



Contents lists available at ScienceDirect

Journal of Radiology Nursing

journal homepage: www.sciencedirect.com/journal/journal-of-radiology-nursing

A Single-Center Experience of Fluoroscopic-Guided Peripherally Inserted Central Catheter Insertion by Nursing Staff: Rationale and Clinical Outcomes

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A B S T R A C T

Keywords:

Peripherally inserted central catheter
PICC
Fluoroscopy
Nurse

Medical staff traditionally perform most peripherally inserted central catheters (PICCs) insertions in our tertiary Australian center. Centers that run ward-based PICC services have higher malposition and reattempt rates than fluoroscopy-guided insertion. Patients with repeated line requirement and pre-existing central venous stenosis or occlusion make these technical difficulties more difficult to overcome without fluoroscopy. A fluoroscopy-guided PICC insertion service by nonmedical staff such as nursing staff may be a viable alternative to the current model of care. Practical and theoretical PICC insertion training was completed using a standardized in-house education package including line placement under supervision. Data were collected on the first 50 unsupervised nurse-inserted PICC lines to assess insertion success, line tip positioning, and long-term outcomes. In the 50 patients assessed, there was 100% insertion success and 0% malposition. There were no insertion complications and a long-term complication rate of 5.12 complications per 1000 catheter-days, which is comparable to existing literature. Complication rates were either at or below expected ranges described in literature, and malposition was significantly lower when inserted under fluoroscopy guidance than prior literature for ward-based services. We propose that a fluoroscopy-guided PICC service performed by nursing staff will be cost-effective and have flow-on effects to improve radiology team productivity and ward access, with similar clinical line outcomes to medical staff insertions.

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Introduction

Peripherally inserted central catheters (PICCs) are routinely used in inpatient and outpatient settings throughout the world. They provide an effective and safe means of central venous access to patients that require a long-term line. PICCs are indicated primarily when there is a need for a reliable venous access device for several weeks up to many months and may be used for a range of indications such as chemotherapy, long-term antibiotic treatment, therapeutic parental nutrition, vasopressors, or ongoing intravenous fluid requirements among many other reasons (Cheung et al., 2009; Chopra, 2019).

The use of ultrasound-guided venous selection when inserting a PICC is well recognized in the literature as best practice and has advantages in terms of avoiding arm flexures, avoiding brachial artery/median nerve, and selecting an appropriately sized vein for the PICC size (Lamperti et al., 2012). The method of inserting a PICC line and confirming tip position may differ between medical centers and within hospital departments. There are different methods available to the proceduralist for navigation and tip confirmation: blind insertion with chest radiograph to confirm final tip position, insertion guided by magnetic navigation with electrocardiogram tip confirmation, and fluoroscopic-guided PICC insertion. At our tertiary teaching and referral center, the total number of PICC lines inserted in 2017 was 1590. This equates to 25 inserted by anesthesia providers, 365 inserted by intensive care providers, and 1200 inserted by radiology providers. As is common in many centers, most PICC insertions at our hospital are put in by the medical staff and most of the insertions are completed in radiology under fluoroscopy guidance with a junior radiologist and a radiographer.

Declaration of conflicts: No conflicts to declare.

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<https://doi.org/10.1016/j.jradnu.2019.06.004>

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There are centers that run nurse-led PICC services that are ward based, and some literature has suggested that these services have a higher malposition and reattempt rate than fluoroscopy-guided insertion (Barber et al., 2002; Glauser et al., 2017). Our hospital has a large cystic fibrosis and lung transplant patient cohort, which is an example of a cohort of patients where multiple PICCs have been placed and patients such as this may present challenges with preexisting central venous stenosis or occlusion. We propose that in this situation, bedside insertion either blind or with navigation technology may be more susceptible to technical difficulties and won't afford the operator the ability to assess venous anatomy with venography and/or intervene with more advanced techniques such as stiff endovascular wires or angioplasty. Malposition is one of the significant complication risks of PICC insertion (Amerasekera et al., 2009), and the literature shows that insertion without the use of direct vision or navigation technology results in higher rates of malposition in comparison to fluoroscopy guidance (Fricke et al., 2005; Glauser, 2017).

In an attempt to ensure accurate placement and thus utilize gold-standard procedural success, a model of trained nursing staff performing the procedure as a part of a radiology team has been established. This model allows utility of imaging technologists to assist with radiation control, and interventional radiologist for assistance if difficulty is encountered or advanced techniques are needed to secure appropriate access. We describe the model, accuracy of placement, and early clinical outcomes in this manuscript.

Methods

Approval was obtained from our local Human Research and Ethics Committee at the Alfred Hospital, Melbourne, Australia, which is a major tertiary referral center.

Line insertion training was completed by using a standardized in-house education package developed for nonradiologist providers. The training involved education on PICC lines, anatomy, ultrasound utilization, and a practical component. The practical component involved 20 PICC insertions supervised by an interventional radiology consultant. Data were collected on the first 50 unsupervised PICC insertions completed by a senior nursing staff member who was trained.

Information on outcomes 50 sequential PICC insertions was gathered retrospectively via a combination of patient electronic medical records, radiology information system records, and the picture archive and communication system. All patients ranging from 18 to 99 years old were included; none were excluded.

Insertion success was defined as placing the tip of the PICC in its intended location, which for a standard insertion is in the lower portion of the superior vena cava (SVC). This was confirmed on fluoroscopy, and the position was double-confirmed for the purposes of this manuscript (nurse/imaging technologist and consultant radiologist). In addition, data gathered included the number of line-days inserted and line complications (e.g., deep venous thrombosis, infection, line occlusion). Access complications such as

multiple punctures, accidental arterial puncture, and median nerve injury were also collated.

Results

There were 50 out of 50 lines (100%) placed at the intended location in the SVC; no lines were malpositioned.

All lines were inserted without injury to the neurovascular bundle using ultrasound guidance and there were no access site hematomas.

Complications are shown in Table 1. Seven out of 50 lines were found to have a complication over a total time of 1367 days in situ (5.12 complications per 1000 catheter-days), including 4 lines were found to be “sluggish” to use after day 20, 1 occlusion at day 36, and 2 with deep vein thrombosis. Both deep venous thromboses were treated with therapeutic anticoagulation (enoxaparin 1 mg/kg BD) until the line was removed.

The average number of days in situ without a line issue was 25.8, and the average number of days in situ before a line developed a problem equated to 41.4 days.

Discussion

The results support that this model of care is a safe procedure with no insertion complications and 100% technical success in placing the line in its exact intended location in the SVC.

The longer-term complication rates found in our group of 5.12 per 1000 catheter-days are similar to that documented in the literature (Amerasekera et al., 2009; Grau et al., 2017; Johnston et al., 2012), and the rates of individual complications are either at or lower than literature would suggest (see Table 1).

There are a number of advantages of a fluoroscopy-based PICC service being performed by nonradiology inserters (e.g., by nurses) that we have found throughout implementation of this new model. The ability of the inserter to deliver a 100% accurate insertion due to the use of fluoroscopy is the main benefit of the model we are using as compared to a ward-based model. As the model is overseen by interventional radiology consultant medical staff, there is always the ability to obtain verbal or hands-on assistance from a consultant if needed. The fluoroscopy model also means the inserter can do a venogram if stenosis or occlusion is suspected or known, allowing the ability to plan access, angioplasty (performed by an interventional radiologist), or negotiate abnormal collateral veins to achieve a desired anatomic target.

This nurse inserter model frees up medical staff to undertake other angiographic procedures, diagnostic fluoroscopy, or other clinical duties such as film reporting. Without this model, there is a large dependence on junior radiologists to insert PICC lines which, although an important aspect of radiology training, at the volume required at our institution may detract from other learning opportunities. The flow-on effects are potential longer wait times for other procedures.

A nonmedical inserter model may also equate to potential cost savings for the department and hospital in general (Walker and

Table 1
Long-term complication rates from PICC insertion compared to literature

Complication	Our data	Literature (Amerasekera et al., 2009; Grau et al., 2017; Johnston et al., 2012)
Line infection	0%	3%–5.7%
Deep vein thrombosis	4%	1%–38%
Hematoma	0%	0.5%
Malposition	0%	6%–10%
Arterial puncture	0%	2%
Line occlusion	6%	8.9%–38%

PICC, peripherally inserted central catheter.

Todd, 2014). In addition, having a dedicated service to oversee all PICCs being placed allows for ward troubleshooting, education for nursing staff and patients, and more streamlined centralized care (Gosselin et al., 2017). How this affects overall ward and patient satisfaction would be interesting to focus on in a future analysis.

As radiation is used in our model, the inserter either requires a radiation license or must have a radiographer (imaging technologist) present. The overall radiation dose to the patient is extremely low and very far below the threshold to cause tissue effects and thus should not detract from this kind of setup. At our institution, there are a number of trained dedicated angiographic and fluoroscopic radiographers on site, which allows for fluoroscopic assistance for those even without their own radiation safety license (i.e., performing under the hospital license with radiographer assistance). This model also lends to training of other nonmedical inserters such as radiographers.

An important aspect of providing this model is access to training, support, audit, and continuing education. This means that a team consisting of nursing manager, consultant interventional radiologists, and radiographers is vital to ensure these services. At our institution, there are 3 angiography suites and 1 fluoroscopy suite with cases being performed frequently but not continuously. There are times when there is a machine not being used or times between cases where a PICC can be placed and would not impact other hospital angiographic work.

It is interesting to note that catheters that remained in for longer periods were more susceptible to complication (average of 25.8 days in situ without complication vs. 41.4 days in situ before complication arose). While this was not statistically significant due to the small overall numbers, the trend supports existing acknowledgment that the risk line of complication increases with dwell time. In the future, a system where a line dwell time could be flagged beyond a threshold and need for the line reviewed by a vascular access team would be ideal and may be available in many of the newer modern electronic patient record systems.

The data provided are not without limitations and we acknowledge the bias in patient selection, as well as the inherent difficulties with a retrospective review as opposed to a prospective audit. In addition, the overall numbers of patients is low, which may account for the very low complication rates, and future analysis with a much larger cohort will be useful. The use of a single operator in achieving these results helps to maintain a degree of

homogeneity in the outcomes but whether these outcomes of nonmedical inserters are affected by the skills and interest of a single operator versus a larger cohort are unknown.

Conclusion

PICC insertion by nursing staff under fluoroscopy guidance has been shown in our study to be a safe and suitable alternative to radiologist insertion with similar technical success and similar long-term complication rates. The team model suggested in this study may have flow-on effects in terms of cost reduction, provision of technical ward support, and allowing radiology medical staff the time to perform other fluoroscopic or angiographic procedures.

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