The Art and Science of Infusion Nursing

Jeong Yun Park, PhD, RN, KOAPN
Hyun Lim Kim, BSN, RN, KOAPN, CRNI®, CPHON®

# A Comprehensive Review of Clinical Nurse Specialist-Led Peripherally Inserted Central Catheter Placement in Korea

## 4101 Cases in a Tertiary Hospital

**ABSTRACT**

Peripherally inserted central catheters (PICCs) are expected to be convenient and reliable venous access devices. The purpose of this study was to analyze clinical nurse specialist (CNS)-led PICC placement and to describe its growth in a tertiary hospital. A computerized database identified 3508 patients who had PICCs placed between November 2001 and June 2010. One thousand, eight hundred ninety-eight of the 4101 PICCs were available for complete follow-up, and 791 of 1898 PICCs were still in place. The mean dwell time of 1898 PICCs was 27.4 days (1~422 days). Most PICCs were removed after the completion of infusion therapy; the remainder were removed following death, occlusion, suspected infection, or phlebitis, or were removed by the patient. The study found that CNS-led PICC placement for infusion therapies was effective and safe with relatively low complication rates and that CNSs played important roles in the increased use of PICCs.

**Key words:** nurse clinicians, catheterization, nursing, central venous catheter, evidence-based nursing

**Author Affiliations:** Department of Clinical Nursing, University of Ulsan, Seoul, Korea (Dr Park); and Department of Nursing, Asan Medical Center, Seoul, Korea (Ms Kim).

**Jeong Yun Park, PhD, RN, KOAPN,** is an assistant professor of clinical nursing at the University of Ulsan in Seoul, Korea. She led Korea's first peripherally inserted central catheter program as a clinical nurse specialist. Dr. Park has conducted clinical research for 10 years and taught graduate students for 3 years.

**Hyun Lim Kim, BSN, RN, KOAPN, CRNI®, CPHON®,** is a clinical nurse specialist at the Asan Medical Center at Seoul, Korea. She has been a clinical nurse specialist in infusion therapy since 2010, specializing in oncology. Her role is to improve nursing practice through standardization of education for infusion nursing, PICC insertion, and the management of vascular devices.

The authors have no conflicts of interest to disclose.

**Corresponding Author:** Jeong Yun Park, PhD, RN, KOAPN, Department of Clinical Nursing, University of Ulsan, 86 Asanbyeongwon-gil, Songpa-gu, Seoul, Korea 138-746 (pjyun@ulsan.ac.kr).

DOI: 10.1097/NAN.0000000000000093

## INTRODUCTION

Reliable venous access devices are essential for patients receiving infusion therapy. Intravenous drug infusion and catheter handling are an important part of patient care, particularly for patients with advanced disease or those undergoing intensive systemic therapy. Peripheral catheters are frequently inserted in infusion therapy but need to be replaced regularly to prevent catheter-related complications, such as phlebitis, thrombophlebitis, and infection.[1,2]

Central venous catheters (CVCs) provide consistent intravenous access without repeated venipuncture but may cause life-threatening complications, such as pneumothorax, hemothorax, and hemorrhage.[3,4] Peripherally inserted central catheters (PICCs) are easily inserted through peripheral veins, such as the basilic or cephalic veins, leaving the tip residing in the superior vena cava (SVC). PICCs have fewer catheter insertion-related complications and allow both drug infusion and blood sampling.[5,6] Most PICCs last for weeks to months. PICCs are expected to be a convenient device, replacing peripheral and central venous catheters. They have been

  

used to administer intravenous fluids, parenteral nutrition, anticancer agents, and antibiotics, as well as for through-line blood sampling. Many studies have shown the use of PICCs to be clinically effective as well as cost-effective.[4-6]

Clinical nurse specialists (CNSs) began inserting PICCs at a major medical center in Seoul, Korea, in 2001; since that time, the use of PICCs has increased. In most hospitals in Korea, PICCs are placed by a certified nurse or an interventional radiologist. There are few reports of PICCs being placed by certified nurses, of their use, or of outcomes.

The purpose of the study is to report on and analyze the use of PICCs in patients since CNSs first began inserting catheters in 2001 through 2010. The study's specific aims were to (1) describe the characteristics of patients who had PICCs inserted, (2) describe the main indications for PICC insertion in the patients, (3) analyze the most frequent complications among the patients, (4) verify reasons for PICC removal, and (5) learn the dwell time of PICCs.

## DESIGN AND METHODS

### Research Design

This was a descriptive study with retrospective data collection, using medical records of the patients who had a PICC inserted between November 1, 2002, and June 30, 2010, at a 2680-bed, acute care hospital that provides a wide range of surgical and medical services. The medical institution is the largest hospital in Korea. Health care professionals are routinely trained in infection-prevention strategies. Yearly evaluations of CVC management help ensure that health care professionals maintain skills and provide consistent care.

### Sampling and Data Collection

PICC insertion service comprises 1 CNS who is credentialed in infusion therapy. PICCs are placed at the bedside under sterile conditions, with the CNS using a mask, sterile gloves, and a sterile gown. PICCs are inserted using a blind-insertion technique; the method involves the use of a "peel-away" over the needle and a plastic cannula. An over-the-needle plastic introducer is inserted into the vein, and the steel stylet is removed, leaving the introducer in place. The PICC is inserted through the introducer, after which the introducer is retracted and broken apart.

Two types of PICCs are used at the hospital: single lumen (3 Fr, 4 Fr, 5 Fr, and 6 Fr) and double lumen (5 Fr and 6 Fr). Typically, the CNS decides which catheter will be inserted, based on patients' venous conditions and indications for the PICC. The diameter of the double-lumen catheter is more than 5 Fr. In patients with difficult intravenous access, it would be more difficult to insert a double-lumen catheter. The CNS inserts the PICC in either the basilic, median cubital, brachial, or cephalic vein. The basilic vein is widely used for PICC insertion because it offers better palpation, visualization, and catheter migration. To confirm when PICCs are placed in the SVC, the location of the catheter tip is determined by radiography. The exit site of the PICC receives dressing changes with aseptic technique once a week or sooner, if soiled. When not in use, PICCs are flushed daily with heparinized solution (100 unit/mL) by ward nurses. When caring for discharged patients with a PICC, PICC education for patients and their family members is conducted before discharge.

Data for 3508 patients who underwent an attempted PICC insertion performed by the CNS between November 2002 and June 2010 were reviewed. Among 3508 patients, 448 had more than 1 PICC placement, and each placement was counted as a new event for the purposes of the analysis. During the study period, 4101 PICC placements were analyzed. Patients were followed until catheter removal, death, or discharge from the hospital. Information obtained included patient characteristics such as age, gender, diagnosis, indication for catheter placement, device type, site of venous access, and catheter tip position. PICC dwell time was calculated as the difference between the insertion and removal dates. The reasons for PICC removal included either the end of therapy or removal with no evidence of a complication, the death of the patient, and PICC-related complications, such as occlusion, dislodgment, dermatitis, and mechanical phlebitis. An *occluded line* was defined as a catheter in which blood could not be withdrawn or one in which there was a total inability to flush the line. *Phlebitis* was defined as the presence of signs of venous inflammation responsive to conservative management (warm compresses) without fever or systemic signs of infection. Damaged PICCs were those that leaked when used. *Infections* were defined with clinical signs, including fever, purulent drainage from the insertion site, or evidence of phlebitis not responding to conservative management, in addition to positive blood cultures drawn from the line or positive line-tip cultures defined as more than 15 colony-forming units using standard catheter roll-plate semiquantitative techniques.

### Data Analysis

All analyses were performed using SPSS 18.0 version software (IBM). Continuous variables were compared by *t* test or analysis of variance. Categorical variables were compared with the chi-square test of the Fisher exact test, when appropriate. The incidence rates of infection were computed per 1000 days of catheterization using a binomial test for incidence rates. All

*P* values were based on a 2-tailed test of significance. The findings were considered statistically significant ($P < .05$).

### Ethical Considerations

The study was approved by the medical center's institutional review board; its institutional review committee determined that the survey met criteria for exempt research.

## RESULTS

### Patient Characteristics

The demographic characteristics of patients, number of PICC placements, and medical units involved are listed in Table 1. A total of 4101 PICCs were inserted into 3508 patients. The patient population included 2010 (57.3%) males and 1498 (42.7%) females. The mean age was 53.3 years (SD = 17.5 years); the minimum and maximum ages were 1 and 96 years, respectively. When analyzing the following age groups: less than 10 years; 10 to 19 years; 20 to 29 years; 30 to 39 years; 40 to 49 years; 50 to 59 years, 60 to 69 years; and 70 years and above, the largest group was 60 to 69 years (23.6%, n = 827), followed by 50 to 59 years (21.3%, n = 747) and 70 years and above (17.7%, n = 622). PICCs had been placed twice in 359 patients, 3 times in 54 patients, 4 times in 22 patients, and 7 times in 3 patients. The PICCs were inserted in a diverse patient population. The medical service having the most patients with PICC placements was oncology-hematology, with 1187 patients (33.6%).

### PICC Placement

Table 2 shows the results related to PICC placement. The rate of successful PICC placement was 92.1%. In 4101 attempts, 302 insertion failures (7.9%) occurred. Figure 1 shows the number of PICC placements from 2001 to 2010 by half-year. The rate of PICC placements steadily rose from 2001 to 2010.

Regarding the indication for PICC insertion, infusion therapy for those patients with difficult venous access was the leading characteristic, present in 88.0% (n = 3608) of all subjects. The other insertions were used for antibiotic therapy (5.0% [n = 207]) and chemotherapy, which occurred in 3.2% of patients (n = 130). In 2492 patients (65.9%), the basilic vein was chosen for venous access.

Some 3466 single-lumen PICCs (84.5%) were placed; 635 (5.5%) were double-lumen catheters. The devices used included L-Cath (n = 1391), an 18 G, single-lumen catheter (Luther Medical Products); and Per-Q-Cath (n = 2075), a 4 Fr, single-lumen catheter (Bard Access Systems). The L-Cath has not been used since 2006, when imports of the product were suspended by vendors.

**TABLE 1**
**Patient Characteristics (N = 3508)**

| Characteristics | Number of Patients | Percentage |
|---|---|---|
| Gender | | |
| Male | 2010 | 57.3 |
| Female | 1498 | 42.7 |
| Age (years), mean (SD), range | 53.3 (17.5), 1-96 | |
| < 10 | 43 | 1.2 |
| 10-19 | 112 | 3.2 |
| 20-29 | 214 | 6.9 |
| 30-39 | 366 | 10.4 |
| 40-49 | 550 | 15.7 |
| 50-59 | 747 | 21.3 |
| 60-69 | 827 | 23.6 |
| ≥ 70 | 622 | 17.7 |
| Number of PICC insertions (per patient) | | |
| 1 | 3060 | 87.2 |
| 2 | 359 | 10.2 |
| 3 | 54 | 1.5 |
| 4 | 22 | 0.6 |
| 5 | 8 | 0.2 |
| 6 | 2 | 0.1 |
| 7 | 3 | 0.1 |
| Medical department | | |
| Oncology/hematology | 1178 | 33.6 |
| Internal medicine | 465 | 13.3 |
| General surgery | 343 | 9.8 |
| Orthopedics | 282 | 8.0 |
| Infection | 208 | 5.9 |
| Pulmonary | 206 | 5.9 |
| Cardiology | 176 | 5.0 |
| Neurosurgery | 174 | 5.0 |
| Obstetrics | 109 | 3.1 |
| Other[a] | 351 | 10.0 |

[a]Nephrology (87; 2.5%); rehabilitation (66; 1.9%); pediatric oncology (65; 1.9%); ENT (40; 1.1%); neurology (23; 0.7%); plastic surgery (23; 0.7%); cardiosurgery (20; 0.6%); urology (13; 0.4%); psychology (6; 0.1%); endocrine (5; 0.1%); dental (3; 0.1%).
*Abbreviations: ENT, otolaryngology; PICC, peripherally inserted central catheter.*

Among patients who had successful placement, 1933 PICCs (51.2%) were inserted using a right-arm approach, and 1846 (48.8%) via a left-arm approach. In addition, 1412 PICCs (37.4%) were located in the upper arm and 2367 (62.7%) in the lower arm.

**TABLE 2**

## PICC Placement (N = 4101)

| Characteristics | Number of Patients | Percentage |
|---|---|---|
| Result of attempted PICC placement | | |
| Successful | 3779 | 92.1 |
| Failed | 322 | 7.9 |
| Indication | | |
| Antibiotic therapy | 207 | 5.0 |
| Chemotherapy | 130 | 3.2 |
| Parenteral nutrition therapy | 119 | 2.9 |
| Venous access | 3608 | 88.0 |
| Other therapy | 37 | 0.9 |
| Venous access site[a] | | |
| Basilic | 2492 | 65.9 |
| Cephalic | 1169 | 30.9 |
| Median antecubital | 118 | 3.2 |
| Device type (and size) | | |
| Single (3 Fr, 4 Fr, 5 Fr) | 3466 | 84.5 |
| Double (5 Fr and 6 Fr) | 635 | 15.5 |
| Inserted arm[a] | | |
| Right side | 1933 | 51.2 |
| Left side | 1846 | 48.8 |
| Arm site[a] | | |
| Upper arm | 1412 | 37.4 |
| Lower arm | 2367 | 62.7 |
| Follow-up[a] | | |
| Complete follow-up | 1898 | 50.3 |
| Follow-up loss | 1090 | 28.8 |
| Still in place at the last follow-up | 791 | 20.9 |

[a]Includes only successful PICC placement.
*Abbreviation: PICC, peripherally inserted central catheter.*

Of the 3779 PICCs inserted, complete follow-up was available on 1898 PICCs (50.2%), with 791 PICCs (20.9%) still in place at the last follow-up or having an unknown PICC status. Some 1090 PICCs (28.8%) could not be followed up on.

### PICC Removal

Of the 1898 PICCs analyzed, total catheter days were 52 060. PICCs were in place before removal for a median of 15 days (range, 1-422 days). Data showed that 47.7% of patients had PICCs in place for 2 weeks; 25.4% of patients used a PICC for more than 1 month (Table 3).

The reasons for PICC removal are listed in Table 4. Some 1167 PICCs (61.5%) were removed following the completion of therapy, and 152 PICCs (8.0%) were removed because the patient died of his or her medical condition. The median time before each occurred was 18 days (range, 1-363) and 14.5 days (range, 1-164), respectively. Additional reasons for removal included a suspected infection in 67 PICCs (3.5%; 1.34 per 10 000 catheter days); accidental dislodgment in 143 PICCs (7.5%; 2.86 per 10 000 catheter days); a catheter occlusion in 86 PICCs (4.6%; 1.74 per 10 000 catheter days); and phlebitis in 59 PICCs (3.1%; 1.18 per 10 000 catheter days). The median time before the occurrence of PICC-related complications was 10 days (range, 1-394); a suspected infection, 15 days (range, 2-360 days); accidental dislodgment, 6 days (range, 1-107 days); a catheter occlusion, 16 days (range, 1-186 days); and phlebitis, 5 days (range, 1-194 days).

## DISCUSSION

This descriptive study is the first to verify the usefulness of a CNS-led PICC insertion program during 9 years of data collection at the medical center. CNS-led PICC insertion can be used for parenteral nutrition, chemotherapy, and transfusion, as well as for measuring central venous pressure. It also offers a safe and effective alternative for central venous access.

The insertion of PICCs continues to increase because of the ease of insertion by nursing staff at the bedside, increased dwell time, and reduced complication rates. In this study, more than 90% of patients had PICCs inserted successfully, and PICCs were used in many clinical situations requiring extended periods of infusion therapy. About 50% of PICCs lasted 2 weeks on average. These results are comparable to studies in the literature that PICCs can be used for more than 5 days of infusion therapy.[7]

In this study, patients with difficult venous access who received infusion therapy represented 88.0% (n = 3608) of subjects. Although the venous condition was good for peripheral IV therapy, PICCs should have been inserted for long-term delivery of antibiotics or parenteral nutrition in less than 10% of cases, indicating that the decision for placement of PICCs depends on peripheral vascular condition. In a review of the literature, the use of PICCs was for infusion of antibiotics and chemotherapeutics.[2]

In 66% of patients, the basilic vein was selected for PICC placement. It was the most widely used vein because it offered better palpation, visualization, and catheter migration. The preferred location of PICCs for patients is the upper arm. Patients who have PICCs in the lower arm are afraid of bending their arm; however,

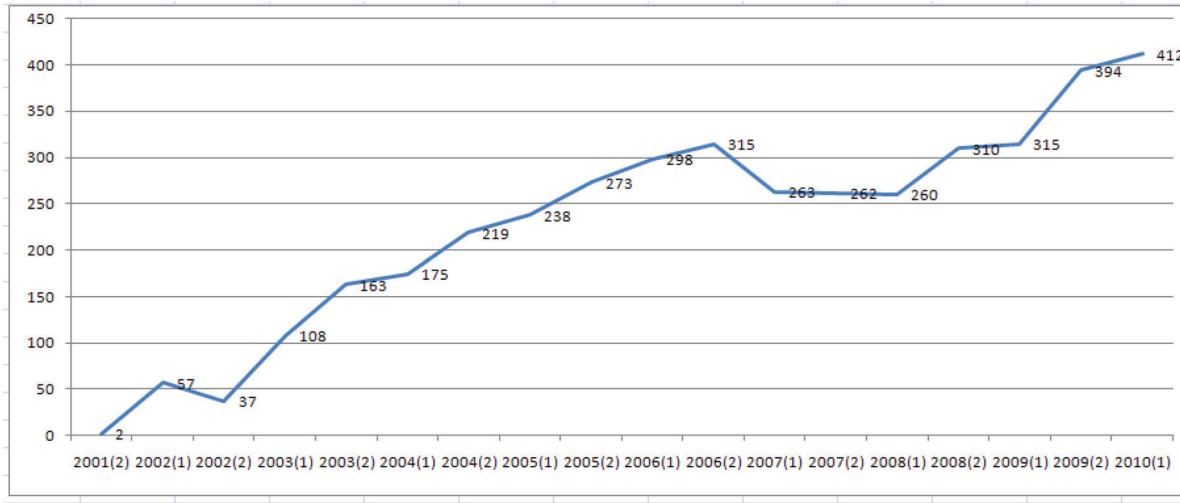


**Figure 1** Peripherally inserted central catheter (PICC) insertion rate by half-year (2001-2010).

the preferred location for the inserter is the lower arm, owing to easier access. Recently, the use of microintroducer and venous ultrasound PICC placement has demonstrated an improved success rate for PICC placements,[8] which enhanced accessibility to upper extremity veins. PICC placement above the antecubital fossa will result in a decrease in mechanical phlebitis and an increase in patient satisfaction and comfort.

One hundred eleven PICCs had a dwell time of 1 day. The reasons for removal included completion of therapy in 48 PICCs (43.2%), self-removal in 35 PICCs (31.5%), and death in 7 PICCs (6.3%). Vesicant chemotherapeutic agents need a central venous catheter for continuous infusion, according the institution's guideline for chemotherapy. Although the administration of repeated cycles of chemotherapy is expected, patients ask that their PICCs be removed at discharge. To maintain catheters at home, patients need to be educated extensively. Early device selection at the beginning of therapy is helpful for patient care, and patients should be involved in the selection of their PICCs.

**TABLE 3**
## Duration of PICC Use (n = 1898)

| Catheter Days | n (%) |
|---|---|
| Total catheter days | 50 060 |
| M (SD), median, range | 27.43 (40.04), 15, 1-422 |
| Duration of PICC use (days) | |
| 1 | 111 (5.9) |
| 2-14 | 794 (41.8) |
| 15-30 | 510 (26.9) |
| ≥ 31 | 483 (25.4) |

*Abbreviations: PICC, peripherally inserted central catheter; M, mean; SD, standard deviation.*

The incidence of PICC-related complications in this study was 9.03 per 1000 catheter days. The results are comparable to research that has reported the incidence of PICC complications to be 2.2 to 16.0 per 1000 catheter days.[1-7,9-22]

Most complications occurred between day 7 and day 14 after the placement of the PICC. The most commonly seen complication was accidental dislodgment. The dwell time of PICCs removed as the result of accidental dislodgment was on average 15 days shorter than for those removed as the result of completion of the therapy (14.4 vs 29.1 days). Because PICCs are not sutured, but are secured by a dressing after insertion, they may move from their original position. Therefore, an appropriate method for securing PICCs is required to prevent PICC dislodgment following insertion.

Suspected infection occurred 1.34 per 1000 catheter days in this study, and the reported incidence was 0.46 to 3.4 per 1000 catheter days.[2,4,6,18] Phlebitis and occlusion occurred 1.18 and 1.74 per 1000 catheter days, respectively. Rates of phlebitis in PICCs of 3.8% to 18%[5,7,11] have been reported in the literature. Factors that significantly decreased the development of phlebitis included a smaller venous lumen, leading to a greater likelihood of catheter occlusion or phlebitis from reduced hemodilution and inadequate blood flow around the catheter. Phlebitis is not as serious as infection; however, it causes financial as well as emotional problems. Phlebitis can lead to the line's removal or progressing to an infective process or to the use of empirical antibiotics. An occluded PICC might require the administration of thrombolytic agents to reestablish patency. If patency cannot be established, the line must be removed. If a line must be reinserted, additional costs of nursing time and the new PICC will be incurred. In addition, the

  

**TABLE 4**

## Reason for Catheter Removal (n = 1898)

| Reasons | n (%) | Duration of PICC (days), M (SD), Median, Range | Rate per 1000 Catheter Days |
|---|---|---|---|
| Completion of therapy (no longer needed) | 1167 (61.5) | 29.13 (39.51); 18, 1∼363 | |
| Death | 152 (8.0) | 24.70 (28.86); 14.5, 1∼164 | |
| Removal as a result of complications | 452 (23.8) | 24.76 (41.71); 10, 1-394 | 9.03 |
| Suspected infection | 67 (3.5) | 29.51 (49.05); 15, 2∼360 | 1.34 |
| Noninfection | | | |
| Breakage and leakage | 50 (2.6) | 70.16 (76.59); 41, 2∼394 | 0.99 |
| Accidental dislodgment | 143 (7.5) | 14.36 (21.45); 6, 1∼107 | 2.86 |
| Phlebitis | 59 (3.1) | 13.83 (29.57); 5, 1∼194 | 1.18 |
| Occlusion | 87 (4.6) | 24.70 (28.57); 16, 1-186 | 1.74 |
| Patient request | 14 (0.7) | 14.07 (19.61); 7.5, 1∼77 | 0.28 |
| Edema | 32 (1.7) | 15.37 (22.53); 6, 2∼92 | 0.64 |
| Undetermined | 127 (6.7) | 24.57 (48.97); 9, 1∼422 | 2.54 |

*Abbreviations: PICC, peripherally inserted central catheter; M, mean, SD, standard deviation.*

discomfort caused to the patient with repeated intravenous cannulation attempts must be considered. PICC occlusion can be prevented by regular flushing.

CNSs successfully placed PICCs at patients' bedside. Because increasing numbers of patients have difficult intravenous access, special equipment such as ultrasound is needed to insert PICCs. Training and education of nursing and medical staff is a crucial factor in reducing the rate of complications in PICC insertion. Careful aseptic technique during PICC insertion and education for maintaining PICCs can help reduce PICC-related complications. CNSs developed educational booklets and a PICC program for patients and health care providers to enhance continuity along the care continuum.

In cases needing the prolonged use of PICCs, although complications rarely occur, close observation and nursing are essential, particularly from the time of insertion to day 14 after insertion. Moreover, appropriate patient self-care is highly recommended. In this study, a small number of patients experienced serious complications, such as suspected infection, breakage, and accidental dislodgment. Typically, patients had PICCs reinserted for further therapy, but some patients needed intensive care. Few patients are considered for PICC insertion at the time of initial therapy. Early placement of PICCs should be needed for long-term infusion therapy. It will decrease complications related to IV therapy.

The results of the study suggest that PICCs may be beneficial for patients with long-term infusion therapy when they are appropriately inserted and placed. Careful aseptic technique during PICC insertion and education for maintaining the PICC are needed for long-term safety. Well-developed PICC management protocols to prevent PICC-related complication rates need to be standardized for insertion and include monitoring the maintenance of the PICC.

In conclusion, CNS-led PICC placement has been an effective and safe approach to intravenous therapy in Korea. The insertion of PICCs was successful in 96% of patients. Although a small number of patients experienced serious complications, the study suggests that PICC use can be a safe, convenient method for patients who require infusion therapy if careful aseptic technique during PICC insertion and education for maintaining PICCs are implemented and followed. PICCs offer reliable sites for IV access, reduced complications, and improved comfort for patients who require venous access. Further studies are needed to clarify when PICCs should be inserted in an efficient and timely manner for patients undergoing IV therapy.


## ACKNOWLEDGMENTS

The authors would like to thank the Nursing Department of Asan Medical Center of South Korea for its support.


## REFERENCES


1. Gabriel J, Dailly S, Kayley J. Needlestick and sharps injuries: avoiding the risk in clinical practice. *Prof Nurse*. 2004;20(1):25-26, 28.
2. Periard D, Monney P, Waeber G, et al. Randomized controlled trial of peripherally inserted central catheters vs. peripheral


  

catheters for middle duration in-hospital intravenous therapy. *J Thromb Haemost*. 2008;6(8):1281-1288.
3. Gabriel J. Vascular access devices: securement and dressings. *Nurs Stand*. 2010;24(52):41-46.
4. Hatakeyama N, Hori T, Yamamoto M, et al. An evaluation of peripherally inserted central venous catheters for children with cancer requiring long-term venous access. *Int J Hematol*. 2011;94(4):372-377.
5. Funk D, Gray J, Plourde PJ. Two-year trends of peripherally inserted central catheter-line complications at a tertiary-care hospital: role of nursing expertise. *Infect Control Hosp Epidemiol*. 2001;22(6):377-379.
6. Matsuzaki A, Suminoe A, Koga Y, Hatano M, Hattori S, Hara T. Long-term use of peripherally inserted central venous catheters for cancer chemotherapy in children. *Support Care Cancer*. 2006;14(2):153-160.
7. Baiocco GG, da Silva JL. The use of the peripherally inserted central catheter (PICC) in the hospital environment. *Rev La Am Enfermagem*. 2010;18(6):1131-1137.
8. Royer T. Nurse-driven interventional technology: a cost and benefit perspective. *J Infus Nurs*. 2001;24(5):326-331.
9. Akers AS, Chelluri L. Peripherally inserted central catheter use in the hospitalized patient: is there a role for the hospitalist? *J Hosp Med*. 2009;4(6):e1-e4.
10. Cowl CT, Weinstock JV, Al-Jurf A, Ephgrave K, Murray JA, Dillon K. Complications and cost associated with parenteral nutrition delivered to hospitalized patients through either subclavian or peripherally inserted central catheters. *Clin Nutr*. 2000;19(4):237-243.
11. Crawford M, Soukup SM, Woods SS, Deisch P. Peripherally inserted central catheter program. *Nurs Clin North Am*. 2000;35(2):349-360.
12. Gamulka B, Mendoza C, Connolly B. Evaluation of a unique, nurse-inserted, peripherally inserted central catheter program. *Pediatrics*. 2005;115(6):1602-1606.
13. Ho J, Archuleta S, Sulaiman Z, Fisher D. Safe and successful treatment of intravenous drug users with a peripherally inserted central catheter in an outpatient parenteral antibiotic treatment service. *J Antimicrob Chemother*. 2010;65(12):2641-2644.
14. Kothari D, Gupta S, Tandon N, Mehrotra A. Accidental cut of peripherally inserted central venous catheter. *Intensive Care Med*. 2010;36(12):2154-2155.
15. Lafrenière J. The central catheter inserted peripherally. *Perspect Infirm*. 2006;3(6):27.
16. Larson J, Hanson J. Developing a peripherally inserted central catheter service with registered nurses. *Can Oncol Nurs J*. 1999;9(3):145-146.
17. Meyer BM. Developing an alternative workflow model for peripherally inserted central catheter placement. *J Infus Nurs*. 2012;35(1):34-42.
18. Miller KD, Deitrick CL. Experience with PICC at a university medical center. *J Intraven Nurs*. 1997;20(3):141-147.
19. Oakley C, Wright E, Ream E. The experiences of patients and nurses with a nurse-led peripherally inserted central venous catheter line service. *Eur J Oncol Nurs*. 2000;4(4):207-218.
20. Roy GB, Cheriyan AA, Rymbai ML. How is that? Knotting of a peripherally inserted central venous catheter. *Indian J Anaesth*. 2010;54(3):272-274.
21. Sette P, Dorizzi RM, Azzini AM. Unexpected obstacle in catheter removal could be due to knots spontaneously forming in peripherally inserted central catheters (PICC). *J Vasc Access*. 2011;12(4):387-388.
22. Tian G, Zhu Y, Qi L, Guo F, Xu H. Efficacy of multifaceted interventions in reducing complications of peripherally inserted central catheter in adult oncology patients. *Support Care Cancer*. 2010;18(10):1293-1298.