Evaluation of midline vascular access: A descriptive study

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Abstract

Background and significance: Vascular access is a mainstay of therapy in acute and chronic care. The use of midline catheters has been controversial, but little research-based evidence shows its benefits and risks. The nursing vascular access team (VAT) in a 400-bed community hospital was asked to provide this service. To ensure the best care for patients, the development of the midline service was approached carefully by designing a study to track the outcomes. Research questions: What's the incidence of complications for midline catheters? What's the average dwell time for midline catheters? What are the relationships between infusates and complications? What are the relationships between dwell times and complications? Methods: This was a prospective descriptive study. The sample was a convenience sample of patients who had midline catheters inserted by the VAT nurses. Findings: Data on 345 midlines were collected. The average dwell time for the midlines was 6.9 days (SD, 6.1). The rate of phlebitis among 345 patients was 2% (7 cases), infiltration rate, 1.7% (6 cases), and thrombosis, 1.7% (6 cases). Two bloodstream infections occurred in 2,304 line days, or a rate of 0.9 per 1,000 line days. No relationships were identified between infusates or length of dwell and complications. Conclusions: In this study, the midline catheter was determined to provide stable and safe vascular access. The complication rate wasn't greater than that of other vascular access devices. This descriptive study adds to the evidence for midline catheter use and provides an impetus for randomized controlled trials on midline catheters and infusates. We'll continue to monitor this practice for safety and efficacy.

Background

The nursing vascular access team (VAT) in a tertiary care regional referral hospital was asked to perform midline catheter insertions at the bedside for adult patients in 2010. This request came from physicians who thought that the midline catheter would provide another choice of peripheral venous access for patients who didn't need a central venous access device (CVAD) but who had poor vascular status, might benefit from a more stable venous access device, or required I.V. therapy with a nonirritant/nonvesicant solution for more than a week. This would be a new procedure for the VAT and for the hospital.

A midline catheter has been considered a bridge or a compromise between a CVAD and a short peripheral catheter.1,2 Although the VAT nurses were dedicated to being team players and providing the best service to their patients, they’d heard from colleagues and others that using the midline was a potentially dangerous practice. For example, they’d heard reports of infiltration from midlines that wasn’t detected until patients suffered severe tissue injury. They recognized that all I.V. therapy options have some associated risks and had seen serious damage to extremities from short peripheral catheter infiltration as well as serious complications from CVAD therapy.

The physicians in the organization didn’t agree that midline catheters presented a higher risk of complications than other venous access devices. Agreement on which infusates were safe for midlines was lacking. At this point, the VAT nurses had only anecdotal evidence and hearsay to support their reservations about the use of midline catheters. To gather evidence, their first step was to search the literature for data on complications and results of midline catheter therapy.

Review of the literature

The literature was searched using the search engine EBSCO and the databases CINAHL, Medline, Cochrane Central Register of Controlled Trials, and the Cochrane Database of Systematic Reviews. No date limit was applied. Neonatal literature was excluded. The keywords “midline catheter” produced 52 results. Of the 52 publications, only nine were original research on children or adult patients. Eight studies were descriptive and prospective; one was retrospective. One used randomization of two types of midline catheters using a small sample size.3

Only one author included a large enough sample to analyze the multiple variables contributing to complications from vascular access, but this author didn’t include an analysis of these relationships.1 Determining adequate sample sizes...
for sufficient inferential power in research is complicated, but a useful general guideline is that about 20 to 40 patients are needed for every variable or patient factor that can impact the outcome.4

The researchers described complication rates in their own settings. Only Lawson attempted to compare complications to specific infusates.5 The authors differentiated vesicant and irritant infusates that by policy were to be infused only into the central circulation and not into midline catheters. These studies don’t represent head-to-head comparisons of peripherally inserted central catheters (PICCs) and midline catheters for thrombosis or phlebitis.

The literature search was continued by reviewing the secondary sources and reference lists found in review articles. In a 2011 review, Alexandrou and colleagues also reported that they found only a few outcome-based studies showing the effectiveness of midline catheters and that most of these were descriptive and quasi-experimental.6 An older manuscript by Ryder references the original work conducted in animal labs in the 1970s and 1980s supporting a theory on the effects of venous access. Since that time, catheter materials have changed.7

One study by Sketch et al., cited by Ryder as a secondary source, compared the effects of an 8-in (20.3 cm) polyvinylchloreide percutaneous peripheral catheter (a midline catheter) with a 21-in (53.3 cm) PICC in coronary care patients.8 The study included 484 catheter placements. Complications were reported to be higher with midline catheters than with PICCs. When antibiotics, potassium chloride, and lidocaine were added to the infusate, the incidence of phlebitis increased and dwell times were shorter with the midline catheters.9

No data support a recommendation for maximal dwell time for midlines, but the general consensus is 4 weeks. The Infusion Nurses Society (INS) and the CDC recommendation for short peripheral I.V. (PIV) catheter dwell time had been 72 to 96 hours. In 2011, evaluation of this practice prompted the INS and the CDC to change the recommendations for dwell time for PIVs to “replacement...when clinically indicated (such as when the patient develops signs of phlebitis, infection or a malfunctioning catheter...).” Clinical data in 2011 at this study institution demonstrated an average PIV catheter dwell time for a sample of 393 patients was 2 days (SD, 1). In general, PIV catheters will have less than a week dwell time while PICCs, implanted ports, and tunneled CVADs can dwell for months to years.10

In the 1990s, the midline catheter fell out of favor because of reports of systemic adverse reactions to the hydrogel material used to make them.11 But recent research studies don’t demonstrate that today’s midlines are any more prone to complications than other types of venous access. Since that time, catheter materials have changed.

In fact, researchers have demonstrated that midline catheters aren’t associated with phlebitis or infection any more often than PICCs or other CVADs and are associated with a lower rate of phlebitis and infiltration than PIVs.12 PIV therapy is also associated with phlebitis, infiltration, extravasation, hematomas, thrombosis, venous sclerosis, nerve injury, and bloodstream infection.13-15

In 2011, the National Healthcare Safety Network reported pooled mean rates for central line-associated bloodstream infections (BSIs) ranging from 0.9/1,000 catheter days in adult inpatient medical/surgical units to 3.7/1,000 catheter days in burn ICUs.16

PIV therapy is a less frequent source of BSI, but it does occur. The BSI rate for PIVs has been reported as 0.5/1,000 catheter days.17,18 Historically the BSI rate for midline catheters is hard to compare because it hasn’t always been reported as a rate (number of BSI/1,000 line days), but has been reported as a percent of infections per catheter at 0.3% to 1%.1,12

One important difference between a midline catheter and a CVAD is that the midline’s tip terminates in the cephalic, brachial, or basilic vein distal to the shoulder (the tip doesn’t enter the central vasculature), which flows into the distal axillary vein. The blood flow rate in the axillary vein (about 150 mL/min), although higher than that of a peripheral vein in the lower arm (40 mL/min), is much less than the blood flow in the superior vena cava (2,000 mL/min).7

Ideally, the tip of a CVAD is positioned in the lower third of the superior vena cava at the caval-atrial junction to allow maximal hemodilution of infusates classified as irritants and vesicants. INS Standard 32 states that it’s not recommended to administer infusates with a pH of less than 5 or greater than 9 or osmolality of greater than 600 mOsm/L in peripheral veins.9 Midline catheters are considered to be peripheral infusion catheters. These criteria virtually eliminate parental nutrition (PN) solutions and some antibiotics such as vancomycin (pH 2.4). Yet in 2009, Pittiruti and colleagues published a study demonstrating that the infusion of PN (osmolality not exceeding 800 mOsm/L) via midline catheters
and PICCs caused no significant difference in complications.\textsuperscript{19} Despite the recommendations for infusing irritants and vesicants into the central circulation only, in practice this isn’t always possible or in some patients’ best interests. For example, if a CVAD isn’t available to administer urgently needed medication, the medication shouldn’t be withheld. Short peripheral catheters; intraosseous, subcutaneous, intraperitoneal, intrathecal, and endotracheal routes; and midline catheters are all possible alternatives for delivering fluid and/or medications. Each has indications and contraindications unique to the anatomy and physiology of the infusion site.

Conclusions of literature review
The current weight of evidence for the use of midline infusion therapy is a level III at best. (See Understanding levels of evidence.) The studies are difficult to compare due to differing designs and variables. The quality of evidence is only fair because most studies were descriptive and had small sample sizes. None of the authors provided statistically significant data about relationships among patient characteristics, infusates, and outcomes.

Although some of the older studies suggest more complications with midline catheters in relation to infusates outside of the recommended physiologic ranges for pH and osmolality, no evidence shows that midline catheters in general pose a higher risk to patients than other types of vascular access devices. In addition, catheter materials and infusate solutions have changed over the years and the data reported in a study done in the 1990s may not be applicable today.

Based on these conclusions, the VAT nurses decided to proceed with offering a midline catheter service to their patients. To ensure safety and quality, they simultaneously conducted a descriptive research study on the midline catheter program. A description of the study and the results follows.

Statement of the problem
Midline catheter insertion was new to the study institution and had been controversial in the past.\textsuperscript{20} This study was conducted to add to the knowledge base of indications and contraindications for use of midline catheters in the acute care setting by describing the researchers’ experience using these vascular access devices.

Protection of human subjects
Institutional review board approval was granted at the study institution.

Research questions
1. What’s the incidence of complications for midline catheters?
2. What’s the average dwell time for midline catheters?
3. What are the relationships between the most common infusates and complications?
4. What are the relationships between dwell times and complications?
5. What are the relationships between patient characteristics and complications?

Methodology
This was an ongoing prospective descriptive study of current practice in a 400-bed acute care hospital. (See Glossary of research terms.) The sample was a convenience sample of all patients who had midline catheters inserted by the VAT nurses beginning in August 2010. Patients were enrolled sequentially as they were determined to meet the criteria for a midline catheter.

Inclusion criteria for midline catheter insertion in the study institution were as follows:

**Understanding levels of evidence**\textsuperscript{24}

Before nurses use evidence to guide their practice, they must consider the quality of the evidence. Several rubrics classify levels of evidence. For example, the Johns Hopkins evidence level and quality guide describe five levels of evidence. The highest level of evidence in this guide is Level I.

- **Level I** evidence is from well-designed randomized controlled trials. Level I evidence is usually very trustworthy.
- **Level II** evidence is from quasi-experimental studies that weren’t as rigorous in their methodology.
- **Level III** evidence is from nonexperimental studies, such as descriptive studies. Level III evidence is valuable, but more research is needed to substantiate the conclusions.
- **Level IV** evidence is based on the opinions of respected authorities such as those found in a consensus panel recommendation and many clinical practice guidelines that haven’t been well researched.
- **Level V** evidence represents that found in case reports and opinions of individual experts.

Often only level IV or V evidence is available because of the difficulty of researching clinical issues. Other considerations are the actual quality of each study; for example, a study could be a randomized controlled trial but the sample size may not be large enough to draw conclusions. In that case, it would be Level I but of low quality.
1. Adult patients (age 18 and older).
2. Requirement for therapy that can be infused through a peripheral vascular access device using the INS guideline recommendations for pH and osmolality, with exceptions only if prescribed by a physician.
3. Poor vascular status requiring frequent short peripheral catheter restarts, and I.V. therapy intended to last more than 6 days but less than 4 weeks.
4. Poor vascular status with inability to obtain short peripheral catheter access, but not requiring a CVAD.

Exclusion criteria were as follows:
1. Infusion of PN or amphotericin. An amphotericin exclusion was requested by the medical staff executive committee.
2. Any patient with acute kidney injury or chronic kidney disease at risk for needing vascular access for hemodialysis was excluded unless cleared by a nephrologist.

Data were collected on patient demographics, infusates, midline catheter insertion site, catheter length, number of lumens, dwell time, and complications. The patients were followed daily by the VAT nurses. To collect data, the VAT nurses used primary assessment of the patients and prospective and retrospective medical record review. Patients discharged to another facility or home with a midline catheter were followed by making phone calls to the agency. The data were entered into SPSS 20.

Procedure
After a VAT RN determined that a midline catheter was appropriate for a patient based on the prescribed therapy and institution policies, the patient (or someone with durable power of attorney for healthcare decisions) was informed about the procedure and asked to give consent. A nurse who’d received competency training for midline catheter insertion used ultrasonography to assess the patient’s veins for appropriate size and location for the prescribed therapy. Ultrasound guidance was used for midline catheter insertion. The basilic, brachial, or cephalic vein in the upper arm was the preferred insertion site.

Two types of midlines were used in this study. The catheter used more often was a nonpower-injectable, 4 French, 7.9-in (20-cm), polyurethane, single-lumen catheter. This type of catheter is inserted using sterile modified Seldinger technique (MST) with maximal sterile barrier precautions. This midline catheter was used from the beginning of the study.

The second midline catheter was a new device introduced in 2013. This midline was a power-injectable (maximum of 5 mL/sec) 20-gauge catheter available in both 3.1-in (8-cm) and 3.9-in (10-cm) lengths. After the intended vein was accessed, the guidewire and catheter were deployed using an integrated all-in-one placement technique, making it unnecessary to use an MST. Sterile technique was maintained using the barrier drapes available in the insertion kit. Both types of midlines were secured using an I.V. stabilization device.

Policies and procedures for midline catheter insertion, use, and maintenance were written and approved by the administrative bodies of the study institution. VAT members monitored all inpatient midline catheters daily and performed all routine dressing changes as per policy. Dressing changes were performed with the same sterile procedure used for central venous catheter dressings. Gauze and tape dressings were changed every 48 hours, and transparent membrane dressings were changed every 7 days. Chlorhexidine gluconate was used to clean the site. Any dressing that became soiled or was no longer intact was changed as soon as possible.

Findings
Patients. To date in this study, midline catheters have been inserted in 345 patients. Thirty-one (9%) of these patients received the newer power-injectable catheter and 314 (91%) received the nonpower-injectable catheter. Of the 345 patients, 215 (62.3%) were female. Patients’ average age was 62.7

Glossary of research terms
- **Convenience sample.** Obtaining the sample of subjects for research by using whoever happens to be available. Although this may be the easiest method, using it causes a higher chance of a biased sample; that is, one that doesn’t fully represent the population being studied.
- **Descriptive study.** A nonexperimental study that simply describes what’s happening.
- **Prospective study.** Subjects are identified and then data are collected as they occur.
- **Standard deviation (SD).** SD paints a picture of the data by measuring the dispersion of data around the mean. A large SD reflects larger variance or extreme differences in the data. A smaller SD reflects less variance or data more similar to the mean. For example, with a multigenerational group of people comprising young children and grandparents, the SD around the mean age would be large.
The youngest was 20; nine patients were 90 or older. The mean catheter dwell time overall was 6.9 (SD, 6.1) days. Mean dwell time for the power-injectable midline catheter was 8 (SD, 7) days and for the nonpower-injectable midline catheter, 6.7 (SD, 7) days. Five patients were lost to follow-up.

**Diagnosis.** The most common patient diagnosis category by affected body system was cardiovascular disease (45.5%). Second most common was a pulmonary diagnosis, such as pneumonia or respiratory failure (21.2%). Following these were gastrointestinal or abdominal complaints at 17%, and general medical conditions such as dehydration, diabetic ketoacidosis, and sepsis, accounting for 9%. The rest were various single diagnoses.

**Infusates.** The most common infusates were anti-infective agents. Many other infusates were given through the midlines in 10 or fewer cases. One medication of particular controversy among the nurses and physicians was vancomycin; 35 patients received at least one dose of vancomycin through their midline catheter. The dosages ranged from 500 mg to 1,500 mg per dose. The number of doses ranged from 1 to 12. Only one patient receiving vancomycin had any complications. This patient received three doses of 1,000 mg each and developed grade 2 phlebitis and grade 2 infiltration, which resolved without sequelae. (See Tipping the scales for phlebitis and infiltration.) Amiodarone, which is also considered to be associated with phlebitis, was administered to seven patients via their midline catheter and none of them experienced a complication.22,23 No trends in complications by any infusate were noted.

**Complications**

Complications included any phlebitis or infiltration (per INS phlebitis and infiltration scales), line-associated BSI, catheter thrombosis, catheter occlusion, hematoma, or bleeding or oozing from the catheter insertion site. (See **Focusing on complications by catheter type.**) Thirty-seven patients (10.7%) experienced some complication, and some patients experienced more than one. Two patients within the sample of 2,315 line days

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**Tipping the scales for phlebitis and infiltration**

*Phlebitis* is inflammation of the vein caused by chemical, bacterial, or mechanical forces. *Infiltration* is the movement of infusates out of the vein and into the surrounding tissues. Using standardized scales such as those provided by the INS in nursing documentation can help to communicate the severity of phlebitis or infiltration and track the patient’s progress. The scales are very useful in research; because they provide a clear definition, they enhance the reliability of the data.

### Phlebitis scale

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<th>Grade</th>
<th>Clinical criteria</th>
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<tr>
<td>0</td>
<td>No symptoms</td>
</tr>
<tr>
<td>1</td>
<td>Erythema at access site with or without pain</td>
</tr>
<tr>
<td>2</td>
<td>Pain at access site with erythema or edema</td>
</tr>
<tr>
<td>3</td>
<td>Pain at access site with erythema or edema; streak formation; palpable venous cord</td>
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<tr>
<td>4</td>
<td>Pain at access site with erythema or edema; streak formation; palpable venous cord &gt;1 in (2.5 cm) in length; purulent drainage</td>
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### Infiltration scale

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<th>Clinical criteria</th>
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<tr>
<td>0</td>
<td>No symptoms</td>
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<tr>
<td>1</td>
<td>Skin blanched; edema &lt;1 in (2.5 cm) in any direction; cool to touch; with or without pain</td>
</tr>
<tr>
<td>2</td>
<td>Skin blanched; edema 1 to 6 in (2.5 to 15.2 cm) in any direction; cool to touch; with or without pain</td>
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<tr>
<td>3</td>
<td>Skin blanched, translucent; gross edema &gt;6 in (15.2 cm) in any direction; cool to touch; mild-to-moderate pain; possible numbness</td>
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<tr>
<td>4</td>
<td>Skin blanched, translucent; skin tight, leaking; skin discoloration; bruised, swollen; gross edema &gt;6 in (15.2 cm) in any direction; deep pitting tissue edema; circulatory impairment; moderate-to-severe pain; infiltration of any amount of blood product, irritant, or vesicant</td>
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(0.86/1,000 line days) were diagnosed with midline catheter-associated BSI.

Four patients were identified as having grade 1 phlebitis and three with grade 2. One patient was identified as having a grade 4 infiltration. This patient’s midline catheter was in place for 3.4 days and infusates included imipenem/cilastatin, metronidazole, pantoprazole, bumetanide, ondansetron, magnesium sulfate, and haloperidol. Which infusate infiltrated isn’t known. The infiltration resolved without sequelae. The longest dwell time was 48 days in a patient who experienced no complications. No relationships or trends were found between catheter dwell time and complications.

**Qualitative anecdotal evidence**
A formal survey of patient satisfaction wasn’t performed. However, many comments from patients indicated higher satisfaction with the midline catheter compared with a short peripheral catheter and no difference compared with a PICC. Some patients who’d had a midline catheter during a previous admission requested to have a midline catheter inserted again. Some patients stated they were grateful that they didn’t have to undergo multiple I.V. restarts.

Preliminary anecdotal experiences identified more complaints of discomfort postinsertion with the newer power-injectable midline catheter compared with the nonpower-injectable midline catheter. Although the sample size isn’t large enough to draw conclusions about the newer power-injectable midline, a trend toward higher complication rates was seen with the power-injectable midline catheters (22.6%) versus the nonpower-injectable midline catheters (9.6%). Inserting the power-injectable midline catheter is a new procedure for nurses on the VAT, and procedural learning curve may be a contributing factor.

**Discussion and limitations**
Although the patients were followed and assessed every day by VAT nurses, some signs and symptoms may have been missed. Ultrasound evaluation for thrombosis isn’t a standard of care for every patient and was used only when thrombosis was suspected, so some incidences of thrombosis may not have been captured. The VAT didn’t have the resources to obtain accurate data on all infusates, dosages, concentrations, and infusion rates 24 hours a day, 7 days a week. The researchers also couldn’t determine the exact pH and osmolality of the infusates, which made defining the relationships between infusates and patient outcomes a challenge. Narrowing the focus to include patients receiving only a specific infusate may be helpful in the design of future research.

Other factors, such as patient manipulation of the midline catheter and/or administration tubing, the original physical condition of the patient’s veins, and the flow rate in the specific vein, can influence the outcomes and are difficult to measure.

The introduction of the power-injectable midline catheter wasn’t anticipated at the beginning of the study. The incidence of complications is small; therefore, much larger sample sizes are needed to provide statistical inference in regard to relationships between infusates, patient characteristics, and dwell time to complications.

**Conclusions and recommendations**
This study has added to the researchers’ knowledge of midline catheter infusion therapy and assured them that they’re providing safe and effective care to their patients who qualify for midline catheters. The sample size in this study hasn’t reached a level for satisfactory inferential statistics. Thus, the study provides only a level III and poor-to-fair quality of evidence. A recent randomized controlled trial by Caparas suggests that infusion of vancomycin through midline catheters is safe practice, but again the sample size was small at 54 subjects.24

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<th>Focusing on complications by catheter type</th>
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<tr>
<td>Type of complication</td>
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<tr>
<td>Any complication</td>
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<tr>
<td>Phlebitis</td>
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<tr>
<td>Infiltration</td>
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<tr>
<td>Infection (BSI)</td>
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<td>Bleeding/oozing</td>
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<td>Hematoma</td>
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<td>Thrombosis</td>
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<td>Occlusion</td>
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I. V. ROUNDS

Descriptive studies and small pilot studies are essential steps in the process of uncovering high-quality evidence. They provide the baseline and impetus for large randomized controlled trials.

Larger sample sizes and better control of select variables are needed to provide evidence for safe infusion of specific infusates. This could be accomplished by a multisite study in which principal investigators at each site use agreed-upon methodology, definitions of the variables, and controlled reliability and validity, and combine their data for a more powerful analysis.

REFERENCES


At Winchester Medical Center in Winchester, Va., Cheryl Dumont is director of nursing research and the vascular access team, and Ozlem Getz and Sheri Miller are members of the vascular access team. Dr. Dumont is also a member of the Nursing2014 editorial board and coordinates both the I.V. Rounds and Research Corner departments.

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