American Journal of Infection Control 000 (2022) 1–4

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major Article

Midline catheters: A 3-year experience at a veterans administration medical center

Andrew Johnson MD [a,b], Ashwin Gupta MD [a,b], Tristan Feierabend MD [a,b], Tracy Lopus BSN, CRNI [b], Richard Schildhouse MD [a,b], David Paje MD, MPH [a,b,*]

[a] The Department of Internal Medicine, University of Michigan Medical School, Ann Arbor, MI
[b] Veterans Administration Ann Arbor Healthcare System, Ann Arbor, MI

Key Words:
Vascular access device
Short-term antibiotic infusion
Catheter dislodgement
Venous thromboembolism
Catheter related bloodstream infection

Background: Midline catheters are recommended over peripherally inserted central catheters as short-term vascular access device for peripherally compatible infusates. We assessed the effectiveness and safety of midline catheters.

Methods: Data from midline catheter placements from June 2016 to May 2019 at a tertiary-care Veterans Administration medical center were retrospectively collected. Patients were followed until catheter removal or death, whichever occurred first. The primary outcome was completion of intended therapy; secondary outcomes were catheter-related complications, including major (eg, catheter-related bloodstream infections [CRBSI] or venous thromboembolism [VTE]) and minor (eg, catheter occlusion, kinking, dislodgement) events.

Results: Of 115 midlines, 62 (53.9%) were for antibiotic infusion and 49 (32.6%) for difficult access. The median dwell time was 11 days (interquartile range, 5.5-19.5 days). Midline catheters lasted through completion of therapy in 93 patients (80.9%). Catheter-related complications occurred in 27 patients (23.5%), including catheter dislodgement in 10 patients (8.7%), catheter kinking in 8 (7.0%), and catheter occlusion in 3 (2.6%). Only 1 patient experienced a major complication, a deep venous thrombosis (0.9%).

Conclusions: Midlines appear to be effective and safe for short-term vascular access in patients requiring peripherally compatible infusates. While the rate of major complications is low, minor complications that necessitate device removal are common.

BACKGROUND

Midline catheters (midlines) have emerged as an alternative to peripherally inserted central catheters (PICCs) when short-term venous access is needed for peripherally compatible infusates. Midlines are inserted in the antecubital fossa or the upper arm with the tip terminating at or near the axilla, distal to the subclavian vein.[1] PICCs are inserted in the same area, but extend proximally to the central veins with the tip terminating in the cavoatrial junction.[2] Imaging or electrocardiographic guidance to verify the correct positioning of the catheter tip is not performed for midlines, but it is required for PICCs to avoid important complications, such as arrhythmia, venous thrombosis and tip migration.[3-5] Both devices are inserted following surgical aseptic non touch technique (Surgical-ANTT) by trained venous access specialists.[5] Current guidelines recommend midlines over PICCs if the expected duration is 14 days or less and central access is not necessary.[1]

A few earlier single-center observational studies that directly compared the rates of major complications, such as catheter-related bloodstream infection (CRBSI) and venous thromboembolism (VTE), between midlines and PICCs have yielded mixed results.[6-8] A recent large multi-institutional cohort study, which focused on devices that were placed for 30 or fewer days for indications of difficult venous access or intravenous antibiotic therapy, showed lower rates of CRBSI and catheter occlusion with midlines compared to PICCs. However, no significant difference in the risk of VTE between both devices was observed.[9] Aside from risk of complications, the rate of therapy completion with the midline placed is another measure used to assess the effectiveness of midline catheters.[6,10,11]

* Address correspondence to David Paje, MD, MPH, Ann Arbor VA Medical Center, 2215 Fuller Road, Ann Arbor, MI, 48105.
E-mail address: dpaje@umich.edu (D. Paje).
Conflicts of Interest: None to report.

https://doi.org/10.1016/j.ajic.2022.08.002

At our Veterans Administration tertiary-care medical center, we implemented a vascular access specialist-driven program that promoted the use of midlines over PICCs for short-term access for peripherally compatible infusates. Here we report our 3-year experience, including clinical indications, catheter dwell times, therapy completion, and complications associated with midline use.

METHODS

Study overview

As part of our Quality Assurance program to evaluate the safety of our institutional midline use, we analyzed retrospective demographic and clinical data from the medical record of all patients that received a midline from June 2016 to May 2019 at the Veterans Administration Ann Arbor Healthcare System (VAAAHS). Clinical outcomes, including completion of intended therapy and catheter-related complications, were assessed up to the time of catheter removal or death, whichever occurred first.

Study setting

VAAAHS provides integrated healthcare delivery to more than 69,000 veterans residing in 15 neighboring counties located in Michigan and Northwest Ohio. The main hospital is a regional referral center for specialty care and includes a 102-bed acute care hospital and a 40-bed post-acute convalescent facility. Beginning in June 2016, the vascular access team at VAAAHS, composed of specially trained and certified nurses, started placing single-lumen midline catheters (Powerwand 10 cm by Smiths Medical) according to criteria established by the Michigan Appropriateness Guide for Intravenous Catheters.[1] The team screened all orders for vascular access across the institution, including those coming from outpatient and inpatient settings, and collaborated with the requesting provider to identify cases appropriate for midlines. In some cases, the ordering provider initially requested a PICC, though a midline was determined to be appropriate and was subsequently placed. Midlines were deemed appropriate if the planned infusate was peripherally compatible based on the Infusion Nurses Society standards,[12] duration of use was estimated to be less than 28 days, and glomerular filtration rate (GFR) was at least 45 mL/min/1.73m^2. Approval from a nephrologist was required for GFR less than 45 mL/min/1.73m^2. All midline insertions were performed using Accelerated Seldinger Technique under ultrasound guidance, and by following Surgical-ANTT with partial-body drape. The target insertion site was identified by measuring 10 cm from the axillary line, and no additional procedure was performed to ascertain the catheter tip position. Catheter dressing with integrated securement system was used (Sorbaview Shield by Centurion). Data including date and indication of midline insertion were maintained in a Quality Assurance registry.

Patients and covariates

Data on all midline catheter placements during the study period were retrospectively collected. Demographic and clinical data, such as patient age at the time of insertion, gender, ethnicity, and body mass index (BMI) were abstracted from the medical record. Charlson-Deyo comorbidity score at the time of catheter insertion was calculated for each patient. Clinical characteristics related to midlines, including indication for placement, reason for removal, ordering provider specialty, and level of care at the time of catheter insertion were also collected. Finally, device characteristics including laterality, vein accessed, and number of insertion attempts were obtained from the standard clinical documentation used by the vascular access team.

Outcomes

The primary outcome of interest was the rate of completion of intended therapy, and the secondary outcome was rate of midline catheter-related complications, which were classified as either major complications (including CRBSI and VTE) or minor complications (eg, catheter occlusion or thrombosis, thrombophlebitis, catheter kinking, skin or subcutaneous infiltration, and catheter dislodgement). We adopted a previously used definition of CRBSI, which included the following criteria: (1) a positive blood culture sampled with a midline catheter present or within 48 hours after catheter removal, (2) a catheter-tip culture positive for the same microorganisms or a blood-culture differential time-to-positivity of 120 minutes or more, and (3) the absence of any other attributable source of bacteremia.[13,14] VTE was defined as either symptomatic deep venous thrombosis (DVT) in any extremity or symptomatic pulmonary embolism (PE) that was not present at time of catheter insertion and was confirmed with imaging (ultrasound or venogram for DVT; computed tomography scan or ventilation-perfusion scan for PE). Minor catheter complications were defined in accordance with prior published definitions.[15,16] Patients were followed up to the time of catheter removal or death, whichever occurred first.

Statistical analysis

The unit of analysis was each midline catheter placement. Measures of frequency, central tendency, and dispersion were used to describe patient and device characteristics, and clinical outcomes related to midlines.

Ethical and regulatory oversight

Our evaluation of patient characteristics and outcomes associated with midline catheter use was for quality assurance and met the criteria for non-research activity as outlined by the Department of Veterans Affairs Office of Research and Development; therefore, our study was exempt from IRB review.

RESULTS

Overall characteristics of the study cohort

There were 116 midline catheters placed at the VAAHS during the 3-year study period. One patient record could not be located, therefore a total of 115 midline placements were included in the analysis (Table 1). The median patient age was 66 years (interquartile range [IQR], 62-72 years), 91.3% were male, 77.4% were white, and the median Charlson-Deyo score was 4 (IQR, 2-5). Most midlines were placed while patients were admitted to the general care unit (67.0%), while the remainder were placed in the intensive care unit (11.3%), post-acute convalescent facility (20.0%), and outpatient setting (1.7%). The median length of stay for patients who were hospitalized at the time of midline insertion was 9 days (IQR, 6-17 days).

The most common indications for midline placement were intravenous antibiotic infusion (53.9%) and difficult venous access for infusion and blood draws (42.6%). The median catheter dwell time was 11 days (IQR, 5.5-19.5 days), and 41 (35.6%) of patients had dwell times longer than 14 days. Of the 90 midlines that were placed during acute hospitalization, 44 (48.9%) were removed during the hospital stay and 46 (51.1%) were removed after hospital discharge.

Nearly all midlines were placed by a vascular access nurse (n = 114, 99%); one was placed by an interventional radiologist who decided to insert a midline in lieu of a previously planned tunneled catheter. Majority of midlines were successfully inserted on the first attempt (83.5%). The most common vein accessed was the basilic

Table 1
Characteristics of patients receiving midline catheters

Characteristics	Patients receiving midline catheters (N = 115)
Age in Years, median (IQR)	66 (62-72)
Gender, n (%)	
Male	105 (91.3%)
Female	10 (8.7%)
Level of Care at Time of Insertion, n (%)	
General Care Unit	77 (67%)
Intensive Care Unit	13 (11.3%)
Post-Acute Convalescent Facility	23 (20%)
Outpatient Clinic	2 (1.7%)
Charlson-Deyo Score, median (IQR)	4 (2-5)
Indication, n (%)	
Antibiotic Infusion	62 (53.9%)
Difficult Access/Blood Draw	49 (42.6%)
End-of-life	3 (2.9%)
Other	1 (0.9%)
Vein Accessed, n (%)	
Basilic	71 (61.7%)
Brachial	29 (25.2%)
Cephalic	10 (8.7%)
Median	2 (1.7%)
Other/unknown	3 (2.6%)
Line Side, n (%)	
Left Arm	58 (50.4%)
Right Arm	57 (49.6%)
Number of Insertion Attempts, n (%)	
1	96 (83.4%)
2	14 (12.2%)
3	5 (4.3%)
Dwell Time in Days, median (IQR)	11 (5.5-19.5)

IQR = interquartile range

vein (61.7%), followed by the brachial vein (25.2%), and the cephalic vein (8.7%).

Clinical outcomes with midline catheters

Of the 115 midlines, intended therapy was completed in 93 (80.9%) with the catheter in place (Table 2). Catheter-related complications occurred in 27 (23.5%) patients, including 6 (5.2%) who completed and 21 (18.3%) who did not complete the intended therapy. One patient (1.0%), a 79-year-old male without relevant comorbidities, had a major complication, a new non-occluding DVT in the cannulated right brachial vein on day 9, while 27 (23.5%) patients experienced a minor complication (Table 3). The most common minor complications were catheter dislodgement (8.7%) and catheter kinking (7.0%). One patient had multiple complications, which were catheter dislodgement and catheter kinking.

Of the 22 patients who did not complete the intended therapy with the midline, 19 (86.4%) subsequently received another vascular access device, including 13 (68.1%) who received a peripheral intravenous catheter (PIV), 5 (26.3%) who received another midline, and 1 (5.26%) who underwent PICC placement. For 3 patients, the intended therapy was modified to an oral regimen. Rates of therapy completion and catheter-related complications by specific therapy infused through the midline are shown in Table 4.

Table 2
Therapy completion with midline catheters

Therapy Completion	Midlines (N = 115)
	n (%)
Therapy/Infusion Completed	93 (80.9)
Complication Occurred	27 (23.5)
Therapy Completed	6 (5.2)
Therapy Incomplete	21 (18.3)
PIV Placed	13 (11.3)
Another Midline Placed	5 (4.3)
PICC Placed	1 (0.9)
Therapy Modified	3 (2.6)

PIV = peripheral intravenous line; PICC = peripherally inserted central catheter.

Table 3
Complications associated with midline catheters

Complications	Midline (N = 115)
	n (%)
Major Complications (Total DVT, PE, or CRBSI)	1 (0.9)
Confirmed new DVT	1 (0.9)
Confirmed new PE	0 (0)
Confirmed new catheter-related bloodstream infection	0 (0)
Minor Complications (Total of any of the following:)	27 (23.5)
Catheter dislodgement	10 (8.7)
Catheter kinking	8 (7.0)
Skin/subcutaneous infiltration	4 (3.5)
Catheter occlusion or thrombosis	3 (2.6)
Thrombophlebitis	2 (1.7)
Total All Complications (Major or Minor)	27 (23.5)

DVT = deep venous thrombosis; PE = pulmonary embolism; CRBSI = catheter-related bloodstream infection.

DISCUSSION

In this report, we describe our 3-year experience with midline catheters at a Veterans Administration Medical Center. Over 80% of patients completed the intended therapy with the midline placed. Antibiotic infusion was the most common reason for midline placement. Most patients had their midlines removed within 14 days, but over a third had longer dwell times. Only 1 patient experienced a catheter-related major complication.

Our therapy completion rate is similar to that recently observed at an institution that also adopted a vascular access nurse driven midline catheter program.[6] Other single-institution studies reported lower therapy completion rates, such as 39% and 63%.[10,11] A large multi-institutional study showed a higher completion rate of over 90%, with only 7.3% of midlines removed because of a complication.[9] The median dwell time in that study was shorter (6 days vs 11 days) and difficult access was a more frequent indication for midline placement (72.4% vs 42.6%) compared to our practice experience. Future studies may further elucidate the relationship between, dwell time, clinical indication, and rate of therapy completion with midlines.

Our observed low rate of major complications is similar to those reported in larger studies, albeit our median dwell time was almost twice as long (11 days vs 6 days).[9,17] Of note, all of our midlines were single-lumen compared to 46% and 85% that were single-lumen in the larger studies. Data on PICCs have shown that single-lumen compared to multi-lumen catheters are associated with a lower risk of both VTE and central line-associated bloodstream infection (CLABSI), but it remains unknown whether the same is true for midlines.[18,19]

While we did not directly compare midline catheters to PICCs within our facility, our rates of catheter-related major complications were favorable compared to those reported for PICCs that were in place for 30 or fewer days.[9] However, as previously reported in other studies, we found that minor complications were not infrequent with midlines.[8,17] Almost 1 in 4 of our patients experienced such complications, most commonly catheter dislodgement and kinking. Although these events were non-life threatening, they were non-trivial as they required device removal, often before the intended therapy was completed, and they could have contributed to delays in care.

Thus far, our local experience with midline catheters supports their continued use as the preferred device for short-term infusion of

Table 4
Therapy completion and midline-related complications by specific infusate

Infusates	Total patients N	Patients completing therapy n (%)	Patients with midline complication n (%)
Antibiotics			
Piperacillin-Tazobactam	22	14 (63.6)	8 (36.3)
Ceftriaxone	13	8 (61.5)	6 (46.2)
Ertapenem	12	11 (91.7)	1 (8.3)
Daptomycin	10	7 (70.0)	3 (30.0)
Cefazolin	11	7 (63.6)	4 (36.3)
Vancomycin	6	6 (100.0)	1 (16.7)
Ampicillin-Sulbactam	4	4 (100.0)	0 (0.0)
Cefepime	3	2 (66.7)	1 (33.3)
Intravenous Fluids	6	6 (100.0)	0 (0.0)
Others			
Unfractionated Heparin	9	8 (88.9)	1 (11.1)
Furosemide	3	3 (100.0)	0 (0.0)

peripherally compatible infusates, consistent with guideline recommendations.[1] However, there may be opportunities to further improve clinical outcomes, particularly with regards to decreasing the risk of minor complications. Clinical practice strategies to optimize midline insertion (eg, measuring catheter to vein ratio), device securement, hub access, and site maintenance may reduce the risks of catheter dislodgement, kinking, and occlusion, as well as skin and subcutaneous infiltration, and thrombophlebitis. Advances in catheter manufacturing technology may also lead to lower complication rates. For example, other studies that reported low rates of CRBSI similar to our experience also used the Powerwand catheter.[6,20] Future investigations may look at specific aspects of catheter design and material composition that may be associated with the risk of catheter-related complications.

Our study has several limitations. First, the single center setting and the predominantly white, male, Veteran population may limit generalizability of our findings. Second, all our patients had their midlines placed either while hospitalized or while admitted to a post-acute convalescent facility; thus, our experience may not be applicable to patients receiving care outside of those settings. Third, the retrospective collection of clinical data used for quality assurance purposes could introduce non-differential misclassification bias from missing or incomplete information. Fourth, our institution only uses the single-lumen Powerwand catheter. Therefore, our findings may not be representative of other midline catheters with different insertion techniques, styles, materials and makes. For example, Powerwand catheters are inserted using the Accelerated Seldinger Technique while other types of midline catheters use the Modified Seldinger Technique, which has been shown to require a significantly longer insertion time compared to the former in studies on PICCs and central venous catheters.[21,22] Finally, we only use Sorbaview Shield dressing with integrated securement system. Thus, our findings may not be representative of other methods of midline securement.

CONCLUSIONS

In conclusion, we found that midline catheters are effective and safe for patients requiring short-term vascular access for peripherally compatible infusates across various clinical care settings, including general care unit, intensive care unit, and post-acute convalescent facility. As device removal prior to therapy completion is common, further investigation may help identify best practices on patient selection, insertion, optimal dwell time, device securement and maintenance of midline catheters to maximize their clinical utility.

References

1. Chopra V, Flanders SA, Saint S, et al. The Michigan Appropriateness Guide for Intravenous Catheters (MAGIC): Results from a multispecialty panel using the RAND/UCLA Appropriateness method. *Ann Intern Med*. 2015;163(6 suppl):S1–40.
2. Chopra V, Ratz D, Kuhn L, Lopus T, Lee A, Krein S. Peripherally inserted central catheter-related deep vein thrombosis: contemporary patterns and predictors. *J Thromb Haemost*. 2014;12:847–854.
3. Bivins MH, Callahan MJ. Position-dependent ventricular tachycardia related to a peripherally inserted central catheter. *Mayo Clin Proc*. 2000;75:414–416.
4. Amerasekera SS, Jones CM, Patel R, Cleasby MJ. Imaging of the complications of peripherally inserted central venous catheters. *Clin Radiol*. 2009;64:832–840.
5. Gorski LA, Hadaway L, Hagle ME, et al. Infusion therapy standards of practice, 8th Edition. *J Infus Nurs*. 2021;44(1S suppl 1):S1–S224.
6. DeVries M, Lee J, Hoffman L. Infection free midline catheter implementation at a community hospital (2 years). *Am J Infect Control*. 2019;47:1118–1121.
7. Bahl A, Karabon P, Chu D. Comparison of venous thrombosis complications in midlines vs peripherally inserted central catheters: are midlines the safer option? *Clin Appl Thromb Hemost*. 2019;25: 1076029619839150.
8. Xu T, Kingsley L, DiNucci S, et al. Safety and utilization of peripherally inserted central catheters vs midline catheters at a large academic medical center. *Am J Infect Control*. 2016;44:1458–1461.
9. Swaminathan L, Flanders S, Horowitz J, Zhang Q, O'Malley M, Chopra V. Safety and outcomes of midline catheters vs peripherally inserted central catheters for patients with short-term indications: A Multicenter Study. *JAMA Intern Med*. 2021;182:50–58.
10. Bundgaard Madsen E, Sloth E, Skov Illum B, Juhl-Olsen P. The clinical performance of midline catheters-An observational study. *Acta Anaesthesiol Scand*. 2020;64:394–399.
11. Meyer BM. Making the most of midlines: a retrospective review of outcomes. *J Infus Nurs*. 2020;43:344–350.
12. Gorski LA, Hadaway L, Hagle ME, McGoldrick M, Orr M, Doellman D. Infusion therapy standards of practice. *J Infus Nurs*. 2016;39(1S suppl 1):S1–S167.
13. Timsit JF, Mimoz O, Mourvillier B, et al. Randomized controlled trial of chlorhexidine dressing and highly adhesive dressing for preventing catheter-related infections in critically ill adults. *Am J Respir Crit Care Med*. 2012;186:1272–1278.
14. Raad I, Hanna HA, Alakech B, Chatzinikolaou I, Johnson MM, Tarrand J. Differential time to positivity: a useful method for diagnosing catheter-related bloodstream infections. *Ann Intern Med*. 2004;140:18–25.
15. Chopra V, Smith S, Swaminathan L, et al. Variations in peripherally inserted central catheter use and outcomes in Michigan hospitals. *JAMA Intern Med*. 2016;176:548–551.
16. Smith SN, Moureau N, Vaughn VM, et al. Patterns and predictors of peripherally inserted central catheter ccclusion: The 3P-O Study. *J Vasc Interv Radiol*. 2017;28:749–756. e2.
17. Chopra V, Kaatz S, Swaminathan L, et al. Variation in use and outcomes related to midline catheters: results from a multicentre pilot study. *BMJ Qual Saf*. 2019;28:714–720.
18. Chopra V, Kaatz S, Conlon A, et al. The Michigan risk score to predict peripherally inserted central catheter-associated thrombosis. *J Thromb Haemost*. 2017;15:1951–1962.
19. Herc E, Patel P, Washer LL, Conlon A, Flanders SA, Chopra V. A model to predict central-line-associated bloodstream infection among patients with peripherally inserted central catheters: The MPC Score. *Infect Control Hosp Epidemiol*. 2017;38:1155–1166.
20. Caparas JV, Hu JP. Safe administration of vancomycin through a novel midline catheter: a randomized, prospective clinical trial. *J Vasc Access*. 2014;15:251–256.
21. Caparas J, Hu JP, Hung HS. Does a novel method of PICC insertion improve safety? *Nursing*. 2014;44(5):65–67.
22. Thaut L, Weymouth W, Hunsaker B, Reschke D. Evaluation of central venous access with accelerated seldinger technique vs modified seldinger technique. *J Emerg Med*. 2019;56:23–28.