Research

Effectiveness of Nurse-Led Peripherally Inserted Central Catheter Placement versus Physician-led PICC Insertion: A Literature Review

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Abstract:
Reliable vascular access remains essential in modern clinical practice, with peripherally inserted central catheters representing an important option for safe and effective medium- and long-term administration of intravenous therapy. In many healthcare systems, specialized Vascular Access Teams, often nurse-led, have been introduced to improve insertion efficiency, safety, and service organization delivery. A descriptive literature review was conducted using the databases Scopus, Web of Science, and PubMed to evaluate nurse-led versus physician-led peripherally inserted central catheters insertion models and the role of vascular access teams. Search terms included combinations of nurse-led, physician-led, vascular access team, intracavitary electrocardiography, tip confirmation and global development. English-language studies involving adult populations and focusing on insertion success, organizational outcomes, and included vascular access service models. A literature review identified that nurse-led vascular access team models achieve high insertion success rates, low complication rates, shorter waiting times, and improved clinical workflow efficiency. Comparative studies reported outcomes comparable to, or better than, traditional physician-led insertion models. The use of intracavitary electrocardiography improved bedside catheter tip confirmation accuracy, reduced reliance on fluoroscopy and chest radiography, shortened procedure times, and lowered healthcare costs. Evidence suggests that multidisciplinary vascular access team supported by modern technologies such as intracavitary electrocardiography represent an effective and progressive model of peripherally inserted central catheters service delivery. Procedural quality depends mainly on training, competency, experience, and adherence to standardized protocols rather than professional background alone. Further multicentre prospective studies are needed to evaluate long-term clinical and economic outcomes.

Keywords: Peripherally inserted central catheter; Nurse-led; Physician-led; Vascular access team; Vascular access device

1. Introduction

Reliable vascular access is a key part of modern health care and is required for the delivery of intravenous therapy, chemotherapy, parenteral nutrition, vasoactive medications, blood products, hemodynamic monitoring, and repeated blood sampling (Pittiruti et al., 2009, Moureau & Chopra, 2016). As healthcare systems have become more complex, the demand for safe, timely, and efficient placement of vascular access devices has increased significantly. Among available vascular access devices, the peripherally inserted central catheter (PICC) has become an important option for medium and long-term venous access due to its broad clinical applicability, relatively safe insertion method, and their role as an alternative to the centrally inserted central catheter (CICC), offering a less invasive and often safer method of placement (Patel et al., 2018).

PICC devices are widely used in oncology patients receiving chemotherapy, in patients requiring prolonged intravenous antibiotic therapy, parenteral nutrition, electrolyte replacement, and in those with difficult peripheral venous access. Compared with CICCs, PICCs represent a less invasive alternative with lower risk of certain insertion-related complications and improved bedside feasibility (Kim et al., 2025, Tsotsolis et al., 2015). Historically, PICC insertion was performed by physicians using blind techniques or fluoroscopy-guided placement, often followed by chest radiography to confirm final tip position. These traditional approaches were associated with delays in treatment initiation, increased procedural costs, radiation exposure, and workflow limitations (Pittiruti et al., 2009).

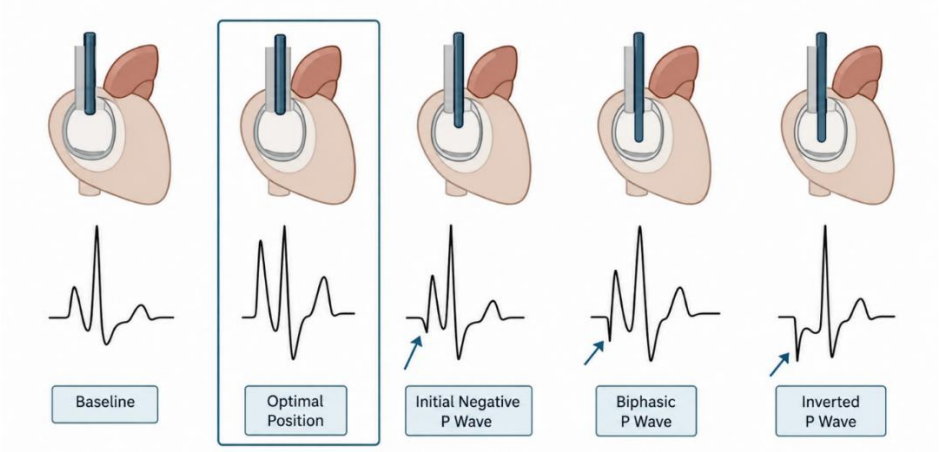

Figure 1. Schematic illustration of intracavitary electrocardiographic (IC-ECG) changes during advancement of a peripherally inserted central catheter (PICC) from the superior vena cava toward the Cavo-atrial junction and right atrium. As the catheter tip approaches the pericardial reflection, the P wave progressively increases in amplitude and becomes peaked. Maximum P-wave amplitude is observed at the Cavo-atrial junction, corresponding to the optimal PICC tip position. Further advancement of the catheter into the right atrium results in a biphasic or inverted P wave. In this study, final PICC tip placement was determined at the point of maximal P-wave amplitude, corresponding to the Cavo-atrial junction.

Over recent decades, many hospitals have introduced specialized vascular access teams (VAT), frequently led by specially trained nurses, to improve catheter insertion and vascular access management. Nurse-led PICC teams are now common in many Western healthcare systems, where they have been established to improve service availability, procedural standardization, patient flow, and quality of care (Sakai et al., 2024). However, in several countries these programs remain in earlier stages of development, and their direct institutional impact has not been fully evaluated. Traditionally, physicians were considered the primary operators for central venous access insertion. However, specialized nurse-led services have expanded in many healthcare systems and challenged this long-known model. Several studies have reported high insertion success rates and low complication rates in nurse-led PICC programs, with some institutions demonstrating reduced utilization of CICCs after implementation of dedicated nurse practitioner-led teams. In addition, the use of modern tip confirmation systems such as intracavitary electrocardiography (IC-ECG) (**Figure 1**) has further improved bedside PICC placement efficiency and accuracy (Freitas et al., 2026).

2. Material and Methods

This study was conducted as a descriptive literature review to evaluate the current evidence regarding peripherally inserted central catheter (PICC) insertion performed by nurses and physicians, as well as the contribution of specialized vascular access teams (VATs), with particular focus on the use of intracavitary electrocardiography (IC-ECK) for catheter tip confirmation and its impact on clinical, organizational, and economic outcomes.

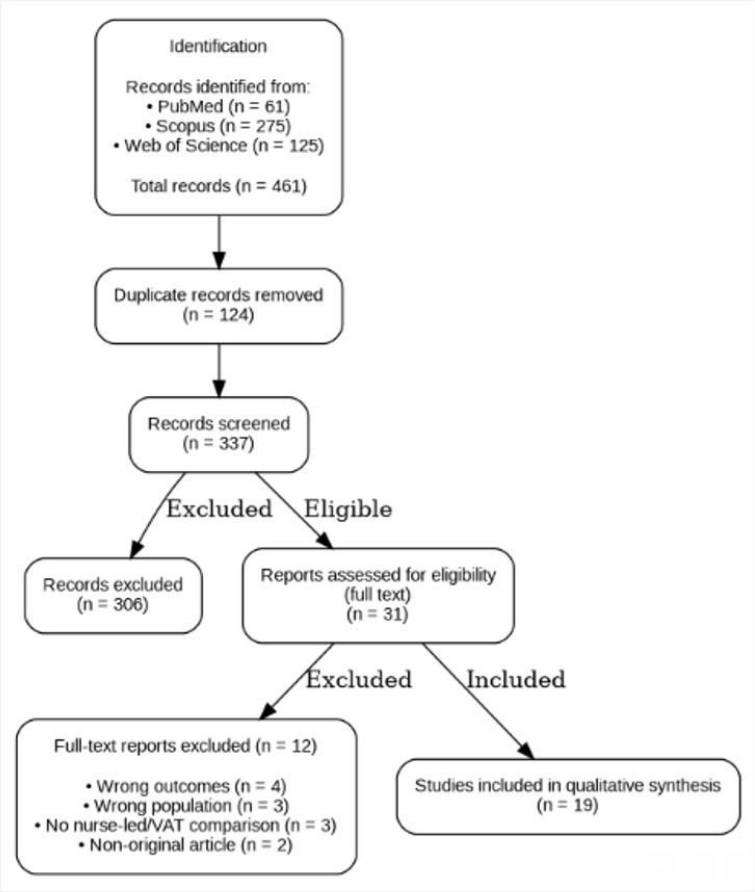

Figure 2. Prisma 2020 flow diagram illustrating the study selection process for literature review.

A literature search was performed in PubMed, Scopus and Web of Science using combination of the keywords: PICC, peripherally inserted central catheter, nurse-led, physician-led, vascular access team, IC-ECG, tip-confirmation, ultrasound-guided, and vascular access service. The search was limited to full-text articles published in English within least 10 years involving adult populations. Eligible studies evaluated nurse-led or physician-led PICC insertion, investigated the role of vascular access teams, assessed the use of intracavitary electrocardiography for catheter tip confirmation, and reported clinical, procedural, organizational, or economic outcomes related to PICC placement.

Studies involving paediatric populations, conference abstracts, editorials, letters to the editor, duplicate records, review articles, and publications not directly related to PICC insertion, vascular access teams, or IC-ECG-guided tip confirmation were excluded.

A total of 461 records were identified through database searching (PubMed, n = 61; Scopus, n = 275; Web of Science, n = 125). After duplicate removal, 337 records remained for title and abstract screening. Following the screening process, 306 records were excluded based on the predefined eligibility criteria. Thirty-one full-text articles were assessed for eligibility, of which 12 were excluded after full-text review. Consequently, 19 studies met the inclusion criteria and were included in the qualitative synthesis. The study selection process is presented in the PRISMA 2020 flow diagram (**Figure 2**).

3. Results

As the first retrospective study of its kind in Saudi Arabia reviewing four years of clinical data, the Saudi study demonstrated that a specialized nurse-led PICC service can achieve outcomes comparable with previous international reports, where ultrasound-guided PICC insertion success rates ranged from 98.6% to 100% (Alsaleh et al., 2025). The specialized nurse-led PICC team achieved a 99.1% overall placement success rate across 330 cases. Of these, 323 PICCs (97%) were successfully inserted under IC-ECG guidance within one or two attempts, while 7 PICCs (2.1%) required fluoroscopy guidance on the third attempt. Only 3 cases (0.9%) required referral to interventional radiology, where 2 PICCs (0.6%) were successfully placed, whereas 1 insertion (0.3%) was unsuccessful for both teams due to tortuous veins and small vein diameter. These findings indicate that specialized nurse-led services can provide highly effective PICC placement with minimal need for physician or radiology support.

Regarding placement accuracy and procedural efficiency, IC-ECG systems have shown excellent outcomes across multiple studies. Previous reports described tip localization accuracy of up to 100%, while a review involving 729 patients found significantly greater placement accuracy compared with landmark-based methods (OR 8.3; $p = 0.02$). Malposition rates were low, with only 1% aberrant tip positions reported in one Sherlock 3CG study. In addition to accuracy, IC-ECG guidance shortened procedure time by approximately 13 minutes compared with fluoroscopy (31.8 vs 44.7 minutes). Time to therapy initiation was also substantially faster (33.9 vs 176.3 minutes) when compared with blind insertion followed by chest X-ray confirmation. Use of IC-ECG technology also reduced radiology dependence, with only 0.03 chest X-rays per patient required after Sherlock 3CG-guided placement compared with 1.25 per patient after blind insertion. One hospital further reported that 227 chest X-rays were avoided after implementation. Collectively, these findings support IC-ECG guidance as an accurate, efficient, and resource-saving approach for PICC placement.

Additional evidence for nurse-led vascular access services was reported in a retrospective study conducted at a university hospital in Japan between 2014 and 2020 (Sakai et al., 2024). Among 6,007 central venous access device placements, 2,230 PICCs were inserted, including 725 by physicians and 1,505 by nurse practitioners (NPs). Following implementation of the NP-led PICC programme, monthly CICC use significantly decreased from 58 to 38 cases, while NP-led PICC insertions increased from 0 to 104 per month. The programme significantly reduced both the immediate rate and long-term trend of CICC utilization. PICC placements performed by NPs were associated with lower immediate complication rates compared with physicians (1.5% vs 5.1%), while rates of central line-associated bloodstream infection (CLABSI) remained similar between groups (5.9% vs 7.2%). These findings suggest that NP-led PICC services can safely reduce reliance on more invasive central venous devices while maintaining comparable infection outcomes.

Further economic and organizational benefits were demonstrated at Hospital Clinic Barcelona in Spain, where implementation of a specialized VAT and intravenous therapy programme was evaluated during its first year of activity (Rosich-Soteras et al., 2025). During this period, the programme generated estimated savings of €867,688.44 through reduced material and labor force costs. Introduction of PICCs and midline catheters prevented insertion of 893 CICCs and 330 implantable venous ports, accounting for savings of €794,538.44. In addition, 34 patients who would otherwise have required hospitalization received treatment through the home hospital model, preventing 488 hospital days and generating a further €73,150 in savings. The programme was also clinically effective, achieving a first-attempt insertion success rate of 95.6%. Due to high service demand, VAT working hours were extended by 6.5 hours per day. An important component of the team's activity was consultation and education of other healthcare professionals, with 80.9% of consultations related to vascular access management, most commonly catheter occlusion. These results highlight the wider institutional value of VAT services in improving efficiency, reducing costs, and supporting safer vascular access care.

Additional European evidence was provided by the multicentre survey The state of vascular access teams: results of a European survey, which evaluated vascular access management across several European countries and included 1,449 healthcare professionals from public and private institutions (Rey et al., 2021).

The comparison between nurse-led PICC teams and physician-led insertion models has emerged as an important clinical and organizational question. Understanding differences in insertion success, complication rates, timeliness of care, catheter tip accuracy, and overall healthcare efficiency is crucial for hospitals seeking to design optimal vascular access services. In response to the increasing demand for reliable venous access, the growing use of PICC and midline catheters, physician workload pressures, and the need for ultrasound-guided insertion expertise, specialized VAT were developed (Fernandez-Fernandez et al., 2024). These teams were also established to prevent catheter-related complications and to implement standardized pathways for catheter insertion and maintenance. In many healthcare institutions, VAT are nurse-led and operate across both inpatient and outpatient settings, providing comprehensive catheter management throughout the entire device lifecycle.

Dedicated VAT models have been associated with improved organizational efficiency, faster access to treatment, and better patient outcomes. By offering rapid bedside availability, scheduled service coverage, fewer referrals to radiology, standardized documentation, and integrated follow-up care, nurse-led teams can reduce delays in therapy initiation, imaging, antibiotic administration, and hospital discharge (Freitas et al., 2026).

Insertion success is considered a key quality indicator of vascular access services. A 2024 retrospective cohort study from Saudi Arabia, a nurse-led PICC service reported an overall successful placement rate of 99.1%, with most catheters inserted using IC-ECG tip confirmation rather than fluoroscopy (Alsaleh et al., 2025). Similarly, comparative data from a Japanese university hospital involving 2,230 PICCs demonstrated that nurse practitioner-led placement quality was equivalent or superior to physician-led insertion, with lower immediate complication rates in the nurse-led group (Sakai et al., 2024). These findings suggest that successful outcomes are strongly associated with training, procedural volume, and dedicated practice rather than professional background alone.

The concept of IC-ECG was first described in 1949, when Hellerstein, Pritchard, and Lewis demonstrated the recording of intracardiac electrical potentials through a saline-filled catheter (Hellerstein et al., 1949). This principle later formed the basis of modern IC-ECG tip confirmation systems, which allow bedside verification of central venous catheter tip location without exposure to ionizing radiation (Tomaszewski et al., 2017). The technique is based on analysis of P-wave morphology, where progressive changes in the P wave indicate the catheter tip approaching the Cavo atrial junction. Increasing evidence supports IC-ECG as a safe, accurate, and efficient method of tip confirmation, with recent meta-analyses demonstrating advantages over traditional blind insertion techniques which includes X-ray confirmation and favourable cost-effectiveness (Liu et al., 2019).

Advanced tip confirmation systems combine electromagnetic navigation with real-time IC-ECG guidance, enabling simultaneous catheter tracking and accurate tip localization during insertion (Pittiruti et al., 2021). This technology allows immediate bedside confirmation of correct catheter tip position without the need for post-procedural chest radiography or fluoroscopy. The integration of IC-ECG systems within specialized VAT provides several important clinical and organizational benefits. Afore mentioned system points to higher first-attempt and overall insertion success rates, improved catheter tip accuracy, fewer malposition's and mechanical complications, as well as reduced dependence on fluoroscopy and chest radiography confirmation. Consequently, radiation exposure for both patients and healthcare staff may be minimized.

In addition, IC-ECG guided insertion is associated with shorter procedure times and faster catheter readiness for therapy, allowing earlier initiation of treatment. From an organizational perspective, this model can reduce physician procedural workload, decrease radiology utilization, and lower associated healthcare costs (Robinson et al., 2005). Because VAT often manage the catheter pathway from insertion through maintenance, they may also improve continuity of care, patient education, and overall patient experience.

Economic evaluations further support this model. Freitas et al. (Freitas et al., 2026) demonstrated that VAT utilizing IC-ECG based tip confirmation systems for PICC insertion improved procedural efficiency while reducing costs related to treatment delays, imaging requirements, and workflow burden. Overall, current evidence suggests that VAT equipped with IC-ECG technology represent an effective modern model of PICC service

delivery, combining clinical safety, procedural efficiency, patient-centred care, and economic benefit (Pinelli et al., 2025).

Results showed that the availability of dedicated VAT varied considerably between countries and hospitals. Institutions with an established VAT were more likely to use formal algorithms or guidelines for vascular access device selection (55% vs. 38%; $p < 0.0002$), as well as to systematically monitor complications and receive structured feedback (40% vs. 28%; $p = 0.015$).

Education was one of the most significant differences, as respondents from hospitals with a VAT reported higher rates of vascular access training (79% vs. 53%; $p < 0.0001$).

The study also identified barriers to VAT development, including unequal service availability, differences between hospital types, and the need for standardized education and competency frameworks.

Overall, findings from Saudi Arabia, Japan, and Spain consistently demonstrate that specialized nurse-led PICC and VAT can deliver safe, accurate, and efficient catheter placement. Implementation of IC-ECG guidance improved catheter tip confirmation, shortened procedure duration, reduced delays to treatment, and lowered use of chest X-ray or fluoroscopy. Such models reduce dependence on physicians and radiology services, lower complication rates, optimise use of vascular devices, and generate substantial organizational and financial benefits. Hospitals with vascular access teams also reported workflow benefits, lower costs, and improved continuity of care.

4. Discussion

Despite favorable findings, the current evidence base has several important limitations. Many published studies are retrospective observational analyses, which increase the risk of selection bias and confounding factors compared with randomized controlled trials (Pittiruti et al., 2020). Many positive findings regarding nurse-led PICC teams are based on retrospective cohort studies rather than randomized trials (Alsaleh et al., 2025). A limitation of the study's is that the survey responses were predominantly provided by nurses, which may have influenced the findings and may not fully reflect the perspectives of other healthcare professionals involved in vascular access management. In addition, retrospective data collection may rely on incomplete clinical documentation, leading to underreporting of adverse events.

Another limitation is the relatively small number of randomized comparative studies and the frequent absence of a true control group. Many investigations evaluate nurse-led services as single-arm cohorts without direct comparison to physician-led models under equivalent conditions, making causal interpretation more difficult (Liu et al., 2019). Simpler cases may be allocated to VAT nurses, whereas more complex patients are referred to physicians or interventional radiologists, introducing selection bias (Paje et al., 2023).

Variation in scope-of-practice legislation, credentialing systems, training standards, and operator experience may also affect the applicability of results across institutions and countries. Furthermore, studies often include heterogeneous patient and catheter populations and are frequently conducted in single-center settings, which may limit generalizability (Pittiruti et al., 2020). Although previous studies have also reported notable PICC related complication rates, current evidence suggests that outcomes improve significantly within VAT models led by expert nurses (McDiarmid et al., 2017).

Therefore, direct comparisons between professions should be interpreted cautiously, and further multicenter randomized studies with standardized methodology are needed.

5. Conclusions

Current evidence suggests that VAT represent an effective and progressive model of PICC service delivery. Multidisciplinary VATs involving specially trained nurses, physicians, and advanced practitioners can achieve clinical outcomes comparable to, and in selected settings better than, traditional physician-led insertion models. Studies have consistently reported high insertion success rates, low complication rates, shorter waiting times, improved clinical workflow efficiency, and better continuity of patient care.

Importantly, the literature indicates that the most significant determinants of procedural quality are training, competency, experience, and adherence to standardized evidence-based protocols, rather than professional background alone. This supports a competency-

based approach in which appropriately trained clinicians perform vascular access procedures according to institutional governance and patient needs.

Looking ahead, VAT services are likely to play an increasingly important role in modern healthcare systems. Future developments may include AI-assisted ultrasound vein mapping, advanced tip confirmation technologies, nurse consultant-led services, formal advanced practice credentialing pathways, international outcome benchmarking, and tele-supervision supported by simulation-based education. These innovations may further improve procedural safety, access efficiency, workforce flexibility, and patient-centered care.

Overall, the survey suggests that VAT services improve staff education, adherence to evidence-based practice, and complication surveillance, although wider implementation and further standardization are still needed across Europe.

However, further multicenter prospective studies are needed to compare service models, define optimal staffing structures, and evaluate long-term clinical and economic outcomes. Overall, healthcare organizations should prioritize development of high-quality VAT programs that combine multidisciplinary collaboration, advanced technology, and standardized competency frameworks to ensure safe and timely vascular access care.

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