Review Article

Role of peripherally inserted central catheters (PICC) in home and in-hospital parenteral nutrition

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ABSTRACT: A central venous access is needed in most patients who are candidates for parenteral nutrition. The technology of these devices has changed considerably since their initial use, one of the most recent trends being the delivery of parenteral nutrition through a peripherally inserted central catheter. Usually composed of silicone elastomer or second- or third-generation polyurethane polymers, peripherally inserted central catheters are 50-60 cm long, with one or more lumens, and may be inserted either in the antecubital space by blind cannulation of the cephalic or basilic vein, or at mid-arm, by ultrasound guidance of the basilic, brachial or cephalic veins. The micro-introducer technique in combination with ultrasound guidance has improved the mid-arm positioning of these catheters. The low rate of infectious complications, equal to or even lower than with other central lines, together with the ease of placement and the avoidance of pneumothorax and arterial puncture, have made peripherally inserted central catheters a reasonable alternative to other central catheters for parenteral nutrition in hospitalized patients. Peripherally inserted central catheters have shown only an increased incidence of local complications such as leaking, phlebitis and malpositioning when compared to other tunneled and non-tunneled catheters. These are acceptable risks in most patients in whom a peripherally inserted central catheter is indicated, as this type of catheter offers other clear advantages. Although the peripherally inserted central catheter has become the standard of care for vascular access devices for home parenteral nutrition at many institutions, a randomized, prospective study of peripherally inserted central catheter versus long-term central catheters is urgently needed in order to establish if the peripherally inserted central catheter is also a good alternative for patients needing home parenteral nutrition. (Nutritional Therapy & Metabolism 2009; 27: 55-61)

KEY WORDS: Parenteral nutrition, Central catheters, Peripherally inserted central catheter, PICC, Catheter-related infections

INTRODUCTION

Parenteral nutrition, together with hemodialysis, both in the hospital and on an outpatient basis, are two of the most common and often lifesaving treatment methods made possible by modern advances in vascular access. Furthermore, the management and treatment of severely ill patients in critical care units, the administration of chemotherapy and long-term antibiotics, and frequent transfusion therapy are all dependent on adequate central venous access.

The first successful percutaneous catheterization was that of the subclavian vein for blood transfusion in military personnel (1), and this gave rise to the widespread use of this technique for volume resuscitation in Europe (2). Fifteen years later, total parenteral nutrition was employed with success both in infants and adults (3, 4), and soon after, the technique rapidly gained widespread acceptance and was used for long-term administration of parenteral nutrition regimens (5). As parenteral nutrition formulas have a high osmolarity, their administration is best accomplished through a central venous access device. The technology of these devices has changed considerably since their initial use, one of the most recent trends being parenteral nutrition delivery through a peripherally inserted central catheter (PICC).

INDICATIONS OF DIFFERENT TYPES OF CENTRAL VENOUS CATHETERS IN PARENTERAL NUTRITION

A central venous access in the superior vena cava or the right atrium is needed in most patients who are can-

didates for parenteral nutrition. Central venous access devices for in-hospital parenteral nutrition include short-term non-tunneled central catheters and PICCs. Home parenteral nutrition, on the other hand, requires tunneled catheters (Hickman, Broviac or similar), totally implantable devices (ports) or PICCs, although Hohn catheters (non-tunneled silicone centrally inserted catheters) may also be considered for medium-term use (6) (Tab. I).

According to the Centers for Disease Control and Prevention (CDC) guidelines, totally implantable access devices should be reserved for patients who require long-term, intermittent vascular access, while for patients requiring long-term frequent or continuous access, as in the case of parenteral nutrition, a tunneled central catheter is preferable (7).

There are some situations in which parenteral nutrition may be safely delivered by a peripheral access such as a short cannula or midline catheter, when a solution with low osmolarity is used and with a significant portion of the non-protein calories given as lipids. It is a general recommendation that a central line should be used when the osmolarity exceeds 800-850 mOsm/L (8), although some studies have shown that it is safe to give parenteral nutrition with an osmolarity of around 1000 mOsm/L for up to 10 days (9). It seems that the lipid content may have a protective effect on the endothelium, so this latter factor may be more important than the osmolarity itself (10). In any case, according to the CDC, midline catheters should be taken into consideration as a preferable option every time peripheral intravenous therapy is expected to last for more than 6 days, as is the case for most in-hospital parenteral nutrition treatments (7).

Short-term central venous catheters coated with chlorhexidine/sulfadiazine or with rifampin/minocycline have a significantly lower infection rate than non-coated ones. Their use is recommended in short-term catheterization of adult patients in clinical settings characterized by a high incidence of catheter-related bloodstream infections despite other common strategies (11). Also, chlorhexidine-impregnated dressings are effective in reducing extraluminal contamination of the exit site, so this is highly recommended for non-tunneled central venous catheters (12).

Short-term non-tunneled central catheters and Hohn catheters are inserted by percutaneous venipuncture of central veins, either using anatomical references (blind method) or by ultrasound guidance. The low lateral approach to the internal jugular vein appears to be the one with less risk of mechanical complications when using the blind method (13). Ultrasound guidance is associated with a significantly lower incidence of complications and a higher rate of success, so it is highly recommended for all central venous catheter insertions (14, 15). Placement of a short-term catheter in the femoral vein for parenteral nutrition is contraindicated (8).

High-osmolarity parenteral nutrition should be delivered through a catheter whose tip is positioned in the lower third of the superior vena cava, the atriocaval junction or in the upper portion of the right atrium, as this is associated with the least incidence of thrombotic and mechanical complications (8). The position of the tip should be checked during the procedure by fluoroscopy, unless the access is obtained by interventional radiology techniques (16). The electrocardiographic method is a possible alternative to check the position of the tip.

TABLE I - CENTRAL VENOUS ACCESS DEVICES FOR PARENTERAL NUTRITION

Short term	- Non-tunneled peripheral cannula
	- Non-tunneled central catheters (subclavian, jugular)
	- Midline catheters
Medium term	- Hohn catheters (non-tunneled silicone centrally inserted catheters)
	- Peripherally inserted central catheters (PICCs)
Long term	- Tunneled catheters (Hickman, Broviac or similar), preferred over ports for home parenteral nutrition
	- Totally implantable devices (ports)
	- PICCs? (more trials are needed to assess widespread recommendation for home parenteral nutrition in all patients, especially if home parenteral nutrition is expected to last for more than 12 months)

CHARACTERISTICS OF PICCS AND THEIR PLACEMENT

The use of PICCs for the administration of total parenteral nutrition was first described in 1975 (17). PICCs are usually composed of silicone elastomer or second- or third-generation polyurethane polymers. They are 50-60 cm long, with one or more lumens, and their placement is only slightly more invasive than the establishment of an intravenous access with a routine intravenous cannula (18). PICCs may be inserted either in the antecubital space by blind cannulation of the cephalic or basilic vein, or at mid-arm, by ultrasound guidance of the basilic, brachial or cephalic veins. The micro-introducer technique in combination with ultrasound guidance has improved the mid-arm positioning of these catheters (Fig. 1). The latter is associated with higher success rates and a decreased incidence of local complications, and it positively affects the compliance of the patients (19), so it should be considered the gold stan-

dard. As stated above, the tip should be positioned in the lower third of the superior vena cava, the atriocaval junction or in the upper portion of the right atrium, as this is associated with the least incidence of mechanical complications (8), and should be checked after PICC positioning by fluoroscopy (16, 20).

PICC should be strongly taken into consideration for parenteral nutrition in patients with a tracheostomy, in those in whom placement of a standard central venous catheter entails an increased risk of insertion-related complications, in patients with coagulation disorders, as well as in candidates for home parenteral nutrition (21) (Tab. II). PICCs are apparently associated with a lower risk of infection, probably because the exit site is less prone to contamination by nasal and oral secretions (6). Moreover, antecubital and mid-arm skin is characterized by a very low colonization of bacteria and these areas are particularly dry compared to the neck and the thorax. However, PICCs are not indicated in patients with end-stage renal disease who are considered for fistula or graft implantation (21).

Specialized nursing teams should attend to venous access devices in patients receiving parenteral nutrition (8). This is particulary important in the case of PICCs, as insertion of these catheters is usually done by nurses. Evidence demonstrates that the risk of infection declines with the standardization of aseptic care and increases when the maintenance of catheters is left to inexperienced personnel (21, 22). Flushing with saline might be enough for locking catheters in frequent use, such as those for continuous infusion of parenteral nutrition or with resting periods of less than 8 hours, unless the manufacturer recommends flushing with heparin (21, 23).

PICCs should not be used for infusion of radiological contrast. Rupture of the external portion of the catheter, most frequently silicone catheters, may occur during high-pressure infusion of contrasts by power injectors. Damaged PICCs should be repaired using specific repair kits. Last-generation PICCs are made of polyurethane resins with aliphatic polyether-based polyurethanes, aromatic polyether-based polyurethanes or aliphatic polycarbonate-based polyurethanes, with increased biocompatibility and biostability. Whether they present a lower complication rate over silicone catheters is unknown yet, and future trials should address this issue (24). It has recently been shown that contrast media can be power-injected via PICCs for routine computed tomography examinations at a rate of 2 mL/second, yielding satisfactory image quality without exposing patients to significant additional risk (25). Furthermore, a lower rate of occlusion and rupture as well as long dwell times have been demonstrated in patients with power-injectable PICCs, which makes them safer to use for administration of chemotherapy and other vesicant agents, and suitable for the management of patients in critical care (26).

Fig. 1 - *One-lumen mid-brachial PICC inserted with the micro-introducer technique in combination with ultrasound guidance.*

TABLE II - INDICATIONS FOR PARENTERAL NUTRITION THROUGH A PERIPHERALLY INSERTED CENTRAL CATHETER (PICC)

– Patients with tracheostomy
– Patients in whom the placement of a standard central venous catheter entails an increased risk of insertion-related complications
– Patients with coagulation disorders
– Candidates for home parenteral nutrition (suitability for long-term use has to be confirmed in randomized clinical trials)

ROLE OF PICCs FOR IN-HOSPITAL PARENTERAL NUTRITION

The use of PICCs for central venous access has greatly increased since their introduction (27). The availability of soft and biocompatible materials for modern PICCs has led to the progressive spread of PICCs, even in acute surgical patients and intensive care units. However, results from published studies have been difficult to interpret and did not yield definitive and clear-cut indications or advantages of PICCs over other central catheters, as the data suffered from retrospective design, or because of differences in the definition and quantification of catheter-related complica-

tions, differences in catheter materials, and sizes and number of catheter lumens (28).

The incidence of catheter-related blood infections has been shown to range from 1.1 to 2.5 per 1,000 catheter days for PICCs (27, 29-31) compared with 1.2 to 14.7 per 1,000 catheter days for central lines (32, 33). The mean time of occurrence of suspected or proven PICC-related total infections in the largest prospective PICC cohort was 32.4 days, with a standard deviation of 26.0 (27, 28). An increased number of PICC lumens is associated with a higher frequency of catheter manipulation, which has been shown to enhance the infection risk (34).

Thrombotic and phlebitic complications with PICCs have been shown to be equally or slightly more frequent than with other central lines. Ultrasonography has shown that up to 3% of patients with jugular or subclavian lines present a totally occlusive thrombus (35), whereas the incidence of upper extremity deep venous thrombosis has been prospectively shown to occur at an average rate of 3.4% with PICCs (28), or even less in recent studies (31). PICC-related phlebitis has been reported to occur in 4-36% of patients with a silicone PICC (36, 37). A recent study showed that the incidence of PICC-associated thrombosis is decreased with the use of anticoagulants for in-hospital patients, so future studies should address if prophylactic anticoagulants are useful in reducing such complications (38).

Catheter occlusion rates of 2-18% have been reported, but restoring function is usually successful in more than 90% of cases, and also safe, with low doses of recombinant tissue plasminogen activator or urokinase (39, 40). Catheter occlusion does not seem to occur more frequently with PICCs than with central lines in the acute-care setting (41, 42). Moreover, pneumothorax is abolished by PICC placement, in contrast to its occurrence in 1.5-3% of insertions of other central catheters, especially by the subclavian approach (43). Arterial puncture is not a complication of PICC insertion either, compared to an incidence of 6-9% with internal jugular access (43).

A recent review has shown that PICCs are similar to central lines in terms of overall complications when used in the acute care of surgical patients, as infectious complications were similar between the two types of catheters and only a slight increase in thrombotic complications with PICC use was shown (28). However, this review included data of PICCs and central lines used not only for parenteral nutrition and with different materials and lumens. Another study found that PICCs used for parenteral nutrition for in-hospital patients showed only an increased incidence of local complications such as leaking, phlebitis and malpositioning compared to other tunneled and non-tunneled catheters (44). However, the authors stated that there was no dedicated team for insertion and management of central lines, and only 15% of catheters were used exclusively for parenteral nutrition. Furthermore, in most of these studies PICCs were inserted by the blind technique, which is associated with more complications than the ultrasound-guided technique.

At our Institution, in 2007 and 2008 a total of 370 PICCs were implanted for a total of 20,220 days of catheter usage. Of these, 108 were used for parenteral nutrition and 11 for home parenteral nutrition. The following complications occurred: 20 catheter occlusions resolved with urokinase administration, 4 cases of local phlebitis resolved without catheter removal, 6 instances of catheter damage repaired by specific kits, and 7 catheter removals, 2 because of thrombosis and the remaining 5 because of bloodstream infections (unpublished data). It is noteworthy that at our Institution modern PICC materials are currently employed, and the management of all inserted PICCs is performed by a specialized team.

ROLE OF PICCS FOR HOME PARENTERAL NUTRITION

Although parenteral nutrition was initially limited to hospitalized patients, it has become a common therapy for patients at home and is then known as home parenteral nutrition (45). It is believed that there are approximately 40,000 patients in the United States receiving home parenteral nutrition therapy (46). The prevalence of home parenteral nutrition ranges from 120 patients per million population in the United States to 2-4 in Europe or 1.5 in Spain, and the most frequent indications are short-bowel syndrome and active cancer (47). The largest group of patients is aged between 40 and 60 years, with children accounting only for 10-20% of. Almost two thirds of patients apply parenteral nutrition through a tunneled catheter, and the most frequent complication is catheter-associated blood infection. At the present time, prognosis and survival in the medium and long term are better with home parenteral nutrition than with intestinal transplant, so the latter should be reserved for those patients who present severe complications with home parenteral nutrition (47). The standardization of care and the development of good education programs may contribute to an improvement in the results, with emphasis on the caregiver, who may be an important contributor to the quality of life in these patients (47-49).

A recent study has shown that patients with PICCs

for home parenteral nutrition had a statistically significant increase in catheter-related infections compared with patients carrying other central venous access devices (50). There was no statistically significant increase in catheter-related infections between diabetic and non-diabetic patients, so this was not a confounding factor in this study. The patients were followed for 12 months or until parenteral nutrition was discontinued. The authors concluded that the use of PICCs for home parenteral nutrition may be associated with an increase in catheter-related infections. However, the study was retrospective, and catheter-related infection was defined as a positive blood culture either before or within 48 hours after a catheter was removed. Therefore, false-negative results may have occurred and some patients with associated infectious complications may have been missed (50).

It must be remembered that the patient receiving home parenteral nutrition is different from the hospitalized patient, as parenteral nutrition is often needed for longer periods of time. In fact, the average length of home parenteral nutrition therapy is around 90 days, and this prolonged therapy is highly dependent on catheter durability and safety (51). The first cause of readmission to the hospital of such patients is catheter-related infection, with a reported rate of 0.9 per 1,000 catheter days (51) to 0.3 per 100 catheter days (52). The etiology of such infections is multifactorial and highly dependent on the patients and their compliance with catheter care and adherence to sterile techniques during catheter placement. It is also possible that, although the arm is believed to be less colonized with bacteria than the chest wall (53), in patients on home parenteral nutrition it may actually be more exposed to the environment, including trauma, temperature and contamination, in contrast to the situation of the hospitalized patient.

Because of the ease of placement, PICC has become the standard of care for vascular access devices for home parenteral nutrition at many institutions, but the risk of catheter infection and other catheter-related complications might not favor PICC over long-term central catheters in this population. Therefore a randomized, prospective study of PICC versus long-term central catheters is urgently needed.

CONCLUSIONS

The availability of modern biocompatible materials for PICCs has made progressive widespread use of PICCs possible, even in acute surgical patients and intensive care units. The low rate of infectious complications, in some cases even less than with other central lines, together with the ease of placement and the avoidance of pneumothorax and arterial puncture, have made PICCs a reasonable alternative to other central catheters for parenteral nutrition of hospitalized patients. PICCs have shown only an increased incidence of local complications such as leaking, phlebitis and malpositioning compared to other tunneled and non-tunneled catheters, which are acceptable risks in most patients in whom a PICC is indicated, because PICCs offer other clear advantages. On the other hand, although PICC has become the standard of care for vascular access devices for home parenteral nutrition at many institutions, a randomized, prospective study of PICC versus long-term central catheters is urgently needed in order to establish if PICC is also a good alternative for patients needing home parenteral nutrition.

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