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Original Contribution

# Evaluation of a simplified augmented reality device for ultrasound-guided vascular access in a vascular phantom

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**Abstract**

**Study Objective:** To investigate whether a novel ultrasound device may be used with a simplified augmented reality technique, and to compare this device with conventional techniques during vascular access using a vascular phantom.

**Design:** Prospective, randomized study.

**Setting:** Anesthesiology and Pain Medicine departments of a university-affiliated hospital.

**Participants:** 20 physicians with no experience with ultrasound-guided techniques.

**Measurements:** All participants performed the vascular access technique on the vascular phantom model using both a conventional device and the new ultrasound device. Time and the number of redirections of the needle until aspiration of dye into a vessel of the vascular phantom were measured.

**Main Results:** The median/interquartile range of time was 39.5/41.7 seconds versus 18.6/10.0 seconds ($P < 0.001$) and number of redirections was 3/3.5 versus 1/0 ($P < 0.001$) for the conventional and novel ultrasound devices, respectively.

**Conclusion:** During vascular access in a vascular phantom model, the novel device decreased the time and the number of redirections significantly. The device successfully improved the efficiency of the ultrasound-guided vascular access technique.



## 1. Introduction

Ultrasound devices visualize both the targeted vessel and the needle itself in real time. Ultrasound-guided vascular access improves vascular access techniques. In the meta-analysis by Randolph et al, ultrasound-guided central venous catheterization decreased the failure rate (relative risk reduction 68%), attempt rate (relative risk reduction 40%), and complication rate (relative risk reduction 78%) compared with the anatomical landmark method [1].

However, conventional ultrasound devices visualize only one plane of a three-dimensional structure. Moreover, this ultrasound view is displayed on the screen of the device with a different ratio and angle from the actual structure. The practitioner must always consider these factors during ultrasound-guided vascular access.

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To overcome these problems, an augmented reality visualization technique has been tried with successful results [2–4]. However, these conventional augmented-reality techniques require visual angle measurement by the practitioner, a head mount display, and complex real-time calculations. Consequently, such techniques are cumbersome. Considering that ultrasound-guided vascular access is frequently performed in time-intensive environments such as emergency rooms, operating rooms, and intensive care units, such cumbersome features may be disadvantageous.

We developed a novel, simplified, augmented-reality visualization device. With this device, the image obtained on ultrasound is transmitted to a microprojector and projected on the skin. The projected image is calibrated to mimic augmented-reality visualization. To evaluate the device's performance, the procedure time and number of redirections of the needle were compared with those of conventional ultrasound-guided techniques on a vascular phantom model.

## 2. Materials and methods

### 2.1. Study design

This prospective, randomized study compared vascular access using a simplified augmented-reality visualization device (projector method) with a conventional ultrasound-guided vascular access technique (conventional method) using a vascular phantom (Blue Phantom™ branched 2-vessel ultrasound training device; SonoSite, Inc., Bothell, WA, USA). The phantom contained a 6 mm vessel that bifurcated into 6 mm and 4 mm individual vessels separated about 6 cm and containing artificial blood.

### 2.2. Study setting and population

This study was conducted in the Anesthesiology and Pain Medicine departments of the Seoul National University Hospital. The 20 participants, 13 residents and 7 interns, had no experience performing ultrasound-guided techniques. For all participants, skills in ultrasound-guided vascular access were taught during a 10-minute instructional lecture.

Participants were not allowed to observe other participants while a session was being conducted.

### 2.3. Device description

The image obtained by the ultrasound device was transmitted to the microprojector (MBP200; Samsung Electronics, Seoul, Korea) attached to the probe and projected directly on the skin. The microprojector was attached to the probe with an assembly consisting of three axis rods and a tilting plate (Fig. 1). In this way, the angle and positioning of the microprojector could be adjusted and calibrated for the projected ultrasound view to align with the edge of the probe and to be the exact size as those of the phantom (Fig. 2).

### 2.4. Experimental protocol

All participants performed both methods, and the order of performance of the two methods was determined by a computer-generated random numbers table.

During the study, an 18-gauge introducer needle on a 5 mL syringe was inserted into the phantom with real-time ultrasound visualization (LogiQ-e; GE Medical Systems, Shenzhen, China) with a 5-10 MHz linear transducer. The Blue Phantom vascular access model is an anthropomorphic phantom whose images on the ultrasound device are similar to real tissues with vessels. The phantom model was semi-translucent and the projected image was not as clearly visible. To mimic real skin, we stained the phantom with ivory colored spray paint so that the projected image could properly be seen as on real skin.

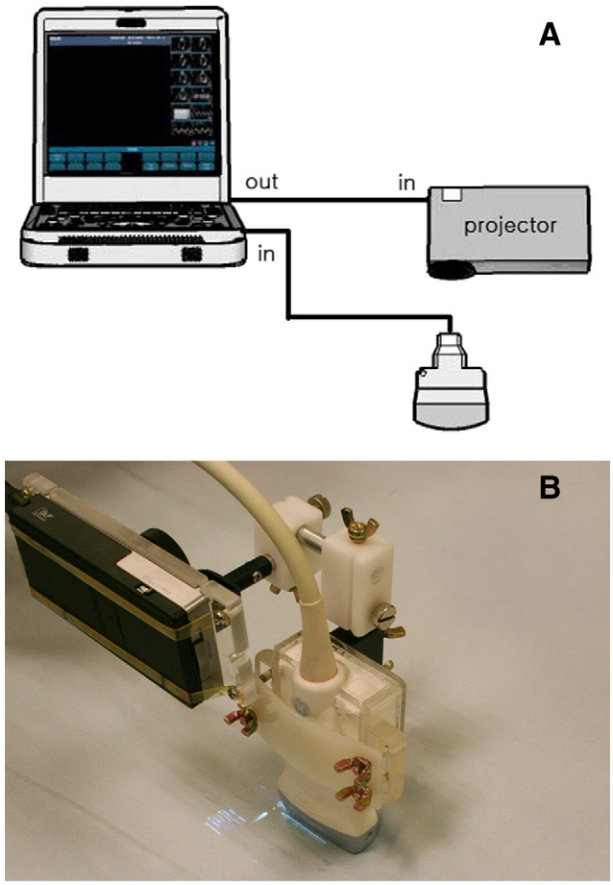


**Fig. 1** (A) Illustration of simplified augmented reality visualization using a microprojector attached to the ultrasound probe. (B) The microprojector attached to the probe with combining assembly. The assembly has three orthogonal axis rods and the microprojector can be tilted to the probe.