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Peripheral and Central Vascular Access Devices: Dwell Time, Indications, and Complications (Narrative Review)

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Abstract

Introduction and Purpose: Vascular access devices (VADs) are essential for modern inpatient care, yet optimal device selection remains complex due to heterogeneous data on dwell time, indications, and complications. Peripheral options such as midline catheters (MCs) and long peripheral catheters (LPCs) are increasingly proposed as alternatives to peripherally inserted central catheters (PICCs) and central venous catheters (CVCs), particularly for intermediate-duration therapy and in patients with difficult intravenous access (DIVA). The aim of this narrative review is to synthesize current evidence on peripheral and central vascular access, focusing on peripheral intravenous catheters (PIVCs), MCs, LPCs, PICCs, and CVCs, with respect to dwell time, therapeutic indications, and complication rates, including catheter-related bloodstream infections (CRBSI) and thrombosis.

State of Knowledge: PIVCs, although most commonly used, have short dwell times and high failure rates, often complicated by phlebitis, infiltration, and occlusion. Midline catheters provide longer dwell times and reduce repeated cannulation but are associated with minor mechanical complications such as superficial thrombophlebitis and occlusion. PICCs and CVCs enable prolonged delivery of vesicant and hyperosmolar therapies but carry higher risks of bloodstream infection and venous thromboembolism. Comparative studies suggest midlines may reduce CRBSI and CLABSI-reportable events relative to PICCs, at the cost of more frequent minor complications.

Conclusion: No single VAD is universally optimal. Device choice should integrate therapy duration, infusate characteristics, vascular anatomy, and the balance of infectious, thrombotic, and mechanical risks. MCs and LPCs appear promising for intermediate-duration, peripherally compatible therapies; however, high-quality randomized studies are needed to refine vascular access algorithms and confirm safety signals.

Abbreviations

VADs - Vascular Access Devices
PIVC - Peripheral Intravenous Catheters
SPC - Short Peripheral Catheter
LPC - Long Peripheral Catheter
MCs - Midline Catheters
DIVA - Difficult Intravenous Access
CVCs - Central Venous Catheters
PICC - Peripherally Inserted Central Catheter
CRBSI - Catheter-Related Bloodstream Infections
CLABSI - Central-Line Associated Bloodstream Infections
DVT - Deep Vein Thrombosis
SVT - Superficial Vein Thrombosis

Keywords

Vascular access devices, midline catheters, long peripheral catheters, peripherally inserted central catheters, difficult intravenous access, central venous catheters

1. Introduction

Intravenous therapy has evolved from experimental infusions in the 17th century to modern practice following the introduction of plastic over-the-needle catheters in the mid-20th century. Advances in catheter materials, including Teflon and polyurethane, have improved safety, reduced mechanical complications, and extended dwell times, making vascular access a cornerstone of contemporary clinical care [1][2].

VAD selection depends on anticipated therapy duration, infusate characteristics (pH, osmolarity), and patient vascular anatomy [3]. Devices are classified as peripheral or central.

- PIVCs: Short catheters (≤7.5 cm), inserted into superficial veins, intended for short-term therapy with peripherally compatible solutions [1][3][4][5]. Long peripheral catheters (6 to 15 cm), typically inserted into upper arm veins (basilic, cephalic, or median cubital veins) [46]
- Midline Catheters (MCs): 7.5–25 cm, inserted into deep peripheral veins of the upper arm, tip remains peripheral. Suitable for medium-duration therapy, particularly in DIVA patients [3][5][6][7][8].
- Central Venous Catheters (CVCs): Tip in central circulation (superior vena cava/right atrium), required for long-term or vesicant therapy [3][4][5].
- Peripherally Inserted Central Catheters (PICCs): Placed peripherally but advanced centrally, offering durable access with lower insertion complications than CVCs [3][4][6][9].

Despite their utility, CVCs and PICCs carry substantial risk of CRBSI and thrombosis [3][6][8]. MCs have emerged as potential alternatives for therapies not requiring central access, challenging routine PICC use for intermediate-duration therapy. Optimal VAD selection requires balancing risks, patient factors, and preservation of vascular health, complicated by variability in clinical practice and limited randomized evidence [3][5][9].

This research aims to review the contemporary literature on vascular access device selection. Specifically, it examines the comparative advantages and limitations of peripheral intravenous catheters, midline catheters and peripherally inserted central catheters to support evidence-based, patient-centered clinical decision-making.

2. Evidence Synthesis

2.1 Establishing intravenous access and insertion-related considerations

SPCs are typically inserted into the dorsal hand veins or forearm veins and are technically the simplest and most commonly utilized devices. [9][10] They represent the most frequently used form of vascular access in hospital settings.[10]

SPC insertion is based on anatomical landmark identification and the over-the-needle technique, usually performed by a single operator. [10] This procedure does not require imaging guidance or specialized staff training; however, it is associated with a relatively high rate of first-attempt failure and the need for repeated cannulation. [9][10] In a pilot study by March et al., the failure rate of PIVC insertion, particularly SPCs was 15.9%, which was higher than that observed for MCs (12.9%), despite staff being more experienced with conventional peripheral access techniques. [11] Each additional cannulation attempt significantly increases the risk of complications and reduces patient comfort.[11] Moreover, the literature highlights that patients with PIVCs report pain and discomfort more frequently than those with MCs.[12][13]

The most common mechanical complications associated with SPCs include hematoma formation, bleeding at the insertion site, infiltration or extravasation of infused fluids, and injury to adjacent structures such as nerves and arteries.[10][12] It should be noted, however, that the incidence of nerve and arterial injuries remains low and is rarely precisely reported in population-based studies.[10] An Australian meta-analysis published in 2020 demonstrated that the most frequent PIVC-related complications were phlebitis (19.3% when a clear definition was applied), infiltration or extravasation (13.7%), occlusion (8%), leakage (7.3%), pain (6.4%), and catheter dislodgement (6.0%).[12]

Long peripheral catheters (LPCs), with lengths ranging from 6 to 15 cm, are typically inserted into upper arm veins (basilic, cephalic, or median cubital veins) using the accelerated Seldinger technique (AST) or the modified Seldinger technique (MST).[13] Due to the proximity of neurovascular structures, ultrasound guidance is required, particularly in patients with difficult intravenous access (DIVA), and appropriate operator training is essential.[13]

In a retrospective study by Krath et al., the most common reasons for LPC removal were phlebitis (17.9%), infiltration (9.4%), and accidental catheter removal (8.5%); cases of venous thrombosis were also reported.[13]Catheters inserted into the radial-side veins were significantly more prone to damage, which was attributed to smaller vessel diameter and reduced blood flow.

MCs are inserted into upper arm veins (basilic, brachial, or cephalic), with the catheter tip positioned in the proximal segment of the arm vein or the axillary region, without entering the central venous circulation.[11][14] Similar to LPC and PICC placement, midline insertion requires ultrasound guidance and trained personnel and most commonly employs the modified Seldinger technique. A major advantage of MCs is the lack of requirement for radiographic confirmation of tip position. [14]

Peripherally inserted central catheters (PICCs) are also placed in upper arm veins (basilic, brachial, or cephalic); however, their tips are positioned in the lower superior vena cava or at the cavoatrial junction. PICC length typically ranges from 45 to 60 cm and is selected based on patient height and body habitus, side of insertion (left-sided placement requires a longer catheter), and vein choice (basilic < brachial< cephalic).[15][16][17]

Even though PICC insertion requires ultrasound guidance for vein identification and needle advancement, similarly to LPC and midline placement, unlike these devices, current American Society of Anesthesiologists guidelines require radiographic confirmation of catheter tip position immediately after insertion. [15][16][18]

Mechanical injuries during MCs insertion occur less frequently than during peripherally inserted central catheter (PICC) placement. In multicenter observational and randomized studies, major mechanical complications (e.g., occlusion, bloodstream infection, thrombosis) were significantly more common with PICCs than with MCs, both for short- and long-term indications (odds ratio for major complications, PICC vs midline: 1.99; 95% CI, 1.61–2.47).[13][20] The most frequent mechanical complications associated with PICCs include catheter occlusion (4.5–7%), tip migration (4.4%), thrombosis (1.5–1.8%), and catheter-related bloodstream infection (1.6–1.8%), whereas MCs are more commonly complicated by dislodgement (3.8%), occlusion (2.1–2.3%), and local insertion-site reactions.[19][20][21]

Placement may also be performed under fluoroscopic guidance, allowing real-time visualization of catheter advancement, though this requires access to an interventional radiology suite and a specialized team.[15][18] Some centers additionally use electrocardiographic (ECG) tip confirmation, which necessitates further staff training.[22][23]

Zi-Xuan Wang et al. highlighted that accurate tip positioning represents a major challenge in PICC use, with catheter malposition accounting for 84.4% of insertion failures under ultrasound guidance.[20] Most patients in this cohort accepted repositioning or reinsertion under fluoroscopic guidance.[18] Reported complications during and after PICC use include upper extremity deep vein thrombosis (2–16%), catheter-related bloodstream infection, catheter occlusion (1–4.5%), migration or dislodgement (4–7%), and mechanical complications such as pain, bleeding, and phlebitis.[18]

In a large multicenter cohort comparing PIVCs, MCs, and PICCs with respect to mechanical complications during insertion, PICCs demonstrated the lowest rate of mechanical complications (3.4%), while MCs (5.7%) had significantly fewer complications than PIVCs.[24] These findings support the

notion
that SPCs are characterized by greater mechanical instability.[24]

2.2 Indications and types of therapy

Peripheral intravenous catheters (PIVCs) are preferred for short-term therapy. They can be used for most intravenous treatments, including blood transfusions [25]. The use of PIVCs for long-term vasopressor administration is generally not recommended; however, a recent review demonstrated that in situations requiring rapid restoration of hemodynamic stability, peripheral intravenous access may be an appropriate option. In such cases, PIVCs are commonly used as a bridge therapy prior to the placement of a central venous catheter [26].

According to current standards, MCs may also be successfully used for most intravenous therapies, with the exception of continuous infusions of vasoconstrictors, parenteral nutrition (PN), or solutions with extreme pH values or osmolarity [27]. Nevertheless, a study evaluating the safety of vasoconstrictor administration via MCs compared with PICCs did not demonstrate a higher incidence of catheter-related complications associated with midlines [28].

Further research is required to establish clear and definitive indications for vasopressor therapy administered through MCs. A placed MCs may also be used for blood sampling; however, additional studies are needed to confirm the safety, accuracy, and reliability of this practice [29].

Peripherally inserted central catheters (PICCs) are indicated for patients requiring prolonged intravenous therapy, particularly those with limited or inadequate peripheral venous access. Their primary therapeutic applications include the administration of irritant or vesicant medications such as chemotherapeutic agents, long-term antibiotic therapy, central venous access for hemodynamic monitoring, and the delivery of parenteral nutrition. PICCs are especially valuable in patients requiring treatment lasting weeks to months. Additional indications include repeated blood sampling, multiple transfusions, and use in neonatal populations for nutritional support and maintenance of central venous access [30,15].

CVCs are indicated for central venous pressure monitoring, infusion of vesicant substances (including electrolyte salts, hyperosmolar fluids, vasoactive agents, cytotoxic drugs, and selected antibiotics), and in cases of inadequate peripheral venous access. They are also essential for high-volume extracorporeal therapies such as hemodialysis, plasmapheresis, and continuous renal replacement therapy (CRRT), administration of multiple incompatible infusions (e.g., total parenteral nutrition, chemotherapy, acidic medications), massive transfusion protocols, and various venous interventions including inferior vena cava (IVC) filter placement, thrombolysis, cardiac pacing, and venous stenting [31,32].

2.3 Catheter dwell time

One of the key parameters evaluated by researchers is the dwell time of intravenous cannulas. According to recommendations and several independent research groups, peripheral intravenous catheters (PIVCs) have the shortest functional lifespan, typically lasting 2-4 days.[11][33][34] However, a study by Zhu et al. demonstrated that PIVCs may remain in place for more than 96 hours, provided specific clinical criteria are met.[35] Manufacturer recommendations for

Midline catheters remain in the body longer than standard peripheral intravenous catheters, which can reduce the number of venipunctures required during hospitalization [11][36]. MCs generally indicate a maximum dwell time of up to 29 days. In clinical practice, however, studies most often report average dwell times ranging from 8 to 14 days. [37][38][39][40] Some evidence suggests even longer durability: a recent randomized clinical trial comparing midlines and PICCs found that midlines may remain functional for up to 26 days on average. [9] Importantly, leaving a midline catheter in place for more than 15 days is associated with an increased incidence of complications. [25][40][41]Current guidelines recommend the use of midline catheters in patients requiring medium-term intravenous therapy and in patients with difficult peripheral access; however, these recommendations are largely based on expert consensus [14][42]

Peripherally inserted central catheters (PICCs) show the greatest variability in reported dwell times. The American College of Physicians recommends the use of PICCs for intravenous therapy lasting longer than 15 days. [16] However, data on the optimal catheter dwell time remain inconclusive. In a prospective cohort study by Grau et al. involving 192 PICC lines, the mean dwell time was approximately 27 days. [43] A study of 455 patients with hematologic malignancies similarly reported a mean indwelling time of 26 days before catheter replacement. [44] In contrast, data collected from 52 hospitals showed a significantly shorter mean catheter dwell time of 9 days in intensive care unit patients and 16 days in non-intensive care unit patients [45] The longest catheter dwell times were reported for PICC lines used for parenteral supportive care, where the mean catheter dwell time was 46 days. [46]

CVCs also show a wide range of dwell times across studies. A retrospective analysis reported an average of 16 days, [47] while another study found a median of 14 days. [48] Research focusing exclusively on ICU populations indicates much shorter dwell times, averaging 6 days. [49]

Taken together, these findings illustrate the considerable variability in reported dwell times for PIVCs, midlines, PICCs, and CVCs. This variability likely reflects differences in patient populations, clinical settings, catheter management strategies, and study methodologies. Further research is needed, especially studies focusing on homogeneous patient groups to enable more precise comparisons and establish reliable benchmarks for catheter dwell times.

2.4 Complications and safety profile

The growing use of PICCs has revealed that their long-term use may be associated with thrombotic complications and CLABSI to a degree comparable to CVCs [50]. MCs were introduced as an alternative to PICCs, which may reduce the need for CVC and PICC access [51][52].

The fact that MCs are not classified as CVCs means that infections associated with them are not reported as CLABSI (central line–associated bloodstream infections). However, the increasing use of this type of catheter should prompt a critical evaluation of complications caused by these devices [6]. The currently available results of analyses on the use of MCs are not unequivocal, or indicate that MCs are associated with a lower proportion of severe complications compared with PICCs [8]. It has been shown that the use of MCs instead of central venous access, in situations where central access was not clearly indicated, contributed to a significant reduction in CLABSI rates, which in turn translated into more than half a million dollars in annual savings for hospitals [53]. The above suggests that the use of MCs may prove beneficial on multiple levels – for patient health and satisfaction as well as from an economic perspective.

Between September 2023 and January 2024 a study by Zhao et al. MCs demonstrated a lower complication rate than LPCs in bariatric surgery patients despite longer insertion times, with similar rates of occlusion, thrombosis, phlebitis, and dislodgement, and extravasation/infiltration occurring significantly less frequently [54].

Interestingly, with the increasing popularity of MCs, observational studies have emerged showing the opposite relationship and suggesting that the incidence of complications associated with MCs may be similar to, or even exceed, that observed with PICCs [55]. Moreover, the incidence of mechanical complications appears to be higher with MCs than with PICCs [8].

The attempt to avoid the use of CVCs in favor of MCs to reduce, among others, the risk of bloodstream infections does not seem to be unequivocally beneficial, and study by Hogle et al. suggests that the incidence of midline catheter–associated bloodstream infection (MLABSI) is not completely eliminated [55].

A study by Bahl et al. demonstrated that the risk of thrombosis with MCs was higher than with PICCs (11.88% for MCs vs 6.88% for PICCs). An additional noteworthy observation was a statistically significant increase in the incidence of thrombosis in the limb contralateral to the catheter insertion site. This indicates that there may be an association between the placement of vascular access and an increased risk of symptomatic thrombosis in the contralateral limb [56].

Xu et al. reported findings suggesting that, although MCs were associated with a higher overall number of complications and hospital readmissions than PICCs, their use was associated with a significant reduction in the number of reported CLABSI. It was concluded that MCs may represent an acceptable alternative to PICCs, allowing the avoidance of CLABSI, which are dangerous for patients, even at the cost of a possible increase in non-severe complications [52].

Results from a meta-analysis conducted by M. Uretcho et al. showed that, on the one hand, the use of a MC was associated with a lower rate of bloodstream infection in patients compared with PICCs, while, on the other hand, a higher risk of superficial thrombophlebitis (SVT) was observed, although the overall rate of local thrombosis (SVT and DVT – deep venous thrombosis) and pulmonary embolism was similar [6]. These findings necessitate more in-depth analysis and the conduct of large, high-quality studies, which will allow a thorough evaluation and comparison of complication rates associated with these types of vascular access.

The collected data suggest that MCs may represent an attractive alternative to PICCs and CVCs, especially in the context of reducing CLABSI rates and potential economic benefits; however, their use is simultaneously associated with a significant increase in the proportion of non-severe complications, which should not be overlooked. The heterogeneity of the available results necessitates further, in-depth evaluation of the safety and efficacy of MCs in different patient populations and the conduct of large, randomized trials with high methodological quality before their optimal place in vascular access selection strategies in the context of potential complications can be clearly defined.

3. Discussion

Taken together, studies reveal considerable variability in dwell times for PIVCs, midlines, PICCs, and CVCs, driven by differences in patient populations, clinical settings, catheter management strategies, and study methodologies. Further research on homogeneous groups is needed to establish reliable benchmarks. Vascular access device selection should be guided by therapy duration, infused substance characteristics, and patient factors like vein quality and clinical stability: PIVCs are first-line for short-term and emergency use (including temporary vasopressors as a bridge to central access); midlines offer a valuable intermediate option with longer dwell times and fewer recannulations, especially in difficult venous access, though their vasopressor role requires more investigation; PICCs suit prolonged central access needs; and CVCs remain essential for critically ill patients needing complex, high-risk, or high-volume therapies. Insertion techniques show SPCs provide the greatest anatomical accessibility and ease but at the cost of mechanical instability and higher complications; midlines strike a balance between safety, durability, and risk; while PICCs should be reserved for long-term therapy after individualized risk assessment.

Regarding complications, MCs emerge as an attractive PICC/CVC alternative due to lower CLABSI rates and economic benefits, yet they increase non-severe complications data heterogeneity calls for large, high-quality randomized trials to define their optimal role in vascular access strategies across patient populations.

4. Conclusion

Device choice should integrate expected therapy duration, infusate characteristics, vascular anatomy, and the balance between infectious, thrombotic, and mechanical risks. MCs and LPCs appear promising alternatives to central access for intermediate-duration, peripherally compatible therapies; however, large, high-quality randomized studies are needed to refine selection algorithms and clarify safety signals.

5. Declarations and references (as provided)

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