Ultrasound-Guided Peripheral Intravenous Access Program for Emergency Physicians, Nurses, and Corpsmen (Technicians) at a Military Hospital

LCDR Lauren Oliveira, MC USN; CDR Matthew Lawrence, MC USN

ABSTRACT Background: Peripheral intravenous (PIV) access is a common procedure in the emergency department (ED). However, conditions such as obesity and hypovolemia can often make access difficult by the traditional landmark technique. The use of ultrasonography has improved the success of PIV placement in this setting. Objectives: A novel Ultrasound (US)-Guided PIV Access program was initiated in our ED to train emergency nurses, U.S. Navy corpsmen, and physicians. Methods: This was an observational study of emergency providers performing US-guided PIV placement. After a training session, all ED providers began utilizing the US for difficult intravenous access patients. All complications, location of access, and previous experience level were recorded. The choice of a transverse, longitudinal, or a combination approach was also recorded. Results: We did not observe significant differences in ability with US-guided PIV access when comparing success rates between emergency physicians, nurses, and technicians ($p = 0.13$). In the novice user, a transverse or a novel combination of a transverse and longitudinal method appears to be the most successful. Conclusion: ED physicians, nurses, and corpsmen can successfully place US-guided peripheral catheters for venous access. Developing a training program for emergency providers in US-guided venous cannulation is feasible and safe.

INTRODUCTION

In the Emergency Department (ED), securing peripheral intravenous (PIV) access is a common and occasionally challenging procedure. Placement of PIV lines in a difficult-to-access patient can be a problem for even the most experienced provider because of etiologies such as obesity, chronic illness, hypovolemia, intravenous (IV) drug abuse, and extremes of age. In many of these patients, the usual landmark and palpation method is difficult or even impossible. Multiple unsuccessful peripheral attempts, delays to diagnostics and treatment, and excess use of central catheters can result.

Several studies have demonstrated the successful use of ultrasound (US)-guidance for PIV placement by physicians.[1,2] In recent years, the literature has expanded to show that nurses also have a high success rate in the placement of US-guided PIV lines.[3] However, to date, only 2 published studies have examined the ability of ED technicians to perform this valuable procedure.[4,5] A corpsman in the U.S. Navy or medic in the U.S. Army or Air Force fills the role of the technician in a military ED. Investigating the use of US-guided PIV lines in this military subset has not been reported.

Department of Emergency Medicine, Naval Medical Center Portsmouth, 620 John Paul Jones Circle, Portsmouth, VA 23708.

doi: 10.7205/MILMED-D-15-00056

Methods of obtaining US-guided PIV access include either a transverse or longitudinal approach. In the transverse approach (Figs. 1 and 2), the operator must fan the probe to find the needle tip whereas in the longitudinal approach (Figs. 3 and 4), the entire length of the needle and catheter can be visualized on the screen without moving the transducer. Previous reports suggest that in the novice operator, the transverse approach is faster and more successful since it is easier to keep the vessel in view during the procedure.[6] In the more experienced operator, the longitudinal method is often preferred since the entire catheter can be visualized entering the vessel. A novel combination method involving starting the procedure in transverse and then changing the view to longitudinal once the needle is centered over the vessel has not been studied in the novice user, and we believe this is an excellent approach.

Emergency nurses and technicians are usually the first to attempt PIV placement and will be better prepared for a patient with difficult access if aided by US. Logically, when another level of ED staff is required for assistance with line placement, valuable time will be lost. The success rate, number of attempts, rate of complications, location of access, and approach to access are important aspects of this procedure.

MATERIALS AND METHODS

On the basis of this data, we sought to improve the efficiency of our practice by implementing the use of US guidance for PIV access. Specifically, we developed a policy, produced a training course, and assessed the progress and success of the program. This project took place at a tertiary care medical center that serves active duty, beneficiaries of active duty, and retired military personnel. Physicians, nurses, and corpsmen completed an optional training session taught by two

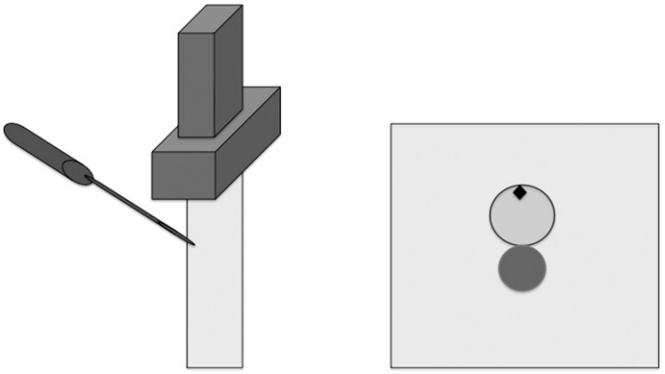

FIGURE 1. Catheter and transducer position illustrating the transverse approach. The graphic on the right depicts the US image obtained. Note that only a portion of the catheter can be visualized.

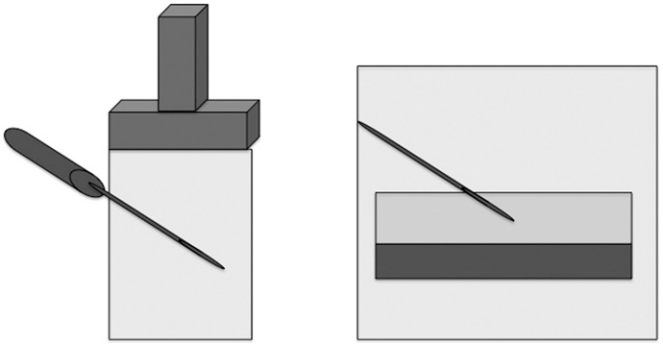

FIGURE 3. Catheter and transducer position illustrating the longitudinal approach. The graphic on the right depicts the US image obtained. Note that the entire length of the catheter can be visualized.

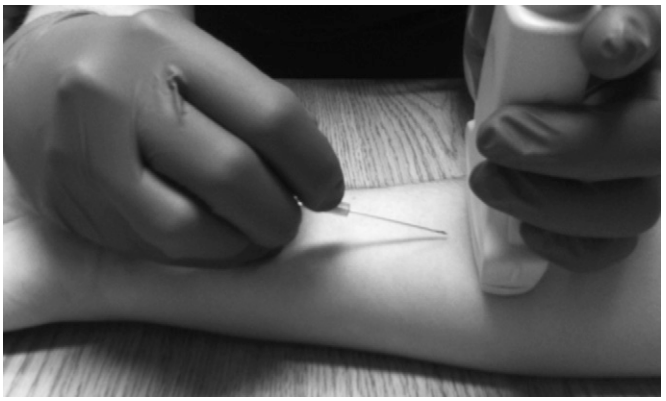

FIGURE 2. Catheter and transducer position illustrating the transverse approach.

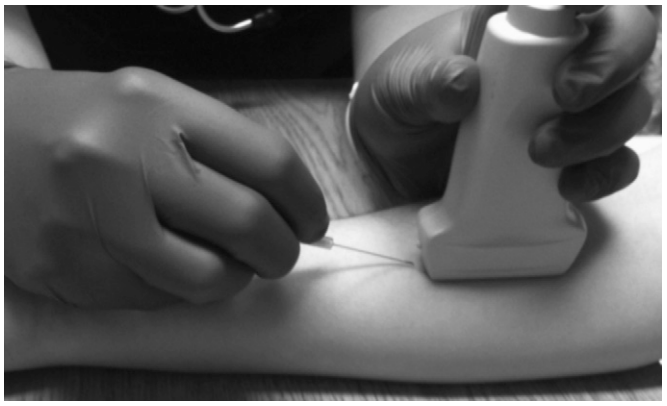

FIGURE 4. Catheter and transducer position illustrating the longitudinal approach.

fellowship-trained ED physicians in US. Four total training sessions were offered immediately before or after a shift to allow maximal attendance. To be competent, emergency nurses and corpsmen had to attend 1 training course and complete 3 US-guided IV's on a patient with a trained provider monitoring their technique. The US director, a fellowship-trained EM attending, determined this number. Four physicians and two nurses had prior experience with US.

The training included a 30-minute didactic session that covered principles of ultrasonography, care and disinfection of the machine, upper extremity venous anatomy, and how to use the US properly to cannulate veins. The students were also given access to an online video lecture that covered the same topics, which they could review at any time on their own. The next 90 minutes consisted of a hands-on session where the learners traced veins on each other's arms and practiced PIV placement with US on gel phantoms (Blue Phantom, Kirkland, Washington). The participants had the additional option to place US-guided PIV lines on each other. Simulation allowed students to learn how to discern vessel differences, measure vessel depth and diameter, and gain hand–eye coordination with manipulation of the probe. The training utilized the same US machine located in the ED (Sonosite M-Turbo, Bothell, Washington) for use with 13 to 6 MHz linear transducer.

The single operator, dynamic technique was taught in which the operator holds the US probe with their nondominant hand and uses their dominant hand to place the line while visualizing the needle entering the vein. Studies have shown no difference in success between one and two operator techniques.[7,8] Although one study revealed that novice users obtain vascular access faster with a transverse approach on inanimate models,[6] we encouraged skill development with both positions. A novel combination approach was also taught, which involves inserting the catheter through the skin in the transverse position and then moving to the probe longitudinal to visualize the catheter entering the vessel. This technique avoids the pitfall of difficult needle tip visualization with the sole use of the transverse position, but is also easier for the novice than completing the entire procedure in the longitudinal view, which requires increased skill to maintain visualization of the vessel. Standard aseptic technique was taught as the literature demonstrates that US placed peripheral lines have no increased rate of infection when compared to traditional PIV lines.[9]

Provider type: Physician, Nurse, Corpsman (circle one)
Patient age: _____
Location: Below AC, Above AC (circle one)
Approach: Longitudinal, Transverse, Combination (circle one)
Catheter length: _____
Catheter gauge: _____
Number of PIVs you have previously placed with ultrasound: ____
Success: Yes, No (circle one)
Complications: _____

FIGURE 5. US-guided PIV placement survey.

It was emphasized to choose a vein at a depth between 0.4 and 1.6 cm with a diameter greater than 3 mm[10] to maximize chance of success. An 18 gauge 2.5-inch angiocath (B Braun Medical, Bethlehem, Pennsylvania) was used for all basilic, brachial, and cephalic vein cannulations. For these proximal sites, anesthetizing the skin with 1% to 2% lidocaine with or without epinephrine was encouraged, but not required. No limitations were placed on catheter selection for other more distal sites.

Feedback was continuously monitored to determine program effectiveness. After each PIV attempt on a patient, the operator was asked to complete a brief survey (Fig. 5). The survey recorded the approach to determine if the operator used a transverse, longitudinal, or a combination technique. Further, the operator documented the patient's age, vein cannulated, the length and gauge of the catheter used, and any complications. Complications were defined as hematoma and arterial puncture. Operators were also able to subjectively record additional complications using free space. Lastly, the operator reported how many peripheral lines they had placed with US in the past.

Blind attempts were not required before US use if no potential sites were located on exam or if the patient had a history of difficulty with venous access. US-guided peripheral lines were placed using standard aseptic technique. Successful cannulation was confirmed by drawing 5 mL nonpulsatile blood and infusing 5 mL saline without discomfort.

RESULTS

From December 2013 to February 2014, a total of 65 US-guided PIV surveys were collected (34 from physicians, 19 from nurses, and 12 from corpsmen). Ten physicians, 8 nurses, and 8 corpsmen participated. Chi-squared, Fisher exact, and descriptive statistics were used to analyze the results. Success rates were analyzed both by the operator's educational background and their experience. A novice user was defined as one who had attempted less than or equal to 15 US-guided PIV lines.

Patient age ranged from 13 to 85 years with mean age of 51 years. The overall success rate for physicians was 79.4%, nurses 63.2%, and corpsmen 50.0% (Fig. 6). There was no significant difference in the success of US-guided PIV placement between operator groups once corrected for experience level ($p = 0.13$) at a power of 83%.

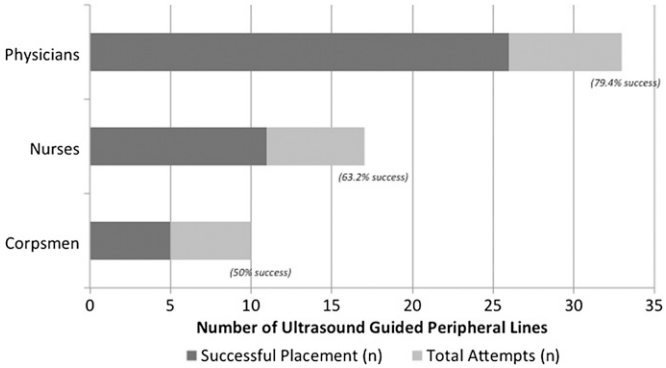

FIGURE 6. Attempts and successful placement of US-guided peripheral lines by provider type.

Among all experience levels, success was 74.1% for the longitudinal approach, 72% for the transverse approach, and 58.3% for the combination approach. In the novice operator, the success rate was the highest (64.3%) with the transverse approach, irrespective of educational level. The combination approach had success rate of 54.5%, whereas the longitudinal approach was least successful in the novice with a completion rate of 53.8%. These differences were not statistically significant.

US-guided PIV attempts by all operators were significantly more successful when placed in the upper arm (basilic, cephalic, or brachial) veins ($p = 0.02$). Of the US-guided PIV attempts by all operators, 55.6% ($n = 35$) were in the upper arm veins and 82.9% ($n = 29$) of these were successful. In contrast, only 53.6% ($n = 15$) of the attempts in the lower arm (antecubital [AC] fossa or forearm) were successful. Even in the novice subset of operators, accessing the upper arm veins had a higher success rate than those of the lower arm (77.8% versus 38.9%, respectively) ($p = 0.02$).

Before US use, the mean number of attempts was 2.8 per patient and a blind attempt at IV placement was not attempted in 7 (11.1%) patients. Excluding patients who had no blind attempts, the average number of attempts before US was 3.1 (max = 10).

There were two (3.2%) complications noted in the ED: one hematoma and one arterial puncture. The arterial puncture was made by a novice nurse operator while attempting to cannulate the brachial vein. This is similar to the complication rate reported in the literature.[4,5]

The completion rate increased with experience. Operators who had attempted US-guided PIV access on 1 to 5 patients only had a success rate of 55.2%. The success rate improved to 80.6% once they had attempted on 6 or more patients, 86.7% after 11 or more, and 88.5% after 16 or more.

DISCUSSION

Numerous studies have shown US-guided PIV placement is an effective and safer alternative to central line placement, which is traditionally the next step after failed PIV access.[2,11,12] The complication rates associated with central venous catheter placement range from 5% to 19% and include pneumothorax,

hematoma formation, catheter-associated bacteremia, thrombosis, and great vessel damage.[13] Shokoohi et al[13] demonstrated that an US-guided PIV program was associated with a marked reduction in central venous catheter use in noncritically ill ED patients.

Physician-performed US-guided PIV placement has been shown to increase success rates and patient satisfaction whereas decreasing the number of attempts and time to acquire access.[1] However, the duty of obtaining PIV access usually falls on the emergency nurses and technicians. Brannam et al[14] demonstrated that ED nurses could be trained to use US to gain peripheral access with a success rate of 87% and few complications. Blaivas et al similarly demonstrated that nurses achieved an 89% success rate for transverse IV catheters and an 85% success rate for longitudinal IV catheters. The same author reported that US decreased the emergency nurse perceived level of difficulty in patients with difficult PIV access. To our knowledge, there have only been two studies to date that have reported on the use of US for PIV access by technicians. Bauman et al[4] demonstrated that ED technicians were 80.5% successful in PIV insertion using US versus 44.1% using traditional methods when failure was defined as greater than three skin punctures. In this subset of patients, US was also found to be two times faster (mean 74.8 versus 26.8 minutes), required less physician intervention, had fewer complications, and received higher patient satisfaction.[4] Schoenfeld similarly reported a success rate of 78.5% in a group of emergency technicians with a significant correlation between operator experience and success rate; emergency technicians with more than 10 previous successful US-guided IVs had a success rate of 86.8%, compared to only 45.8% in those with 0 to 3 successfully placed PIVs.

We had a success rate slightly lower across all operators than previously reported data. One reason for this is over half of our collected surveys were from novice users who had performed less than 5 US-guided PIV lines in the past. We suspect as we continue our efforts, our success rate will continue to rise across all groups. Not surprisingly, our results illustrate that the success rate increased with experience. Operators who had attempted US-guided PIV access on 1 to 5 patients only had a success rate of 55.2%. After 16 or more, success rate improved to 88.5%. This is similar to other literature, which documented novice user success rates at 20% to 50% for the first 10 attempts.[15]

Many of the novice users chose to access vessels in the AC fossa, which is not surprising given their previous experience with PIV placement. However, across all experience and educational level operators, this location was less successful than the basilic, cephalic, and brachial veins. This is likely because the veins in the AC are smaller in diameter and perhaps too superficial. Previous literature has shown that when cannulating a vein with US, a depth of at least 0.4 cm is optimal in contrast to the traditional PIV approach.[10] We emphasize an optimal depth of 0.4 to 1.6 cm and a vessel diameter of at least 3 mm.[10] We also noted that the most successful approach for the novice appears to be the transverse or combination approach. We will continue to teach all methods, but will encourage using longitudinal once the operator has gained some experience.

We did have one arterial puncture by a novice nurse operator and one hematoma by a novice physician operator for a complication rate of 3.2%. This is similar to reports in the literature.[1,4,14,16]

We found no discernable differences in ability and efficacy with US-guided PIV access among ED physicians, nurses, or technicians when controlled by experience level. We will continue to train physicians, nurses, and corpsmen to become proficient in this potentially life-saving procedure.

LIMITATIONS

The chance of reporting bias is always present. It is possible that the subjects did not record every attempt they made at US-guided IV access, although they had little motivation to misreport data. It is also possible that the operators were less likely to complete a survey if they had a failed attempt, potentially resulting in a falsely elevated success rate.

A second limitation is that individual operators who are adept at US-guided PIV placement will continue to utilize the skill whereas operators who are not as proficient will stop attempting them, also positively affecting success rate.

Finally, it is likely that the small sample size of this study limited our ability to detect statistically significant differences in the success rates between the various cannulation approaches and between educational levels of the participants. Larger studies in the future are recommended to further investigate this.

CONCLUSIONS

Developing a program to train EM physicians, nurses, and technicians in US-guided venous cannulation is viable, easy, and safe. After a brief training session, physicians, nurses, and corpsmen had a high success rate in patients with difficult access. By encouraging and training ancillary staff, the need for central line placement and physician involvement will likely be low thereby increasing patient throughput, reducing cost, decreasing complications, and increasing emergency nurse and corpsmen autonomy. The longitudinal approach had the highest success rate overall. In the novice user, the transverse or combination method was most successful. In all users and novices, the upper arm (basilic, brachial, or cephalic) was the most successful location.

REFERENCES

1. Costantino TG, Parikh AK, Satz WA, Fojtik JP: Ultrasonography-guided peripheral intravenous access versus traditional approaches in patients with difficult intravenous access. Ann Emerg Med 2005; 46(5): 456–61.
2. Keyes LE, Frazee BW, Snoey ER, Simon BC, Christy D: Ultrasound-guided brachial and basilic vein cannulation in emergency department

patients with difficult intravenous access. Ann Emerg Med 1999; 34(6): 711–4.
3. Blaivas M, Lyon M: The effect of ultrasound guidance on the perceived difficulty of emergency nurse-obtained peripheral IV access. J Emerg Med 2006; 31(4): 407–10.
4. Bauman M, Braude D, Crandall C: Ultrasound-guidance vs. standard technique in difficult vascular access patients by ED technicians. Am J Emerg Med 2009; 27(2): 135–40.
5. Schoenfeld E, Boniface K, Shokoohi H: ED technicians can successfully place ultrasound-guided intravenous catheters in patients with poor vascular access. Am J Emerg Med 2011; 29(5): 496–501.
6. Blaivas M, Brannam L, Fernandez E: Short-axis versus long-axis approaches for teaching ultrasound-guided vascular access on a new inanimate model. Acad Emerg Med 2003; 10(12): 1307–11.
7. Rose JS, Norbutas CM: A randomized controlled trial comparing one-operator versus two-operator technique in ultrasound-guided basilic vein cannulation. J Emerg Med 2008; 35(4): 431–5.
8. Milling T, Holden C, Melniker L, Briggs WM, Birkhahn R, Gaeta T: Randomized controlled trial of single-operator vs. two-operator ultrasound guidance for internal jugular central venous cannulation. Acad Emerg Med 2006; 13(3): 245–7.
9. Adhikari S, Blaivas M, Morrison D, Lander L: Comparison of infection rates among ultrasound-guided versus traditionally placed peripheral intravenous lines. J Ultrasound Med 2010; 29(5): 741–7.
10. Panebianco N, Fredette J, Szyld D, et al: What you see (sonographically) is what you get: vein and patient characteristics associated with successful ultrasound-guided peripheral intravenous placement in patients with difficult access. Acad Emerg Med 2009; 16(12): 1298–303.
11. Gregg SC, Murthi SB, Sisley AC, Stein DM, Scalea TM: Ultrasound-guided peripheral intravenous access in the intensive care unit. J Crit Care 2010; 25(3): 514–9.
12. Dargin JM, Rebholz CM, Lowenstein RA, Mitchell PM, Feldman JA: Ultrasonography-guided peripheral intravenous catheter survival in ED patients with difficult access. Am J Emerg Med 2010; 28(1): 1–7.
13. Shokoohi H, Boniface K, McCarthy M, et al: Ultrasound-guided peripheral intravenous access program is associated with a marked reduction in central venous catheter use in noncritically ill emergency department patients. Ann Emerg Med 2013; 61(2): 198–203.
14. Brannam L, Blaivas M, Lyon M, Flake M: Emergency nurses' utilization of ultrasound guidance for placement of peripheral intravenous lines in difficult-access patients. Acad Emerg Med 2004; 11(12): 1361–3.
15. Miles G, Salcedo A, Spear D: Implementation of a successful registered nurse peripheral ultrasound-guided intravenous catheter program in an emergency department. J Emerg Nurs 2012; 38(4): 353–6.
16. White A, Lopez F, Stone P: Developing and sustaining an ultrasound-guided peripheral intravenous access program for emergency nurses. Adv Emerg Nur J 2010; 32(2): 173–88.