Nurses' Short Peripheral Catheter Flushing Practices: Implications for Patient Care, Nursing Education, and Policy

Crystal B. Norton, BSN, RN ● Heather Alico Lauria, DNP, RN ● David Baker, MSN, RN ● Paloma Hauser, BA ● Cheryl A. Smith-Miller, PhD, RN-BC

ABSTRACT

Nursing practice and institutional policies regarding short peripheral catheter (SPC) flushing vary. These variations result in a lack of understanding about the factors that influence nurses' SPC flushing practices and leave their effect on outcomes unexplored–information that could potentially enhance nurses' clinical education, institutional policy efforts, and patient care. Using a mixed-methods design, this study examined SPC flushing practices and outcomes among a cohort of medical-surgical nurses and explored their rationale for flushing. Trends were noted in the timing of flushes, and the factors that influenced nurses' SPC flushing practices included patient acuity, experience, and workload.

Key words: clinical education, focus group, hospital, IV, mixed methods, nurse experience, patient acuity, practice, short peripheral catheter, workload

BACKGROUND

The placement of short peripheral catheters (SPCs) is the most commonly performed medical procedure, and registered nurses (RNs) are most often responsible for their care and maintenance. Although there are detailed guidelines[1,2] to inform the care of these devices, policies and practices vary from institution to institution, unit to unit, and nurse to nurse. These variations have consequences for patients, nurses, and health care facilities.[3-6] *Clinical judgment* and *critical thinking* are often used to summarize the processes that nurses use in the care of SPCs,[7] but these terms fall short of elucidating the complex decision-making processes, knowledge, or skills that are used or needed.[8,9]

The Infusion Nurses Society recommends that all nurses receive education regarding SPC care on hire and on an annual basis to have the most current information and evidence.[2] Although implementing ongoing education programs communicates a commitment to excellence in SPC care and helps standardize practice, they are not universally implemented. As a result, nurses' SPC practices are often guided by institutional policy, personal and professional experience, and by those with whom they work.[10] While using more than 1 source of information has potential benefits,[11] this approach can also contribute to confusion and inconsistency in practice,[12] particularly when the information is based on inaccurate or outdated evidence.

However, current evidence related to SPC care is often lacking[13] and guidance inconclusive.[11] Some researchers found a once-per-24-hour flushing schedule sufficient to avoid complications,[14] whereas others concluded an every-12-hour schedule to be effective.[15] Recommendations regarding flush volumes may be challenging to implement.

Author Affiliations: *University of North Carolina Medical Center, Chapel Hill, North Carolina (Ms Norton, Drs Lauria and Smith-Miller, and Mr Baker); University of North Carolina Gillings School of Global Public Health, Chapel Hill, North Carolina (Ms Hauser).*

Crystal B. Norton, BSN, RN, *currently serves as a clinical nurse IV for the acute care Neurology and Neurosurgery Unit in the Neurosciences Hospital at University of North Carolina Healthcare in Chapel Hill, North Carolina.* **Heather Alico Lauria, DNP, RN,** *is currently a clinical nurse III on the acute care Neurology and Neurosurgery Unit in the Neurosciences Hospital at University of North Carolina Healthcare.* **David Baker, MSN, RN,** *is a clinical nurse IV on the acute care Neurology and Neurosurgery Unit in the Neurosciences Hospital at University of North Carolina Healthcare.* **Paloma Hauser, BA,** *is currently a doctoral student in the Department of Biostatistics, Gillings School of Global Public Health, at the University of North Carolina, Chapel Hill.* **Cheryl A. Smith-Miller, PhD, RN-BC,** *currently serves as a nurse scientist in the department of Nursing Quality and Research, UNC Healthcare, and as vice chair on the nonbiomedical institutional review board committee at the University of North Carolina, Chapel Hill, office of human research ethics.*

The authors of this article have no conflicts of interest to disclose.

Corresponding Author: *Cheryl A. Smith-Miller, PhD, RN-BC, Nursing Quality & Research, UNC Medical Center, 101 Manning Drive, 3rd Floor Old Infirmary, Chapel Hill, NC 27514 (Cheryl.Smith-Miller@unchealth.unc.edu).*

DOI: 10.1097/NAN.0000000000000337

One study[14] proposed that 3 mL of 0.9% sodium chloride were adequate to maintain catheter patency, because the volumes used in clinical settings depend on whether prefilled 0.9% sodium chloride syringes are used, the size of the syringes that are available (3 mL, 5 mL, or 10 mL), institutional policy, or other factors. In addition, many of the SPC research studies that are conducted in clinical settings follow prescriptive protocols and procedures or the research is conducted in laboratory settings where conditions are controlled[16]—circumstances that are neither likely to translate to nor represent the complex realities of clinical environments.

Catheter site assessment and flushing may be dictated by policy, but nurses also take patient acuity, vascular health, catheter dwell time, and the type, frequency, and infusion rates of the medications or fluids into account. Based on these considerations, a nurse often determines the frequency of flushing that is warranted.[8,17] However, as with much expert knowledge and skill, nurses' practices regarding SPC care remain difficult to discern because of its subtlety, the context of where it occurs, and the limitations of documentation to capture the nuances of *routine* SPC care.[8,18,19] Although surveys and observations have been conducted regarding nurses' SPC care,[6,20] there is a dearth of understanding about the factors that influence nurses' SPC care decisions and the outcomes of these actions, information that could be used to inform clinical education, best practices, and patient care. The purpose of this study was to examine the current SPC flushing practices among a cohort of medical–surgical nurses. The specific study aims included: (1) exploring the factors, including experience, that influence nurses' care of SPCs; (2) quantifying the frequency and type of SPC flushing; (3) quantifying the volume of flush solution used; and (4) examining the relationship between frequency and volume on SPC end-of-shift status.

METHODS

Design

A mixed-methods approach was used to meet the study aims. Quantitative data were collected using an intravenous (IV) data collection sheet to record SPC care, including years of experience, occurrence, time, purpose, and flush fluid volume (Figure 1). The IV data collection sheet was developed by the research team and modified based on pilot testing with 5 clinical nurses before the start of the study. Qualitative data collection was achieved using focus groups. To meet the study goals, the research team developed a semistructured focus group guide that focused on understanding nurses' practice and rationale for flushing and the factors that influenced SPC care (Table 1).

Setting

This study was conducted at a 935-bed academic medical center on a 32-bed acute care neurology and neurosurgery unit. The unit employs 35 RNs and has an average daily census of 29 patients. The RN-to-patient ratio is typically 1:5, and all of the patients on the unit are required to have a minimum of 1 SPC per hospital policy unless otherwise ordered.

Procedures

Ethical Review

Before beginning any study activities, the proposed procedures were reviewed by the University Office of Human Research Ethics and were determined not to constitute human subjects research as defined under federal regulations. Participation in all of the study activities was voluntary. The confidentiality of participants' identity was enhanced by limiting the requested demographic information to 1 item (years of experience), the completion of which was also voluntary.

Recruitment

All of the clinical nurses (N = 35) employed on the unit full-time were encouraged to document their SPC care activities, participate in a focus group, or both—participating in 1 activity was not a prerequisite for the other. Information about the study purposes and invitations to participate were communicated by members of the research team during monthly staff meetings and through the unit email distribution list. Part-time staff and nurses who floated from other units within the hospital were excluded from participating, because their practices and reasons for flushing could differ from those of the full-time nurses on the unit. Clinical nurses who were interested in participating contacted the study team.

Data Collection

Training sessions about how to complete the data collection form were provided for those who volunteered to participate. Nurses were asked to develop and use a unique identifier on their data collection sheets throughout the study period.

The blank datasheets were distributed by the outgoing charge nurse to all incoming nurses at the start of the 12-hour day or night shift (07:00-19:00 or 19:00-07:00). Participating nurses were asked to record the patient's room number, SPC insertion date, and site location. Throughout the shift, nurses were asked to record each flush, the time of the flush, the reason for the flush, and the fluid volume that was used (Figure 1). Charge nurses were encouraged to periodically check the participating nurses' progress in completing the data collection form during the shift and to offer assistance if needed. At the end of the shift, SPC patency was recorded. Participating nurses were free to discontinue or suspend their participation at any point during a shift for any reason including but not limited to personal preference, patient load, or patient acuity. Nurses were encouraged to note patient conditions, such as fluid restrictions, that may have influenced the amount of flush volume used. Completed datasheets were collected in

IV Flush Data Collection Sheet

Years of experience: _____________
RN Unique ID: _______________ **Date:**

Room & IV	Flush #1	Flush #2	Flush #3	Flush #4	Flush #5	Flush #6	IV status/End of shift
IV #1 Rm # 61_ _ Insertion date: ______ Location of IV _______	Time________ Type of flush: ☐ Maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	Time________ Type of flush: ☐ maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	Time________ Type of flush: ☐ maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	Time________ Type of flush: ☐ maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	Time________ Type of flush: ☐ maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	Time________ Type of flush: ☐ maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	☐ Patent ☐ Occluded ☐ Infiltrated ☐ RN pulled ☐ Other pulled (pt., etc.)
IV #2 Rm # 61_ _ Insertion date: ______ Location of IV _______	Time________ Type of flush: ☐ Maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	Time________ Type of flush: ☐ maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	Time________ Type of flush: ☐ maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	Time________ Type of flush: ☐ maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	Time________ Type of flush: ☐ maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	Time________ Type of flush: ☐ maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	☐ Patent ☐ Occluded ☐ Infiltrated ☐ RN pulled ☐ Other pulled (pt., etc.)
IV #3 Rm # 61_ _ Insertion date: ______ Location of IV _______	Time________ Type of flush: ☐ Maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	Time________ Type of flush: ☐ maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	Time________ Type of flush: ☐ maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	Time________ Type of flush: ☐ maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	Time________ Type of flush: ☐ maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	Time________ Type of flush: ☐ maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	☐ Patent ☐ Occluded ☐ Infiltrated ☐ RN pulled ☐ Other pulled (pt., etc.)
IV #4 Rm # 61_ _ Insertion date: ______ Location of IV _______	Time________ Type of flush: ☐ Maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	Time________ Type of flush: ☐ maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	Time________ Type of flush: ☐ maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	Time________ Type of flush: ☐ maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	Time________ Type of flush: ☐ maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	Time________ Type of flush: ☐ maintenance ☐ pre-med. ☐ post-med. ☐ cont. infusion Flush volume_______	☐ Patent ☐ Occluded ☐ Infiltrated ☐ RN pulled ☐ Other pulled (pt., etc.)

Figure 1 Short peripheral catheter flushing data collection sheet. Abbreviations: cont. infusion, continuous infusion; ID, identifier; IV, intravenous device or short peripheral catheter; pre-med., preflush medication; post-med., postmedication administration; pt., patient; rm, patient room number.

a folder at the nurses' station and were checked within 12 hours by a member of the research team for completeness and accuracy. For each shift that a nurse collected data, they were entered into a weekly drawing for a $15 coffee or meal card.

TABLE 1

Focus Group Questions

1. How would you describe your routine practice for caring for SPCs? Prompts: For example, what do you do when you come on shift when you have patients with an SPC? Explain why you do what you do (experience level? Your [or someone else's] past negative experience(s)?)
2. Can you tell me about the factors that you consider when caring for a SPC? Prompts: If the decision is to flush or not to flush, do you go by physician order? Patient complaint/request? Desire to know if it is working?
3. Are there times when you are prevented from performing your routine practice?

Abbreviation: SPCs, short peripheral catheters.

Focus groups

To accommodate nurses working both day and night shifts, focus groups were scheduled at 07:30 AM, 11:15 AM, 13:30 PM, and 06:30 AM. Only 1 focus group was scheduled during night shift hours, but night shift nurses were encouraged to attend the 07:30 session if they were unable/did not want to attend a session during their shift. The sessions were facilitated by a member of the study team. The groups were held in a private conference room and recorded using 2 digital recorders. Participants were asked to sign in using their unique identifier but were not required to do so and were asked to keep information shared during the session confidential. The facilitator also recorded field notes and impressions during the session.[21]

ANALYSIS

Quantitative

The information documented on the data collection sheets were entered into an Excel spreadsheet (Microsoft, Redmond, WA) and double checked for accuracy and completeness by the principal investigator before analysis.

Descriptive statistics and other quantitative data analysis procedures were performed using Statistical Analysis System software (SAS Institute Inc., Cary, NC). Frequency counts and correlations were calculated to examine flush frequency and flush solution quantity. The strength and direction of the association among flush frequency, flush volume, and SPC end-of-shift status values (patent = 5, occluded = 4, infiltrated = 3, RN removed = 2, and other = 0) were analyzed using point biserial tests of significance for the correlations among the 5 binary variables and flush frequency and amount of flush solution (Figure 1). Trends regarding the time of day (work shift) and flushing practices were also examined and graphed.

Qualitative

The focus group digital recordings were transcribed into text by a professional transcription service. The completed transcripts were accessed via a password-protected website and downloaded and printed for manual review and coding. The members of the research team reviewed the transcripts concurrently with the digital recordings to ensure the completeness and accuracy of the transcriptions and to become more familiar with the data that were shared during sessions facilitated by other team members. Any proper names were redacted from the transcripts on review. Field notes and memos were also used to inform analysis.

After concordance between the transcripts and digital recordings was confirmed, paper copies of the transcripts were independently reviewed and manually coded by 3 members of the research team. Coding focused on identifying themes related to SPC care and were categorized under the areas of interest.[22] Notations were made when unique aspects of SPC care were identified and when similar practices or constructs were expressed by more than 1 participant.[23] The team coding sessions involved reviewing the transcripts for the themes and codes that were identified by each team member. The identified data were entered into a matrix display to better visualize the commonalities and differences.[24] Data analysis continued through discussion until consensus was achieved.[21,25]

After data analysis was complete, team meetings were held to discuss and compare the qualitative and quantitative findings.[26] When applicable, data from each source (focus group, data collection sheet) were compared for commonalities and differences, and new categories were identified. The use of the unique identifiers on the data collection sheets and focus group attendance sheets allowed for a deeper understanding of participants' flushing practices.

RESULTS

Sample

Data collection occurred during one 2-week period and one 1-week period in May 2018. Thirty-three unique identifiers were recorded on the data collection sheets. Given that the number of clinical nurses was 35 and participating nurses were asked to use a unique identifier, this finding suggests that a majority of RNs on the unit (>18) completed at least 1 data collection sheet. The years of experience of RNs who completed a data collection sheet ranged from 12 weeks to 26 years. The nurses on day shift had an average of 5.4 years of experience, whereas those on night shift averaged 7.7 years.

Information regarding 538 flushes was collected, and a majority (n = 458; 85%) of flushes were performed before or after medication administration or for maintenance purposes (Table 2). The SPC length was 3 inches, and the gauges (diameter) included 18, 20, 22, and 24 gauges. The end-of-shift status data were missing for 15% (n = 58) of the 412 unique SPC observations, and 80 flushes were documented as a continuous infusion. Four focus groups were held according to the previously described procedure. A total of 13 nurses participated in the sessions. The session durations ranged from 20 to 30 minutes.

SPC Flushing

Frequency

Overall, 100% (n = 13) of focus group participants said that they flushed SPCs at least once per shift. Participants noted that, during the flushing procedure, they assessed the SPC site for phlebitis and functionality, checked the date of SPC dressings, and shared the same opinion about the importance of this assessment. Most RNs did not rely on a licensed independent provider order (eg, physician or nurse practitioner) for flushing because the guidelines are

TABLE 2

Flush Type and Frequency: Reasons for Flushing

Data Collection Sheet	Frequency (N = 538)
Premedication	60
Postmedication	63
Maintenance	335
Continuous infusion	80
Focus group	
Giving medication	13
Patient discomfort	7
To check patency	5
Per patient request	5
Patient condition (ie, unstable, frequent medications, seizure patient)	5
Blood in catheter	2
Per LIP order	1
Per hospital policy	1

Abbreviation: LIP, licensed independent practitioner.

outlined in hospital policy and negated the need for orders to guide SPC care. However, 1 participant referred to flushing SPCs per policy (flushing once per shift), which suggests that some nurses may use a standardized rather than a patient-specific approach to care.

Preparedness

A majority (n = 10; 77%) of focus group participants said that they flushed SPCs at the beginning of their shift to verify patency. They prioritized the SPCs of patients who were identified as being at high risk for seizures, requiring frequent pain medication, or being unstable. It is important to note that the rationale for flushing an SPC at the beginning of the shift was not on the basis of a patient's current condition per se but on a patient's *potential* to deteriorate and expressed desire to be prepared for the worst as one nurse explained:

> "It's my duty…to make sure [the SPC is] patent so that we can use it if necessary. Whether they're med locked or not you need to make sure that if you need it in an emergency it's patent." (Focus Group 4, Interviewee 3).

The focus group participants reported that they flushed SPCs at the beginning of the shift, but the time parameters for this activity were not discussed. The research team initially considered this time period to be within the first or second hour of the shift; however, analysis of time-of-first-flush frequency within specific time periods during the day and night shift revealed that a majority of first flush(es) were documented within the first 6 hours of the 12-hour shifts (Figure 2). The first-flush practices did not statistically differ between day and night shift ($P = .55$), but the proportion of SPCs that were flushed during night shift was significantly ($P = .01$) higher than during day shift (Table 3). However, the data analysis indicated that more experienced nurses worked the night shift (19:00 PM-7:00 AM), which, based on more experienced nurses who reported a tendency to flush SPCs more often, could explain why more SPC flushes were performed on night shift (Figure 2).

The differences in SPC care on day shifts versus night shifts were also noted during the focus group sessions as participants discussed how the priority of SPC care changed based on other responsibilities, patient status, and the amount of time available. In spite of this fact, participants were in accord about the importance of SPC assessment and flushing. Nevertheless, time constraints and the presence of continuous fluid infusions contributed to prioritizing other aspects of patient care over SPC flushing. One nurse explained, "During the day is when I do not flush everybody's IV, [it is] because I am so crazy busy."

Another noted, "I have time, like I'm working nights and I'm going and flushing everybody's IV. If it's during the day I would only flush it if I know this is something that I'm gonna need." However, this account also suggests that, despite time constraints, nurses remain mindful of patient acuity and their potential for physical deterioration.

Before and After Medication

Participants' behaviors regarding flushing after IV medication administration are illustrated in Table 2. A majority of flushes (62%; n = 335) were documented as being

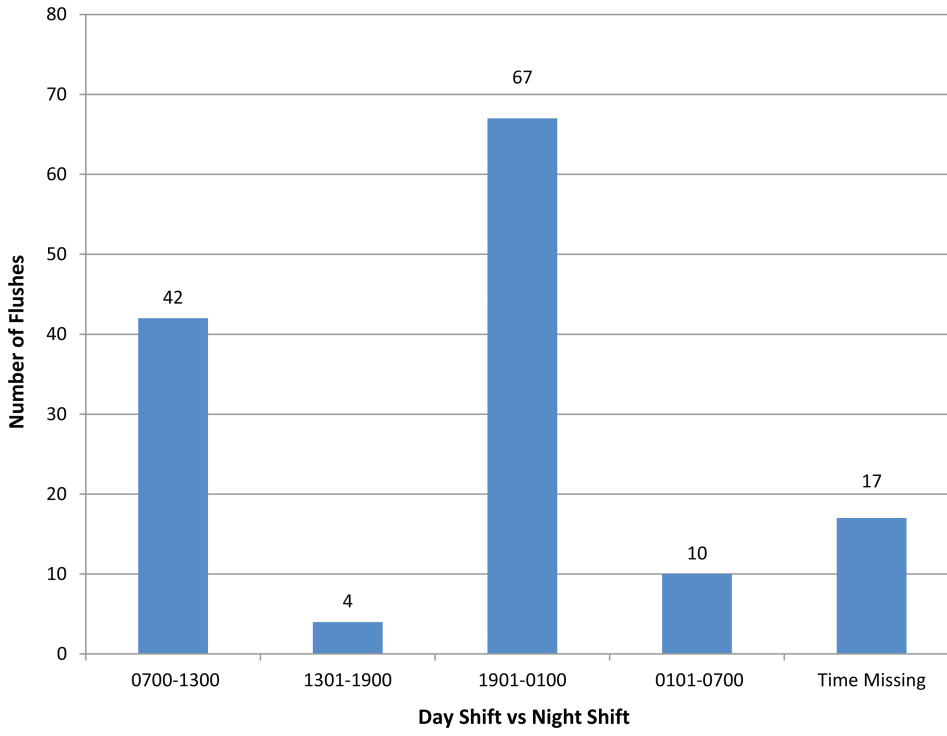

Figure 2 Day shift versus night shift flushes in 6-hour increments (N = 140).

TABLE 3

Statistical Analysis of Day Versus Night Shift Flushing Practices

Time of Flush	*P* Value	Conclusion
Day shift vs night shift	.0123	Proportions are significantly different
Beginning of day shift vs beginning of night shift	.5516	Proportions are not significantly different

performed for maintenance. Although focus group participants reported that they regularly flushed before and after IV medication administration, a discrepancy was noted between the number of premedication flushes (n = 60) that were performed compared with the number of postmedication flushes (n = 63). In cases of a continuous fluid infusion, most nurses said that they flushed after administering medications to assure timely and complete dosing.

Flush Volume

During the focus groups, 6 participants mentioned the flush volume of 0.9% sodium chloride that they regularly used. However, SPC flushing and catheter longevity were not mentioned during the focus group sessions—an omission that may reflect a lack of knowledge about the mechanics of flushing or that the longevity that matters is during the 12 hours of their shift[27] and the prioritization of short-term patency rather than the life of the SPC.

The flush volumes documented on the data collection sheets ranged from 2 mL to 10 mL, with 10 mL the most frequent (Table 4). Analysis on effect size of the association between flush frequency and volume and SPC end-of-shift status found weak biserial correlations, which indicated that patent SPCs (n = 5) were flushed more frequently and with larger flush volume than those that were occluded (n = 4), infiltrated (n = 3), RN removed (n = 2), or other (n = 0; Table 5).

Experience

The Spearman correlation between years of nursing experience and average number of flushes was 0.17, a relatively weak but positive result indicating a linear relationship between years of experience and flush frequency. This relationship was further evidenced through the use of a linear model that showed the average number of flushes increased by 0.036 for each additional year of experience. Although the experience-to-flush frequency correlation was statistically weak and the increase was incrementally low, the role of experience in SPC care was one of the first topics mentioned during the focus group sessions.

Data from the focus groups indicated that nurses were more mindful and more cautious with SPC treatment if they had previous experience with complications related to treatment or personal experience of patient pain related to SPCs. When discussing the factors that informed their flushing practices, nurses referred to a cognitive dimension of knowing, as 1 nurse explained, "I would say 'experience,' knowing that there are certain medications that are vesicants or irritants." The other type of experience originated from an awareness of the unpredictable nature of patients' condition and nurses' ability to detect subtle changes that develop over time. It was the potential for deterioration that prompted nurses to prepare for the worst—which translated to flushing SPCs, "We've all had a patient or heard about a patient who we deemed was stable and then all of a sudden you're calling a rapid [response team] on them and you need IV access."

DISCUSSION

This study examined the SPC catheter flushing practices among a cohort of medical–surgical nurses working on a neurology–neurosurgery acute care unit. Patient acuity, experience, and the amount of time available influenced nurses' SPCs flushing practices. Johansson et al[10] noted similar results on the effects of workload and time constraints on catheter care.

TABLE 4

Maintenance of Short Peripheral Catheter Flush Volumes

Maintenance Flush Number[a]	Minimum, mL	Maximum, mL	Median, mL	Mean, mL
1	2	10	10	8.94
2	5	10	10	9.42
3	10	10	10	10
4	5	5	5	5

[a]Maintenance flush number refers to the first, second, third, and fourth flush for a given catheter.

TABLE 5

Point Biserial Correlation/End-of-Shift Status: Flush Volume and Frequency

Component	End-of-Shift Status (Assigned Value)				
	Patent (5)	Occluded (4)	Infiltrated (3)	RN Removed (2)	Other (0)
Total flush volume	0.0832	–0.0491	–0.0723	–0.1177	0.0188
Flush frequency	0.1236	–0.0315	–0.0209	–0.0783	–0.0653

Abbreviation: RN, registered nurse.

Reasons for Flushing

Although only 5 focus group participants mentioned flushing SPC in relation to patency, it is possible that this task is so routine that some nurses just failed to mention it. However, the small discrepancy between the number of premedication flushes (n = 60) compared with the number of postmedication flushes (n = 63) suggests that SPCs are not always flushed before medication administration. It is unlikely that this difference could have been a documentation error, because the information was recorded by the nurse performing the procedure in real time. Keogh et al[20] also found that premedication flushing was omitted. This finding is concerning, because omitting this step leaves patency unconfirmed before medication administration, thereby increasing the risk for medication infiltration and vascular compromise and assuming that an incompatible solution is not in the catheter.[6,20]

Flush Volume

A weak but positive relationship was found between frequency and volume of flush solution to end-of-shift patency. This result suggests that patency may be better achieved with 10-mL prefilled syringes and once-a-shift flushing for all SPCs. Although nurses were less likely to flush SPCs when there was continuous maintenance fluid (eg, 0.9% sodium chloride) infusing, they did flush after IV medication administration. Whereas Keogh et al[28] concluded that definitive trials of flushing volume and flushing frequency of SPC management were achievable, those procedures could be difficult to implement in clinical settings and may be misguided for all patients. Belief that SPC flushing is a low priority or not needed in the presence of a maintenance fluid is widespread and one that presents an opportunity for education focusing on the mechanics of flushing and the limitations of infusion pumps regarding patency.[2,17,27]

Experience

The SPC flushing practices among more experienced nurses in this study were guided by their clinical knowledge of the unpredictable nature of some conditions, a finding that aligned with that of Johansson et al,[10] who also found a relationship between experience and SPC management. Similarly, nurses in this study also articulated ways in which they used their experience and skills to identify and prioritize the care of patients who they assessed and identified as having a higher potential for decline, SPC complications, and communicated their need to be watchful for these patients. Although the need to be diligent when caring for a patient whose condition is uncertain or unpredictable is obvious, maintaining a state of hypervigilance is unsustainable; however, the act of flushing SPCs at the beginning of shift offered experienced nurses peace of mind.

Less experienced nurses were more likely to prioritize tasks based on the amount of time available and to use policies to inform their practice. This practice may be beneficial in the short term but could prove problematic over time. The differences between the experienced and less experienced nurses' described practices align with Benner's[8] developmental framework of novice-to-expert development.

STRENGTHS AND LIMITATIONS

Strengths of the study are primarily associated with the use of a mixed-methods approach that combined the individual strengths of quantitative and qualitative research while at the same time compensating for the weaknesses of these methodologies when used alone.[29,30] This methodology allowed researchers to connect the practice patterns captured in the qualitative data with nurses' rationale for flushing practice, resulting in a more complete understanding of both the actual practice and the factors motivating practice. In addition, quantitative practice patterns were validated by themes discovered in focus groups and vice versa. Efforts were made to maintain the confidentiality of the data collection.

Using only the full-time nursing staff on a single unit may limit the generalizability of the study but also provided a rich understanding of nurses' practice. Although data collection relied on self-report, the data collection form was pilot tested before use and deemed sufficient to meet the study aims. Nurses self-selected to participate, but the number of unique identifiers that were used on the data collection sheets suggest that a majority of RN staff on the unit participated. Focus group participants may have been reluctant to voice certain motivations or practices in the presence of their peers, but participants were encouraged to contact or schedule a one-on-one interview with a member of the research team with any additional information

or questions. The clinical environment (ie, staffing levels, patient acuity, and workload) may have influenced data collection, but the duration of the data collection period (3 weeks at 2 points in time) was intended to mitigate these effects.

IMPLICATIONS FOR PRACTICE

The behaviors that were identified and the rationale provided by the nurses in this study correspond with Benner's[8,9] description of the stages of clinical competence, with newer nurses demonstrating a task-based motivation for flushing practice and more experienced nurses drawing on experientially based intuitive clinical wisdom. As noted, SPC flushing practice was often motivated by the desire to prepare for unexpected patient events that might require immediate SPC access. Expert nurses are often better able to read and evaluate subtle clinical cues,[8] anticipate the need for vascular access, and use this information to guide practice.[29] In light of this finding, unit staffing should ensure the presence of experienced and proficient nurses along with newer and less proficient nurses. In addition, exploring and understanding experience-level differences in knowledge, motivation, and practice may help guide future policy and education.

Barriers to flushing, which were identified in the focus groups, included lack of time and lack of priority and warrant further exploration. Flushes occurred more frequently on night shifts, and focus group data suggest that tasks are prioritized based on perceived importance of a task and the amount of time available. Many studies show correlations among increased nurse workload, inadequate staffing levels and missed care,[31-33] which suggest that periods of respite, such as formalized quiet times, may provide intervals for tasks such as SPC flushing to be performed. Research on other nurse interventions has identified lack of knowledge, lack of standardization,[15] and the perception of an activity as a low priority as barriers to task completion.[34] Future research should be directed toward a better understanding of the effects of these variables, as well as the influence of staffing levels and annual education on nurses' SPC flushing practices.

CONCLUSIONS

The quantitative findings showed correlations among years of experience, work shift, and SPC flushing. These results were supported in the qualitative findings, which identified themes related to practice behavior, including experience with complications, patient acuity, and workload. Although an SPC can fail after verifying patency, flushing afforded a sense of preparation or peace of mind to the nurses. Future research may be directed toward using these findings to design policy, education, and practice interventions to optimize SPC flushing practice and ensure proper SPC maintenance and patency. Future studies could explore the connections between policy and nurse practice and identify ways to increase the utility of policy in shaping practice.

REFERENCES

1. O'Grady NP, Alexander M, Burns LA, et al. Guidelines for the prevention of intravascular catheter-related infections, 2011. https://www.cdc.gov/infectioncontrol/pdf/guidelines/bsi-guidelines-H.pdf. Centers for Disease Control and Prevention. Updated October 2017. Accessed April 23, 2019.
2. Gorski L, Hadaway L, Hagle M, McGoldrick M, Orr M, Doellman D. Infusion therapy standards of practice. *J Infus Nurs*. 2016;39(suppl 1):S10-S18.
3. Gonzalez Lopez JL, Arribi Vilela A, Fernandez del Palacio E, Olivares Corral J, Benedicto Marti C, Herrera Portal P. Indwell times, complications and costs of open vs closed safety peripheral intravenous catheters: a randomized study. *J Hosp Infect*. 2014;86(2):117-126. doi:10.1016/j.jhin.2013.10.008.
4. Dychter SS, Gold DA, Carson D, Haller M. Intravenous therapy: a review of complications and economic considerations of peripheral access. *J Infus Nurs*. 2012;35(2):84-91.
5. Miliani K, Taravella R, Thillard D, et al. Peripheral venous catheter-related adverse events: evaluation from a multicentre epidemiological study in France (the CATHEVAL Project). *PLoS One*. 2017;12(1):e0168637. doi:10.1371/journal.pone.0168637.
6. Keogh S, Flynn J, Marsh N, Higgins N, Davies K, Rickard CM. Nursing and midwifery practice for maintenance of vascular access device patency. A cross-sectional survey. *Int J Nurs Stud*. 2015;52(11):1678-1685. doi:10.1016/j.ijnurstu.2015.07.001.
7. Nibbelink CW, Brewer BB. Decision-making in nursing practice: an integrative literature review. *J Clin Nurs*. 2018;27(5-6):917-928. doi:10.1111/jocn.14151.
8. Benner P. *From Novice to Expert Excellence and Power in Clincial Nursing Practice*. Upper Saddle River, NJ: Prentice Hall Health; 2001.
9. Benner P. Using the Dreyfus model of skill acquisition to describe and interpret skill acquisition and clinical judgment in nursing practice and education. *Bull Sci Technol Soc*. 2004;24(3):188-199. doi:10.1177/0270467604265061.
10. Johansson ME, Pilhammar E, Willman A. Nurses' clinical reasoning concerning management of peripheral venous cannulae. *J Clin Nurs*. 2009;18(23):3366-3375. doi:10.1111/j.1365-2702.2009.02973.x.
11. Ray-Barruel G, Rickard C. Helping nurses help PIVCs: decision aids for daily assessment and maintenance. *Br J Nurs*. 2018;27(8):S12-S18. doi:10.12968/bjon.2018.27.8.S12.
12. Vizcarra C, Cassutt C, Corbitt N, Richardson D, Runde D, Stafford K. Recommendations for improving safety practices with short peripheral catheters. *J Infus Nurs*. 2014;37(2):121-124. doi:10.1097/NAN.0000000000000028.
13. Goossens GA. Flushing and locking of venous catheters: available evidence and evidence deficit. *Nurs Res Pract*. 2015;2015:985686. doi: 10.1155/2015/985686.
14. Campbell SG, Trojanowski J, Ackroyd-Stolarz SA. How often should peripheral intravenous catheters in ambulatory patients be flushed? *J Infus Nurs*. 2005;28(6):399-404.
15. Fujita T, Namiki T, Suzuki T, Yamamoto E. Normal saline flushing for maintenance of peripheral intravenous sites. *J Clin Nurs*. 2006;15(1):103-104. doi:10.1111/j.1365-2702.2005.01238.x.
16. Keogh S, Marsh N, Higgins N, Davies K, Rickard C. A time and motion study of peripheral venous catheter flushing practice using manually prepared and prefilled flush syringes. *J Infus Nurs*. 2014;37(2):96-101. doi:10.1097/NAN.0000000000000024.

17. Hadaway L. Technology of flushing vascular access devices. *J Infus Nurs*. 2006;29(3):137-145.
18. Fishman CE, Weinberg DD, Murray A, Foglia EE. Accuracy of real-time delivery room resuscitation documentation. *Arch Dis Child Fetal Neonatal Ed*. In press. http://dx.doi.org/10.1136/archdischild-2018-315723.
19. Wilbanks BA, Berner ES, Alexander GL, Azuero A, Patrician PA, Moss JA. The effect of data-entry template design and anesthesia provider workload on documentation accuracy, documentation efficiency, and user-satisfaction. *Int J Med Inform*. 2018;118:29-35. doi:10.1016/j.ijmedinf.2018.07.006.
20. Keogh S, Shelverton C, Flynn J, Davies K, Marsh N, Rickard C. An observational study of nurses' intravenous flush and medication practice in the clinical setting. *JVAD*. 2017;3(1):3-10.
21. Lofland J, Snow D, Anderson L, Lofland L. *Analyzing Social Settings: A Guide to Qualitative Observation and Analysis*. 4th ed. Belmont, CA: Wadsworth; 2006.
22. Saldaña J. *The Coding Manual for Qualitative Researchers*. 2nd ed. Thousand Oaks, CA: SAGE; 2013.
23. Miles M, Huberman AM. *Qualitative Data Analysis*. Thousand Oaks, CA: SAGE; 1994.
24. Tashakkori A, Teddlie C. *Handbook of Mixed Methods in Social & Behavioral Research*. 2nd ed. Thousand Oaks, CA: Sage Publications; 2010.
25. Guest G, MacQueen KM, eds. *Handbook for Team-Based Qualitative Research*. Lanham, MD: Altamira Press; 2008.
26. Teddlie C, Tashakkori A. *Foundations of Mixed Methods Research: Integrating Quantitative and Qualitative Approaches in the Social and Behavioral Sciences*. Thousand Oaks, CA: SAGE; 2009.
27. Piper R, Carr PJ, Kelsey L, Bulmer A, Keogh S, Doyle B. The mechanistic causes of peripheral intravenous catheter failure based on a parametric computational study. *Sci Rep*. 2018;8(1):3441.
28. Keogh S, Flynn J, Marsh N, Mihala G, Davies K, Rickard C. Varied flushing frequency and volume to prevent peripheral intravenous catheter failure: a pilot, factorial randomised controlled trial in adult medical-surgical hospital patients. *Trials*. 2016;17(1):348.
29. Pluye P, Hong QN. Combining the power of stories and the power of numbers: mixed methods research and mixed studies reviews. *Annu Rev Public Health*. 2014;35:29-45.
30. Roszell SS, Rabinovich HB, Smith-Miller CA. Maintaining short peripheral catheter patency: a comparison of saline lock versus continuous infusion in the acute care setting. *J Infus Nurs*. 2018;41(3):165-169. doi:10.1097/NAN.0000000000000276.
31. Hoffman KA, Aitken LM, Duffield C. A comparison of novice and expert nurses' cue collection during clinical decision-making: verbal protocol analysis. *Int J Nurs Stud*. 2009;46(10):1335-1344. doi:10.1016/j.ijnurstu.2009.04.001.
32. Orique SB, Patty CM, Woods E. Missed nursing care and unit-level nurse workload in the acute and post-acute settings. *J Nurs Care Qual*. 2016;31(1):84-89. doi: 10.1097/NCQ.0000000000000140.
33. Ball J, Day T, Murrells T, et al. Cross-sectional examination of the association between shift length and hospital nurses job satisfaction and nurse reported quality measures. *BMC Nurs*. 2017;16:26. https://doi.org/10.1186/s12912-017-0221-7.
34. Fisher CC, Cox VC, Gorman SK, et al. A theory-informed assessment of the barriers and facilitators to nurse-driven antimicrobial stewardship. *Am J Infect Control*. 2018;46(12):1365-1369.

Erratum

Best Practices to Decrease Infusion-Associated Medication Errors: Erratum

In the July/August 2019 issue of *Journal of Infusion Nursing*, there was an error in the article entitled "Best Practices to Decrease Infusion-Associated Medication Errors" by Zane Robinson Wolf and Ronda G. Hughes.

On page 186 in the Results section, the total number of articles identified should be 490, not 491 as printed. The corrected sentence should read:

"A total of 490 articles were identified in the 504 newsletters."

REFERENCE

Wolf ZR, Hughes RG. Best practices to decrease infusion-associated medication errors. *Journal of Infusion Nursing*. 2019;42(4):183-192.

DOI: 10.1097/NAN.0000000000000348