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Minimizing Risks Associated With Peripherally Inserted Central Catheters in the NICU

[Feature Articles: CE]

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Abstract

Peripherally inserted central catheters (PICC lines) provide prolonged venous access, a means of administration of needed medications that would otherwise be irritating to peripheral vessels, and a means of assuring better parenteral nutrition to infants who are unable to tolerate enteral feedings. Not only do these central lines provide life-saving therapy, they are easily inserted, cost effective, and convenient.

Although there are many benefits to the use of these catheters, physicians and nurses within the NICU must remain acutely aware of the risks involved with placement of PICC lines so that complications can be minimized. Prevention of sepsis in neonates is always a priority, and several measures can be implemented to reduce this risk, including scrupulous aseptic technique, knowledgeable selection of the insertion site, and consistent daily care. Other complications such as thrombosis, extravascular collection of fluid due to catheter migration or blockage, vessel perforation, and line leakage are all concerns when using this valuable tool in the care of infants. Careful catheter tip placement and conscientious ongoing monitoring can assist in reducing morbidity as well as mortality related to PICC lines.

Outline

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Recent History

Minimizing Risks Associat... GO

FIGURE 1 Peripherally Inserted Central Catheters (PICC lines) have become increasingly popular in Neonatal Intensive Care Units (NICUs). With minimal invasiveness, PICC lines provide optimal long-term venous access to a central vessel. These catheters are radiopaque, made of silicone or polyurethane, and are inserted in the peripheral venous system with the catheter tip located in the superior vena cava. Advances in the care and nutrition of low birthweight (LBW) and extremely low birthweight (ELBW) infants has been made possible through the use of central catheters. Although the use of PICC lines has many advantages, those caring for these infants must remember that PICC lines are not without serious hazards. As with all procedures in the NICU, the risks and benefits must be carefully weighed prior to initiation (Hruszkewycz et al., 1991).

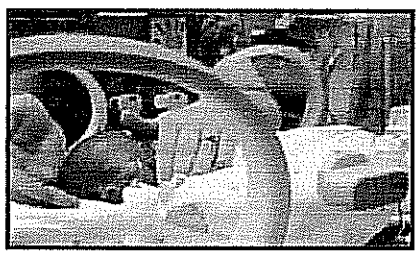

Figure 1. No caption available.

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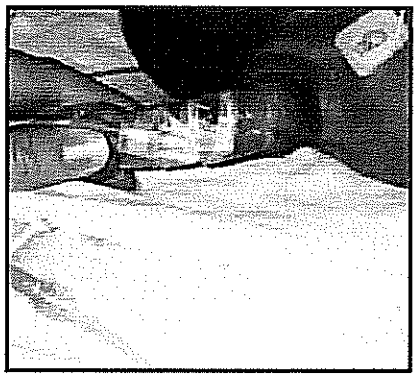
Use of PICC lines in the NICU was first described in the literature in the 1970s. Their popularity grew in the 1980s, and their use has now become standard practice for most infants requiring long-term therapy. Insertion is accomplished by cannulating a peripheral vein with a metal or plastic needle and then introducing the small gauge catheter through the needle. The needle is removed, and most needles peel or break away from the catheter. The catheter is then advanced into a central vessel and placement is radiographically confirmed (Brown, 1994). Previous to PICC lines, Broviac catheters were generally used to provide central access for therapy, but they could require insertion by a surgeon as well as ligation of the vessel used for insertion (Trotter, 1996). FIGURES 2-4

Figure 2. PICC in lower arm.



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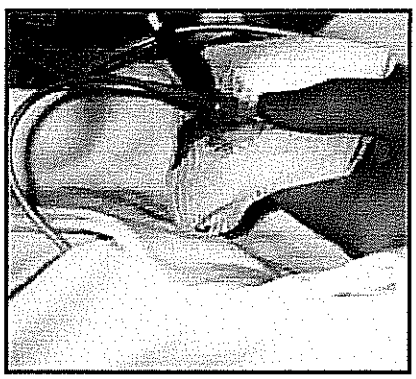

Figure 3. Cleaning PICC hub with Betadine before changing IV fluids and flushing line.

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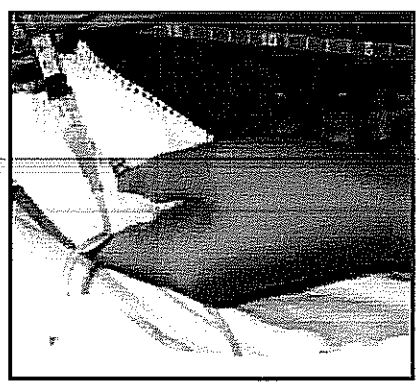

Figure 4. Flushing PICC.

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Benefits

Reduction of Needle Sticks

PICC lines evolved in order to appropriately deal with the common problem of minimal vascular access in premature infants. Even when peripheral veins are available, IVs do not last long, as the veins are easily irritated or infiltrated. A PICC line can reduce the number of painful and costly needle sticks that an infant must endure. A wise approach considers placement of the PICC line long before peripheral access becomes scarce, thereby preserving precarious vasculature (Brown, 1994). PICC line placement sometimes becomes part of the admission process with ELBW babies due to the usually long length of stay of this population.

Administration of Total Parenteral Nutrition

Providing nutrition to infants within the NICU has long been a challenge. Illness and prematurity increase nutritional needs but also hamper attempts to provide nourishment. Simultaneously, brain growth is dependent upon obtaining adequate substrate. Total parenteral nutrition (TPN) has improved delivery of necessary nutrients but presents its own problems (Chathas & Paton, 1997). The hyperosmolality of these solutions can be extremely irritating to peripheral veins, and dextrose concentrations of no more than 12.5% can be given without a central line. Central catheters provide for administration of these solutions in larger vessels that provide greater hemodilution, thereby reducing risk of venous irritation and allowing delivery of a higher carbohydrate load (Brown, 1994).

Safe Administration of Irritant Medications

Problems arise with many medications used in the NICU. Vessel irritation can occur from hyperosmolar medications, solutions with high or low pH, or vesicant drugs, and can result in chemical phlebitis or tissue necrosis. Many of these medications may be given more safely through a PICC line, for the larger vessel and increased hemodilution protect against irritation.

Long-Term Therapies

PICC lines are also useful for long-term therapy whether it be parenteral nutrition, fluids, or medications. The ELBW infant may require prolonged delivery of nutrition before enteral feedings can be well established. The same is true for infants who have gastrointestinal problems such as tracheal-esophageal fistula, omphalacele, gastroschisis, necrotizing enterocolitis, or intestinal obstruction. Infants who have had central nervous system insults from intracranial hemorrhage, asphyxia, meningitis, or congenital problems often establish enteral feeding much later than other infants. There are several other conditions seen in the NICU that delay feedings. These infants will most likely require prolonged TPN and should be considered for insertion of PICC lines.

Ease of Insertion

Ease of insertion makes PICC lines a favorite choice in many NICUs. Rather than requiring a surgeon or intensivist, this central catheter is often inserted by specially trained RNs who may be clinical nurse specialists, nurse practitioners, or staff nurses with exceptional IV skills. After a

training course and preceptorship these nurses can expertly insert PICC lines (Trotter, 1996). This is both cost effective and convenient.

Risks

PICC lines, despite their benefits, are not without hazards, some of which can be life threatening. Infection, venous thrombosis, embolism, and vascular erosion have all been encountered with PICC lines. However, complications can be greatly reduced by conscientious insertion, use, and maintenance of these catheters (Puntis et al., 1991).

Sepsis

Catheter-related sepsis is a frequently cited complication in the literature. Trotter (1996) reviewed the research done between 1990 and 1994 to more clearly define catheter-related sepsis and evaluate its true incidence. Trotter's definition of catheter-related sepsis was "colony count from the catheter blood culture is significantly higher than the count from the blood culture obtained from the peripheral site" (Trotter, 1996, p. 23). This review of the literature showed a catheter-related sepsis incidence of 15.3% infections per 1,000 catheter days (Trotter). The most frequently identified organisms were Staphylococcus epidermidis and fungemia due to Malassezia furfur.

Minimizing sepsis due to the PICC line can be accomplished in several ways. Careful selection of insertion site as well as scrupulous aseptic techniques during insertion help to prevent introduction of organisms. Insertion sites need to be well away from any potential source of infection such as a preexisting skin infection or surgical wound (Brown, 1994). Goutail-Flaud et al. (1991) reported that septic complications were reduced when a distal site (rather than proximal site) of insertion was chosen. Distal veins were those in the scalp or superior limb. Proximal sites were usually in the neck veins.

A sterile dressing at the insertion site is recommended; however, the exact method of dressing the site has not been fully studied. A small pilot study done by Zenk et al. (1993) examined the use of transparent dressings and found no increased incidence of infection when the dressings were used. The standard of care in most NICUs seems to warrant change of dressing only when it is loose or soiled (Trotter, 1996). Further studies are needed in this area to help clarify the safest standard of practice.

Ongoing maintenance techniques for PICC lines are also implicated in the incidence of sepsis. More research is necessary to help understand how often the integrity of the line can be violated for tubing changes, medication administration, etc., or how and if the hub should be treated. Infants who have multiple medications administered via the PICC line may pose increased infection risk due to frequent breaking into the line. Contamination of the hub has been identified as being one potential as a source of nosocomial infections involving PICC line (Trotter, 1996). Because of the risks of PICC line contamination, special precautions should be also be instituted when central lines are in use. Staff training on the proper care of PICC lines has been shown to dramatically reduce the catheter sepsis rate (Puntis et al, 1991).

Duration of time with the catheter in place also seems to affect the incidence of sepsis, with the rate of infection increasing the longer the catheter remains in the body. A prospective study done by Chathas (1991) identified the risk of central line colonization as 1.85 times greater when the line was in place for over 2 weeks. This study also showed that colonization rate continued to increase with each subsequent week. Septic complications increased inversely to birth weight, with infants weighing <2500 grams more frequently found to develop catheter-related sepsis than infants >2500 grams (Goutail-Flaud et al., 1991). Therefore, it seems prudent to discontinue PICC lines as soon as possible.

TPN itself may be an additional factor in catheter-related sepsis. Regardless of method of delivery, sepsis has been shown to increase with duration of TPN therapy (Chung & Ziegler, 1998). Every attempt at enteral feeding needs to be made in order to minimize the length of TPN therapy. However, while TPN therapy is necessary, additional precautions may help minimize contamination. Antibacterial in-line filters should be used to infuse IV solutions (with a separate line that bypasses the filter for lipid infusion), and solutions should be prepared under a laminar flow hood. Careful aseptic technique when changing and priming the line is paramount. Limiting the need to break into the line to give intermittent IV medication can be accomplished by establishing a permanent connection between the medication infusion set and the rest of the tubing. Some of the newer needleless systems have adaptors that remain in place and allow access without opening the line.

The prophylactic use of Vancomycin after PICC line placement has been advocated by some, but remains controversial. In one study (Spafford, Sinkin, Cox, Reubens, & Powell, 1994) adding low dose Vancomycin to total parenteral nutrition reduced the incidence of catheter-related sepsis with coagulase-negative staphylococci in the NICU. No adverse effects were associated with the addition of Vancomycin; however, concerns still remain about vancomycin-resistant organisms. Therefore, recommendations for widespread implementation of this procedure have not been made.

Thrombosis

While clinically evident thrombosis is unusual with central catheters (reported as between 2%-10%) subclinical thrombosis may be present more frequently. This can be due to obstruction of blood flow or injury to the intima of the vein wall. Even though evidence of thrombosis may be uncommon, it could be responsible for catheter dislodgments or other unusual complications. Heparinizing the catheter may reduce the risk of caval or catheter thrombosis (Goutail-Flaud et al., 1991). The use of heparin as well as the most effective dose remain issues of debate in neonatal care.

Mah, Fain, Hall, & Wood (1991) reported a unique complication of thrombosis. A double lumen central catheter was inserted femorally to provide total parenteral nutrition. Eleven days later a septic work-up was performed that included a lumbar puncture. A milky white liquid was recovered from the spinal tap, which was found to contain high glucose, protein, and lipids from the TPN solution. Evidently, the thrombosis had caused retrograde flow of the TPN from the side port of the catheter to the inferior vena cava, through a lumbar vein and into the epidural venous

plexus anterior to the subarachnoid space from which it was recovered during the spinal tap. The central line was removed and a repeat lumbar puncture (LP) after 3 days was completely clear. Although this represents a very unusual case it emphasizes the need to be aware of possible adverse consequences of any central catheter.

Extravascular Collections of Fluid

Several cases of extravascular collections of fluid, most often being hydrothorax and pleural effusions, or incidents of fluid in the pericardial sac and peritoneum have been reported in the literature (Seguin, 1992). Awareness of these complications is critical so early recognition and intervention can occur, because these problems can be life threatening.

Three cases of right-sided hydrothorax have been described by Seguin (1992). In each of these cases the fluid aspirated from the hydrothorax resembled the fluid being infused. It was differentiated from chylothorax because laboratory examination of the fluid showed low lymphocyte count. A chylothorax is the effusion of chyle from the thoracic duct into the pleural space. It would have a high composition of lymph, and usually only occurs in infants who are being fed. Two of the three infants were not being fed at the time of the incident. The fluid also had high glucose and protein values consistent with the infusate. Possible causes included vein perforation during insertion, erosion of the vein by the central catheter, or positioning of the catheter tip into the opening of the right lymphatic duct. With malpositioning, retrograde infusion could flow into the right lymphatic system located near the junction of the right subclavian and internal jugular veins. As the flow exceeded capacity of this system, pleural effusion would result. An interesting aspect of these cases was that reposition of the catheter resolved the problem and removal of the PICC line was avoided (Seguin, 1992).

Duntley, Siever, Korwes, Harpel, & Heffner (1992) discussed eight patients who developed unilateral or bilateral pleural effusions secondary to vascular erosion by PICC lines. Although these were not neonates, the report emphasizes the need to carefully monitor anyone with central catheters in place. Of interest in this article was that seven of the eight lines were inserted from the left side, and six of those seven had catheters that abutted the superior vena cava wall within 45° of perpendicular due to insufficient catheter length. Instead of being inserted well into the superior vena cava the catheters remained at the area of the axygous arch where the axygous vein enters the superior vena cava which may promote "catching" of the catheter tip. Therefore, the authors recommended that PICC lines be inserted from the right side. Erosions have also been noted to occur when the catheter tips are located in the right and left brachiocephalic veins above the proximal superior vena cava. Catheters should be positioned parallel to the long axis of the superior vena cava distal to the azygous recess. Concurrently, the catheter tip needs to remain 1-2 cm. above the right atrium (Duntley et al., 1992).

Perforations

Perforations of intrathoracic or intraabdominal veins by central catheters is a known risk. These can occur upon insertion, but are often seen several days to weeks later. Resulting hydrothorax can be treated with thoracentesis or insertion of a chest tube. Peritoneal fluid from

perforation of intraabdominal veins will usually dissipate following cessation of the infusion (Nour, Puntis, & Stringer, 1995). More serious is pericardial effusion and cardiac tamponade from atrial perforation (Mupanemunda & MacKanjee, 1992) It is imperative that placement of the catheter tip be above the right atrium. Catheters are known to migrate secondary to their pliability and positioning of the infant (Brown, 1994). Goutail-Flaud et al. (1991) describe two infants who died due to cardiac tamponade; the catheter tip in both cases was at the junction of the vena cava and right atrium. Periodic radiographic confirmation of catheter tip placement is recommended.

Both pleural effusions and pericardial effusions occurred with the use of polyurethane catheter. The use of polyurethane vs. silastic catheters remains an area of intense debate; however, further research may assist in clarifying the issue (Dhande, 1983; Mupanemunda & Mackanjee, 1992). Perforations remain rare, but any acute deterioration in an infant with a central line in place should prompt immediate investigation into the possibility of perforation of a major vessel or right atrium.

Leaking

PICC lines may be discontinued due to extracorporeal leaking due to perforation of the catheter. This can be caused by catheter obstruction due to blood reflux and clotting or by pressure exerted when flushing the catheter (Goutail-Flaud et al., 1991). Manufacturers usually recommend daily flushing of the catheter with heparin to prevent blood clotting as well as adding low-dose heparin to TPN or other fluids infusing through the PICC line. The pressure being applied to the line during the daily flushing is an important concern because pressures are inversely related to size of syringe. A 1 cc syringe can generate more that 300 psi, far beyond the bursting pressure of small catheters, and should, therefore, not be used. Ten cc syringes are recommended, filled to 50% capacity to decrease the pressure exerted. Polyurethane catheters are slightly stronger than silastic catheters because the small gauge silastic PICC lines have a bursting pressure of 40 psi (Brown, 1994). Repair kits are usually available for any type of PICC line catheter, and staff need to be skilled in repair as the need arises to prevent unnecessary discontinuance of the line.

Other Complications

Phlebitis can present with edema, erythema, or red streak, and a "cord" feel to the vein. It can result from infection, but is more likely mechanical from insertion. Most frequently it is seen in the first 72 hours after insertion, and can be treated with hot packs and elevation of the extremity. If no improvement is seen, discontinuing the line may be necessary (Brown, 1994).

Catheter embolism is possible upon removal of the PICC line. To prevent the risk, the line should never be forced or stretched. There are times that the catheter resists removal and seems to be held firmly in place. Possible causes include vasoconstriction, vasospasm, thrombophlebitis, and valve inflammation. If resistance is met, removal must *not* be attempted. Before repeating the procedure, application of warm compresses and rotation of the extremity may help alleviate the difficulty. Occasionally, successful removal is achieved by placing mild tension on the catheter, replacing the dressing and attempting removal after 4 to 6 hours (Brown, 1994). Should an

embolism occur during removal, a tourniquet can be immediately applied to the extremity. The infant should be placed on his or her right side to decrease flow to the heart, and the physician must be promptly notified. Interventional radiology may be immediately warranted.

Conclusion

As use of central lines flourish, nurses need to be keenly aware of both the benefits and the risks involved. Sepsis, thrombosis, extravascular collection of fluid, vessel perforation, leaking, phebilitis, and embolism can not only threaten the effectiveness of the therapy but may have life-threatening consequences for the infant. Careful insertion, care, and monitoring helps decrease hazards and provides for early detection when problems arise. PICC lines are an excellent means of providing needed therapy to many infants in the NICU. Proactive measures to reduce complications provide for the greatest amount of benefit while minimizing risks.

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