

Ultrasonographically Guided Peripheral Intravenous Cannulation in Emergency Department Patients With Difficult Intravenous Access: A Randomized Trial

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Study objective: We seek to compare ultrasonographically guided peripheral intravenous access to a non-ultrasonographically guided method in a randomized trial of emergency department patients with difficult intravenous access.

Methods: A prospective cohort of patients with difficult intravenous access was established. Patients were randomized to 2 groups: (1) intravenous access obtained through an ultrasonographically guided technique or (2) intravenous access obtained through non-ultrasonographically guided methods. Outcomes measured were number of attempts after enrollment, time to cannulation from enrollment, and patient satisfaction. Groups were compared with nonparametric analysis.

Results: Fifty-nine patients were randomized. Twenty-eight patients were randomized to the ultrasonography group and 31 to the no ultrasonography group. A median of 2 further intravenous attempts was required in each group before successful cannulation, corresponding to a difference of 0 attempts (95% confidence interval [CI] 0 to 1 attempts). Time to cannulation showed a median of 39 minutes in the ultrasonography group compared with 26 minutes for the no ultrasonography group, giving a median increase of 13 minutes for the ultrasonographically guided group (95% CI -5 to 28 minutes). Patients in the ultrasonography group had a median Likert satisfaction score of 8 compared with 7 for the no ultrasonography group, giving a median increase of 1 on this scale in the ultrasonography group (95% CI 0 to 2).

Conclusion: Ultrasonographically guided peripheral intravenous cannulation did not decrease the number of attempts or the time to successful catheterization, nor did it improve patient satisfaction compared with the group that did not use ultrasonography. Superiority of ultrasonographically guided peripheral intravenous cannulation is not supported by this study. [Ann Emerg Med. 2009;54:33-40.]

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INTRODUCTION

Background

Obtaining peripheral intravenous access is a common undertaking in the emergency department (ED) to obtain blood samples, as well as to provide a route for intravenous medications and fluids. In the majority of cases, this proves to be routine. Some patients, however, may have difficult intravenous access because of obesity, history of intravenous drug use, chronic illness, or vascular pathology.¹ In such cases, once nurses are unable to place an intravenous catheter, the responsibility to obtain intravenous access typically is the emergency physician's, which can be a time-consuming process

and can slow efficiency. Physicians may undergo further peripheral attempts, including external jugular cannulation, or be forced to place a central catheter.

Importance

The use of ultrasonography as an aid to the placement of central venous catheters has been well established, generally showing increased success and decreased rates of complications.²⁻¹⁸ Largely according to the success of this technology for central venous catheters, emergency physicians began to explore the use of ultrasonography for the placement of peripheral intravenous catheters. Keyes et al¹⁹ showed a 91%

Editor's Capsule Summary

What is already known on this topic

Ultrasonographic guidance has proven beneficial in central venous catheterization, yielding improved success rates with fewer complications.

What question this study addressed

Do the benefits of ultrasonographic guidance apply to peripheral venous catheterization in which vessels can already be directly visualized?

What this study adds to our knowledge

In this randomized controlled trial of 59 patients with difficult intravenous access, ultrasonographic guidance did not improve success rates, time to access, or patient satisfaction in obtaining peripheral venous catheterization, for emergency department attending physicians with moderate experience in this technique.

How this might change clinical practice

Rather than commit time and resources to ultrasonographic guidance, practitioners without extensive experience with this technique should pursue further attempts at standard intravenous cannulation or consider central line placement to obtain venous catheterization for patients with difficult peripheral access.

success rate for ultrasonographically guided placement of the basilic or deep brachial intravenous catheters in an observational trial in 1999. In 2005, Costantino et al²⁰ performed a prospective systematically allocated trial and demonstrated a 97% success rate when using ultrasonography to guide intravenous placement in any peripheral arm vein compared with 33% success rate without ultrasonographic guidance. These observations suggest that ultrasonography may improve the process of intravenous access in patients with difficult access.

Goals of This Investigation

We sought to compare the effectiveness of ultrasonographically guided intravenous catheterization to non-ultrasonographically guided methods in a population with difficult intravenous access. We conducted a prospective randomized trial of ultrasonographically guided intravenous placement compared with non-ultrasonographically guided technique in difficult intravenous patients in the ED. Our primary endpoint was the number of attempts that were required for successful cannulation. Secondary endpoints were patient satisfaction and time to successful cannulation. The hypothesis was that there would be a clinically significant

difference in the number of attempts that were required to successfully cannulate a difficult intravenous patient between ultrasonographically guided versus non-ultrasonographically guided groups.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective, nonblinded, randomized trial comparing ultrasonographically guided peripheral intravenous access with no ultrasonographically guided intravenous technique. The study was performed at the University of California, San Francisco, an urban tertiary care university teaching hospital with approximately 40,000 ED patient visits per year. Data were collected on consecutive patients who presented between June 15, 2005, and August 15, 2005, during daytime hours. This study was approved by the University of California, San Francisco committee on human research.

Selection of Participants

Patients became eligible for the study if they were at least 18 years of age, required an intravenous line, and had undergone 2 failed peripheral intravenous attempts by the nursing staff.¹⁹ Patients were excluded from the trial if they were unstable or otherwise required emergency intravenous placement. A trained research assistant was available to enroll patients from 9 AM to 9 PM only. Patients were eligible to participate only once in this trial.

Of the 20 attending physicians in the ED before the start of the trial, 12 were previously credentialed in ultrasonography according to American College of Emergency Physicians (ACEP) guidelines. The remainder of the staff was in the process of credentialing and had received a 16-hour introductory course 1 year before the start of this study. The introductory course included a 1-hour didactic session on central and peripheral intravenous access. Additionally, the 8 who were undergoing credentialing plus 3 others who had further interest underwent an extra 1-hour training program on ultrasonographically guided peripheral intravenous access with the use of synthetic training models 6 months before the beginning of this trial. After this training, an observational period ensued for 6 months, during which time all physicians had practice performing this technique (unpublished data). After this training period, we began enrollment of patients for this trial.

Our research assistants were trained at the same time. They observed the educational sessions for the physicians. They were responsible for recording data during the observational period, and their methods for timing venous access and counting number of attempts were verified by the research staff. They were also responsible for recording some of the baseline demographic information such as whether the nurse thought the initial failure of intravenous attempts was due to patient intravenous drug abuse, body weight, or chronic medical condition. They were also given feedback on how to ask for

patients' satisfaction in an impartial manner, and the research staff observed them perform these tasks.

Methods of Measurement

After enrollment and consent by research staff, the patients were individually randomized by our research computer. A simple (unrestricted) randomization algorithm was used.²¹ The computer simultaneously created a time stamp in the research database, which represented the time of enrollment. The research staff then contacted the attending physician and treating nurse to alert them to the randomization group placement. The ultrasonographic machine was brought immediately into the room by the research assistant for those patients enrolled in the ultrasonography group.

Ultrasonographic guidance was performed only by the attending emergency physician in real time, with a Sonosite Titan ultrasonographic machine with a 10-MHz linear transducer (Sonosite, Bothell, MA). Veins were sought by using standard anatomical landmarks. Once veins were found, their location was confirmed by the ease of collapsibility and lack of pulsatility.^{19,22} For the purposes of this trial, further vascular attempts were limited to external jugular and arm veins (brachial, forearm, cephalic, and basilic veins). An intravenous attempt was defined as 1 percutaneous needle puncture, without regard to the amount of subcutaneous exploration from that single puncture site. The research assistant was trained to assess this number of attempts by the research staff, and verification of the counting method was assessed during the observational period. A successful intravenous attempt was defined as blood return or ability to infuse intravenous fluid without infiltration.

Attending physicians were instructed to use the method they believed would best provide intravenous access to the patient, as long as they stayed within the study groups. We thought this approach would simulate the real clinical environment the closest and thus provide the most generalizable results. Thus, for patients who were randomized to the ultrasonography group, the attending physician was the only one who could use the ultrasonographic machine, but they were allowed to guide themselves using 1-person technique in the intravenous placement, or they could guide a nurse or a resident with 2-person technique. They were instructed to use their most effective ultrasonographic method. Leg veins were not allowed, but external jugular placement was allowed. If patients were randomized to the no ultrasonography method, attending physicians could direct an emergency resident to initiate intravenous attempts, or they could attempt it themselves. Physicians could palpate and otherwise assess their targets (as long as ultrasonography was not used) if they believed this would improve their chances. Leg veins were not allowed, but external jugular placement was allowed.

Primary Data Analysis

The endpoints measured included number of attempts that were required to place an intravenous catheter successfully, time from enrollment to successful intravenous catheterization, and

patient satisfaction of the procedure (by Likert 0 to 10 scale). Regarding satisfaction, patients were asked to rate their satisfaction with the process of placing their intravenous. No provider who performed subsequent intravenous attempts once the patient was enrolled was allowed to ask for the patient satisfaction score. Complications were also documented, and rate of failure requiring central line was recorded. Data are presented as mean, median (with interquartile ranges), and 95% confidence interval (CI).

Sample size was calculated according to the previous unpublished observational research at University of California, San Francisco. After our training period, we allowed physicians 6 months to practice and collected observational data to examine a useful effect size and standard deviation. For the randomized trial, we wanted 80% power to find an effect size of 1 decreased intravenous attempt with a 2-tailed α of 0.05 and an SD of 1.3. This resulted in 27 patients in each group (<http://www.epibiostat.ucsf.edu/dcr/>). Nonparametric Mann-Whitney analysis was used to examine significance of differences between groups with regard to number of attempts, time, and patient satisfaction. Because several physicians had more than 1 patient who was enrolled, and thus may have performed multiple interventions, the results were adjusted for this potential clustering effect. Summary and analytic statistics were done with Stata version 10 (StataCorp, College Station, TX).

RESULTS

A total of 68 patients were eligible for our trial during the study period (Figure 1). Nine patients refused to consent, which left 59 patients who were randomized to the 2 groups. Twenty-eight patients were randomized to the ultrasonography group and 31 were randomized to the no ultrasonography group. Baseline demographics are shown in Table 1. There was a higher percentage of overweight patients in the ultrasonography group, but there were no other clinically important differences between the groups.

All patients in the ultrasonography group had peripheral intravenous catheter placement, except for one patient who was admitted to the hospital before any additional intravenous attempts were made (patient went to interventional radiology, where they placed a central line en route to dialysis). Although the patients was enrolled and continued in the ultrasonography group, there were no intravenous attempts. Two patients in the no ultrasonography group did not have peripheral intravenous catheter placement. One patient required central venous access after 7 failed peripheral attempts, and 1 patient was reassessed after enrollment in the study and found no longer to require intravenous access (he had femoral venipuncture for blood draw and intramuscular pain medications given and was discharged). Although the patient was enrolled and continued in the no ultrasonography group, he/she had never received an intravenous attempt. Thus, our analysis is based on intention-to-treat methodology.

For the 28 patients who underwent ultrasonographically guided technique, a median of an additional 2 (interquartile

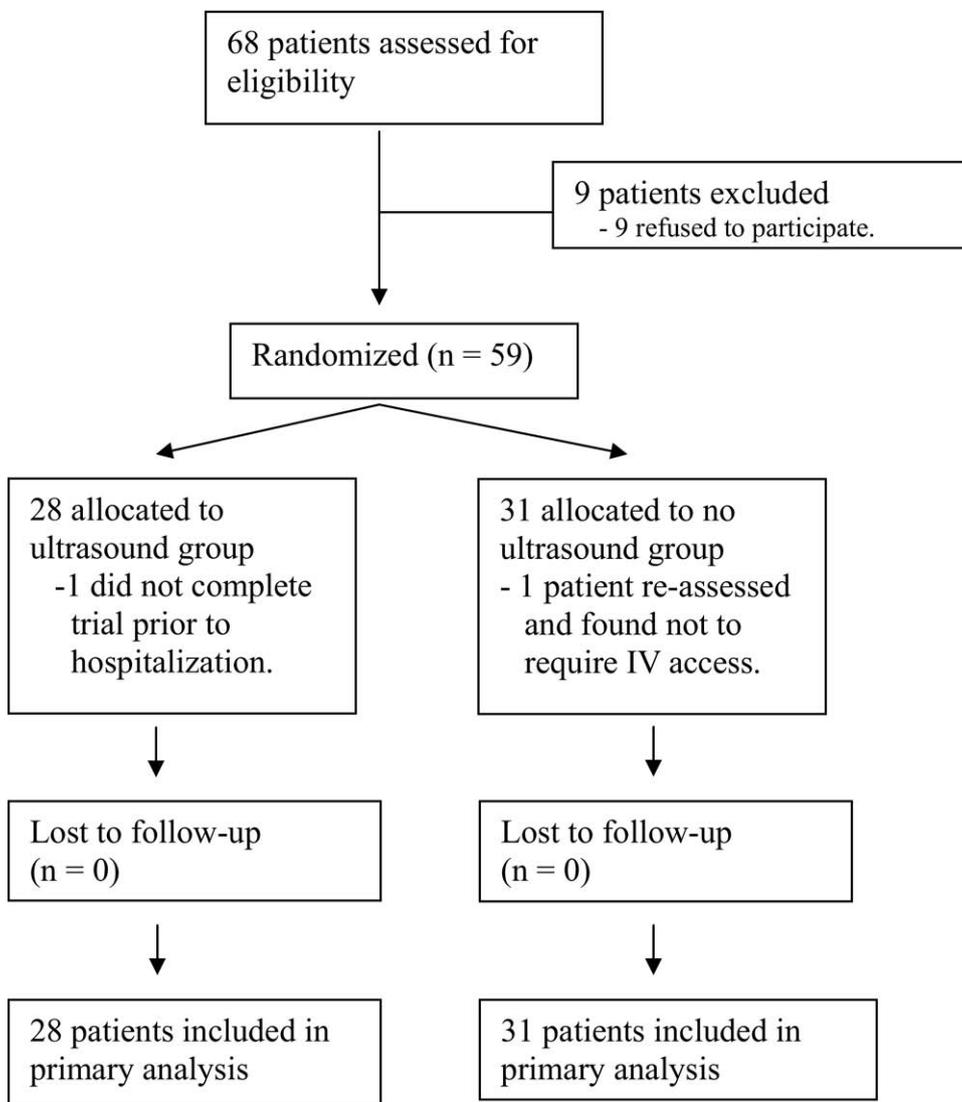


Figure 1. CONSORT diagram summarizing inclusion, allocation, and follow-up.

Table 1. Baseline patient characteristics.

Characteristic	n	Ultrasonography Group (n=28)	No Ultrasonography Group (n=31)
Age, y, mean (SD)	58	58.1 (15.6)	54.8 (17.8)
Female, No. (%)	59	20 (71)	18 (58)
Race, No. (%)			
Asian	57	4 (14.8)	5 (16.6)
Black		11 (40.7)	11 (36.7)
White		8 (29.6)	11 (36.7)
Other		4 (14.8)	3 (10)
History of intravenous drug abuse, No. (%)	49	6 (25)	11 (44)
History of chronic medical condition, No. (%)	51	23 (96)	24 (89)
Overweight, No. (%)	47	8 (36)	3 (12)

range [IQR] 1 to 2) attempts was required before intravenous catheterization (Table 2). For the 30 patients who underwent non-ultrasonographically guided intravenous catheter technique, a median of 2 (IQR 1 to 2) further attempts was also

required. Thus, when ultrasonography was used, we recorded no difference between the medians (95% CI 0 to 1; P=.81).

When we examined the time to successful intravenous completion, we found that the patients who had

Table 2. Number of attempts, time to successful intravenous line placement, and patient satisfaction among patients with difficult intravenous access randomly assigned to ultrasonography or no ultrasonography groups.

Characteristics	Ultrasonography Used?	N	Mean	95% CI of Mean	Median (IQ Range)	Median Difference (95% CI)
Number of attempts	Y	27	2.07	(1.6–2.6)	2 (1–2)	0 (0–1)
	N	30	2.37	(1.6–3.1)	2 (1–2)	
Time to successful completion, minutes	Y	26	60.2	(33.3–87.0)	39 (18–74)	13 (-5–28)
	N	29	48.2	(19.5–76.9)	26 (17–45)	
Patient satisfaction	Y	24	7.96	(6.9–9.0)	8 (6,10)	1 (0–2)
	N	28	7.04	(6.1–7.9)	7 (5.5–9)	

ultrasonography guidance required a median of 39 minutes (IQR 18 to 74 minutes) until successful intravenous placement after their enrollment. For the patients who underwent non-ultrasonographically guided intravenous catheter technique, a median of an additional 26 minutes (IQR 17 to 45 minutes), was required. Thus, when ultrasonography was used, we measured a median increase of 13 minutes (95% CI -5 to 28 minutes; $P=.20$).

Examining the patient satisfaction data, we found that for the patients who received ultrasonographically guided intravenous placement, the median Likert score was 8 (IQR 6 to 10). For the patients who had no ultrasonographically guided intravenous catheter technique, the mean score was 7 (IQR 5.5 to 9). Thus, when ultrasonography was used, there was a mean increase in Likert score of 1 (95% CI 0 to 2; $P=.10$).

There were no complications recorded in either group, and no patients were excluded because of clinical instability.

LIMITATIONS

One limitation of the trial is that we did not have enough sample size to test variations in success among different physician providers. However, it was not our goal to assess whether a subgroup of highly trained physicians can perform this technique better than a less skilled subgroup. Rather we wanted to assess the generalizability of this technique to a staff of emergency physicians that has a level of ultrasonographic experience that may approximate that in common clinical practice.

A possible limitation of this trial was that study participants were enrolled only between 9 AM and 9 PM, when we had a research assistant available for data collection. We suspect, but did not verify, that there was at least an equal number of patients who were eligible during the off hours. Thus, it is conceivable that this portion of the total difficult intravenous population may be different from the patients who are reported in this study.

In addition, we decided to use a definition of 2 failed attempts for our study population. This is the same definition as that used by Keyes et al,¹⁹ but Costantino et al²⁰ used 3 failed attempts to define their study population. It is possible that this difference is clinically important; however, we were unable to approve the study through our committee on human research unless we were limited to 2 failed attempts before enrollment.

DISCUSSION

Placing an intravenous catheter is a common procedure in the ED, and one that typically is accomplished without difficulty. However, when intravenous access is difficult, it can be incredibly time intensive. Most emergency physicians are familiar with groups of patients who have notoriously difficult intravenous catheter placement, such as intravenous drug abusers, renal dialysis patients, obese patients, and chemotherapy patients.¹

It would be ideal to develop a method for rapidly and safely obtaining intravenous access for those patients whose access otherwise would be difficult and time consuming. Because of the success of sonography for placing central lines, Keyes et al,¹⁹ began to investigate the use of ultrasonography in the placement of peripheral intravenous access. This group was able to demonstrate that ultrasonographically guided technique allowed successful cannulation in 91% of the difficult intravenous access patients in the deep brachial or basilic vein. There was no control or comparison group in this trial.

In a prospective trial from 2005, Costantino et al²⁰ reported a similar success rate for ultrasonographically guided peripheral intravenous placement not restricted to the deep brachial or basilic veins. Successful peripheral cannulation was achieved in 97% of the ultrasonography group versus 33% in the no ultrasonography group. They also showed decreased time required for cannulation using ultrasonography, a decrease in number of punctures when using ultrasonography, and higher patient satisfaction when using ultrasonography. However, Costantino et al²⁰ used a systematic allocation trial; they enrolled patients on odd days to the ultrasonography group and on even days to the no ultrasonography group, ending up with unbalanced study arms (39 patients in the ultrasonography group and 21 in the no ultrasonography methods group). Although the difference in group size may have little or no significance, it could also reflect a tendency for staff to hesitate to enroll patients on those days that ultrasonography was not being offered (because ultrasonography presumably could be used if a patient was not enrolled in the trial). This could possibly confound the results. Further, Costantino et al²⁰ had established a rescue arm such that after 3 peripheral attempts the patient defaulted to further attempts with ultrasonographic guidance. The rescue arm may have introduced bias into the

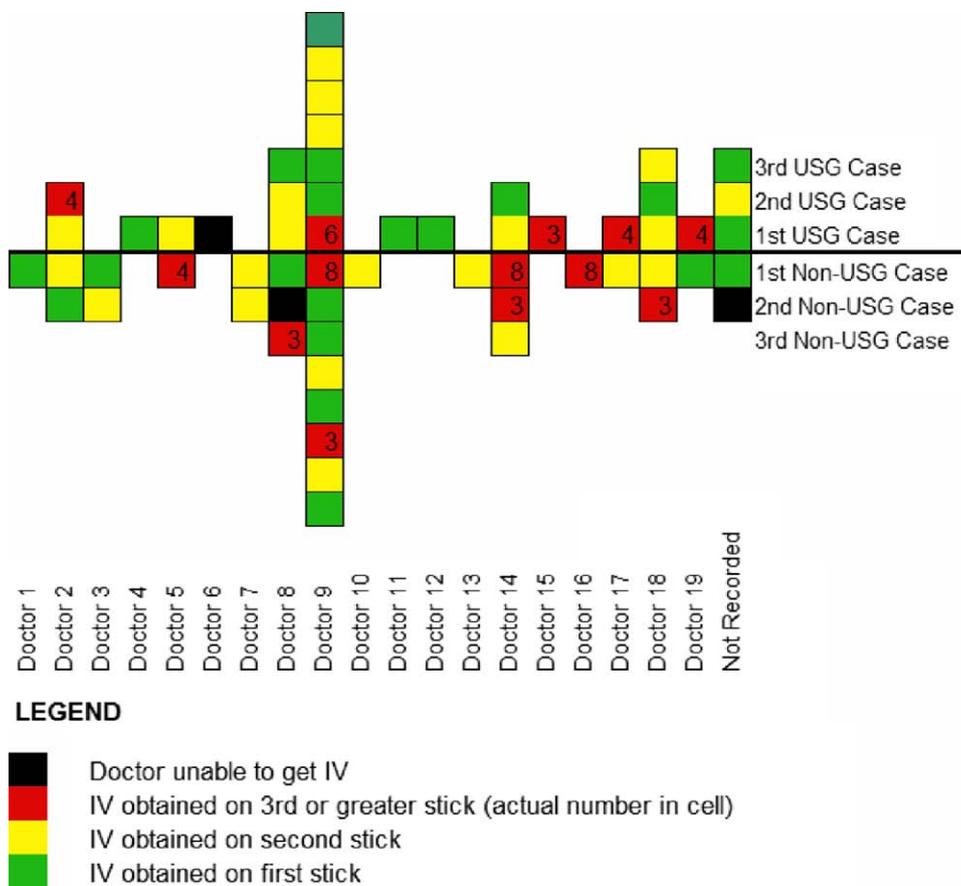


Figure 2. Number and type of intravenous case by physician, with result. *USG*, Ultrasonographically guided.

determination of the providers who were attempting the non-ultrasonographically guided catheter placements, knowing that they could then fall back on ultrasonography if 3 further attempts failed.

The main outcome measure in our trial was to evaluate whether ultrasonographically guided intravenous technique could result in a clinically important difference compared with non-ultrasonographically guided intravenous technique. We powered our study to find a difference of at least 1 peripheral intravenous attempt between groups. We believed that this would be a clinically meaningful result and that any difference that did not approach at least 1 attempt was unlikely to effect change in clinical practice. In our trial, we were unable to demonstrate such an effect. Both groups showed a median of 2 further attempts, and we can be 95% confident that the true result for this analysis lies between 0 and 1 attempt.

Looking at the first of our secondary outcomes, time to successful catheter placement, we found that the patients who had ultrasonographic guidance required an additional 13 minutes before intravenous access was achieved compared with the non-ultrasonographically guided group. Our time measurements started after notification of the attending physician by the research assistant about the group randomization. Although this trend may seem plausible, noting

that there is typically an increased time requirement with the use of ultrasonography compared with no ultrasonography, this was not the primary outcome of our trial, and thus we did not power our study to confirm such a result. The resulting CIs show that if we were to have larger sample size, the likely result is that the difference in time between groups is less than 30 minutes.

The patient satisfaction data also showed no clinically important difference between groups. Although there was a difference in one point on the scale between groups favoring ultrasonography, the magnitude of this difference is not likely to change clinical practice. We had believed that the satisfaction would be higher with the ultrasonography group because of the common patient perception that any use of technology is an improvement in their care. Although there was a trend in that direction, it did not achieve clinical relevance. Because the providers who performed the intravenous attempts after enrollment were not allowed to ask about patient satisfaction, we believe that there was limited patient bias about their answer that would affect one group more than another. However, our research staff was not blinded to the treatment arm.

For better assessment of these findings, it is important to examine the practice environment in which the study took place. The University of California, San Francisco is a large

university teaching hospital with approximately 40,000 patient visits per year to the ED. Faculty actively teach emergency medicine residents, as well as internal medicine and psychiatry residents who rotate through the ED, but our residency program in emergency medicine has only recently been established. The ultrasonography program was officially set into place in 2003, and as a result, the experience of our faculty at the trial was varied. Roughly 60% of the faculty when this trial started had extensive training for more than 4 years during residency. The other 40% had been using ultrasonography for just over 1 year, on their way to full credentialing as per the ACEP guidelines. We believe that our faculty represents what is currently encountered in EDs all over the country with respect to training in ultrasonography, namely, that some physicians have extensive experience and some have had limited experience. We believe that our physicians represent a generalizable population with regard to ultrasonographic training and experience. All faculty participated in the trial, but we do not have adequate numbers of patients to evaluate differences between physicians with regard to level of training (Figure 2).

In conclusion, despite several early reports of the value of ultrasonographic guidance in the placement of peripheral intravenous catheters, we were unable to show any difference between an ultrasonographically guided group and a non-ultrasonographically guided group in our randomized trial of ED patients. As in many previous assessments of the use of ultrasonography, in which the results tend to be operator dependent, we believe that this will likely be the result when further investigation is done in this topic. It would be interesting to pursue future studies to determine whether there are certain patients who are most likely to benefit from this tool and whether there is a certain physician training threshold at which patients are likely to benefit more consistently. Considering the time and costs associated with implementation and training in emergency ultrasonography, it may be prudent for those without established ultrasonographic experience to focus their efforts on ultrasonographically guided central venous access (because of its proven record) until further testing of this technology for the use of peripheral intravenous cannulation can be completed.

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Dr. Callahan recused himself from the decision process for this article.

Author contributions: JS, BG, and DM conceived the study and designed the trial. JS, BG, and DM supervised the conduct of the trial and data collection. JS provided statistical advice on study design and analyzed the data. JS drafted the article, and all authors contributed substantially to its revisions. JS and DM take responsibility for the paper as a whole.

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REFERENCES

1. Brannam L, Blaivas M, Lyon M, et al. Emergency nurses' utilization of ultrasound guidance for placement of peripheral intravenous lines in difficult-access patients. *Acad Emerg Med.* 2004;11:1361-1363.
2. Leung J, Duffy M, Finckh A. Real-time ultrasonographically-guided internal jugular vein catheterization in the emergency department increases success rates and reduces complications: a randomized, prospective study. *Ann Emerg Med.* 2006;48:540-547.
3. Denys BG, Uretsky BF, Reddy PS. Ultrasound-assisted cannulation of the internal jugular vein. A prospective comparison to the external landmark-guided technique. *Circulation.* 1993;87:1557-1562.
4. Fry WR, Clagett GC, O'Rourke PT. Ultrasound-guided central venous access. *Arch Surg.* 1999;134:738-740; discussion 741.
5. Hatfield A, Bodenham A. Portable ultrasound for difficult central venous access. *Br J Anaesth.* 1999;82:822-826.
6. Hrics P, Wilber S, Blanda MP, et al. Ultrasound-assisted internal jugular vein catheterization in the ED. *Am J Emerg Med.* 1998;16:401-403.
7. Hudson PA, Rose JS. Real-time ultrasound guided internal jugular vein catheterization in the emergency department. *Am J Emerg Med.* 1997;15:79-82.
8. Keenan SP. Use of ultrasound to place central lines. *J Crit Care.* 2002;17:126-137.
9. Miller AH, Roth BA, Mills TJ, et al. Ultrasound guidance versus the landmark technique for the placement of central venous catheters in the emergency department. *Acad Emerg Med.* 2002;9:800-805.
10. Randolph AG, Cook DJ, Gonzales CA, et al. Ultrasound guidance for placement of central venous catheters: a meta-analysis of the literature. *Crit Care Med.* 1996;24:2053-2058.
11. Hind D, Calvert N, McWilliams R, et al. Ultrasonic locating devices for central venous cannulation: meta-analysis. *BMJ.* 2003;327:361-368.
12. Milling T, Holden C, Melniker L, et al. Randomized controlled trial of single-operator versus two-operator ultrasound guidance for internal jugular central venous cannulation. *Acad Emerg Med.* 2006;13:245-247.
13. Chikungwa M, Lim M. Ultrasound guidance for central venous catheter insertion. *Emerg Med J.* 2005;22:608-609.
14. Abboud PA, Kendall JL. Ultrasound guidance for vascular access. *Emerg Med Clin North Am.* 2004;22:749-773.
15. Dunning J, Williamson J. Ultrasonic guidance and the complications of central line placement in the emergency department. *Emerg Med J.* 2003;20:551-552.
16. Gilbert TB, Seneff MG, Becker RB. Facilitation of internal jugular venous cannulation using an audio-guided Doppler ultrasound vascular access device: results from a prospective, dual-center, randomized, crossover clinical study. *Crit Care Med.* 1995;23:60-65.

17. Augoustides JG, Horak J, Ochroch AE, et al. A randomized controlled clinical trial of real-time needle-guided ultrasound for internal jugular venous cannulation in a large university anesthesia department. *J Cardiothorac Vasc Anesth.* 2005;19:310-315.
18. Wachter RM. Making health care safer: a critical analysis of patient safety practices. In: Agency for Healthcare Research and Quality, ed. *Evidence Report/Technology Assessment, No. 43*, Rockville, MD: Agency for Healthcare Research Quality; 2001.
19. Keyes LE, Frazee BW, Snoey ER, et al. Ultrasound-guided brachial and basilic vein cannulation in emergency department patients with difficult intravenous access. *Ann Emerg Med.* 1999;34:711-714.
20. Costantino TG, Parikh AK, Satz WA, et al. Ultrasonography-guided peripheral intravenous access versus traditional approaches in patients with difficult intravenous access. *Ann Emerg Med.* 2005;46:456-461.
21. Schulz KF, Grimes DA. Generation of allocation sequences in randomised trials: chance, not choice. *Lancet.* 2002;359:515-519.
22. Costantino TG, Fojtik JP. Success rate of peripheral IV catheter insertion by emergency physicians using ultrasound guidance. *Acad Emerg Med.* 2003;10:487.

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