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Original Article

Fluoroscopy-guided peripherally inserted central catheter line insertion: assessment of technical success, complications, and quality metrics in a clinical audit: A cross-sectional study.

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Abstract

Background
Objective: To assess the technical success rate, complication profile, and selected quality metrics of fluoroscopy-guided PICC line insertions performed in a clinical setting.

Methodology
This clinical audit was conducted in a hospital-based interventional radiology unit over a defined study period. All patients who underwent fluoroscopy-guided PICC line insertion during the audit period were included. Data were collected retrospectively from procedure records and patient case files. Parameters assessed included technical success, catheter tip position, procedure-related complications, and predefined quality indicators such as procedure time and need for repositioning. Data were analysed using descriptive statistical methods.

Results
Fluoroscopy-guided PICC line insertion demonstrated a high technical success rate with accurate catheter tip placement in the majority of cases. Procedure-related complications were infrequent and predominantly minor in nature. Quality metrics indicated satisfactory procedural efficiency with minimal requirement for catheter repositioning. Overall performance was found to be consistent with established quality benchmarks. The PICC line insertion using fluoroscopy resulted in a technical success rate of 95.9% (70/73 cases) and the optimal catheter tip placement at the cavoatrial junction in 82.2% of the patients. There were very few complications, and only minor ones were observed in 9.6% of cases, and no major complications. The efficiency and safety were confirmed by quality metrics (90.4% first-attempt accuracy, mean procedure time 25 + 6 minutes).

Conclusion
The clinical audit suggests that fluoroscopy-guided PICC line insertion is a safe and effective technique with high technical success and a low complication rate. Regular auditing of procedural outcomes and quality indicators is essential for maintaining standards of care and for continuous quality improvement in vascular access services.

Recommendation
To maintain a high level of technical success, reduce the risk, and enhance the quality control of the services in the sphere of vascular accesses, standardized protocols and constant training are recommended.

Keywords: *Peripherally inserted central catheter; Fluoroscopy-guided insertion; Clinical audit; Vascular access; Quality metrics*
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Introduction

Peripherally inserted central catheters (PICCs) are an integral component of modern clinical practice, providing reliable venous access for patients requiring prolonged intravenous therapy, parenteral nutrition, chemotherapy, or frequent blood sampling [1]. Compared to conventional central venous catheters, PICCs are associated with lower rates of insertion-related complications and can be safely used in both inpatient and outpatient settings. As their use has expanded across medical and surgical specialties, ensuring optimal placement techniques and maintaining high standards of care have become increasingly important [2].

Traditionally, PICC line insertion has been performed using anatomical landmarks or bedside techniques, often guided by ultrasound. While these methods are widely practiced, they may be associated with malposition of the catheter tip, multiple insertion attempts, and increased risk of complications such as thrombosis, catheter

dysfunction, and infection [3]. Fluoroscopy-guided PICC line insertion offers the advantage of real-time visualization, allowing precise advancement and accurate positioning of the catheter tip at the desired central venous location, typically at the cavoatrial junction [4].

Fluoroscopic guidance has been shown to improve technical success rates and reduce the need for post-procedural catheter repositioning. Additionally, immediate confirmation of tip position during the procedure can minimize delays in catheter use and reduce dependence on post-insertion chest radiography [5]. Clinical audits play a crucial role in assessing procedural outcomes, identifying gaps in practice, and promoting continuous quality improvement. By systematically evaluating technical success, complication rates, and quality metrics, audits provide objective data that can be used to benchmark performance against established standards and guide evidence-based improvements in patient care [7]. In resource-constrained healthcare settings, such audits are particularly valuable for optimizing the use of available facilities and ensuring patient safety.

Therefore, it is of interest to conduct a clinical audit of fluoroscopy-guided PICC line insertions to assess technical success, complication profiles, and key quality indicators, thereby contributing to the ongoing evaluation and improvement of vascular access services.

Objectives

- To assess the technical success rate of fluoroscopy-guided peripherally inserted central catheter (PICC) line insertions.
- To evaluate the procedure-related complications associated with fluoroscopy-guided PICC line placement.
- To analyse selected quality metrics, including catheter tip position accuracy, need for catheter repositioning, and procedural efficiency, as part of a clinical audit.

Materials and methods

Study design

This study was conducted as a hospital-based clinical audit with a cross-sectional observational design, evaluating fluoroscopy-guided peripherally inserted central catheter (PICC) line insertions.

Study setting

The audit was carried out in the Interventional Radiology Unit of a tertiary care hospital, where fluoroscopy-guided PICC line insertions are routinely performed as part of standard clinical practice.

Study duration

The audit was performed in a continuous period of 12 months, namely, January 2020 to December 2020, whereby all the consecutive fluoroscopy-guided PICC line insertions in the Interventional Radiology Unit were captured.

Study population

All patients who underwent fluoroscopy-guided PICC line insertion during the audit period were considered for inclusion.

Inclusion criteria

- Patients of any age and gender who underwent fluoroscopy-guided PICC line insertion
- Procedures performed for indications such as prolonged intravenous therapy, chemotherapy, parenteral nutrition, or difficult peripheral venous access

Exclusion criteria

- PICC line insertions performed without fluoroscopic guidance
- Procedures with incomplete documentation or missing outcome data

Sample size calculation

Although clinical audits typically include all eligible procedures performed during a defined audit period, a formal sample size estimation was calculated to ensure adequacy of the audit sample.

The sample size was calculated using the formula for the estimation of a single proportion:

$n=(Z^2\times p\times q)/d^2$

Where:

n = required sample size

Z = standard normal deviate at 95% confidence level (1.96)

p = anticipated proportion of technical success for fluoroscopy-guided PICC insertion

q = 1 − p

d = absolute precision (allowable error)

Based on published literature, the anticipated technical success rate of fluoroscopy-guided PICC line insertion was assumed to be 95%. Allowing an absolute precision of 5%, the sample size was calculated as follows:

$n=(1.96)^2ⓜ\times 0.95ⓜ\times 0.05┤/(0.05)^2 ┤$

$n=(3.84\times 0.0475)/0.0025$

$n=73$

Thus, the minimum required sample size was 73 procedures. All consecutive eligible fluoroscopy-guided PICC line insertions performed during the audit period were included, and the final sample size exceeded the calculated minimum requirement.

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Data collection

Data were collected retrospectively from interventional radiology procedure logs, imaging records, and patient case files using a structured audit proforma. The following variables were recorded:

- Patient demographics
- Indication for PICC line insertion
- Technical success of the procedure
- Catheter tip position at the end of the procedure
- Immediate and early procedure-related complications
- Requirement for catheter repositioning or reinsertion
- Procedural duration and documentation of quality indicators

Ethical considerations

The following clinical audit has been conducted on the basis of anonymized retrospective data. On 15 th January 2020, the Institutional Ethics Committee granted ethical clearance (Approval No: IEC/IRU/2020/015). The confidentiality of patients was well upheld during the study as per institutional and national requirements.

Outcome measures

Technical success is defined as the successful placement of the PICC line with an acceptable catheter tip position under fluoroscopic guidance.
Complications, categorized as immediate or early and classified as minor or major
Quality metrics, including accuracy of catheter tip placement, procedural efficiency, and need for additional interventions.

Statistical analysis

Data were entered into Microsoft Excel and analysed using descriptive statistical methods. Categorical variables were expressed as frequencies and percentages, while continuous variables were summarized using means and standard deviations where applicable.

Results

A total of consecutive fluoroscopy-guided peripherally inserted central catheter (PICC) line insertions performed during the audit period were analysed. The audit assessed technical success, procedure-related complications, and predefined quality metrics. The outcomes are presented in a structured tabular format.

Table 1. Socio-demographic characteristics of patients undergoing fluoroscopy-guided PICC line insertion

Variable	Number (n)	Percentage (%)
Age group (years)		
<18	12	16.4
18–40	25	34.2
41–60	20	27.4
>60	16	22.0
Gender		
Male	40	54.8
Female	33	45.2
Indication for PICC		
Chemotherapy	28	38.4
Prolonged IV therapy	30	41.1
Parenteral nutrition	10	13.7
Difficult venous access	5	6.8
Total	73	100.0

Table 2. Technical success of fluoroscopy-guided PICC line insertion

Technical outcome	Number (n)	Percentage (%)
Successful	70	95.9
Unsuccessful	3	4.1
Total	73	100.0

Table 2 shows the proportion of procedures that achieved successful catheter placement with satisfactory tip position under fluoroscopic guidance.

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Table 3. Catheter tip position at completion of procedure

Cathetertip position	Number (n)	Percentage (%)
Cavoatrial junction	60	82.2
Superior vena cava	10	13.7
Malposition requiring adjustment	3	4.1
Total	73	100.0

Table 3 depicts the final catheter tip position as confirmed by fluoroscopy.

Table 4. Procedure-related complications

Complication type	Number (n)	Percentage (%)
None	66	90.4
Minor complications*	7	9.6
Major complications	0	0.0
Total	73	100.0

*Minor complications included transient pain, minor bleeding, or local hematoma, all managed conservatively.
Table 4 outlines the immediate and early complications observed during or after PICC line insertion.

Table 5. Quality metrics assessed during the audit

Quality indicator	Observation
Accurate tip placement at first attempt	90.4%
Need for catheter repositioning	4.1%
Mean procedure duration (minutes)	25 ± 6
Post-procedure radiograph required	No

Table 5 summarizes selected quality indicators related to procedural efficiency and performance.

Table 2 demonstrates a high technical success rate of fluoroscopy-guided PICC line insertion, indicating effective procedural performance. Table 3 shows that the majority of catheters were accurately positioned at the cavoatrial junction, reflecting optimal tip placement under fluoroscopic guidance. Table 4 indicates a low complication rate, with only minor complications observed and no major adverse events recorded. Table 5 highlights favourable quality metrics, including minimal need for catheter repositioning and acceptable procedural duration, suggesting efficient workflow and adherence to quality standards.

Discussion

The present clinical audit evaluated fluoroscopy-guided peripherally inserted central catheter (PICC) line insertions with a focus on technical success, complication profile, and selected quality metrics. The findings of this audit demonstrate that fluoroscopy-guided PICC insertion is a reliable and safe technique, with high procedural success and favourable quality outcomes in a tertiary care hospital setting [8].

In this audit, a high technical success rate was observed, indicating that the majority of PICC line insertions were completed successfully with satisfactory catheter placement under fluoroscopic guidance. This finding is consistent with existing literature, which has shown that fluoroscopy-guided PICC insertion is associated with superior success rates compared to blind or landmark-based techniques. Real-time visualization during the procedure allows accurate navigation of venous anatomy, thereby reducing failed insertions and minimizing the need for multiple attempts [9].

Accurate catheter tip positioning is a critical determinant of PICC line functionality and long-term safety. In the present audit, most catheters were positioned at the cavoatrial junction, which is considered the optimal location for central venous access. Proper tip placement reduces the risk of catheter dysfunction, thrombosis, and arrhythmias and allows immediate use of the catheter without the need for post-procedure repositioning. The low proportion of malpositioned catheters observed in this audit highlights the advantage of fluoroscopic guidance in achieving precise tip placement [10].

Procedure-related complications were infrequent and predominantly minor in nature. No major complications were observed during the audit period. Minor complications, such as transient pain or minor bleeding, were self-limiting and managed conservatively. These findings align with previous studies reporting low complication rates for fluoroscopy-guided PICC insertion. The absence of major adverse events underscores the safety of the procedure when performed by trained personnel under standardized aseptic conditions [11].

Quality metrics assessed during the audit further support

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the effectiveness of fluoroscopy-guided PICC insertion. The majority of catheters were accurately positioned on the first attempt, and the requirement for catheter repositioning was minimal. The mean procedure duration was within acceptable limits, reflecting procedural efficiency and operator proficiency. Additionally, the lack of requirement for routine post-procedure chest radiography highlights an important operational advantage of fluoroscopic guidance, as it reduces additional radiation exposure, procedural delays, and healthcare costs [12].

Clinical audits play a vital role in evaluating adherence to best practices and identifying areas for improvement. The findings of this audit indicate that current practices related to fluoroscopy-guided PICC insertion meet established quality benchmarks. However, ongoing audits are essential to ensure sustained performance, particularly with changes in staff, workload, or patient complexity. Regular monitoring of outcomes also facilitates early identification of trends that may necessitate protocol modification or targeted training interventions [13,14].

Despite its strengths, this audit has certain limitations. As a single-centre audit with a relatively limited sample size, the findings may not be generalizable to all healthcare settings. Additionally, long-term complications such as catheter-related bloodstream infections or delayed thrombosis were not assessed. Future audits incorporating longer follow-up periods and multicentre data may provide a more comprehensive evaluation of outcomes [15].

The clinical audit showed that there was a technical success rate of 95.9% (70/ 73 cases), which proves the reliability of fluoroscopy-directed PICC line insertion. The accuracy of the Catheter tip was good, where 82.2% of the tips were located on the cavoatrial junction and only 4.1% had to be repositioned. There were a few complications, with a low rate (9.6 percent) of minor complications and none with major complications. The results are consistent with the literature that fluoroscopic guidance increases accuracy and minimizes undesirable effects, in comparison to the blind or landmark methods.

Generalizability

In spite of being carried out in one tertiary care hospital, the success rate is high, and the complication profile is low, which indicates that fluoroscopy-guided PICC insertion may be extended to other limited-resource tertiary care settings with a trained workforce and routine procedures. Nonetheless, more particularly, the multicentre audits involving larger and more heterogeneous populations are required to foster wider applicability.

Overall, the findings of this clinical audit reinforce the role of fluoroscopy-guided PICC line insertion as a safe, effective, and quality-assured method for establishing central venous access in a tertiary care setting.

Conclusion

This clinical audit demonstrates that fluoroscopy-guided peripherally inserted central catheter (PICC) line insertion is a safe and effective technique with a high technical success rate and a low incidence of procedure-related complications. Accurate catheter tip placement at the desired central venous location was achieved in the majority of cases, reflecting the advantages of real-time fluoroscopic guidance in ensuring procedural precision and reliability.

The favourable quality metrics observed in this audit, including minimal need for catheter repositioning and acceptable procedural duration, indicate good adherence to institutional standards and efficient workflow within the interventional radiology unit. These findings support the continued use of fluoroscopy-guided PICC insertion as a preferred method for establishing central venous access in appropriate clinical settings.

Regular clinical audits such as this are essential for maintaining quality assurance, monitoring performance against established benchmarks, and identifying opportunities for ongoing improvement in vascular access services.

Limitations

The design of this audit was single-centred, and the sample used was not very large. Long term problems like catheter-related bloodstream infections or delayed thrombosis were not evaluated. The data collection can also be subjected to documentation bias since the data were collected retrospectively.

Recommendations

Multicentre audits involving bigger numbers of cohorts and long-term follow-up to assess long-term outcomes should be incorporated in future studies. It is suggested to maintain quality assurance and enhance patient safety through continuous staff training and following standardized protocols and frequent audits.

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List of abbreviations

PICC: Peripherally Inserted Central Catheter
IV: Intravenous
IEC: Institutional Ethics Committee
SVC: Superior Vena Cava

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This study did not receive any external funding.

Conflict of interest

The authors declare no conflict of interest.

Author contributions

Dr Tripuraneni Rajesh Kumar: Conceptualization, data collection, manuscript drafting.
Dr Elaprolu Praveen: Study design, statistical analysis, and critical revision of manuscript.
Dr Yogesh P Tandel: Literature review, data interpretation, and final approval of the manuscript.

Data availability

The anonymized data supporting the findings of this study are available from the corresponding author upon reasonable request, in line with institutional policies.

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