# Peripheral Intravenous Access Using Ultrasound Guidance: Defining the Learning Curve

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## Abstract

***Background:*** *The need for peripheral intravenous (IV) access in anatomically challenging patients is becoming a more commonly encountered clinical problem. The significant investment devoted to physician training for ultrasound-guided vascular access has not yet been matched by a similar commitment to nursing. Nurses, paramedics, and physicians are becoming more enthusiastic about peripheral IV access with ultrasound (PIVUS); however, institutional and clinician support has not yet been forthcoming. The learning curve for PIVUS has never been rigorously studied, and may be flatter than previously assumed.*

***Methods:*** *Registered nurses were selected to participate as trainees. Training involved 1:1 sessions consisting of formal orientation to portable ultrasound, mentoring, and practice sessions with a nurse practitioner who has expertise in ultrasound-guided peripheral vascular access; hands-on, supervised practice cannulating vessels on a nonhuman tissue simulator; and supervised attempts on live patients.*

***Results:*** *Seven of 8 trainees completed the training. The average number of patient encounters required to achieve 10 successful IV placements was 25 (range = 18-32). The average time required for successful vessel cannulation was 19.57 minutes (range = 5-62 minutes). An average of 25 attempts was required to achieve proficiency, and average of 50 cases was required to maintain consistency.*

***Conclusions:*** *In today's practice environment, PIVUS skills are increasingly important. The results of our study demonstrate that, with appropriate hands-on training and supervision, these skills can be effectively taught to registered nurses.*

***Keywords:*** *peripheral IV placement, procedure training, ultrasound guidance*

## Introduction

The need for peripheral intravenous (IV) access in anatomically challenging patients is becoming a more commonly encountered clinical problem.[1-3] The Agency for Healthcare Research and Quality declared the use of ultrasound a requisite adjunct for patient safety during all central line placements, and ultrasound use has been enthusiastically endorsed for this purpose for many years.[4] Peripheral IV access using ultrasound (PIVUS) has also been studied with no appreciable difference in ability or efficacy among emergency department physicians, physician assistants, registered nurses (RNs), or technicians.[5] However, efforts to pursue training for PIVUS has generally not been forthcoming, and the learning curve for PIVUS skills appears to be the main barrier.[6,7] Prior studies have demonstrated similar success rates for nurses compared with other practitioners: These studies reported a success rate at first attempt ranging from 56% to 97% for emergency department physicians, 74% for nurse anesthetists, 75% to 81% for emergency department technicians, and 44% to 87% for emergency department RNs.[5,8-15] Time to successful cannulation on first attempt was variable among physicians, ranging from a few minutes to about an hour.[6,8-11] The number of attempts before achieving successful

cannulation for emergency department physicians ranged from 1.3 to 3, and for emergency department technicians the range was 1.3 to 2.3.[5,8-12,14] However, neither time to successful cannulation nor the number of attempts to successful cannulation were measured for nurses.[14,15] We report the results of implementing a standardized training curriculum for RNs on how to place peripheral IVs using ultrasound guidance.

## Methods

RNs from Cedars-Sinai's Procedure Center were selected as trainees for PIVUS based on the following criteria: documented proficiency in traditionally placed peripheral IV placement, a lack of prior experience with ultrasound for vascular access, and a desire to learn the techniques necessary for PIVUS. Participation was voluntary. The ultrasound machine used for training was a Sonosite M Turbo (Sonosite Inc, Bothell, WA), with either an HFL 38 linear probe or an SLA 21 linear high frequency probe. All trainees practice PIVUS skills using either a 1.88-inch 20-gauge or an 18-gauge BD Insyte Autoguard (Becton, Dickinson, and Company, Franklin Lakes, NJ). Institutional protocol for intravenous access was used, including wide sterile barriers and the use of buffered 1% lidocaine for local anesthesia. Institutional review board exemption for the study was obtained.

Training consisted of 3 major phases. Phase 1 consisted of 1:1 mentoring sessions led by a nurse practitioner who had extensive expertise with ultrasound-guided peripherally inserted central catheter placement and peripheral vascular access. This initial training included a 2-hour didactic session on the principles of ultrasound and a review of vascular anatomy. Discussion and demonstration emphasized a review of basic ultrasound physics, the ultrasound probe, and knobology; how to differentiate vein from artery; how to differentiate local structures such as tendons and nerves from veins; how to select an appropriate site, vein, and angiocath (gauge and length) based on each patient's medical history, indications for the procedure, and results of preliminary ultrasound mapping; how to select an optimal needle entry point and proper "angle of attack"; and the importance of localizing and tracking the needle tip on its way to cannulating the target vessel. The second phase of training required another 2-hour, 1:1 hands-on training session using a validated nonhuman tissue model for practice.[16,17] Each trainee was required to demonstrate competency on the simulator before attempting PIVUS on patients. Competency was defined as being able to select the correct ultrasound probe, depth, and target vessel; properly positioning the target vessel in the center of ultrasound screen; correctly aligning the angiocath needle tip in the middle of the probe over the target vessel; tracking the needle tip through the skin and tissue to the vessel wall, including indenting the vessel under ultrasound guidance before cannulating; and cannulating the vessel and achieving a bull's-eye image (Figure 1). Each trainee was required to successfully cannulate 2 large synthetic vessels (6 mm diameter) and 3 small synthetic vessels (3 mm diameter) before graduating to live patients. Once each trainee graduated from the practice environment, he or she was then permitted to attempt supervised PIVUS on patients.
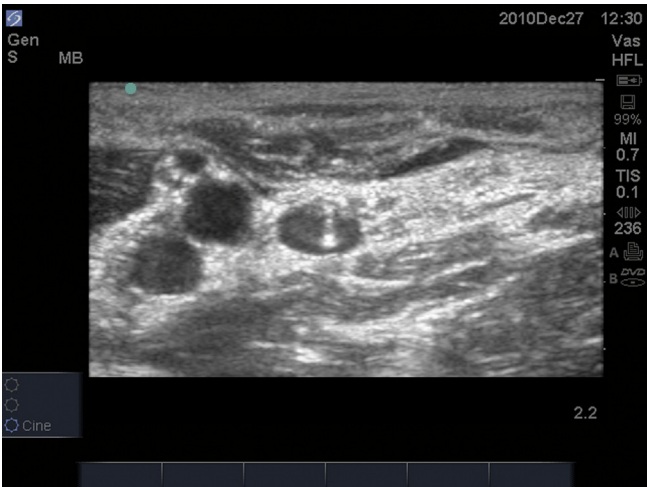


*Figure 1.* **Bulls-eye.**

Phase 3 involved live patients. Patients were selected for the study based on the following criteria: The presence of a physician's order to place an ultrasound-guided IV line and either a lack of palpable or visible peripheral vessels or having a history of requiring ultrasound-guided peripheral or central venous access on prior encounters. Patients were excluded from the study if they had an allergy to lidocaine or were unwilling to consent to participate in the study.

No trainee was allowed to attempt more than 3 cannulations of a single vessel or make attempts at more than 2 sites. All attempts were rated according to proficiency criteria outlined in Table 1. *Proficiency* was defined by the trainee achieving 10 supervised ultrasound-guided IV placements with a score of 4 or 5. Supervision was no longer required when the trainee both achieved proficiency and when IV placement was performed at the level of 4 or 5 for 3 consecutive attempts (ie, the criteria for achieving consistency). Premature termination

*Table 1.* **Proficiency Score Definitions**

| Proficiency score | Criteria |
| --- | --- |
| 0 | Unable to locate a suitable vessel |
| 1 | Suitable vessel located but vessel not accessed by trainee but ultimately accessed by supervisor |
| 2 | Suitable vessel located but vessel not accessed by trainee and ultimately not accessed by supervisor |
| 3 | Suitable vessel located but 3 attempts at 1 or 2 sites required |
| 4 | 2 attempts at 1 or 2 sites required |
| 5 | 1 successful attempt required |