

# THE USE OF ULTRASOUND FOR PLACEMENT OF INTRAVENOUS CATHETERS

**Capt Hector Aponte, CRNA, MSN, USAF, NC**

Aviano, Italy

**Capt Said Acosta, CRNA, MSN, USAF, NC**

Crestview, Florida

**Donald Rigamonti, PhD**

Arlington, Virginia

**Barbara Sylvia, RN, PhD**

Bethesda, Maryland

**Lt Col Paul Austin, CRNA, PhD, USAF-ret, NC**

Boys, Maryland

**Maj Timothy Samolitis, CRNA, ND, USAF-ret, NC**

Vienna, West Virginia

*Ultrasound has been used to aid cannulation of veins of the neck, chest, antecubital fossa, and femoral vein. This investigation compared the traditional method of peripheral intravenous (IV) cannulation of veins of the hands and forearms with ultrasound-guided IV cannulation of these veins.*

*After obtaining institutional review board approval and written informed consent, 35 adult subjects with a history or suspicion of difficult IV cannulation were prospectively enrolled with 16 subjects randomly assigned to the traditional group and 19 to the ultrasound group. Time taken for successful venous cannulation and number of attempts between the groups were compared using a Mann-Whitney U test. The number of subjects in whom IV cannulation was*

*successful on the first attempt was compared between the groups using the Fisher exact test.*

*No significant differences were noted between groups in demographics, time to successful cannulation, number of attempts, and number of subjects in whom IV cannulation was successful on the first attempt. Ultrasound was as efficacious as the traditional method of IV cannulation in this subset of patients. Future investigations should examine the efficacy of the ultrasound-guided technique of IV cannulation of these veins in patients in whom the traditional method failed.*

**Key words:** Adult, human, peripheral catheterization, ultrasonography.

**P**lacement of peripheral intravenous (IV) catheters for administration of fluids and/or medications is a common procedure. These catheters are typically inserted by palpating or directly visualizing the target vein.

Patients may lack the visual and/or palpable venous anatomy necessary for successful IV cannulation. Patients' medical history, body habitus, fluid status, and extremes of age are all factors that can pose challenges to practitioners attempting IV cannulation.<sup>1</sup> Aids to IV catheter placement include locally applied vasodilators, use of a blood pressure cuff as a tourniquet, and using ultrasound to locate potential peripheral veins.<sup>2</sup>

Ultrasound has been used for the placement of central venous catheters for many years.<sup>3</sup> Its use in placement of central venous catheters has been established in adults and in infants and children.<sup>4</sup> The use of ultrasound for central venous catheterization has been endorsed by the National Institute for Clinical

Excellence in the United Kingdom and the Agency for Healthcare Research and Quality in the United States.<sup>5,6</sup> Ultrasound has also been used to place IV catheters in the femoral veins and in veins in the antecubital fossa in routine and emergency situations.<sup>7-9</sup> Although the results of these investigations support the use of ultrasound in placement of IV catheters in the upper extremities, previous investigators have generally limited the use of the technique to veins of the antecubital fossa.

The purpose of this investigation was to compare the success rate and time to successful placement of IV catheters placed in hand and forearm veins of adults with potentially difficult peripheral venous access using traditional and ultrasound-guided methods of IV cannulation.

## Materials and methods

After institutional review board approval, written informed consent was obtained from 35 subjects older

than 18 years. A power analysis revealed that 35 subjects were required for the investigation (power of 0.80 with an  $\alpha$  of .05). Subjects were included in the study if during the preoperative interview they reported past difficulties with peripheral IV access or if the anesthesia provider identified them as having the potential for difficulty with IV access. Enrolled subjects were randomly assigned to have the IV catheter placed using the traditional or ultrasound-guided method.

All IV attempts, ultrasound imaging, and data collection were conducted by 1 of 2 Certified Registered Nurse Anesthetists (CRNAs) with more than 3 years of experience. The IV catheters used in the study ranged from 18 to 22 gauge (Insyte, BD Medical, Sandy, Utah). The size was determined by the CRNA based on the clinical situation. Ultrasound imaging was performed with the portable Site-Rite 3 Ultrasound Unit (Bard Access Systems, Salt Lake City, Utah) equipped with a 9.0-MHz probe. Each CRNA had training in the use of the ultrasound device and had previously used the device as an aid in peripheral venous cannulation successfully 5 or more times. When attempts at IV cannulation failed using either method, an alternative anatomical site was selected, and subsequent attempts used the same method.

- *Traditional method.* A tourniquet was applied to an upper extremity. Procedure start time was defined when the CRNA started identifying potential target veins visually and/or by palpation. Before cannulation of the chosen vessel, the skin was cleansed with alcohol and 0.25 to 1 mL of 1% lidocaine was infiltrated intradermally, and the catheter was inserted. Successful IV cannulation, as determined by the CRNA performing the procedure, was defined as advancement of the catheter into the vein confirmed by blood return from the catheter. Procedure stop time was defined as successful IV cannulation.

- *Ultrasound-guided method.* As in the traditional method, a tourniquet was applied to an upper extremity. Procedure start time was defined when the transducer was placed onto the skin and a vein identified on the ultrasound monitor (Figure). Before cannulation of the chosen vein, the skin was cleansed and local anesthesia given as in the traditional method. The IV catheter was inserted distal to the transducer, guided via the ultrasound image. One operator performed the procedure. Successful IV cannulation and procedure stop time were defined as for the traditional technique.

The CRNA inserting the catheter determined failure of either technique. In these circumstances, timing continued until successful insertion using the same method.

**Figure. Ultrasound image showing lumen of vein**



Statistical analysis was performed with the aid of a commercially available software package (SAS 8.2, SAS Institute, Inc, Cary, NC). Demographic data (age, gender, body mass index or BMI), size of IV catheter of successful cannulation, time to cannulation, and number of attempts were recorded. The Student *t* test was used to compare age and body mass index. The traditional group included 4 men and 12 women, and the ultrasound group included 4 men and 15 women. Time to successful cannulation, time to successful cannulation when success was obtained on the first attempt, and number of attempts per subject were compared between groups by using the Mann-Whitney *U* test. The number of successful IV catheter placements on the first attempt was compared between groups by using the Fisher exact test. All data are expressed as the mean  $\pm$  SD. An  $\alpha$  value of less than .05 was considered significant.

## Results

A total of 35 subjects were enrolled in the study, with 16 randomly assigned to the traditional group and 19 to the ultrasound-guided group. Demographic data are shown in Table 1. Although the mean age of the subjects was significantly different between groups, the difference is not clinically significant.

In both groups, catheter sizes ranged from 18 to 22 gauge (Table 2). The time to successful IV cannulation, number of attempts, number of subjects in whom IV cannulation was successful on the first attempt, and time to successful IV cannulation when successful on the first attempt did not differ significantly between groups (see Table 2).

## Discussion

Obtaining IV access in patients can be problematic and require multiple attempts. If the vein cannot be

**Table 1. Demographic data for 35 subjects\***

	Traditional group (n = 16)	Ultrasound group (n = 19)	P
Age (y)	57.3 ± 18.9	55.5 ± 15.7	.025
Sex			—
M	4	4	
F	12	15	
Body mass index	28.0 ± 7.3	29.4 ± 10.2	.649

\* Data are given as mean ± SD or number of subjects.

**Table 2. Comparison of size of intravenous (IV) catheter used in successful cannulation, time to successful IV cannulation, number of attempts per subject, number of subjects with successful IV cannulation on first attempt, and mean time to successful IV cannulation when successful on the first attempt\***

	Traditional group (n = 16)	Ultrasound group (n = 19)	P
Location of successful cannulation			—
Hand	4	0	
Wrist	2	2	
Forearm	8	12	
Antecubital	2	5	
Size of IV catheter (gauge)			—
18	8	4	
20	7	12	
22	1	3	
Time to successful IV cannulation (s)	172.1 ± 222.1	303.7 ± 294.6	.15
No. of attempts per subject	1.3 ± 0.9	1.4 ± 0.7	.98
Subjects with successful IV cannulation on first attempt	13 (81)	14 (74)	.70
Time to successful IV cannulation when successful on the first attempt (s)	78.0 ± 33.1	187.3 ± 228.3	.59

\* Data are given as number of cases, mean ± SD, or number (percentage).

located by visualization and/or palpation, the practitioner may resort to blindly cannulating the vein, ie, insertion of the catheter based on landmarks in a trial-and-error manner. Blind insertion of peripheral IV catheters, besides being potentially painful and time-consuming, may result in arterial puncture, nerve damage, and paresthesias.<sup>2</sup> Venous cutdown and central venous and intraosseous routes may be considered; however, practitioners must weigh the risks and benefits of each route given the specific clinical situation.<sup>10,11</sup> Ultrasound-guided peripheral IV cannulation offers practitioners another technique to aid in gaining venous access.

The use of ultrasound is advantageous because it lacks adverse biological effects, provides real-time images, gives quantitative imaging and measurement

of blood flow, and does not use ionizing radiation.<sup>12</sup> The results of previous investigations have indicated that the use of ultrasound as an aid in the placement of central venous catheters via veins in the neck and chest lessens the risk of complications such as arterial puncture and pneumothorax.<sup>4</sup> The evidence supporting the use of the ultrasound as an aid in placing central venous catheters by lessening the frequency of complications has led to its endorsement by health-care agencies in the United Kingdom (National Institute for Clinical Excellence) and United States (Agency for Healthcare Research and Quality).<sup>5,6</sup>

Ultrasound has also been used as an aid in cannulation of veins outside of the neck and chest. It has been shown to be effective in a wide array of clinical scenarios. By using a convenience sample of 20

patients in cardiopulmonary arrest, Hilty et al<sup>7</sup> found that the use of ultrasound compared with a landmark technique to place a femoral venous catheter resulted in a higher success rate with fewer needle passes and a lower rate of arterial puncture. Ultrasound was only slightly faster than the landmark technique.<sup>7</sup>

The use of ultrasound in IV cannulation of the deep brachial or basilic vein has been successful when traditional attempts at peripheral vein cannulation have failed. In an investigation of 101 adults admitted to the emergency department who had undergone 2 or more unsuccessful attempts at peripheral IV cannulation, Keyes et al<sup>9</sup> used ultrasound to guide placement of an IV catheter into the deep brachial or basilic vein. Cannulation was successful 91% of the time, with 73% of the cannulations successful on the first attempt and a mean  $\pm$  SD time to successful cannulation of  $77 \pm 129$  seconds. The investigators noted problems in securing the catheter in the deep brachial or basilic vein due to arm movement, with the catheter falling out or IV fluid infiltrating in 8% of patients.<sup>9</sup> Complications of cannulating the deep brachial vein can preclude its future use for long-term vascular access or dialysis.<sup>13</sup> Cannulation of veins in the hand and forearm may offer a decreased likelihood of these complications.

By using 2-dimensional ultrasound, the veins of the hand and forearm can be easily identified (see Figure). The veins are projected onto the monitor as a black circle that is compressible onto a white background. Unlike an artery, which projects as a pulsating black circle and is not compressible, the veins can be compressed with the ultrasound transducer. The Site-Rite 3 Ultrasound Unit is a battery-powered portable device marketed as an aid for placing vascular catheters and for locating landmarks when performing nerve blocks. Its small size and ease of use are attributes that make it ideal for use as a guide in venous cannulation.

The results of this investigation indicate that ultrasound-guided peripheral IV cannulation is as efficacious as the traditional method of IV cannulation in subjects with a self-reported history of difficult IV cannulation or suspicion of difficult IV cannulation. A possible explanation for this finding is that although subjects reported a history of difficult IV cannulation or IV cannulation was suspected to be difficult, IV cannulation of subjects in both groups was truly not difficult, ie, this study did not assess difficulty of IV cannulation. A more rigorous comparison would be to compare the use of ultrasound-guided peripheral IV cannulation with continued traditional IV cannula-

tion techniques with subjects in whom initial IV cannulation has failed.

Limitations of this investigation include not including the time to transport the ultrasound device into the procedure time. It should be noted that the device is not a part of the usual IV insertion equipment. Cost of the procedure, including cost of the ultrasound device and the CRNA time, was not analyzed. The CRNAs placing the catheters were well experienced in the use of the ultrasound device, limiting the generalization of the findings to experienced practitioners. Finally, due to personnel and time constraints, the CRNAs placing the catheters also collected the data.

Future investigations should examine not only the ultrasound-guided technique as a rescue in cases in which the traditional approach fails, but also the total time and cost of the procedure as mentioned. Operators with a range of experience in the specialty and technique should be included in future investigations. Future subjects should be followed up longitudinally and examined for complications such as longevity of the catheter, phlebitis, and infection. In addition, future investigations should include children and infants, and an independent observer should collect the data.

An incidental finding was the visibility the investigation brought to the ultrasound-guided method among anesthesia practitioners at the study facility. After conclusion of the investigation, there was an increase use of the ultrasound device in placement of potentially difficult or proven difficult peripheral IV catheters. Reasons provided by the practitioners included the perceived avoidance of blind IV catheter insertion with decreased incidence of complications.

Ultrasound is a potentially useful adjunct in placing peripheral IV catheters in the veins of the wrist and forearm. Its use may decrease the need to place IV catheters in the veins of the antecubital fossa that are uncomfortable for the patient and have stabilization problems. Ultrasound used in this manner may also decrease the need for placement of central venous catheters. A number of future investigations are indicated, including the use ultrasound in cases of failure in the placement of peripheral IV catheters in the hands and/or forearm by traditional techniques.

## REFERENCES

1. Vyskocil JJ, Kruse JA, Wilson RF. Alternative techniques for gaining venous access. What to do when peripheral intravenous catheterization is not possible. *J Crit Illn.* 1993;8:435-442.
2. Liu S, Zane R. Peripheral intravenous access. In: Roberts J, Hedges J, eds. *Clinical Procedures in Emergency Medicine.* 4th ed. Philadelphia, Pa: Saunders; 2004:401-411.

3. Denys BG, Uretsky BF, Reddy PS, Ruffner RJ, Sandhu JS, Breishlatt WM. An ultrasound method for safe and rapid central venous access [letter]. *N Engl J Med.* 1991;324:566.
4. Hind D, Calvert N, McWilliams R, et al. Ultrasonic locating devices for central venous cannulation: meta-analysis. *BMJ.* 2003;327:361.
5. *Guidance on the Use of Ultrasound Locating Devices for Placing Central Venous Catheters.* London, England: National Institute for Clinical Excellence; 2002:21.
6. *Making Health Care Safer: A Critical Analysis of Patient Safety Practices.* Rockville, Md: Agency for Healthcare Research and Quality, US Department of Health and Human Services; 2001. Evidence Report/Technology Assessment Number 43.
7. Hilty WM, Hudson PA, Levitt MA, Hall JB. Real-time ultrasound-guided femoral vein catheterization during cardiopulmonary resuscitation. *Ann Emerg Med.* 1997;29:331-337.
8. LaRue GD. Efficacy of ultrasonography in peripheral venous cannulation. *J Intraven Nurs.* 2000;23:29-34.
9. 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;34:711-714.
10. Mark J, Slaughter T, Reves J. Cardiovascular monitoring. In: Miller R, Cucchiara RF, Miller ED, Reves JG, Roizen MF, Saverese JJ, eds. *Anesthesia.* Vol 1. 5th ed. Philadelphia, Pa: Churchill Livingstone; 2000:1117-1206.
11. Kovarik W, O'Rourke P. Pediatric and neonatal intensive care. In: Miller R, Cucchiara RF, Miller ED, Reves JG, Roizen MF, Saverese JJ, eds. *Anesthesia.* Vol 2. 5th ed. Philadelphia, Pa: Churchill Livingstone; 2000:2443-2498.
12. Hedrick W, Hykes D, Starchman D. *Ultrasound Physics and Instrumentation.* 3rd ed. St Louis, Mo: Mosby; 1995.
13. Ault MJ. Ultrasound-guided brachial and basilic vein cannulation [letter]. *Ann Emerg Med.* 2000;36:399.

#### AUTHORS

Captain Hector Aponte, CRNA, MSN, USAF, NC, is a staff nurse anesthetist at Aviano Air Base, Italy. He was a student at the Uniformed

Services University of the Health Sciences Graduate School of Nursing Nurse Anesthesia Program, Bethesda, Md, while conducting this study. Email: hector.aponte@aviano.af.mil.

Captain Said Acosta, CRNA, MSN, USAF, NC, is a staff nurse anesthetist at Eglin AFB Regional Hospital, Fla. He was a student at the Uniformed Services University of the Health Sciences Graduate School of Nursing Nurse Anesthesia Program, Bethesda, Md, while conducting this study.

Donald Rigamonti, PhD, is an associate professor of Nursing, Graduate School of Nursing, Uniformed Services University of the Health Sciences.

Barbara Sylvia, RN, PhD is associate professor, Graduate School of Nursing, Uniformed Services University of the Health Sciences.

Paul Austin, CRNA, PhD, is an adjunct associate professor of Nursing, Graduate School of Nursing, Uniformed Services University of the Health Sciences.

Timothy Samolitis, CRNA, PhD, was the assistant clinical site director, Nurse Anesthesia Clinical Training, Wright-Patterson Air Force Base, FB, Ohio, and adjunct assistant professor, Graduate School of Nursing, Uniformed Services University of the Health Sciences, at the time this study was conducted. He has since retired from the US Air Force.

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