Cost-effectiveness of introducing a nursing-based programme of ultrasound-guided peripheral venous access in a regional teaching hospital

ÉMILIE GOSSELIN RN, PhD(C)[1,2], JOHANNE LAPRÉ RN, MSc[3], STÉPHAN LAVOIE RN, PhD[4] and STÉPHANE RHEIN MD, CCFP-EM[5,6]

[1]PhD Candidate (Student), [4]Associate Professor, *École des sciences infirmières, Faculté de médecine et des sciences de la santé, Université de Sherbrooke, Sherbrooke,* [2]Practices as a Registered Nurse, [3]Clinical Nurse Specialist, *Centre intégré de Santé et de Services Sociaux de l'Estrie, Centre hospitalier universitaire de Sherbrooke, Sherbrooke*, [5]Emergency Physician, *Centre intégré de Santé et de Services Sociaux de la Montérégie-Centre, Hopital Charles-Lemoyne, Greenfield Park and* [6]Associate Professor, *Département de médecine d'urgence, Université de Sherbrooke, QC, Canada*

Correspondence
Stéphane Rhein
Département de médecine d'urgence, Université de Sherbrooke, QC
Canada
E-mail:
stephanerheinmd@gmail.com

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Aim To analyse the cost-effectiveness of care provided to patients in need of peripheral venous access by comparing the traditional approach with a nurse-based ultrasound-guided programme.
Background Letting nurses insert ultrasound-guided catheters is a promising cost-saving approach, but there are few data available to document the efficiency of this type of programme.
Method A cost-efficiency evaluative research design was used. Data were collected over a 6-year timeframe, before and after the implementation of the nurse-based programme.
Results Results show that the evaluation conducted by nurses ensures the right choice of catheter for each patient based on the patient's needs, which decreases costs. The programme also shortens the waiting period between consultation and insertion of the catheter, which reduces costs related to prolonged hospitalisation.
Conclusion The nurse-based programme puts nurses' skills to good use as part of a new practice and helps enhance the efficiency of care and services provided to patients.
Implications for nursing management In addition to the significant cost savings this programme offers, the evaluation leads to an effective use of resources while ensuring optimal care.

Keywords: cost-effectiveness analysis, nursing role, peripheral venous access, ultrasound, ultrasound-guided

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Introduction

Health care institutions are always on the lookout for innovative ways to control costs without decreasing the quality of patient care. Obtaining intravenous access in difficult situations is one area that has received much attention in recent years (Emergency Nursing Association 2011a). Not only is it a major source of distress to patients, it often requires a greater expenditure of time by staff and the insertion

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of more costly catheters such as peripherally inserted central catheters (PICCs). Such catheters are often inserted by a specialist (a radiologist or anaesthesiologist) in the radiology suite or the operating room, resulting in even greater costs due to waiting lists, transportation and the need to confirm correct placement of the catheter with radiography.

In the last decade, ultrasound has gained popularity for obtaining difficult intravenous access in the emergency department, the intensive care unit and even the ward. Several studies have shown the efficacy of such a technique performed by non-radiologists with reduced access time, a similar complication profile and greater patient satisfaction (Bauman *et al.* 2009, Stokowski *et al.* 2009, Adhikari *et al.* 2010). In 2011, the Emergency Nurses Association adopted a resolution to include ultrasound-guided peripheral intravenous insertion in the scope of practice of emergency nurses (Emergency Nursing Association 2011b). It is in this context that a new programme for ultrasound-guided peripheral venous access (UPVA) by nurses was developed. The hypothesis was that implementation of the programme would lower insertion costs for difficult intravenous access while improving the quality of care for the patients concerned.

Literature review

Several similar nurse-based ultrasound-guided programmes have been studied in recent years, but to our knowledge, only three have addressed the cost-effectiveness of such an endeavour. The first, conducted by Robinson *et al.* (2005), showed that having a dedicated team for PICC insertions seemed to lower costs. The study demonstrated a cost reduction of 9% when the programme was established and 24% when ultrasound was used. The dedicated team was composed of physicians, physician assistants and interventional radiologists. Unfortunately, the team did not include nurses, the focus of the present study.

The second study (Johnson *et al.* 2009) showed that PICC placement at the bedside was three to four times less expensive, provided greater patient comfort and lower risk than having this done in the radiology suite. That study specifically concerned PICC insertions. However, portable ultrasound can be used to install several types of cheaper and less invasive catheters depending on indications, potentially resulting in a further reduction of costs and complications.

The third study (Walker & Todd 2013) is a retrospective analysis of two groups performing PICC insertion. It showed a 42% greater cost when done by radiologists than by nurses. Though the success rate was slightly higher in the radiologist group, there were fewer complications and patient satisfaction was greater in the nurse group. The study demonstrated the feasibility and cost-effectiveness of a nurse-based programme. However, the added value of ultrasound in the nurse's armamentarium was not shown clearly. There was no performance comparison before and after the nurses were trained to use it.

Thus, replacing traditional methods by a nurse-based programme of UPVA appears to be cost-effective while maintaining the quality of patient care. These results inspired the creation and implementation of a new programme in a university hospital.

Programme description

The programme targets three types of catheters. The PICC, a 55 cm catheter inserted in radiology, which the patient can keep for several weeks or months as long as it remains functional. The midline catheter, a 10 cm catheter inserted at the bedside, which can stay in place for 29 days. Finally, the short peripheral catheter, less than 7.5 cm, which can also be placed at the bedside, can stay in place for up to 4 days, depending on local protocols.

Peripherally inserted central catheters used to be inserted by specialists. Treating physicians had to file a request for this service. Between 2006 and 2010, the number of PICC requests doubled (rising from 400 to 811), which significantly prolonged the average patient stay. The hospital became unable to meet demand with the available staff and facilities. Ultrasound-guided insertion of midline and short peripheral catheters was not performed at the hospital because nurses had not been trained to insert them.

To improve this situation, the hospital's management team supported a process that would empower nurses to insert the three aforementioned types of ultrasound-guided catheters. A committee of individuals active in the workplace was put together to guide this practice.

A training plan for the two programme nurses was developed. It was divided in to three parts and included theory and practice lab sessions.

Part 1 consisted of learning how the ultrasound machine works and the basics of ultrasound-guided venous access. The continuing education centre affiliated with the hospital provided a 4 hours training session called 'Accès veineux périphérique échoguidé' or UPVA; this was followed by supervised practice on 10 patients, as suggested by White *et al.* (2010). In part

2, participants learned about the specifics of inserting PICCs, during 10 hours of training and supervised practice on 25 patients. Part 3 included becoming familiar with the midline through 2 hours of training and supervised practice on 10 patients.

In the programme, nurses did the following: assessed patients to identify vascular access needs; selected the appropriate device; used the intravenous catheter ultrasound-guided insertion technique they had learned; ensured that the venous access was working properly; performed clinical monitoring; detected complications; intervened when appropriate; educated patients and family members; developed a treatment plan when needed; and documented procedures. As for continuity of care, health care partners were informed of practice changes and the introduction of new types of catheters. Nurses ensured that all relevant information was communicated to the outpatient service that would be following patients as they continued intravenous treatments at home.

Methodology

Goal

The goal of this study was to analyse the cost-effectiveness of care provided to patients in need of a peripheral venous access by comparing the traditional approach with the nurse-based ultrasound-guided programme described above.

Design

The effectiveness analysis from the evaluative research design by Brousselle *et al.* (2011) supported this study. This type of analysis focuses on relations between resources used and clinical outcomes.

Population and description of the teaching hospital

The study took place in a supra-regional teaching hospital that provides general and specialised care at two sites.

Variables, data collection and data analysis

The dependent variable was the cost of inserting the UPVA. Independent variables were: (1) number of catheters; (2) type of catheter used; (3) type of health professional installing the catheter; and (4) mean cost estimate per catheter. Costs associated with material resources included the catheter (depending on type) and all items required to perform the technique (e.g. smocks and gloves, disinfecting devices, bandages). Human resources included staff remuneration for each type of catheter, including the nurse or specialist performing the technique, the radiology technician, room disinfection and patient transport (if the catheter was inserted in the radiology suite). All costs reported are measured in canadian dollar.

As the goal of the study was to compare the traditional approach and the nurse-based programme, we established two periods. T1 represents the 3-year period before implementation of the nurse-based programme (2009–10, 2010–11, 2011–12), while T2 represents the 3-year period following implementation of the programme (2012–13, 2013–14, 2014–15). For data presentation purposes, we refer to these six periods as Year 1, 2, 3, 4, 5 and 6.

Variables were collected from the hospital's operational statistics and cost tables from the RAMQ (Quebec's health insurance authority). A descriptive analysis of the data was conducted.

Results

Number of catheters installed

Table 1 shows the number of catheters inserted each year, from 2 years before implementation of the programme until the end of the study. The nurse-based programme was implemented in 2011–12 (Year 3) as part of a pilot project. The project was subsequently renewed, and two nurse clinicians were assigned full-time to inserting catheters with ultrasound guidance.

Direct cost comparison

The special training given to the two nurses in the programme cost $2405. Part 1 of the training (UPVA) incurred costs of $500 for classroom training, $360 for direct supervision and $965 in remuneration for

Table 1
Comparisons of numbers of catheters installed

	PICC				
Year	Specialist	Nurse	Midline Nurse	Short peripheral catheter Nurse	Total
2009–10	811	–	–	–	811
2010–11	407	–	–	–	407
2011–12	396	13	–	–	409
2012–13	276	145	29	10	460
2013–14	82	297	220	341	940
2014–15	54	349	180	738	1321

Table 2
Cost comparison

Catheters installed	*PICC*		*Midline*	*Short peripheral catheter*
	Specialist	*Nurse*	*Nurse*	*Nurse*
Material resources	$195.06	$195.06	$77.22	$5.08
Human resources	$235.50	$150.25	$6.91	$3.45
Length of installation (minutes)	20	20	10	5
Duration of catheter (days)	365	365	30	4
Total	$430.56	$345.31	$84.13	$8.53

$ referes to canadian dollar.

Table 3
Installation costs for each type of catheter and professional involved

		Installation costs/catheter type/professional involved					
		PICC		*Midline*	*Short peripheral catheter*		*Cost per catheter*
	Catheters installed (n)	*Specialist ($)*	*Nurse ($)*	*Nurse ($)*	*Nurse ($)*	*Total ($)*	*($)*
T1							
Year 1	811	$349 184.16	N/A	N/A	N/A	$349 184.16	$430.56
Year 2	407	$175 237.92	N/A	N/A	N/A	$175 237.92	$430.56
Year 3	409	$170 501.76	$4489.03	N/A	N/A	$174 990.79	$427.85
Sub-total	1627	$694 923.84	$4489.03	N/A	N/A	$699 412.87	$429.88
T2							
Year 4	460	$118 834.56	$50 069.95	$2439.77	$85.30	$171 429.58	$372.67
Year 5	940	$35 305.92	$102 557.07	$18 508.60	$2908.73	$159 280.32	$169.45
Year 6	1321	$23 250.24	$120 513.19	$15 143.40	$6295.14	$165 201.97	$125.06
Subtotal	2721	$177 390.72	$273 140.21	$36 091.77	$9289.17	$495 911.87	$239.25

$ referes to canadian dollar.

the two nurses in training. There were no extra costs for the specifics of inserting PICCs, midlines and short peripheral catheters, except for the nurses' salary during parts 2 and 3 of the training: $580.

Two ultrasound machines worth $32 000 each were bought to be dedicated to the program, for a total cost of $64 000.

Table 2 compares the costs associated with inserting each type of catheter. PICC, the most expensive choice mainly due to equipment cost and the involvement of several types of human resources, costs 430.56$. Inserting a PICC costs $85.25 less when performed by a nurse instead of a specialist. Incorporating midlines in the nurse-based programme offered an interesting alternative, as they last as long as PICCs but cost $346.43 less than the traditional approach. The less expensive catheter is the short catheter, which costs $8.53; however, its lifespan is considerably shorter than the other two types of catheters. PICCs require the longest installation time, followed by the midline, then the short peripheral catheter.

Table 3 shows installation costs per type of catheter and professional involved, relative to the number of catheters installed each year. At T1, almost all catheters (1627) were inserted by specialists, leaving only 13 for the nurses starting the pilot project. Once the nurse-based programme was implemented (T2), 412 catheters were inserted by specialists and 2309 by nurses. As can be seen in Table 3, the average cost per catheter dropped significantly during the study, falling from $430.56 in year 1 to $125.06 in Year 6.

If all catheters inserted during T2 had been inserted using T1 parameters (specialists and PICC lines only), the total cost would have been $1 171 553.78. As catheter insertion during T2 actually cost $495 911.87, we can estimate that the nurse-based programme operating since 2012 generated $675 641.91 in savings. If the original cost of the nurses training and the purchase of dedicated ultrasound machine are withdrawn ($66 405), the net amount of savings is $609 236.91.

Discussion

Direct cost comparison

Our results show a significant decrease in costs when peripheral venous accesses are inserted after a nurse-

based ultrasound-guided programme is introduced, as compared to the traditional approach. The initial investment in training dedicated nursing staff and ultrasound machine was recovered within a few months and is expected to be even less today, as the price of ultrasound machines is constantly decreasing with advances in technologies.

This decrease is due to better patient evaluation leading to the right catheters being chosen, combined with a more effective use of nursing staff. As mentioned in other studies, in-depth patient evaluation by nurses in the programme results in selection of the most appropriate catheter for the patient's needs, given the expected duration of intravenous treatment (Walker & Todd 2013). In 2012–13 (Year 4), less invasive catheters were introduced, which significantly enhanced demand. In fact, the increasing number of catheters inserted was the result of adding the use of midline and short peripheral catheters. Several times, a midline was used instead of a PICC, while a short peripheral catheter was often chosen for shorter treatments. As the PICC is more expensive to insert, requires more human and material resources and needs an X-ray to confirm proper placement, using the other types of catheters when possible lowers costs. A previous study also showed that inserting venous accesses at the bedside using ultrasound guidance is a much more cost-efficient solution (Johnson *et al.* 2009). This study confirms that significantly reducing PICC insertions in radiology suites has a major impact on overall costs, even though some PICCs were still being inserted in the operating room, either in emergencies or when patients weighed more than 150 kg (the maximum weight accepted on the radiology table).

Furthermore, training nurses rather than physicians to use ultrasound for difficult venous access also lowers costs. Similar cost reductions have been noted by other researchers (Walker & Todd 2013). Doctors in Quebec are not paid by hospitals but by the *Régie de l'assurance maladie du Québec* (RAMQ), a publicly financed government agency. Of the savings of $675 641.89, a portion ($270 739.50) was directly saved by the hospital. The nurse-based programme therefore offered considerable savings not only for the hospital but for the provincial health system as a whole.

Finally, having catheters installed by a dedicated team at the patient's bedside eliminates the delay between consultation request and catheter installation when a radiology room is unavailable. This shortening of wait time reduces indirect costs related to extended hospitalisation, as noted by other researchers (Robinson *et al.* 2005, Johnson *et al.* 2009). Such indirect costs were not included in our analyses for this study.

Non-monetary benefits

The cost reduction reported was not achieved at the expense of quality of care and safety, though nothing in particular was done to ensure this outcome. Other studies have shown that quality of care does not decline and can even improve when ultrasound-guided catheter installations are performed by nurses (Bauman *et al.* 2009, Stokowski *et al.* 2009, Adhikari *et al.* 2010, Walker & Todd 2013). Several patients reported that the ultrasound-guided long catheter technique was less painful and took less time than the blind technique (Bauman *et al.* 2009). In addition, as proportionally fewer PICCs were inserted, there was less exposure to the complications associated with more invasive venous catheters (Nolan *et al.* 2016). It would be useful in future studies to measure quality of care and patient satisfaction before and after a nurse-based programme is implemented.

Such a programme also promotes rigorous patient monitoring. Unlike specialists, who would rarely see patients again after the procedure, the nurse team systematically reassesses each patient. This allows them to verify the functionality of the venous access, reassess the need for it as the patient's clinical status evolves, and answer any questions raised by patients and caregivers. Thus, inserting catheters using ultrasound guidance involves more than technical skills, for it includes activities that are exclusively performed by nurses (OIIQ 2004). In future studies, it would be interesting to quantify the degree to which personalised patient care by a nurse-based programme affects quality of care and the frequency of complications.

Limitations

There is a possibility of historical bias, as integration of the new types of catheters (midline and short peripheral catheter) was concurrent with the introduction of the nurse-based ultrasound-guided programme. Results for the two measuring periods are therefore not totally equivalent, as the new catheters only became available in T2. The lack of a control group and clinical data about the patients prevent us from documenting a risk of confusion bias. As previously mentioned, indirect costs related to implementing the nurse-based programme, such as length of

hospitalisation, were not considered in the study results. Finally, care quality indicators related to patient satisfaction and complication rates were also not considered in this analysis.

Conclusions

The present study shows that introducing a nurse-based ultrasound-guided programme for the insertion of peripheral venous accesses results in a significant cost reduction compared to the traditional approach. Despite the initial costs of developing the programme and training staff, total costs fell thanks to better patient assessment (leading to the right choice of catheter) and the optimal use of nursing staff. This nurse-based programme applies nursing skills to a new professional practice, improving the efficiency with which care and services are provided to patients. Future studies could validate patient satisfaction and the impact of such a nurse-based ultrasound-guided programme on complication rates and quality of care.

Implications for nursing management

This study demonstrates that, beyond the major cost savings of introducing a nurse-based ultrasound-guided programme, having a nurse assessing patient's needs results in a better use of resources, while ensuring optimal quality of care. For managers, the results confirm the soundness of making such changes to hospital operations. Using the published guidelines of organisations that set practice standards – in the present case the Emergency Nursing Association – managers can implement real and significant structural changes. Basing change on an algorithm that guides nursing practice facilitates change management and the rigorous evaluation and quality assurance of decisions made for patients. The study also shows how important it is to analyse and compare the costs associated with introducing a new programme. Finally, this study clearly establishes the key role of management in the implementation of new ways of doing things that combine nursing leadership and interdisciplinary collaboration with medical teams.

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Ethical considerations

In view of the nature of the data (no data involving human subjects), no ethical approval was needed.

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