Advanced Emergency Nursing Journal
Vol. 32, No. 2, pp. 173–188

Developing and Sustaining an Ultrasound-Guided Peripheral Intravenous Access Program for Emergency Nurses

Ann White, MSN, RN, CCNS, CEN, CPEN
Fernando Lopez, MD
Phillip Stone, RN

ABSTRACT
Ultrasonography use in the emergency department (ED) has been well established. The use of ultrasonography that falls into the traditional practice of the emergency nurse is peripheral intravenous (IV) access. Benefits of using ultrasonography for peripheral IV access include decreasing patient throughput, cost reduction, decreasing complications, increased patient and emergency medicine physician satisfaction, and emergency nurse autonomy. Review of the literature demonstrates no discernable differences in ability and efficacy with ultrasound (US)-guided peripheral IV access when comparing data from studies about emergency medicine physicians, certified registered nurses anesthetists, emergency department technicians, physician assistants, and emergency registered nurses. In 2006, Duke University Hospital Emergency Department started a US-Guided Peripheral IV Access program for emergency nurses. Similar patient populations have been observed and the same types of complications have been encountered as described in the literature. Future goals include perfecting nurses' vein selection, and to study skill mastery with US-guided peripheral IV access. **Key words:** emergency nurse, peripheral intravenous (IV) access, ultrasonography, ultrasound (US), US-guided peripheral IV

THE utility of ultrasonography in the emergency department (ED) has been well established in the last decade. Emergency medicine (EM) physicians utilize ultrasonography for diagnostic purposes to evaluate multiple organ systems in different clinical scenarios. It is also used for central and peripheral venous catheter access. The use of EM ultrasonography that falls into the traditional practice of the emergency nurse is peripheral intravenous (IV) access. Even the most experienced emergency nurse may have difficulty obtaining IV access in patients with conditions such as injection drug use, obesity, chronic illness, hypovolemia, shock, vasculopathy, and extremes of age. These patients lack easy access to peripheral venous sites using the traditional techniques of direct visualization, anatomic landmarks, palpation, and trial-and-error blind cannulation.

Author Affiliations: *Duke University Hospital Department of Advanced Clinical Practice and Duke University School of Nursing (Ms White), Duke University Medical Center (Dr Lopez), and Duke University Hospital Emergency Department (Mr Stone), Durham, North Carolina.*

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.AENJournal.com).

Corresponding Author: *Ann White, MSN, RN, CCNS, CEN, CPEN, Duke University Hospital, DUMC 3677, Durham, NC 27710 (ann.white@duke.edu).*

Figure 1. DUH ED nurse, P. Stone, using ultrasonography to start IV. Reprinted with permission of Sonosite Inc.

Although these patients require timely peripheral venous access, their condition may not be so acute as to require emergent central venous or intraosseous access.

An evolving option for peripheral IV access is the utilization of ultrasonography by the emergency nurse (Figure 1). This option is employed after traditional techniques have failed. This technique can also be used by the nurse for the initial IV attempt for patients who have a history or suspicion of difficult IV access based on medical history.

BENEFITS

There are several benefits of using ultrasonography:

- decreasing patient throughput time and delays in diagnosis and treatment due to less time spent in obtaining venous access,
- cost reduction by avoiding critical care time and use of expensive equipment for central catheter insertion, at the same time eliminating exposure to iatrogenic complications such as pneumothorax and bloodstream infection, which increase mortality, hospital length of stay, and healthcare costs, and
- decreasing complications of traditional insertion that include pain, arterial puncture, nerve damage, and paresthesias (Aponte et al., 2007; Blaivas, Brannam, & Fernandez, 2003; Blaivas & Lyon, 2006; Bauman, Braude, & Crandall, 2009; Brannam, Blaivas, Lyon, & Flake, 2004; Witting, Schenkel, Lawner, & Euerle, in press).

Additional benefits include

- increased patient comfort and satisfaction,
- increased EM physician satisfaction due to sustained productivity because of less interruptions to work flow to complete a routine procedure normally accomplished by nurses, and
- increased emergency nurse autonomy (Bauman et al., 2009; Blaivas, 2005; Costantino, Parikh, Satz, & Fojtik, 2005; Mills, Liebmann, Stone, & Frazee, 2007; Stein, Cole, & Kramer, 2004).

The use of ultrasonography is advantageous because there are no biological effects and no use of ionizing radiation; ultrasonography also measures blood flow and can provide real-time vascular imaging (Aponte et al., 2007).

REVIEW OF THE LITERATURE

The literature provides varied information about formal research findings and clinical experience with the use of ultrasonography for peripheral IV access. Six studies published between 1999 and 2009 describe the success rate in difficult peripheral IV access using ultrasonography by EM physicians (Costantino et al., 2005; Keyes, Franzee, Snoey, Simon, & Christy, 1999; Mills et al., 2007; Stein et al., 2004; Stein, George, River, Hebig, & McDermott, 2009; Witting et al., in press). In ED patients with difficult peripheral IV access, researchers from all studies except one (Stein et al., 2009) concluded that US-guided vein cannulation was safe and rapid and had a high success rate. In addition, the majority of cannulations were accomplished with one attempt ($n = 387$; Costantino et al., 2005; Keyes et al., 1999; Mills et al., 2007; Stein et al., 2004; Witting et al., in press). Physicians reported untoward outcomes such as mechanical, infectious, and thrombotic complications (Table 1). In contrast to the five other studies, Stein et al. (2009) concluded that US-guided

Table 1. Incidence of complications from ultrasound-guided peripheral IV access by EM physicians

Complication type	Keyes et al., 1999 ($N = 100$)	Costantino et al., 2005 ($N = 60$)	Mills et al., 2007 ($N = 25$)	Witting et al. in press ($N = 180$)	Stein et al., 2009 ($N = 59$)
Mechanical	8% Infiltrated or fell out	0	4%	1% Paresthesias	0
Arterial blood flow through the catheter, US evidence of arterial puncture, hematoma formation, paresthesias, and venous infiltration	2% Brachial arterial puncture 1% Paresthesia due to contact with brachial nerve			2% other	
Infectious	Not measured	Not measured	0	Not measured	0
Erythema, pain, edema consistent with catheter-associated cellulitis or phlebitis, or positive catheter-tip culture					
Thrombotic	Not measured	Not measured	0	Not measured	0
Any clinical or US evidence of upper-extremity venous thrombosis					

Note: US = ultrasound. Data from "Ultrasound-Guided Brachial and Basilica Vein Cannulation in Emergency Department Patients With Difficult Intravenous Access," by L. Keyes, B. Franzee, E. Snoey, B. Simon, and D. Christy, 1999, *Annals of Emergency Medicine, 34*, pp. 711–714; "Ultrasonography-Guided Peripheral Intravenous Access Versus Traditional Approaches in Patients With Difficult Intravenous Access," by T. Costantino, A. Parikh, W. Satz, and J. Fojtik, 2005, *Annals of Emergency Medicine, 46*, pp. 456–461; "Ultrasonographically Guided Insertion of a 15-cm Catheter Into the Deep Brachial or Basilic Vein in Patients With Difficult Intravenous Access," by C. Mills, O. Liebmann, M. Stone, and B. Frazee, 2007, *Annals of Emergency Medicine, 50*, pp. 68–72; "Effects of Vein Width and Depth on Ultrasound-Guided Peripheral IV Success Rates," by M. Witting, S. Schenkel, B. Lawner, and B. Euerle, B, in press, *The Journal of Emergency Medicine,* doi:10.1016/j.jemermed.2009.01.003. "Ultrasonographically Guided Peripheral Intravenous Cannulation in Emergency Department Patients With Difficult Intravenous Access: A Randomized Trial," by J. Stein, B. George, G. River, A. Hebig, and D. McDermott, 2009, *Academic Emergency Medicine, 54*, pp. 33–40.

peripheral IV cannulation did not decrease the number of attempts, time to successful catheterization, nor did it improve patient satisfaction and suggested that there is no superiority of this technique.

The literature has also described other types of clinicians using ultrasonography to start peripheral IVs. In 2007, Aponte et al. described successful use of ultrasonography by certified registered nurse anesthetists. Researchers randomized subjects to a traditional group and a US-guided group and measured time to successful cannulation on first attempt and number of attempts per subject. White, Sturges, Barton, Battaglia, and McCowan (2007) and Bauman et al. (2009) described similar studies with ED technicians that also showed that the use of ultrasonography increases the success rate of peripheral IV placement. In 2009, Witting et al. studied the effects of vein width and depth in US-guided peripheral IV success rates. Three percent of the attempts studied were performed by physician assistants, and 1% of the attempts were performed by a registered nurse.

Only three observational, descriptive studies have been published about specific emergency nurse experience with US-guided peripheral IV access. Two are from the same healthcare institution, with analysis solely from the EM physician's perspective. These two studies use the same sample of emergency nurses. The 2004 study (Brannam et al.) actually measured the utility of nurses, using US in the clinical setting, and the 2006 study (Blaivas & Lyon) measured the perception of technical difficulty by the same nurses with the same patient sample. In 2007, Chinnock, Thornton, and Hendey studied predictors of success in emergency nurse-performed US-guided cannulation. This is the only study measuring complications from cannulation by an emergency nurse. In comparing the studies measuring certified registered nurse anesthetists', emergency technicians', physician assistants', and emergency nurses' success with US-guided peripheral IV access with studies measuring EM physicians' success with US-guided peripheral IV access, there are no discernable differences in ability and efficacy (Table 2).

DUKE UNIVERSITY HOSPITAL EMERGENCY DEPARTMENT'S US-GUIDED PERIPHERAL IV ACCESS

Program for Emergency Nurses

The motivation to develop emergency nurse competency in US-guided peripheral IV access began as a grassroots effort in 2006 by staff nurses. The nurses observed the utility of the technology when used by EM physicians after they were unsuccessful in obtaining IV access with the traditional approach and sought information about ultrasonography for peripheral access from their EM physician colleagues.

A small number of nurses were instructed on the technique during actual application with a real patient by the EM physicians and requested to be able to use this new knowledge independently when attempting to start IVs on patients. After consulting the State Nursing Practice Act and securing support from ED and organizational leadership, a program was developed to train the emergency nurses in US-guided venous cannulation. Organizational experts who assisted with the training included an ultrasonography fellowship-trained EM attending physician, clinicians from the IV therapy department who use bedside ultrasonography for peripherally inserted central catheters, and a representative from SonoSite Inc. (Bothell, WA, manufacturer of the portable US machine).

Senior staff nurses are selected to be trained on this advanced skill. This approach is used as a retention strategy to recognize the nurse's experience and as an appeal to their request for advanced education and responsibility. The role is highlighted as an advanced clinical role in the department and something that less-experienced nurses can strive for, as novice nurses, especially new graduate nurses, need to remain focused on improving

Table 2. Comparison of ability with US-guided peripheral IV access by different clinicians (Aponte et al., 2007; Bauman et al., 2009; Brannam et al., 2004; Costantino et al., 2005; Keyes et al., 1999; Mills et al., 2007; Stein et al., 2004; Stein et al., 2009; White et al., 2007; Witting et al., in press)

Type of clinician/study	Number of subjects	Subjects with successful US-guided cannulation on first attempt	Time to successful US-guided IV cannulation when successful on first attempt	Number of attempts per subject	Incidence of complications
EM attending physician					
Stein et al. (2009)	28	Not reported separately	39 ± 52 (Measured in minutes from enrollment to blood return; could use one- or two-person technique and it was not reported which one was used)	2 ± 1	See Table 1
EM attending physician and resident physician					
Keyes et al. (1999)	100	73%	77 ± 129 (Measured in seconds when transducer placed on skin and vein cannulated; used two-person technique, time started after cleaning)	Not measured	See Table 1
Stein et al. (2004)	15	86%	Not measured	1.3	Not measured
Costantino et al. (2005)	39	97%	4 ± 5.6 (Measured in minutes from needle puncture to vein cannulated)	1.7 ± 0.7	See Table 1
Mills et al. (2007)	25	61%	3 ± 5 (Measured in minutes when transducer placed on skin and vein cannulated; could use one or two-person technique and it was not reported which one was used)	1.52	See Table 1

(*continues*)

Table 2. Comparison of ability with US-guided peripheral IV access by different clinicians (Aponte et al., 2007; Bauman et al., 2009; Brannam et al., 2004; Costantino et al., 2005; Keyes et al., 1999; Mills et al., 2007; Stein et al., 2004; Stein et al., 2009; White et al., 2007; Witting et al., in press) (*Continued*)

Type of clinician/study	Number of subjects	Subjects with successful US-guided cannulation on first attempt	Time to successful US-guided IV cannulation when successful on first attempt	Number of attempts per subject	Incidence of complications
EM attending physician and resident physician (95% of attempts), physician assistant (3% of attempts), registered nurse (1% of attempts)					
Witting et al. in press)	180	56%	Not measured	1.32	See Table 1
Certified registered nurse anesthetist					
Aponte et al. (2007)	19	74%	187.3 ± 228.3 (Measured in seconds when transducer placed on skin and vein cannulated; used one-person technique, time started before cleaning)	1.4 ± 0.7	Not reported
Emergency department technician (EM technician-paramedic or EM technician-intermediate)					
White et al. (2007)	45	75.6%	Not measured	1.29 ± 0.56	0
Bauman et al. (2009)	75	80.5%	26.8 (Measured in minutes when transducer placed on skin to vein cannulated; used one-person technique)	1.6 ± 0.7	9.8% arterial punctures with no distal vascular compromise, bleeding stopped with 5-min compression; hematoma 29.3%; nerve pain 2.4%
Emergency nurse					
Brannam et al. (2004)	321	87%	Not measured	Not measured	1.2%, all arterial punctures
Chinnock, Thornton, & Hendy; 2007	119	44%	Not measured	Not measured	4.2% arterial; 2.5% arm numbness; 6.7% severe pain; all resolved during ED stay

Note: EM = emergency medicine, IV = intravenous, US = ultrasound.

LWW/AENJ TME200073 April 29, 2010 19:10 Char Count= 0

Table 3. Summary of ultrasound didactic training

Ultrasound physics—30 min	Highlighting potential physiological effects affecting safety: ultrasonography enhances inflammatory response; and it can heat soft tissue
Operation of US machine—30 min	Screen settings, gain, field depth, and image optimization
How to scan—1 hr	Use of ultrasonographic gel, transducer probe selection, transverse or longitudinal beam, pressure of probe, needle tip location, and anatomy
US-guided IV procedure—1 hr	Preparation, transducer probe orientation, equipment positioning, scout scan, asepsis, needle angle, evaluation, pearls and pitfalls

Note: IV = intravenous; US = ultrasound.

their basic psychomotor skill with traditional IV access techniques. Another benefit of limiting the number of nurses who are trained to use ultrasonography is that their proficiency will develop and remain because their opportunity to use ultrasonography will not be diluted as it might if all nurses were trained. This approach to prevent decay in skill level is also described in the literature (Chinnock, Thornton, & Hendey, 2007).

The training consists of a 3-hour initial training session that includes didactic information, simulation, and hands-on practice. Table 3 summarizes major concepts of the initial training. Table 4 lists the behavioral objectives used to evaluate competency with the skill. The initial skill acquisition revolves around the nurse being able to manipulate the transducer probe to view the vessels from a longitudinal (long axis) or transverse (short axis) approach (Figures 2–4). Although studies demonstrate that novice ultrasonography users obtain vascular access faster with a short-axis approach and it seems to be the preferred approach for cannulation because the blood vessel is easier to see and less alignment needs to be performed, we encourage skill development, mainly hand–eye coordination, using both positions (Blaivas et al., 2003; Brannam, Fernandez, & Blaivas, 2003).

In the long-axis approach, the entire length of the needle can be tracked on the ultra machine screen as it enters the blood vessel allowing greater visualization of the needle-tip location, whereas with the short-axis approach, this is not the case, because only a portion of the needle can be tracked as it passes through the US beam under the transducer probe (Blaivas et al., 2003). If the nurse prefers to gain IV access with the short-axis approach, we emphasize the technique with the US transducer probe of fanning off the end of the needle tip to visualize the bevel end. This deforms the target vessel prior to cannulation and then upon insertion, positioning the US transducer probe with the long-axis view for definitive confirmation of location and effective function potential (Supplemental Digital Content, Videos demonstrating this are available at http://links.lww.com/AENJ/A1 and http://links.lww.com/AENJ/A2, see videos 1 and 2).

After the initial session, nurses are required to be observed starting peripheral IVs with ultrasonography by a core group of proctors. At least 10 proctored attempts were selected as the benchmark for competency before the emergency nurse can perform ultrasonography independently. This number was determined by the ultrasonography fellowship-trained EM attending physician who acts as a medical director for the program, which is facilitated and coordinated by the ED clinical nurse specialist (CNS). The core proctors are limited to the ultrasonography fellowship-trained EM attending physician, the ED CNS, and three other trained nurses selected by the ED CNS on the basis of their overall technical

Table 4. Performance criteria to evaluate competency for ultrasound-guided peripheral IV insertion

Competency	Performance criteria
Assessment of patient	Assesses patient for need to utilize US-guided intravenous access
	Reviews most recent history and physical, medication history, and allergies
	Confirms patient identification armband
Planning for procedure	Collects necessary supplies, personal protective equipment, and sets up as needed
	Explains procedure to patient
	Teaches patient symptoms to report during procedure
Patient safety	Differentiates and identifies arteries versus veins using ultrasonography
	Utilizes appropriate infection-control measures to reduce risk of invasive line infection
	Determines the depth of the target vein utilizing depth scale on US device and selects the appropriate length IV catheter (1.16 in. for standard, 1.88 in. for deeper target veins)
	Removes tourniquet promptly when indicated
	Monitors line patency and infusion to detect signs and symptoms of infiltration
Evaluation	Confirms blood return, easy flush, and absence of swelling or tenderness at site
	Documents use of ultrasonography for IV placement, catheter size, length, location, and site condition
	Labels IV site with insertion date, catheter size, and whether deep brachial vein was used
	Reevaluates site frequently for signs of infiltration
	Evaluates patient's response to procedure

Note: IV = intravenous, US = ultrasound.

skill and ability to teach and mentor others. Once the proctored insertions are completed, a signed document confirming the competencies that were observed is placed in the nurse's personnel file and an announcement recognizing the nurse's accomplishment is sent out electronically to all ED staff. Also, the nurse's name is added to a reference that is posted in the clinical area that lists the names of the nurses that ED staff can consult when IV access using the traditional approach has failed. The process of consulting one of these nurses first, before involving an EM physician to start the IV, is stressed.

The objective in using a small core group of proctors is to allow a greater chance for consistency in technique, mainly focusing on aseptic technique and how to avoid arterial puncture when venous cannulation is the goal. The cited literature inconsistently mentions in a detailed fashion infection prevention technique used while inserting US-guided venous catheters. For example, Mills et al. (2007) state that the catheter was inserted by EM physicians with unsterile ultrasonographic gel and unsterile gloves and Bauman et al. (2009) mention using a semisterile technique with a nonsterile transducer probe. With a major focus on reducing bloodstream infections, and also because blood cultures are frequently obtained with the IV insertion, Duke's procedure includes the use of sterile ultrasonographic gel and covering the probe with a sterile transparent

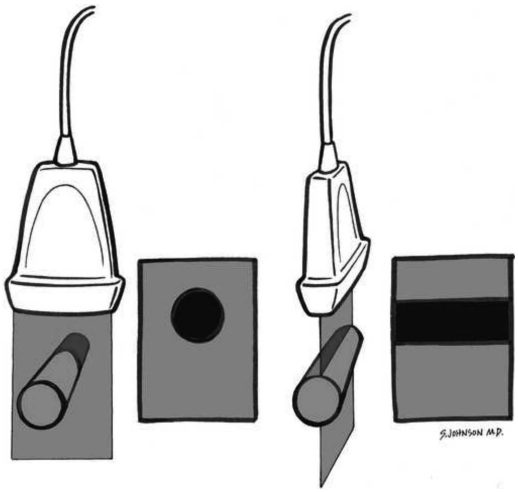


Figure 2. First two images show transducer placement for short-axis (transverse) view including how image appears on ultrasound machine screen. Last two images show transducer placement for long-axis (longitudinal) view including how image appears on ultrasound machine screen. Used with permission from SonoSite® Inc.

dressing before placing it on the cleansed skin over the preselected puncture site.

Along with instruction on peripheral venous access, which includes recognizing the difference between a vein and an artery,

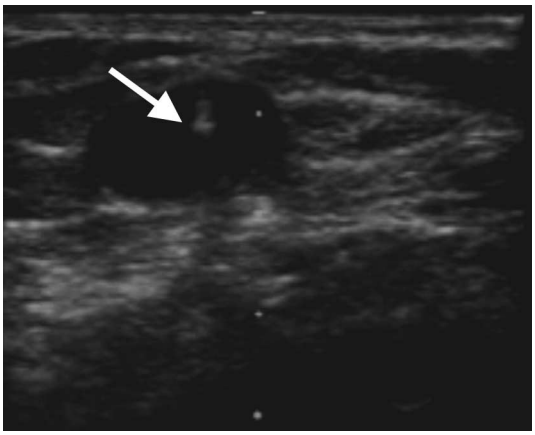


Figure 3. A cannulated vein using the short-axis (transverse) view, needle appears as bright, white point in center of vein at a depth of approximately 1 cm. Bright white dots are depth indicators spaced at 1 cm increments.

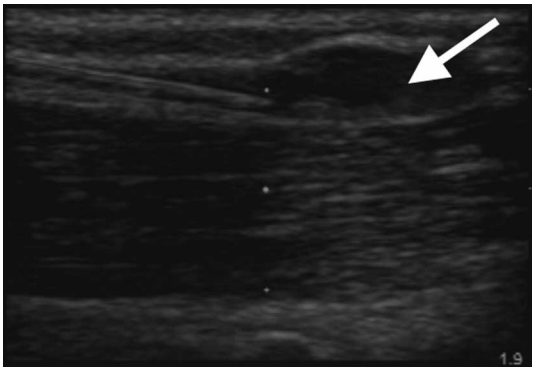


Figure 4. A cannulated vein using the long-axis (longitudinal) view, cannula appears as long white line in middle of vein at a depth of approximately 1 cm. Bright white dots are depth indicators spaced at 1 cm increments.

nurses are taught how to use this same technology for arterial puncture to obtain blood sampling for blood gas analysis. Another application of ultrasonography is fetal heart rate visualization. Nurses are taught how to visualize fetal heart rate after hand-held Doppler assessment is unsuccessful. These two applications are infrequently used compared with the use for establishing IV access. However, anecdotally, nurses seem to grasp the technique and concept quite readily.

Since 2006, the training class has been offered four times. At present, 13 nurses (approximately 10% of registered nurse full-time equivalents with an equal distribution on the day and night shift are trained to perform US-guided peripheral IV access independently and approximately 10 nurses are currently in the process of being proctored.

We have observed similar patient populations described in two studies that highlighted poor peripheral vasculature with sclerosis and scar tissue from chronic injection drug use followed by chemotherapy, obesity, and hypotension (Keyes et al., 1999; Mills et al., 2007) as the most prevalent patient types who present with difficult peripheral IV access. Two chronic conditions also mentioned in the literature that we found in our clinical setting who are common candidates for ultrasonography as the initial modality

for IV insertions are patients with sickle cell disease and chronic renal failure (Aponte et al., 2007; Brannam et al., 2004; Costantino et al., 2005; Witting et al., in press).

Blaivas and Lyon (2006) also noted many patients with chronic medical conditions who experience acute exacerbations and frequent visits to the ED, attempt to avoid blind IV attempts and request immediate use of ultrasonography when blood sampling or IV therapy is required. It has become common since the start of our ultrasonography program that patients with chronic conditions, who visit the ED frequently, ask for their IV to be started initially with the US technique. The ability to provide this US-guided service has resulted in increased patient comfort, satisfaction, and improved rapport with the healthcare team.

We have also encountered the same types of complications described in the literature about ED technicians by Bauman et al. (2009) and emergency nurses by Brannam et al. (2004) and Chinnock, Thornton, and Hendey (2007). These authors cited the occurrence of arterial puncture during cannulation. This complication was also noted in the studies with EM physicians (Costantino et al., 2005; Keyes et al., 1999; Mills et al., 2007; Witting et al., in press). Arteries may be difficult to identify and differentiate from veins. This can be due to low systolic pressure or poor arterial wall tone. We have outlined for the US-trained nurses a *decision-making process* (Table 5) to confirm whether the IV is where they want it to be.

First, the tendency is to compress vessels quickly and completely flat. Sometimes, pulsations can be obscured by complete compression. Try *slowing the compression rate* and hold the vessel at a *partially compressed* position and look for subtle pulsations. This may require observation for several seconds (a video of this is available at http://links.lww.com/AENJ/A3, see video 3). Second, if cannulation has already occurred, confirm the absence of pulsations by aspirating blood halfway or less into the extension tubing and *observe for pulsatory fluctuations in the column of blood*, possibly very subtle, similar to those observed in a sphygmomanometer. Following cannulation of the vessel, try confirming the catheter position in the vessel by using a *longitudinal view*. Apply mild compression in that view to confirm that there are no pulsations. Pulsations would indicate arterial cannulation. The *color Doppler signal* feature can also be used to discern catheter location and is defined as red representing blood flow toward the transducer (arterial) and blue representing blood flow away from the transducer (venous; video available at http://links.lww.com/AENJ/A4, see video 4). Also, an arterial blood gas can be analyzed to evaluate the values for arterial blood.

Anecdotal reports of inconsistent longevity of the catheter function after insertion have been common. This phenomenon seems to be correlated with experience and skill of the

Table 5. Decision-making process to confirm IV location

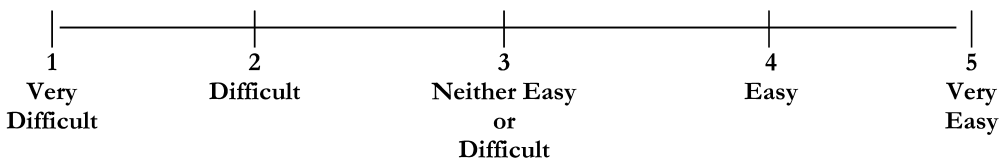
Slow the compression rate and hold the vessel at a *partially compressed* position and look for subtle pulsations. This may require observation for several seconds.
If cannulation has already occurred, confirm absence of pulsations by aspirating blood halfway or less into the extension tubing and *observe for pulsatory fluctuations in the column of blood,* possibly very subtle, similar to those observed in a sphygmo manometer.
Following cannulation of the vessel, try confirming the position in the vessel by using a *longitudinal view*. Apply mild compression in that view to confirm that there are no pulsations. Pulsations would indicate arterial cannulation.
The color Doppler signal feature can be used to discern catheter location and is defined as *red representing blood flow toward the transducer (arterial)* and *blue representing blood flow away from the transducer (venous).*
An arterial blood gas can be analyzed to evaluate the values for arterial blood.

Date:	RN initials:	Leave blank_____
MR #:	Patient age:	Patient Gender:
SBP/DBP:	Intravascular Volume status(√ one): Extremity edema Yes☐ No☐ Euvolemic ☐ Hypovolemic ☐ Hypervolemic ☐ Can't determine ☐	
Height: Weight (kg): Calculated BMI (Software on Wellsoft Link):		
Check presence of any of the following disease conditions affecting venous access ability: Renal failure requiring hemodialysis ☐ Cancer requiring recent chemotherapy ☐ Systemic lupus erythematosis ☐ Diabetes ☐ Morbid obesity ☐ Other ☐ _____		

Venous Ultrasonography (VUS)

Ultrasound Unit used for access: I-View ☐ Sonomax ☐ Other ☐_____
Reason for IV (√ all that apply): General Access ☐ Fluid ☐ Medication ☐ Blood sampling ☐ Diagnostic procedure ☐
How many venous access attempts PRIOR to attempting VUS?
How many attempts DURING VUS?
Location of successful cannulation:
Size needle:
Use of local analgesia?
Estimated diameter of vein: _____cm Depth of vein at inferior margin:_____cm
Vein confirmation using longitudinal view? Yes☐ Vessel confirmation using Color Doppler? Yes☐
# of minutes for procedure completion (Time from **needle to skin** to **dressing site**):

Rate level of cannulation difficulty:



Check approximate # of prior VUS placements you have completed: 10-19 ☐ 20-39 ☐ 40-59 ☐ 60-79 ☐ 80-99 ☐ ≥ 100 ☐
Rate patient's level of discomfort with stick (use appropriate pain scale):
Describe patient's subjective response to VUS:
Opportunity for Patient Teaching: Yes ☐ No ☐
Status of VUS site and catheter upon ED discharge, check any present: ☐ In use with no difficulty ☐ Positional with frequent alarms ☐ Infiltrated, removed ☐ Removed as no longer needed ☐ Erythema ☐Ecchymosis ☐ Hematoma ☐Swelling ☐ Tenderness ☐ Other
Next calendar day follow-up: Completed by _____ ☐ In use with no difficulty ☐ Positional with frequent alarms ☐ Infiltrated, removed ☐ Removed as no longer needed ☐ Other

Anecdotal Information:

Figure 5. Nurse-provided venous access using ultrasonography data collection form, Duke University Hospital emergency department.

US-trained nurse. Failed cutaneous punctures are cited as common in the literature (Bauman et al., 2009; Mills et al., 2007; Witting et al., in press). In 2009, Witting et al. studied vein width and depth on the probability of success in US-guided IV insertion. The results of this study showed that success rates are higher in larger veins (≥0.4 cm) and veins at

moderate depth (0.3–1.5 cm; Witting et al., in press). The researchers suggested that moderate depth is more successful because more shallow veins do not allow enough distance to visualize the needle approaching the target requiring a shallower needle angle and veins at greater depths have inadequate needle length to pass into the vein (Witting et al., in press).

A problem frequently cited in the literature is the proximity of the US-guided IV site to the biceps muscle and tendon and the occasional practice of securing the IV tubing across the antecubital fossa when that site is used, resulting in more tip movement during arm manipulation, movement of the catheter in and out of the vessel, and extravasation when a shorter catheter is used (Bauman et al., 2009; Blaivas, 2005; Keyes et al., 1999; Witting et al., in press). To mitigate these problems, this information was shared with the current US-trained nurses. The use of longer catheters (1.88 in.) exclusively for US-guided IV access is taught. We will be periodically validating that the US-trained nurses are adept at measuring width and depth and we will be stressing avoidance of veins with unfavorable characteristics (too small, shallow, or deep) more prominently in future training for nurses new to the skill to ensure greater longevity of IV function.

Data collection for performance-improvement purposes has recently started. The US-trained nurses complete the form after each patient encounter, documenting patient characteristics, degree of patient satisfaction, and information about the access and patient outcomes elucidating the potential benefits and complications of US guidance in IV access (Figure 5). The choice was made not to approach this data collection as research but rather as quality improvement because a research process would have required obtaining informed consent from the patient before using ultrasonography. It was felt that consenting the patient as a research subject would delay IV access and patients might think that the use of ultrasonography was experimental as opposed to an established tool to accomplish a standard procedure.

FUTURE RESEARCH

The literature already clearly identifies the patient characteristics that support ultrasonography use and the benefits and risks. What is not identified clearly in the literature is time and number of patient encounters required by the ultrasonographer to feel proficient. The literature provides anecdotal information about how different clinician types acquired their skill with starting IVs with ultrasonography (Table 6).

The research question that needs to be answered is: How does the ultrasonographer develop skill mastery with US-guided peripheral IV access? Are the 10 proctored insertions an adequate number to measure skill mastery? Plans are under way to study emergency nurses' skill mastery with the technique by analyzing how many cannulations it takes for a nurse to feel proficient with US-guided peripheral IV access and what other types of resources contributed to that perception of skill mastery.

CONCLUSION

Developing a program to train emergency nurses in US-guided venous cannulation is viable, easy, and safe. Future goals include increasing the number of nurses trained to perform US-guided venous cannulation, perfecting the nurses' vein selection decisions to increase longevity of the IV, and to study how nurses develop their skill mastery with US-guided peripheral IV access. We are also considering exploring training nurses to use ultrasonography for bladder scanning to impact incidence of urinary tract infections from unwarranted urinary catheter insertion in the ED.

Overall, senior nurses are acknowledged for the benefit their skills add to the efficiency of the care team and patient throughput. The EM physicians appreciate the contribution these nurses' independent ability to manage this technology provides to patient length of stay and the physicians' productivity due to less interruptions for what is

Table 6. Skill acquisition statements in the literature (Aponte et al., 2007; Bauman et al., 2009; Blaivas et al., 2003; Blaivas et al., 2006; Brannam et al., 2003; Brannam et al., 2004; Costantino et al., 2005; Keyes et al., 1999; Stein et al., 2004; Stein et al., 2009; Witting et al., in press)

Reference	Sample type	Statement about US IV -skill acquisition
Keyes et al. (1999) EM attending physician and resident physician	ED patients	EM attending physician or senior residents who had US experience and underwent brief training in identification of deep brachial and basilic vein
Blaivas et al. (2003) EM resident physicians	Simulated inanimate arm model	Studied novice US users 30-minute didactic session, then immediately attempted US IV access with 100% success rate Little investigation regarding teaching models for US IV access have been reported If efficiency is the goal, teach short-axis approach first because it yields fastest access
Brannam et al. (2003) EM resident physicians	Simulated inanimate arm model	Studied novice US users 30-minute didactic session, then immediately attempted US IV access either using SA or LA approach. Mean time to SA was 2.36 min and LA was 5.02 min difference statistically significant ($p = 0.03$). Mean difficulty scores for SA and LA were 3.99 and 5.86 (difference not statistically significant) Novice US users obtain vascular access much faster using SA approach
Brannam et al. (2004) Blaivas et al. (2006) Both studies used same sample of emergency nurses	ED patients	None of the nurses had used US previously for any application Performed US after 45-minute didactic session with hands-on practice with simulated inanimate arm model 89% success rate with SA technique, 85% success rate with LA technique (difference not statistically significant) Nurses reported decrease in perceived difficulty in obtaining IV access by US despite the use of technology being new—familiarization with equipment and technique for both visualization and cannulation occurred quickly and easily

(*continues*)

LWW/AENJ TME200073 April 29, 2010 19:10 Char Count= 0

Table 6. Skill acquisition statements in the literature (Aponte et al., 2007; Bauman et al., 2009; Blaivas et al., 2003; Blaivas et al., 2006; Brannam et al., 2003; Brannam et al., 2004; Costantino et al., 2005; Keyes et al., 1999; Stein et al., 2004; Stein et al., 2009; Witting et al., in press) (*Continued*)

Reference	Sample type	Statement about US IV -skill acquisition
		The most difficult skill was dependence on eye–hand coordination (visualizing the vein on the US machine screen and maintaining proper transducer probe placement with one hand and cannulation with the other)
Stein et al. (2004) EM Attending Physicians	ED patients	The nurse would seek the assistance of a physician comfortable with US-guided peripheral IV cannulation.
Costantino et al. (2005) EM attending physician and resident physician	ED patients	Physicians were familiar with US from residency training—3-week ED rotation with sole focus on doing US, 15 hr of didactic lecture and 100 emergency US scans performed *More experienced* was defined as physician who placed more than 10 previous US-guided IV catheters with experience ranging from no previous US-guided IV access experience to 50 or more placements
Aponte et al. (2007) Certified registered nurse anesthetists	Perioperative patients	Certified registered nurse anesthetists placing the catheters were well experienced in the use of US (3 years' experience). Operators with a range of experience in US should be included in future investigations
Chinnock, Thornton, & Hendey; 2007 Emergency Nurses	ED patients	Performed US after 90 minute didactic session with hands on practice with simulated inanimate arm model. Trained only in short-axis approach. Work-shifts with less US-trained nurses had more cannulation opportunities with modest improvement in skill. Inclusion criteria limited patient selection to worst access patients making nurses wait months in between attempts leading to lack of confidence and decay in skill. Possible solution would be to train all nurses and to do occasional refreshers to maintain skill.
Witting et al. (in press) EM attending and resident physicians (95% of attempts), physician assistants (3% of attempts), and registered nurses (1% of attempts)	ED patients	Success rate lowest in group with less than 20 prior attempts and plateaus after 20 attempts

(*continues*)

Table 6. Skill acquisition statements in the literature (Aponte et al., 2007; Bauman et al., 2009; Blaivas et al., 2003; Blaivas et al., 2006; Brannam et al., 2003; Brannam et al., 2004; Costantino et al., 2005; Keyes et al., 1999; Stein et al., 2004; Stein et al., 2009; Witting et al., in press) (*Continued*)

Reference	Sample type	Statement about US IV -skill acquisition
Bauman et al. (2009) ED technicians	ED patients	Performed US after 1-hour didactic session with hands-on practice with simulated inanimate arm model Delay in time to access may have been a result of ED technicians' inexperience with the US machine and the technique or locating a suitable site. Previous studies used residents and EM attending physicians with considerable US experience.
Stein et al. (2009)	ED patients	12 credentialed in US according to American College of Emergency Physicians guidelines, 8 in process of credentialing and had received a 16-hour introductory course. All physicians practiced performing US-guided IVs for 6 months training period prior to study. Goal was not to assess whether a subgroup of highly trained physicians could perform this technique better. Further study is recommended to determine whether there is a physician training threshold at which patients are likely to benefit more consistently

Note: ED = emergency department, EM = emergency medicine, IV = intravenous, LA = long axis, SA = short axis, US = ultrasound.

perceived as a nurse's procedure. Patients benefit from decreased exposure to risk from central venous access and, as cited in the literature, experience satisfaction during their ED visit with this nurse-provided intervention.

REFERENCES

Aponte, H., Acosta, S., Rigamonti, D., Sylvia, B., Austin, P., & Samolitis, T. (2007). The use of ultrasound for placement of intravenous catheters. *American Association of Nurse Anesthetists Journal, 75*, 212–216.

Bauman, M., Braude, D., & Crandall, C. (2009). Ultrasound-guidance vs. standard technique in difficult vascular access patients by ED technicians. *American Journal of Emergency Medicine, 27*, 135–140.

Blaivas, M. (2005). Ultrasound-guided peripheral IV insertion in the ED. *American Journal of Nursing, 105*, 54–57.

Blaivas, M., Brannam, L., & Fernandez, E. (2003). Short-axis versus long-axis approaches for teaching ultrasound-guided vascular access on a new inanimate model. *Academic Emergency Medicine, 10*, 1307–1311.

Blaivas, M., & Lyon, M. (2006). The effect of ultrasound guidance on the perceived difficulty of emergency nurse-obtained peripheral IV access. *The Journal of Emergency Medicine, 31*, 407–410.

Brannam, L., Blaivas, M., Lyon, M., & Flake, M. (2004). Emergency nurses' utilization of ultrasound guidance for placement of peripheral intravenous lines in difficult-access patients. *Academic Emergency Medicine, 11*, 1361–1363.

Brannam, L., Fernandez, E., & Blaivas, M. (2003). Short axis versus long axis approaches for teaching ultrasound guided vascular access [Abstract]. *Academic Emergency Medicine, 10*, 572–573.

Chinnock, B., Thornton, S., & Hendey, G. (2007). Predictors of success in nurse–performed ultrasound–guided cannulation. *The Journal of Emergency Medicine, 33*, 401–405.

Costantino, T., Parikh, A., Satz, W., & Fojtik, J. (2005). Ultrasonography-guided peripheral intravenous access versus traditional approaches in patients with difficult intravenous access. *Annals of Emergency Medicine, 46*, 456–461.

Keyes, L., Franzee, B., Snoey, E., Simon, B., & Christy, D. (1999). Ultrasound-guided brachial and basilica vein cannulation in emergency department patients with difficult intravenous access. *Annals of Emergency Medicine, 34*, 711–714.

Mills, C., Liebmann, O., Stone, M., & Frazee, B. (2007). Ultrasonographically guided insertion of a 15-cm catheter into the deep brachial or basilic vein in patients with difficult intravenous access. *Annals of Emergency Medicine, 50*, 68–72.

Stein, J., Cole, W., & Kramer, N. (2004). Ultrasound-guided peripheral intravenous cannulation in emergency department patients with difficult IV access [Abstract]. *Academic Emergency Medicine, 11*, 581–582.

Stein, J., George, B., River, G., Hebig, A., & McDermott, D. (2009). Ultrasonographically guided peripheral intravenous cannulation in emergency department patients with difficult intravenous access: A randomized trial. *Annals of Emergency Medicine, 54*, 33–40.

White, S., Sturges, Z., Barton, E., Battaglia, D., & McCowan C. (2007). Ultrasound-guided peripheral venous access by emergency medical technicians in patients with difficult access [Abstract]. *Annals of Emergency Medicine* (Suppl.) 50, S85.

Witting, M., Schenkel, S., Lawner, B., & Euerle, B. (in press). Effects of vein width and depth on ultrasound-guided peripheral IV success rates. *The Journal of Emergency Medicine.* doi:10.1016/j.jemermed.2009.01.003.