



Research article

Midline Catheters Versus PICCs in Hospitalized Medicine Patients: Bloodstream Infection, Thrombosis, and Device Failure

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ABSTRACT

Peripherally inserted central catheters (PICCs) and midline catheters have become the main options for intermediate-term venous access in hospitalized medicine patients, yet the choice between them is often made by habit or local convention rather than evidence. Midlines have gained popularity as a safer alternative because their tip remains in a peripheral vein, which is expected to reduce bloodstream infection, but this assumption has rarely been weighed against their effects on thrombosis and device reliability. This review compares the two devices across bloodstream infection, catheter-related thrombosis, and device failure, drawing on comparative cohort studies, trials, meta-analyses, and clinical guidance published up to 2023, together with health systems, quality improvement, and supply chain literature that explains why device outcomes differ between hospitals. The evidence suggests that midlines reduce bloodstream infection and catheter occlusion when outcomes are counted per patient, although much of this advantage fades when risk is measured per catheter or per day of use, because midlines remain in place for shorter periods and their infections are less consistently captured by surveillance. In contrast, midlines carry a higher burden of superficial venous thrombosis, an equal or greater daily risk of deep vein thrombosis, and more frequent dislodgement, infiltration, and leakage, so they are more often removed before treatment is complete. The safety of either device therefore depends less on the device alone than on expected duration of therapy, the nature of the infusate, catheter size, and the quality of insertion, maintenance, surveillance, and supply in the hospital where it is used. Midlines are best suited to peripherally compatible therapy expected to last up to about two weeks, while PICCs remain preferable for longer courses and central-only treatments. Because the available evidence is largely observational and shaped by differences in patient selection, well-designed randomized trials are needed to guide device selection with greater confidence.

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INTRODUCTION

Reliable venous access is a routine but consequential need in hospital medicine. Many patients on general wards require intravenous therapy for longer than a short peripheral catheter can reliably support, or have veins that make repeated peripheral cannulation difficult. Short peripheral catheters fail frequently, with a large share removed before therapy ends because of phlebitis, infiltration, occlusion, or dislodgement (Alexandrou et al., 2018; Helm et al., 2015; Marsh et al., 2020), and each failure means another cannulation, delayed treatment, and added cost (Dychter et al., 2012). For roughly two decades the default response was the PICC, a device that is placed at the bedside, avoids the procedural risks of neck or chest central lines, and can remain in place for weeks to months (Simonov et al., 2015).

That convenience came with recognized harms. Systematic reviews established that PICCs carry a substantial risk of upper-extremity deep vein thrombosis and a bloodstream infection risk among hospitalized patients comparable to that of conventional central venous catheters (Chopra et al., 2013a; Chopra et al., 2013b). Commentators argued that the ease of PICC placement had encouraged use beyond clear indications, and reappraisals of the evidence called for more selective use (Chopra et al., 2012a; Chopra et al., 2012b). Multicenter data showed that many PICCs in medical patients are placed for short courses, frequently remaining in place for five days or fewer, which exposes patients to central line risk without a matching benefit (Paje et al., 2018). In some hospitals, roughly one in five physicians did not know that their patient had a

central catheter in place, which makes timely removal less likely (Chopra et al., 2014a).

The stakes of device-associated harm are high. Health care-associated infections remain common in United States hospitals (Magill et al., 2018), central line-associated bloodstream infection (CLABSI) carries meaningful attributable mortality (Ziegler et al., 2015), and CLABSI is among the costliest health care-associated infections per case (Zimlichman et al., 2013). National surveillance recorded a rise in CLABSI during the COVID-19 pandemic, reversing years of progress (Weiner-Lastinger et al., 2022). Health systems research has also argued that clinical innovations improve patient outcomes only when delivery infrastructure, data systems, and governance are in place to support them (Ilodigwe & Adesemoye, 2019b; Ilodigwe & Adesemoye, 2021).

Midline catheters emerged as a middle option. They are inserted in the upper arm, usually under ultrasound guidance, but terminate in a peripheral vein at or below the axilla rather than in the superior vena cava (Adams et al., 2016). Midlines are not new: an early prospective study in hospitalized patients reported low infection rates with midline catheterization (Mermel et al., 1995), and nurse-led midline programs were described in acute care well before the current wave of interest (Alexandrou et al., 2011). The Michigan Appropriateness Guide for Intravenous Catheters (MAGIC) formalized this niche in 2015, rating midlines as preferred over PICCs for peripherally compatible infusions expected to last roughly 6 to 14 days and rating PICC placement for very short durations as inappropriate (Chopra et al., 2015; Moureau & Chopra, 2016). Midline use has since grown quickly, in part because infections in midlines are not counted toward CLABSI metrics.

The two devices share an insertion site and technique but differ in where the tip sits, and that difference drives most of their contrasting risk profiles (Table 1). Both are placed under ultrasound guidance, which improves first-pass success and reduces insertion complications (Lamperti et al., 2012; Stokowski et al., 2009). For PICCs, systematic selection of an insertion zone on the upper arm (Dawson, 2011) and tip confirmation with intracavitary electrocardiography (Pittiruti et al., 2012) are now standard in many programs, and consensus documents define minimum training requirements for inserters (Moureau et al., 2013) and indications for peripheral, midline, and long peripheral devices (Pittiruti et al., 2023). Device characteristics matter for both catheters. The ratio of catheter diameter to vein diameter influences blood flow around the catheter in experimental models (Nifong & McDevitt, 2011), a prospective cohort linked higher catheter-to-vein ratios with more symptomatic venous thromboembolism in PICC patients (Sharp et al., 2015), and risk reduction tools built around this ratio have been proposed for routine use (Spencer & Mahoney, 2017). Defaulting to single-lumen PICCs reduces complications and cost (O'Brien et al., 2013; Ratz et al., 2016), and central-only infusates such as parenteral nutrition require a central tip by definition (Pittiruti et al., 2009).

Earlier syntheses have compared midline and PICC complication rates, but they have generally pooled

Table 1. Key characteristics of midline catheters and PICCs

Feature	Midline catheter	PICC
Insertion site	Basilic, brachial, or cephalic vein of the upper arm, usually ultrasound guided	Same upper-arm veins, ultrasound guided
Tip position	Peripheral; at or below the axillary vein, distal to the shoulder	Central; lower superior vena cava or cavoatrial junction
Typical length	About 8 to 20 cm	About 40 to 60 cm, trimmed to patient
Tip confirmation	Not required	Required (ECG tip location or imaging)
Infusates	Peripherally compatible only; vesicants, parenteral nutrition, and irritant solutions generally avoided	Peripheral and central infusates, including vesicants, parenteral nutrition, and chemotherapy
Intended dwell	Up to about 2 to 4 weeks	Weeks to months
Infection surveillance	Not counted as a central line in CLABSI metrics	Counted in CLABSI metrics
Blood sampling	Possible but less reliable	Generally reliable

Compiled from MAGIC (Chopra et al., 2015), the Infusion Therapy Standards of Practice (Gorski et al., 2021), and a clinical review of midline catheters (Adams et al., 2016).

outcomes per patient, treated surveillance data at face value, and left aside the organizational factors that explain why the same device performs differently in different hospitals. This review addresses those gaps by interpreting infection, thrombosis, and failure outcomes both per patient and per catheter-day, by examining how surveillance rules and laboratory capacity shape the apparent safety of each device, and by linking the clinical comparison to the prevention practices, workforce, data systems, and supply chains on which safe device use depends. The aim was to compare midlines and PICCs in adult medical inpatients on bloodstream infection, thrombosis, and device failure, and to derive practical guidance for device

selection and for the hospital systems that support both devices.

2. RESEARCH METHOD

Literature search and study selection

This narrative comparative review followed a structured search of PubMed and Google Scholar for publications from inception to December 2023, using combinations of the terms midline catheter, peripherally inserted central catheter, PICC, bloodstream infection, CLABSI, thrombosis, occlusion, and complication. Reference lists of key reviews and guidelines were hand-searched. Priority was given to direct comparative studies of midlines and PICCs in adult inpatients, systematic reviews and meta-analyses that pooled such comparisons, cohort studies describing the outcomes of each device separately, and clinical guidelines and consensus statements relevant to device selection and prevention. Studies dominated by oncology, parenteral nutrition, dialysis, pediatric, or intensive care populations were used only for context, because their risk profiles differ from those of general medicine patients.

Because device outcomes depend on how hospitals organize care, a second search drew on health systems, quality improvement, safety science, informatics, workforce, and supply chain literature. These sources were used to frame implementation questions rather than to estimate clinical effect sizes, and most are conceptual frameworks or narrative reviews rather than empirical outcome studies.

Outcomes and synthesis

Three outcome domains were examined. Bloodstream infection was defined as CLABSI or CRBSI as reported by each study, recognizing that diagnostic criteria differ between guideline and surveillance definitions (Mermel et al., 2009). Thrombosis included symptomatic upper-extremity deep vein thrombosis (DVT), superficial venous thrombosis (SVT), and pulmonary embolism. Device failure included occlusion, dislodgement, infiltration or leakage, phlebitis, and premature removal before completion of therapy. Findings were synthesized narratively and, where possible, interpreted both per patient and per catheter-day, since the two devices are used for very different lengths of time. The direction and certainty of evidence for each outcome were judged qualitatively from study design, consistency, and precision.

3. RESULTS AND DISCUSSION

Characteristics of the evidence

No randomized trial comparing midlines and PICCs in general medical inpatients had been published by the end of 2023. The evidence consisted of retrospective and registry cohorts, a quality improvement pilot, single-device cohort studies, and meta-analyses that pooled largely observational data. One randomized trial compared a midline-based access strategy with-

Table 2. Principal comparative studies and syntheses

Study	Design and population	Main findings	Notes
Swaminathan et al. (2022)	Registry cohort, 48 Michigan hospitals; 5,105 midlines, 5,758 PICCs for difficult access or IV antibiotics of 30 days or fewer	PICCs had about twice the odds of a major complication (aOR 1.99). BSI 1.6% vs 0.4%; occlusion 7.0% vs 2.1%. DVT not different in logistic models but lower hazard with PICCs in time-to-event models (HR 0.53)	Median dwell 14 days (PICC) vs 6 days (midline); strong selection by indication
Urtecho et al. (2023)	Systematic review and meta-analysis of RCTs and observational studies; excluded populations mostly on chemotherapy, TPN, or dialysis	Fewer patients with CRBSI using midlines (OR 0.24; 95% CI 0.15 to 0.38) but no difference per catheter. No difference in DVT or PE; more SVT with midlines (OR 2.30; 95% CI 1.48 to 3.57)	Heterogeneous definitions; mostly observational inputs
Lu et al. (2021)	Meta-analysis of comparative studies of CRBSI	No significant difference in CRBSI (RR 0.77; 95% CI 0.50 to 1.17)	Included mixed populations
Bahl et al. (2019)	Retrospective, 1,100-bed academic center; 1,094 midlines, 1,483 PICCs	Symptomatic thrombosis 11.9% vs 6.9% (OR 1.82). DVT 7.0% vs 4.7%; SVT 4.8% vs 2.2%	Larger lumen count and catheter size associated with more thrombosis in both devices
Mushtaq et al. (2018)	Retrospective, tertiary hospital; 411 midlines vs 282 central lines	CRBSI 0.2% vs 3.5%; mechanical complications 2.6% vs 0.3%	Comparator included non-PICC central lines
Xu et al. (2016)	Retrospective comparison at a large academic center	Fewer bloodstream infections with midlines than with PICCs	Single center; mixed indications
Sharp et al. (2014)	Retrospective cohort of adults with cystic fibrosis	Compared safety and efficacy of midlines and PICCs for intravenous antibiotic courses	Specialized population with repeated access needs

Study	Design and population	Main findings	Notes
Chopra et al. (2019)	Multicenter quality improvement pilot of midline use	Wide variation in midline use and outcomes across hospitals; occlusion and other complications common	Highlights practice variation rather than a head-to-head comparison

aOR, adjusted odds ratio; BSI, bloodstream infection; CRBSI, catheter-related bloodstream infection; DVT, deep vein thrombosis; HR, hazard ratio; PE, pulmonary embolism; SVT, superficial venous thrombosis; TPN, total parenteral nutrition.

-standard peripheral and central access rather than directly with PICCs (Nielsen et al., 2021). The most informative comparative sources are summarized in Table 2.

Single-device cohorts add context. Prospective PICC cohorts in hospitalized and outpatient populations documented the range of infectious, thrombotic, and mechanical complications (Grau et al., 2017; Leroyer et al., 2013), and patients reported frequent problems with PICCs after discharge that clinicians may not record (Krein et al., 2019). Midline cohorts from academic and community settings described low infection rates alongside more frequent mechanical failure (Bundgaard Madsen et al., 2020; Scoppettuolo et al., 2016; Seo et al., 2020). Reviews of long peripheral catheters, which overlap with short midlines, described a similar pattern (Badger, 2019), and a randomized trial found that ultrasound-guided catheters of greater length survived longer than standard-length peripheral catheters (Bahl et al., 2020).

Bloodstream infection

Catheter-related bloodstream infection arises mainly from skin organisms that migrate along the external surface of the catheter early in dwell, and from intraluminal contamination of hubs and connectors as dwell lengthens (Raad et al., 1993; Safdar & Maki, 2004). Every intravascular device carries some infection risk, and a large systematic review showed that risk differs substantially by device type, with peripherally placed devices generally lower than centrally placed ones (Maki et al., 2006). Even short peripheral catheters cause bloodstream infections, which are underappreciated because they are not counted in central line metrics (Guembe et al., 2017; Mermel, 2017), and targeted interventions can reduce these infections and their associated mortality (Saliba et al., 2018).

PICC-associated bloodstream infection in hospitalized patients is not rare. Multicenter data identified patient and device factors, including lumen number and critical illness, that predict infection (Chopra et al., 2014c); similar predictors were described in earlier hospital cohorts (Ajenjo et al., 2011) and combined into a bedside prediction score for PICC-associated CLABSI (Herc et al., 2017). A contemporary meta-

analysis suggested that PICCs inserted with current best practices carry lower infection and thrombosis risk than older studies implied (Schears et al., 2021). The direction of the comparative infection signal favored midlines in most studies. In the Michigan registry, bloodstream infection occurred in 1.6% of PICC patients versus 0.4% of midline patients, and the difference persisted in time-to-event models that accounted for dwell time (Swaminathan et al., 2022). One tertiary-care cohort found CRBSI in 0.2% of midline patients compared with 3.5% of patients with central lines, although that comparator group was not restricted to PICCs (Mushtaq et al., 2018), and an earlier academic center comparison also reported fewer bloodstream infections with midlines (Xu et al., 2016). Hospitals that introduced midline programs, including a ventilator unit and a community hospital, reported falls in central line infections (DeVries et al., 2019; Pathak et al., 2015), multi-hospital surveillance found midline-associated bloodstream infections to be less frequent than CLABSI (Hogle et al., 2020), and case studies have described how such programs are established (Moureau et al., 2015). A randomized trial also found midlines safe for administering vancomycin, a commonly used irritant antibiotic (Caparas & Hu, 2014).

The pooled evidence was less clear-cut. The 2023 meta-analysis by Urtecho and colleagues found about a 76% reduction in the odds of CRBSI per patient with midlines, but this association disappeared when risk was expressed per catheter (Urtecho et al., 2023), and an earlier meta-analysis found no statistically significant difference (Lu et al., 2021). Because midlines are used for shorter periods and replaced more often, a lower per-patient rate partly reflects less exposure time rather than a safer device. Patients chosen for PICCs also tend to be sicker, receive longer or more complex therapy, and more often have multi-lumen devices, all of which raise infection risk independent of tip location (Swaminathan et al., 2022).

Ascertainment differs between the devices. Because midlines are not counted as central lines, their bloodstream infections may be less systematically captured by surveillance programs, which can make midlines appear safer than they are (Urtecho et al., 2023). Hospital-wide surveillance that includes all catheter types has repeatedly uncovered infections outside traditional central line reporting (Zingg et al., 2009). Detection of device-related infection also depends on how well laboratory and clinical information systems link positive blood cultures to the device in place (Abdulrazag et al., 2019) and on integrated microbiology workflows that turn culture results into timely clinical action (Asiedu, 2023). Laboratory capacity, quality systems, and physical design influence the reliability of blood culture results (Ogbete et al., 2018; Ogbete et al., 2019; Yusuf & Abdulrazag, 2018), investment in diagnostic laboratory infrastructure has been framed as a public health intervention in its own right (Aminu-Ibrahim & Ogbete, 2023; Aminu-Ibrahim et al., 2018; Aminu-Ibrahim et al., 2020), and laboratories designed for surge capacity and evaluated across

their lifecycle are better placed to sustain surveillance during events such as a pandemic (Aminu-Ibrahim et al., 2022; Ogbete et al., 2023). Biomarker-based decision support may in future help distinguish catheter infection from other sources (Abdulrazaq et al., 2023), although uptake of newer diagnostic techniques in routine practice depends on overcoming cost, training, and workflow barriers (Abdulrazaq et al., 2021). Recurrent device infections also drive antibiotic exposure and so feed into antimicrobial resistance, which multi-laboratory reporting networks and attention to medicine quality both address (Aneke et al., 2022b; Yusuf et al., 2020).

Thrombosis

PICCs are a well-established cause of upper-extremity DVT (Chopra et al., 2013a). Multicenter data described patterns and predictors of PICC-related DVT (Chopra et al., 2014b), an earlier hospital cohort related symptomatic DVT risk to catheter size (Evans et al., 2010), and a narrative review summarized the clinical consequences (Fallouh et al., 2015). PICCs were associated with venous thromboembolism in the lower as well as the upper extremities, suggesting a systemic prothrombotic effect in at-risk patients (Greene et al., 2015). Among medical inpatients, central catheters accounted for a substantial share of upper-extremity DVT (Winters et al., 2015), a condition with its own management challenges (Kucher, 2011). Thrombosis risk can be estimated before insertion with the Michigan Risk Score (Chopra et al., 2017), and placement guided by intracavitary electrocardiography was not associated with higher thrombosis than traditional methods (Kleidon et al., 2021).

Midlines sit in smaller peripheral veins with lower blood flow, where the catheter occupies a larger fraction of the vessel, a geometry that favors stasis and endothelial injury. A prospective observational study documented symptomatic upper-limb thrombosis associated with midline catheters (Lisova et al., 2018). In the Michigan registry, crude DVT rates did not differ between devices, but when dwell time was accounted for the daily hazard of DVT was lower with PICCs (HR 0.53), meaning that for each day in place a midline carried roughly twice the DVT risk (Swaminathan et al., 2022). A single-center series of more than 2,500 catheters found symptomatic thrombosis in 11.9% of midlines versus 6.9% of PICCs, with higher rates of both DVT and SVT among midlines, and double-lumen and larger-diameter catheters roughly doubled thrombosis risk for both devices (Bahl et al., 2019). The 2023 meta-analysis found no significant difference in DVT or pulmonary embolism but a clear excess of superficial venous thrombosis with midlines (Urtecho et al., 2023).

Superficial thrombosis is usually less dangerous than DVT but still causes pain, leads to device removal, and can extend. A midline-associated DVT of the brachial or axillary vein carries management implications similar to those of a PICC-associated DVT, and anticoagulation decisions follow general venous thromboembolism guidance (Ortel et al., 2020). Taken together, the data indicate that midlines do not reduce thrombosis and probably increase it per day of use,

with the total burden depending on dwell time and catheter-to-vein sizing (Sharp et al., 2015; Spencer & Mahoney, 2017).

Device failure

The two catheters failed in different ways. Occlusion favored midlines: in the Michigan cohort it occurred in 7.0% of PICCs and 2.1% of midlines (aOR 2.24) (Swaminathan et al., 2022), plausibly because of the longer, narrower internal path of a PICC and its frequent use for blood sampling. Flushing and locking practice influences occlusion for both devices, although evidence for specific regimens is limited (Goossens, 2015), and saline appears adequate in place of heparin for most adult central catheters (Lopez-Briz et al., 2018).

Mechanical failure favored PICCs. Midlines are shorter and anchored in a smaller, more mobile segment of vein, making them more prone to dislodgement, infiltration, leakage at the insertion site, and phlebitis. Mushtaq and colleagues reported mechanical complications in 2.6% of midlines versus 0.3% of central lines (Mushtaq et al., 2018). Infiltration and extravasation can cause serious tissue injury, especially with irritant infusates (Hadaway, 2007), phlebitis is measured inconsistently across studies (Ray-Barruel et al., 2014), and dressing and securement choices affect dislodgement and infection (Timsit et al., 2012; Ullman et al., 2015). Within the Michigan cohort, midlines were more often removed because of a complication, while some PICC complications could be managed without removing the line (Swaminathan et al., 2022).

Premature removal and failure to complete therapy were more common with midlines in most series. A midline that fails on day 9 of a planned 14-day course may lead to a second device, frequently a PICC, so the intended reduction in central line exposure is not always realized. A multicenter quality improvement pilot documented substantial hospital-to-hospital variation in how midlines were used and how often they failed (Chopra et al., 2019). Nurse staffing and workload shape how reliably dressings, flushing, and site checks are performed (Omaghomi et al., 2023), and a device that is safer in principle improves outcomes only when the delivery systems around it are in place (Ilodigwe & Adesemoye, 2019b). For peripheral catheters, clinically indicated rather than routine replacement is safe (Rickard et al., 2012), and the same principle of removal for a reason rather than by schedule applies to midlines.

Special populations

Patients with advanced chronic kidney disease need their arm veins preserved for future dialysis access, yet PICCs are frequently placed in this population (Paje et al., 2019). Nephrology position statements and the KDOQI vascular access guideline recommend avoiding PICCs, and limiting upper-arm cannulation more generally, in patients who may need hemodialysis (Hoggard et al., 2008; Lok et al., 2020). Upper-arm midlines raise the same concern.

Table 3. Direction and certainty of evidence by

outcome

Outcome	Direction of effect	Certainty	Main reasons for uncertainty
Bloodstream infection	Lower with midlines per patient; unclear per catheter	Low to moderate	Shorter midline dwell, surveillance differences, confounding by indication
Deep vein thrombosis	Similar crude rates; higher per-day hazard with midlines	Low	Inconsistent definitions, symptomatic-only detection, dwell differences
Superficial venous thrombosis	Higher with midlines	Moderate	Variable reporting of superficial events
Pulmonary embolism	No clear difference	Low	Rare events; underpowered studies
Occlusion	Lower with midlines	Moderate	Mostly one large registry
Dislodgement, infiltration, leakage	Higher with midlines	Low to moderate	Definitions vary; often not reported
Premature removal	Higher with midlines	Low to moderate	Removal reasons inconsistently recorded

Certainty ratings are the author's qualitative judgment based on study design, consistency, and precision.

Many medical inpatients complete intravenous antibiotics at home. Guidelines for outpatient parenteral antimicrobial therapy address device choice, laboratory monitoring, and follow-up (Norris et al., 2019), and a large cohort found vascular access complications to be a common problem during home therapy (Shrestha et al., 2016). Mobile health tools for monitoring and adherence could extend oversight into the home (Oparah et al., 2021b), and care coordination frameworks aim to reduce readmissions among patients with chronic conditions (Akinlolu et al., 2023). Patients going home with a midline or PICC also need practical support with daily activities such as bathing and dressing so that the device stays protected, and structured support for activities of daily

living has been framed as a clinical intervention in its own right (Osinem et al., 2021).

In patients with difficult venous access, ultrasound-guided short midlines placed in the emergency department have been described as a practical solution (Scoppettuolo et al., 2016), and longer ultrasound-guided catheters outlast standard ones (Bahl et al., 2020). Table 3 summarizes the direction and certainty of the comparative evidence by outcome.

Overall comparison and interpretation

This review found a consistent trade-off rather than a clear winner. Compared with PICCs, midlines appear to lower the risk of bloodstream infection and occlusion, the outcomes most visible to infection prevention programs, but they likely increase superficial thrombosis, carry at least an equal and possibly higher per-day DVT risk, and fail mechanically more often. Whether a midline is the safer choice for a given patient therefore depends on which harm is most likely and most consequential for that patient, and above all on how long the device will be needed.

Duration is the central modifier. Because midline thrombosis and failure risks appear to accumulate faster per day, the benefit of a midline is greatest for short dwell times and erodes as therapy lengthens. This is consistent with MAGIC, which positions midlines for roughly one to two weeks of peripherally compatible therapy and PICCs for longer courses or central-only infusates (Chopra et al., 2015), and with European recommendations on peripheral venous access devices (Pittiruti et al., 2023). The finding that the infection advantage of midlines weakens when measured per catheter, and that their thrombosis disadvantage appears only when dwell is accounted for, shows how much the choice of denominator shapes conclusions in this field.

Prevention and implementation

Many prevention measures apply regardless of device. Guidelines set out insertion and maintenance standards for intravascular catheters (Gorski et al., 2021; O'Grady et al., 2011), and updated compendium recommendations for acute care hospitals emphasize insertion bundles, chlorhexidine skin antisepsis, and prompt removal (Buetti et al., 2022). Chlorhexidine-alcohol outperformed povidone iodine-alcohol for skin antisepsis in a large randomized trial (Mimoz et al., 2015), and the Michigan intensive care collaborative showed that a checklist-based bundle combined with a culture of safety produced large and sustained reductions in catheter-related bloodstream infection (Pronovost et al., 2006). Reviews summarize how to prevent, recognize, and manage complications across device types (Timsit et al., 2018), and the COVID-19 experience showed that hardwiring these practices so that they persist under pressure is as important as introducing them (Weiner-Lastinger et al., 2022).

Infection prevention and control compliance has

been described as multidimensional, spanning leadership, resources, training, and audit (Omaghomi et al., 2022). Safety science from high-hazard industries offers parallel lessons in leadership-driven safety culture (Obogo et al., 2019), management walkthroughs linked to culture outcomes (Obriki & Arumosoye, 2019), organizational learning for continuous safety improvement (Arumosoye & Obriki, 2021), and behavioral safety programs (Obriki et al., 2023b). Systematic use of near-miss and hazard data (Arumosoye & Obriki, 2019), attention to the causes of human error (Obriki & Arumosoye, 2020), and understanding why unsafe behaviors recur (Obriki & Arumosoye, 2022) are relevant to recurring line complications, while data-driven and continuous hazard monitoring (Obriki & Arumosoye, 2018; Obriki & Arumosoye, 2023; Obriki et al., 2023a), structured safety training (Obriki et al., 2022), and internal audit systems (Obogo et al., 2020) have direct analogues in line rounds, competency checks, and device audits. Device outcomes vary widely between hospitals. Michigan data showed large variation in PICC use and complications (Chopra et al., 2016), a similar picture emerged in Brazil (Rabelo-Silva et al., 2022), and inappropriate intravascular device use is common (Tiware et al., 2011). Quality improvement collaboratives that applied MAGIC criteria improved PICC appropriateness and reduced complications, first in an interrupted time series (Swaminathan et al., 2018) and then across 52 hospitals (Chopra et al., 2022), and practical guidance for hospitalists is available (Simonov et al., 2015). Sustaining such gains depends on general improvement methods: standard operating procedures that act as change infrastructure (Agboada et al., 2019), standardized reporting and decision workflows (Alieme et al., 2022), structured change management (Eyetsemitan et al., 2023), Lean Six Sigma approaches adapted for resource-constrained settings (Ambali et al., 2021; Ezeugwa et al., 2023), and digital transformation of operations (Agboada et al., 2018). Key performance indicator frameworks (Akin-Oluyomi & Akhigbe, 2023b; Sakyi et al., 2022), quality measurement models from geriatric and long-term care (Ekemezie et al., 2023a; Ekemezie et al., 2023b), public health governance built on performance metrics (Anioke & Atima, 2023b), and analytics-driven performance models in health care operations (Nnaji & Akinlolu, 2023) offer templates for device metrics such as appropriateness, dwell, and complication rates. Evidence linking multidisciplinary collaboration to better outcomes in emergency care (Ohunyon et al., 2023) supports vascular access teams that include physicians, nurses, pharmacists, and infection preventionists.

Insertion and maintenance quality also depend on the workforce. Beyond minimum training standards (Moureaux et al., 2013) and safe nurse staffing (Omaghomi et al., 2023), frameworks addressing talent development across distributed operations (Falemi et al., 2020), staffing volatility (Falemi et al., 2023b), retention linked to productivity (Falemi et al., 2023a), and recruitment and integration of new staff (Akhigbe et al., 2020) apply to building and sustaining a vascular access service. The preparedness and supervision of newly qualified house officers, who

often request, review, and remove venous access devices on medical wards, also shape the quality of care, particularly in low-resource hospitals (Peteranaba et al., 2023b). Staff stress affects how reliably routine maintenance is carried out, and mindfulness-based interventions have been reviewed as one means of reducing it (Osinem et al., 2023). Digital learning platforms and real-time performance dashboards have been proposed for health professional training (Orise & Niniola, 2020; Orise & Niniola, 2022), with attention to privacy and ethical data practices in educational technology (Orise & Niniola, 2023).

Data systems and supply chains

Knowing which patients have which device, for how long, and why is a prerequisite for safe use, yet clinicians are often unaware of central lines in their own patients (Chopra et al., 2014a). Real-time health informatics can shorten decision delays (Nnaji & Akinlolu, 2022), and a governed data backbone with interoperability and data quality controls underpins analytics at scale (Ilodigwe & Adesemoye, 2021). Informatics frameworks for protecting vulnerable populations (Anioke & Atima, 2023c), business intelligence for resource allocation and program accountability (Anioke & Atima, 2023a; Owode et al., 2022), and IT service management approaches (Ladapo et al., 2023) are relevant to building device registries and line-day dashboards, while real-time surveillance dashboards (Oparah et al., 2023) and predictive models for infectious disease patterns (Oparah et al., 2022) show how such data can be turned into action. Prediction tools already exist for PICC thrombosis and infection (Chopra et al., 2017; Herc et al., 2017), and artificial intelligence could extend them through risk stratification (Oparah et al., 2021a), early detection systems (Afrihyia et al., 2023), or composite risk scores that combine clinical and imaging data (Okwah, 2022). Such tools should keep clinicians in the loop (Ladapo et al., 2022), be subject to model risk management (Ominyi & Anichukwueze, 2023), and be introduced after a realistic assessment of organizational readiness (Alieme et al., 2023). Device registries must meet data integrity and governance standards (Aneke et al., 2023; Peteranaba et al., 2022), including documentation workflows that protect data integrity and patient confidentiality (Peteranaba et al., 2023a), comply with data protection regimes (Annan, 2022; Ominyi & Anichukwueze, 2022), and manage legal, ethical, and security risks (Mbonu et al., 2018; Ozowara et al., 2022), ideally with automated compliance monitoring (Uchechi et al., 2022).

Device choice is also constrained by what is available and affordable. Health care-associated infections impose large costs (Zimlichman et al., 2013), intravenous therapy complications add to that burden (Dychter et al., 2012), and limiting lumen number reduces both complications and cost (O'Brien et al., 2013; Ratz et al., 2016). Machine learning dashboards have been proposed for hospital supply chain risk assessment (Filani et al., 2022), predictive analytics can improve demand forecasting and reduce inventory inefficiency

(Aifuwa et al., 2020; Akin-Oluyomi & Akhigbe, 2023a; Akin-Oluyomi et al., 2023a), and resilience frameworks (Anene, 2021; Awulu et al., 2022b; Efobi et al., 2023), shortage early warning models (Eze et al., 2022), and supply chain governance for sustainable access (Eze et al., 2023) bear on the reliable supply of catheters, dressings, and securement devices. Procurement practice shapes what reaches the bedside through supplier relationship management (Akinleye & Adeyoyin, 2022), supplier risk assessment and regulatory compliance (Akin-Oluyomi et al., 2023b), data visualization and business intelligence (Akinleye et al., 2023; Babatope et al., 2023), and procurement automation (Akinleye & Adeyoyin, 2021). Traceability (Aneke & Adesemoye, 2019; Nnabueze et al., 2021), risk-based quality decisions (Aneke & Adesemoye, 2020), corrective and preventive action systems (Aneke et al., 2022a), and supply chain governance for compliance and quality (Akin-Oluyomi & Akhigbe, 2022) help ensure that devices meet specification. Operational performance measurement and digital transformation in manufacturing (Awulu et al., 2022a; Obukadata et al., 2021b), Lean approaches to distribution bottlenecks (Obukadata et al., 2021a), and attention to affordability and last-mile delivery (Asiedu & Asiedu, 2022; Asiedu & Asiedu, 2023) matter most in resource-constrained settings, where pharmacy-led access models also play a role (Ilodigwe & Adesemoye, 2020). Financing arrangements influence whether hospitals can invest in vascular access teams and ultrasound equipment (Ilodigwe & Adesemoye, 2019a), and capital project and program management models determine how well facilities and laboratories are built and expanded (Aminu-Ibrahim et al., 2019; Aminu-Ibrahim et al., 2021).

Implications for practice

Pending randomized evidence, the available data and guidance support a small number of principles (Chopra et al., 2015; Gorski et al., 2021), summarized in Table 4. Device selection should start with the infusate, since vesicants, parenteral nutrition, and other central-only therapies require a central device regardless of expected duration (Pittiruti et al., 2009). Expected duration should then be estimated honestly: an ultrasound-guided peripheral catheter usually suffices for about 5 days or less, a midline is generally reasonable for roughly 6 to 14 days, and a PICC becomes more attractive for longer courses because midline failure and thrombosis accumulate. The smallest suitable device should be used, since single-lumen, smaller-gauge catheters are associated with less thrombosis for both device types (Bahl et al., 2019). Midlines should not be used as a strategy for avoiding CLABSI metrics; their infections should be tracked through internal surveillance within a broader infection prevention program (Abdulrazaq et al., 2019; Omaghomi et al., 2022). Need should be reviewed daily, with informatics prompts to shorten the delay between a device becoming unnecessary and its removal (Nnaji & Akinlolu, 2022). When therapy will continue after discharge, device choice should be coordinated with the outpatient plan so that the line

suits the full course (Akinlolu et al., 2023; Norris et al., 2019). Finally, outcome variation between hospitals suggests that insertion and maintenance practices matter as much as the choice of device (Chopra et al., 2019), which supports multidisciplinary vascular access teams where available (Ohunyon et al., 2023).

Table 4. Simplified device selection framework for adult medical inpatients

Clinical scenario	Preferred device	Comments
Peripherally compatible therapy, 5 days or less	Peripheral IV (ultrasound-guided if access is difficult)	Avoid PICC placement for very short durations
Peripherally compatible therapy, about 6 to 14 days	Midline	Monitor arm for swelling, pain, or infiltration
Peripherally compatible therapy, more than 14 days	PICC (midline acceptable in selected cases)	Midline failure and thrombosis risk rises with dwell
Vesicants, parenteral nutrition, or other central-only infusates	PICC or other central device	Midline not appropriate
Advanced chronic kidney disease or possible future dialysis access	Avoid PICC and upper-arm midline where possible; consult nephrology	Preserve arm veins (Lok et al., 2020)
Frequent blood sampling needed	PICC more reliable	Midline sampling is less dependable

Adapted from MAGIC (Chopra et al., 2015) and the Infusion Therapy Standards of Practice (Gorski et al., 2021); individual patient factors should guide final decisions.

Strengths and limitations

This review integrates comparative clinical evidence with guideline recommendations and implementation literature, and it distinguishes per-patient from per-catheter-day findings, which explains several apparent contradictions in earlier work. It has limitations of its own. It is a narrative rather than a systematic review, no formal risk-of-bias tool or meta-analysis was applied, and study selection may reflect the author's judgment. The implementation literature drawn on is largely conceptual and much of it comes from outside vascular access, so it informs rather than tests the

practice recommendations.

The underlying evidence has further limitations. Confounding by indication is substantial: in the Michigan registry, about 72% of midlines were placed for difficult access, while about 71% of PICCs were placed for antibiotics (Swaminathan et al., 2022). Exposure time differs, with median dwell of about 6 days for midlines and 14 days for PICCs (Swaminathan et al., 2022). Ascertainment is uneven, because midline infections fall outside CLABSI reporting and thrombosis is usually detected only when symptomatic; experience with routine disease surveillance shows how data quality and reporting capacity shape what gets counted (Ekemezie et al., 2018; Ogunboye et al., 2023). Catheter length, material, gauge, lumen number, insertion technique, and outcome definitions vary across studies, and because CRBSI classification rests on laboratory confirmation, differences in blood culture practice and diagnostic quality add further noise (Yusuf & Abdulrazaq, 2018). Device size alone substantially changes thrombosis risk (Bahl et al., 2019). Finally, as of 2023 no randomized comparison had reported; a Danish trial comparing midlines with PICCs in adults receiving intravenous therapy had been registered but not completed (Aalborg University Hospital, 2019).

Future research

Randomized trials in general medicine populations are the priority, with outcomes measured per patient and per catheter-day, systematic or standardized assessment for thrombosis, and uniform infection definitions applied to both devices, ideally captured through coordinated multi-site laboratory reporting networks (Yusuf et al., 2020). Trials should report device characteristics and patient-centered outcomes such as completion of therapy without additional devices, comfort, and cost. Comparative work on longer peripheral catheters, which overlap with midlines, would clarify the options for short-to-intermediate access, and implementation studies should test how appropriateness criteria, vascular access teams, informatics prompts, and supply chain reliability interact (Ilodigwe & Adesemoye, 2019b; Ilodigwe & Adesemoye, 2021).

4. CONCLUSION

In hospitalized medicine patients needing peripherally compatible intravenous therapy for up to about two weeks, midline catheters appear to offer lower bloodstream infection and occlusion risk than PICCs. That advantage is offset by more superficial thrombosis, a probably higher per-day risk of deep vein thrombosis, and more frequent mechanical failure and premature removal. Neither device is uniformly safer. The right choice depends on infusate, expected duration, and patient factors, and outcomes for both devices depend on appropriateness programs, trained inserters, reliable surveillance, and resilient supply chains. Randomized evidence is

needed to settle the comparison.

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