The Art and Science of Infusion Nursing

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A Time and Motion Study of Peripheral Venous Catheter Flushing Practice Using Manually Prepared and Prefilled Flush Syringes

ABSTRACT

Peripheral venous catheters (PVCs) are the simplest and most frequently used method for drug, fluid, and blood product administration in the hospital setting. It is estimated that up to 90% of patients in acute care hospitals require a PVC; however, PVCs are associated with inherent complications, which can be mechanical or infectious. There have been a range of strategies to prevent or reduce PVC-related complications that include optimizing patency through the use of flushing. Little is known about the current status of flushing practice. This observational study quantified preparation and administration time and identified adherence to principles of Aseptic Non-Touch Technique and organizational protocol on PVC flushing by using both manually prepared and prefilled syringes.

Key words: ANTT, flush, guidelines, nurse, peripheral intravenous catheter, practice, prefilled, time

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The progress of medical science and technology has been accompanied by the use of new diagnostic and therapeutic devices, each of which is associated with its own complications. Venous cannulation via peripheral intravenous catheters (PVCs) is the simplest and most frequently used method for drug, fluid, and blood product administration. Researchers estimate that as many as 85% of hospital patients require infusion therapy, with 70% of patients needing a PVC.[1-4]

Approximately 330 million PVCs are sold in the United States each year.[1] However, PVCs are associated with inherent mechanical and infectious complications. Mechanical complications include thrombosis, dislodgment, extravasation, leakage, phlebitis, and scar formation. Infectious complications include bacterial or fungal sepsis. Thrombosis or phlebitis at the catheter site can act as a focus for nosocomial infection, which is associated with extended admission time and increased mortality.[5,6] Phlebitis accounts for approximately 4% to 7% of catheter failures; between 30% and 40% fail for other reasons, such as accidental removal, infiltration, or occlusion.[7-11]

Maintaining catheter patency is vital, and a range of strategies have been used to prevent PVC occlusion and infiltration. These include optimizing patency through either continuous infusion or intermittent flushes of saline or heparinized preparations, and use of saline, heparin, antibiotic, and ethanol locks.[12-14] Frequent catheter resiting requires multiple penetrations of the skin barrier, which has implications for patient comfort and staff time. It also predisposes patients to infection through commensals in the skin. Research has shown that PVCs need to be changed only as clinically indicated, rather than the traditional 48 to 72 hours.[7] Methods that can prolong the duration of viability of these catheters hold significant benefit to patient and organizational outcomes.

The results of research comparing continuous infusion and intermittent flushes to maintain PVC patency remain inconclusive, with studies yielding contradictory findings as well as having methodological issues.[15,16] There are no studies comparing different flushing regimes (ie, regular versus as needed; 6 hourly versus daily). Nor are there studies comparing practice associated with preparation and administration of manually prepared flushes and prefilled flushes. Additionally, organizational guidelines vary. The current status of flushing practices is unknown.

Similarly, there is little research on the quality of infection prevention measures used during the flush administration. Given that it is impossible to achieve a sterile environment (ie, complete absence of microorganisms) in typical health care settings because of the prevalence of microorganisms in the air, asepsis (the absence of pathogenic organisms) is the accepted standard for procedures on patients in the general clinical environment.

The invisible but ubiquitous presence of microorganisms in the clinical environment means that aseptic technique represents a patient's last line of defense from microorganisms during invasive clinical procedures.[17] A framework for aseptic nontouch technique (ANTT), which was developed more than a decade ago, accurately defines infection prevention measures and precautions required during invasive clinical procedures and has become the de facto standard for aseptic technique in hospitals in Australia, the United Kingdom, and 15 other countries.[18] The framework also has been included in the *Australian Guidelines for the Prevention and Control of Infection in Healthcare*.[19]

In practice, however, ineffective hand hygiene and cleaning of intravenous device ports, as well as confused and inaccurate application of the terms *sterile*, *aseptic*, and *clean* persist, posing ongoing risks to patients.[20-22] Therefore, it seems prudent to quantify current practice related to maintenance of PVC patency and related infection prevention measures through observational study, practice audit, and survey. This research is urgently needed to inform practice and future research.

METHODS

Aims and Objectives

The aim of this study was to observe the nursing practice of flushing PVCs in a laboratory setting when using 2 different flushing syringes—manually prepared and prefilled. The objectives were to quantify nursing preparation and administration time and to identify adherence or deviations to key principles of ANTT and organizational protocol related to PVC flushing.[23,24]

Study Design

The study used an observational design and involved a laboratory-based time and motion study of preparation and use of manually prepared flushes versus prefilled flush syringes.

Data Collection and Analysis

A convenience sample of 12 registered nurses was invited to participate in an observational study to compare the time and practice of preparing and administering manually prepared PVC flushes with that of manufacturer-prepared prefilled flushes. Ethics approval was granted for the study by the university's human

research ethics committee, and written consent was obtained from all participants.

Two observational sessions, each lasting 2 to 3 hours, were scheduled in a Queensland Health Clinical Skills Development Service laboratory that replicated a typical ward setting. Orientation to the lab setting and explanation of the research protocol were provided at the beginning of the session. Each nurse then were given a hypothetical case study to contextualize the 5 flushing scenarios, which were to be carried out and observed using manually prepared flushes as their standard practice.

After observation of the nurses administering manually prepared flushes, the group was given a brief education session about the use of the prefilled flush syringes because these were not in common use in the study setting. The nurses then repeated the same flushing scenarios using the prefilled syringes.

Data collected included individual task times as well as total task time, equipment used, adherence to the principles of ANTT, adherence to organizational protocol for flushing, and any significant anecdotal comments volunteered by the participants (ie, alternative or preferred equipment).[23,24]

Data were collated and analyzed using PASW Statistics version 19 (SPSS Inc., Chicago, IL). Means, standard deviations, frequencies, and percentages were used to summarize the central tendency, spread, and empirical distribution of continuous and categorical variables. Differences between continuous variables were analyzed using the Student *t* test. For skewed data, median values and interquartile ranges were calculated and subjected to nonparametric analysis.

RESULTS

Seven of the 12 nurses invited to participate in the study were available and agreed to participate. Each completed 10 scenarios: 5 manually prepared and 5 prefilled syringe flushes. A total of 70 scenarios were observed (35 in each arm). All participants were registered nurses working in a variety of acute care settings in a tertiary metropolitan hospital. The duration of their postgraduate experience ranged from 5 to 25 years; the majority (6) were female. None of the participants had used manufacturer-prefilled flush syringes previously.

Timing

The mean total flushing time was 169 seconds for manually prepared flushes and 120 seconds for prefilled flushes, with a mean difference of 49 seconds (95% CI, 35-64, $P > .001$). Preparation time constituted the largest individual task time. The mean preparation time for manual flushes was 75 seconds versus 44 seconds for prefilled flushes, with a mean difference of 31 seconds (95% CI, 22-39, $P < .001$).

Breakdown of further individual tasks revealed large variation within and between groups, but no other significant differences were found. Some of the times were highly skewed (eg, patient preparation, hub decontamination, flush administration), so median and interquartile range values were also calculated and subjected to the Wilcoxon signed rank test. The difference in these times was not statistically significant, however. A more detailed report of individual and overall task times and

TABLE 1

Comparison of PVC Flushing Times for Manually Prepared and Prefilled Syringes

Procedure	Manually Prepared (Time, Seconds), Mean (SD)	Prefilled (Time, Seconds), Mean (SD)	Time Difference (Seconds)	Paired *t* Test 95% CI
Equipment preparation	75 (± 28)	44 (± 29)	−31	22 to 39[a] ($P < .001$)
Handwash	26 (± 15)	21.00 (± 13)	−5	1 to 9
Patient preparation	16 (± 15)	12 (± 11)	−4	4 to 10
Hub decontamination	12 (± 10)	6 (± 4)	−6	2 to 9
Flush administration	31 (± 22)	27 (± 17)	−4	−3 to 11
Equipment disposal	11 (± 7)	10 (± 4)	−1	−2 to 4
Total time	169 (± 58)	120 (± 40)	−49	35 to 64[a] ($P < .001$)

Abbreviations: CI, confidence interval; PVC, peripheral venous catheter; SD, standard deviation.
[a]*Statistically significant.*

differences appears in Table 1. Times are rounded to the nearest whole second.

Adherence to ANTT Guidelines

All participants adhered broadly to the principles and steps of ANTT, with the exception of the use of personal protective equipment (PPE) and hub decontamination. Both were rarely adhered to. Table 2 outlines in detail the level of adherence to ANTT principles and steps.

Adherence to IV Flushing Guidelines

In general, there was low awareness and a lack of adherence to the organizational protocol for administration of a PVC flush. None of the participants calculated the potential flush volume based on the catheter and device, and only 2 (28%) used a drawing-up needle or pulsatile infusion method. One participant used a syringe less than 10 mL. Table 3 outlines details of protocol adherence.

TABLE 2

Observed Level of Compliance With ANTT During Administration of a PVC Flush

Administering IV Drugs Using ANTT	Level of Compliance, n (%)
Decontaminate hands[a]	7 (100%)
Tray use	
Select and use tray	7 (100%)
Clean tray with chlorhexidine alcohol wipe/solution	1 (14%)
Prepare drug and equipment on tray	7 (100%)
Use of PPE	
Use of gloves	3 (42%)
Use of apron	1 (14%)
Prepare patient and gain access to IV line	
Repeat decontamination of hands[a] and use fresh gloves	1 (14%)
Introduce yourself to patient and inform patient about procedure	7 (100%)
Identify and isolate line and port for flushing	7 (100%)
Decontaminate hub or access port (30s)	0 (0%)
Dispose of equipment safely and appropriately	7 (100%)

Abbreviations: ANTT, aseptic nontouch technique; IV, intravenous; PPE, personal protective equipment; PVC, peripheral venous catheter.
[a]If hands are socially clean, disinfectant rub may be used.

DISCUSSION

The aim of the study was to observe the nursing practice of flushing PVCs in a laboratory setting using 2 different flushing syringes: manually prepared and prefilled. The results quantified nursing preparation and administration time when using 2 different flushing methods and identified deviations from recommended practices for aseptic technique and administration of an IV flush.

The results also demonstrated that the time to prepare a flush was reduced significantly (by 22-39 seconds) when using a prefilled syringe. This contributed to a significant difference in overall flush time (by 35-64 seconds), although no other part of the flushing process was significantly influenced by the change in flush device. In the clinical setting, the difference of a minute per flushing episode would translate to a time saving of as much as 10 minutes a patient a day for 5 flushes a day, depending on frequency (eg, daily flush plus before and after each medication dose). This would be more significant

TABLE 3

Observed Level of Compliance With Organizational Protocol for PVC Flushing[a]

Recommended Steps for Flushing PVCs	Level of Compliance, n (%)
Calculation of flush volume (ie, double the volume of the catheter and extension set [approximate minimum, 2 mL])	0 (0%)
Use of single-dose solutions only	7 (100%)[b]
Use of syringe ≥ 10 mL only	6 (85%)
Use of a drawing-up needle	2 (28%)
Hub decontamination, including drying time	0 (0%)
Pulsatile action of delivery	2 (28%)

Abbreviation: PVC, peripheral venous catheter.
[a]Queensland Health iCARE Protocol for Insertion and Management of Peripheral Intravascular Catheters, 2011.
[b]Three participants spoke of multiple use of intravenous injections.

in high-use situations, such as in intensive care units or operating rooms.

Standardization of ANTT, visual reminders, and easy access to appropriate equipment are key strategies to help ensure improved compliance with infection prevention.[17] The results from this study demonstrated a wide variation in practice largely because of different interpretations of related guidelines, availability of equipment, and perceived risk. Adherence to all key steps of ANTT was not observed. This has implications for infection control and related risks in the clinical area.[17] Non-use of PPE and decontamination of intravenous device hubs were the biggest areas of deviation from recommended practice. All nurses adhered to hand decontamination (either by washing or using disinfectant rub). However, only 3 nurses used gloves, and 1 said she would normally have used an apron. Although all participants wiped the hub before administering the flush, none waited the recommended 30 seconds for the disinfectant solution to dry. This is possibly due to a lack of understanding of the principles of asepsis and/or perceived risk.

The use of a pulsatile delivery action and reduced pressure of delivery through a larger syringe are recommended to optimize flush outcomes and minimize damage to the vein.[25-27] During the actual administration of the PVC flush, there was variation within and between individuals' rate of delivery and the use of a pulsatile action. Participants who did not use a pulsatile action admitted to either not being aware of this requirement or simply forgetting. One participant used a smaller-than-recommended (ie, <10 mL in diameter) syringe to deliver the flush in the manually prepared group, and this may have caused higher-than-desired flushing pressure. The ability to use a syringe of smaller diameter was negated in the prefilled flush group because the prefilled syringes are produced in diameters consistent with a traditional 10-mL syringe diameter, although with smaller-volume and smaller-size syringes (available in 3 and 5 mL).

During the study, participants made a number of anecdotal comments and observations about flushing practice, including the potential for reduced contamination of the administering flush or syringe as well as needlestick injury, when using prefilled flushes. This would negate the need for drawing up a solution either through a drawing-up needle or, as in the case of this study, direct from the ampoule. This observation is supported by research. A contamination rate of 8% was observed in 1 observational study of manual flush preparation.[28] Use of a contaminated syringe solution increases the risk of developing phlebitis and even bloodstream infection.[29] In a recently published cohort study of flushing of totally implantable venous access devices, a higher rate of catheter-related bloodstream infection was observed in a group using manually prepared flushes compared with a group using prefilled syringes.[30] The ability to minimize even the theoretical risk of contamination and infection warrants further exploration.

Participants also commented on the value of the labeling of the prefilled flushing device. Precautions in medication safety that apply to other intravenous medications should be followed when administering flush solutions. This includes never administering a drug from an unlabeled container. The Australian Commission on Quality and Safety in Health Care's national labeling recommendations for syringes and infusion devices state that basic labeling should include drug name, strength, amount, and time and date of preparation.[31] Medication errors are less likely to occur with appropriate and standardized labeling and single-user preparation.[32-34]

This research has limitations related to observational design in a laboratory setting and small sample size. An observational study in the clinical setting was considered too labor-intensive and costly, with potentially little additional information in return. Nonetheless, the study gives valuable insight into flushing practice in nursing and on the potential beneficial impact a prefilled device might have on flushing practice from a resourcing aspect as well as quality and safety. The results also inform ongoing research into intravenous device flushing practice, including randomized controlled trials on flushing regimes.

CONCLUSIONS AND IMPLICATIONS

An important aspect of everyday acute care nursing is the care and maintenance of intravascular devices. This study has assisted in clarifying nursing practice related to flush preparation and administration. The results from this study demonstrate that using a prefilled flush is associated with a significant reduction in the time required to prepare the equipment for a PVC flush and, therefore, in overall time. A prefilled flush syringe also has the potential to promote adherence to some key principles of ANTT. These include a reduction in the risk of device or solution contamination as a result of minimized handling and the maintenance of positive pressure during flush administration. A prefilled flush also could potentially help promote adherence to clinical protocols and guidelines for intravenous flushing practice (eg, use of single-dose solution and appropriate-size syringes). In addition, automatic labeling may reduce the risk of medication error. It is clear that standardization of ANTT and PVC care and maintenance is required. This needs to be coupled with ongoing education about the risk that deviation from these poses for infection control and medication safety. The use of

adjunct visual reminders in the clinical area may help promote compliance. Further rigorous research is required to establish the benefits of optimal flushing mechanisms and regimes to promote PVC comfort, patency, and safety.

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