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Brief Report

Medical Student Instruction in Peripheral Nerve Blockade Utilizing Fresh Cadaver Limbs in a Simulation Center

Daniel P. Huettner, MD
Lindsay K. Hahn, MD
Mackenzie A. Noonan Haase, MD
Francesca A. Jung, MD
Steven L. Orebaugh, MD

Introduction

Ultrasound imaging is increasingly used in both medical practice and medical education, providing a bedside, real-time, 2-dimensional view into a patient's anatomy[1]; however, instruction related to this imaging modality is only sparingly incorporated into the curriculum at many medical schools. Several studies indicate that participation in ultrasound-based coursework increases functional knowledge of anatomy and ultrasound skills.[2-4] We hypothesized that creation of an elective course to introduce preclinical medical students to ultrasound imaging and ultrasound-guided peripheral nerve blockade (PNB) would permit students to image and identify a slate of 6 anatomic structures in cadaver upper extremities. The primary outcome measurement was the ability to scan and independently identify anatomic structures using ultrasound. Secondary outcomes included the ability to perform a simulated nerve block in cadaver extremities in comparison with a standardized checklist,[5] and student perception of the educational utility of the course through use of an online evaluation.

Description and Methods

The course, "Introduction to Regional Anesthesia: Learning Ultrasound-Guided Nerve Blocks Mini Elective," was offered to preclinical medical students. It consisted of four 90-minute sessions involving 1 session per week over 4 weeks. Each session began with a 30-minute didactic session, which included basic nerve block concepts, specifics of upper extremity nerve blocks, and outcomes and safety of PNB. These lectures were followed by 1 hour of hands-on exercises in various skills stations.

The collection of student performance scores for this study was approved by the University of Pittsburgh Institutional Review Board (STUDY19050235). Seven fresh cadaver upper extremities were purchased at a cost of $350 per limb from an independent, nonprofit organ donation organization (Anatomy Gifts Registry, Hanover, MD) and cooled until use.

The students spent 60 minutes completing each of the following 3 sessions. During the first 2 sessions, students were taught basic ultrasound concepts and how to use ultrasonography to image upper extremity anatomic structures on live patients. In addition, gel-block phantoms were used to provide instruction on needle visualization and guidance with ultrasound. During the third session, students were shown how to identify the same anatomic structures on 3 cadaver limbs using ultrasound, specifically biceps muscle, triceps muscle, humerus bone, ulnar nerve, radial nerve, and median nerve. They were then instructed on how to perform ultrasound-guided PNB on 1 of the 3 previously stated peripheral nerves on the cadaver limbs.

The fourth session, during which 4 additional cadaver extremities were used, was for student evaluation. Students were required through individual practical examination to image and identify the 6 anatomic structures in a cadaver upper extremity (they had not previously examined these 4 limbs). They were subsequently asked to perform a simulated ultrasound-guided nerve block on 1 of the 3 nerves that they had identified at the level of the elbow. The specific nerve was chosen by the student. Motor skills were evaluated against a standardized, 8-point checklist adapted from Cheung et al.[5] We also provided verbal prompting, when necessary, and noted whether or not this was necessary for successful completion of the task by the student. The students were given 30 seconds to self-correct before prompting, but the prompting statements were not standardized. Hands-on or tactile correction was not provided. When placing the simulated nerve block, 3 to 5 mL of saline was injected around the visualized nerve to allow the students to visualize spread. This small volume did not appear to distort anatomy for subsequent students.

The students were queried, at the beginning of the course, about prior ultrasound experience. All of the students had limited prior exposure to ultrasound use, including three 2-hour demonstration sessions within their gross anatomy course that included viewing images of the abdomen, the heart, and the popliteal fossa. None had performed ultrasound of upper extremity structures, or conducted ultrasound-guided needle placement, for nerve block or other procedures. Based on this very limited prior exposure, we assumed that they would be unable to independently

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image anatomic structures and needles. Therefore, a pretest of ultrasound skills was not performed.

Outcomes for the anatomy recognition and the nerve block checklist items are presented as simple descriptive statistics. The students were also asked to fill out a follow-up survey after completion of the class to elicit feedback on what specific aspects of the class they found effective. Questions stressed the perceived educational value of using ultrasound to identify anatomic structures, learning nerve block techniques, and use of a cadaver extremity as a form of simulation.

Results

Eight first-year medical students elected to take the course and 7 completed the assessments (1 was unable to attend the final session). Students accurately identified 38 of 42 (90%) anatomy structures, and 17 of 21 (81%) nerve structures (Table 1). One verbal prompt was required for 4 of 42 (10%) anatomy structures (Table 1). Of the 8 checklist items for assessment of nerve block skills, students were entirely successful with 2 items without any prompting: orientation of the transducer and successfully identifying the target nerve (Table 2). Two of the 7 (28%) students required verbal prompting to image the needle tip on insertion through the skin, but all the students required some prompting to keep the needle tip in constant view during advancement, as well as at the time of injection. Six of the 7 (86%) students achieved appropriate spread of local anesthetic around the target nerve by adjusting the needle tip to multiple positions to direct the injectate in a circumferential fashion around the nerve (Table 2). The mean time to perform the "nerve block" was 4.6 (±3.8) minutes. One student was a clear outlier with a time more than twice the second-longest duration.

On the course evaluation, 100% of students noted that they strongly agreed that the cadaveric component of the course added significant value to their learning experience (Table 3). In addition, 4 of 5 (80%) of students strongly agreed that their confidence in using ultrasound to identify anatomic structures increased by the end of the course (Table 3).

Discussion

The aim of this course was to review upper extremity gross anatomy and teach students how to use ultrasonography to image anatomic structures. In addition, instruction was provided on how to use ultrasound to provide simulated PNB as a clinical illustration of the importance of understanding anatomy. The students were able to identify more than 90% of the designated anatomic structures and had a high degree of success identifying peripheral nerves in the upper extremity. In addition, they reported that they found the course instructive and were able to develop basic ultrasound skills related to needle identification and guidance.

Understanding how to use ultrasound to image anatomic structures and to guide needle placement for invasive procedures is essential for numerous clinical disciplines, including regional anesthesia. Visualization of anatomy and needle guidance with ultrasound has been demonstrated to improve efficacy and performance for PNB, when compared with landmark or nerve-stimulation techniques.[6,7] It also reduces the incidence of complications, such as vascular puncture and local anesthetic systemic toxicity.[8,9]

Training students to use ultrasound requires time and effort. Barrington et al[4] demonstrated that anatomy imaging and recognition with ultrasound, specifically identifying nerve and other structures in the axilla, required 8 to 10 15-minute training sessions in a nonclinical environment using live models. In a separate study by these authors, senior-level, novice anesthesiology residents were able to achieve competency in sciatic nerve blocks in human cadaver models after several practice sessions.[8] Our study corroborates these findings; novice students were able to visualize nerves and perform simulated nerve blocks with reasonable success per a validated checklist after three 1-hour practice sessions. In light of this success, we have integrated this course into the orientation period of our residency. In the future, we intend to offer the course to larger numbers of medical students and to increase the breadth of training to include the lower extremity.

Limitations of this preliminary education study include a small sample size and voluntary enrollment, which may have skewed student participants toward those with a predilection for experiential learning. Expansion of this course to involve all enrolled medical students would allow for more informative data on its utility in undergraduate medical education. Providing verbal prompts during the nerve block evaluation was not specifically standardized, which may have led to different responses by students. Also, the students were directed to select the nerve that they imaged most clearly for the simulated nerve block, because optimal image of the target structure is essential, and this varied from student to student, so several different nerves were the subject of this skills assessment. The evaluation questions were decided on by consensus, and were not subject to external validation, but we feel that these provide a reasonable summary of students' impressions of the course. In addition, it may be difficult to generalize our results to much larger groups of students or to other institutions with more limited resources, given the costs of the limbs. Finally, during practice and testing, multiple injections were placed in each upper extremity; however, the volumes injected were quite small, and there was no obvious distortion of the anatomic structures as visualized on ultrasound.

Conclusion

A highly realistic simulation with fresh cadaver extremities was developed to teach preclinical medical students how to use ultrasound to demonstrate relevant anatomy, and, as a clinical correlation, to practice ultrasound-guided PNB. The students, with limited prior ultrasound exposure, had a high degree of success in imaging and identifying 6 anatomic structures in the upper limb. Further, they found the experience highly valuable as an introduction to the use of ultrasound in the clinical realm.

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The authors are at the University of Pittsburgh Medical Center, Department of Anesthesiology and Perioperative Medicine. ***Daniel P. Huettner*** *and* ***Lindsay K. Hahn*** *are Anesthesiologists.* ***Mackenzie A. Noonan Haase*** *is an Anesthesiology PGY-4 Resident.* ***Francesca A. Jung*** *is an Anesthesiology PGY-5 Fellow.* ***Steven L. Orebaugh*** *is a Professor.*

Corresponding author: *Mackenzie A. Noonan Haase, MD, University of Pittsburgh Medical Center, Department of Anesthesiology and Perioperative Medicine, 228 38th Street, Floor 2, Pittsburgh, PA 15201. Telephone: (319) 551-9285*

Email address: *Mackenzie A. Noonan Haase: noonanjhaasema@upmc.edu*

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Abstract

Background: Ultrasound imaging is increasingly used in medical practice, but many institutions have room for growth regarding its incorporation into medical education. An elective hands-on course was developed for preclinical medical students using ultrasound to review and enhance their understanding of anatomy as well as to teach ultrasound-guided nerve blocks on cadaver extremities. The hypothesis was that after 3 instructional sessions students would be able to identify 6 anatomic structures, representing 3 types of tissue, in cadaver upper extremities.

Methods: Students received didactic instruction on ultrasound and regional anatomy at the beginning of each class, followed by hands-on practice, including ultrasound use with phantom task trainers, live models, and fresh cadaver limbs. The primary outcome was the students' ability to correctly identify anatomic structures using ultrasound. Secondary outcomes included their ability to perform a simulated nerve block in the cadaver extremities in comparison with a standardized checklist, as well as their response to a post-course survey.

Results: Overall, the students had a 91% success rate in identifying anatomic structures and showed capability of performing simulated nerve block with occasional instructor prompting. The post-course survey revealed that the students felt strongly that both the ultrasound and cadaveric components of the course were beneficial to their education.

Conclusion: Ultrasound instruction with live models and fresh cadaver extremities in a medical student elective course resulted in a high degree of recognition of anatomic structures, as well as permitted a valued clinical correlation in the form of simulated peripheral nerve blockade.

Keywords: Cadaver, ultrasound, sonoanatomy, simulation

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Tables

Table 1. *Anatomy Identification Results*

Structure Identified	Students Performing Task Successfully, n/N (%)	
	Required No Prompt	Required 1 Prompt
Humerus	7/7 (100)	—
Biceps muscle	7/7 (100)	—
Triceps muscle	7/7 (100)	—
Median nerve	7/7 (100)	—
Ulnar nerve	4/7 (57)	3/7 (43)
Radial nerve	6/7 (86)	1/7 (14)

Table 2. *PNB Assessment*

Practical Exam Assessment	Students Performing Task Successfully, n/N (%)		
	Required No Prompt	Required 1 Prompt	Required 2 Prompts
Holds probe appropriately	5/7 (71)	2/7 (29)	—
Describes screen orientation	7/7 (100)	—	—
Proper target identification	7/7 (100)	—	—
Appropriate needle alignment	5/7 (71)	2/7 (29)	—
Needle tip continuously visible during advancement	—	6/7 (86)	1/7 (14)
Needle tip visible during injection	3/7 (43)	3/7 (43)	1/7 (14)
Proper needle adjustment around target	3/7 (43)	3/7 (43)	1/7 (14)
Recognition of local anesthetic spread around target	6/7 (86)	1/7 (14)	1/7 (14)

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Tables *continued*

Table 3. *Survey Results*

Question	Score, n/N (%)				
	1	2	3	4	5
How satisfied are you with the hands-on experience with ultrasound offered in this course? (1, very dissatisfied to 5, very satisfied)	—	—	—	—	5/5 (100)
The cadaveric component added significant value to my learning experience. (1, strongly disagree to 5, strongly agree)	—	—	—	—	5/5 (100)
My confidence in using an ultrasound machine to identify anatomic structures of the upper extremity increased by the end of the course. (1, strongly disagree to 5, strongly agree)	—	—	—	1/5 (20)	4/5 (80)
My confidence in performing ultrasound-guided peripheral nerve blocks of the upper extremity increased by the end of the course. (1, strongly disagree to 5, strongly agree)	—	—	—	1/5 (20)	4/5 (80)
Participation in this course helped me to review gross anatomy of the upper extremity and understand how the ultrasound produces 2-dimensional images of these structures. (1, strongly disagree to 5, strongly agree)	—	—	—	1/5 (20)	4/5 (80)
How helpful do you feel that learning ultrasound techniques will be to your medical training? (1, very unhelpful to 5, very helpful)	—	—	—	—	5/5 (100)
Likelihood of recommending this course to a colleague. (1, very unlikely to 5, very likely)	—	—	—	—	5/5 (100)
Effectiveness of the in-person education you received. (1, very ineffective to 5, very effective)	—	—	—	—	5/5 (100)