Midline Catheters

Could They Replace a Central Vascular Access Device?

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ABSTRACT

In the past 30 years, midline catheter use has grown rapidly. For several reasons, many providers and facilities are attempting to reduce the number of central venous catheters and subsequent central line–associated bloodstream infections (CLABSIs) by using midline catheters. Vessel preservation requires attention to all vascular access device (VAD)-associated complications and not only central line bloodstream infection. There is still much confusion about the appropriate tip location and the characteristics of fluids and medications that can safely be infused through a midline catheter residing in a peripheral vein. The *Infusion Therapy Standards of Practice* (the *Standards*) focuses on assessment of characteristics of infusion therapies that must be considered for VAD selection as an evidence-based list of fluids and medications for infusion through peripheral veins has yet to be established. This review of midline catheter studies evaluates the evidence regarding the substitution of a midline catheter for a central venous catheter. Many issues need to be addressed, such as studies that include an outcome list that mixes defined clinical complications (eg, thrombosis) with signs and symptoms of complications (eg, leaking). Another issue is basing a major change of clinical practice on retrospective chart reviews. Although a midline catheter may be appropriate for some patients, additional studies of a higher level of evidence are needed before this major practice change should occur.

Key words: central venous catheter, CLABSI, infiltration/extravasation, midline catheter, thrombosis

INTRODUCTION

Midline intravenous (IV) catheters have recently become the preferred choice for vascular access in hospitalized patients, with some clinicians using them to replace most, if not all, central venous access devices (CVADs). Common reasons for this change in preference include patients with difficult IV access, the need to reduce the use of unnecessary central venous catheters (CVCs) and their associated risks, and high rates of central line-associated bloodstream

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infections (CLABSIs) that lead to significant financial loss for the facility. Infusion and vascular access nursing specialists have concerns because inappropriate use of midline catheters thrombose large peripheral veins, cause deep tissue injury from infiltration/extravasation, and can cause peripheral nerve injury. In addition, published evidence does not support the use of midline catheters when infusion therapy characteristics indicate the need for a CVC.[1]

BACKGROUND

Since the first commercial midline catheter was introduced in 1989, there has been confusion about definitions, the most appropriate tip location, and the medications and fluids appropriate for infusion through peripheral veins. The original concept for midline catheters was based on tip location in veins of the upper part of the arm where vein diameter and subsequent hemodilution were thought to be greater. The midline catheter was anticipated to reduce the excessive number of peripheral venipuncture attempts and was never intended as a replacement for a CVC.

Overreliance and inappropriate use of midline catheters give rise to questions about patient safety. The current perceived need to reduce the use of CVCs and the associated financial loss from CLABSIs appear to be driving increased use of midline catheters in some locations.[2-4] The complications of thrombosis and extravasation are not identified as a hospital-acquired condition with financial penalties similar to CLABSIs. Treatment of these complications are billed to all third-party payers, and malpractice lawsuits are paid by facility insurance and produce no direct financial loss to the facility.

Available research has not answered questions about the types and characteristics of infusion therapy that are acceptable for successful infusion through peripheral veins versus those that require a CVAD. The definition of a successful outcome with any vascular access device (VAD) involves management of vessel health and preservation. This approach is the desired goal to reduce the number of serious negative outcomes and ensure that a patient's veins will be accessible for the entire therapeutic course, a need that could span their entire life.[5]

Clinicians have become accustomed to the frequent failure of short peripheral IV catheters (PIVCs), accepting it rather than working to change this situation.[6] Failure is related to site selection, condition of the patient's veins, insertion technique, and the varieties of IV fluids and medications prescribed. Traditionally, the decision about peripheral versus central venous access focused on infusion of vesicants (drugs that cause tissue destruction outside the vein) and irritants (drugs that cause endothelial vein damage producing thrombophlebitis). Others consider drug and solution characteristics such as final osmolarity and pH as the critical criteria; however, the evidence for parameters of appropriate values is inconclusive. The *Infusion Therapy Standards of Practice* (the *Standards*) lists 6 factors that should be considered when making the decision about VAD selection, including the diluent and final osmolarity, pH, method of administration, infusion rate, the number of infusion therapies, and anticipated duration of therapy.[7] The *Standards* also states, "Do not insert a PIVC or midline catheter as a central line-associated bloodstream infection (CLABSI) prevention strategy," although the ranking is Committee Consensus due to the sparsity of evidence.

REVIEW OF MIDLINE STUDIES

There have been 3 randomized, controlled trials (RCTs) in humans and 1 animal study involving midline catheters. Two small RCTs compared a standard-length peripheral catheter of 4.78 cm to approximately 6.00-cm peripheral catheters. Although not labeled as midline catheters, these studies used ultrasound to guide insertion, and both placed all catheters in the proximal portion of the upper extremity in adults, avoiding insertion in the antecubital fossa. A specific midline tip location was not identified; however, the 6-cm catheters would have been close to the recommended midline tip location. Neither study reported information about the number of infusion therapies administered, although 1 study[8] reported a low rate of infection and thrombosis in both cohorts. Both studies reported greater dwell times with the longer catheters.[8,9]

One RCT compared the strategies for choosing a VAD in patients requiring more than 5 days of infusion therapy. A group of 58 patients receiving a midline catheter were compared with a group of 58 patients receiving conventional short PIVCs and CVCs.[10] Patients were not candidates for a midline catheter if they were in an intensive care unit, were to have major surgery or infusion of vasoconstrictors, had high osmolarity parenteral nutrition, or had experienced a local reaction to peripheral infusion of irritant medications, insufficient performance of peripheral catheters, or difficult venous access. There was no significant difference in premature catheter removal between the 2 groups. The use of midline catheters led to a reduction in escalation to a CVC and a reduction in the number of patients needing 4 or more PIVCs to deliver the required length of therapy.

The fourth RCT was an animal study comparing outcomes of 10-cm, 18-gauge single lumen midline catheters inserted into the cephalic veins of 24 sheep.[11] Six groups of solutions were studied, including vancomycin in concentrations of 4.0 and 10.0 mg/mL, doxycycline (an acidic medication) 1.0 mg/mL, and acyclovir (an alkaline medication) 3.5 mg/mL, as well as 2 parenteral nutrition formulas (final osmolarity of 675 and 930 mOsm/L). As a control, the contralateral extremity of each sheep was infused with 0.9% sodium chloride. Histologic examination of the excised vein was performed by a pathologist blinded to the specific type of infusions. Four sheep were excluded due to infection,

thrombophlebitis, and an adverse drug reaction, leaving 20 animals with 20 test and 20 control catheters. Catheter failure within 14 days was seen in 19 of 20 test catheters (95% failure rate; median time to failure = 7.5 days) and 12 of 20 control catheters (60% failure rate; median time to failure = 8 days).[11] Occlusive perivascular mural thrombosis occurred in 50% and 5% of test and control catheters, respectively. Absence of blood return, a method for assessing catheter patency was lost in 42% of aspiration attempts with the test catheters and 32% of attempts with the control catheter. The mean vein diameter at the catheter tip was 4.5 mm, and the preinsertion blood flow rate was 20 mL/min. With an 18-gauge catheter in the vein, blood flow would be reduced to approximately 11 mL/min, allowing greater exposure of the venous endothelium to the infusing drug or solution. Due to severe vascular injury seen in these sheep, the authors recommended against infusing any of the tested solutions through a midline catheter and limiting catheter dwell to less than 6 days.[11]

Other studies reporting midline catheters survival include a mean dwell time of 6.7 days[12] and median catheter dwell times of 5.5 to 14.0 days.[8,10,13,14]

Prospective, observational studies have focused on difficult venous access in cardiac surgery patients,[13] hematopoietic progenitor cell collection by apheresis,[15] palliative care,[16] emergency medicine patients,[12] and various other hospitalized patient groups.[17-20] Early or premature removal was reported in 41% of cardiac surgery patients,[13] and other patient groups reported 60% of 98 patients or 72/1000 catheter days[17]. Symptomatic thrombosis was diagnosed in 4.5% of 430 patients with 439 midline catheters, or 3.3/1000 catheter days.[20] Complications reported by patients were fewer with midline catheters than with peripherally inserted central catheters (PICCs).[19] With regard to midline catheters for infusion of vasopressors and inotropic agents in patients in the emergency department, 57 (14%) of 403 failed to aspirate, and 60 (14.9%) experienced complications during the dwell time.[12] Dwell time complications were described as minor but included leaking from the puncture site, erythema, pain, and drainage. These complications could be indicative of thrombosis; however, no diagnostic examination was reported. Vesicant extravasation occurred in 2 patients (0.5%). Most of these prospective studies did not report the types of fluids and medications infused through the midline catheters.

The largest group of published studies on midline catheters were retrospective review studies, a limitation that leaves many questions.[2,13,14,21-26] Four studies reported midline catheter use for infusion of parenteral nutrition, continuous inotropes, and use for rapid fluid replacement in hemodynamically unstable patients.[13,14,23,24] One study described catheter tip location in the "midpoint of the lateral clavicle" but labeled this as a midline catheter.[21] Most reported a decrease in CVC use along with a reduction in CLABSIs. Infiltration and extravasation rates were not reported or were reported in very low numbers.

Venous thrombosis is a common complication of midline catheters. In a retrospective chart review of 1094 midline catheters and 1483 PICCs, 12% of midline catheters had catheter-related deep or superficial venous thrombosis compared with 6.9% of PICCs. A multivariate logistic regression model of these data analyzed for thrombolytic events in midline catheters relative to the same events in PICCs, adjusting for age, sex, lumen size, location, deep vein thrombosis/pulmonary embolism history, number of attempts, line side, and indication for use. Patients with midline catheters had 22% catheter-related thrombosis, whereas those with PICCs had 12% (adjusted odds ratio [AOR] = 2.04 [range, 1.46-2.86]). Pulmonary embolism was observed in 7.2% of patients with midline catheters and 4.9% of those with PICCs (AOR = 1.51 [range, 0.74-3.09]). Double lumen 5 French (Fr) midline catheters had higher rates of thrombosis compared with single-lumen 4 Fr midline catheters.[24]

DISCUSSION

This review highlights several issues related to complication identification, tip locations, and venous anatomy. Venous diameter and subsequent blood flow through the basilic, brachial, or cephalic veins used for midline catheter tip location are significantly less than the superior vena cava for CVC tip location. Less hemodilution can lead to increased chemical and mechanical injury to the venous endothelium depending on the medication infused through the catheter. Inserting a catheter so the catheter-to-vein ratio is less than 45% is a concept first applied to PICCs and is now strongly encouraged for midline catheters at the time of insertion.[7,27]

Vein depth requires the use of ultrasound to locate appropriate veins for midline catheter insertion. Clinical assessment of complications associated with all peripheral catheters relies on observation of changes in color or temperature of the skin over the catheter location. The midline catheter tip location lies in deep peripheral veins, often underneath muscle tissue. Significant damage can occur to the vein wall and surrounding tissue before signs or symptoms are noticed on the skin surface. In addition, the length of catheter inserted requires careful measurement to avoid placing the tip in the shoulder area where motion can increase mechanical trauma.

Signs and symptoms noted in publications are frequently listed as "complications" such as leakage from the puncture site, pain, "nonpatent," and edema. The specific diagnosis of the condition (ie, vein thrombosis, infection, phlebitis) is not reported. More details about diagnosis are needed to identify the specific complications, such as thrombosis, phlebitis, or infiltration/extravasation.

Midline catheters may be successfully substituted for some but not all CVCs. Most studies of successful midline catheter use did not include fluids and medications that

traditionally require a CVC (ie, parenteral nutrition, known vesicants such as inotropes, and highly concentrated electrolytes).

The total number of available veins for midline catheter insertion must be considered. Although there are 8 possible veins for a midline catheter—bilateral basilic, cephalic, and paired brachial veins—previous infusion therapy, injuries, and surgery may limit the number of accessible veins suitable for midline catheter placement.

These midline catheter studies provide a good beginning but leave many unanswered questions. These studies seem to be inadequate as the basis for a major practice change of replacing all CVCs with midline catheters. As new studies are published, critical evaluation is required, including the type of study, number of patients or catheters, specific midline catheter tip location used in the study, number and characteristics of infusion therapies administered through the midline catheter, and complication rates and other clinical outcomes.

CONCLUSION

Insertion of a midline catheter in place of a CVC could be considered if the planned infusion therapy is associated with positive outcomes when infused through peripheral veins. It is important that ultrasound-guided insertion with appropriate catheter-to-vein ratio is followed, and there should be correct tip positioning at the level of the axilla distal to the shoulder, daily assessment of the extremity used for catheterization for signs of complications (eg, swelling, leakage from puncture site), resistance during flushing or infusion, inability to aspirate a blood return, and daily discussion with the patient regarding any related discomfort. Promoting vessel health and preservation involves attention to all complications. CLABSI reduction is important; however, the risk of other complications could leave the patient with serious functional limitations due to deep vein thrombosis, infiltration and extravasation, and nerve injuries.

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