

Reducing Risks and Improving Vascular Access Outcomes

Elizabeth Morrell, DNP, RN, NEA-BC

ABSTRACT

Short peripheral catheter (SPC) insertion is a common invasive procedure performed in hospitalized patients. Variations in this fundamental nursing skill exist among nurses, with significant impacts on budgets, patient satisfaction, and worker safety—key concerns for nurse leaders. A performance improvement project focused on vascular access management was undertaken, with the goal to improve SPC practice and associated outcomes. Assessment of current SPC policies, practices, products, and outcomes identified areas of potential improvement. A performance improvement program was undertaken, and its effects on clinical, safety, and economic outcomes were assessed at 5 hospitals in 1 health care system. Clinical, safety, and economic outcomes improved, as demonstrated by longer average catheter dwell times, increased first-insertion success, improved patient satisfaction, reduced blood exposure, and annual cost savings. A vascular access management program can support leaders in achieving consistent guideline adherent practice among nurses while reducing cost and increasing patient and nurse satisfaction.

Key words: catheter dwell time, cost savings, first attempt success, peripheral intravenous catheters, short peripheral catheter

More than 300 million short peripheral catheters (SPCs) are inserted annually in the United States,¹ and up to 90% of patients receive an SPC during their hospital stay.² SPC insertion requires knowledge, confidence, and clinical proficiency on the part of the clinician and can be challenging to manage with workload demands.³ Success rates of SPC insertion on the first attempt ranging from 86% to 96% have been reported.⁴⁻⁶ In the

emergency department, where the procedure is frequently performed in a fast-paced clinical environment, first-attempt success tends to be lower, up to 73%.⁷ Repeated needle-insertion attempts may cause patient psychological complications, such as distress and anxiety, as well as pain, vein injury, and enhanced risk of infection.^{5,6,8-10} They may also contribute negatively to patient satisfaction.⁶ In more controlled settings with specialized intravenous (IV) catheter teams and implementation of process improvement programs, success rates can be improved.¹¹

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COMPLICATIONS

Dwell time is associated with catheter-related complications. The average dwell time for an SPC is 66 hours.¹² A number of factors can affect dwell time, including patient age, vein condition, skin condition,⁷ and length of stay, which is typically 4 days.¹³ Current SPC practice has seen a shift from routine replacement every 72 hours to replacement when clinically indicated.¹⁴ The reported incidence rate of complications in patients undergoing catheter insertion is up to 42%.¹⁵ The most common complications include phlebitis, occlusion, infiltration and extravasation, and catheter-related bloodstream infection (CR-BSI).¹⁵ Replacement of SPCs as the result of these factors could increase the risk of infection. The incidence of CR-BSI was up to 2.2%, while insertion-site infection rates varied from

0.1% to 5.1%.² Such complications lead to unscheduled restarts and failure of SPCs. Failure occurs when an SPC stops working properly before its intended dwell time.² Estimates of failure rates of SPCs are high, ranging from 42% to 69%.^{15,16}

COSTS

Multiple IV insertion attempts can drive up cost and resource utilization at hospitals.¹⁷ Complications resulting from catheter use can compromise patient care, as they may cause cancellation or delay of procedures, necessitate catheter replacement, or interrupt drug administration.¹⁸ Therefore, complications present a substantial burden to the health care system and patients in terms of consumption of health care resources and decreased patient quality of life.^{17,18} This economic burden can be in the form of direct costs (eg, increased hospital stay, drug treatment, or medical and surgical procedures) or indirect costs (eg, lost patient income or demands on caregiver time). Multiple studies have demonstrated that catheter-related complications such as CR-BSI lead to increased cost, including costs associated with increased patient hospital stay.^{19,20} Increased cost has also been reported for other complications, which include occlusion, phlebitis, and infiltration and extravasation.^{2,6}

SAFETY

Accurate and comprehensive documentation of clinical interventions and processes can improve patient safety and quality of care, as well as minimize the possibility of malpractice claims.²¹ However, a gap exists between interventions performed and accurate documentation.^{21,22} Because errors and complications during vascular access and IV administration may result in severe adverse effects, which include life-threatening outcomes in the patient, insertion and management of SPCs can also leave health care workers vulnerable to malpractice claims. According to the Closed Claims Project database, from 1970 to 2001, 2.1% of all injury claims were related to SPCs, and more than half resulted in successful lawsuits against health care workers.²¹ Efforts to improve documentation may help call attention to complications and hence reduce the lack of data, thus leading to better outcomes.

Clinicians are at risk for needlestick injury and exposure to bloodborne pathogens during SPC insertion. In a study conducted among clinicians, 14% to 68% reported a blood leakage event during SPC insertion.²³ A study in the United Kingdom revealed that hospitals sometimes experience problems in providing a reliable supply of equipment, which includes clean tourniquets, appropriate IV cannula dressings, and sharps disposal bins; such deficiencies could increase risk to health care workers during SPC insertion.²⁴

OBJECTIVE

Significant variation in vascular access practice exists among individual hospitals within systems, with a wide range of first-insertion success, catheter complication, and failure rates. Such variability and the resulting gaps can put patients and health care workers at risk, as well as place an economic burden on the hospital. Hence, it is important to implement process improvement programs tailored to individual institutions in partnership with hospital personnel.

As part of an initiative to improve vascular access and infusion practices and related laboratory specimen collection, the health care system collaborated with the vascular access management (VAM) team from Becton, Dickinson and Company (BD; Franklin Lakes, NJ) to develop and initiate process improvement projects and strategies. The BD team provided specific and practical recommendations on multiple aspects of infusion practices, including process changes, policy updates, and product recommendations. As a result of the collaboration, the VAM program focused on the goal of identifying and reducing risk, mitigating SPC complications, improving clinical performance, and reducing cost. The current study investigated the impact of the program on clinical, safety, and economic outcomes at 5 hospitals that are part of 1 health care system.

METHODS

A baseline inpatient assessment was conducted in October 2014 at 5 hospitals in a health care system in Southern California. A new integrated closed IV catheter system (Nexiva; BD, Franklin Lakes, NJ) was introduced system wide, and a reassessment was completed in August 2017. A separate follow-up study was conducted in January 2020 at one of these hospitals. The assessments included random selection of SPC and central catheter insertions, observation of SPC insertions, health care worker interviews, and review of patient electronic health records for proper documentation. The corporate vice president of nursing of the hospital system approved this quality improvement study.

Some of the quantitative parameters assessed included the number of insertion attempts; catheter dwell time; SPC site risks, including blood or fluid leakage, nonocclusive dressing, and inappropriate clamp use; and observed SPC insertion risks, including blood exposure, inappropriate site selection, and inappropriate proper personal protective equipment (PPE) use.

As part of the VAM program, current practices, processes, and products relevant to infusion therapy were assessed to identify areas of risk that could lead to needlestick injury, blood exposure, CR-BSI, or other catheter-related complications. The guidelines included assessment in these areas: device selection and assessment, SPC insertion, dressing change, needle-free connector change, catheter flush and lock, blood draw, device removal, port access, and port

de-access. Preprogram baseline assessment was performed in October 2014.

Hospital staff were trained in the use of updated vascular access products in May 2015. New products and policy updates were implemented. Continuing education was provided to staff on both products and infusion best practices. Postprogram assessment was performed in August 2017 to evaluate change in parameters. The January 2020 follow-up investigated practice guidelines for placing a venous catheter to monitor compliance.

To assess the significance of differences in the proportions of events before and after VAM program implementation, the 2-sided Fisher exact test was used to compare preprogram and postprogram data sets for injection port cleaning; blood leakage or exposure; and insertion-site risks, including an unlabeled insertion site, nonsterile tape under dressings, inappropriate site selection, a nonvisible insertion site, insertion-site redness or swelling, visible blood in a connection, or fluid leakage from a site. Analysis of variance was used to compare preprogram and postprogram dwell times.

Based on the cost of IV products and supplementary materials (ie, needle-free connectors, extension sets, blood spill cleanup kits, IV start kits, flushing materials, and alcohol caps) used before and after the VAM program, economic data were evaluated during each assessment. Pre-VAM program cost data were collected in October 2014, and post-VAM program data, in August 2017. Total saving was calculated by subtracting total postprogram IV cost (IV products + supplementary materials) from total preprogram IV cost.

Before VAM program implementation, a safety IV catheter (Jelco Protectiv; Smiths Medical, Dublin, Ohio) was used for all SPC insertion. After VAM program implementation, the closed IV catheter system was used.

RESULTS

Placement Data

Patient length of stay and number of attempts per insertion are summarized in Table 1.

Documentation and First-Insertion Success

Documentation of the number of insertion attempts improved from 15% to 68% after the implementation of the

TABLE 1

Patient Length of Stay and Number of Attempts Per Placement

	Before VAM program	After VAM program
Average patient length of stay, d	4.39	4.39
Number of placements	73	157
Number of attempts per placement, n (%)		
1	8 (11.0)	92 (58.6)
2	2 (2.7)	14 (8.9)
3	0 (0.0)	1 (0.6)
4	1 (1.4)	0 (0.0)
Not documented	62 (85.0)	50 (31.8)

Abbreviation: VAM, vascular access management.

VAM program ($P < .001$). When nondocumented cases were factored in, a 30% increase in reported first-attempt success during SPC insertion was observed (Figure 1). In a separate study in January 2020, the first-insertion success was 87%.

Insertion Site Risks

Significant reductions in nonocclusive dressing, blood or fluid leakage from an insertion site, or a site not being visible were observed after VAM program implementation. Blood or fluid leakage from an insertion site decreased from 18% to 1% ($P < .0001$), nearly a 90% decrease. Decreases in inappropriate clamp use and site selection also were observed but were not statistically significant (Figure 2). In a separate study in January 2020, the following SPC site risks were observed: nonocclusive dressing (24%), blood or fluid leakage from insertion site (18%), site not visible (15%), and inappropriate clamp use (30%).

Blood Exposure and Other SPC Insertion Risks

Reported blood exposure during insertion was reduced by 61% in the postprogram data set, with near-total reduction of observed blood exposure (Figure 3A; $P < .001$). This reduction resulted in avoidance of \$112,050 in annual exposure and cleanup cost. Improvements were observed in other insertion risks, such as site selection ($P = .065$) and use of appropriate PPE ($P = .02$) (Figure 3B).

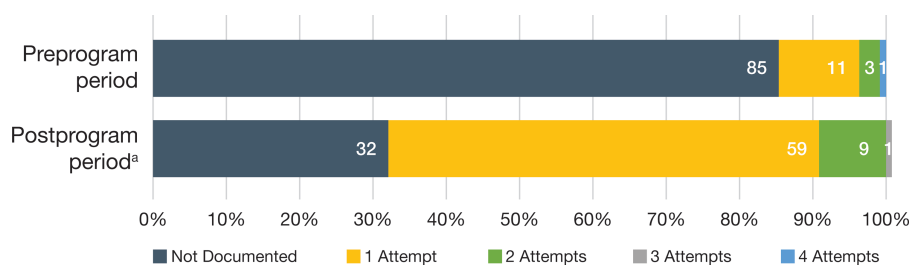


Figure 1 Documentation of SPC insertion success collected during the preprogram (October 2014) and postprogram (August 2017) periods. Abbreviation: SPC, short peripheral catheter.

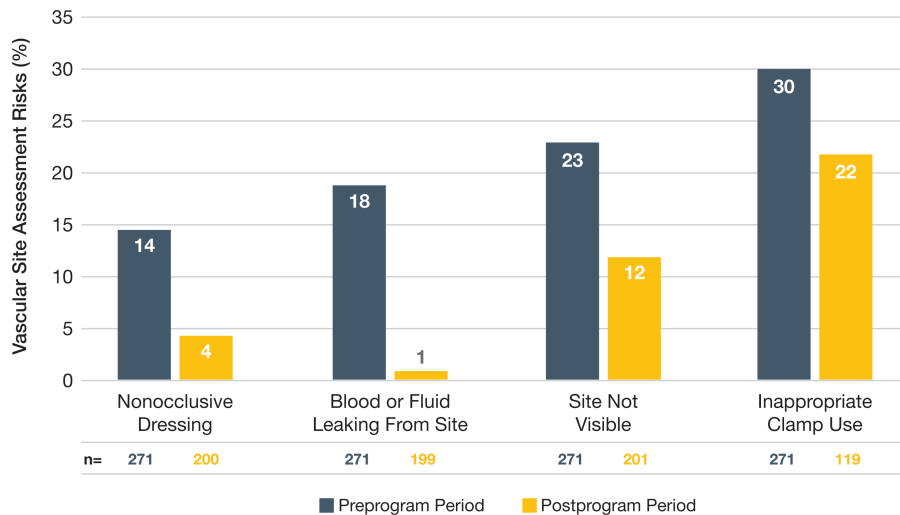


Figure 2 Assessed SPC site risks observed during the preprogram (October 2014) and postprogram (August 2017) periods. *Abbreviations:* n, number of peripheral vascular access sites assessed; SPC, short peripheral catheter.

Dwell Time

SPC dwell time improved significantly between groups ($P < .001$) as a result of VAM program implementation. Dwell time increased by 36 hours from 67 hours in 2014 to 103 hours in 2016. A 53-hour (79%) increase in average dwell time was observed between preprogram and postprogram groups (Figure 4). In a separate study in January 2020, dwell time was 93 hours.

Economic Impact

The estimated total annual postprogram saving, calculated as the product of total inpatient SPC starts and cost per SPC start, was \$192,570. Most of this saving arose from the reduction in the average number of SPC devices used and total number of inpatient SPC starts (Table 2).

DISCUSSION

The study evaluated the impact of a VAM program on improving clinical outcomes, patient and health care worker safety, and cost at 5 hospitals that are part of 1 health care system. The health care system partnered with BD to assess and improve infusion practices, processes, and products throughout its facilities, with the goal of delivering better outcomes for patients, health care workers, and the hospital system. The postprogram products included a system that was better aligned with the Infusion Nurses Society's *Infusion Therapy Standards of Practice*²⁵ to reduce add-on devices and manipulation.

After VAM program implementation, significant improvement was observed in first-insertion success,

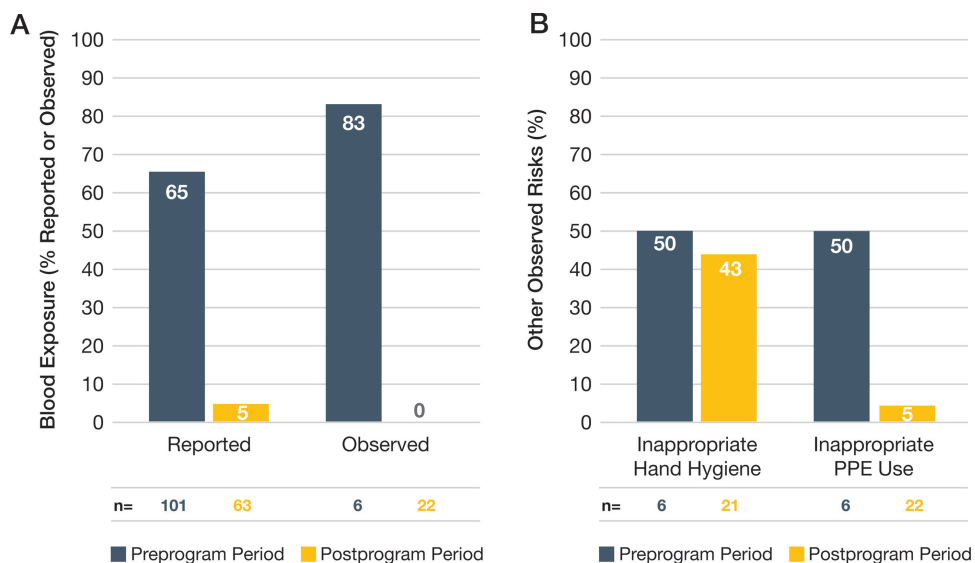


Figure 3 SPC insertion risks; n = number of peripheral vascular access sites assessed. (A) Reported or observed blood exposure; (B) Other observed risks, including inappropriate hand hygiene and inappropriate PPE use. *Abbreviations:* PPE, personal protective equipment; SPC, short peripheral catheter.

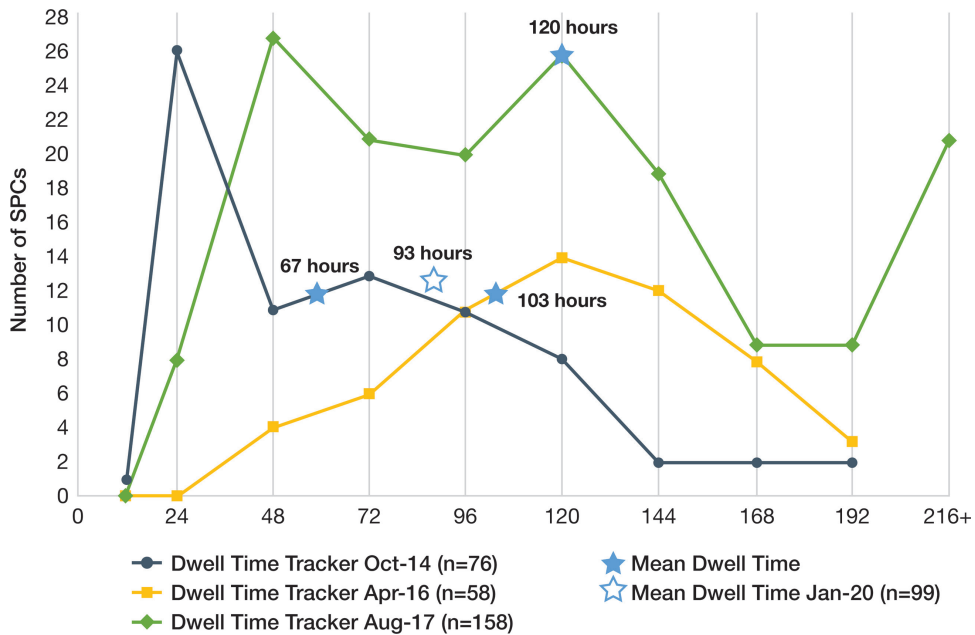


Figure 4 Mean preprogram and postprogram SPC dwell times. *Abbreviation: SPC, short peripheral catheter.*

catheter dwell time, and documentation of catheter insertion attempts. Repeated needle-insertion attempts cause patient discomfort and decrease patient satisfaction^{6,10}; they lead to venous depletion and increase infection risk.⁸ An improvement in first-insertion success thus reduced cost by minimizing increased expenditure associated with these negative outcomes. Better first-attempt success rates were also associated with greater ease of vascular access and improved efficiency for health care workers, which resulted in higher health care worker satisfaction.²⁶ A significant postprogram improvement of 53 hours in average catheter dwell time was also observed. Longer dwell times

can increase patient satisfaction and reduce cost associated with catheter reinsertion or replacement. Under the Affordable Care Act, the Hospital Consumer Assessment of Healthcare Providers and Systems surveys of patient satisfaction with care by the provider play a part in the calculation of value-based incentive payments²⁷; hence, fewer insertion attempts could indirectly impart economic benefits to the hospital in addition to more direct savings.

Both health care worker training and the use of more advanced products are likely to contribute to a decline in insertion-related complications that lead to catheter failure. Phlebitis can arise from mechanical factors such as improper catheter securement.¹⁶ Phlebitis from failed SPC insertion can lead to infection, blood clot, or deep venous thrombosis.²⁸ Suboptimal SPC stabilization can also lead to other undesirable outcomes, which include IV fluid leakage and infiltration into surrounding tissue.²⁹ Use of integrated closed catheter systems like those used after VAM program implementation may reduce the incidence of such complications.

The safety risks to health care workers during SPC insertion decreased after VAM program implementation. A 90% decrease in blood or fluid leakage from insertion sites was observed. Blood exposure to health care workers was significantly reduced, with a 61% decline in reported exposure and an almost complete reduction in observed exposure. Significant reduction was also observed in other potential safety risks, which included unlabeled catheter insertion sites, nonocclusive dressings, and nonvisible sites.

Since the VAM program was introduced, there has been a 353% increase in documentation of SPC insertion attempts. Significant improvement on the part of health care workers in the use of appropriate hand hygiene and PPE was observed; additional training of health care workers on infusion practices as part of the VAM program likely

TABLE 2

Economic Data Collected in Preprogram and Postprogram Periods

Data collected	Preprogram period	Postprogram period
	October 2014	August 2017
Discharged patients (N)	66 971	68 798
Average SPCs per patient (N)	1.568	0.878
Total inpatient SPC starts (N)	105 000	60 404
Cost per SPC start ^a (\$)	\$5.51	\$6.39
Total annual cost for inpatient SPC starts (\$)	\$578,555	\$385,985
	Total savings	\$192,570

^aEstimated cost includes SPC, start kit, extension set, and needle-free connectors. N = estimated total discharged patients. *Abbreviation: SPC, short peripheral catheter.*

played a major role in the results. Accurate and complete documentation can increase patient safety and protect the health care worker and the hospital in the event of a medical malpractice claim.^{21,22} Furthermore, better adherence to process improvements, such as better hand hygiene and use of appropriate PPE, can enhance health care worker and patient safety.

The introduction of the VAM program resulted in cost saving. By increasing first-insertion success, reducing the number of IV attempts, training personnel on proper infusion practices, and using new-technology IV products designed to improve outcomes, the VAM program produced an estimated annual cost saving of \$192,570 for the health care system.

LIMITATIONS

The limitation of the study was that the observations were performed over a 6-year period. There can be staff turnover, and new employees may not receive the same product training. Another limitation may have been that the reassessment performed in 2020 was only at 1 hospital. The results may disclose variation in outcomes if the reassessment was completed at all hospitals in the system. However, there was consistency with the same observers performing the assessments and reassessments. The results of the study reveal that, to maintain safe practices for nurses, a consistent plan for monitoring and tracking is paramount.

CONCLUSION

Nurse leaders and nurses have the potential to produce cost saving, improve patient and worker satisfaction and safety, and achieve adherence to best practices by undertaking process improvement programs focused on VAM. Using evidence-based guidelines, improving vascular access practices by implementing streamlined processes, educating clinical staff on these practices, emphasizing patient safety and satisfaction, and selecting more advanced vascular access products benefit a hospital's patients, health care workers, and economic prospects.

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