

Do echo-enhanced needles improve time to cannulate in a model of short-axis ultrasound-guided vascular access for a group of mostly inexperienced ultrasound users?

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Abstract

Background Vascular access is a critical skill for emergency physicians. However, it can be unpredictably challenging in some patients. While ultrasound-guided vascular access has been encouraged in emergency departments, there have been few studies evaluating echo-enhanced needles and their usefulness in performing vascular access.

Aims Our purpose was to determine if the use of an echo-enhanced needle tip results in faster vascular access times, with fewer needle sticks, fewer redirections, and improved needle visualization in ultrasound-guided vascular access with the vessel in the short axis.

Methods This is a prospective, randomized, observational study of ultrasound-guided vascular access on a vascular phantom comparing an echo-enhanced needle with a standard needle. Each participant viewed a teaching video demonstrating typical ultrasound-guided vascular access and then attempted ultrasound-guided vascular access using both a standard and an echo-enhanced needle with the vessel in the short axis. The numbers of needle sticks, redirections, and time to dye flash were measured.

Results The 69 participants attempted 69 short-axis ultrasound-guided vascular cannulations with no difference in time to dye flash between needle types: the median time

from needle stick to flash was 17.56 s [interquartile range (IQR): 12.37–33.15] for the standard needle and 19.22 s (IQR: 10.19–31.10) for the echo-enhanced needle. There was no difference between needle types for number of needle sticks or redirects.

Conclusion Echo-enhanced needles did not provide objective performance improvement compared to standard needles during ultrasound-guided vascular access with a vascular access model in the short axis.

Keywords Emergency ultrasonography · Vascular access · Ultrasound-guided line placement · Vascular access phantom · Ultrasound education · Echo-enhanced needles

Introduction

Vascular access is a critical skill for emergency physicians. However, it can be unpredictably challenging in some patients. In most emergency departments, nursing personnel or medical technicians attempt initial intravenous catheter placement. If the initial attempts are unsuccessful, physicians are then asked to either assist or attempt a line placement. In cases where initial attempts have been unsuccessful, ultrasound can be used as an adjunctive technique. Ultrasound-assisted vascular access has been shown to provide a greater margin of safety in central venous cannulation and is an efficient means to obtain both peripheral and central venous access [1–3]. Ultrasound-guided vascular access is an acquired skill, with a steep learning curve. There are few studies looking at the best approach to ultrasound-guided vascular access [4]. Traditionally this procedure is taught and performed in the short axis with a standard needle [5].

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Manufacturing technology has the ability to produce intravenous catheter needles with an enhanced ultrasonographic image. An echo-enhanced needle has a tip that produces a high-intensity echo so that it creates a very bright echogenic focus at the needle tip on the ultrasound screen [6]. Commercially available echo-enhanced needle tips are used in radiology for ultrasound-guided procedures to assist localizing the needle on the ultrasound screen by enhancing the reflectivity of the needle itself [6]. The theoretical advantage of the echo tip is that enhanced visualization, compared to standard needles, should therefore improve procedural ease and success. While ultrasound-guided vascular access has been encouraged in emergency departments, there have been few studies evaluating echo-enhanced needles and their usefulness in performing vascular access.

Our purpose was to perform a prospective, randomized, observational study to evaluate the effect of echo-enhanced needles on venous cannulation in a vascular access phantom. We presumed that participants using an echo-enhanced needle would have a significant reduction in time to cannulate because the needle should have been easier to visualize. To determine if these needles provided any benefit we utilized a standard vascular access model, standard short-axis vessel visualization, and measured the number of needle sticks, number of redirects, and time to dye flash. We chose time to dye flash as our surrogate of successful vascular access cannulation.

Methods

Study design

This was a prospective, randomized, observational study evaluating ultrasound-guided vascular access in the short axis of the vessel using an echo-enhanced needle (EchoTip Needle, Cook, Bloomington, IN, USA) compared to a standard needle using a phantom vascular access model (Blue Phantom, Advanced Medical Technologies, LLC, Kirkland, WA, USA). This study was reviewed and approved by the Institutional Review Board for verbal consent for all participants.

Study setting and population

This study was conducted in the emergency departments of two Midwestern urban tertiary care centers with a shared emergency medicine residency program. Both residents and staff physicians participated on a voluntary basis. As part of their training, emergency medicine residents are instructed in ultrasound techniques through a combination of didactic lectures, lab time, and a 1-month dedicated rotation in

emergency medicine ultrasound. Following this baseline training, residents are expected to incorporate ultrasound into their daily patient care practices. Skills in ultrasound-guided vascular access are taught through lectures and direct supervision by attending physicians certified in the technique.

Study protocol

A random number generator with a ten-subject block design was used to randomly assign which needle each participant would use first. Each subject was then shown a 10-min video describing ultrasound-guided vascular access (produced by Blue Phantom, Advanced Medical Technologies, LLC, Kirkland, WA, USA). They then attempted to obtain vascular access with both standard and echo-enhanced needles. Ultrasound imaging was performed with the Sonosite Titan ultrasound machine (Sonosite, Bothell, WA, USA), with a 38-mm broadband (10-5 MHz) linear array transducer (Titan L38, Sonosite, Bothell, WA, USA).

The Blue Phantom vascular access model is a durable anthropomorphic phantom that images similar to real tissue with ultrasound and contains simulated blood vessels. For this study, the phantom was modified to further obscure the embedded vessel such that there were no visual or palpable anatomic clues for vascular access. This was done by placing a separate rectangular flap made of the same material as the phantom over the phantom obscuring any visualized vessels. This added approximately 1.0 cm extra depth, an insignificant amount, but provided excellent camouflage of the vessel. The same phantom was used for each study participant. We did our best to reposition the flap after multiple uses to hide obvious needle sticks. The vessel was 8 mm in diameter and was filled with a blood simulation material (water colored with red food dye).

Participants attempted to obtain vascular access with the 18-gauge standard needle and echo-enhanced needle in the short axis view. A successful attempt was defined as a flash of dye returned into the syringe. Residents and staff members were not allowed to observe others attempting to gain vascular access.

Measurements/outcome measures

Physicians were directly observed by a trained research assistant during all of their attempts to gain vascular access. Using a stopwatch, time from ultrasound probe placement on the phantom until dye flash within the cannula was measured. The research assistant also recorded the number of needle sticks required and the number of needle redirections.

Data analysis

Median differences between echo-enhanced and standard needles for the variables – time to dye flash, number of sticks, and number of redirects were calculated by subtracting the standard needle tip value from the EchoTip value. A positive value corresponded to higher echo-enhanced needle values and negative values indicated a higher standard needle value. Wilcoxon rank sum testing was used for analysis with a $p < 0.05$ taken to indicate statistical significance. All analyses were done using the SAS® software, version 9.1 (Cary, NC, USA).

Results

Overall there were 69 participants with a median of 3 years [interquartile range (IQR): 2–7] of clinical experience (including residency). Of the participants, 46.4% (32/69) were staff emergency medicine physicians and 53.6% (37/69) were residents. Most [82.6% (57/69)] reported that they had little or no experience (zero to nine actual attempts) with ultrasound-guided vascular access before participating in this study; 100% of placement attempts were successful, and no placement required more than three attempts. The overall median time from needle stick to flash was 17.56 s (IQR: 12.37–33.15) for the standard needle and 19.22 s (IQR: 10.19–31.10) for the echo-enhanced needle. There was no difference for number of needle sticks, redirects, or time to dye flash (Tables 1 and 2).

Discussion

Our study showed that there was no significant difference in vascular access metrics for ultrasound-guided intravenous catheter placement between echo-enhanced or standard needles using a vascular access surrogate with the vessel in the short axis.

As ultrasound becomes more prevalent in emergency departments, physicians will increasingly be using this device for both peripheral and central vascular access.

Table 1 Median number of sticks, redirects, and time to dye flash

	<i>n</i>	Median	25th, 75th percentile
Echo sticks	69	1.00	1.00, 1.00
Standard sticks	69	1.00	1.00, 1.00
Echo redirects	69	1.00	0.00, 2.00
Standard redirects	69	1.00	0.00, 2.00
Echo time to dye flash	69	19.22	12.37, 33.15
Standard time to dye flash	69	17.56	10.19, 31.10

Table 2 Median differences between needle sticks, redirects, and time to dye flash

	<i>n</i>	Median ^a	25th, 75th percentile	<i>p</i> value ^b
Stick diff.	69	0.00	0.00, 0.00	0.99
Redir. diff.	69	0.00	-1.00, 0.00	0.35
Time diff.	69	2.06	-9.22, 14.50	0.35

^aMedian of the difference between echo and standard (calculated by echo–standard). Thus, positive numbers correspond to higher echo values and negative values indicate higher standard values

^b*p* value from Wilcoxon rank sum test, testing the median difference (echo–standard)=0

Some of these procedures may benefit from having a needle tip that is more easily localized. Needle visibility is critical to performing any ultrasound-guided procedure. There are several commercially available needles that have been altered to improve needle visibility [7, 8]. The potential to facilitate placement of a needle into a vessel with a needle that shows up brighter on the ultrasound screen seems obvious.

When performing ultrasound-guided procedures using a non-echo-enhanced needle tip, it is often challenging to visualize the needle tip especially in the short axis. Visualization of the needle is one of the most common difficulties encountered during ultrasound-guided vascular access. Typically the probe can be maneuvered directly perpendicular to the needle improving visualization. The steeper the angle of the needle to the probe the more difficult it is to visualize. Studies have shown that at a decreasing angle of insonation, it is more difficult to visualize the needle; some echogenic needles are advantageous and show significantly improved visibility [9]. Optimization of conditions, like angle of insertion, are sometimes limited because of anatomy and when unfavorable conditions exist, utilizing a needle that has been echo-enhanced can make it more visible [10]. Often the physician placing the needle estimates its location by watching for changes in the soft tissue or vessel itself during insertion, never fully seeing the needle tip as a reflection on the screen.

The advantages of an echo-enhanced needle tip for ultrasound localization, especially for teaching purposes, seem obvious. Many practitioners of ultrasound, like interventional radiologists and gynecologists, have been using echo-enhanced products when performing their ultrasound-assisted procedures. Echo enhancement can come in a number of different categories including a chemical coating or even etches in the wall of the needle [11, 12].

There are several limitations to our study. Most of the participants had little or no experience with ultrasound. Despite this fact and with minimal training all participants successfully cannulated the vascular access phantom. Moreover, despite a core curriculum that includes ultrasound

lectures, we did not control or document who actually completed the lectures. This was a heterogeneous group of participants and this may have affected our results. Most of the residents (especially upper level) had some previous ultrasound education/lectures while the emergency medicine staff did not, but all participants watched the same brief video. A group of experienced ultrasound-guided vascular access participants may have performed better with the echo-enhanced needle knowing how to better localize the tip.

The ultrasound phantom, although a good approximation of human tissue, does not in fact mimic actual human tissue, and this needs to be taken into consideration when extrapolating the data. The visibility of the needle is much more obvious in the phantom than during ultrasound-guided vascular access in human tissue. We used a vascular access phantom for ease of study and to avoid subjecting patients to training procedures. The results found here may have been different had we studied real patients or cadavers. While this phantom represented our best available vascular access model, the differences with human tissue and the location of deeper vessels make extrapolation of this study difficult in a live human setting. However, it still appears that inexperienced ultrasound users may not benefit from the advantages of an echo-enhanced needle until further along in their training and understanding of ultrasound-guided vascular access.

Conclusion

In a group of mostly ultrasound inexperienced participants attempting ultrasound-guided vascular access visualizing the vessel in the short axis, the echo-enhanced needle did not improve measures of successful vascular access.

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