INTERNAL MEDICINE

□ ORIGINAL ARTICLE □

Experience of Peripherally Inserted Central Venous Catheter in Patients with Hematologic Diseases

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Abstract

Objective Although use of the peripherally inserted central venous catheter (PICC) has become increasingly common, there are few reports of PICCs used for patients with hematologic diseases. In this study, we analyzed the safety of PICC placement in patients with hematologic diseases where PICCs had been placed to perform blood collection, blood transfusion, drug administration, and hematopoietic stem cell transplantation.

Methods This study included 142 PICCs placed in 95 patients managed at our department from November 2013 to December 2015. The PICCs used were the Groshong® Catheter (NXT single-lumen; BARD Inc.).

Results A total of 95 patients underwent the placement of 142 PICCs. The mean patient age was 65.5 years. The total duration of catheterization was 8,089 days, with a mean duration of 57.0 days. Chemotherapy was administered through 107 catheters. Stem cells were injected through 12 catheters. Although a fever was observed in association with 103 catheters, it was generally controlled by antimicrobial therapy. There were 18 catheter-related bloodstream infection (CRBSI) cases, an incidence equivalent to 2.1 cases per 1,000 catheter-days.

Conclusion The present study demonstrated a low CRBSI incidence rate and found no evidence of serious complications with PICC placement. PICCs can be used for blood collection, blood transfusion, drug administration, and hematopoietic stem cell transplantation without problems. Thus, PICC placement appears to be a safe procedure for patients with hematologic diseases. Safe catheters are therefore urgently needed for these patients. We expect that PICCs will be widely adopted in Japan in the near future.

Key words: peripherally inserted central venous catheter, hematologic diseases, catheter-related bloodstream infection, ultrasonographic guidance

(Intern Med 56: 389-393, 2017)
(DOI: 10.2169/internalmedicine.56.7625)

Introduction

Patients with hematologic diseases are often required not only to provide frequent blood samples, but also to undergo medium- to long-term chemotherapy, blood transfusion, antimicrobial therapy, and hematopoietic stem cell transplantation. While these procedures have conventionally been performed with a central venous catheter (CVC) inserted through the subclavian vein or the internal jugular vein, these approaches are associated with the potential development of serious complications, such as inadvertent arterial puncture, hemothorax, pneumothorax, and mediastinal emphysema. Indeed, patients often experience anxiety and discomfort regarding CVC placement. Furthermore, patients with hematologic diseases, who are compromised hosts, are reportedly more likely to develop catheter-related bloodstream infection (CRBSI) than those with other diseases (1). In recent years, the use of the peripherally inserted central venous catheter (PICC) has become increasingly common. The PICC is inserted into a vein of the upper limb under ultrasonographic guidance and advanced through the axillary and subclavian veins, to place the catheter tip in the superior vena cava. Because the PICC puncture site is in the upper limb, patient anxiety can be alleviated, since PICC placement is regarded as being similar to peripheral intravenous

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Received for publication April 26, 2016; Accepted for publication June 14, 2016
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Table 1. **Patients Characteristics.**

Disease	Number of PICC (%)
AML	53 (37.3)
ML	51 (35.9)
MDS	11 (7.7)
MM	8 (5.6)
CML-BC	5 (3.6)
AA	5 (3.6)
POEMS syndrome	3 (2.1)
ALL	2 (1.4)
Others	4 (2.8)
Total	142 (100)

AML: acute myeloid leukemia, ML: malignant lymphoma, MDS: myelodisplastic syndrome, MM: multiple myeloma, CML-BC: chronic myelogenous leukemia-blast phase, AA: aplastic anemia, ALL: acute lymphoblastic leukemia

(PIV) infusion. There are few complications associated with puncture. The safety and efficacy of this procedure have been reported (2). In this study, we analyzed the safety of PICC placement, in patients with hematologic diseases, including benign disorders, in whom PICCs were placed to perform blood collection, blood transfusion, drug administration, and hematopoietic stem cell transplantation.

Materials and Methods

Patients

This study included 142 PICCs placed in 95 patients managed at our department from November 2013 to December 2015.

Methods

PICCs were placed by physicians who had been trained on simulators, including residents supervised by senior physicians. The PICC used was the Groshong® Catheter (NXT single-lumen; C.R. BARD Inc., NJ, USA), which was placed in the right or left basilic vein or brachial vein. In principle, PICCs were inserted under ultrasonographic and fluoroscopic guidance using Site-Rite V® (BARD Inc.), an ultrasound system for vascular access. As for the insertion procedure, the PICCs were inserted under maximum barrier precaution conditions in accordance with the package insert provided with the device. The catheters were fixed with dedicated anchors but not sutured. For needleless catheter connectors, mechanical valves had initially been used, but they were replaced with CLC2000® (ICU Medical Inc., CA, USA), which has a positive displacement mechanism, in November 2015.

Definitions

The diagnostic criteria for CRBSI were based on *the Practical Clinical Guidelines for the Diagnosis and Treatment of Intravascular Catheter-related Infection: Revised by the Infectious Diseases Society of America in 2009* (3), as follows: CRBSI was definitively diagnosed when the same microorganism was isolated from at least one set of blood cultures of samples collected from the skin and the catheter tip or when two blood culture samples (one collected from a catheter hub and the other from a peripheral vein) satisfied the diagnostic criteria for CRBSI (as determined by quantitative blood culture, when the number of colonies of microorganisms isolated from a blood sample collected from a catheter was at least three times larger than that from a peripheral blood sample, or when the difference in time to detection of a positive blood culture was two hours or longer essentially, when a culture of a blood sample collected from a catheter turned positive at least two hours earlier than that of a peripheral blood sample). Hematologists, ward nurses, and nurses certified in infection management diagnosed CRBSI.

Bloodstream infection was defined in as either CRBSI or central line-associated bloodstream infection. Because the definition of the latter was developed based on surveillance of bloodstream infections occurring within 48 hours after central venous catheterization, the definition of CRBSI was used in this study.

Results

From November 2013 to December 2015, 95 patients underwent placement of 142 PICCs (men/women: 62/80 catheters). Catheterization was performed multiple times in 29 patients (a total of 76 catheters), while the procedure was repeated a maximum of 5 times in the same patient during this period. The mean patient age was 65.5 years (range, 22-88 years), and the median age was 67.0 years. With respect to diseases, 53 catheters were placed for acute myeloid leukemia, 51 for malignant lymphoma, and 11 for myelodysplastic syndrome (Table 1).

A total of 107 catheters were inserted as PICCs for chemotherapy and 25 for intravenous hyperalimentation. Ten PICCs were placed because it was difficult to insert the PIV catheter. The most common reason for PICC removal was treatment completion, in 63 cases, while 22 catheters were removed because the patients died. In patients transferred to another hospital, six of seven catheters were kept in place. Events directly involving the PICCs included occlusion in 14 catheters, infection in 10, a fever in 4, catheter damage in 2, and pain at the insertion site and pruritus around the dedicated anchor in 1 each (Table 2). Only 1 of the 142 catheters was removed by a patient. There were no cases developing phlebitis or deep vein thrombosis. The total duration of catheterization across all patients was 8,089 days, with a mean duration of 57.0 days (range, 3-329 days). The mean insertion period of catheters removed due to treatment completion was 60.7 days (range, 4-266 days); occlusion, 64.9 days (range, 3-168 days); infection, 24.6 days (range, 4-66 days); a fever, 40.3 days (range, 14-66 days); death, 43.0 days (range, 5-136 days); and transfer another hospital,

Table 2. Reasons for PICC Removal.

Disease	Number of PICC (%)
Treatment completion	63 (44.4)
Catheter occlusion	14 (9.9)
Clinical suspicion of infection	10 (7.0)
Fever of unknown origin	4 (2.8)
Catheter damage	2 (1.4)
Pain at the insertion site	1 (0.7)
Pruritus around the dedicated anchor	1 (0.7)
Accidental removal	1 (0.7)
Other	1 (0.7)
Death	22 (15.5)
Transfer to another hospital	7 (4.9) (6/7 catheters were kept in place)
In use	16 (11.3)
Total	142 (100)

48.0 days (range, 10-93 days).

As expected, the mean insertion period of catheters removed due to infection and fever tended to be short.

Chemotherapy was administered through 107 catheters. Stem cells were injected through 12 catheters. Opioids and analgesics were administered through 15 catheters. There were no serious complications due to puncture. Although fever was observed in association with 103 catheters, it was generally controlled by antimicrobial therapy. There were 18 CRBSI cases, an incidence equivalent to 2.1 cases per 1,000 catheter-days. The microorganisms involved were *Staphylococcus aureus* in four patients, other *coagulase-negative staphylococci* in three patients, *Pseudomonas aeruginosa* in three patients, *Helicobacter cinaedi* in one patient, *Citrobacter koseri* in one patient, *Candida albicans* in one patient, and *Enterobacter cloacae* in one patient, *Streptococcus parasanguis* in one patient, *Streptococcus sanguis* in one patient, *Corynebacterium striatum* in one patient, *Escherichia coli* in one patient. CRBSI did not occur in the case of hematopoietic stem cell transplantation.

Discussion

CVC insertion is an important medical procedure that is necessary for patients with hematologic diseases, based on disease specificity. While CVCs have conventionally been inserted from the subclavian, internal jugular, or femoral vein, McGee et al. reported that CVC insertion leads to complications (arterial puncture, hematoma, hemothorax, and pneumothorax) in approximately 6% to 19% of cases (4). Furthermore, the CRBSI incidence rate, which varies among different types of CVCs, is high, ranging from 1.2% to 20.9%. According to the United States Centers for Disease Control and Prevention, there are 250,000 CRBSI incidents per year in the United States, and the mortality rates are estimated to range from 12% to 25%, which cannot be overlooked (5).

PICCs are a type of CVC inserted via a vein of the elbow or another site of the upper limb, in order to place the catheter tip in the superior vena cava (6). From an anatomical perspective, PICCs do not cause serious complications, such as hemothorax and pneumothorax. Furthermore, PICCs are considered to be associated with a significantly lower incidence of CRBSI than conventional CVCs. Crnich et al. reported a meta-analysis indicating the number of CRBSI incidents per 1,000 catheter-days to be 2.3 cases for non-tunneled CVCs and 0.4 cases for PICCs (7). This is attributable to the surface of the forearm, as compared to the subclavian region, being associated with a smaller number of bacteria, lower skin surface temperature, lower skin surface humidity, lower risk of contamination with sebum and other substances, and so forth (8). Although PICCs were widely adopted as a safe type of CVC in Europe and the United States in the 1990s, the frequency of PICC use in Japan remained low due to lack of knowledge and low reimbursement rates. In the recent revision of the medical treatment fees under the health insurance system in Japan, reimbursement rates appropriate for the procedure were finally set, and PICCs have since been adopted in some medical facilities. Although there are few reports of PICCs used for patients with hematologic diseases, who are compromised hosts, Sakai et al. indicated that PICCs are useful for hematologic malignancy patients because the incidence of CRBSI in those undergoing PICC placement is low, at just 1.23 cases per 1,000 catheter-days (9). Worth et al. reported that the incidence of CRBSI in patients undergoing PICC placement was 6.6 cases per 1,000 catheter-days, with no significance in terms of the CRBSI incidence rate in patients undergoing PICC placement compared with that in patients undergoing CVC placement, supporting the conclusion that PICC placement is a practical and safe option for patients with hematologic malignancies (10). Our study demonstrated a low CRBSI incidence rate, supporting the results reported by Sakai et al., Bellesi et al. (11), and Lim et al. (12). The difference in the CRBSI incidence rates between each study might be due to variations in the definition of CRBSI. At any rate, PICCs appear to be associated with fewer complications at and after the time of insertion than CVCs.

However, despite these benefits, deep vein thrombosis remains a major complication of PICC placement. In 2013, Chopra et al. conducted a meta-analysis showing that the incidence of deep vein thrombosis was significantly higher with PICC than with CVC placement (odds ratio, 2.55) (13). Although there was no marked difference in the pulmonary embolism incidence, the risk of thrombosis is not negligible when a catheter measuring approximately 40 cm in length is placed in a blood vessel. Medical personnel who are involved in the insertion and management of PICCs should always take the occurrence of thrombosis into consideration and employ innovative approaches to reduce the incidence of and, whenever possible, prevent this complication. The incidence of deep vein thrombosis in the upper limb may have been underestimated, as it is minimally symptomatic and is not generally examined with the aim of making a definitive diagnosis. Furthermore, little is known about the

clinical significance of a thrombus formed on the outer surface of a catheter. These are issues that need to be addressed in the future.

In the present study, there were no cases of deep vein thrombosis. Possible reasons for this include, but are not limited to the blood vessel was punctured under ultrasonographic guidance to minimize vessel damage; a single-lumen catheter with a relatively small diameter was placed in a vein with an adequate diameter; PICCs were not left in place longer than necessary; and blood pressure was measured as infrequently as possible, using a manchette, in the catheterized upper limb. Using a dedicated needle guide may improve the procedural success rate for untrained physicians. However, in order to prevent hematoma from developing around an accidentally punctured blood vessel, the needle guide is not used in our hospital. Instead, we attempt to puncture only the anterior wall with an appropriate motion (called a jabbing motion). To shorten the inserted portion of the catheter as much as possible, its insertion from the right basilic vein or brachial veins is our first choice. However, there is a report describing a multivariate analysis which revealed the insertion of a PICC from the right upper limb to be associated with a higher incidence rate of CRBSI (hazard ratio, 1.60; 95% confidence interval, 1.05-2.44) (1). The optimal insertion site therefore remains controversial.

Finally, the usefulness of PICCs in terms of medical economics merits discussion. As described above, 250,000 patients develop CRBSI annually in the United States, and an additional cost increase of $18,432 US and prolongation of hospital stay by 12 days on average per patient are expected (5). In Canada, an analysis of matching data on patients in the intensive care unit showed that the costs associated with CRBSI rose by $12,000 CA in fatal cases and by $25,000 CA in non-fatal cases, while hospitalization was prolonged by 13.2 days (14). Similar data have been presented in Japan. Morikane et al. estimated that the use of PICCs reduces the incidence of CRBSI and can help reduce the costs of antimicrobial agents by approximately ¥410,000 and the duration of additional time in the hospital by approximately 22 days for each case prevented (15). In this study, an additional cost of approximately ¥220,000 for antimicrobial agents was incurred, and hospitalization was prolonged by 14.0 days on average per CRBSI case. Moreover, a comparison between PICCs and PIV catheters indicated that the cost for exchanging PIV catheters six times is almost the same as that for using a PICC once (16). When infusion is anticipated to be needed for more than six days, the use of PICCs can reduce costs and is thus recommended by the guideline (17).

Several limitations associated with the present study warrant mention. Bias cannot be ruled out because of the single-center, single-arm study design. The incidence of CRBSI or occlusion may have been altered because needleless catheter connectors were changed to a different type during the follow-up period. Finally, there are several sets of diagnostic criteria for bloodstream infection, which lack a standardized diagnostic procedure.

Despite these issues awaiting resolution, the present study demonstrated a low CRBSI incidence rate and found no evidence of serious complications with PICC placement. PICCs can be used for blood collection, blood transfusion, drug administration, and hematopoietic stem cell transplantation without problems. Thus, PICC placement appears to be a safe procedure for patients with hematologic diseases. Well-trained operators can complete this procedure in a few minutes, and there is a great need among patients for such a safe catheter as this. We expect that PICCs will be widely adopted in Japan in the near future.

The authors state that they have no Conflict of Interest (COI).

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