Techniques in Regional Anesthesia and Pain Management 18 (2014) 110–117

Available online at www.sciencedirect.com

ScienceDirect

www.elsevier.com/locate/trap

Ultrasound-guided regional anesthesia simulation and trainee performance

Imanuel R. Lerman, MD, MS[a,*], *Dmitri Souzdalnitski, MD, PhD*[b], *Thomas Halaszynski, DMD, MD, MBA*[c], *Feng Dai, PhD*[d], *Maged Guirguis, MD*[e], *Samer N. Narouze, MD, PhD, FIPP*[f]

[a]*Department of Anesthesiology, University of California, 9350 Campus Point Dr, La Jolla, San Diego, California 91111*
[b]*Center for Pain Medicine, Summa Western Reserve Hospital, Cuyahoga Falls, Ohio*
[c]*Department of Anesthesiology, Yale University School of Medicine, New Haven, Connecticut*
[d]*Yale Center for Analytical Sciences, New Haven, Connecticut*
[e]*Ochsner Medical Center, New Orleans, Louisiana*
[f]*Center for Pain Medicine, Summa Western Reserve Hospital, Cuyahoga Falls, Ohio*

ARTICLE INFO

Keywords:
Ultrasound-guided regional anesthesia
Ultrasound simulation
Ultrasound education
Femoral nerve block

ABSTRACT

The objective of this study was to measureand record trainee performance during an ultrasound-guided femoral nerve block (FNB) with a novel high fidelity feedback based simulator device. The method decribes a novel phantom simulator that was built, capable of objectively recording trainee performance and providing visual and audio feedback on the completion of a successful FNB. Overall, 33 subjects were comprised of medical students and residents performed 2 separate ultrasound simulation sessions, and were placed in 1 of 3 groups: light emitting diode and piezoelectric buzzer feedback (LED and PBZ), voice feedback alone, or no feedback. This phantom simulator measured 2 separate performance parameters including; the time (in seconds) to carry out a FNB and the number of needle passes. Each trainee was then evaluated with a global rating scale. Trainee confidence in ultrasound-guided procedures was also recorded.

All trainees improved their performance in the simulated block time ($p < 0.005$) and gained significant confidence in ultrasound-guided procedures ($p < 0.0005$). The LED and PBZ group improved the most in block time performance ($p < 0.0001$). Only the LED and PBZ group improved in visualizing the simulated nerve and advancing needle ($p < 0.05$), as well as simultaneously visualizing the needle reach the simulated nerve target ($p < 0.005$). For all groups there was robust correlation (-0.72, $p < 0.0001$) between the time to carry out a FNB and correct visualization of the needle during a successful FNB.

The high fidelity ultrasound phantom simulator used in this study, recorded and improved performance, and confidence in ultrasound guided procedures carried out by novice trainees.

Introduction

Ultrasound (US) guidance (USG) techniques are rapidly developing in both regional anesthesia and pain medicine. Mastering USG procedures can be a challenging and daunting new skill set for the novice, especially when the initial USG procedures are carried out on actual patients.[1-4] Although the knowledge required to carry out USG procedures can be gained by reading

*Corresponding author.
E-mail address: ilerman@mail.ucsd.edu (I.R. Lerman).

http://dx.doi.org/10.1053/j.trap.2015.10.008
1084-208X/

the literature, the motor skills, and manual dexterity necessary to manipulate a US probe and needle during ultrasound-guided regional anesthesia (UGRA) ultimately requires hands on practice.[4-8] The American Society of Regional Anesthesia and Pain Medicine recommends training in UGRA that includes continuing medical education, proper mentorship, practicing US scanning on self, and colleagues in addition to practice of needle insertion techniques with simulators and phantoms.[9] An important advantage of training with phantom simulators is that the trainee can practice both US probe handling and needle visualization simultaneously, whereas, in some advanced phantoms, the trainee can appreciate the underlying simulated anatomy, including surrounding tissues, nerves, and blood vessels.[7,8,10-15] More importantly, the current literature substantiates that practice on phantom simulators can translate into improved performance in the clinical setting.[8,16-18]

Automated assessment tools such as the Imperial College Surgical Assessment Device and composite checklists (Delphi Method)[19,20] have been shown to be valid objective measures of UGRA trainee performance in the clinical setting. Similarly, UGRA simulation training before performing in the clinical setting can identify areas that need further practice and remediation.[2] Optimized objective trainee performance measures during UGRA simulation, before training in a clinical setting, could identify and weaknesses of the trainee, which may or may not need remediation.

To improve UGRA simulation training, 2 innovations were incorporated into an US phantom simulator: (1) the US phantom simulator provides the trainee feedback comprised of visual (light emitting diode, [LED] light) and audio (piezoelectric buzzer [PBZ]) when a successful nerve block is performed, and (2) a mechanism that can automatically record the performance of each trainee during the simulation exercise. A feedback terminal based simulator has been described in the literature previously, first by our group,[21-22] and more recently by Moore et al.[23,24] The feedback based ultrasound simulator described in this article can be distinguished from the simulation model of Moore et al, because of its superior high fidelity features, including a mannequin shell, and also because it affords real-time automatic recording of clinician performance as well as detection of needle pass rates (NPRs).

"The UGRA simulator phantom described here has been developed specifically for femoral nerve block (FNB), practice with objectives to improve the trainee motor and dexterity skills, and by building confidence in ultrasound-guided" procedures. This study includes 3 aims: (1) to demonstrate that this phantom simulator tool can record and track trainee performance in a simulated USG FNB, (2) to demonstrate that light and sound based feedback can have an effect on trainee performance in USG FNB, and (3) to validate that the objective computer recorded data obtained with this simulator can accurately reflect trainee performance as measured by an expert regional anesthesia attending.

Materials and methods

Study population

The Yale University School of Medicine, Human Investigation Committee, approved this study for residents and medical students to practice UGRA on phantom simulators. Thirty-three medical students and residents volunteers were recruited and placed in 1 of 3 groups: (1) LED and PBZ feedback, voice feedback alone (VF), or a no feedback group (NF). Performance measures and confidence in carrying out ultrasound-guided procedures were compared in all 3 groups. Although the current study may have been more robust if randomized, time constraints, and the initial device limitations restricted randomization. The prototype model used in this study required prolonged rewiring to change from an LED and PBZ feedback setting to NF setting. Because of the time consuming rewiring process required for this prototype the study was designed as a prospective controlled convenience trial that was composed of 2 separate sessions of USG FNB simulation sessions 5–7 days apart. Recruited subjects volunteered their time (approximately 30-40 minutes) while on their anesthesiology, neurology, and psychiatry clinical rotations. Each group comprised of equal numbers of participants, including 5 anesthesia residents, 4 medical students, and 2 neurology residents. The order of groups testing was LED and PBZ feedback, followed by VF, and then NF, (approximately 2 weeks at a time for each). The testing phase lasted approximately 2 months time and subjects were recruited into the study based on whether or not they had availability during their clinical rotation.

Device construction

The UGRA simulator phantom for FNB practice was prepared from commercially available products. The UGRA simulator phantom was initially under provisional patent, but is now considered public knowledge. The UGRA simulator phantom has been assembled with the aim to provide a life like resemblance of an USG FNB. When describing simulators the term "fidelity" has been used to characterize how life like or real a phantom simulator seems. Low-fidelity phantoms have been made from many different materials ranging from water balloons, water baths, tofu, gelatin, agar, sponges, cheese, chicken, and turkey breasts, porcine, and other similar objects.[11,12,25] In contrast, a high fidelity phantom would have several characteristics that can mimic the human body, of which a human cadaver is one of the highest fidelity phantoms currently available.[26]

The UGRA simulator phantom used in this study was constructed with high fidelity features including: a life size mannequin placed on life size stretcher bed, an embedded moldable poly-vinyl plastic (plastisol) insert which is soft, opaque, and houses the simulated femoral nerve and imitated the underlying soft tissue. This soft plastic insert mimics human tissue qualities by; first, providing tissue like resistance as the needle is advanced, and both the needle and underlying targeted structures are clearly visualized under USG, as previously described.[15,22,27] (Figures 1 and 2). The simulated femoral nerve, comprised of electroencephalogram (EEG) conductive gel, was inserted into a hollowed tube within a soft plastic insert (Figure 1). When visualized with ultrasound the EEG conductive gel within the hollow tube appears hyperechoic, simulating the appearance of a peripheral nerve (Figure 1A and B). At 1 end of the simulated