Training Program for Ultrasound-Guided Intravenous Catheter Insertion

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ABSTRACT

Introduction:

Ultrasound guidance is now widely available in military treatment facilities and civilian hospitals alike, both in the USA and in forward-deployed military environments. Technical mastery of ultrasound-guided peripheral intravenous (USGPIV) catheter insertion can be easily achieved through a short training course. Mastery can be achieved even when trainees have a limited medical background before course attendance. An evidence-based practice project team sought to improve the knowledge, confidence, and skills in the placement of USGPIV catheters by clinicians at Naval Hospital Jacksonville. Completion of an USGPIV training program can equip healthcare providers with knowledge and confidence for placement of peripheral access necessary in critical situations such as those requiring medications or blood products.

Materials and Methods:

The project team conducted a literature review to evaluate the appropriateness of USGPIV training for the nurses and military medical technicians in this setting. The team developed and delivered a USGPIV training program based on adaptations from the literature. During the training period, knowledge and confidence scores were reported by each trainee to evaluate the perceptions of the quality of training. The number of attempted catheter placements and ultrasound utilization was recorded in the pre- and post-implementation periods to evaluate the project's effect on the delivery of patient care. Statistical analysis was conducted to evaluate project outcomes.

Results:

In the pre-intervention period, none of the 252 intravenous catheters were placed with the USGPIV technique, compared to 50 of 267 in the post-intervention period. These results demonstrate an 18.7% increase in the USGPIV access approach by nursing staff. Mean knowledge scores significantly increased following the delivery of the training, 60% versus 80% in the pre- and post-training assessments, respectively ($P < .001$). Mean self-reported skill confidence scores also significantly improved ($P < .001$).

Conclusion:

Knowledge and self-reported confidence in USGPIV access improved for the trainees. Mean knowledge improved from 60% to 80%, while mean confidence scores increased from 2.74 to 3.79 for corpsman and from 3.0 to 3.88 for nurses. Utilization of the USGPIV technique increased by 18.7% in the post-intervention period. These results demonstrate that implementing this training program can improve knowledge, confidence, and use of ultrasound during the placement of PIV catheters.

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INTRODUCTION

When attempts at peripheral intravenous catheter (PIV) insertion fail, it may cause pain, exhaust supplies, delay diagnostic testing, or result in deleterious outcomes from delayed treatment during trauma resuscitation.[1] Hypovolemia, obesity, extremes of age, anatomical derangements, and chronic illness are associated with difficulty establishing peripheral venous access.[1,2] Peripheral intravenous catheter insertion is a fundamental skill for military medical personnel. Multiple attempts at PIV access may increase patient anxiety and infection risk, delay care, or result in patient harm.[1,3,4] Catheters are also discarded after each attempt, wasting thousands of dollars per year for each nursing unit.[3] Ultrasound guidance can be taught to staff to reduce the number of unsuccessful attempts and the associated untoward effects.

Significance of the Problem

Peripheral intravenous catheter access requires approximately 3 minutes when performed by nursing staff without assistance

from physicians or specialty care providers.[3] If provider intervention is required, the procedure may be delayed by 1 hour or more, resulting in the deleterious effects described above. An ultrasound-guided peripheral intravenous (USGPIV) access training program was available but underutilized at Naval Hospital Jacksonville. Before the project began, the staff reported an average of two to three insertion attempts on the obstetric and preoperative units to achieve PIV access. These recorded attempts were made without ultrasound guidance, and subsequent attempts at PIV access were also usually performed without ultrasound guidance. Ultrasound guidance should be used to improve the chances of successful catheter insertion, especially after two failed access attempts.[1,2,4,5] Improving familiarity with ultrasound guidance may also improve the frequency of its use.[1]

Relevance to Military Nursing

One of the 2017 National Defense and Authorization Act's core provisions is to ensure the development of a trained and ready health team and training medical personnel domestically to treat service members in the operational setting.[6] Navy nurses and hospital corpsmen in the deployed environment must obtain intravenous access to deliver critical, life-saving interventions such as blood products, antibiotics, and vasoactive medication.[4] Military medical personnel must become proficient in ultrasound use, delivering the same quality care whether in austere environments, tents, or afloat.[5,6] The project team sought to prepare military nurses and hospital corpsmen in the skills of USGPIV insertion, using a training program that could be replicated in any military medical environment.

METHODS

General Approach

The project team sought to determine the local effect of USGPIV training on the rate of ultrasound utilization and the number of intravenous catheter insertion attempts. Efforts to achieve this by the project team involved using the Johns Hopkins Nursing Evidence-Based Practice three-step process model of asking a practice question, searching for evidence, and translating the evidence into practice.[7] Our search of the literature revealed remarkable homogeneity in training methods for USGPIV. Comparisons of the standard multimodal training with other methods were lacking. The literature on this topic also featured very little in terms of productivity and cost benefits of this intervention.

This project team chose to focus on a study conducted at another military hospital[4] because it provided a detailed review of the implementation of its quality improvement project and methods for sustainment in military populations. While most other sources supported a USGPIV-blended training program for single departments, their study created a training process involving an initial 1-hour didactic session for military populations in military treatment facilities (MTFs). They simulated initial attempts with a gel model and then inserted three proctored USGPIV access attempts on live patients. The authors described having created a policy for nursing USGPIV access and a tracking document to renew individual nurses annually. Members of nursing leadership were included in the training sessions to create resident subject-matter experts, and their efforts led to skill sustainment.[4]

The project team merged preexisting training materials and built upon that training with evidence from another study.[4] The team delivered this training to nurses and hospital corpsmen in the obstetric ward and preoperative units. The number of PIV access attempts before and after the intervention was measured. The effectiveness of the training on knowledge and confidence was also measured immediately before and after the training.

Setting

U.S. Navy staff at this community-sized facility initiating PIV access most often include nurses and hospital corpsmen, assistive personnel who provide skilled services either within hospitals or on the battlefield. The preoperative unit consists of a rotating staff of 24 nurses and 18 corpsmen who prepare patients for surgery, including establishing PIV access. The obstetric unit's rotating staff consist of 21 nurses and 24 corpsmen to establish large-bore PIV access on all laboring patients. There is one ultrasound machine readily available in each of these patient care areas. However, at any given time, these devices may be utilized for other procedures such as regional anesthesia or obstetric assessments. During these times, the use of ultrasound for PIV insertion may not be feasible. Before the implementation of our evidence-based practice project, USGPIV access training modules were available for nurses and corpsmen online. Although the training was readily available, none of our participants had completed these preexisting modules due to a lack of in-person training, high staff turnover, and low sustainability. Online training module topics included vessel anatomy, ultrasound device operation, and a stepwise approach to ultrasound use during catheter insertion. Our project team found these training topics valuable and planned to continue utilizing them with the addition of hands-on skills learning and improving accessibility.

Procedural Steps

Starting in 2019, staff on both units logged the number of attempts per patient to obtain PIV access. Although the team replaced the preexisting training program, the use of some preexisting components was made more robust by merging training methods and leadership involvement demonstrated by the prior MTF project.[4] The project team created a training program centered on providing didactic and face-to-face, hands-on skills training to nurses and corpsmen. The facilitators received formal graduate-level classroom instruction in

ultrasound science, and their skills were validated by nurse anesthesia faculty to perform USGPIV access before training others.

The project team worked with leaders in each of the two units to determine appropriate times and dates for optimizing staff attendance at 1-hour in-person training sessions. The facilitators conducted training sessions that overlapped shifts to accommodate nurses and corpsmen working days and nights. These sessions centered on using the training tools readily available at this institution: three ultrasound machines, two gel models, a large-screen portable monitor to deliver a slide presentation, laser pointers, and USGPIV insertion supplies such as transparent dressings, tourniquets, ultrasound gel, cleansing prep wipes, tape, gauze, gloves, and intravenous catheters. Four training sessions occurred in 2019.

At the start of training, students completed a seven-question pre-assessment quiz. The quiz included five questions derived from the preexisting online training to assess knowledge. The project team included a Likert scale question sourced from our literature review to measure confidence.[1] The final demographic question asked whether the participant was a "nurse" or a "corpsman."

The project team then presented the policy and procedures for USGPIV catheter placement using a 12-slide 20-minute presentation emphasizing vessel anatomy, ultrasound science, and approach techniques. For the remaining 40 minutes, the facilitators asked students to return-demonstrate ultrasonography skills and encouraged questions. The transverse short-axis ultrasound technique was taught to the participants since it has shown to be easier to learn for novice users.[4] After participants demonstrated competency with the ultrasound machine, they were given the option to identify vessel anatomy on each other and place USGPIV catheters utilizing gel models. At the end of each training session, the project team readministered the quiz for post-training data collection. The training intervention ended after 100% of staff on these units completed the USGPIV access training sessions.

After students attended the in-person training sessions, the online training modules were assigned to reinforce knowledge. Staff members' respective leadership assigned modules and designated USGPIV access champions verified completion. The project team selected unit champions from volunteers to continue teaching the program after completion of both face-to-face training and online modules. These champions would be the foundation for the sustainability of USGPIV competency. A minimum of five proctored USGPIV access procedures were required to achieve proficiency—a process facilitated by unit leadership.[4]

Following each training session, the project team collected live feedback from nurses and corpsmen. After completing all training, the project team provided new PIV access logs and asked the nurses and corpsmen to continue recording: the type of technique, either traditional or ultrasound-guided, and the number of attempts for PIV insertion. Based on the literature review, at least 30 USGPIV access attempts would create a sample size large enough to approximate a normal distribution.[1] These post-intervention data were collected over 6 months in 2020.

The project team analyzed post-intervention knowledge scores using a paired *t*-test and descriptive statistics. The team completed calculations with Microsoft Excel for Mac version 16.40, Microsoft Corp. The project team analyzed skill confidence on a Likert scale with a Wilcoxon matched-pairs test using RStudio software version 1.3, Public Benefit Corp.

RESULTS

In the pre-intervention period, clinicians recorded 252 PIV access procedures. Given that no nurses or corpsmen in these units had completed the existing USGPIV catheterization training modules, all PIV access attempts were performed using the visualization and palpation technique. In the post-intervention period, staff recorded 267 PIV access procedures. Nurses and corpsmen described having used ultrasound for patients with a history of difficult PIV access or after two traditional attempts failed. Ultrasound was used in 50 of the 267 total procedures, accounting for 18.7% of all attempts in this period.

A total of 40 corpsmen and 8 nurses completed all portions of the self-assessment. Pre-intervention knowledge scores ranged from 20% to 100% correct. Post-intervention knowledge scores likewise ranged from 20% to 100%. Results from our knowledge assessment can be found in Table I, reflecting that the mean knowledge score was 60% pre-intervention and 80% post-intervention, demonstrating a statistically significant improvement ($P < .001$).

Of the 48 participants, 1 nurse and 1 corpsman failed to record both pre-training and post-training confidence scores, leaving 46 participants in the final confidence analysis. Pre-intervention self-report of confidence ranged from 1 to 5 on a Likert scale, with the higher numbers indicating lower skill confidence. Post-intervention confidence scores ranged from 1 to 5. The mean confidence score pre-intervention was 2.74 for corpsman and 3.00 for nurses. In the post-intervention survey, this improved to a mean of 3.79 for corpsman and 3.88 for nurses, constituting a statistically significant improvement in self-reported skill confidence with $P < .001$ for corpsmen and $P < .04$ for nurses. Our pre- and post-implementation data results for confidence are found in Table I.

DISCUSSION

Strengths

The implementation of this project's USGPIV access training program fostered attainment sustainability of new skills readily applicable to the deployed military setting, MTF, and civilian facilities alike. The project team informed that their project with the work from a different military hospital[4] using both didactic and hands-on training methods proved to be beneficial in the outcomes. The project team improved nurse

TABLE I. Knowledge and Confidence Assessment Results

Provider	Question	Percentage correct		Percentage improvement	Count correct	
		Pre	Post		Pre	Post
Knowledge assessment questions						
HM	1	53	75	22.5	21	30
	2	10	90	80	4	36
	3	73	95	22.5	29	38
	4	95	92	−2.5	38	37
	5	75	50	−25	30	20
RN	1	88	87	0	7	7
	2	0	100	100	0	8
	3	63	100	37.5	5	8
	4	88	87	0	7	7
	5	50	38	−1	4	3
Confidence assessment questions						
Provider	Pre	Post	*P*-value			
HM	2.74	3.79	.001			
RN	3.00	3.88	.04			

Abbreviations: HM, hospital corpsman; RN, registered nurse.

and corpsman autonomy to support the appropriate allocation of manpower while increasing confidence, knowledge, and the use of ultrasound. Nurses and corpsmen or other civilian ancillary staff who possess knowledge, confidence, and ultrasound interpretation skills can successfully execute USGPIV access in any environment. This skill aligns with the Military Health System's Quadruple Aim by improving the medical force's readiness.[6] Timely and accurately placed PIV access supports providing the highest quality, value-based care.

Our overall process and implementation followed the work of the previous MTF[4] and reinforced the feasibility of USGPIV access training in an MTF. The multimodal training method implemented at their facility was easily replicated at Naval Hospital Jacksonville using existing material and achieved the project's primary aims for our population. Our project team based our design for measuring outcomes on the Kirkpatrick Model, which describes how learning translates into practice rather than focusing on downstream patient outcomes.[8] Due to frequent and unexpected staff turn over in our MTF, our project team found that use of the Kirkpatrick Model where we performed implementation, collection, and evaluation of data prior to staff turn over strengthened immediate composite results. This project demonstrated that teaching this technique could result in a change of practice, and this change was also reported to have impacted patients directly, noted in the "Results" section with staff reporting the use of the ultrasound machine for PIV placement. Although not quantified, this practice may have avoided potentially unsuccessful visualization/palpation attempts in favor of using USGPIV as is demonstrated in other literature, where USGPIV access is achievable when traditional methods fail or when there may be perceived difficulty by staff.[5,9,10]

Weaknesses

The aggregate results of our knowledge assessment revealed possible issues with our didactic content and the wording of our questions. Item number 4 regarding the indications for USGPIV was not addressed explicitly in our didactic training, and appropriate changes will be made. The wording of the answer choices for item number 5 on our assessment appears to have confused our participants, and several participants raised the issue with item 5 during the implementation of our training sessions. The question will be reworded in future iterations of this training intervention to improve clarity.

Although we tracked the total number of attempts during data collection, we failed to distinguish PIV catheters that were placed by traditional methods versus by the use of ultrasonography, and demographic data for these attempts were also not collected. Failure in collecting patient demographics was due in part to this being an evidence-based project, where the feasibility of achieving reliable data collection from the staff was a concern; therefore, we aimed to minimize respondent burden. The results were not intended to be generalizable, but they were intended to be relatable, therefore causing us to limit our variables as defined in this article to those that other MTFs could feasibly replicate for their populations. Additionally, because it had already been widely established that the number of PIV attempts is reduced when USGPIV is used, we did not seek to confirm this finding further, thereby limiting our project results.[5,9,10]

Limitations

With regard to study size, we found it more feasible to implement our project in the two units with the most PIV attempts that lacked a preexisting form of ultrasound training, whereas other projects performed facility-wide implementation.[2,4] Implementation across multiple units is a significant time investment for both the trainers and the departments, emphasizing the importance of unit champions for program sustainment. During implementation, the project team faced resistance to change, as is common to most implementation

efforts. In some cases, new staff arrived after the training sessions were given, and designated project champions would leave their positions without designating a new champion. As is demonstrated in the literature, successful sustainment is highly reliant on consistently designated proctors.[4] Future project implementation should include strategies to address this barrier by providing training at hours convenient for military staff while ensuring training sessions are brief, focused, and targeted to their audience.

The severe acute respiratory syndrome coronavirus 2 pandemic provided our project team with the limitation of decreased hospital census and the obstetric ward's closure during the data collection period. Restrictions of patient care made data collection more challenging, given there was a limited requirement for PIV access and limited clinician's ability to perform a follow-up training and discussion with the staff. The global pandemic has also highlighted the awareness of the importance of achieving PIV access on the first encounter. Doing so helps decrease the number of staff members who need to enter a patient care area, decreasing the potential transmission of infectious agents.

Future Directions for Research and Practice

Following implementation, the project team interviewed the staff and noted that more outcomes would be of interest in future projects and provided further opportunities for practice improvement. Our work is being utilized to inform another follow-on project at our facility, focusing on more patient-specific factors related to PIV placement—specifically, the integration of local anesthetics at the PIV catheter entry site as a means of analgesia to positively impact the patient experience through decreased pain. Another future direction for practice in USGPIV access is applying newly available portable smartphone-based ultrasound technology. The added convenience of these devices may increase their utilization at the bedside compared to bulkier console-style devices.

CONCLUSIONS

This project's primary focus was to increase nurses and corpsmen's knowledge and confidence when using ultrasound and facilitate PIV placement while simultaneously increasing the overall use of ultrasound for PIV access. A statistically significant increase was found in both knowledge and self-reported confidence using our pre- and post-intervention tests and self-reported confidence tool. The project team increased the ultrasound utilization by 18.7% in the post-intervention period. Implementation of this ultrasound training program positively impacted these military clinicians' confidence and knowledge and has demonstrated the ability to be implemented in MTFs and civilian hospitals alike.

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CONFLICT OF INTEREST STATEMENT

None declared.

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