Multifactor Analysis of Malposition of Peripherally Inserted Central Catheters in Patients With Cancer

Xuying Li, RN, MSN, Honghong Wang, RN, PhD, Yongyi Chen, RN, PhD, and Zhong Yuan, RN, BSN

Background: Peripherally inserted central catheters (PICCs) are used widely in patients with cancer, but catheter malposition often occurs.

Objectives: This study aimed to provide a reference for clinically safe catheterization through multifactor analysis of malposition of PICCs in patients with cancer.

Methods: The occurrence of PICC malposition in patients with cancer was retrospectively reviewed, and a multivariate logistic regression analysis was performed.

Findings: Of 2,084 patients with PICCs, 170 cases (8%) of malposition occurred. The multivariate logistic regression analysis revealed that the risk of adverse events from malposition was higher in the right upper limb than in the left upper limb. The highest risk from malposition was cephalic vein puncture, followed by brachial vein puncture. The risk in the lower part of the elbow joint was higher than that in the upper part of the elbow joint. During PICC insertion, the left upper limb and upper part of the elbow joint should be selected for the puncture, and the basilic vein should be selected as the first-choice vein to reduce the incidence of malposition and adverse events.

The safety and convenience of peripherally inserted central catheters (PICCs) have proven to be useful for the administration of anesthetics and toxic drugs, as well as for parenteral nutrition supply (Abedin & Kapoor, 2008; Ahn, Illum, Wang, Sharma, & Dowell, 2013). In modern nursing, PICCs have been widely used for long-term infusion in adults and children. The average retention time of a PICC line is 44–161 days (Yap, Karapetis, Lerose, Iyer, & Koczwara, 2006). A number of significant complications are related to the insertion and maintenance of PICC lines, including catheter malposition, migration, venous thrombosis, and line fracture (Amerasekera, Jones, Patel, & Cleasby, 2009). If the catheter tip is inserted into the heart, precordial discomfort, arrhythmia, cardiac tamponade, and heart valve damage may occur (Song & Li, 2013). If the catheter remains in a peripheral vein, it may induce swelling, pain, edema of the limb, discomfort, and pain at the site where the catheter tip is inserted through the vessel wall. In addition, the placement of the catheter tip in the jugular vein may result in discomfort, difficulty in turning the head and neck, and soreness in the affected side (Moraza-Dulanto et al., 2012). The current study aimed to evaluate and summarize the impact of factors associated with catheter malposition by evaluating a large sample of PICC cases to inform best clinical practices.

Methods

Data from 2,084 patients with cancer with PICCs inserted at vascular access centers and hospital wards were retrospectively analyzed from December 2012 to November 2013. None of the patients had a history of radiation treatment, superior vena cava (SVC) syndrome, or vascular surgery. The tumors were confirmed by pathologic diagnosis.
All patients in the current review had their first PICC catheterization using a number 4 French catheter. The catheterization was performed by a professional PICC nurse who had PICC qualification and more than two years of clinical practice experience. The 10 PICC nurses all were trained and followed the unified PICC catheterization procedures. Of 2,084 patients with cancer, 720 cases (35%) were performed with traditional catheterization, 640 cases (31%) were performed with the modified Seldinger technique (MST), and 704 cases (34%) were performed with ultrasound-guided MST catheterization. All patients were in the supine position when the catheterization was performed and had successful first-time puncture for placement. After the successful catheterization, a chest x-ray was performed to determine the catheter tip position. When the catheter tip position was confirmed as correct, the guide wire was pulled out. If the catheter tip position was not correct, it was adjusted, and then the guide wire was pulled out.

PICC malposition was defined as a catheter tip not in the SVC but did not include situations in which the catheter was too long and entered the atrium and ventricle. The constituent ratio was used to describe PICC malposition situations. PICC malposition-related factors (age, gender, disease type, catheterization limb, puncture site, puncture vein, catheter type, and puncture method) were analyzed with descriptive statistics and logistic regression models. The independent variables were added to the model using the backward stepwise regression method, with the inclusion criterion as 0.05 and the exclusion criterion as 0.1. Statistical analysis was performed with SPSS®, version 18.0.

Results

The sample included 2,084 patients aged 16–76 years old, with a median age of 47 years (SD = 11.23 years). Descriptive information about the participants is shown in Table 1. Of the 2,084 patients with PICCs, 170 cases of malposition were seen (8%). The cases of catheter malposition are shown in Table 2.

Of the 170 cases of malposition, the PICC was correctly readjusted in 145 cases (85%). In 21 cases (12%), the readjustment failed and the midline catheter was kept. Of those 21 cases, one case exhibited thrombosis after chemotherapy; therefore, extubation was performed. The rest of the cases were extubated after two-cycle chemotherapy.

Discussion

Acceptable catheter placement for a PICC line is the tip of the catheter being located between the middle third of the SVC and the right atrium. A catheter tip in any other position was considered malpositioned (DeChicco et al., 2007; Trerotola, Thompson, Chittams, & Vierregger, 2007). The current study used a multifactor analysis, which may avoid mutual interference among individual factors or multiple factors, overcoming the one-sidedness of unifactor analysis. The logistic regression analysis was performed to assess the impact of the eight PICC malposition factors.

Two opinions exist about the impact of different puncture sites on malposition. One opinion is that the incidence of malposition when the PICC is inserted in the left upper limb is higher than when it is inserted in the right upper limb (Wrightson, 2013). The distance between the left upper limb and the SVC is longer than the distance between the right upper limb and the SVC; therefore, the right upper limb should be the preferred site for insertion. In another study, no statistical significance was seen between placement in the left and right limbs (Loewenthal et al., 2002). When advocating for PICC placement in the right upper limb, the problem of patients’ handedness also may need to be considered. For example, in right-handed patients, the left upper limb may be preferred. Therefore, selection of left or right upper limb for catheterization is still controversial.

The current study compared the PICC malposition rates of 2,084 cases and found that the malposition rate was higher in right upper limb insertion than left upper limb insertion (p < 0.001). The anatomical lumen was larger in the right than in the left.

Table 2. Cases of Catheter Malposition (N = 170)

<table>
<thead>
<tr>
<th>Location</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jugular vein</td>
<td>103</td>
<td>61</td>
</tr>
<tr>
<td>Axillary vein</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Ipsilateral subclavian vein</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Contralateral subclavian vein</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Brachiocephalic artery</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Other veins*</td>
<td>36</td>
<td>21</td>
</tr>
</tbody>
</table>

*Could not be determined through the anatomic location of chest x-ray

Note. Because of rounding, percentages may not total 100.
In right-side catheterization, the catheter directly touched the left side of the jugular vein, causing malposition in some cases (Paulson & Miller, 2008). In another study (Trerotola et al., 2007), the jugular vein was the most common site of malposition, accounting for 36% of all cases of PICC malposition. The current study also showed that jugular vein malposition accounted for 103 of 170 (61%) cases of PICC malposition. In the current study, the risk ratio of the jugular vein was high at 4.329, but it did not reach statistical significance. The p value was 0.086, which was near the level of statistical significance. In a comprehensive analysis of the evidence of malposition incidence, right upper limb insertion had a higher incidence of malposition. Selection of the left upper limb may reduce malposition incidence, which further broke the traditional concept that the right limb was the preferred catheterization choice.

In the current study, the risk of malposition in the lower part of the elbow joint was 2.185 times of that in the upper part of the elbow joint. The reason may be related to the selection of veins in the upper and lower part of the elbow joint. Nurses often choose PICC catheterization in the veins in the upper elbow, and they commonly use the basilic vein, median cubital vein, and cephalic vein. Theoretically, the basilic vein should be the first choice. However, the basilic vein lies in the cubital fossa, obliquely upward along the ulnaris. Its position is deeper, which increases puncture difficulty. The median cubital vein and cephalic vein lie in the superficial position of the cubital fossa and the directions of the vessels are intuitive, which makes identification and location easy. Catheterization typically is performed in the lower part of the elbow joint by naked eye observation or palpation. Most nurses choose the median cubital vein and cephalic vein for punctures. The median cubital vein has many branches and vein grafts at the cubital fossa, and the cephalic vein has a tortuous venous path, leading to higher malposition incidence. Catheterization in the upper part of the elbow joint is performed mostly under ultrasound guidance. Nurses can select the basilic vein for the puncture with ultrasound guidance.

Malposition rates of different veins were significantly different, which could be seen from the data showing that malposition incidence was higher when the cephalic vein was used than when the median cubital vein and basilic vein were used as insertion sites. Therefore, when selecting the vessel for insertion, the basilic vein should be the first choice to reduce the incidence of malposition, consistent with evidence from domestic and international studies (Moret, Tequi, & Lombrail, 2004). However, in clinical practice, because of the anatomic characteristics of the basilic vein, the selection of the basilic vein requires the operator to be very familiar with the strike characteristics of the three veins in the cubital fossa. In particular, the path of the median cubital vein may vary, with a division in the median cephalic vein and median basilic vein in the elbow area and insertion into the cephalic vein and basilic vein with a “Y” shape (Moureau, 2013). All operators need to clearly determine the right path; otherwise, the catheter may easily lead to the cephalic vein, increasing malposition incidence. In addition, the use of the B-mode ultrasound-guided PICC catheterization technique is strongly recommended to improve the preferred selection of the basilic vein.

Interventions, such as chest x-ray confirmation of placement before withdrawing the guide wire, strict disinfection and isolation measures, and establishment of specialized patient file maintenance, are known to have the potential to greatly reduce the risk of PICC complications (Paulson & Miller, 2008). Since the clinical introduction of PICC lines, reducing malposition has been a focus of clinical nursing practice. The incidence of malpositioned catheters is 5%–31%, which includes malpositioned catheters, catheter slides or extrusions, and catheter drifts (Song & Li, 2013). In the current study, the malposition rate was 8%, which is within the range proposed by other studies. The researchers believed that this was related to the recent specialization and standardization of PICC technology and guidelines, with many local hospitals requiring insertion by trained and qualified PICC nurses. PICC malposition has been reported to be related to the compression of lymph nodes or lumps in the puncture side, as well as the patient’s emotional stress and incorrect posture (Baxi et al., 2013). Professional PICC nurses have specialized training to assess the patient’s local and systemic vessels before catheterization, effectively exclude contraindicated sites, and choose the best puncture location and vessel. Throughout the entire process, nurses include health education for the patient so the patient understands the relevant knowledge and can properly cooperate with the catheterization procedure under the guidance of professional PICC nurses.

Many factors may influence PICC malposition. The literature shows that it has been related to age but not gender, puncture method, or lesion location (Song & Li, 2013). Wrightson (2013)
Implications for Practice

- Use the left upper limb and upper part of the elbow joint for peripherally inserted central catheter (PICC) line insertion to reduce the incidence of malposition.
- Improve the placement accuracy of PICC insertion with standardized and specialized operations and specialty training for professional nurses.
- Select the basilic vein as the first-choice vein to avoid malposition and adverse events.

revealed that changing puncture position from supine posture to semirecumbent posture or sitting straight could reduce the incidence of malposition. In the current study, analyses of 2,084 cases revealed that age, gender, disease type, catheter type, and puncture method had no effect on incidence of malposition.

In the current study, although most malpositioned PICCs could be adjusted correctly through a variety of methods, vascular anatomic differences exist that do not allow for readjustment of malpositioned PICCs. The success rate of malpositioned PICC readjustment has been reported to be 77% (Zhang, Jiang, Wei, & Yu, 2011), and another study reported a success rate of 79% (Leung, Malhotra, & Eisen, 2010). In the current study, the successful readjustment rate was 85%, which is higher than the levels reported in other studies.

For the readjustment of a malpositioned PICC, an x-ray machine can measure the length and observe the anatomic position, giving real-time guidance to the operator. Under ultrasound guidance, the appropriate length of catheter to be advanced or withdrawn can be visualized to correct the malposition. All of the cases of PICC in the researchers’ hospital had guide wires for positioning, which were only pulled out when the adjustment was correctly performed and confirmed with chest x-ray. Using the guide wire may reduce PICC malposition and improve the readjustment rate. In the current study, patients were always in the supine posture during insertion, and the researchers did not compare the effect of different postures on malposition. Therefore, the relationship between malposition and punctures still needs to be validated by additional studies.

Conclusion

Among the factors that influence malposition of PICCs, the main ones were catheterization position, catheterization limb, and puncture vein. To reduce the incidence of malposition, the left upper limb and upper part of the elbow joint are preferred for PICC line insertion, and the basilic vein is the preferred vein. Other factors that could improve placement accuracy are standardized and specialized operations and specialty training in PICC insertion for professional nurses.

References


