Standardized Method for Insertion of Peripherally Inserted Central Catheters (PICCs) in Patients with Gastroenterological Diseases: A Retrospective Analysis

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Abstract

Background: Peripherally inserted central catheters (PICCs) are a better alternative to conventional central venous catheters (CVCs). However, PICCs are not widely used in several countries, including Japan, because of the difficulties involved in ultrasound-guided venipuncture and catheter placement under X-ray guidance.

Methods: Patients in whom indwelling PICCs were inserted by the standardized method developed in our department between 2015 and 2016 were enrolled. We analyzed the rate of successful placement of PICCs and the frequency/nature of complications associated with their placement. In all the patients enrolled in the present study, a 4-Fr single-lumen Groshong® catheter had been placed in the upper arm above the antecubital fossa. These catheters were inserted under ultrasound guidance and evaluated by X-ray.

Results: Successful placement was accomplished in 107 (92.2%) of the 116 attempts made to place a PICC. These 107 patients comprised 62 men and 45 women, with a mean age of 68 ±13 years. The major vessel of insertion was the basilic vein (97 patients; 91%). The median procedure time was 32 minutes (9–149 minutes). Complications included bloodstream infection in three (2.8%) patients, phlebitis in three (2.8%) patients, and thrombotic line occlusion in two (1.9%) patients. The median indwelling period was 20 days (13–30 days).

Conclusion: We consider that placement of PICCs is uncomplicated, based on the short procedure time and relatively low rate of complications. Placement of PICCs using a standardized method should be widely adopted as a feasible alternative to CVC placement.

Keywords: catheterization, catheter-related infection, central venous catheter, peripherally inserted central catheter, ultrasound guidance

Introduction

Peripherally inserted central catheters (PICCs) are being increasingly used worldwide as a route for central venous access. In the European Society for Clinical Nutrition and Metabolism (ESPEN) guideline, insertion of a PICC is recommended for short- and medium-term parenteral nutrition for shorter than 3 months1). The Centers for Disease Control and Prevention (CDC) guideline recommends insertion of a PICC for infusions for longer than 6 days2). Numerous reports have suggested that PICC insertion is associated with a lower risk of mechanical complications, along with the advantages of a lower cost of insertion and lower rate of catheter-related infection2–8). The ESPEN guideline also suggests that percutaneous ultrasound-guided cannulation of the basilic vein or brachial vein in the mid-arm is preferred over central venous catheter insertion. However, a conventional central venous catheter (CVC) inserted via the internal jugular vein or subclavian vein remains the most widely selected cen-
tral venous access route in several countries, including Japan. This is because of the difficulty in ultrasound-guided insertion into peripheral vessels and the reluctance in moving patients to an X-ray room for PICC placement. Although no detailed reports have been published recently, the Japan Society for Parenteral and Enteral Nutrition (JSPEN) reported that PICCs were selected for central venous access in only 1.7% of all patients in 2006.

Recently, Hashimoto et al. analyzed the data of 95 patients with hematological diseases who underwent PICC insertion, and found that PICC insertion was safe and had a low rate of complications. In their study, the PICCs were placed by physicians, including residents who had been trained on simulators. For better training and education on PICC placement so as to promote wider use of PICCS, it is important to establish a standardized method, including for preparation of the device and the insertion technique.

We developed a standardized method for PICC insertion following the ESPEN guideline at our Department of Gastroenterological Surgery in April 2015 (Fig. 1). Since that time, all PICCs have been placed in accordance with this standardized method. The staff of our hospital are properly educated on this method and trained for safe insertion of PVCCs with a minimized risk of complications.

Although several reports have analyzed the effectiveness and safety of PICCs, there have been no reports on the usefulness of a standardized method. Therefore, the present study was aimed at determining the effectiveness of standardization of this technique for safe management and better training on PICC placement. We analyzed the rate of successful insertion of PVCCs and the frequency/nature of complications associated with these catheters.

Materials and Methods

This study was conducted as an observational, retrospective study. Patients who had undergone PICC insertion at our department between April 2015 and December 2016 were enrolled. The standardized method for PICC insertion developed at our department is shown in Fig. 1. A PICC is the first choice for all patients who require central venous access at our department. Patients who are expected to fast for longer than 14 days or require preoperative nutrition management received total parenteral nutrition (TPN) via a PICC. The catheter was a 4-Fr single-lumen Groshong® catheter (C. R. Bard, Inc., NJ, USA). All venipunctures were performed under ultrasound guidance. For venipuncture, the basilic vein was chosen first, followed, in case of unsuccessful attempts, by the brachial vein, and then the cephalic vein in the upper arm above the antecubital fossa. All catheters were placed under X-ray in the upper portion of the right atrium and secured on the skin by a sutureless device (StatLock®; C. R. Bard, Inc.).

Most of the PICCs were placed by surgeons, including residents under the supervision of senior surgeons. The procedure was performed under maximal barrier precautions. All of the senior surgeons were certified as being skilled in the procedure after participating in a training seminar for educators of PICC at our institution.

We analyzed the rate of successful placement of PICCs and the complications associated with their insertion. The procedure time was defined as the period from entry of the patient into the X-ray room until the catheter was secured in place.

Complications were defined as all incidents that inevitably necessitated premature removal, and comprised blood stream infection (BSI), phlebitis, and thrombotic line occlusion. BSI was diagnosed in accordance with the guideline of the Infectious Diseases Society of America, and phlebitis was diagnosed in accordance with the guideline of the Infusion Nurses Society. Thrombotic line occlu-
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A complication was defined as catheter obstruction caused by a thrombus, which was diagnosed by observing the catheter itself after its removal, and not by the presence of superficial or deep vein thrombosis.

The protocol for this research project was approved by a suitably constituted Ethics Committee of Kitano Hospital, The Tazuke Medical Research Institute (Approval No. S17-11-001), and conformed to the provisions of the Declaration of Helsinki.

Statistical analysis

Data are presented as the means ± standard deviation, median [range], or n (%).

Results

Among the 116 attempts to place PICCs, successful placement was accomplished in 107 cases (92.2%). The causes of placement failure were as follows: no suitable vessels available for catheter placement (five cases; 4.3%) and axillary venous obstruction (four cases; 3.4%). Although all of these patients eventually underwent PICC placement on another day, they were categorized as failure cases at the first trial and excluded from the present study. Finally, we analyzed the data of the remaining 107 patients. The patients’ characteristics are shown in Table 1. There were 62 men and 45 women, with a mean age of 68 ± 13 years. Among these, 71 (66%) patients were expected to need fasting for longer than 14 days, 31 (29%) required perioperative nutritional management by TPN, and five (4%) had limited venous access for infusions; these last five patients required central venous access for chemotherapy. The vessel of insertion was the basilic vein in 97 (91%) patients, the brachial vein in six patients (5.6%), and the cephalic vein in four patients (3.7%). All of the punctured veins were in the upper arm above the antecubital fossa. The median procedure time was 32 minutes (9–149 minutes).

Table 2 shows the outcomes of the study. The complications were BSI in three cases (2.8%, 1.16/1000 catheter days), phlebitis in three cases (2.8%, 1.16/1000 catheter days), and thrombotic line occlusion in two cases (1.9%, 0.72/1000 catheter days). There were no complications during the procedure. The median indwelling period was 20 days (13–30 days) and the total duration across all of the patients was 2774 days.

Discussion

In the present study, we obtained good results in terms of a short procedure time and a low complication rate, despite the long duration of placement of the catheters. Our definition of procedure time included the time needed for preparation of the devices, ultrasound examination for a suitable vein before the puncture, and other preoperative preparations in the X-ray room. Therefore, our median procedure time of 32 minutes might be comparable with that for conventional CVC placement, despite the apparently more complicated technique of ultrasound-guided puncture for a smaller vein and placement of the catheter under X-ray. We considered that the short procedure time was attributable to the following: insertion of the Groshong catheter using the modified Seldinger technique (MST) instead of over-the-guidewire placement (OTW), and use of a sutureless device (StatLock) for securing the catheter.

Table 1: Patients’ characteristics

| Variables (n=107) |                |
|------------------|---------------|
| Age (years)      | 68±13         |
| Sex              |               |
| Male             | 62 (58)       |
| Female           | 45 (42)       |
| Purpose of placing a PICC |            |
| Fasting for a long period | 71 (66)   |
| Nutritional deficiency | 31 (29)   |
| Venous access limited | 5 (5)     |
| Procedure time (minutes) | 32 [11–149] |
| Punctured vein   |               |
| Basilic vein     | 97 (91)       |
| Brachial vein    | 4 (3.7)       |
| Cephalic vein    | 6 (5.6)       |

Data are presented as mean ± standard deviation, median [range], or n (%).

Table 2: Complications and Outcomes

| Variables (n=107) |                |
|------------------|---------------|
| Complications    |               |
| Blood stream infection | 3 (2.8)   |
| Phlebitis        | 3 (2.8)       |
| Thrombotic line occlusion | 2 (1.9) |
| Period of indwelling (days) | 20 [13–30] |

Data are presented as median [interquartile range], or n (%).
as mentioned below. We consider that establishment of a standardized method, including the above, is important.

The Groshong catheter contains a wire that enables smooth progression of the catheter; the wire is removed after the catheter is placed in the appropriate position. In contrast to the MST described above, OTW placement involves handling of a guidewire that could be as long as 130 cm, can be time-consuming, especially for PICC insertion, and is associated with the risk of contamination of the long guidewire. Therefore, we prefer insertion of the Groshong catheter by the MST.

The appropriate CDC guideline recommends use of a sutureless device (StatLock) for securing the catheter\(^1\). This device is useful, because it does not necessitate the additional use of local anesthesia needed when skin sutures are used for securing the catheter. This device is easily attached to the skin using an adhesive, also enabling shortening of the procedure time. Use of the sutureless device has also been reported to be associated with a reduced risk of PICC-associated thrombosis and BSI\(^{10,11}\). It also eliminates potential festering of wounds associated with skin sutures. Therefore, we included use of this sutureless device for securing the PICC in our protocol.

All venipunctures in our study were performed under ultrasound guidance, in the mid-arm above the antecubital fossa\(^2\). Puncture of visible veins in or below the antecubital fossa is easily performed without ultrasound guidance\(^3\). However, most of the veins above the antecubital fossa are not visible to the naked eye or palpable, and ultrasound guidance is indispensable for venipuncture. The use of ultrasound in our study enabled exercising a choice as to the vein for PICC placement, and reduced the risk of complications, increased the success rate, and reduced the rate of accidental catheter removal\(^{14-18}\). Our comparatively high success rate could also be attributable to standardization of the order of preference for accessing veins (i.e., basilic vein selected first, and if it fails, the brachial vein, followed by the cephalic veins). Furthermore, PICCs that are inserted in the upper arm do not move with each bending of the patient’s arm, unlike the case for catheters inserted in or below the antecubital fossa; this reduces the rate of mechanical phlebitis\(^{27}\). This situation is also beneficial for the patients’ comfort, because it affords them freedom of movement of the arm\(^{17}\).

In the present study, we examined the three major complications: BSI, thrombotic occlusion, and phlebitis. Our study showed that each of these complications occurred at relatively low rate as compared to previous reports, as follows. First, with regard to BSI, several studies have shown advantages of PICC insertion over insertion of conventional CVCs. Kluger et al. reported, from their meta-analysis of 206 published studies, that BSI occurred at the rate of 3.3%/2.3 per 1000 catheter-days with conventional CVC insertion, whereas the corresponding figures for PICC insertion were 1.2%/0.4 per 1000 catheter-days\(^7\). Most of the patients included in their study were outpatients. Safdar et al. analyzed the rate of BSI in their systematic review of 33 studies in hospitalized patients\(^{19}\). They reported that BSI occurred at the rate of 3.2%/2.1/1000 catheter-days. Although PICCs are associated with a lower risk of BSI than CVCs in the outpatient setting, in hospitalized patients, the rate of BSI associated with PVCCs is comparable with that of CVCs\(^{5,14,15,20}\). In Japan, Hashimoto et al. analyzed the rate of BSI associated with PICCs exclusively in patients with hematological diseases, and reported a figure of 2.1 per 1000 catheter-days\(^7\). Considering the fact that their study population comprised entirely of immunocompromised hosts who were more prone to BSIs, selection of a PICC may be preferable for patients with a high risk of developing infectious diseases\(^21\).

Second, the incidence of thrombosis as a complication of CVCs has been analyzed in several studies\(^6,22-24\). A recent meta-analysis showed that PICCs were associated with a higher risk of deep vein thrombosis (2.7%) than CVCs\(^{25}\). Although none of the patients in the present study had symptomatic thrombosis, the occurrence of non-symptomatic thrombosis cannot be excluded. This is because no ultrasound examination or contrast-enhanced computed tomography was performed routinely for patients with PICCs at our department. Because a thrombus causing occlusion of a catheter necessitates catheter removal, this situation is clinically important and should also be avoided. Therefore, we analyzed the rate of thrombotic obstruction of the catheter as a complication of PICCs. Although PICCs have a longer lumen than conventional CVCs
and appear to be more easily prone to thrombotic obstruction, the rate of thrombotic obstruction in the present study was low (1.9%). We consider that this result could be attributable to the valve system in the Groshong catheter; the tip of this catheter has a specific valve that prevents blood from entering the catheter and avoids clot formation.

Third, phlebitis is also an important complication of PICCs, especially as these catheters must be inserted in a vessel of smaller diameter than conventional CVCs. In the present study, the occurrence rate of phlebitis was 2.8%. Previous studies have reported rates of phlebitis after PICC placement in the range of 0.7%–15%\(^{16-20}\). Turcotte et al. reported from their review of 48 studies that phlebitis necessitating catheter removal occurred at the rate of 6%. Insertion of PICCs in or below the antecubital fossa is associated with a higher risk of phlebitis, and they should be inserted above the antecubital fossa, as described in our standardized method\(^{16,17}\). A recent literature review reported that the risk of phlebitis is higher when a polyurethane PICC is used as compared to a silicone catheter (the Groshong catheter is made of polyurethane)\(^29\). Furthermore, the most recent guideline of the INS recommends that PICCs should be inserted in vessels where the catheter-to-vein ratio is equal to or less than 45\(^{\circ}\). Theoretically, the catheter-to-vein ratio may influence the risk of occurrence of phlebitis, just like for the case of thrombosis. Although the size of the punctured vein was not determined in our protocol, the type of catheter was standardized. All of the PICCs had a single lumen of a relatively small diameter (4-Fr), and these features could have contributed to the low rate of phlebitis.

Unfortunately, during our study period, only one patient received conventional CVC placement. There was a high risk associated with moving the patient to an X-ray room for PICC placement due to the severity of the disease, and conventional CVC placement was performed in the patient’s own room. Therefore, we could not compare the rate of complications associated with PICC vs. CVC insertion, which was a limitation of the present study. A randomized trial is necessary for detailed comparison between these two types of catheters.

Most of the PICCs in this study were placed by surgical residents under the supervision of senior surgeons in our department. Our standardized method is an important tool for education and training of surgical residents, contributing to their motivation for medical treatment. This technique is undoubtedly important in the clinical setting at any hospital.

In conclusion, placement of PICCs appears to be uncomplicated, based on the short procedure time and low rate of complications. Use of a standardized method for PICC insertion is also useful and effective in terms of training for the procedure.

**Acknowledgments**

We would like to thank Seiji Inori and Toshiaki Ogino of the Department of Radiology at our institution for help with the procedure and useful discussion. We thank Ellen Knapp, PhD, of the Edanz Group (www.edanzediting.com/ac) for editing the draft of this manuscript.

Conflict of Interest: None.

**References**

1) Pittiruti M, Hamilton H, Biﬁ R, et al.: ESPEN Guidelines on Parenteral Nutrition: central venous catheters (access, care, diagnosis and therapy of complications). Clin Nutr 28: 365–377, 2009

2) O’Grady NP, Alexander M, Burns LA, et al.: Guidelines for the prevention of intravascular catheter-related infections. Clin Infect Dis 52: e162–193, 2001

3) Graham DR, Keldermans MM, Klemm LW, et al.: Infectious complications among patients receiving home intravenous therapy with peripheral, central, or peripherally placed central venous catheters. Am J Med 91: 95S–100S, 1991

4) Raad II, Hohn DC, Gilbreath BJ, et al.: Prevention of central venous catheter-related infections by using maximal sterile barrier precautions during insertion. Infect Control Hosp Epidemiol 15: 231–238, 1994

5) Maki DG, Kluger DM, Crnich CJ: The risk of bloodstream infection in adults with different intravascular devices: a systematic review of 200 published prospective studies. Mayo Clin Proc 81: 1159–1171, 2006

6) Duerksen DR, Papineau N, Siemens J, et al.: Peripherally inserted central catheters for parenteral nutrition: a comparison with centrally inserted catheters. JPEN J Parenter Enteral Nutr 23: 85–89, 1999

7) Hashimoto Y, Fukuta T, Maruyama J, et al.: Experience of Peripherally Inserted Central Venous Catheter in Patients with Hematologic Diseases. Intern Med 56: 389–393, 2017

8) Mermel LA, Allon M, Bouza E, et al.: Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 Update by the Infectious Diseases Society of America.
9) Gorski LA: The 2016 Infusion Therapy Standards of Practice. Home Healthcare Now 35: 10-18, 2017
10) Yamamoto AJ, Solomon JA, Soulen MC, et al: Sutureless securement device reduces complications of peripherally inserted central venous catheters. J Vasc Interv Radiol 13: 77-81, 2002
11) Petree C, Wright DL, Sanders V, et al: Reducing bloodstream infections during catheter insertion. Radiol Technol 83: 532-540, 2012
12) Joing S, Strote S, Caroon L, et al: Videos in clinical medicine. Ultrasound-guided peripheral i.v. placement. N Engl J Med 366: e38, 2012
13) Uchida Y, Kitade H, Kaibori M, et al: Our Experience with the Groshong Catheter. J Kansai Med Univ 53: 141-147, 2001
14) Cowl CT, Weinstock JV, Al-Jurf A, et al: Complications and cost associated with parenteral nutrition delivered to hospitalized patients through either subclavian or peripherally-inserted central catheters. Clin Nutr 19: 237-243, 2000
15) Janes M, Kalyn A, Pinelli J, et al: A randomized trial comparing peripherally inserted central venous catheters and peripheral intravenous catheters in infants with very low birth weight. J Pediatr Surg 35: 1040-1044, 2000
16) Stokowski G, Steele D, Wilson D: The use of ultrasound to improve practice and reduce complication rates in peripherally inserted central catheter insertions: final report of investigation. J Infus Nurs 32: 145-155, 2009
17) Anstett M RT: The impact of ultrasound of PICC placement. J Assoc Vasc Access 8: 24-28, 2003
18) McMahon DD: Evaluating new technology to improve patient outcomes: a quality improvement approach. J Infus Nurs 25: 250-255, 2002
19) Safdar N, Maki DG: Risk of catheter-related bloodstream infection with peripherally inserted central venous catheters used in hospitalized patients. Chest 128: 489-495, 2005
20) Crnich CJ, Maki DG: The promise of novel technology for the prevention of intravascular device-related bloodstream infection. II. Long-term devices. Clin Infect Dis 34: 1362-1368, 2002
21) Mollee P, Jones M, Stackelroth J, et al: Catheter-associated bloodstream infection incidence and risk factors in adults with cancer: a prospective cohort study. J Hosp Infect 78: 26-30, 2011
22) Chopra V, Anand S, Hickner A, et al: Risk of venous thromboembolism associated with peripherally inserted central catheters: a systematic review and meta-analysis. Lancet 382: 311-325, 2013
23) Grove JR, Pevec WC: Venous thrombosis related to peripherally inserted central catheters. J Vasc Interv Radiol 11: 837-840, 2000
24) Torrione T, Angelo D, Abu Abdou A, et al: Risk factors for upper extremity venous thrombosis associated with peripherally inserted central venous catheters. J Vasc Access 13: 231-238, 2012
25) Warren DK, Quadir WW, Hollenbeak CS, et al: Attributable cost of catheter-associated bloodstream infections among intensive care patients in a nonteaching hospital. Crit Care Med 34: 2084-2089, 2006
26) Turcotte S, Dube S, Beauchamp G: Peripherally inserted central venous catheters are not superior to central venous catheters in the acute care of surgical patients on the ward. World J Surg 30: 1605-1619, 2006
27) Valbeunensquet Schneider L Jr, Duron S, Arnaud FX, et al: Evaluation of PICC complications in orthopedic inpatients with bone infection for long-term intravenous antibiotics therapy. J Vasc Access 16: 299-308, 2015
28) Wang Q, Wang N, Sun Y: Clinical effect of peripherally inserted central catheters based on modified seldinger technique under guidance of vascular ultrasound. Pak J Med Sci 32: 1179-1183, 2016
29) Seckold T, Walker S, Dwyer T: A comparison of silicone and polyurethane PICC lines and postinserterion complication rates: a systematic review. J Vasc Access 16: 167-177, 2015