Does the Midline Peripheral Intravenous Catheter Have a Place in Critical Care?

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Background The goals of infusion therapy are to preserve vascular health and safely deliver needed treatment. Achieving these goals is challenging in critical care because of the complexity of the treatment required. Daily justification of retaining an existing central venous catheter also creates urgency to change to a peripheral vascular access device. The midline catheter has had a resurgence in use because of the need for a long-term peripheral vascular access device not linked to central catheter–associated bloodstream infection risk.

Objective To review the characteristics of midline catheters, the benefits and risks of midline catheters, and current evidence regarding midline catheter use in critical care.

Results Research related to midline catheters has greatly expanded the body of knowledge regarding vascular access device selection and midline catheter use.

Discussion Although the quality and results of research on vascular access devices vary widely, a more accurate safety profile is emerging to illustrate how midline catheter use can support the goals of infusion therapy.

Conclusions Optimizing vascular access device selection requires recognition that every vascular access device can cause patient harm. Although the midline catheter appears to fill an important niche in infusion therapy, use of the midline catheter should be carefully evaluated. Midline catheters should not be used as a catheter-associated bloodstream infection prevention strategy, should be inserted to administer peripherally compatible solutions, and should be considered for short-term continuous vesicant therapy only in emergent situations until more definitive vascular access can be achieved. (*Critical Care Nurse*. 2021;41[6]:e1-e21)

Common vascular access challenges (as illustrated in Table 1) must be navigated wisely to achieve the critical and at times competing goals of vessel preservation and effective delivery of needed infusion therapy.[2-5] Resources and algorithms are available to guide vascular access device (VAD) selection and placement, but the evolving nature of these situations, varied available resources, and conflicting or limited evidence-based recommendations create uncertainty.[6-8] In addition, the process of daily justification of retaining an existing central venous catheter (CVC), an important strategy to prevent central line–associated bloodstream infections (CLABSIs), creates a sense of urgency to de-escalate infusions to a peripheral VAD. This process is often used in an effort to avoid reportable hospital-acquired infections.[5,7-14] Use of the midline catheter (MC) has undergone a resurgence because of the need to provide a long-term peripheral vascular access option that is not

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Table 1 Vascular access selection scenarios

Scenario	Questions to consider
A patient presented to the emergency department with respiratory distress, fever, and cough. Vital signs were temperature 101.2 °F, heart rate 124/min, respiratory rate 32/min, blood pressure 148/90 mm Hg, and lactic acid 3.4 mmol/L. A COVID-19 test result was negative. A midline peripheral catheter was placed for fluids and antibiotic therapy because of difficult venous access. The patient was diagnosed with severe sepsis due to recurrent aspiration pneumonia and was admitted to the telemetry floor. Later that night, the patient became increasingly hypoxic and hypotensive. A rapid response team was called to the room. Orders were obtained to infuse a 30 mL/kg 0.9% normal saline bolus and transfer the patient to the ICU. A short PIVC was placed before transport. The patient's blood pressure suddenly dropped to 72/48 mm Hg once in the ICU room. The provider ordered a norepinephrine infusion to be started in addition to fluids.	Which peripheral VAD should be used to infuse the norepinephrine on an emergency basis? Is a CVC required for this patient?
A patient with a temporary hemodialysis catheter had a fever shortly after a hemodialysis session began. Blood cultures later indicated a CLABSI. The provider determined that a peripheral VAD needed to be placed for multiantibiotic therapy in preparation for dialysis catheter replacement.	What is the best vascular option for this patient to receive long-term antibiotics in the inpatient and, potentially, outpatient settings?
A patient undergoing chemotherapy for B-cell lymphoma was admitted with an acute GI bleed. The provider ordered a unit of packed red blood cells, a proton pump inhibitor infusion, and fresh frozen plasma for reversal of anticoagulation. The patient's last regimen of chemotherapy was 3 days earlier, and their implanted port was not accessed.	What are the best vascular access options for this patient? Should the implanted port be accessed and used during treatment of this GI bleed?
A patient, admitted for COVID-19–related pneumonia, was extubated a day earlier after receiving mechanical ventilation for 4 days. The patient no longer required vasopressors but was receiving IV fluids and electrolyte replacement, intermittent IV bolus sedation, and low-dose dexmedetomidine for delirium.[1] The ICU manager met with the primary nurse to ask if the multilumen CVC could be removed.	What are the best vascular access options for this patient?

Abbreviations: CLABSI, central line–associated bloodstream infection; CVC, central venous catheter; GI, gastrointestinal; ICU, intensive care unit; IV, intravenous; PIVC, peripheral intravenous catheter; VAD, vascular access device.

associated with the risk of CLABSI.[4,7-9,11-18] This article reviews the evolution and composition of MCs, the benefits and risks of current MC use patterns, and current evidence regarding the role of MCs when selecting the optimal VADs for critically ill patients.

Evolution and Composition of the MC

The MC was originally developed in the 1950s and was used as a peripheral vascular access option into the 1990s.[14] Rigid catheter components and reported hypersensitivity reactions to specific catheter components caused a reduction in MC use.[9,15,16] However, recent advancements in catheter design and characteristics have improved the safety profile of the MC, and several options are now on the market.[15,18] The MC is generally composed of silicone or polyurethane. Midline catheters with single or dual lumens, a variety of sizes, and power injection options are available.[9,14,15] Catheters with lengths ranging from 7.5 cm to 25 cm are identified as MCs in the literature,[15,17,19-21] creating some confusion in nomenclature and product selection.[2,3,18,22] Because of the various lengths, insertion locations, and expanding peripheral VAD options, the Infusion Nurses Society (INS) published standardized definitions for peripheral intravenous access catheters in 2021 (Table 2).[23]

An MC is inserted under sterile conditions into a deep vessel of the upper arm (eg, the basilic, cephalic, or brachial vein) by specially trained staff.[2,14,17,24,25] Depending on the design of the catheter, a modified, accelerated, or traditional Seldinger technique is required.[5,9,15,17,26,27] The optimal position for the MC distal tip is just inferior to or at the level of the axilla.[18,21,23,28] A more proximal tip position (eg, midclavicular position, or proximal to the axillary-subclavian transition) is not recommended because this position has been associated with increased

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Table 2 Standardized peripheral intravenous catheter definitions[a]

Peripheral intravenous catheter	". . . inserted into and reside in veins of the periphery that includes all extremities, the external jugular vein, and scalp veins in neonates. PIVCs are inserted into superficial veins located just under the skin in the superficial tissue, as well as deep veins located under the muscle tissue."[23(pS74)]
Short peripheral intravenous catheter	". . . an over-the-needle catheter with a hollow metal stylet (needle) positioned inside the catheter, generally inserted in superficial veins."[23(pS74)]
Long peripheral intravenous catheter	". . . inserted in either superficial or deep peripheral veins and offers an option when a short PIVC is not long enough to adequately cannulate the available vein. A long PIVC can be inserted via traditional over-the-needle technique or with more advanced procedures, such as Seldinger and accelerated Seldinger techniques."[23(pS74)]
Midline peripheral catheter	". . . inserted into a peripheral vein of the upper arm via the basilic, cephalic, or brachial vein with the terminal tip located at the level of the axilla in children and adults."[23(pS74)]

Abbreviation: PIVC, peripheral intravenous catheter.

[a] Because the market is evolving, definitions are based on technique and vessel placement of catheter. Where appropriate, the distal tip rather than catheter length was used in these definitions.

thrombotic risk.[28-31] Ultrasonography guidance is strongly recommended to evaluate the length of the catheter in relation to the depth, width, and length of the selected vessel.[5,8,23,32,33] Radiological imaging is not required to confirm tip placement.[9,15,32,34] Because the distal tip of the MC is located in peripheral vasculature, most references recommend limiting MC use to infusions that are appropriate for peripheral vascular administration.[7,8,19,23,25-27,35] Criteria for osmolarity and pH limits that are safe for peripheral vascular administration, however, are uncertain.[14]

Multiple factors fostered the push to improve the efficacy of the MC and the resultant acceleration in use. The high failure rate of the short peripheral intravenous catheter (PIVC) is an important impetus for MC use. Failure of the short PIVC, defined as a dwell time of less than the prescribed duration of treatment,[32] is reported to be as high as 63%.[36] In their systematic review of PIVC dwell times and complications, Hopkinson et al[37] found an average dwell time of 3.5 days, with the presence of at least 1 complication significantly associated with dwell times of greater than 2 days ($P < .01$).[37] Premature failure of the short PIVC, common in critical care, is associated with patient dissatisfaction, increased discomfort, and an increasing rate of failure with each subsequent insertion attempt.[36,38] Inappropriate use of the peripherally inserted central catheter (PICC) and significant adverse events such as CLABSI and catheter-related thrombosis have also strengthened the push to identify a VAD option that would provide long-term, reliable access with fewer concomitant risks.[6,12,14-16,39] Recognition of the impact of VAD placement on patient comfort and satisfaction is further incentive to explore options with a high first-insertion success rate, with the added potential for reduced procedural costs.[3,4,7,9,15-17] Table 3 presents adverse events associated with peripheral intravenous therapy.

The MC can provide a valuable VAD option in patients in whom venous access is difficult, and a PICC may have been placed for a duration of therapy that a short PIVC cannot typically support.[2-4,8,15] Although the expected dwell time of a VAD should not be used to dictate planned removal, the dwell time of the MC, 1 to 4 weeks, is certainly more favorable than that of other peripheral VADs.[3,7,8,15] Another possible patient satisfier is the potential to collect blood specimens from the MC,[9,42] although the 2021 INS standards indicate that no evidence is yet available to guide technique or validate the accuracy of blood specimen collection from the MC.[23] The exponential increase in MC use, particularly in difficult venous access scenarios and as a CVC alternative,[8,11,12,14,32,43] has stimulated expanded research into the benefits and risks of peripheral VAD use.

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Benefits of Current MC Use Patterns

The quest for the optimal VAD to safely reduce CVC use rates is daunting. The device would need to be a versatile

Table 3 Peripheral intravenous therapy–related adverse events[a,b]

Adverse event	Definition
Vesicant	"An agent capable of causing tissue damage when it escapes from the intended vascular pathway into surrounding tissue.[23(pS213)]
Infiltration	"Inadvertent administration of a nonvesicant solution or medication into surrounding tissue; rated by a standard tool or definition."[23(pS207)]
Extravasation	"Inadvertent infiltration of vesicant solution or medication into surrounding tissue; rated by a standard tool or definition."[23(pS206)]
Compartment syndrome	"Fluid build-up within a compartment that leads to increased pressure on capillaries, nerves, and muscle. An increase in hydrostatic pressure leads to vascular spasm, pain, and muscle necrosis inside the compartment. Ischemic nerve damage can result in functional loss. Characterized by pain, pallor, paresthesia, pulselessness, and paralysis."[23(pS205)]
Occlusion	"Obstruction of a vascular access device lumen, preventing or limiting the ability to flush and/or administer solutions through a lumen or withdraw blood [consistency of whole blood]. Complete occlusion: Inability to administer solutions or withdraw blood from the [CVAD] lumen. Partial occlusion: Decreased ability to administer solutions and/or withdraw blood from the CVAD lumen. Withdrawal occlusion: Ability to infuse solutions with decreased ability or inability to obtain blood return."[23(pS210)]
Phlebitis	Inflammation of a vein; may be accompanied by pain/tenderness, erythema, edema, purulence, and/or palpable venous cord; rated by a standard scale or definition.[23,36] Symptoms may include pain/tenderness, erythema, swelling, purulence, or palpable venous cord.[23] Diagnosis remains controversial and a number of grading systems have been proposed, although with limited validation testing performed.[40]
Catheter-related thrombus	Thrombophlebitis: "Inflammation of the vein in conjunction with formation of a blood clot (thrombus)."[23(pS213)] Thrombosis: "The formation, development, or existence of a blood clot within the vascular system."[23(pS213)] Catheter-associated DVT: "Thrombosis (blood clot) formation associated with the presence of a vascular access device occurring in the deep veins of the upper extremity (radial, ulnar, brachial, axillary) that may extend into the subclavian, brachiocephalic, superior vena cava, and/or the internal jugular. Central vascular devices placed in the femoral vein may result in an iliofemoral DVT."[23(pS204)] Catheter-associated DVT may be asymptomatic, and may result in reduced or absence of blood return from the catheter. It may result of thrombophlebitis (although cause is unclear) with associated pain, swelling, erythema, palpable cord, lack of flow, and lack of compressibility.[4,41]
Local and systemic infection	Exit-site infection: Should be suspected when symptoms are noted at the catheter insertion site, including purulent drainage, erythema, and/or tenderness.[4] Catheter-related bloodstream infection: "Positive blood culture from a peripheral vein; clinical signs of infection; no other apparent source for the bloodstream infection except the intravenous catheter; and colonized intravenous catheter tip culture with the same organism as identified in the blood."[41(p6)]
Catheter dislodgment	"Catheter movement into or out of the insertion site indicating tip movement to a suboptimal position; may be partial (catheter tip still remains within the venous system, but is in a suboptimal location) or total (catheter tip is removed completely from the venous system)."[23(pS204)]

Abbreviations: CVAD, central vascular access device; DVT, deep venous thrombosis.

[a] An adverse event is "unintended or untoward event that occurs with a patient receiving medical treatment that is related to a medication, product, equipment, procedure, etc."[23(pS202)]

[b] Significant overlap in symptoms between the complications and various definitions in literature have increased complexity in determining true rates of occurrence.[36]

peripheral VAD with a high rate of success on first insertion attempt, a low adverse event rate, and a predictable dwell time that would allow for long-term courses of treatment. The MC has been promoted as fulfilling all of these characteristics.[9,15,16] Multiple studies have indicated support for the safety profile of the MC while acknowledging that further study is needed.[4,5,12,13,34,39,43-45] The MC, with enhancements to catheter characteristics and design, would appear to fill a very important niche in infusion therapy.

Initially, 2 priority research questions for MC use were whether MCs were associated with higher complication rates than CVCs (particularly PICCs) and whether MCs could be safely used to administer vancomycin (pH < 5).[7] The long-term administration of antibiotics that can cause vessel and tissue damage, such as vancomycin, is a notable challenge because a CVC has traditionally been recommended for their administration.[7,46] This recommendation was made in part because of pH limitations included in early iterations of the INS standards. The 2011 iteration recommended that the peripheral route of intravenous administration be limited to infusates with a pH between 5 and 9 and/or an osmolality

of less than 600 mOsm/L.[47] Concerns that these parameters may have contributed to overuse of CVCs stimulated research to determine the safety of administering vancomycin through the MC.[46] For example, in a small randomized controlled trial, Caparas and Hu[48] found no significant difference in adverse events for vancomycin administration via an MC versus a PICC. These results and those of similar studies prompted challenges to the INS limitations for peripheral intravenous administration of infusates.[46] After a thorough review of the evidence, the INS Standards of Practice Committee removed specific pH limitations from the 2016 infusion therapy standards of practice.[49] The lack of conclusive evidence to substantiate limitation to a pH range between 5 and 9 and the vesicant designation of a number of infusates with pH levels within that range led to their conclusion that the pH of an infusion should not be the sole reason for evaluating peripheral compatibility.[50] Rather, evaluation of the best route of delivery should include the full complement of characteristics of an infusate, the patient's vascular health, and available VAD options.[23]

In a retrospective review of 1538 MC placements, Campagna et al[4] evaluated the incidence of adverse events to determine which factors resulted in premature MC removal. The overall rate of adverse events was determined to be acceptably low at 2.49 per 1000 catheter-days, and the median dwell time was 26 days. In another retrospective review, Mushtaq et al[13] found that the catheter-related bloodstream infection (BSI) rate was significantly lower for MCs than for CVCs and that the composite complication rate was also lower, indicating an acceptable safety profile. DeVries et al[8] conducted a prospective study to determine the impact of a bundle of interventions on MC-related BSI. Using interventions such as chlorhexidine gluconate dressings and standardized insertion by a vascular access nurse–led MC program, they found no MC-related BSIs during their 2-year study, illustrating that standardization of insertion and management may improve outcomes.[8]

A crucial niche for MC use has been for patients with difficult intravenous access (DIVA).[3,5-7,13-15] Although various definitions have been used to identify DIVA in the literature, the 2021 INS standards definition is as follows:

> Difficult IntraVenous Access (DIVA). Refers to multiple, unsuccessful attempts to cannulate a vein; the need for special interventions to establish venous cannulation based on a known history of difficulty due to diseases, injury, and/or frequent unsuccessful venipuncture attempts; may be acute due to sudden illness (eg, fluid volume deficit) or chronic due to lengthy history of difficult intravenous access.[23(pS205)]

Scoppettuolo et al[20] conducted a retrospective study to evaluate the use of an 8- to 10-cm MC (which they called a "short" MC) in patients with DIVA presenting to the emergency department. They found a high rate of success at insertion, with 73% of the MCs present for longer than 7 days.[20] Fabiani et al[3] conducted a study in patients with DIVA and acute cardiovascular disease. They compared outcomes for an 8- to 10-cm PIVC (which they called a "long" PIVC) with outcomes for an 18-cm MC and found a higher complication rate with use of the 8- to 10-cm catheter.[3] These studies illustrate the variability in catheter characteristics and outcomes represented in MC-related research.

The rapid rise in popularity of the MC has led to the expansion of its use into areas that have traditionally been reserved for CVC administration. Sharp et al[44] conducted a retrospective review to evaluate the use of the MC versus the PICC for long-term antibiotic administration in patients with cystic fibrosis, a population in whom vascular preservation is paramount. They found that adverse events of MCs were not statistically different from those of PICCs. They were, however, surprised to find that the premature removal rate of MCs was more than twice that of PICCs.[44] Pathak el al[43] conducted a retrospective cohort study to determine the impact of increased MC use on the CLABSI rate in a unit with ventilator-dependent patients. With a standardized approach to VAD selection and increased use of MCs, they found a significant reduction in the CLABSI rate.[43]

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The location of the MC distal tip in the axillary vein may contribute to lower reported MC-associated phlebitis rates because of the higher blood flow in this area as compared with more distal vessels.[10,15,17] In their clinical review of the MC, Adams et al[15] postulated that the tip location nearer to the central circulation may lead to use

of the MC for some critical care scenarios. As facilities expanded the use of the MC, research continued to challenge conservative criteria for peripheral administration. In a prospective, observational case series, Spiegel et al[51] described their experience with MC use in critically ill patients in the emergency department. They found a mean dwell time of 6.7 days, with a 99% placement success rate and a 2.5% insertion-related complication rate. They also reported that 29.5% of these MCs were successfully used to administer vasopressors, a criterion previously approved by their facility policy.[51]

The requirement to place a CVC for vasopressor administration has been challenged in PIVC-related research. A systematic review by Loubani and Green[52] included 85 studies (primarily case reports) that evaluated peripheral administration of vasopressors. Administration using a PIVC was identified as use of a VAD that was not placed in the internal jugular, subclavian, or femoral vein. The authors stated that the degree of tissue injury from PIVC extravasation was likely related to infusion duration and to localized tissue hypoperfusion inherent in patients in unstable condition. They also stated that tissue injury was more likely to be noted in areas distal to the antecubital fossa.[52] They recommended that peripheral administration of vasopressors be limited to a duration of less than 2 hours using a PIVC that is well placed in a proximal location (eg, antecubital fossa or external jugular vein).[52] Prasanna et al[17] conducted a retrospective review of vasopressor administration via the MC route. They found an average vasopressor administration duration of 7.8 days and a complication rate of 3.5%, with only 11.7% of patients in the study later requiring a CVC insertion.[17]

The lack of high-quality VAD-related randomized controlled trials reduces the applicability of research recommendations to guide VAD selection and management.

Potential Risks of MCs

Despite the benefits of MCs, there are growing concerns about the expanding use of the MC. The primary concern is the paucity of accurate and reliable MC-related outcomes by which to measure the impact of the MC on vascular health and the ability of the MC to effectively provide long-term infusion therapy needs.[14,16,51] Unfortunately, MC-related research studies are often plagued with the limitations common to VAD-related research as a whole: retrospective analyses; single-site studies; small sample sizes; risk of bias; documentation gaps; and wide variability in research methods, VAD-related adverse event definitions, inclusion criteria, and VAD characteristics.[14,18,37,40,53-55] The lack of high-quality VAD-related randomized controlled trials reduces the applicability of research recommendations to guide VAD selection and management.[6] The following paragraphs include examples of recent MC-related studies suggesting that MCs may be associated with a higher risk of adverse events than previously thought. A more complete description of recent MC-related research is provided in Table 4.

In their retrospective review of adverse events associated with MC versus PICC use, Xu et al[12] found a significantly higher total complication rate with MC use and no significant difference in serious complications between the 2 routes. They found a significantly higher 30-day readmission rate with MC use.[12] Highlighting the potential risks of MC use in the outpatient setting, Underwood et al[57] found in a retrospective review that use of an MC that was not placed under radiologic guidance was associated with a significantly higher incidence of extravasation, blockage, and displacement as compared with other PIVCs in outpatients.[57]

The role that peripheral venous access plays in the incidence of BSIs is also an area of expanding study. The PIVC may be implicated in BSIs much more often than is currently estimated.[61] In their systematic review of MC practices and complications, Tripathi et al[18] reviewed 31 MC-related studies that included placement of 18 972 MCs in 5 countries. They found that MCs appear to have a low rate of BSI but a higher rate of premature removal before therapy completion and a composite failure rate of 12.5%. They acknowledged, however, that MC-related BSI rates are likely inaccurate because of inadequate surveillance.[18] In their prospective quality improvement program, Hankins et al[58] implemented a VAD selection algorithm that included an MC option and then monitored VAD-related outcomes. Although the MC-associated BSI rate was lower than the CLABSI rate during this initiative, they found significant correlations between MC dwell times and rates of BSI and thrombophlebitis, with an apparent increase in risk in patients who required multiple concurrent VADs.[58]

Thrombotic risk is multifactorial and is generally attributed to or worsened by vessel trauma, patient

Table 4 Review of midline catheter–related research from 2015 to 2021

Source	Design of study	Population	Catheter characteristics	Limitations	Outcomes and conclusions
Moureau et al,[5] 2015	Two-site retrospective, descriptive study	2 Hospitals that initiated MC programs	Multiple different products used as technology advanced	Small sample size; lack of demographic data; narrow outcome reporting	14 Steps to initiate an MC program. Both hospitals had reductions in infection rates; one had a 78% reduction in the CLABSI rate. Evidence suggests that MCs provide a reliable, safe form of vascular access that reduces cost and may reduce infections related to CVC use.
Pathak et al,[43] 2015	Retrospective cohort	Ventilator-dependent unit, treating various conditions	Only the MC brand name is listed	Single-center study	Catheter days decreased from 2408 before MC introduction to 1521 when MCs were used when appropriate ($P<.05$); there were no reported CLABSIs. MC may be used to replace CVC for difficult IV access, decreasing incidence of CLABSI in this setting. MCs were not used for vasopressors.
Scoppettuolo et al,[20] 2016	Retrospective	76 ED patients who had difficult venous access	8-10 cm polyurethane "short" MC	No control group; probable gaps in documentation	Mean number of attempts before success was 1.57; catheters used for fluid and medications, with 27% of the MCs removed prematurely The "short" MC appears to provide safe and fast PVC access for acutely ill patients with difficult venous access in the ED.
Xu et al,[12] 2016	Retrospective	367 Adult patients	Only manufacturer name listed	Single-center, nonrandomized study, limited to inpatients only; short study period; complication rates reported as percentages; not generalizable to other product brands	Minor complications were discontinuation of catheter due to nonpatent vessel, leaking, pain, edema, dislodgment, and catheter fracture. Severe complications were discontinuation due to infiltration or phlebitis or infection, DVT, readmission due to vascular access issues, positive blood culture. 206 PICCs, 200 MCs; 10 patients had both in place. Significantly higher total complication rate in MC vs PICC (19.5% vs 5.8%; $P<.001$). 30-day readmission significantly higher with MC use in ICU and non-ICU patients ($P=.01$ and $P<.001$, respectively). Median duration of dwell was 12 days for PICCs and 5 days for MCs. No significant difference in rate of serious complications. MC can be considered an acceptable alternative, but outcomes and utilization data should be carefully reviewed and findings should be shared for better global understanding.
Caparas and Hung,[39] 2017	Retrospective chart review	1086 Adult patients who received vancomycin via an MC	No MC characteristics listed	Used a broad definition of phlebitis due to variation in literature; 10 charts did not include reason for removal	Average duration of vancomycin therapy was 7.5 days. Phlebitis rate, 0.6%; infiltration rate, 1.2% with no extravasations, DVT, or BSIs reported. Illustrates 5-year experience of safety and cost efficiency in administering vancomycin through a nontrimmable MC. Large-scale multicenter RCT comparing PICC and MC administration of vancomycin needed.

Continued

Table 4 *Continued*

Source	Design of study	Population	Catheter characteristics	Limitations	Outcomes and conclusions
Campagna et al,[4] 2018	Retrospective	1538 MCs were inserted in adult patients in 2 Italian hospitals	4F-5F, 20-25 cm in length, majority were single lumen	Incomplete documentation; unable to compare inpatient and outpatient outcomes	Complications included occlusion, exit-site infection, symptomatic thrombosis, accidental removal. The rate of all adverse events was 2.49/1000 MC days or 10%; median dwell time 26 days, with possible extension to much longer dwell time. MC can be considered a safe device when inserted by trained clinicians, even beyond stated period of dwell.
Keller et al,[56] 2018	Prospective cohort	339 Adult patients receiving antimicrobial therapy at home	No MC characteristics listed	Not generalizable to other OPAT populations; review relied on documentation so incidence may be underestimated	Complications included occlusion, CR-DVT, extravasation, and phlebitis. Excluded complications included BSI, dislodgment, occlusion, catheter fracture, leakage as these were not likely to be associated with antimicrobial administration. Vancomycin, daptomycin, *Staphylococcus aureus,* and MC were associated with an increased rate of catheter complications. MC use and administration of vancomycin were noted to be independent predictors of catheter failure. Vancomycin and daptomycin should be considered as vesicants. Other antimicrobials with extremes of pH not associated with catheter failure.
Lisova et al,[27] 2018	Prospective, observational	430 Adult patients admitted to the hospital	4F, 20-cm unmodified catheter, mid upper arm placed with US guidance, modified Seldinger, with vein required to be at least 4 mm in diameter	Single-center study	Rate of ULVT was 4.5%. If patient received 2 or more insertion attempts, this incidence increased to 6.4%; if 3 or more attempts, incidence was 9%. Incidence depends on skill of inserter and patient disposition; increased risk if cephalic vein used. Is MC-related ULVT truly lower than that of PICC?
Mushtaq et al,[13] 2018	Retrospective cohort	411 Adult patients with MCs and 282 adult patients with CVCs (all types)	No MC characteristics listed	BSI not calculated per catheter days; limited to inpatient setting, lack of follow-up after dismissal	CR-BSI: CVC 3.5%, MC 0.2% ($P < .001$). Mechanical issues (leaking, occlusion): CVC 0.3%, MC 2.6% ($P = .03$). CVCs were associated with higher crude mortality, CR readmission, and transfer to the ICU. MC use implies a better safety profile when compared to CVC; further larger studies needed.

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comorbidities, catheter-to-vein ratio, VAD securement, infusate characteristics, and longer VAD dwell times.[23,27,58] Because of the extended dwell time of the MC, the thrombotic risk has gained increasing attention. Thrombus related to VADs may delay delivery of needed therapy, increase costs, and lead to significant adverse events, such as BSI and pulmonary embolism.[16] Lisova et al[27] conducted a prospective observational study to evaluate the rate of upper limb venous thrombosis in a group of adult patients with MCs. They noted an upper limb venous thrombosis rate of 4.5% with first-time successful insertion, increasing to 9% with 3 or more insertion

Table 4 *Continued*

Source	Design of study	Population	Catheter characteristics	Limitations	Outcomes and conclusions
Bahl et al,[16] 2019	Retrospective comparison of PICC and MC insertion	Adult patients in academic medical center	4F single-lumen MC, PICC 5F double-lumen MC, PICC	Unable to account for impact of caustic medications on thrombosis; lack of data on catheter to vein ratio; unable to correlate catheter characteristics with thrombosis risk	PICC: 6.88% developed symptomatic CR thrombosis. MC: 11.88% developed symptomatic CR thrombosis (DVT or SVT)—53% greater odds (P=.01). MCs have 2.29 greater odds of developing CR-SVT compared to PICCs and are an independent predictor of increased odds of CR thrombosis by multivariate analysis. Using double- rather than single-lumen MC increased the odds of thrombosis by 2.87 (P<.001). Also found significantly higher rate of contralateral arm thrombosis compared to general population. Time to thrombosis for both catheters were 7-8 days. Symptomatic CR thrombosis occurs more frequently with MCs than with PICCs, with increased risk in larger diameter catheters. Single-lumen catheters with smallest diameter should be considered. All VAD options should be carefully considered for intermittent duration of therapy; larger prospective trials needed.
Chopra et al,[14] 2019	Multicenter, prospective cohort	Adult patients admitted to medical-surgical or ICU; 1161 MC in 12 hospitals	No MC characteristics listed (included trimmed PICC as MC option)	Data relied on accurate documentation; applied to hospitalized patients; variety of MC design and characteristics led to variability	Minor complications were accidental dislodgment, leaking, infiltration, and thrombophlebitis. Major complications were MC-related BSI, symptomatic upper extremity DVT, and catheter occlusion. Wide variability in MC volumes and outcomes across hospitals; device removal due to adverse events is common; guidance on proper MC indications and management needed to improve safety.
DeVries et al,[8] 2019	Prospective	Community hospital, 5430 MC days	8- and 10-cm fixed length power injectable MC, added alternate trimmable, non-power injectable option if longer MC was required	Single center, small sample size	Reviewed complications included infiltration, dislodgment, kinking, occlusion, and BSI. No MC-associated BSIs were noted in 2-year period with 80% completion of therapy; 35% reduction in PICC placement noted. PICC-associated BSI incidence was 1.83/1000 catheter days for same period, with 92% completion of therapy before removal. With clear guidelines on device selection and appropriate infection prevention practices, MC-associated BSI rate maintained at 0 for 2 years.
Dickson et al,[32] 2019	Retrospective cohort	Patients admitted to outpatient therapy with MC or PICC	MCs were modified PICCs, adjusted to patient size by cutting to length; mean insertion length of 13.4 (2) cm	Small sample size, limiting ability to make conclusions; trimmed MCs may have contributed to failure	Facility allowed MCs in place >14 days, but noted increased failure; which resolved when returning to ≤14 days of MC dwell time. Catheter failure before completion of therapy was 55% for MCs and 3% for PICCs. MC dwell time significantly shorter for failed vs successful MCs: 25.17 vs 13.47 (P=.02), with higher rate of success for bolus dosing. Confine MC use in outpatient setting to patients requiring 14 days or less of IV therapy.

Continued

Table 4 *Continued*

Source	Design of study	Population	Catheter characteristics	Limitations	Outcomes and conclusions
Tao et al,[34] 2019	Retrospective	487 Patients received either an MC (study) or PICC (control), for perioperative IV chemotherapy and IV nutrition	Distal tip location noted; no MC characteristics listed	Lack of comparison to other infusion tools; data not fully conclusive; not generalizable outside of gastric cancer	Adverse reactions included CR-BSI, obstruction, displacement, and thrombosis. Adverse reaction incidence for MC and PICC was 2.51% and 9.13%, respectively ($P<.001$). Patient satisfaction was significantly higher in MC vs control groups ($P<.001$). Use of MC in this population can effectively reduce CR adverse reactions with reduced cost and improved patient satisfaction.
Underwood et al,[57] 2019	Retrospective	544 OPAT episodes	Nonradiographically guided MC	Potential for unrecognized bias in cohort study; limited multivariate analyses; occurred over 32 months so study conditions may have changed	CR events included hospital readmission related to IV complication, blockage, displacement, extravasation, or phlebitis requiring replacement. The rate of CR adverse events was statistically higher than that of drug-related adverse events ($P<.001$), with the rate of MC adverse events much higher than other vascular options ($P<.004$); self-administration also was significantly higher ($P<.007$). Outcomes driven largely by MCs, specifically shorter length MCs and those less secured. Need to fully evaluate antibiotic stewardship to ensure VADs are used effectively.
Bundgaard Madsen et al,[24] 2020	Retrospective	70 Patients with cardiologic or infectious diseases; 98 MCs	10 cm, 18G/20G polyurethane catheter, US guided	Dwell time likely influenced by 38 catheters that were removed when therapy was completed as these may have survived longer; study was descriptive; limited to an MC brand	Indications for premature removal were accidental removal/displacement, clotted catheter, signs of infection at insertion site, venous thrombosis found in ipsilateral arm, patient request, leakage, pain during infusion, catheter malfunction, and CVC requirement. Median dwell time of 8 days, with wide variation; only 38 of 98 survived to completion of therapy; overall incidence of premature catheter removal was 71.8/1000 catheter days; most frequent reasons for catheter removal were pain during infusion, clotted catheter, and signs of infection at site. The majority of MCs in this study were removed prematurely.
Elli et al,[26] 2020	Retrospective observational analysis	981 MC catheter placements	20-cm, 4F and 5F MCs placed with US guidance (study, n=458); 25-cm, 4F MCs placed without US guidance (control 1, n=412); 20-cm, 4F and 5F MCs placed without US guidance (control 2, n=111)		US guidance was feasible; significant increase in CR venous thrombosis in control 2 group vs study group ($P=.002$). The ideal tip position of an MC to reduce the risk of CR thrombosis may be within the axillary vein, below to the axillary-subclavian transition point, or within the subclavian vein (proximal to that transition area). US-guided placement should be used routinely to properly place the distal tip.

Continued

Table 4 *Continued*

Source	Design of study	Population	Catheter characteristics	Limitations	Outcomes and conclusions
Fabiani et al,[3] 2020	Retrospective cohort	184 DIVA patients admitted to a cardiothoracic-vascular department	Polyurethane MC power injectable PICC trimmed to 20-cm length, inserted via modified Seldinger; 2 lengths of polyurethane long peripheral catheters 8/10 cm and 18 cm via direct Seldinger	Characteristics of populations that had long PVC and MC not comparable; observation ended while some catheters were still in place so true rates may not have been captured	Criteria for catheter removal with no complication were end of use, inappropriate removal, accidental removal, death, and discharge/transfer. Criteria for catheter removal due to complication were occlusion, leakage, catheter fracture, symptomatic CRT, and CR-BSI. Dwell times for 8/10-cm, 18-cm, and 20-cm MCs were approximately 8, 14, and 21 days, respectively, and complication rates were 15.84, 10.64, and 6.27 per 1000 catheter days, respectively. CR-BSI rate for 18 cm was 1.32/1000 catheter days and for MC 0.48/1000 catheter days. Having 2 antibiotics infused in the same catheter was significantly associated with CR complications (P=.013). MCs were associated with significantly longer and uncomplicated time of use compared to long PVCs. Based on cost, consideration of MC vs long PVC should entail length of therapy and patients' vascular health.
Hankins et al,[58] 2020	Prospective quality improvement	858 MCs, total of 3588 MC days	No MC characteristics listed	Single center, quality improvement initiative	Significant correlation between MC length of dwell and thrombophlebitis (P=.004), median dwell time was 9.24 days, and BSI (P=.002), median dwell time was 16.17 days. MC-associated BSI was lower than CLABSI rate at same time. VAD selection algorithm including an MC may reduce CVC use and CLABSI. DVT and thrombophlebitis rates correlate with duration of MC dwell time and may be increased with multiple VADs used concurrently in a patient.
Hawes,[42] 2020	Prospective open-label study	497 MCs, 112 of which received dose of 1 mg alteplase to restore patency	3 different brands of polyurethane catheters placed with micro-introducer technology	Single center; 2.5-year study period; blood specimen collection per MC is common practice at this facility, which may have altered occlusion	Alteplase-related complications monitored were sepsis, major hemorrhage, GI bleeding, venous thrombosis, intracranial hemorrhage, and embolic event. The option of restoring patency of MCs with alteplase may be considered to prevent replacement of the catheter (but is listed as off-label use), reducing cost, enhancing patient satisfaction, and preserving vessel health.

Continued

Table 4 *Continued*

Source	Design of study	Population	Catheter characteristics	Limitations	Outcomes and conclusions
Hogle et al,[11] 2020	Retrospective	165 166 central catheter days and 26 063 MC days in 5 hospitals	No MC characteristics listed	Use of standard surveillance for CLABSI may be over- or underestimate of true CR-BSI; likely underpowered; 5 hospitals varied in size and population but were in 1 system so not generalizable	MC-related BSI incidence of 0.88 per 1000 catheter days. CLABSI incidence of 1.10 per 1000 CVC days, per NHSN determination (no MC in place). MC-related BSI was not significantly different than CLABSI rate. MC-related BSI risk should be considered if using MCs. Additional research needed. The DeVries study differed likely due to their additional infection prevention practices, use of different MC, and smaller population.
Lescinskas et al,[59] 2020	Prospective observational	Convenience sample of adult hospitalized patients in urban safety net hospital	10-cm, 18G MC using US guidance; inserted for therapy intended for <14 days	Qualitative, may have bias for recall, possible documentation gaps regarding complications; small sample size	Interviews of patients, with collaborating review of medical records for documented complications. Difficult venous access was the most common reason for MC insertion. Patients with an MC (n=50) reported fewer potential complications compared to those with PICCs (n=63). No MC-related DVT or BSI were noted in the chart review. MCs appear to be an effective option for short-term venous access.
Lu et al,[21] 2020	Meta-analysis	10 studies in meta-analysis, involving 33 322 patients	8- to 20-cm, inserted into antecubital fossa or upper arm with tip at or below axillary vein	May not have included all studies; heterogeneity amount studies low, 1 study was an abstract, 4 studies were of poor quality	Prevalence of CR-BSI was not significantly different between MCs (0.58%) and PICCs (0.48%; $P=.22$). If 4 low-quality studies are removed, CR-BSI with MCs was lower ($P=.02$). Interpret findings cautiously; further study recommended.
Meyer,[2] 2020	Retrospective	165 MC insertions reviewed	Open-ended 5F double lumen antithrombogenic catheter	Single-center study; unable to determine the impact of catheter length and vessel size on complication and failure rates	62.8% of MCs lasted to therapy completion, with a mean dwell time of 8.5 days. The complication rate was 15.8%; 58% of complications were with dual-lumen catheters. Blood return algorithm and staff education were developed in quality improvement. To prevent vessel damage and catheter failure, consider limiting MC to therapies of 6 or less days, limiting blood draws from MC, and removing MC when a blood return cannot be established.

Continued

attempts. They recommended that thrombotic risk of the MC be considered when choosing the optimal VAD for a patient.[27] Dickson et al[32] conducted a retrospective analysis of a cluster of MC failures and also noted an increased thrombotic risk when MC use was extended beyond 14 days. The rate of thrombosis decreased once they limited MC use to 14 days or less. An important aspect of their study, however, was that the MC in use was a trimmed PICC.[32] The abraded edges of the trimmed catheter may have contributed to thrombus development. Recommendations in the literature warn of the potential for vascular damage in the use of PICCs

Table 4 *Continued*

Source	Design of study	Population	Catheter characteristics	Limitations	Outcomes and conclusions
Ryder et al,[10] 2020	Experimental, randomized controlled blinded trial	20 Sheep, all in good health, ovine model chosen due to similarities in vasculature and hematological factors between sheep and humans	10-cm, 18G single-lumen MC, with color Doppler to ensure vessel circumference, area and blood-flow	Ovine model, may not represent ill human patients; time to failure may be overstated, criteria required >1 day of a symptom before removal; use of the contralateral leg as the control with recent reports of thrombus in the limb contralateral to a VAD	Clinical criteria of failure were swelling, pain (withdrawal of limb during flushing or palpation), leakage, and unresolved catheter occlusion. Secondary outcomes were occurrence of occlusive pericatheter mural thrombus. Infusate properties: low and high cytotoxicity (vancomycin 4 mg/mL and 10 mg/mL); low and high pH (acyclovir 3.5 mg/mL and doxycycline 1 mg/mL, respectively), and low and high osmolarity (amino acid in dextrose 4.25/5 and 4.25/10), with control infusion of normal saline in contralateral limb. 95% test catheter failure by median 7.5 day, 60% control catheter failure by median day 7. Higher rates of VIS, pain, swelling, and pericatheter mural thrombus comparing test and control arms. Infusates with varied osmolarity, pH, and cytotoxicity were associated with severe vascular injury and premature MC failure. Consideration should be given to limitation of MC use for infusion duration of <6 days for preservation of vessel health.
Seo et al,[45] 2020	Single-center, retrospective chart review	82 Patients with MC placement for inpatient and/or outpatient IV therapy; 50 patients with PICC inserted for outpatient antibiotic therapy	Approved dwell time of MC listed; no MC characteristics listed	Small single-center study with inpatient and outpatient record reviews; missing data noted on medication dosage and symptoms of catheter dysfunction	Complications included dislodged catheter, infiltration, occlusion, CR thrombosis, extravasation, and catheter infection. No statistical difference noted between inpatients and outpatients. An average of 8 days to noted complication for all catheters. The use of MCs appears generally safe for prolonged (no longer than 14 days) IV therapy when compared to PICCs.
Spiegel et al,[51] 2020	Prospective, observational case series	403 MCs placed by ED practitioners	10-cm single-lumen and 5F, 20-cm trimmable dual-lumen MCs, US guided with Seldinger technique	Bedside clinicians recorded data and used procedural notes to identify patients—may have missed cases; BSI related to MC was investigated only if there clinical indications—may be incomplete	Insertion complications were inability to aspirate, arterial puncture, failed insertion, infiltration, hematoma, and symptomatic DVT. There were 2.5% insertion-related complications with 99% successful placement. Dwell-time–related complications were dislodgment, leaking, erythema, pain, drainage, edema, infiltrated, superficial thrombosis, ecchymosis, and vesicant extravasation. The mean dwell time was 6.7 days; 12% dwell-time–related complications. MC may offer an alternative to central venous access in critically ill ED patients. This facility allowed indefinite infusion of vasopressors and inotropic agents through properly placed MCs (29.5% used for pressors with 2 noted extravasations).

Continued

Table 4 *Continued*

Source	Design of study	Population	Catheter characteristics	Limitations	Outcomes and conclusions
Viviani et al,[60] 2020	Case report	2 OB case reports	4F, 55-cm–long catheter cut to midline length	Modified PICC used as MC	Both patients developed CR thrombosis. Since pregnancy is prothrombotic, MC catheter use should be further studied in this population.
Nielsen et al,[25] 2021	Open-label, prospective, randomized active-controlled trial	116 Adult patients with infectious disease; 58 had dual-lumen MCs (study group) and 58 had IV therapy per PVC or CVC (conventional group) based on needs	10-cm (100-mm) 18G/20G dual-lumen MC	Patients in study had infectious diseases with high need of IV therapy; use of 10-cm MC not generalizable to other devices; randomization not completely followed due to complex environment	MC use did not include patients who required major surgery, vasopressors, high osmolarity parenteral nutrition, or some irritant infusates. In the study group, 21% of patients with MCs required a CVC or >4 PVCs to complete therapy; median dwell time was 7 days. In the conventional group, 66% of patients with no MC inserted required a CVC or >4 PVCs to complete therapy; median dwell time was 4 days. No significant difference in incidence of premature catheter removal ($P = .51$). Signs of infection around the insertion site were significantly more common in the study group ($P = .04$), but no documented CR-BSIs in the study group. MC strategy for VAD selection for patients that require IV therapy for an estimated 6 or more days reduces the number of patients that required insertion of a CVC or >4 PVCs ($P < .001$).
Prasanna et al,[17] 2021	Retrospective	248 Adult patients receiving vasopressors through MC	4F, 20 cm	Single center	Vasopressors included norepinephrine, phenylephrine, epinephrine, angiotensin II, and vasopressin. The average dwell time was 14.7 days; 11.7% required later CVC placement; the average duration of continuous vasopressor infusion was 7.8 days; early complication rate was 3.6%, with 6 BSIs, 1 extravasation, 1 thrombophlebitis, and 1 later DVT. MC may be an option for vasopressor infusions and may function as a bridge for DIVA patients, between PVCs and CVCs.
Tripathi et al,[18] 2021	Systematic review	18 972 MCs in 5 countries, including pediatric and neonatal studies	No MC characteristics listed	Discrepancy in how dwell time was calculated; most studies were descriptive and quasi-experimental; considerable variability in data and sample sizes	Average dwell time was 16.3 days; adjusted mean infection rate was 0.28/1000 MC days; 64% of studies had no reported infections; failure rate of MCs was 12.5%. MCs had lower reported infection rates than CVCs, but more mechanical complications. Dwell time and failure rate of MCs is similar to published data of other types of VADs. Active monitoring for MC-related infections recommended; choice of VAD needs to be made on the basis of patient needs.

Abbreviations: BSI, bloodstream infection; CLABSI, central line–associated bloodstream infection; CR, catheter-related; CR-DVT, catheter-related deep vein thrombosis; CR-SVT, catheter-related superficial vein thrombosis; CVC, central venous catheter; DIVA, difficult intravenous access; DVT, deep vein thrombosis; ED, emergency department; ICU, intensive care unit; IV, intravenous; MC, midline catheter; NHSN, National Healthcare Safety Network; OB, obstetric; OPAT, outpatient parenteral antibiotic therapy; PICC, peripherally inserted central catheter; PVC, peripheral venous catheter; RCT, randomized controlled trial; SVT, superficial vein thrombosis; ULVT, upper limb venous thrombosis; US, ultrasound; VAD, vascular access device; VIS, vessel injury score.

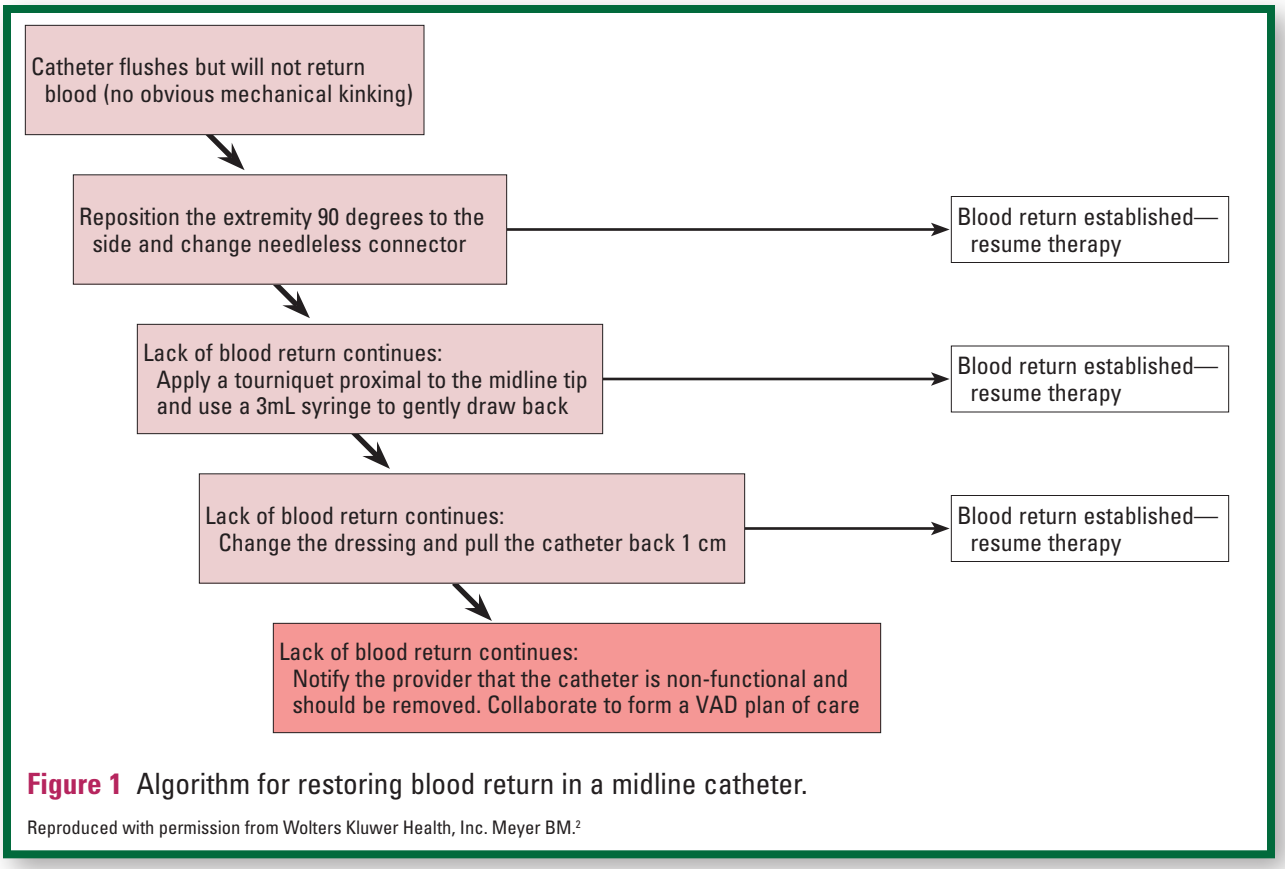

Figure 1 Algorithm for restoring blood return in a midline catheter.

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trimmed to MC length.[8,32] In their retrospective comparison of PICC and MC insertion over a 13-month period, Bahl et al[16] conducted a multivariate analysis and reported that the "MC is an independent predictor of increased odds for the development of CR [catheter-related] thrombosis."[16(p4)] The study also coincidentally found isolated contralateral upper extremity thrombosis in 2.41% of patients with MCs.[16]

In a retrospective review of 165 MCs, Meyer[2] found that 62.8% of MCs lasted to therapy completion, with a mean dwell time of 8.5 days. The overall complication rate was 15.8%, and 58% of complications occurred with dual-lumen catheters. The mean time to loss of blood return from the catheter was 3.89 days.[2] Acknowledging the thrombotic risk of the MC, the study facility did not allow blood to be drawn from MCs and developed a blood return algorithm to determine if loss of blood return was due to mechanical issues or was thrombotic in nature. If blood return was not restored with a needleless connector change, the use of 3-mL syringe to withdraw blood, or repositioning of the extremity or MC, removal of the MC was indicated to prevent further vascular compromise (Figure 1).[2]

Ryder et al[10] conducted a blinded randomized controlled trial with MCs placed in sheep to explore the impact of infusates on vascular integrity. Controlling for insertion technique and tip placement, they placed 2 separate catheters for interventional and control infusions in each of the sheep. In the interventional (test) catheter, infusates with low and high pH (pH of 2.12 and 11.06, respectively), osmolarity (675 and 930 mOsm/L), and cytotoxicity were administered. In the control catheter, normal saline was infused. At the conclusion of the trial, the sheep were euthanized and histological examination was performed to determine the vessel injury score, which represents the combined extent of vascular damage and thrombosis. As the vessel injury score increases, the risk of irreversible damage to the vessel increases. The authors found clinically significant elevated vessel injury scores in all of the vessels in which test infusates were administered. They noted that symptoms of leaking, discomfort, and swelling should be considered probable indications of vascular damage and thrombosis. They postulated that PIVC failure may be a function of dwell time and duration of exposure to the test infusates.[10]

Clinical Summary of MC Use in Critical Care

How does the bedside clinician or the vascular expert sort through the mounting data and often inconclusive

Table 5 Summary of evidence-based peripheral intravenous access management

2021 Infusion Nurses Society Standards: General Peripheral Intravenous Access Management[23]

Peripheral versus central venous administration

Collaborate with an interprofessional team to develop a list of medications that should be administered peripherally, with the following characteristics:

- The medication should ideally be isotonic with physiological pH. If not possible, avoid extremes of pH and osmolarity to reduce endothelial damage.
- Additional considerations include (but are not limited to) impact of diluent on final osmolarity, method of administration (eg, IV bolus, continuous), rate of infusion, number of infusates to be delivered, the VAD characteristics, and the patient's vascular condition.

Anticipated duration of therapy per VAD:

- < 4 days: short or long PIVC
- 5 to 14 days: MC; a long PIVC may be appropriate. These catheters may remain longer than 14 days if it aligns with the patient's vasculature status and preference and if local patient outcomes support this practice. Further research is needed to confirm appropriate use and duration of these VADs.
- ≥ 15 days: consider insertion of a central vascular access device

Assessment of a VAD site should be based on patient, VAD, and infusate risks

- Inpatient and nursing facilities: PIVCs should be assessed at least every 4 hours; every 1-2 hours in patients who are critically ill, sedated, or cognitively impaired; hourly for neonatal/pediatric patients; increase frequency if administering vesicant medications.
- Avoid back pressure on PIVC and PICC insertion sites (blood pressure cuff, tourniquet) when infusions are administered.
- Lock PIVCs with preservative-free 0.9% sodium chloride immediately following each use.
- Change the transparent semipermeable membrane dressing every 7 days and as needed if compromised.
- PICC, MC: Because of increased risk of thrombosis, measure arm circumference of the involved extremity at insertion. Then reassess measurement and compare to baseline when clinically indicated (eg, edema).

Abbreviations: IV, intravenous; MC, midline catheter; PICC, peripherally inserted central catheter; PIVC, peripheral intravenous catheter; VAD, venous access device.

or conflicting guidelines to choose the best vascular access option for a particular patient? The first step is to realize that all VADs carry risk.[7,46] The twin goals of vessel preservation and completion of therapy must be considered equally when choosing a VAD.[6] Evidence-based VAD selection requires a clear understanding of the individual patient's needs and risks, vascular health preservation concepts, urgency of needed therapy, skill of the inserter, available VAD options, and length and nature of the prescribed therapy.[6,8,23,24,62] Once a VAD is placed either peripherally or centrally, it should be managed with the utmost care for prevention and early recognition and treatment of VAD-related complications.[4,7,8,10,23,55] Table 5 provides a summary of evidence-based peripheral intravenous access management.

The Michigan Appropriateness Guide for Intravenous Catheters, published in 2015, provided a valuable summary of expert consensus on scenario-based VAD selection and placement according to patient need, duration of therapy, infusate, and duration of treatment.[19] These guidelines recommended using the MC for peripherally compatible infusates for up to 14 days (possibly up to 4 weeks) of therapy, preferring the PICC for therapy durations of 15 days or more.[19] As illustrated in the preceding paragraphs and in Table 4, MC-related research has greatly expanded the body of knowledge since the Michigan guidelines were released in 2015. The 2021 INS standards include updated guidance for VAD selection, identifying the MC as appropriate for peripherally compatible therapy with an expected duration of 5 to 14 days and recommending use of the smallest catheter that will deliver needed therapy. The INS standards also state that a PIVC may remain appropriate for 14 days or more according to the patient's desires and vascular needs and clear quality outcomes that support patient safety.[23] Both documents include multiple recommendations for further VAD-related research. Table 6 provides a summary of VAD guidelines related to MC placement and related research priorities, including information to guide the scenarios presented in Table 1.

Because of the complexity and variability in health care and a lack of well-defined and universally recognized limits for infusate pH and osmolarity, neither document lists infusates that require CVC placement or are considered peripherally compatible.[2,7,19,23] Instead, facilities are encouraged to develop these resources on the basis of local practices and evidence-based references.[23] In the study by Ryder et al,[10] the extent of vascular

Table 6 Midline and selected venous access device placement guidelines and research priorities

INS Infusion Therapy Standards of Practice[23] related to midline and selected venous access device placement
"Do not insert a PIVC or midline catheter as a central line-associated bloodstream infection (CLABSI) prevention strategy."[23(pS75)] Patient with implanted port: "Use a patient's port, unless contraindicated (eg, existing complication with the device) as the preferred IV route in preference to insertion of an additional VAD."[23(pS86)]
"Vascular visualization technology is employed to increase insertion success of the most appropriate, least invasive vascular access device (VAD), minimizing the need to escalate to an unnecessary, more invasive device and to reduce insertion-related complications."[23(pS63)] "Measure the catheter-to-vessel ratio prior to insertion of an upper extremity VAD; ensure a catheter-to-vessel ratio of less than 45%; while research is focused on peripherally inserted central catheter (PICC) insertion, this ratio can be applied to midline catheters as well, as they are placed in the same veins."[23(pS63)]
Choose an MC as follows: "The least invasive VAD with the smallest outer diameter and fewest number of lumens needed for the prescribed therapy is selected. Vessel health and preservation are prioritized when planning vascular access."[23(pS74)] "Use a midline catheter for medications and solutions such as antimicrobials, fluid replacement, and analgesics with characteristics that are well-tolerated by peripheral veins."[23(pS76)] "Do not use midline catheters for continuous vesicant therapy, PN [parenteral nutrition], or infusates with extremes of pH or osmolarity."[23(pS76)] "Increase catheter site surveillance when administering intermittent infusions of known irritants and vesicants due to increased risk of phlebitis or extravasation."[23(pS76)] "Evaluate the risk and benefit of intermittently infusing vesicant medication for more than 6 days."[23(pS76)] "Avoid the use of a midline catheter when the patient has a history of thrombosis, hypercoagulability, decreased venous flow to the extremities, or end-stage renal disease requiring vein preservation."[23(pS76)]
Michigan Appropriateness Guidelines for Intravenous Catheters (MAGIC)[19] regarding MC utilization
PIVCs were rated as appropriate for proposed durations of 5 or fewer days with peripherally compatible infusates.
"Midline catheters and ultrasonography-guided PIVCs were preferred to PICCs for use between 6 and 14 days,"[19(pS1)] including patients with difficult vascular access, acknowledging that MCs may be used for up to 4 weeks. "When the proposed duration of infusion was 15 or more days, PICCs were preferred to MCs, given the possibility of failure of the latter beyond this period."[19(pS6)]
"For infusion of irritants or vesicants (eg parenteral nutrition or chemotherapy), PICC use was rated as appropriate at any proposed duration of use." Ultrasound-guided PIVC and MC were rated as "inappropriate for this indication for all durations of use."[19(pS6)]
PICCs and MCs were rated as inappropriate "for patients with stage 3b CKD or greater (estimated glomerular filtration rate <45 mL/ min)," due to the "imperative to preserve peripheral and central veins for possible hemodialysis or creation of arteriovenous fistulae and grafts."[19(pS7)]
"Although limited data supporting the recommendation for MC use in critical care patients were available at the time of the meeting, a recent study reported favorable outcomes and cost savings with this device."[19(pS9)]
"Use of PICCs for home-based infusions or in skilled nursing facilities (where resources are limited) is inappropriate for short-term durations (<14 d). In such settings, use of peripheral intravenous catheters or midlines was rated as appropriate."[19(pS11)]
Future indications for MC-related research
MAGIC: Recommends a randomized controlled trial comparing PICCs with MCs for less than 2 weeks of peripherally compatible infusions to determine MC noninferiority, rates of therapy completion, and device-related complications[19]
INS: More high-quality clinical trials are needed to confirm the safety and efficacy of MC use in: • extremes of age (eg elderly, neonates and infants), • appropriate use (eg, single versus multiple therapies) and duration of these catheters, • intermittent vesicant therapy, and • as a strategy for reducing CLABSI.[23]

Abbreviations: CKD, chronic kidney disease; CLABSI, central line–associated bloodstream infection; INS, Infusion Nurses Society; IV, intravenous; MC, midline catheter; PICC, peripherally inserted central catheter; PIVC, peripheral intravenous catheter; VAD, vascular access device.

damage in vessels with test catheters led to the conclusion that pH should be considered an independent risk factor for VAD-related adverse events. The authors concluded that a pH range of 5 to 9 and osmolarity level of less than 600 mOsm/L were appropriate for infusates used for peripheral intravenous therapy. They also recommended reducing the dwell time of the MC to 6 days or less to preserve vascular health.[10]

Manrique-Rodríguez et al[63] conducted a 3-phase study to standardize the dilutions of intravenous drugs commonly administered to hospitalized adult patients and to provide guidance on PIVC and CVC selection.

Table 7 Facility example of indications for central venous catheter placement

Nebraska Medicine indications for CVAD placement
Inadequate peripheral access • 3 failed peripheral attempts by 2 persons (total) – 2 experienced persons, not learners-by experienced operators—PICC/SWOOP/Lead • Agreement by 2 persons of inadequate peripheral veins
Treatments • Plasmapheresis • Apheresis • Emergent hemodialysis access • Continuous renal replacement therapy • Interleukin-2 (IL-2) • Therapeutic hypothermia • Therapeutic active warming for which CL access is required
Emergent interventions: • Transvenous cardiac pacing • Shock • Rapid massive transfusion
Hemodynamic monitoring • CVP monitoring • Pulmonary artery catheter • Introducer for one of the above
Medications • Anticipated length of IV antibiotic or other medication therapy > 6 days • Antineoplastic medications • Complex IV therapies including need for multiple IV meds/fluids • See below for medications that are commonly administered via central line • Required by surgery by nature of surgery—i.e., excessive blood loss

Abbreviations: CL, central line; CVAD, central venous access device; CVP, central venous pressure; IV, intravenous; PICC, peripherally inserted central catheter; SWOOP, vascular access team.

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Table 8 Facility example of infusate indications for central venous catheters

Nebraska Medicine Infusate indications for central venous catheters
Please consult the medication order administration instructions for information regarding which medication should be infused via a central line only • In general, the following medications are infused via a central venous catheter.* MOST other medication s (NOT on the table below) can be infused via a midline or a peripheral line.
Amiodarone: concentration > 2 mg/mL
Dextrose > 20%: in emergent situations, peripheral administration may occur in concentrations up to 50%
Hypertonic saline: recommended for 3% and required for 7.5% and 23.4%
Most TPNs: some with lower concentrations can be given peripherally
Vesicant infusions >60 minutes: dactinomycin, daunorubicin, doxorubicin, epirubicin, idarubicin, mechlorethamine, mitomycin C, trabectedin, verteporfin, vinblastine, vincristine, vindesine, vinorelbine
Calcium chloride: central line or deep vein preferred
Epoprostenol
Potassium concentrations >0.1 mEq/mL
Vasopressors (central line preferred): dopamine, epinephrine, norepinephrine, phenylephrine, vasopressin • *This list is not all inclusive and may change. Consult the MAR, Lexicomp, and/or a pharmacist if there are questions. • MAR: Medication administration record • *Note CVAD (central venous access device), CVC (central venous catheter) and central line are used interchangeably per authors.*

Abbreviation: TPN, total parenteral nutrition.

Reproduced with permission from Cambridge University Press. Figure 2 in Cawcutt KA, Hankins RJ, Micheels TA, Rupp ME.[7]

They categorized the infusates according to their pH, osmolarity, and cytotoxic nature, indicating a continuum of risk based on infusate characteristics. High-risk infusates that required a CVC were solutions that were considered vesicants, had an osmolarity of greater than 600 mOsm/L or a pH of less than 4 or greater than 9, or were required for patients with poor or limited vascular access options. Moderate risk factors were osmolarity of 450 to 600 mOsm/L and pH values of 4 to 5 or 7.5 to 9. Low-risk factors were osmolarity of less than 450 mOsm/L and pH values of 5 to 7.5. Their study, which drew on the INS article "Development of an Evidence-Based List of Noncytotoxic Vesicant Medications and Solutions,"[64] has a detailed list of medication properties, including vesicant designation and VAD selection recommendations based on these limits.[63] Tables 7 and 8 also provide examples of indications for CVC placement and infusates requiring CVC placement.

As research continues to explore MC risks and benefits, safe use of the MC will rely on a culture of safety that places the patient's needs at the center of VAD selection rather than adhering to a "somewhat misguided philosophy that no central lines equal no CLABSI (and its associated penalties)."[8(p1120)] A question that contributes to this mistaken philosophy is asked at many daily patient care reviews or huddles: "Can the patient's CVC be removed today?" That question should be amended because it is often prompted by fear of a negative quality

Policy for tubing change:	Policy for dressing change:	Examples of approved indications for midline:
Standard: Wednesday/Saturday Intermittent: every 24 hours TPN/lipids: every 24 hours, propofol every 12 hours	Every 7 days and PRN loose or soiled Change extension set every 7 days or with malfunction	Long-term antibiotic therapy: Generally, up to 2 weeks Patient unable to have a central catheter due to existing bloodstream infection Very difficult venous access inpatient Patients with anticoagulation concerns

Observer: _____ Date: _____ Unit: _____

Room #				
Date of midline insertion				
Location of midline				
OBSERVATION **Caps, saline syringes, and wipes:**				
Prevantics or alcohol wipes available at the bedside?				
Can staff verbalize correct use of Prevantics or alcohol wipes, and should be used on EVERY access of the line (such as between medications and flushes)?				
Can staff verbalize correct use of saline syringes (single use product)?				
Dressing:				
Clean, dry, and intact?				
Labeled with date and time?				
Changed in the last 7 days or <7 days old?				
Tubing: (see legend above)				
Is the correct sticker and dates on all tubing sets?				
DOCUMENTATION—accurate dates				
Tubing and extension set charted				
All disconnected tubing is capped, not looped				
Dressing change charted				
Site with no redness, edema, or pain to palpation				
Line justification charted daily/accurately (if no longer needed, encourage provider notification)				
Additional comments				

Figure 2 Midline catheter audit form.

Abbreviations: PRN, as needed; TPN, total parenteral nutrition.

metric and may actually cause negative outcomes by transitioning from a CVC that is generally well monitored to a PIVC that may not receive the same standard of care.[7] The appropriate question for each patient in the patient care huddle is "What is/are the best VAD option(s) for this patient today?" Unless the individual patient's needs are fully addressed and current standards of VAD management and monitoring are effectively in place, a transition from a CVC to an MC (or multiple MCs) is not in the patient's best interest. Figure 2 provides an example of an MC audit form.

Conclusions

The MC provides a valuable VAD option for critical care patients, with 2 notable examples. If a patient requires emergency treatment, short PIVC or intraosseous needle placement is preferred when there is increased risk or delay with CVC placement. However, if other peripheral access is not available and the resources to safely place an MC are in place, MC placement may be a viable option. If continuous vesicant therapy (eg, vasopressors) is required, prompt transition to a more

definitive VAD is indicated.[15,23,35] Midline catheters are also valuable for patients with DIVA who require a relatively simple regimen of peripherally compatible infusates for an estimated 5 to 14 days, preferably with a single-lumen MC.[2,6,7,14,16] Optimizing VAD selection and outcomes requires that clinicians recognize that every VAD carries the potential for a significant risk of patient harm. It is imperative that facilities use current guidelines and research to develop VAD-related expertise, resources, and workflow to provide evidence-based guidance on VAD selection, placement, and management.[7,14,23,24,55,63,64] It is equally imperative that VAD-related outcomes are effectively monitored, analyzed, and disseminated to further optimize patient outcomes in the rapidly evolving environment of critical care.[2,11,12,14,18] CCN

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See also

To learn more about using catheters in the critical care setting, read "Narrative History of the Swan-Ganz Catheter: Development, Education, Controversies, and Clinician Acumen" by Headley and Ahrens in *AACN Advanced Critical Care,* 2020;31(1):25-33. Available at **www.aacnacconline.org**.

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