a positive result of culture from a CVC is obtained at least 2 hours earlier than a positive result of culture from peripheral blood" (CDC, 2002b; Mermel et al., 2001).

The term catheter-associated bloodstream infection (CABSI) is intended as a surveillance definition for use in benchmarking performance and directing quality improvement activities (Ryder, 2005).

Sepsis appears to be the most consistently reported serious problem associated with PICCs. The incidence figures of CRBSI reported in the literature vary due to inconsistent use of diagnostic criteria and reporting (Trotter, 1996). Comparing rates is difficult because of inconsistencies in the definition of CRBSI; the insertion, care, and maintenance procedures; and the population of infants included.

A retrospective study of infants matched by birthweight and admission date concluded that PICCs do not lead to a greater number of CRBSIs than PIVs (Parellada, Moise, Hegemier, & Gest, 1999). These data have been confirmed in a randomized, comparative trial of very-low-birthweight infants (Janes et al., 2000). Equal numbers of infants developed bacteremia in the group with a PICC and the group with a PIV. More recently, infants weighing <1,000 g were matched by weight, gestational age, gender, and Clinical Risk Index for Babies (CRIB) scores to evaluate success during insertion and short- and long-term catheter complications (Liossis, Bardin, & Papageorgiou, 2003). Infants in the treatment group received IV fluids and medications via a PICC while the control group was managed with PIVs. Placement of a PICC was successful in the majority of cases and carried a significantly lower risk of infection than those infants in the control group managed with PIVs.

Etiology

CRBSI is an inherent risk with the use of any vascular access device. This multifactorial nature of infection can be due to migration of skin flora from the insertion site along the catheter tract and colonization of the catheter (CDC, 2002b). Other mechanisms of catheter colonization include contamination of the catheter hub, contamination of the catheter at the time of insertion, administration of contaminated infusates, and hematogenous seeding of the catheter from a distant site of infection (CDC, 2002b; Salzman, Isenberg, Shapiro, Lipsitz, & Rubin, 1993; Sitges-Serra et al., 1997).

Risk factors

Premature infants, particularly those with a birthweight <1,000 g, are at higher risk of infection because of deficiencies in their host defense mechanisms and the number of invasive procedures to which they typically are subjected. Additional risks for CRBSI may include

- PICC insertion or care by relatively inexperienced staff (Puntis et al., 1991; Sherrod et al., 2005)
- catheter repair (Golombek et al., 2002; Neubauer, 1995)
- multiple manipulations of catheter (Neubauer, 1995)
- contamination of the catheter hub (Salzman et al., 1993; Sitges-Serra et al., 1997)
- long catheter dwell time (i.e., >3–6 weeks) (Chathas et al., 1990; Golombek et al., 2002).

Treatment

There are no controlled clinical trials to provide data about the appropriate management of CRBSI in infants (Mermel et al., 2001). Controversy exists regarding treatment decisions with infants who require vascular access devices to survive. Based on a retrospective review of infants who had a variety of CVCs and developed bacteremia without an identified source, removing the PICC with a CRBSI of Gram-negative rods, Staphylococcus aureus, or Candida could improve a patient's outcome (Benjamin et al., 2001; Karlowicz, Hashimoto, Kelly, & Buescher, 2000). Successfully treating infants having four or more positive blood cultures for coagulase negative Staphylococcus without removing the CVC is unlikely (Karlowicz, Furigay, Croitoru, & Buescher, 2002).

The literature reports that the following are alternatives to be used based on a case-by-case assessment of each infant:

- Treat the infection with antimicrobials through the catheter and repeat a blood culture after 48 hours. If it is positive, consider removing the catheter (Klein & Shahrivar, 1992; Maki & Crnich, 2003; Ramanathan & Durand, 1987).
- Discontinue the catheter without attempting to clear the infection (there is the potential for ineffective treatment when attempting in situ therapy, especially with systemic fungal infections) (Maki & Crnich, 2003). A new catheter often can be placed, if necessary, after 24–48 hours of effective therapy.

Prevention

Recommended strategies for preventing CRBSI include

- using a central line bundle, such as that recommended by the Institute for Healthcare Improvement (IHI)

that includes five key components: hand hygiene, maximal barrier precautions upon insertion, chlorhexidine skin antisepsis, optimal catheter site selection, and daily review of line necessity with prompt removal of unnecessary lines (IHI, 2007).
- Ensuring staff competency in inserting and maintaining a catheter (Linck et al., 2007).
- Limiting the number of staff members who insert catheters.
- Using standardized protocols for maintaining PICCs (Golombek et al., 2002; Linck et al., 2007; Rourke & Higgins, 1998).
- Using maximum sterile barrier precautions for catheter insertion and sterile technique for dressing changes (CDC, 2002b; INS, 2006; Maki, 1994; Raad et al., 1994).
- Practicing appropriate hand hygiene before the catheter is inserted and when entering the PICC.
- Using PI or CHG for skin disinfection prior to catheter insertion and with dressing change (Anderson et al., 2005; AWHONN & NANN, 2001; CDC, 2002b).
- Dressing the insertion site with a sterile, occlusive material. If dressing integrity is lost, change the dressing (CDC, 2002b; Zenk et al., 1993). A multidimensional strategy to decrease CRBSI that included weekly dressing changes showed a statistically significant decrease in CRBSI (Aly et al., 2005).
- Eliminating stopcocks from tubing and instead using capped injection ports that must be vigorously cleaned with alcohol prior to entry (Bouza et al., 2003; Casey et al., 2003; Pettit, 2002; Sitges-Serra et al., 1997; Yebenes et al., 2004).
- Exercising meticulous care when using the catheter or changing IV tubing.
- Minimizing entry into the line. A closed medication system (entry restricted to once every 24 hours) used as a component of a multidimensional strategy to decrease CRBSI was found to significantly decrease the incidence of CRBSI (Aly et al., 2005).
- Providing continuing education and monitoring staff compliance with hand hygiene and care regimes. Following up with subsequent reporting and feedback to staff (Kilbride et al., 2003).
- Antibiotic lock strategies have demonstrated a reduction in CRBSI in a small clinical trial (Garland, Alex, Henrickson, McAuliffe, & Maki, 2005).
- Removing the PICC as soon as a vascular access device is not required. The optimal time for removing a PICC remains unclear. Previous reports have suggested 3–6 weeks as a common interval between insertion and the appearance of CRBSI (Chathas et al., 1990; Golombek et al., 2002).

Catheter migration

Etiology

- In vivo and ex vivo reports commonly document movement or migration of the catheter at any time while in situ.
- The movement of PICCs within the body may occur spontaneously or as the result of patient movement, as outlined in **Table 2.** Movement may cause a catheter shift to a more peripheral or central location (Brandt, Foley, Fink, & Regan, 1970; Lang-Jensen, Nielsen, Sorensen, & Jacobsen, 1980; Lingenfelter, Guskiewicz, & Munson, 1978; Nadroo et al., 2002).
- A catheter can migrate further inside or outside the body if the dressing is not secure (Frey, 1999).
- Difficulty in securing external jugular insertions has led to increased migration (Goutail-Flaud et al., 1991; Nadroo et al., 2002).

Risk factors

Patients at higher risk for migration (based on reports primarily from adults) include those who experience the following (Hadaway, 2005; Jacobs & Zaroukian, 1991; Lum & Soski, 1989):

- increased thoracic pressure
- high-frequency ventilation
- frequent vomiting
- severe coughing
- extreme physical activity
- rapid infusion of fluid or forceful flushing.

Signs and symptoms

Catheter migration may be asymptomatic although reported symptoms can include

- pain and irritability based on the catheter location and infusate
- erythema or edema of shoulder, neck, or arm (for arm-inserted catheters)
- change in catheter function (difficulty flushing or withdrawing) (Hadaway, 1998; Pettit, 2003a)
- change in length of external catheter segment (Pettit, 2003a)
- symptoms specific to a particular complication (i.e., dysrhythmias due to catheter migration into the heart or pericardial or pleural effusion, which are described under "Complications").

Treatment

- Obtain radiographic verification of the catheter tip location (Pettit, 2003a).
- Refer to strategies identified in "Malposition."
- Patient repositioning maneuvers have been shown to successfully adjust PICCs in some instances (Nadroo et al., 2002).

– For basilic vein insertions with catheter tip in the jugular vein, abduct arm at the shoulder and extend the elbow as far as possible to pull the catheter into a more peripheral location. Follow these maneuvers by adducting the arm and flex the elbow to reinsert the catheter.
– For cephalic vein insertions with catheter tip in the axillary vein, adduct the arm and extend the elbow as far as possible to withdraw the catheter into a more peripheral location. Abducting the arm and flexing the elbow will reinsert the catheter.

- Determine whether it is safe to leave the catheter in its current position; doing so may not be acceptable, especially if the patient is symptomatic.
- Consider removing the catheter or performing a catheter exchange if the tip is outside the appropriate location in the vena cava. Pulling the tip back into an acceptable location and using it as a midline or peripheral IV also may be an option. If the catheter is retracted to a midline tip location only solutions and medications that can safely be infused into a peripheral vein should be used.

Table 2. Relationship Between Patient Position and Catheter Tip Location

Catheter Insertion Site	Infant Position	Resultant Tip Movement
Cephalic vein	Abduction of arm	Inward migration
	Adduction of arm	Outward migration
Basilic and axillary veins	Abduction of arm	Outward migration
	Adduction of arm	Inward migration
Antecubital insertion	Flexion of arm	Inward migration
	Extension of arm	Outward migration
External jugular	Full lateral neck flexion	Inward migration
Catheters traversing neck	Neck flexion	Inward migration
Leg vein insertion	Leg flexion	Inward migration
	Leg extension	Outward migration

Note. From "Mechanism of perforation of the heart with the production of hydropericardium by a venous catheter and its prevention," by R. L. Brandt, W. J. Foley, G. H. Fink, and W. J. Regan, 1970, *American Journal of Surgery, 119,* 311–316; "Primary and secondary displacement of central venous catheters," by T. Lang-Jensen, R. Nielsen, M. B. Sorensen, and E. Jacobsen, 1980, *Acta Anasthesiologica Scandinavica, 24,* 216–218; "Displacement of right atrial and endotracheal catheters with neck flexion," by A. L. Lingenfelter, R. A. Guskiewicz, and E. S. Munson, 1978, *Anesthesia and Analgesia, 57,* 371–373; and "Changes in upper extremity position cause migration of peripherally inserted central catheters in neonates," by A. M. Nadroo, R. B. Glass, J. Lin, R. S. Green, and I. R. Holzman, 2002, *Pediatrics, 110,* 131–136.

Complications

Complications that can arise from catheter migration include the following:

- thrombosis (Racadio et al., 2001)
- dysrhythmias
- vascular perforation or extravasation (Pigna, Bachiocco, Fae, & Cuppini, 2004)
- myocardial perforation, effusion, tamponade (Little, Petty, & Beeram, 2004; Nadroo et al., 2002).
- pleural effusion (Pigna et al., 2004)
- neurologic abnormalities (Refer to discussion of neurologic complication for symptomatology.) Adults and children have reported hearing water-like sounds when catheters migrate into the jugular vein. The infusate may be directed against the flow of blood and can allow infusion into smaller veins or into the intracranial venous sinuses and create neurological problems (Hadaway, 2005)
- catheter knotting, looping
- pain.

Prevention

Migration may not be preventable due to dynamic forces within the body. Strategies that minimize the risk of migration include

- maintaining the security of the catheter with intact dressing (Frey, 1999)
- verifying the catheter tip location upon insertion, repositioning, and an ongoing basis (FDA, 1989)
- verifying the position of the extremity or head on radiograph. This can alter the catheter tip position (Nadroo et al., 2002).

Catheter dislodgement

Inadvertent partial or complete removal of the catheter from the body is termed catheter dislodgement.

Etiology

- Loss of secure dressing (Hadaway, 2005)
- Catheters are retracted during a dressing change (Hadaway, 2005)
- Excessive bleeding or drainage at the insertion site prevents catheter securement (Pettit, 2003a)
- Extension set and tubings are not secured to the infant (Frey, 1999)
- Tension placed on catheter and dressing (Pettit, 2003a), particularly excess catheter remaining external (Frey, 1999)

Treatment
- Radiographically verify tip location to determine safety of leaving catheter indwelling (Pettit, 2003a).
- Remove catheter or perform a catheter exchange if new tip location is unsatisfactory (Pettit, 2003a).

Prevention
- Maintain the security of the catheter with an intact dressing.
- Consider using specially designed catheter securement devices.
- Avoid using ointment under the dressing.
- When performing a dressing change, remove the old dressing by pulling toward and not away from the insertion site.
- Secure extension tubing to the infant.

Dysrhythmias

Atrial and ventricular dysrhythmias can occur if the catheter enters either chamber of the heart. Pacing tissue may also be present in the lower segment of the superior vena cava.

Identification
- Monitor the heart rhythm during insertion, and slightly withdraw the catheter if dysrhythmias occur.
- If dysrhythmias occur without an identified etiology, verify the catheter tip placement by radiograph or another imaging technique.

Prevention
- Measure the patient to determine the correct length of the catheter to be inserted.
- Verify and maintain the catheter tip location in the vena cava and outside the heart.
- Maintain a secure dressing to prevent catheter migration.

Myocardial perforation, effusion, or tamponade

Myocardial perforation occurs anytime during catheter dwell—the median time of occurrence is 3 days postinsertion. Based on retrospective data, however, effusion may occur at any time during catheter dwell (Nowlen et al., 2002). This review also identified catheter tips to be predominantly within the pericardial silhouette at the time the effusion was identified. Pericardial effusion, tamponade, and death can result if the symptoms are not readily identified and the pericardial effusion drained (Cartwright, 2004; Garden & Laussen, 2004). Heightened awareness of this potential complication may decrease mortality (Nowlen et al.). (See **Figure 5.**)

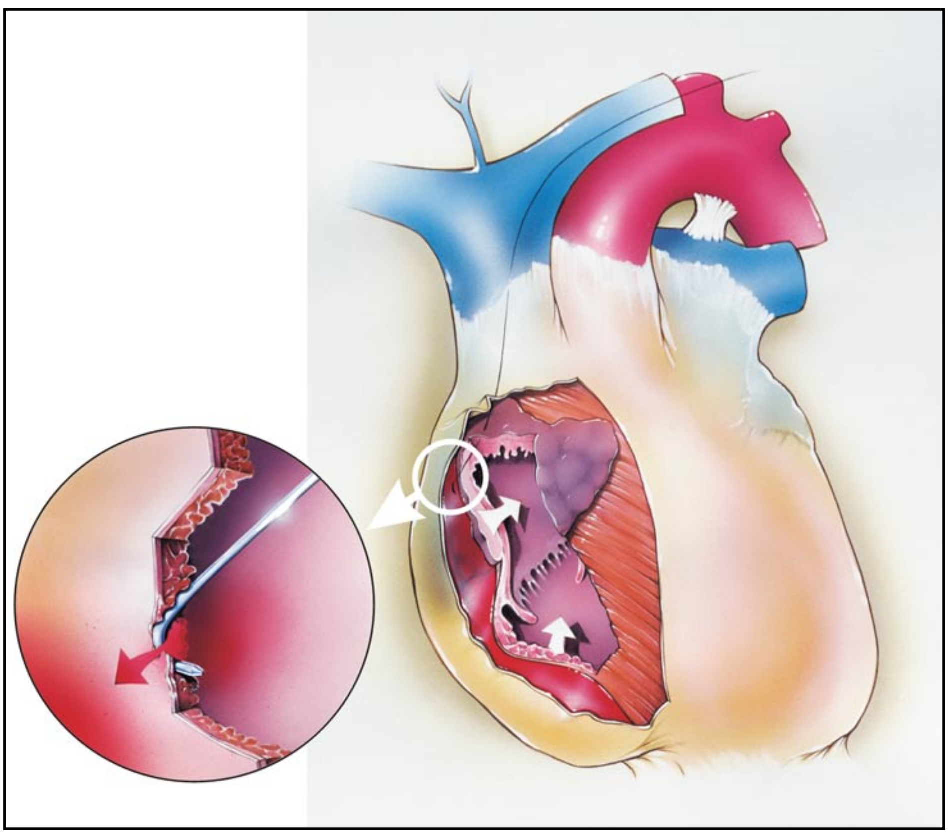

Figure 5. *Catheter erosion through the myocardium, leading to pericardial effusion*

Proposed etiologies

More data are required to determine the precise etiologies, but those reported include

- myocardial damage as the catheter tip contacts the cardiac muscle with each contraction, becoming fixed with resultant thrombus or causing a direct myocardial perforation (Nowlen et al., 2002)
- osmotic injury due to infusion of hyperosmolar fluid directly contacting the myocardium leading to diffusion injury (Nowlen et al., 2002)
- rapid injection of fluid (Nowlen et al., 2002)
- erosion of catheter through the lower portion of the superior vena cava just outside the heart and infusion of fluid into the pericardial space (Collier, Blocker, Graff, & Doyle, 1998).

Risk factors

Factors that can increase the risk include

- catheter tip residing within heart (Nowlen et al., 2002)
- catheter angulation, curvature or looping allowing contact with myocardium when catheters reside in the heart (Cartwright, 2004; Darling et al., 2001)
- displacement of the catheter into the heart due to movement of the extremity, head, or neck (Lingenfelter et al., 1978; Nadroo et al., 2002)
- faulty catheter securement allowing migration (Pettit, 2003a).

Signs and symptoms

Signs and symptoms can vary in severity, with some infants being asymptomatic, and may be due to the rate and volume of infusion and the size of the infant. Symptoms may include the following (Little et al., 2004; Nadroo & Al-Sowailem, 2001; Nowlen et al., 2002; Schulman, Munshi, Eastman, & Farina, 2002):

- tachycardia or bradycardia
- narrow pulse pressure
- hypotension
- muffled heart tones
- dysrhythmias
- weak peripheral pulses
- respiratory distress
- poor color or extreme pallor
- poor response to resuscitation
- resistance to external cardiac compressions
- sudden cardiovascular or respiratory compromise
- pulseless electrical activity.

Identification and treatment

Rapid identification and treatment are critical for survival (Schulman et al., 2002). If myocardial perforation, effusion, or tamponade are suspected or occur the following management strategies should be used:

1. Stop the infusion of fluid and notify the medical care provider (Pettit, 2003a).
2. Immediately obtain a chest X ray (which may show a widened mediastinum or enlarged heart, but not the effusion because the pericardial fluid is a similar density to that of the heart) or an echocardiogram and locate the catheter within or near the heart. An echocardiogram is the preferred method because it facilitates viewing the effusion, but it may not be readily available (Little et al., 2004).
3. Attempt to aspirate blood from the catheter while awaiting the imaging study (Little et al., 2004; Nowlen et al., 2002). If the aspirate appears consistent with the infusate, continue to aspirate until as much fluid as possible is removed (Little et al.). If the fluid cannot be retrieved by direct aspiration from the catheter, pericardiocentesis may be necessary. The infant's condition may require life-saving intervention (i.e., pericardiocentesis) before the radiologic procedure can be accomplished.
4. Withdraw the catheter to the appropriate position in the vena cava; removal of the PICC is not required (Nowlen et al., 2002).
5. Follow up with an X ray or ultrasound because effusion can reoccur (Little et al., 2004).

Prevention

To help prevent myocardial perforation, effusion, or tamponade the following steps should be taken:

- Maintain the catheter tip in the appropriate location in the vena cava (FDA, 1989; Nadroo et al., 2002).
- Dress the catheter securely to prevent possible migration and trim the catheter to the length required for the infant to facilitate assessment (Pettit, 2003a).
- Verify during each nursing shift that the correct length of catheter is outside the body (Pettit, 2003a).
- Obtain an X ray at periodic intervals to detect migration (FDA, 1989). Ensure that the extremity containing the PICC or head is in the same position with each X ray (Nadroo et al., 2002).

Suggested, but unproven, strategies to consider

- Position the infant for the postinsertion X ray to allow the maximal inward movement of the catheter (Nadroo et al., 2002). Refer to the radiographic assessment of tip location located in the insertion procedure for these strategies.
- Maintain the catheter tip 1 cm outside the cardiac reflection in a premature infant and 2 cm in a term infant (Nowlen et al., 2002).

Pleural effusion/hydrothorax

Pleural effusion has been reported when catheter tips reside in the right atrium, inferior or superior vena cava,

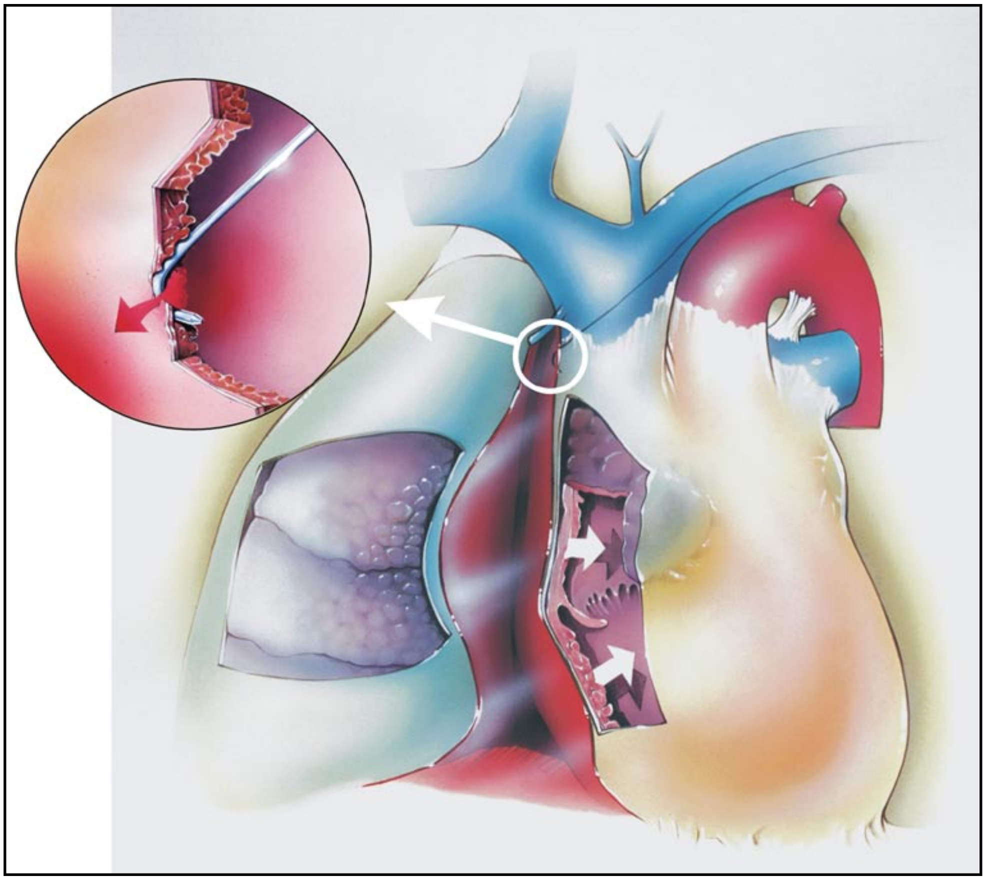

Figure 6. *Catheter erosion at the junction of the brachiocephalic vein and the superior vena cava, which may lead to pleural effusion*

Figure 6 ©BD Medical Systems. Used with permission.

braciocephalic and subclavian veins, and a small branch of the pulmonary artery. This complication occurs infrequently, is typically unilateral, and has been reported to occur due to a variety of factors. (See **Figure 6**.)

Etiology

- Perforation of a central vein during or after catheter insertion (Mupanemunda & Mackanjee, 1992; Seguin, 1992)
- Catheter tip or thrombus blocking the opening of the thoracic duct or migrating into the lymphatic vessels, leading to retrograde flow (McDonnell, Qualman, & Hutchins, 1984)
- Catheter tip against the vessel wall or malpositioned or migrated into a small vessel and not into the vena cava (Pigna et al., 2004; Ryder, 1993)
- Erosion of the vessel due to contact with the catheter can result in pleural effusion or hydrothorax (Ellis, Vogel, & Copeland, 1989)
- Mechanical and chemical irritation, which can act synergistically to erode the vessel (Ellis et al., 1989)
- Infusion of hyperosmolar solutions leads to osmotic injury and vascular leakage without catheter perforation of the vein (McDonnell et al., 1984; McGettigan & Goldsmith, 1996)
- Superior vena cava thrombosis leading to chylothorax (Amodio et al., 1987; Kurekci, Kaye, & Koehler, 1998).

Risk factors

- The left brachiocephalic vein inserts into the superior vena cava at an acute angle. Left-sided insertions in the upper body may place the infant at increased risk if the catheter does not complete the curve from the brachiocephalic vein to the superior vena cava and is left with the tip at this junction. If left in the brachiocephalic vein, the catheter's movement may allow contact with the vein wall or the infusate may be directed at the vein wall without the benefit of adequate hemodilution, leading to erosion and subsequent effusion (Mukau, Talamini, & Sitzmann, 1991).
- A large catheter placed in a small vessel allows the catheter to remain in contact with the vessel wall and can lead to erosion of the vessel's inner layer and infiltration into the mediastinal or pleural space. Placement outside the vena cava increases this risk (Marino, Aslam, Kamath, Rosenberg, & Rajegowda, 2006).

- Thrombus formation at the catheter tip results in a decreased dilution of hyperosmolar solutions, necrosis of the wall, and leakage of fluid. The leakage of concentrated solutions draws large amounts of fluid into the pleural space (McDonnell et al., 1984).

Signs and symptoms

The signs and symptoms can vary with the size of the effusion, rate of fluid accumulation, size of the infant, and degree of venous damage. Some effusions occur slowly or they can be obscured with preexisting cardiorespiratory disease (Ellis et al., 1989). Signs and symptoms include

- respiratory distress with decreased breath sounds over the affected lung (Marino et al., 2006; Pigna et al., 2004)
- soft-tissue swelling (McGettigan & Goldsmith, 1996)
- absence of blood return from the catheter (this may also be due to other causes).

Identification

- Radiologic imaging studies confirm the diagnosis of pleural effusion and hydrothorax. Chest X rays reveal opacification of an affected lung with the ultrasound demonstrating pleural fluid. The injection of a contrast agent may demonstrate entry into the lymphatic system.
- Blood may not be aspirated from the catheter.

Management

- Stop the infusion of fluid through the catheter.
- Notify the medical care provider.
- Obtain imaging studies (e.g., chest X ray, ultrasound).
- Attempt to withdraw infiltrated fluid back through the catheter (Seguin, 1992).
- Thoracentesis to remove effusion fluid may be required (Marino et al., 2006).
- Some pleural effusion and hydrothorax resolve themselves spontaneously without catheter removal (Spriggs & Brantley, 1977).
- Monitor for reaccumulation with radiologic imaging studies.

Prevention

- Maintain the catheter tip in the appropriate position within the superior or inferior vena cava.
- Ensure the catheter lies parallel with the vein wall (Duntley, Siever, Korwes, Harpel, & Heffner, 1992; Goutail-Flaud et al., 1991; NAVAN, 1998).

Phrenic nerve injury/diaphragmatic paralysis

This infrequently reported complication has been seen with catheter tips that reside in the subclavian vein (D'Netto & Bender, 2001; Williams, Hunter, Kanto, & Bhatia, 1995).

Etiology

The specific mechanism of action is speculative, but the reported cases include

- extravasated fluid from the catheter tip residing in the subclavian vein causes irritation of the underlying phrenic nerve (Williams et al., 1995)
- thrombosis and the resulting engorgement of the subclavian vein, which compresses the phrenic nerve (D'Netto & Bender, 2001).

Symptoms

- Respiratory distress
- Persistent elevation of the diaphragm on X ray (D'Netto & Bender, 2001; Williams et al., 1995)

Diagnosis

Radiologic imaging (e.g., X ray, ultrasound, fluoroscopy) can be used to diagnose phrenic nerve injury and diaphragmatic paralysis (D'Netto & Bender, 2001).

Prevention

To prevent phrenic nerve injury and diaphragmatic paralysis, the catheter tip should be located in the superior or inferior vena cava (INS, 2006; Kearns et al., 1996; NAVAN, 1998; Racadio et al., 2001).

Catheter fracture and embolism

Etiology

This multifactorial complication has several proposed etiologies, with fracture being identified on the internal or external portion of the PICC.

- Shearing of the catheter can occur during insertion if the catheter is withdrawn while the insertion needle is in place or if the infant moves significantly during the insertion and damages the catheter (Ochikubo, O'Brien, Kanakriyeh, & Waffarn, 1996; Pigna et al., 2004)
- Catheter fracture from high pressure created using small volume syringes for infusion or flushing against resistance (Catudal, 2002; Chow et al., 2003)
- Removal of the catheter using force (Miall, Das, Brownlee, & Conway, 2001)
- Disconnection of the catheter from the original or a repaired hub (Hwang et al., 1997; Trotter & Carey, 1998)
- Break in external segment of the catheter secondary to securement failure or force is also a cause (Frey, 1999)

Signs and symptoms

Symptomatology varies depending upon the location of the fracture and the presence of embolus. Some infants remain asymptomatic with the fracture or catheter embolus being identified radiographically or clinically based on the assessment of the length of the external catheter segment (Pigna et al., 2004).

Other symptoms include

- fluid leaking from the insertion site (Chow et al., 2003; Hadaway, 2005)
- inflammation or swelling along the catheter pathway (Hadaway, 2005)
- difficulty flushing or withdrawing blood (Catudal, 2002; Chow et al., 2003)
- respiratory distress
- cardiac dysrhythmias.

Treatment

If the catheter snaps during withdrawal

- Apply digital pressure over the vein or apply a tourniquet to the involved extremity to prevent further migration into the central circulation (Wall & Kierstead, 1995). The tourniquet should not be tight enough to occlude arterial flow.
- Keep the patient immobile.
- Obtain radiographic verification of the location of the catheter fragment.

Catheters kept in the peripheral circulation can be removed by venotomy. Catheters embolizing to the central circulation may require removal by interventional radiology, cardiology, or surgical procedures (Chow et al., 2003; Linz, Bisset, & Warner, 1994).

Prevention

To prevent catheter embolism

- Assess the need for analgesia or sedation for the insertion procedure.
- If catheter repositioning is needed at the time of insertion, do not retract the PICC through the introducer needle to prevent catheter shearing.
- Maintain the catheter securely under the dressing, while preventing tension to the catheter. Ensure connecting tubing (i.e., T-connector) is also connected to patient.
- Monitor catheter repair sites diligently. Consider exchanging the catheter for a new PICC rather than repairing.
- Avoid forceful infusion through the catheter using syringes.
- Don't flush if resistance is encountered.
- Only healthcare professionals with demonstrated clinical competency should remove PICCs.
- Remove the catheter gently, while holding the catheter at the point of insertion rather than the hub, and do not use force.

Thrombosis

Etiology

The intact venous endothelium is nonthrombogenic. Damage to the intimal layer of the vessel exposes the subendothelial layer of the vein, allowing adherence of platelets and activation of the extrinsic and intrinsic coagulation cascade. Vascular trauma, inflammation of the vessel wall, alteration in coagulation, and stasis of blood flow can cause the endothelial injury (Jacobs, 2003). Left-sided arm and scalp insertion catheters may fail to make the transition from the brachiocephalic vein to the superior vena cava, leading to vein damage (Mukau et al., 1991). Catheter tips residing outside the vena cava can lead to an increased risk of thrombosis (Racadio et al., 2001).The incidence of thrombosis varies due to the lack of a standardized method of diagnosis, but is higher in smaller children. Clinical diagnosis of thrombosis is made in approximately 1% of patients with all CVCs, but diagnosis by ultrasound and venography shows an overall risk of thrombosis in 20% of patients with CVCs (Garden & Laussen, 2004).

Signs and symptoms

Most of the signs and symptoms are silent, but may include the following (Jacobs, 2003):

- prominent superficial or collateral vessels
- edema or discoloration of the extremity in which the catheter is located (Clark, 2004)
- unexplained fever (Jacobs, 2003)
- unexplained thrombocytopenia (Jacobs, 2003)
- chylothorax, which may be the only sign of a superior vena cava thrombosis (Garden & Laussen, 2004; Kramer, Taylor, Garfinkel, & Simmons, 1981)
- unexplained cardiorespiratory decompensation, particularly with hypoxia, is suggestive of pulmonary embolus or pericardial effusion (Garden & Laussen, 2004; Jacobs, 2003)
- discoloration or pain in affected limb (Clark, 2004; Garden & Laussen, 2004).

Prevention

- The catheter tip should be located appropriately (Racadio et al., 2001).
- The catheter size should be appropriate for the size of the vessel to be cannulated. An appropriately sized catheter facilitates blood flow around the catheter and allows adequate dilution of the infusate, preventing irritation of the venous wall (Jacobs, 2003).
- Powder-free gloves should be used for catheter insertion to decrease the risk of tissue reactions.
- Secure the catheter to prevent vessel damage, stimulation of the coagulation cascade, and thrombosis secondary to migration.

Vena cava thrombosis

Superior and inferior vena cava thrombosis is subclinical in most instances. This condition can be diagnosed using ultrasound or a venogram. Many of the etiologies are inclusive of those outlined under "Thrombosis."

Signs and symptoms

Signs and symptoms can include the following (Carey, 1989):

- edema of the upper extremity, neck, and head (superior vena cava thrombus)
- edema of the lower body and limbs (inferior vena cava thrombus) (Edstrom & Christensen, 2000)
- dilation of veins on the skin (collateral circulation)
- respiratory distress
- cardiac murmur
- central nervous system disturbances (superior vena cava thrombus)
- full fontanel (superior vena cava thrombus).

Treatment

The treatment of superior vena cava thrombosis varies depending on its severity. A variety of treatment options have been proposed though there is no consensus about which is the preferred method. Treatment options may include the infusion of a thrombolytic agent via the PICC or an alternative vascular access device, anticoagulation, surgical removal of the thrombus, transcatheter recanalization, or catheter removal with supportive care (Clark, 2004; Ries, Zenker, Girisch, Klinge, & Singer, 2002).

Mechanical phlebitis

Etiology

Mechanical phlebitis is an inflammatory reaction of the vein associated with placement and the ongoing dwell of a catheter within the vein. The constellation of symptoms vary and may inlcude pain at the insertion site or along the track of the vein, enema, erythema, palpable venous cord, and purulent drainage. Mechanical phlebitis is most commonly reported during the first 72 hours to week following catheterization, but it may occur at any time during the catheter dwell time (Camara, 2001; Mazzola, Schott-Baer, & Addy, 1999). The incidence, clinical symptomatology, treatment, and outcomes are not well defined in neonates. Symptoms of phlebitis have also been referred to in the neonatal literature as erythematous tracking or cording.

Risk factors

Risk factors for mechanical phlebitis include the following:

- rapid or traumatic insertion, which can damage the intima of the vein (Hadaway, 1998)
- use of a large-gauge catheter in relation to the size of the vein (Mazzola et al., 1999)
- catheter tip outside of the vena cava (Racadio et al., 2001)
- cephalic vein insertion (Mazzola et al., 1999; Neubauer, 1995)
- saphenous vein insertion (Neubauer, 1995)
- inadequately secured catheter (Mazzola et al., 1999)
- manipulation of the PICC during insertion (Mazzola et al., 1999)
- inexperienced clinicians placing the catheter have been anecdotally associated with a more rapid insertion, which may foster contact with the vein intima.

Treatment

The need for and type of treatment for phlebitis remains unclear. Some consider this a benign condition with spontaneous resolution (Evans & Lentsch, 1999; Rastogi et al.,1998). Treatment options include

- applying warm compresses over the vein every 4 hours until the phlebitis is resolved (Frey, 1999; Pettit, 2003a)
- elevating the involved extremity and administer a gentle range-of-motion exercise if the infant has little spontaneous activity.

With early identification and treatment, phlebitis usually resolves itself within 24–72 hours (Frey, 1999; Mazzola et al., 1999; Pettit, 2003a). If there is no improvement or if the phlebitis advances after 24 hours of therapy (as indicated by a red streak, palpable cord, or purulent drainage), discontinuing the catheter should be considered (Camara, 2001).

Prevention

- Maintain the catheter tip within the vena cava (NAVAN, 1998; Racadio et al., 2001).
- Frequently monitor (observation and palpation) the vein of catheter insertion to allow for early identification and treatment.
- Slowly and gently insert the catheter (Hadaway, 1998).
- Use the smallest catheter capable of delivering the required therapies (Frey, 1999; INS, 2006).
- Avoid using the cephalic vein (Mazzola et al., 1999; Neubauer, 1995).
- Saphenous vein insertions may carry an increased risk for phlebitis (Neubauer, 1995).
- Secure the catheter to prevent movement (Mazzola et al., 1999; Pettit, 2003a).
- Avoid touching the catheter with gloves containing powder.

Chemical phlebitis

Chemical phlebitis is most commonly associated with PIVs and midline catheters, but can be associated with an improperly positioned or functioning PICC.

- With a peripheral catheter tip (i.e., in the extremity or scalp) this form of phlebitis has a rapid onset.
- Erythema is seen within hours of infusing medications or solutions that are irritating to the vessel, were improperly mixed or diluted, were rapidly administered, or contain particulate matter.
- Formation of a fibrin sheath surrounding the catheter may allow fluid to exit into a vein smaller than the vena cava, which can lead to chemical phlebitis.

Risk factors
- Indwelling portion of the catheter is damaged and contains holes. (The damage may occur during insertion, flushing against resistance, or infusing with pressure that exceeds the burst strength of the catheter.) The properties of the infusate may lack adequate hemodilution, which leads to venous damage.
- A fibrin sheath forms around the tip and propagates along the length of the catheter. Infused fluid follows the path of least resistance and exits into the sheath. If the sheath covers part of the catheter, the symptoms are seen at the end of the sheath. If the sheath covers the entire catheter, the fluid exits around the catheter insertion site.
- Catheter tip in a location with adequate hemodilution leading to chemically induced vessel irritation and erosion (Sztajnbok & Troster, 2002).

Signs and symptoms

The symptoms are similar to those of mechanical phlebitis.
- Pain during and after infusion can indicate chemical phlebitis.
- Chemical phlebitis due to a fibrin sheath or hole in the catheter can be diagnosed by means of a contrast injection into the catheter, venogram, or ultrasound.

Treatment
- Chemical phlebitis due to tip location (non-vena cava) warrants catheter removal.
- If chemical phlebitis is caused by a fibrin sheath, the catheter should be removed or the fibrin sheath can be treated using a thrombolytic agent. (Review the risks and benefits of this treatment before proceeding.)

Catheter occlusion

Most cases of catheter occlusion are due to improper flushing or catheter locking protocols, but may also be due to infusate characteristics and compatibilities, fibrin sheath formation, catheter tip location, and possibly low rates of flow through the catheter (Hadaway, 2005; Racadio et al., 2001). Catheter occlusions can be partial (i.e., the catheter is sluggish to flush), one-way (i.e., the catheter can be flushed but blood cannot be aspirated), or total (i.e., the catheter cannot be flushed or aspirated through). Thrombotic occlusions represent the most common etiology.

Etiology

Thrombotic occlusions, which account for the majority of catheter occlusions, are due to (Jacobs, 2003)
- fibrin or clot formation inside or outside the lumen
- venous thrombosis from injury to the vessel wall
- large catheters with insufficient venous flow around them, which creates turbulence and increases the risk of thrombus.

Risk factors
- Improper flushing technique, which leads to an inability to create positive pressure within the catheter with heparin lock or blood refluxing into the catheter (Hadaway, 2006)
- Failure to adequately flush before and after medication administration

Nonthrombotic or mechanical occlusions

Etiology
- Incorrectly set pump occlusion alarm
- Closed clamps on tubing
- Kinks or bends in catheter tubing
- Infant's position (i.e., flexion of extremity containing PICC)

Risk factors
- failure to adequately flush before and after medication administration or incompatable solutions
- calcium-phosphate imbalance of total parenteral nutrition (TPN)
- lipid residue
- fungus infection (e.g., Malassezia furfur) (Azimi et al., 1988; Nguyen, Lund, & Durand, 2001)

Signs and symptoms for all types of catheter occlusion

Signs and symptoms include the following (Hadaway, 1998):
- sounding of pump occlusion alarms
- visible clots, particulate matter, or lipid clumps in the catheter
- change in ability to aspirate or flush the catheter
- pain during infusion and fluid exiting the catheter insertion site (due to a fibrin sheath).

Identification

The cause of catheter occlusion should be sought by reviewing the etiologies of each type of occlusion and the patient's history with the catheter and recent infusates (Flurkey, 1994; Holcombe, Forloines-Lynn, & Garmhausen, 1992; Jacobs, 2003; Pettit, 2002; Shulman et al., 1986).

- The catheter should be inspected under the dressing for kinks and bends and secured to prevent bends or movement (Pettit, 2002).
- An X ray may determine whether the catheter is malpositioned or bent internally.
- The hub and the external portion of the catheter should be checked for leaks and assessed for malpositioning and migration (Pettit, 2002).
- Contrast injections through the catheter, venogram, or ultrasound can be used to detect thrombotic occlusions (Jacobs, 2003).

Management

The etiology determines the course of treatment.

- Repositioning may be required if the catheter is lodged against a vessel wall.
  - The infant can be moved from side to side or from prone or supine.
  - If the catheter is in an extremity, the arm or leg can be repositioned. Abducting or extending the arm can alleviate a catheter bend.
- The catheter can be removed and a new one inserted if needed. In general, this is necessary for fungal occlusion (Mermel et al., 2001).
- Remove the blockage by instilling a "clearing agent." Some of these agents return the precipitate into solution by creating a favorable pH balance. Most reports of success have been anecdotal. Tissue plasminogen activator (tPA) has been used in neonates and is the approved thrombolytic agent used for catheter clearance in children and adults (Deitcher et al., 2002; Torres-Valdivieso et al., 2003). A protocol should be in place and staff should be trained in the procedure. The risks and benefits of the procedure must be examined to determine whether the catheter is essential for care. The volume of the clearing agent instilled should approximate the catheter volume (or be slightly more in the case of a thrombolytic) to minimize entry into the bloodstream (INS, 2006).
- Catheter-clearing agents can be instilled into the catheter using one of these techniques:
  - Gentle push: Use for catheters with partial occlusion.
  - Negative pressure using a three-way stopcock:
    1. Attach the stopcock to the hub of the catheter.
    2. Using a 10-ml syringe, aspirate until enough resistance is felt to indicate the presence of a vacuum within the catheter.
    3. Attach a 10-ml syringe containing the clearing agent.
    4. Open the stopcock to the syringe containing the clearing agent, and the agent will be gently drawn into the catheter.
    5. Close the stopcock to the patient to allow the cleaning agent to dwell within the catheter for the prescribed time.
    6. Verify the catheter patency by assessing for blood return.
    7. If patency is achieved, aspirate the clearing agent and blood from the catheter, flush the catheter well with saline, and begin infusion of prescribed fluids.

Clearing agents

In cases of thrombotic occlusion, thrombolytic agents (e.g., tPA) have to be instilled into the catheter according to the manufacturer's recommendations (Blaney et al., 2006; Deitcher et al., 2002; Hartmann, Hussein, Trowitzsch, Becker, & Hennecke, 2001; Lee, 2002). Using tPA to treat vascular thrombus in neonates has been frequently described, but less so for catheter-related thrombus (Torres-Valdivieso et al., 2003).

For occlusions related to calcium-phosphate precipitate, parenteral nutrition, and acidic drugs, 0.1 *N* hydrochloric acid (HCl) may clear the blockage (Breaux, Duke, Georgeson, & Mestre, 1987; Duffy, Kerzner, Gebus, & Dice, 1989; Shulman, Reed, Pitre, & Laine, 1988; Zenk, Sills, & Koeppel, 2003). An amount equal to the catheter volume is instilled into the catheter. After 20 minutes, the HCl is withdrawn. If patency has not been restored, the procedure can be repeated once or twice.

Sodium bicarbonate (1 mEq/ml) has been reported to clear alkaline drug-related occlusions by restoring the alkaline environment and allowing the precipitate to regain solubility. An amount equal to the catheter volume is instilled into the catheter. After 20 minutes, the sodium bicarbonate is withdrawn. If patency has not been restored, the procedure can be repeated once (Goodwin, 1991).

For lipid occlusions, 70% ethanol, which breaks down lipid, is instilled in an amount equal to, but not exceeding, the catheter volume and is allowed to dwell for 1–2 hours. The ethanol then is withdrawn. If patency has not been restored, the procedure can be repeated once (Pennington & Pithie, 1987; Zenk et al., 2003).

Prevention

- Heparinization of infusion fluid reduces the risk of thrombotic occlusions (Shah et al., 2007). (Refer to "Infusion of Fluids" for more information.)
- Consider the minimum infusion rate orders based on NICU outcome data reporting rate of throm-

botic catheter occlusion (Evans & Lentsch, 1999).
- The flushing method must be monitored. Use pulsatile movements (i.e., short bursts) when flushing.
- Ensure compatibility of medications and coinfusing solutions (Hadaway, 2005).
- Create a positive or neutral pressure within the catheter when heparin locking (refer to the heparin-locking procedure).
- Flush before and after giving medications or changing solutions to prevent drug incompatibility and precipitate formation (Hadaway, 2005).
- Promptly respond to occlusion alarms on the infusion pump.
- Ensure TPN components are balanced.

Assessment after clearing

Possible complications related to the clearing agent and the procedure include the following:
- catheter damage
- leakage
- fever as a reaction to HCl (Breaux et al., 1987)
- thrombolytic-induced bleeding (Hartmann et al., 2001; Torres-Valdivieso et al., 2003).

Catheters that resist removal

Catheters infrequently resist removal at the conclusion of therapy. Most catheters can be removed over time (some take a few days to remove) and do not require surgical intervention. Aggressive traction should never be applied during removal due to the risk of catheter breakage and venous damage.

Etiology
- Venous spasm caused by mechanical irritation of the vein by catheter movement or patient anxiety accounts for the majority of cases. The catheter may be partially removed with the tip typically being in the peripheral circulation before resistance is encountered (Camara, 2001; Marx, 1995).
- Thrombus may trap part or all of the catheter within the vein during the removal process (Bautista, Ko, & Sun, 1995; Camara, 2001; Rothkopf et al., 2000). Thrombus may be associated with infection (e.g., Staphylococcus epidermidis, Malassezia furfur) and the catheter may become adherent to the vein wall (Bautista et al.; Gladman, Sinha, Sims, & Chiswick, 1990; Kim, Cohen, Ramachandran, & Glasscock, 1993; Nguyen et al., 2001; Rothkopf et al.).
- Phlebitis and thrombophlebitis (Marx, 1995) may contribute to resistance.
- The presence of a fibrin sheath can cause resistance. The catheter may be partially removed before the sheath assumes an accordion appearance and is seen in the peripheral portion of the vein or a lump is visible or palpated and resistance is encountered (Filan, Woodward, & Ekert, 2005; Frey, 1999).
- Fibers (i.e., lint) attached to fibrin may cause resistance to removal (Filan et al., 2005; Miall et al., 2001).

Procedure

Several approaches to discontinuing catheters resistant to removal have been described in the literature, but two methods appear to be favored, both of which may take several days to complete, but are not guaranteed to be successful.
- Apply warm compresses along the tract of the vein for 20–30 minutes, then attempt removal (Rothkopf et al., 2000). If the PICC still cannot be removed, one to two additional attempts to remove the catheter during the following 12–24 hours are reasonable. Continue to apply intermittent warm compresses, then attempt removal. This method has less potential to cause catheter breakage than the following method (Camara, 2001; Frey, 1999; Marx, 1995; Wall & Kierstead, 1995). The catheter and surrounding skin should be prepped with an antimicrobial agent and a sterile dressing applied to secure the catheter between removal attempts.
- An alternative method involves applying gentle traction to the catheter, then securing the catheter to the site. The process is repeated every few hours until the catheter is removed. Removal can take a few days. There are case reports of catheter breakage using this method (Bautista et al., 1995; Gladman et al., 1990; Miall et al., 2001).
- Evaluate catheter location radiographically if the catheter is not removed within approximately 4 hours to determine further strategies for removal.
- Other measures that can be considered, based on suspected cause, include
  - placing a tourniquet on the extremity above the catheter tip to dilate the vein
  - flushing through the catheter (Marx, 1995)
  - rotating the extremity (Marx, 1995)
  - massaging the skin overlying the vein (Camara, 2001)
  - infusing vasodilators, which have been used in pediatrics and adults but not discussed in neonates (Marx, 1995; Miall et al., 2001)
  - using nonsteroidal antinflammatories, which have been used in children and adults (Marx, 1995)
  - using relaxation techniques (Miall et al., 2001)
  - obtaining a radiograph to rule out knots in the catheter and an ultrasound to rule out thrombus as etiology for resistance (Nguyen et al., 2001)
  - infusing a thrombolytic agent (Edstrom & Christensen, 2000; Hartmann et al., 2001;

  Rothkopf et al., 2000)
  - removing the catheter using interventional or surgical techniques (Bautista et al., 1995; Miall et al., 2001).
- If catheter breakage occurs, grasp the external segment of the catheter to prevent embolism.
- If embolism occurs, compress the vein containing the catheter with your hand or a tourniquet to trap the catheter within the peripheral circulation. Place the infant on the right side to trap the catheter within the right heart (Camara, 2001).

Prevention

- Indentify proper PICC tip location within the vena cava.
- Use infusates that are appropriate for tip location.
- Use lint-free products during the procedure.
- Use a no-touch technique when manipulating the catheter
- Remove the catheter slowly without forcing or stretching it.
- Implement strategies to prevent a hospital-acquired infection.

Drainage from catheter or insertion site

Drainage at the insertion site may be a normal serous fluid or a leak in the catheter due to catheter damage or a fibrin sheath surrounding the catheter.

Etiology

- Leaks can be caused by excessive pressure created by syringes, sharp objects (e.g., clamps, introducers) piercing the catheter, and the catheter having been flushed when resistance was felt.
- Leaks can signify a catheter obstruction (Pettit, 2003a).
- Leaks can be seen at the catheter hub or external portion of the catheter, usually due to damage.
- Fibrin sheath formation along the catheter allows fluid to follow the path of least resistance back down the catheter. Fibrin sheaths can cover the tip of the catheter or travel part or all of the way down the catheter to the entrance site. Ultrasound or contrast injection can diagnose fibrin sheaths.
- Drainage can occur because of decreased skin turgor at the insertion site.

Prevention

To prevent leaks

- Use techniques to minimize catheter damage (i.e., do not apply clamps or sharp objects to the catheter or hub, use the appropriate syringe size and pressure when infusing, do not flush when resistance is encountered).
- Do not pull the catheter back through the needle introducer.
- Cautiously remove break-away needles.
- Secure the catheter and extension tubing to the patient to prevent stretching and breakage.

Management

If a leak occurs because of a catheter fracture, prevent embolization of the catheter (refer to "Catheter embolism"). Determine if the catheter can be repaired or exchanged for a new catheter (Camara, 2001), or if removal is necessary.

Extremity edema

Throughout the catheter dwell, mild to gross edema surrounding the insertion site or in the extremity may be identified.

Etiology

This condition can be caused by the following factors:

- restrictive dressing
- bend in the extremity
- dependent positioning
- decreased movement
- thrombus
- catheter that is too large for the size of the vein so that it restricts adequate venous return
- extravasation of infusate.

Treatment

The treatment is based on the cause.

- Redress and straighten the extremity (possibly using a limb board for a short period of time) or elevate the extremity (Serrao et al., 1996).
- Measure the circumference of the proximal portion of the extremity and compare to the opposing extremity until the edema improves.
- Obtain a venogram or ultrasound if thrombus is suspected.
- If the edema is mild and stable without compromising the health of the extremity, the catheter may be left in place if it is monitored vigilantly.
- If the edema is progressive or if the extremity is compromised, consider removing the catheter.

Neurologic complications

The most commonly reported neurologic symptoms stem from catheters placed via veins in the lower extremities. Catheters placed through the scalp or arm veins have rarely been linked to complications and will not be discussed in this document (Anderson et al., 2004). PICCs inserted via a leg or femoral vein pose a risk of entering the ascending lumbar veins rather than the inferior vena cava. The ascending lumbar veins drain the vertebral venous plexus into the common iliac vein. Infusion through a catheter in this location can result in venous stasis, and pressure and fluid transmitted to the spinal cord, thereby leading to a variety of neurologic complications (Clarke et al., 2003; Vidwans, Neumann, Hussain, Rosenkrantz, & Sanders, 2000). Migration of the central venous catheter or redistribution of the infusate into the ascending lumbar vein is thought to occur in infants who are experiencing an increase in intra abdominal pressure (i.e., abdominal distention, necrotizing enterocolitis, repaired congenital diaphragmatic hernia) (Kelly, Finer, & Dunbar, 1984; Lussky, Trower, Fisher, Engel, & Cifuentes, 1997; Odaibo, Fajardo, & Cronin, 1992; Zenker et al., 2000).

Risk factors

- Left-sided insertions pose a higher risk of entering the ascending lumbar vein because of the angle of entry from the common iliac vein (Carrion et al., 2001; Chen, Tsao, & Yau, 2001).
- Difficulty advancing the catheter to a premeasured depth also represents a risk for malposition and neurologic complications (Carrion et al., 2001; Chen et al., 2001).
- The rapid insertion technique has been anecdotally linked to catheter malposition.
- Catheters allowed to reside in the femoral, iliac, or lower portion of the inferior vena cave have migrated into or near the ascending lumbar vein or produce venous thrombus and lead to retrograde flow into the ascending lumbar vein (Mah, Fain, Hall, & Wood, 1991).

Signs and symptoms

- The infant may be asymptomatic, particularly if the malposition is identified on insertion X rays (Chedid, Abbas, & Morris, 2005; Lussky et al., 1997).
- Lack of blood return has been noted from some catheters, particularly upon insertion (Lavandosky, Gomez, & Montes, 1996).
- Resistance when the catheter is inserted (Carrion et al., 2001)
- Sepsis-like symptoms such as unexplained respiratory distress and lethargy (Chen et al., 2001; Clarke et al., 2003; Mitsufuji, Matsuo, Kakita, & Ikuta, 2002)
- Parenteral nutrition retrieved following lumbar puncture or markedly abnormal levels of glucose, protein, or lipid obtained
- Seizures, flaccid quadriplegia, or neurologic deficits (Bass & Lewis, 1995; Chen et al., 2001; Lavandosky et al., 1996; Mitsufuji et al., 2002; Rajan & Waffarn, 1999; White, Montes, Chaves-Carballo, Presberg, & Young, 1987)
- Death (Lavandosky et al., 1996)
- Radiographic findings
  - left-sided insertion that fails to cross the midline to enter the inferior vena cava and appears to overlay the spine (Carrion et al., 2001; Chen et al., 2001)
  - a bend or hump in the catheter at the L4-5 level on AP view, particularly on left-sided insertions and when the catheter is threaded to or beyond the level of L3 (Carrion et al., 2001; Chen et al., 2001)
  - a marked posterior deviation of the catheter at L4-5 on a lateral view (Chen et al., 2001; Vidwans et al., 2000)
  - a 360° curl or loop in the catheter in the inguinal region prior to advancement up the ascending lumbar vein (Chedid et al., 2005; Schoonakker & Harding, 2005)
  - posterior deviation of the catheter through the spinous processed in the lateral radiograph (Schoonakker & Harding, 2005)

Prevention

- Maintain a high index of suspicion throughout treatment. Experienced personnel should meticulously assess the radiograph for the catheter location. Observe the length of the catheter from the leg to the tip for subtle clues of malposition. (Chedid et al., 2005; Chen et al., 2001; Vidwans et al., 2000).
- If malposition is suspected, obtain a radiograph from the lateral perspective. The catheter presenting anterior to the spinal column is typically in the inferior vena cava, while the catheter deviating posteriorly may be in the ascending lumbar vein (Chen et al., 2001; Coit & Kamitsuka, 2005; Schoonakker & Harding, 2005; Vidwans et al., 2000).
- A contrast injection through the catheter may highlight the area of malposition, however, there is some concern that this may lead to irritation or damage (Chen et al., 2001; White et al., 1987). The instillation of a contrast agent has failed to identify all malpositioned catheters (Chen et al., 2001; Lussky et al., 1997).

Medical Device Reporting and MedWatch

When a medical device causes or contributes to the death of a patient, federal law requires that a report be made to the FDA and the manufacturer within 10 working days (Lowe & Scott, 1996). Other device complications that require reporting to the manufacturer within 10 working days include the following:

- serious injury caused by the device
- if the patient was at risk of dying at the time of the adverse reaction or if it is suspected that continued use of the product would cause death
- if the adverse reaction caused a significant or permanent change in bodily function, physical activity, or quality of life
- if using a medical product required medical or surgical treatment to prevent impairment.

The facility is responsible for adhering to reporting requirements and faces substantial penalties for failing to report. The goal of reporting is to improve patient care by identifying problems unforeseen at the time of the initial FDA product review.

Catheter Care and Maintenance

All nurses who care for infants with PICCs must be knowledgeable about effective management to prolong the catheter's dwell time and prevent complications and injury to the infant. Using a team of caregivers with troubleshooting expertise and the ability to change dressings and repair catheters has been found to enhance success with PICCs (Golombek et al., 2002; Rourke & Higgins, 1998). Few care regimens, however, have been subjected to scientific scrutiny and those outlined identify recommendations for practice. Where one clear choice is not available, several options are identified. Each patient care unit should have protocols available to address the following areas.

Assessment and documentation

The following factors related to the PICC should be monitored and documented in the medical record during every shift and more frequently as necessary:

- site (i.e., color, appearance, temperature, presence of drainage, bleeding, edema, erythema). The area along the course of the vein should be palpated for pain or venous cord.
- catheter (i.e., the amount outside the body, configuration of the catheter, presence of kinks or bends, leaking of fluid from catheter tubing, precipitate in catheter or tubing)
- patency (i.e., the ability to infuse fluid or flush, and the presence of a blood return if evaluated)
- dressing (should be intact around edges and hold the catheter in place in the center of the dressing; no part of the catheter, except the hub, should protrude from the dressing)
- infusion pump occlusion alarm setting
- infusion tubing (i.e., security of connections, precipitate in tubing)
- complications specific to the known location of the catheter tip (i.e., a tip in the subclavian vein near the shoulder or midline catheter can lead to development of edema and erythema over the site).

Hourly assessment and documentation should cover visual inspection of the site, from the insertion point along the course of the vein to the tip location and the quantity of fluid infused by the infusion pump (Pettit, 2002, 2003a).

The use of blood pressure cuffs or tourniquets should be avoided on an extremity with a PICC because of the risk of vessel or catheter damage.

Infusion tubing configuration

The configuration of the infusion tubing is integral to the efficient and safe use of the PICC. Infants may require a continuous infusion of one or more fluids along with continuous or intermittent medication administration. When assembling the infusion tubing, requirements for all infusates must be considered to ensure the appropriate number of injection ports are available for set-up and to prevent unnecessarily entering the catheter at a later time.

- Infusion tubing should be assembled using clean technique, however, using sterile technique is a part of the successful multidimensional efforts to decrease CRBSI (Aly et al., 2005).
- All infusion tubing connected to the PICC should be luer-locked.
- To minimize entry into the PICC and decrease the risk of contamination, intermittent injection tubing (used for medication administration) should remain attached to the primary administration set and not removed after each injection (Aly et al., 2005). A closed medication system (i.e., entry restricted to once every 24 hours) used as a component of a multidimensional strategy to decrease CRBSI was found to significantly decrease the incidence of CRBSI (Aly et al.).
- Eliminate stopcocks from tubing and instead use capped injection ports, which must be vigorously cleaned with alcohol before entry (Bouza et al., 2003; Casey et al., 2003; Pettit, 2002; Sitges-Serra et al., 1997; Yebenes et al., 2004).

Medication administration

Providing medications through the PICC is a desired feature of the device. Safety with this process is integral to the successful dwell of the catheter. The long, narrow catheter configuration provides an opportunity for mixing of incompatible infusates. Care must be exercised when following the established principles of medication administration.

- Flush thoroughly before and after the administration of medications (if this is not contraindicated based on infusate).
- Ensure medication is compatible with other infusates.

- If a PICC is heparin locked, flush the PICC before injecting medication, and flush with saline before instilling heparin back into the catheter to prevent precipitation.
- Consider using a closed medication delivery system as described by Aly and colleagues (2005).

Infusion of fluids

- Fluids should be heparinized to prevent thrombotic catheter occlusion and extend catheter survival (Shah et al., 2007). No increase in heparin-induced thrombocytopenia or hemorrhage was identified with the addition of 0.5 U/kg/hr of heparin.
- Catheter lumens smaller than 26 gauge are difficult to maintain patency without a continuous infusion of fluid.
- Fluids should be administered by an infusion pump.
- There are no data to suggest a minimum amount of hourly flow is required to maintain catheter patency, though some have suggested 2 ml/hr (Evans & Lentsch, 1999). This may differ depending on the infusion characteristics of individual pumps, length of catheter dwell, flushing protocols, and the size of the catheter. Hospitals should monitor the occlusion risk as defined in their outcome data to determine the effect of infusion flow rate on occlusion.

Flushing

Maintaining patency of these small-bore catheters requires meticulous care to prevent occlusion due to thrombus or precipitate.

Frequency

- Flush before and after administering potentially incompatible solutions and medications.
- If routine blood sampling is desired, consider flushing with 1 ml twice a day to enhance patency.
- Flush as needed to assess catheter patency.

Flush solution

- Both sodium chloride and diluted heparinized saline solutions (dextrose solutions may be used if medication is incompatible with saline) have anecdotally been described and preferred use is facility specific.
- Solutions should be obtained from a single-use vial or syringe (CDC, 2002b; Joint Commission on Accreditation of Healthcare Organizations [JCAHO], 2003). Multiuse containers as well as flush syringes manually filled by nurses have been associated with an increased risk of contamination. The syringe should be used one time and discarded (Mattner & Gastmeier, 2004; Worthington et al., 2001).

Volume of flush

- Data are not available to suggest the appropriate volume to instill with each flushing action.
- At least twice the catheter volume and any add-on devices, such as T-connectors, has been suggested and is reasonable (INS, 2006). This is approximately 1 ml.

Syringe size

For safe practice, do not rely on syringe size alone when delivering medications or solutions; consider all of the factors mentioned below.

Syringe size dynamics

- Follow the catheter manufacturer's recommendations about the minimum syringe size for manual infusion (most specify a 5- or 10-ml syringe).
- Use a technique to infuse that will be within the maximum pressure limits (i.e., pounds per square inch [psi]) for the catheter and does not create catheter damage.
- The smaller the syringe, the greater the pressure that is exerted. Using normal hand pressure to deliver a solution from a full 1-ml syringe can generate more than 300 psi and a full 10-ml syringe will generate less than 40 psi (Conn, 1993; Macklin, 1999).
- The greater the force applied on the syringe plunger, the greater the pressure delivered to the catheter. Even the largest syringe can deliver excessive pressure if great force is applied (Macklin, 1999).
- Applying too much pressure on the catheter and flushing when resistance is felt can lead to the fracture or embolization of the catheter (Catudal, 2002; Pigna et al., 2004). A PICC should never be forcefully flushed if resistance is felt.
- Syringe pumps also can exceed the catheter's burst strength when small-volume syringes are used. Check with the syringe pump's manufacturer.

Catheter Material

PICCs made of polyurethane have greater tensile strength than those made of silicone. This makes them more resistant to damage due to applied pressure and may allow for use of syringes smaller than 10 ml (DiFiore, 2005).

Cathether patency

- Completely patent catheters outside the body offer no resistance to flow, and fluid will exit without increasing pressure inside the catheter.
- Once a catheter is inserted into the body, complete patency cannot be ensured, especially when resistance to flushing is encountered, is sluggish, or no blood return is appreciated.
- The smallest neonatal catheters offer some resistance to flushing because of the minute size of the internal lumen.

Management of heparin locks

Catheter lumens larger than 28 gauge or 1.9 F may allow heparin locking. Saline locks for PICCs have not been studied in the small-size catheters used in infants and are not an acceptable option for maintaining patency at this time. Anecdotal reports suggest limited success maintaining catheter patency with heparin locking most PICCs used in the NICU (Evans & Lentsch, 1999).

Heparin concentration

The concentration of heparin reported to be effective varies from 1 to 10 U/ml (Evans & Lentsch, 1999). Greater success has been found using the 10 U/ml concentration (Evans & Lentsch, 1999).

Flush volume

- There are no data to suggest the most appropriate volume to instill with each flushing action.
- At least twice the catheter volume and any add-on devices, such as T-connectors, has been suggested and is reasonable (INS, 2006). This is approximately 1 ml.
- Do not completely depress the plunger when flushing to prevent reflux into the catheter at the conclusion of the procedure (Hadaway, 2006).

Frequency

- Heparin locks should be flushed every 6 hours (Evans & Lentsch, 1999).
- Flush with normal saline before and after giving medications and incompatible solutions to prevent reactions leading to precipitation and lock with heparinized saline (10 units heparin/ml) (Evans & Lentsch, 1999).
- Using a pulsatile method (i.e., short bursts or start-stop technique) creates turbulence within the catheter and has been anecdotally linked to enhanced clearing of substances and blood residing within the catheter (Pettit, 2002).
- Prevent blood reflux into the catheter following flushing or locking by using one of the following methods:
  - Withdraw the syringe from the injection port or clamp the extension set as you infuse the last 0.5 ml.
  - For valve-style injection ports, clamp the tubing while injecting the last 0.5 ml of flush.
  - Use a positive or neutral displacement device attached to the hub of the catheter or extension set to create positive pressure.

Blood sampling and administration

Withdrawal of blood specimens through a PICC carries a theoretical risk of catheter occlusion. Anecdotal reports of success in reliably obtaining blood samples from 24 or 26 gauge or 1.9 F PICCs are surfacing and warrant further investigation.

- Catheter lumens smaller than 26 gauge are probably too restrictive to allow this practice. Evidence supports this practice through a 3 F PICC without a significant increase in occlusion or other catheter-related complications (Knue, Doellman, Rabin, & Jacobs, 2005).
- The values of some tests may not be accurate when the blood has been drawn through the PICC (i.e., blood glucose when dextrose-containing solutions are infusing, coagulation studies due to heparin in the catheter, therapeutic drug levels due to residual drugs present in the catheter).
- A second PICC may be considered to be strictly used for blood sampling.

To draw blood specimens

1. Perform hand hygiene and apply clean gloves.
2. Pause the infusion pump.
3. Place a sterile 4 x 4 under the injection port and prep with alcohol using vigorous friction prior to each entry.
4. Flush with at least 0.5 ml of saline.
5. Withdraw at least two times the catheter and extension set volume to clear catheter of infusates. (For most neonatal PICCs this averages 1 ml.) Cap syringe.
6. Obtain a specimen.
7. Reinfuse blood withdrawn to clear catheter if the infusate contains heparin (otherwise microclots may be present in this syringe).
8. Flush the catheter well with normal saline using at least twice the volume of the catheter and extension set (INS, 2006). This is approximately 1 ml. Remove residual blood from injection port.
9. Resume infusion.
10. Perform hand hygiene.
11. Document the amount of blood drawn and the test obtained.

Troubleshooting techniques if difficulty is encountered obtaining specimen

- Use a small-volume syringe for aspiration, which creates less pressure on the catheter during the withdrawal of blood and facilitates sampling.
- Reposition the infant so that the catheter tip is not against the vessel wall.
- Flush with a small amount of normal saline.

Tranfusion of blood products

Some manufacturers and some NICUs allow transfusion of blood products through 26 gauge and larger PICCs in neonates. There are limited reports of efficacy for the practice. Interruption of other infusates, increased frequency of entry into the catheter, and potential for occlusion are important concerns.

Catheter repair

Catheter repair may be considered in cases of damage to the hub or a portion of the catheter outside the body. During repair the damaged segment of the catheter will be removed along with the catheter hub and a new hub will be provided. A catheter that has been broken or leaking for a period of time may be contaminated and is not a candidate for repair. Follow the manufacturer's recommendations and instructions for repair (some may not recommend repair). The need for and viability of repair can be assessed by the following means:

- Determine whether replacing the catheter is a better option, depending on the length of therapy remaining and the infusate properties.
- Assess the potential for placing another catheter if other venous access sites are available.
- Another option is exchanging a damaged catheter for a new one rather than repairing it (Fabian, 1995; Pettit, 2007). Performing this procedure requires special training.

Perform repairs according to the manufacturer's directions in a sterile manner, using maximum sterile barrier precautions.

Risks

- If the catheter does not remain secured to the new hub, embolization of a catheter has been noted following the repair. The security of the connection between the catheter and hub needs to be routinely assessed (Trotter & Carey, 1998).
- Infection can occur if the catheter has become contaminated before or during the repair process (Evans & Lentsch, 1999).

Dressing changes

A secure dressing holds the catheter in place and prevents migration in and out of the body (Frey, 1999; Neubauer, 1995). Dressing-change practices have not been subjected to formal evaluation in neonates, except for one small study using transparent, semipermeable polyurethane dressing (Zenk et al., 1993). Most NICUs change dressings only when dressing integrity is lost, which is supported by low rates of infection (Cartwright, 2004; Evans & Lentsch, 1999; Trotter, 1998). Reports of routine, weekly dressing changes are surfacing as components of bundles designed to decrease the incidence of CRBSI, though there have been no randomized clinical trials to support this practice (Aly et al., 2005). In light of the potential for damage to the stratum corneum layer of the skin and dislodgement of the catheter when the dressing is removed, a dressing change is recommended in the following situations:

- Transparent dressings should be changed when they no longer adhere to the catheter or skin or they are damp or soiled (CDC, 2002b; Zenk et al., 1993).
- Dressings with gauze and tape, a transparent dressing with gauze placed underneath, or an occlusive tape on top require changing every 48 hours (CDC, 2002b; INS, 2006).
- Fluid or bleeding at the insertion site indicates the need for a dressing change (INS, 2006).

Dressing changes require sterile technique. At a minimum, face masks and sterile gloves should be worn by those making contact with the area of skin or the catheter under dressing. If contamination of the catheter is possible or a long segment of the catheter is external, consider using sterile drapes and a sterile gown. Assistants should wear a face mask. Securement devices under the dressing should be removed and the site cleaned with an antimicrobial agent prior to placing a new dressing.

Catheter removal

Personnel removing PICCs should be educated in the appropriate techniques for reducing serious complications. The infant should be calm both before removal is attempted and during the process. Removal is performed as follows:

1. Gently remove the dressing by pulling it toward the insertion site (pulling it away will remove the catheter along with the dressing).
2. Remove the catheter using a slow, steady motion. Grasp the catheter, not the hub, as the removal progresses. Always pull from the insertion site (this allows better control and earlier identification of tension). Rapid removal and application of pressure to the vein over the site can allow the catheter to contact the vein wall and stimulate vasoconstriction (Camara, 2001; Marx, 1995).
3. Measure the length of catheter removed and compare it to the length that was inserted. If the removed length of the catheter is less than the length that was inserted, notify the medical care provider immediately, as embolization may have occurred.
4. Document the length removed, the appearance of the site, the patient's tolerance of the procedure, and any complications during removal.
5. Cover the insertion site with sterile dressing.
6. If resistance to removal is encountered, STOP. Do not attempt to remove a catheter by applying tension to the device. Redress the site using a sterile technique and refer to strategies outlined under "Catheters that resist removal." Pulling against resistance can damage the vein wall and weaken the integrity of the catheter leading to catheter fracture and possible embolism.

Conclusion

Maintaining vascular access is critical for the survival of an increasing number of extremely low-birthweight infants. Improved technology, advanced training, and appropriate use have made PICCs a life-saving device for infants. Utilization of PICCs offers a cost-effective approach to care and minimizes pain, stress, and risk of infection associated

with multiple PIV insertions. PICCs can be used not only during hospitalization, but also facilitate early discharge by allowing home-based infusion therapy. These catheters should be considered a standard of care for many infants who require intravenous therapy to reduce stress and pain and to promote the delivery of medications and solutions into the most appropriate vessel. PICCs should be used as a first line of treatment rather than a last resort.

NANN endorses appropriate training for healthcare providers in the insertion and maintenance of PICCs as a means of ensuring optimal outcomes.

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Appendix A. Clinical Competencies for the Nurse

COMPETENCIES

Step	Verbalize	Demonstrate Competency
Clinical competencies for PICC Inserter		
1. Identify the indications for use of a peripherally inserted central catheter.		
2. Identify possible contraindications or special considerations for use.		
3. Explain to the family the procedure, risk, and benefits and potential complications.		
4. Choose the best accessible vein based on the infant's diagnosis and assessment.		
5. Demonstrate and correctly measure the length of catheter to use for the selected insertion site.		
6. Assess need for analgesia and obtain order if warranted.		
7. Position and prepare infant, including swaddling, to facilitate restraint and comfort.		
8. Select catheter with appropriate size and number of lumens for the size of the selected vein and the infant's identified infusion needs.		
9. Prepare catheter		
a. Flush		
b. Trim catheter based on required measured insertion length		
c. Demonstrate care of stylet during trimming process		
10. Select appropriate catheter introducer and demonstrate insertion and removal technique.		
11. Discuss and demonstrate PICC insertion per procedure including the rationale for decisions.		
12. Flush the catheter using a pulsatile technique.		
13. Identify catheter tip placement on radiograph.		
14. Demonstrate sterile technique during insertion.		
15. Demonstrate dressing stabilization of the catheter and added tubing during the initial application of the dressing.		
16. Document the procedure and placement according to facility guidelines.		
Clinical competencies for the RN caring for the infant with a PICC		
1. Demonstrate how to assess and maintain catheter placement.		
2. Maintain strict aseptic technique for all catheter management, including tubing changes, medication delivery and blood sampling.		
3. Demonstrate how to heparin lock the catheter.		
4. Demonstrate how to flush the catheter using pulsatile technique.		

Appendix A. Clinical Competencies for the Nurse *(continued)*

Step	Verbalize	Demonstrate Competency
5. Apply sterile technique during a dressing change.		
6. Demonstrate technique for obtaining blood specimens via PICC.		
7. Discuss the complications that can occur while a PICC is in place.		
8. Demonstrate sterile technique and stabilization of the catheter during the application of the dressing and added tubing.		
9. Describe how to instill a clearing agent into an occluded catheter.		
10. Describe and demonstrate catheter removal.		
11. Discuss the treatment necessary to remove a retained catheter	.	
12. Identify the complications that can occur as a result of PICC placement or while the catheter is indwelling along with possible intervention and prevention strategies.		
a. Phlebitis		
b. Bleeding		
c. Migration/dislodgement		
d. Infiltration (peripheral; pleural, pericardial, peritoneal leakage)		
e. Occlusion		
f. Catheter-related bloodstream infection		
13. Document all interventions for PICC lines according to facility guidelines.		

Appendix B. Troubleshooting Guide

Problem	Assessment Considerations/Possible Solutions
Sounding of pump occlusion alarm	• Tubing clamped or pinched
	• Patient position
	• Catheter kinked, either externally or internally
Catheter can't be flushed	• Assess external catheter for kinks/bends
	• Check minimum infusion rate
	• Determine if injection port occluded
Vein at insertion site is red and hard	• Evaluate for and treat if mechanical phlebitis
Extremity with catheter is puffy	• Dressing too tight
	• Vascular thrombus within extremity
	• Dependent positioning
Catheter can't be removed	• Refer to strategies for catheters resistant to removal

Appendix C. Sample Consent Forms and Parent Education Tools

Pediatric and Neonatal Units

SWEDISH

Risks and Benefits of a PICC Line

A Parent's Information Guide

A Peripherally Inserted Central Catheter (PICC) line is being considered for your child. It is a long, very thin and flexible tube inserted into a vein in the arms, legs or scalp and threaded to a larger vein in the chest.

Because it is central, it is a safe way for your child to receive medications and solutions into the vein for the course of your child's treatment. A trained PICC insertion nurse or health-care provider will place it at the bedside. Care will be taken to keep your child comfortable during the procedure. X-rays will be done to verify correct placement.

When placed in the correct position, PICC lines have a low rate of complications. As with any procedure, there are potential risks and benefits we want you to be aware of and understand.

Benefits

- Reduces the pain and stress from several I.V. starts
- Allows safe infusion of the medications your child needs
- Prevents injury to the walls of the vein that can come from irritating medications or solutions
- Long lasting; it offers reliable access for the course of treatment
- May be used for lab draws (if the catheter is large enough)
- Can be easily removed by an R.N.
- Decreased risk of fluid leaking into the tissue around the catheter
- Also ideal for home infusion

Risks

- Bruising around the insertion site
- Inflammation of the vein wall (phlebitis)
- Catheter or blood stream infection
- Changes in heart rhythm (cardiac arrhythmia) if the tip drifts into the heart
- A broken catheter or a hole in the catheter (catheter rupture or embolism)
- Clotting of blood within the catheter (catheter occlusion)
- Movement of the catheter tip from its original location (catheter migration)
- Leakage of fluid into the tissue surrounding the vein (infiltrate)
- Air entering the catheter and traveling to the lungs and the heart (air embolism)
- Piercing an artery or nerve close to the insertion site
- A blood clot inside the vein near the catheter (vein thrombosis)

Questions and Concerns

Please ask your nurse or doctor for any questions or concerns about this line. Your child will be monitored carefully for any complications that may arise. We believe this is the best option and we also want you to feel this is the best treatment option for your child. You always have the right to refuse or discuss this decision further until your questions and concerns are fully answered.

Swedish Medical Center • Pediatric and Neonatal Units
747 Broadway • Seattle, WA 98122-4307
www.swedish.org

NU-05-05965 R-2/06

SWEDISH

Provide the following information prior to obtaining consent for PICC insertion.

Description: Having a PICC (Peripherally Inserted Central Venous Catheter) inserted means that a soft, flexible catheter – a special kind of tube – will be inserted in the vein of an arm, hand, leg, foot or scalp and the tip will rest in the large blood vessels above or below the heart called the 'vena cava'. At MultiCare's NICU we have a specially trained group of nurses who place these lines. They are placed under sterile conditions and will remain indwelling for as long as they are needed, from one week to several months. The position of the catheter tip will be confirmed by a x-ray after insertion and may be repositioned if necessary. Your baby will be given appropriate medication and/or sedation for the procedure to minimize any discomfort.

Reason for the PICC insertion: The treatments ordered by the physician include IV fluids and/or medications that may be irritating to smaller veins. Because the large vessels around the heart have rapid blood flow, these products will not irritate the vein and the catheter can remain in place until therapy is completed. These lines also save the babies from multiple IV attempts and provide us with an access for blood sampling and at times blood administration.

Possible complications and how they are handled:

Catheter sepsis (infection): Great care is taken to prevent infection but there is always a risk for infection with any form of IV or central line access. If an infection occurs the line may need to be removed.

Bleeding: In the first 24 hours after placement some bleeding is common and generally stops on its own. In some circumstances a small pressure dressing is applied to help control the bleeding.

Hematoma (bruising): There may be some bruising near the catheter. This will go away in a few days without further treatment.

Irritation of the blood vessel (phlebitis): The catheter may cause some redness and tenderness along the vein during the first 2-3 days after insertion. Treatment is with warm, moist heat.

Dislodged catheters: Catheter placement is very important and we place an occlusive dressing over the line to help prevent the catheter from accidentally being dislodged. Your baby's nurse is highly skilled at assessing the PICC for problems.

Clotted line: The PICC catheters we use are very small and can be prone to clotting. Clotted lines will need to be removed.

RARE COMPLICATIONS:

Cardiac dysrhythmia (irregular heartbeat): The location of the catheter tip may cause an irregular heartbeat. A chest x-ray will be used to check the tip location and the catheter will be repositioned if necessary.

Pleural/Pericardial effusion and tamponade: Pericardial effusion is the presence of fluid in the sac enclosing the heart. Fluid in this space can cause cardiac compression (tamponade). Pleural effusion is the presence of fluid in the space that surround the lungs. Both are a life-threatening situation and requires emergency drainage.

Air Embolus (air bubble): An air bubble may occur when the syringe or tubing is connected or disconnected. This is rare due to the small size of the catheter.

I acknowledge that I have been given information about the PICC. I have been informed about how the PICC works and why it is being used. I have also been informed about the expected results of the PICC and what alternative forms of treatment are available. I have been told of the possible risks and complications of the proposed treatment and of the alternative forms of treatment. I acknowledge that the information in this document has been discussed with me and I give my consent for treatment using a PICC. This consent includes placing the catheter for the first time as well as exchanging and replacing the catheters as needed during hospitalization. All of my questions have been answered to my satisfaction.

________________________________ ________________

Signature of person authorized to give consent — Date/Time

________________________________ ________________

Relationship to patient — Witness

Patient Identification

PICC CONSENT - NEONATE FORM

MultiCare
Health System

88-2797-2 (5/05)

Appendix D. Procedure Documentation and Maintenance Records

PICC & Midline Catheter Insertion Record for Pediatric / Neonatal Lines

PATIENT INFORMATION:

Age ____________ D M Y Gestational age ______ Room #/Unit ______________ Allergies ____________________

Birth wt. (for neonates) __________ Current wt. __________

☐ Safety Pause Diagnosis ______________________________

Consent Received: ☐ Verbal ☐ Written ☐ Unable due to: ______________

PICC/ML is to be used for:
☐ Hydration ☐ TPN ☐ Antibiotics
☐ Pain Medication ☐ Vancomycin
☐ Blood Draws ☐ Other ______________

CATHETER INFORMATION:

Catheter Brand ________________ Lot # ____________ Fr ___ Type of Line: ☐ PICC ☐ Midline # of Lumens: ☐ single ☐ double

INSERTION INFORMATION:

Date __________ Time _______ Inserter ______________________ Assistant ______________________

Medications Administered ______________________________ Procedural Sedation: ☐ Yes ☐ No

Use of Topical Anesthetics: ☐ EMLA/LMX ☐ Buffered Lidocaine ☐ Oral Sucrose Solution Heat applied to extremity: ☐ Yes ☐ No

☐ Use of Child Life Specialist ☐ Parents present for procedure ☐ Maximum sterile barrier use

Number of attempts ______

Vein Utilized: ☐ Right ☐ Left
☐ Basilic ☐ Cephalic ☐ Saphenous ☐ Median Cubital ☐ Other ______________

Other Veins Attempted: ☐ Basilic(R) ☐ Cephalic(R) ☐ Saphenous(R) ☐ Median Cubital(R)
☐ Basilic(L) ☐ Cephalic(L) ☐ Saphenous(L) ☐ Median Cubital (L) ☐ Other ______________

Insertion Difficulties: ☐ None ☐ Unable to access vein ☐ Unable to thread cath/guidewire beyond ________ cm
☐ Some resistance threading catheter ☐ Pull back and rethreading required ☐ No blood return ☐ Other ______________

Blood return: ☐ Positive ☐ Negative ☐ Brisk ☐ Sluggish

Introducer Used to Access Vein:
☐ Peel-away sheath _____g. ☐ Break-away needle _____g. ☐ Microintroducer _____g.

Technique Used:
☐ Standard ☐ Modified Seldinger Technique (MST) ☐ Ultrasound/MST

Catheter trimmed to ________cm. Length inserted ________cm. Amt. External ________cm.

Securement device: ☐ Steri-strips ☐ Stat Lock ☐ Tegaderm ☐ Biopatch

Comments on insertion ____

Catheter Malpositioned: ☐ IJ ☐ Looped ☐ Brachiocephalic ☐ Subclavian ☐ Right Atrium ☐ Other ______________

Catheter Adjustment: ☐ Power flush ☐ Sterile advance _____cm ☐ Pull back _____cm ☐ Exchange ☐ Replacement
☐ Sterile pull back and rethread ☐ Wait and re-x-ray in am ☐ Repeat x-ray

Final catheter tip location: ☐ SVC. ☐ IVC. ☐ Upper ☐ Mid ☐ Lower ☐ Other ______________

Final length of internal catheter ________cm. Final length of external catheter ________cm.

ADDRESSOGRAPH

SWEDISH MEDICAL CENTER
FIRST HILL CAMPUS

DO NOT THIN

Form 52098 Nonstock Rev. 6/19/06 CC

PICC & MIDLINE CATHETER INSERTION RECORD FOR PEDIATRIC / NEONATAL LINES

PICC & Midline Maintenance Record
for Pediatric / Neonatal Lines

FOLLOW-UP X-RAY:

Date__________ Initial_____ Catheter Location: ☐ SVC. ☐ IVC. ☐ Upper ☐ Mid ☐ Lower ☐ Other__________

Date__________ Initial_____ Catheter Location: ☐ SVC. ☐ IVC. ☐ Upper ☐ Mid ☐ Lower ☐ Other__________

DRESSING CHANGES:

Date __________ Initial______ Length of external catheter _______cm. ☐ No Local Complications

Date __________ Initial______ Length of external catheter _______cm. ☐ No Local Complications

Date __________ Initial______ Length of external catheter _______cm. ☐ No Local Complications

CATHETER ASSOCIATED PROBLEMS:

Problem:	Treatment:	Outcome:
☐ No Blood return Date______ Initial____	☐ tPA ☐ Left in place untreated	☐ No blood return ☐ Flushes easily ☐ Positive blood return
☐ Catheter does not flush Date______ Initial____	☐ tPA x1 ☐ tPA x2	☐ Patency resumed ☐ Catheter sluggish ☐ Catheter removed
☐ Leaking at insertion site Date______ Initial____	☐ Dressing changed	☐ Leaking resolved ☐ Catheter removed
☐ Swelling of extremity Date______ Initial____	☐ Extremity elevated ☐ Warm compresses applied ☐ Dressing adjusted ☐ Armboard applied	☐ Swelling resolved ☐ Catheter removed ☐ Circumference stable, good CMS
☐ Pain/Phlebitis/redness Date______ Initial____	☐ Warm compresses QID for 20-30 min until resolved	☐ Phlebitis resolved ☐ Stable ☐ Catheter removed
☐ Bleeding at insertion site greater than 24 hours Date______ Initial____	☐ Pressure gauze applied with dressing change	☐ No further bleeding
☐ Cardiac Arrhythmias Date______ Initial____	☐ Catheter pulled back _____cm	☐ Norml sinus rhythm & tip in SVC/IVC _______cm ext.
☐ Catheter tip migration or dislodgment of cath. Date______ Initial____	☐ X-ray for tip location ☐ Catheter pulled back ☐ Power flush ☐ Catheter used as a midline	☐ Tip in SVC/IVC _______cm external ☐ ML cath_______cm external
☐ Suspected infection/sepsis Date______ Initial____	☐ Peripheral BC ☐ BC from PICC ☐ Catheter tip culture	☐ + peripheral BC ☐ - peripheral BC ☐ + PICC BC ☐ - PICC BC ☐ Cath removed
☐ Catheter requiring repair Date______ Initial____	☐ Catheter repair	☐ Catheter functioning intact ______cm ext. ☐ Unable to repair ☐ Catheter removed

☐ Other ____________________

CATHETER REMOVAL:

Date PICC/ML removed: _______________ Initial: _______ Length of intact catheter: ________cm

Condition of site: ☐ No Local Complications ☐ Red ☐ Tender ☐ Swollen ☐ Serous discharge ☐ Purulent discharge

Reason for removal: ☐ Therapy complete ☐ Noncentral location ☐ Other _______________ ☐ See above

Difficulty on removal: ☐ No ☐ Yes Treatment: ☐ Warm compresses for 20-30 min. over the path of the vein

☐ Warm compresses QID for 24 hours ☐ X-ray obtained Outcome: ☐ Catheter removed easily ☐ Other __________

Discharged with catheter in place? ☐ Yes List agency or facility____________________ Date of discharge __________

ADDRESSOGRAPH

SWEDISH MEDICAL CENTER
FIRST HILL CAMPUS

DO NOT THIN

Form 52326 Nonstock Rev. 1/30/06 CC

PICC & MIDLINE MAINTENANCE RECORD FOR PEDIATRIC / NEONATAL LINES

Patient Name: ______________ Birth Date: ______________ Consent Signed: ______________
Current Wt: ______________ Gestational Age: ______________ Day of Life: ______________ Current Dx: ______________
Time Out Procedure: ❑ MD Order ❑ Correct Patient ❑ Correct Site
Signature: ______________ Signature: ______________

INSERTION PROCEDURE: **Inserted by:** ______________ ❑ **Failed Attempt** ______________
Reason: ❑ Long Term IV Access ❑ Difficult IV Access ❑ Medication Administration ❑ Other ______________
Date: ______________ Start Time: ______________ End Time: ______________ # of Attempts: ______________
❑ Central ❑ Peripheral
Medication for Procedure: ❑ Yes ❑ No Medication Ordered: ______________

Site:
❑ right ❑ left
❑ scalp ❑ hand ❑ basilic ❑ antecubital ❑ cephalic
❑ saphenous ❑ femoral ❑ subclavian ❑ other ______________

Type of Line:
❑ PICC ❑ VCD
❑ Broviac ❑ Other ______________

Draws:
❑ Yes
❑ No

INSERTION COMPLICATIONS: Blood loss: ______________ ❑ Unable to access vein ❑ Unable to thread catheter
❑ Difficulty advancing catheter ❑ Other (specify) ______________
Notes: ______________

CATHETER: ***Measure PICCs from 1st mark***
Brand ______________ **Size** ______________ **Lot #** ______________ **Exp. Date** ______________
Original Length: ______________ **Trimmed length (cm)** ______________ **Length inserted (cm)** ______________
Length pulled back (cm) ______________ ***Length left external (cm & black marks)*** ______________
Other: ______________

X-RAY: ❑ Post-Insertion X-ray for Line Placement
Number of X-rays: ______________
Location of Tip: ❑ SVC ❑ IVC ______________
Other: ______________

FOLLOW-UP XRAY (approx. 24 hrs.):
Date: ______________
Line Changes: ______________
Tip Location: ❑ SVC ❑ IVC
Other: ______________

FOLLOW-UP X-RAY VERIFICATION

Date	MD Signature	Line Change	Date	MD Signature	Line Change

Note: These orders should be reviewed by the attending provider, appropriately modified for the individual patient and signed below.

Provider Signature ______________ Print Name ______________ Phone/Pager ______________ Date ______________ Time ______________

Order Verified (Nurse Signature): ______________ Date: ______________ Time: ______________

Patient Identification

Page 1 of 2

NICU CENTRAL LINE ORDER AND DOCUMENTATION FORM

MultiCare Health System

88-0702-6 (Rev. 3/05) usa 3/05

ORDER SET

DRESSING CHANGE DOCUMENTATION Date line inserted:________ Site: ___

Date	RN Signature	Reason for Dressing Change	Type of Dressing	Condition of Site	Length CM	Marks
		24 Hour Change				

INFECTIONS ISSUES OF CENTRAL LINES

Date Blood Culture Drawn	Results (Pos./Neg., Organism)	Tx via Line (yes/no)	RN Signature

PHLEBITIS

Date of Onset	Site/Type (mechanical, chemical, etc.)	Treatment (length, type, effectiveness)	RN Signature

DATE HEPARIN LOCKED: ____________________

CATHETER OUTCOME: (place ***yellow copy*** in PICC Book) Date Discontinued:________________ ❑ MD Order: ______

REASON:

❑ No longer needed ❑ Clotted ❑ Sepsis ❑ Infiltrate ❑ Line Malfunction ❑ Phlebitis

❑ DC ❑ Pt transferred to ____________________

❑ Unintentional removal ❑ Other ____________________

Line Intact ❑ Yes ❑ No # Days Indwelling__________________ Condition of Site ________________

____

RN Signature: ____________________

Patient Identification

Page 2 of 2

ORDER SET

NICU CENTRAL LINE ORDER AND DOCUMENTATION FORM

MultiCare Health System

88-0702-6 (Rev. 3/05) usa 3/05

NICU PICC Procedure Form

Date: ___________ **Time:** _____________
Inserted by: _________________________
Indications:
☐Weight: __________ gms Age: ______ days
☐Poor Peripheral Access
☐Type of Therapy Required – Specify: _______________

Tip Location:
PICC: _________
Midline: _________

Vein of Insertion:

Basilic	**R ___ L ___**	**Axillary**	**R ___ L ___**	**Greater Saphenous**	**R ___ L ___**
Temporal	**R ___ L ___**	**Post Auricular**	**R ___ L ___**	**Lesser Saphenous**	**R ___ L ___**
Cephalic	**R ___ L ___**	**Popliteal**	**R ___ L ___**	**Femoral**	**R ___ L ___**
Ext. Jugular	**R ___ L ___**	**Geniculate**	**R ___ L ___**	**Other:** __________________	

Time Out: ☐ Infant Identification ☐ Correct Side & Site

Catheter:
Brand: __________ Original Length (cm) ___________
Size: __________ Trimmed Length (cm) ___________
Lot: __________ Length Inserted (cm) ___________
Used: ________
Introducer: ☐ Needle ☐ Sheath Size: _____ gauge # Used ___

Insertion Complications:
☐ Unable to Thread Catheter
☐ Difficulty Advancing Catheter
☐ Malposition → Repositioning Successful ☐ Yes ☐ No
☐ Unable to Place Catheter
☐ Other Specify: ______________________________

Prep Solution: ☐ Chlorhexidine ☐ Betadine
Procedural Medication: ☐ Yes ☐ No
-Type: ______________________________
Dressing: ☐ Transparent ☐ Gauze

Radiographic Tip Location:
Number of x-rays for placement: _____
Contrast Used ☐ Yes ☐ No
Location of Tip ☐ SVC ☐ IVC
☐ Other: ______________

CXR & Action:
Date: _________ Tip Location: _________________
____
Date: ________ Tip Location: _________________
____

Complication During Catheter Dwell:
☐ **No Complications**
☐ Leaking
☐ Phlebitis Attempted to Treat ☐ Yes ☐ No
☐ Infiltration
☐ Limb Edema
☐ Malposition
☐ Patient Infection: Date: _________ Organism in peripheral culture: ____________
Organism from PICC culture __________________ Attempted to Treat ☐ Yes ☐ No → Successful ☐ Yes ☐ No
☐ Occlusion: Type: ________________ Treatment: ____________________
☐ Breakage: ☐ Catheter ☐ Hub
☐ Repair Date: __________ Catheter trimmed ______cm Amount external ______cm

Removal Data:
Date: ________ Time: ________ Days Indwelling: _______ Person Removing: ______________________________
Amount of Catheter Removed: _______ cm
☐ Difficulty with Removal: Interventions: ____
☐ Removed at end of therapy ☐ Unintentional Removal ☐Patient Transferred/Death
☐ Removed for Complications (specify) ____

White copy to "Procedure" tab in chart, yellow copy to PICC Data book after PICC removal, pink copy to PICC Data book upon insertion

Appendix E. PICC Order Forms

DATE	TIME	PHYSICIAN'S ORDERS	NOTED BY

PEDIATRIC/NEONATAL PICC PLACEMENT ORDERS

MD: Please indicate order selections with an "X" and sign at end.

Placement Orders:

☐ PICC
☐ Midline (not central, x-ray not required)

PICC placement date (when needed)________________________

PICC/ML to be used for:
☐ hydration ☐ TPN ☐ antibiotics ☐ Vancomycin
☐ pain medications ☐ blood draws ☐ Other______________________________

Procedural Sedation required? ☐ Yes ☐ No
If needed, contact peds anesthesiologist & arrange for room in PICU. Initiate Pediatric Procedural Sedation Protocol.

Medication Orders:

☐ fentanyl IV (1-2 mcg/kg/dose suggested): ______ mcg/kg x _______ kg = _______ mcg
If given, monitor patient continuously on Cardio Respiratory Monitor and SaO_2 monitor during procedure and 1 hour post procedure.
Topical anesthetics: ☐ EMLA/ELA-Max Cream at insertion site 30 minutes to 1 hour prior to procedure. (Child must be over 38 weeks gestation).
☐ Lidocaine 1% sodium bicarbonate 1 mEq/ml. Inject 0.2 ml intradermally at insertion site.
☐ May give oral sucrose solution.

X-RAY: Reason for exam: PICC location.
☐ Stat portable chest (or abdominal x-ray for saphenous insertions).
☐ For neonates, 2 view chest (arm up & arm down) or
2 view abdomen (frog-leg & leg down). Repeat in am.
☐ Omnipaque dye 300 mg/ml. Inject 0.2 ml into catheter prior to x-ray (0.5 ml if extension tubing is in place) then withdraw medication. (For Vygon 1.1 Fr PremieCath or 1.9 Fr V-Cath).

☒ May use PICC line when radiologist/specially-trained ARNP confirms PICC tip is located in the SVC or IVC.

Physician's Signature ____

Post Insertion Orders: to be completed by inserter.
Placement verified. Central? ☐ Yes ☐ No

Final tip location:_______________________________

☐ OK to use.
☐ OK to heplock: Flush with 5 ml PF normal saline in a 10 ml syringe using a pulsatile technique. Follow with 2.5 ml of 10 unit/ml heparin in a 10 ml syringe. Clamp with positive pressure. Flush every 8 hours or after use.
☐ Change dressing 24 hours after insertion then every 7 days and as needed, using sterile technique.
☐ For neonates, change dressing only as needed.
☐ OK for blood draws. Use only if blood draws freely & swiftly.
Use a 3 ml - 5 ml syringe to draw, discard 1 ml of waste, then flush with 5 mls normal saline in a 10 ml syringe using a pulsatile technique.

Signature ____

A DRUG EQUIVALENT MAY BE DISPENSED UNLESS CHECKED ☐

SIGNATURE IS REQUIRED FOLLOWING ENTRY OF EACH ORDER

SWEDISH MEDICAL CENTER
FIRST HILL CAMPUS

Form 52099 Nonstock Rev. 8/05 CC

PHYSICIAN'S ORDERS

DATE	TIME	ORDER(S)	DIAGNOSIS/INDICATION
		ANOTHER BRAND OF DRUG IDENTICAL IN CONTENT MAY BE DISPENSED UNLESS BOX IS CHECKED. ☐	
		1. Initial follow-up: ❑ Chest/abdominal x-ray for PICC line placement due ___________ at 0800. ❑ Chest x-ray for PICC placement ________ due at 0800. 2. Initial PICC dressing change due ___________. (After follow-up x-ray verified by M.D.) 3. Heparin flush (10 units/cc) 0.5cc due every: ❑ 12 hours via PICC line with running IV fluid. ❑ 8 hours via PICC line that is heparin locked. ❑ Defer flush while ______________ infusing. M.D. Signature: ______________________________	

DATE	TIME	ORDER(S)	DIAGNOSIS/INDICATION
		ANOTHER BRAND OF DRUG IDENTICAL IN CONTENT MAY BE DISPENSED UNLESS BOX IS CHECKED. ☐	

Place Patient ID Label Here

All orders must be signed by presciber.

PHYSICIAN ORDER

MultiCare Health System

87-9977-0 (1/05)

ORDER SET

Neonatal Intensive Care Unit
Peripherally Inserted Central Catheter (PICC) Orders

Date: _________ Time: ________

- ❑ **Place PICC**

- ❑ **Medication for Placement**
  - ❑ Morphine ______ mg IV 30 minutes before procedure
  - ❑ Fentanyl (Sublimaze) _______ mg IV 15 minutes before procedure

- ❑ **X-ray for PICC placement**
  - ❑ AP of Chest
  - ❑ Chest & Abdomen
  - ❑ Lateral
  - ❑ Repeat x-ray for repositioning of catheter

- ❑ **PICC Infusates**

  - ❑ Infuse PICC with current fluids (today) ordered for ____PIV ____UVC
  - ❑ Infuse:____
  - ❑ Infuse: ____

- ❑ **Discontinue catheters following placement of PICC**

  - ○ Umbilical vein
  - ○ Peripheral IV

- ❑ Flush PICC using pulsatile motion with 1 ml normal saline containing 1 unit heparin/ml twice a day. Do not flush if continuous medication infusions ordered.

- ❑ Heel warmer to extremity proximal to PICC insertion site every 3 hours for 48 hours

- ❑ May obtain lab tests from PICC if 24 gauge single lumen

- ❑ Do not heparin lock or transfuse blood products if PICC is dual-lumen or 28-gauge

- ❑ Notify charge nurse immediately if occlusion alarm sounds and cause cannot be identified.

_________________________________ NP