Implementing a Midline Catheter Program in an Acute Care Hospital

Process and Outcomes

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ABSTRACT

Midline catheters are a viable alternative to central vascular access devices in appropriate patients. Successful midline catheter programs require robust surveillance plans to monitor for appropriateness of use and complications, including bloodstream infections. This retrospective study evaluated the impact of implementing a midline catheter program in a midsize teaching medical center in the northeastern United States from January 2014 to May 2019. After implementation, the midline catheter utilization rate was 5.6% with bloodstream infections and other complication rates of 0.44 and 6.57 per 1000 midline catheter days, respectively. Results further revealed a reduction in central vascular access device utilization from 17.8% to 14.5% ($P < .001$).

Key words: central line-associated bloodstream infection, CLASBI, infection prevention, midline catheter, peripherally inserted central catheter, PICC

Intravenous (IV) therapy is one of the most common components of acute patient care management and the most common invasive procedure performed in the hospital.[1] Selecting the most appropriate access for IV therapy is essential to both optimize care and maintain patient safety. The Centers for Disease Control and Prevention[2] (CDC) and the Infusion Nurses Society (INS)[3] recommend vascular access device (VAD) selection based on the complete patient status, including clinical presentation, medical history, and planned type and duration of therapy. In addition, for patients with chronic conditions that require frequent hospitalization and/or vascular access, instituting a structured approach to selecting VADs is essential for vein preservation.[4,5]

A wide range of VADs are available, the most common of which include short peripheral catheters, peripherally inserted central catheters (PICCs), and central VADs (CVADs). Although these VADs remain the most frequently used, the midline catheter is an alternative device that can be considered in select patient populations. Midline catheters are longer-length (7.5–25 cm) peripheral catheters placed in the antecubital fossa or upper arm. Unlike PICCs and other CVADs, the distal tip of midline catheters terminates in the large veins of the upper arm (basilic, brachial, or cephalic) at or below the axillary fold, distal to the shoulder and not in the central vasculature.[6] Although these catheters were first introduced in the 1950s, they fell out of use during the

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1990s because of adverse reactions to the manufacturing materials and design limitations.[7-9] In recent years, there has been a renewed interest in midline catheters due to improvements in product design and the imperative to decrease central line-associated bloodstream infections (CLABSIs) associated with PICCs and other CVADs.[6,8,10-13]

Although midline catheters are an appealing alternative to PICCs, there are specific indications for use in defined patient populations, because not all candidates for PICCs are also appropriate for midline catheter placement. Indications for midline catheter use include medium- to long-term IV therapy, typically lasting >6 days,[2,6,14] and difficult venous access[6,13] in patients without specific indications for CVADs. Notably, the Michigan Appropriateness Guide for Intravenous Catheters criteria[6] recommend a preference for midline catheters compared with PICCs for patients with difficult venous access and for those whose therapy is anticipated to last ≤14 days, although midline catheters are approved for use up to 4 weeks. Moreover, midline catheters are generally not indicated for any peripherally incompatible solutions, such as irritants and vesicants,[6] although this absolute contraindication as it relates to the pH of solutions has been challenged.[13,15]

In addition to potentially reducing CVAD utilization and CLABSIs,[10,13] research has further demonstrated several key practical and clinical benefits to midline catheter use. Because they are peripheral catheters that do not terminate in the large central veins, midline catheters can be inserted at the bedside by vascular access nurses[12,13] and do not require radiographic confirmation of tip placement, both of which facilitate the timely delivery of care.[8]

Despite the many benefits of midline catheters, as with any other invasive device or procedure, there is an inherent level of patient risk involved. Although increased midline catheter use can result in a decrease in CLABSI, the potential for midline catheter bloodstream infections (BSIs) remains and must be closely monitored to ensure patient safety.[12,16] Although recent studies reported 0 midline catheter BSIs during the first 2 years[11] and 4 years[13] of implementing a midline catheter program, Hogle et al[12] found the incidence of midline catheter BSI to be 0.88 per 1000 midline catheter days across 5 hospitals over a 12-month period. Additionally, other non-BSI reported complication rates vary significantly across studies,[11,16-18] although comparisons are limited because of variation in metrics used (eg, deep vein thrombosis, superficial venous thrombosis, phlebitis, mechanical issues, and infiltration). Nevertheless, the rate of non-BSI complications has been shown to be higher in midline catheters when compared with PICCs (19.5% vs 5.8%).[16] Mushtaq et al[19] also found a significantly higher rate of mechanical issues with midline catheters compared with central venous catheters (2.6% vs 0.3%).

As the use of midline catheters continues to expand, development of targeted education and surveillance strategies is essential to ensure successful program implementation, and a growing body of literature is emerging outlining such strategies.[10-13] Common features of successful programs include clear indications for midline catheter use, patient assessment by vascular access nurses, education and training for bedside nurses, and a robust surveillance plan to monitor utilization and complications. Before implementing midline catheters, the overall CVAD use rate at the study facility was 17.8%. Midline catheters were initially introduced to reduce the dependence on CVADs by offering an alternative VAD option for appropriate patients. The aim of this retrospective study was to report the organizational experience implementing a midline catheter program and to evaluate clinical outcomes.

METHODS

Design and Setting

This retrospective study was conducted at a 504-bed teaching medical center in the northeastern United States. The organization employs a dedicated vascular access team (VAT), composed of 15 registered nurses, 1 licensed practical nurse, and 1 phlebotomist available from 7:00 AM to 10:00 PM on weekdays and 7:00 AM to 5:00 PM on weekends. Data were collected between January 2014 and May 2019 and maintained in an internal database. For analysis, data were categorized into 2 time periods: the preimplementation phase (January 2014 to September 2015) and the postimplementation phase (October 2015 to May 2019).

Human Subjects Protection

The study protocol was submitted to the institutional review board of the organization. It was determined to not meet the definition of human subject research due to the retrospective nature and exclusive use of deidentified health record data and was not subject to institutional review board oversight.

Midline Catheter Program Development: Education and Training

The midline catheter program was launched in October 2015. The infection preventionists, VAT assistant nurse manager, and chair of vascular surgery collaborated to establish guidelines for use based on a review of existing literature and device manufacturer recommendations (Table 1). Because of limited research at the time, the organization deferred to the manufacturer recommendations for a maximum dwell time of up to 29 days.

The organization selected 2 options for midline catheters: the PowerGlide Pro (Bard Access Systems, Inc., Salt Lake City, UT) and the PowerMidline (Bard Access Systems, Inc). The PowerGlide Pro was appealing because of its unique design that addressed many issues with previous versions of midlines.[7-9] The PowerGlide Pro is available in sizes of 18- or 20-gauge, with each gauge available in lengths of 8 or 10 cm. It is designed as a closed system

TABLE 1

Midline Catheter Indication and Contraindications

Indications	Contraindications
Intravenous therapy for duration >5 days but no longer than 29 days	Lymphedema
Difficult venous access	Deep vein thrombosis in upper extremity
	Extremity with an arteriovenous fistula or graft
	Total parenteral nutrition
	Continuous vesicant therapy
	Solutions with an osmolarity > 900 mOsm/L

TABLE 2

Vascular Access Device Utilization and BSI Rate Formulas

	Midline Catheter	CVAD
Utilization rate	Midline catheter days/patient days × 100	CVAD days/patient days × 100
BSI rate	Midline catheter BSI/midline catheter days × 1000	CLABSI/CVAD days × 1000

Abbreviations: BSI, bloodstream infection; CLABSI, central line-associated bloodstream infection; CVAD, central vascular access device.

with needle, guidewire, and catheter all-in-one housing; insertion is performed under sterile technique. The organization also offered the PowerMidline as an option for patients whose vasculature was too deep for the shorter PowerGlide Pro, either because of anatomy or body habitus. The PowerMidline is available in sizes of 3 or 4 Fr, with a standard length of 20 cm, which can be cut according to the patient's needs. Insertion is performed under the maximal sterile barrier using the Modified Seldinger Technique. The PowerGlide Pro is more commonly used in the organization.

Initial training for midline catheter insertion and maintenance was provided to the VAT by the manufacturer. All of the physicians and nurses were advised that midline catheters were available, and education regarding the devices and indications was provided. Physician orders were required for midline catheter placement. To promote consistent, appropriate use, if a PICC was ordered, the VAT recommended midline catheter placement in patients based on clinical indications and anticipated duration of therapy. On receipt of a physician's order, the VAT determined which midline catheter type, length, and gauge was most appropriate based on assessment of the patient vasculature using ultrasound to visualize the veins. The VAT performed all routine maintenance and dressing changes. All of the other nursing staff were educated on maintenance, complications, and troubleshooting of the devices. For the first 3 months of the program, only the VAT was permitted to draw blood from and to discontinue midline catheters. After 3 months, designated nurses outside of the VAT were trained to draw blood; all nurses were trained to discontinue PowerGlide Pro midline catheters.

Data Collection

Data collected included utilization and BSI rates for midline catheters and CVADs (including PICCs), as well as midline catheter complication rates. Nurses who were board certified in infection prevention surveillance reviewed patient records for BSIs following the CDC National Healthcare Safety Network (NHSN) definition of BSI events.[20] If a patient experienced a BSI, the infection was attributed to the most invasive VAD present. Midline catheter days were collected following the same NHSN method for collecting CVAD days. If a patient had a midline catheter, they contributed 1 day to the total midline catheter count for that day. The count was taken at the same time daily and totaled for the month. This daily count was used to calculate the total midline catheter utilization and BSI rates analogous to the calculations for CVADs (Table 2). Utilization and BSI rates are maintained in an internal organizational database, which was used to obtain the data for this study.

Patients with midline catheters were also monitored for complications including venous thrombosis, infiltration, and occlusion using the INS phlebitis scale[3] and infiltration scale.[21] Although the infiltration scale has not been published by INS since 2006 due to a lack of studies to support its validity and reliability, it remains in use in the organization. The VAT assessed each patient with a midline catheter daily and recorded complications in an internal organizational database that is shared with the infection prevention department. Midline catheters can be used for blood draws during initial insertion; however, no professional organization guidelines or existing literature were found to provide definitive recommendations for blood draws beyond initial insertion. Because there were limited data in the literature on the effectiveness and safety of midline catheters for use in blood draws, data for the length of time the midline catheter was able to provide adequate blood supply for sampling and whether there were any complications related to the blood draws were collected over a 3-month period.

Statistical Analysis

Descriptive statistics were used to report midline utilization, BSI, and complication rates. Comparative analyses were performed using the 2-sample Poisson test to examine differences in pre-post CVAD utilization and BSI rates. Statistical significance was set at $\alpha = 0.05$. All data were analyzed using Minitab17.

RESULTS

During the postimplementation period, a total of 4968 midline catheters were placed corresponding with a utilization rate of 5.6%. Between the pre-post implementation period, there was a significant decrease in overall CVAD utilization (17.8% vs 14.5%; $P < .001$), primarily driven by a decrease in PICC utilization (11.0% vs 5.7%; $P < .001$; Figure 1).

There were 11 midline catheter BSIs corresponding with a rate of 0.44 BSIs per 1000 midline catheter days. There was a nonstatistically significant decrease in CLABSI rates between the pre-post implementation period (1.14 vs 0.87 BSI per 1000 CVAD days; $P = .199$; Figure 2).

Excluding BSIs, there were 150 complications identified in 4968 midline catheters placed (22 928 midline catheter days) for a complication rate of 3% or 6.57 per 1000 midline catheter days (see Table 3). Blood was able to be drawn from midline catheters for an average of 4 days after insertion.

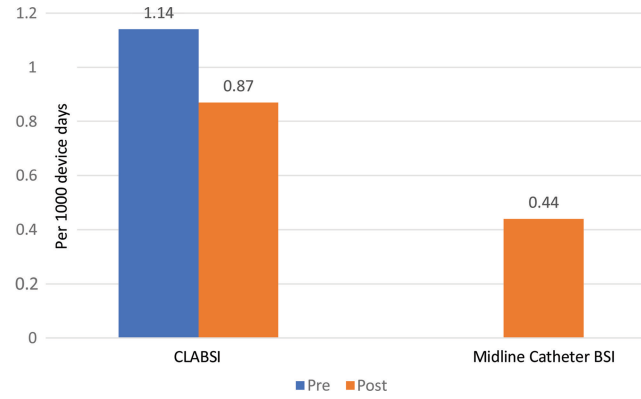

Figure 2 Vascular access device BSI rates pre-post midline catheter implementation. *Abbreviation: BSI, bloodstream infection; CLABSI, central line-associated bloodstream infection.*

DISCUSSION

The aim of this study was to report the organizational experience and identify the clinical outcomes associated with implementation of a midline catheter program. Reductions in CVAD utilization rates, as well as decreases in CLABSIs, were noted.

Utilization

Midline catheter utilization rates have varied both within and across studies. A multihospital study found significant differences in utilization across sites ranging from 0.97% to 12.92% ($P < .001$).[17] The initial 3-year midline catheter utilization rate in the current study was 5.6%, which was slightly less than the 7.04% reported by Chopra et al[17] but greater than the 3.4% reported by others[12] across a 5-hospital system.

A statistically significant decrease in CVAD utilization was noted after introducing midline catheters in this study. Further data analysis determined that the decrease in overall CVAD use was primarily the result of a decrease in PICC utilization from 11.0% to 5.7% ($P < .001$), representing a 48% decrease. This finding is similar to a case study of 2 hospitals that reported a 58% reduction in the average number of PICCs inserted annually after implementing a midline catheter program.[13] The finding was also expected considering that midline catheters are more likely to serve as an alternative for PICCs than other CVADs given the indications for use.[6]

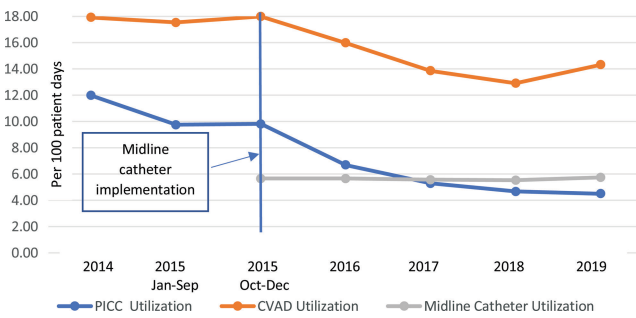

Figure 1 Midline catheter, CVAD, and PICC utilization rates. *Abbreviations: CVAD, central vascular access device; PICC, peripherally inserted central catheter.*

Complications

A decrease in CVAD utilization is often associated with parallel reductions in CLABSIs. In this study, the CLABSI rate decreased by 19% after midline catheter implementation (1.14 vs 0.87 BSIs per 1000 CVAD days; $P = .199$). This reduction in CLABSI rate is consistent with existing literature. One study found a CLABSI rate of 1.10/1000 CVAD days after midline catheter implementation,[12] which was slightly higher than the rate in this study of 0.87. Other researchers reported a more significant 78% decrease in their CLABSI rates from 1.7/1000 days to 0.2/1000 days.[13] Similarly, Pathak et al[10] reported a statistically significant reduction in CLABSI rates after the sequential implementation of the CDC central venous catheter bundle followed by midline catheters ($P = .0113$). Although the findings of this study were not statistically significant, clinically important improvements were realized, and this is an area that continues to be monitored.

This study further revealed a midline catheter BSI rate of 0.44 per 1000 midline catheter days. Researchers have reported widely variable midline catheter BSI rates. The rate in the current study was lower than published results of 0.88[12] but still contrasts with other findings of 0.20[8] and those of DeVries et al,[11] which found no midline catheter BSIs within the first 2 years of implementation, although the rates were 1.07 and 0.80/1000 midline catheter days in subsequent years. Seo et al[18] similarly found 0 midline catheter infections in a small sample of 32 patients. Differences in sample size, patient days, and length of data collection could explain the variations noted across studies, although 1 study reported 0 midline infections over 3 years across 2 hospitals.[13]

Midline catheters have been linked to a higher number of minor complications compared with PICCs, which had fewer incidents but more severe complications like bacteremia.[16]

TABLE 3

Non-BSI Midline Catheter Complication Rates

Complication	Occurrences	Rate per device, %[a]	Rate (per 1000 midline catheter days)[b]
Deep vein thrombosis	11	0.22	0.48
Superficial venous thrombosis	13	0.26	0.57
Infiltration	43	0.87	1.88
Occlusion	83	1.67	3.64
All	150	3.02	6.57

Abbreviation: BSI, bloodstream infection.
[a]Denominator is 4968 midline catheter devices.
[b]Denominator is 22 828 midline catheter days.

Most non-BSI midline catheter complications are mechanical and are often attributed to manipulation of the catheters.[16] The non-BSI complication rate was low in the current study (3.02%). Occlusion was most frequently reported (1.67%), which was comparable to the 1.7% rate found by DeVries et al[11] during their second year of midline catheter implementation. Again, variation in reported complications was observed in a multisite study where it ranged from 3.4% to 16.7% across 12 hospitals.[17] It is important to note that the study by Chopra et al[17] included BSIs in the complications, whereas the current study did not, which could partially explain the observed differences. Additionally, the finding in this study of 6.57 complications per 1000 midline catheter days is markedly lower than the 23 complications per 1000 catheter days reported by others.[19]

Difficult venous access is one established indication for midline catheter use.[6] Although they can be used to draw blood, this is often not the primary purpose for use but may be a benefit to patients. Midline catheters are more stable than short peripheral catheters and can be inserted into a deeper vein due to their length with the associated benefit of extended dwell time.[6] The organization of this study chose to use midline catheters to draw blood because there were no contraindications to the practice in the literature or from the manufacturer. Blood was able to be successfully drawn from midline catheters for an average of 4 days. INS standards state that VADs should be flushed and aspirated for blood return before each infusion to assess device function and prevent complications.[3] Recent literature reports that midline catheters often do not yield blood return after a few days and that they may be used in the absence of blood return if they flush easily and other signs of complications, for example, phlebitis or infiltration, are not present on careful assessment.[22] When unable to obtain blood return, the VAT assesses and attempts to troubleshoot by repositioning the catheter and changing the dressing to ensure that no kinks are present, which often results in restoring blood return. In addition, the midline catheter is assessed daily for patency and swelling by measuring arm circumference for comparison with initial assessment, as well as using ultrasound during flushing to assess for infiltration. Recently, it was reported that in a small sample of 17 midline catheters, 90% experienced loss of blood return in a mean of 3 days.[23] Blood return was reestablished in 5 of the catheters using a troubleshooting algorithm that could be considered in other organizations.

Costs

In addition to the clinical benefits of decreased CVAD use and potential reductions in CLABSIs, implementation of midline catheters can result in cost savings. The average cost of a PICC and midline catheter insertion in the study organization is $6,422.75 and $4,491.14 (−$1,931.61), respectively. These costs include charges for the procedure and supplies. By reducing PICC insertion from an average of 2000 to 700 each year and utilizing midline catheters at an average of 1600 each year, the organization saved an estimated $1,163,733. Reducing PICC placement and appropriately using midline catheters combined with the likely reduction in CLABSIs could yield significant savings in organizations. Continued judicious VAD selection is needed to realize the maximum potential cost and clinical benefits.

LIMITATIONS

This study was subject to several limitations. First, the study was retrospective and conducted in a single organization, which limits generalizability of the findings. In addition, the researchers did not collect or adjust for patient-level factors that may impact VAD selection, infection risk, and complication risk. Finally, the organization only used 1 midline catheter brand/manufacturer, which could impact performance and patient outcomes based on variations in catheter materials and insertion techniques. Despite these limitations, the study was strengthened by use of data collected by board-certified, expert infection preventionists using established CDC NHSN criteria.

CONCLUSIONS/IMPLICATIONS

The implementation of a midline catheter program can yield both clinical and financial benefits. This study expanded

the existing knowledge base for midline catheter implementation, safety, and efficacy. Findings revealed that a comprehensive program reduced CVAD use and infections, with relatively low risk of complications and infections in midline catheters. These programs cannot exist in isolation and must be part of a larger interprofessional organizational approach to enhance VAD education, selection, maintenance, and surveillance to promote patient safety and quality outcomes. Future research should also aim to address the issue of using midline catheters for blood draws, because this still requires resolution.

Given the significant variation in methodology and outcomes related to midline catheters in the literature, more standardized data collection and reporting of complications is needed to allow for synthesis across studies and assist in establishing national benchmarks. In the interim, it is imperative that organizations continue to collect and share experiential and research data to strengthen the evidence base for appropriate midline catheter utilization.

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