The impact of an ultrasound-guided regional anesthesia workshop on resident knowledge: a pilot study
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Original Article

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Abstract

Objective: There has been a rapid growth in the use of ultrasound-guided regional anesthesia in the past decade. Residency programs have been trying to find the best way to teach these newer techniques. Our department decided to develop a teaching workshop for our residents with the purpose of improving knowledge and skills in ultrasound-guided regional anesthesia. The hypothesis was that the workshop would improve overall knowledge of ultrasound-guided regional anesthesia as determined by a test developed for this activity. In addition, the goal was to help improve imaging and technical skills.

Methods: A one-day workshop was organized for the CA1 and CA3 resident classes. The workshop was organized with the following learning objectives: (1) be able to identify basic ultrasound anatomy; (2) learn how to apply principles of ultrasound physics in order to obtain good ultrasound images; (3) develop basic ultrasound imaging skills on human models; and (4) develop needle visualization skills on gel models. The workshop included: a pre-test, a 2-hour didactic session, a 2-hour imaging and skills workshop, and a post-test. A twenty-question exam was developed by our faculty for this activity.

Results: A total of 20 residents participated in the two workshops. Tests scores (number correct out of twenty) were 9.5 ± 2.8 for the pre-test and 16.0 ± 1.9 for the post-test ($P < 0.0001$). This is an improvement in test scores of 68% from the pretest. CA1 pre-test scores were 10.1 ± 2.7, with post-test scores of 15.9 ± 1.7 ($P < 0.0005$). CA3 pre-test scores were 9.1 ± 3.9, with post-test scores of 16.1 ± 2.0 ($P < 0.0001$). There was no statistical difference between the classes ($P = 0.129$). Test scores obtained from the CA1 class (n = 7) one-year after the workshop were 16.7 ± 0.95. There was no significant difference between the post test scores and one-year scores ($P = 0.262$).

Conclusions: Both CA1 and CA3 resident post-test scores improved at the end of the ultrasound guided regional workshop. Our study showed a 68% improvement in test scores, which is larger than the 50% improvement previously reported. These results show that fast learning can occur in this type of setting. Furthermore, knowledge acquired during the workshop was retained when CA1 residents were re-tested one year after the workshop. The ultrasound-guided regional anesthesia workshop will become part of the didactic series for our CA1 residents

and will be a required learning activity. Additional work still needs to be done to find out the best way to test knowledge and skill outcomes in residents learning new technology and techniques.

Key words: anesthesia; peripheral nerve blocks; ultrasound guidance; residency education.

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Introduction

There has been a rapid growth in the use of ultrasound-guided regional anesthesia in the past decade. Residency programs have been trying to find the best way to teach these newer techniques. The American Society of Regional Anesthesia has recently published guidelines for education and training of ultrasound-guided regional anesthesia.[1] They recommend a didactic curriculum taught during residency that addresses the following four competencies: 1) understanding device operations; 2) image optimization; 3) image interpretation; and 4) visualization of needle insertion and injection.[1] New regional anesthesia curricula are being developed which concentrate on standardized educational content, quality care and patient safety, and resident evaluation and improvement.[2]

Ultrasound-guided regional anesthesia requires two distinct skills to attain and master: the ability to obtain good anatomical images of desired structures, and the ability to manipulate a needle under ultrasound visualization and deposit the local anesthetic while observing its spread. There is a learning curve associated with becoming proficient at both of these skills. Recent studies on how to teach residents different ultrasound-guided procedures and hand-eye coordination have shed light into what works when it comes to teaching these new techniques.[3-9] Videotape analysis of residents performing procedures[5] and the effect of a regional rotation on improving scores on a test identifying anatomical structures[7] have been described. Compared to the minimal risk associated with ultrasonography, the penetration of needles through the skin towards deep anatomical structures presents the potential for greater morbidity.[8] Practicing imaging and needle advancement using simulation models such as an olive in a turkey breast[4], a block of tofu with wood dowels and electrical wire[8], and a piece of foam inside a bag of saline treated with liquid solidifying agent[9], has been shown to help in learning these important skills. Our department decided to develop a teaching workshop for our residents with the purpose of improving knowledge and skills in ultrasound-guided regional anesthesia. An exam was developed to test basic ultrasound knowledge and use of ultrasound in regional anesthesia for the first and third-year clinical anesthesia residents in our department before and after attending an ultrasound-guided regional anesthesia teaching workshop. The hypothesis was that the workshop would improve overall knowledge of ultrasound-guided regional anesthesia as determined by this test. In addition, the goal was to help improve imaging and technical skills.

Materials and Methods

Approval to perform this study was obtained from the Baylor College of Medicine IRB in June 2010. During conversations with some of our graduating residents, they made it known that they wanted more hands-on experience and teaching on regional anesthesia outside of the operating room. A needs assessment was done by using an online survey that was sent out to all anesthesiology residents in the spring of 2010 (Appendix A). This was done in order to gauge interest in this activity and to get their input as to how to put this workshop together. The author also wanted to find out how much exposure our residents had to workshops at local and national meetings. One-hundred percent of responders were interested in a resident workshop with the goals of practicing imaging on healthy volunteers and needle guidance under ultrasound using

simulation models. Thirty-one percent of residents wanted the workshop to take place during the second part of their first year and seventeen percent would prefer it during the second year of residency.

The department decided to do separate workshops for the CA3 and CA1 classes in order to account for potential issues with the call schedule. Because of difficulty with coordination of schedules, the CA2 class was not invited during this pilot project. The workshop was organized with the following learning objectives: (1) be able to identify basic ultrasound anatomy; (2) be able to apply principles of ultrasound physics in order to obtain good ultrasound images; (3) develop basic ultrasound imaging skills on human models; and (4) develop needle visualization skills on gel models. The workshop included: a pre-test, a 2-hour didactic session, a 2-hour imaging and skills workshop, and a post-test.

The lecture material covered the following topics: basic ultrasound physics, knobology, common imaging artifacts, and peripheral nerve block sonographic anatomy. As described in Appendix B, the imaging and skills workshop had four stations. One station had gel models where residents practiced needle visualization under ultrasound and hand-eye coordination exercises. The other three stations where set up for imaging practice on human volunteers and were divided into upper extremity blocks (interscalene, supraclavicular, infraclavicular and axillary nerve blocks), lower extremity blocks (femoral, saphenous and sciatic nerve blocks), and other blocks (neuraxial techniques, transversus abdominis plane block). To facilitate active learning, a checklist, shown in Table 1, was given to all residents with a list of structures they needed to identify during their imaging stations. Residents were required to have all structures checked off before finishing the workshop. The author was assisted with the hands-on teaching portion of the workshop by three Baylor Anesthesiology faculty members. Four medical students interested in a career in anesthesiology were our volunteers for the ultrasound imaging by residents. The author also borrowed 5 ultrasound machines from Sonosite (SonoSite[TM], Bothell, WA, USA) to use at the workshops.

The pre-test and post-test was developed by the author with assistance from faculty with experience in teaching ultrasound-guided regional anesthesia. It is a twenty question multiple-choice test which contains questions on basic ultrasound physics, identification of anatomical structures at common nerve block locations, and identification of common artifacts of ultrasound imaging. About half the test contains ultrasound images used to answer the specific question. It was initially given to a group of five CA3 residents who had never attended an ultrasound workshop. Their mean test score was 9.6 out of 20, indicating validity with regard to our pre-test. This group of residents did not attend the later workshops, as they had finished residency by the time they were held. Data from a previous study by Orebaugh[7] showed close to 50% improvement between pre and post-test scores in residents taking a similar test identifying anatomical structures under ultrasound guidance after an educational intervention. Our goal was to improve the test scores by 50% to an average test score of 15 out of 20.

ACGME competencies taught by this workshop were patient care (imaging practice on human models), medical knowledge (didactics, pre and post-test), systems-based practice (how to use an ultrasound machine), and practice-based learning and improvement (evidence-based medicine, use of ultrasound in daily practice).

Results

The workshop was an optional resident activity which took place on two separate Saturdays. Both workshops were taught in exactly the same manner and lasted four hours. A total of twenty residents attended the workshops. This was 53% of the total thirty-eight CA1 and CA3 residents who were invited.

A twenty-question exam was given to all attendees before and after the workshop. Mean test scores were compared using paired t-tests. The comparison between the CA1 and CA3 resident classes and between pre, post, and one-year scores in the CA1 class was done by use of ANOVA. No power analysis was performed as this was a pilot study and the author wanted as many residents as possible to participate in the activity.

Mean tests scores (number correct out of twenty) were 9.5 ± 2.8 for the pre-test and 16.0 ± 1.9 for the post-test for the combined groups (n = 20). This was an improvement in test scores of 68% from the pretest. This difference was statistically significant with a $P < 0.0001$. The CA1 class had mean test scores of 10.1 ± 2.7 for the pre-test and 15.9 ± 1.7 for the post-test ($P < 0.0005$), while the CA3 class had scores of 9.1 ± 3.9 for the pre-test and 16.1 ± 2.0 for the post-test ($P < 0.0001$). There was no statistical difference between the classes ($P = 0.129$).

Additional test scores were obtained from the CA1 class (n = 7) one year after the workshop. The mean test scores at one-year were 16.7 ± 0.95. There was no significant difference between the post test scores and one-year scores ($P = 0.262$). No one-year data was obtained from the CA3 class as they had already finished residency.

A post-workshop survey was sent to all attendees (Appendix C). One-hundred percent responded that they would attend this type of workshop again and recommend it to a colleague. Ninety-one percent indicated that the didactics and tests were a useful teaching tool.

Discussion

Our department developed a workshop to teach ultrasound-guided regional anesthesia to our residents outside of the operating room. Overall, scores on the exam that was developed for the workshop greatly improved at the end of the workshop. In addition, the knowledge was retained by the CA1 residents who were re-tested one year after the workshop.

It is expected that test scores will improve on any test when repeated to the same group of learners. Excellent test-retest reliability is defined by a correlation between scores of 0.75 or higher[10]. Therefore, one can assume a difference in test scores of at least 25% to be present when the same test is repeated even without an intervention. The improvement in test scores in the current study was greater than we expected when compared to a previous study. As mentioned before, the study by Orebaugh[7] is the only published data looking at improvement of resident test scores after an educational intervention for this type of skill. Our study showed a 68% improvement, which is larger than the 50% improvement in the study by Orebaugh[7]. Because this was an optional educational activity, our turnout was not as good as it would have been if it had been a required didactic session. We found it more difficult than expected to

coordinate a group of residents to be off from clinical duties on a specific date and time. This was due to the call schedule, vacations, and duty hour requirements. After discussion with the residency program director, the plan is to make the future workshops part of the CA1 didactic program. Due to time constraints, it will be divided into lectures on day one and workshop on day two.

Even more important than being able to answer the questions on an exam, the real skill in ultrasound-guided nerve blocks is the ability to locate the target anatomy and nerve structures, to place the tip of the needle in the right location under direct visualization, and to visualize the local anesthetic solution spread around the correct nerve structures. The ultrasound workshop checklist (Table 1) was a tool used to make sure the residents learned to identify all the important structures for each of the blocks, not just the nerve structures. Practicing with needles on gel models gave the residents early experience with needle guidance. It may also enhance patient safety compared to the traditional approach of performing a procedure for the first time on a real patient. These skills will not be mastered solely by attending a workshop, or even performing a handful of blocks on patients. As with any skill we learn throughout medical school and residency, performance of these techniques multiple times is the only way to master them. Although we did not have a specific measure to assess an improvement in image localization and needle visualization of our residents, we expect that their experience at the workshop will speed up their learning curve for both skills.

There are a few limitations to the study. The first is whether or not this workshop would be repeatable at other residency programs. Although the framework of the workshop can be set up similarly at other programs, the difference in knowledge and experience of the faculty teaching ultrasound is going to be an important factor. Secondly, our test was developed by our faculty and as such, has not been previously formally validated. We did test the questions by administering it to another group of residents beforehand, and found that the workshop naive residents scored about the same as residents in our pre-test. Whether or not the questions chosen are the best to help determine how much our residents learned during the workshop can be debated. How much baseline knowledge any group of residents has depends on previous education and clinical experiences prior to any testing. It is also difficult to accurately quantify retention of knowledge as the clinical experience will vary for each resident at the time of re-testing. We were only able to re-test the CA1 group as the CA3 residents had already graduated when the data was initially analyzed. The test data showed no significant difference between the post-test and one-year scores in the CA1 group. This indicates good retention of knowledge obtained at the workshop by this group of residents. It would be useful to develop a skills test that could be given at the workshop and then again during residency to assess improvement of skills, not just knowledge.

In addition, self-selection bias is an important factor as not all residents who were invited chose to or were able to participate in this optional activity. Residents with more interest and motivation to learn are likely to be a large part of the group that took part in this activity. Therefore, the improvement in test scores shown by this group at the workshop could be higher than it would have been for the entire class. Since the residents took the tests anonymously, it was not possible to determine how the cohort of participating residents compared to the class as a

whole on in-training exams. This might have helped decide whether or not there was selection bias with this activity.

In conclusion, the workshop helped improve the knowledge of the residents who attended. The results of the tests show that, in the setting of the leaning activity described, fast learning can occur with good knowledge retention at one year. The ultrasound-guided regional anesthesia workshop will become part of the didactic series for our CA1 residents and be a required learning activity. It took some extra effort on the part of the faculty to put this workshop together and make it as beneficial as possible. The ability to develop this type of workshop in other departments depends on having faculty trained in ultrasound techniques and having the time and necessary resources available. This type of workshop should be considered an essential component in a learning curriculum for anesthesiology residents. In addition, there are other skills learned during residency such as advanced airway techniques, transesophageal echocardiography, and line placement which may benefit from this type of workshop teaching. Further work still needs to be done to find out how to best test knowledge and skill outcomes in residents learning new technology and techniques.

Tables

Table 1. ULTRASOUND WORKSHOP CHECKLIST

INTERSCALENE	INFRACLAVICULAR
Common carotid artery	Pectoralis major muscle
Internal jugular vein	Pectoralis minor muscle
Sternocleidomastoid muscle	Axillary artery
Anterior and middle scalene muscles	Axillary vein
Brachial plexus (roots/trunks)	**AXILLARY**
SUPRACLAVICULAR	Axillary artery
Subclavian artery	Axillary vein
Subclavian vein	Musculocutaneous nerve
First rib	**TRANSVERSUS ABDOMINIS PLANE BLOCK**
Brachial plexus (trunks/divisions)	External oblique muscle
FEMORAL	Internal oblique muscle
Femoral artery	Transversus abdominis muscle
Femoral vein	Bowel
Femoral nerve	**NEURAXIAL ANATOMY**
Fascia lata, fascia iliaca	Spinous process/ vertebral body
SCIATIC AT POPLITEAL FOSSA	Lamina
Femur	Transverse process
Popliteal artery	Facet joint
Sciatic nerve (tibial and peroneal)	Ligamentum flavum

Appendix A. Needs assessment survey

42 residents responded (CA1, CA2, and CA3 residents as of spring 2010)

Would you be interested in attending an ultrasound-guided regional anesthesia workshop for our residency program?
a.   Yes   100%
b.   No   0%

Have you ever attended an ultrasound-guided regional anesthesia workshop?
a.   Yes   23.8%
b.   No   76.2%

How many ultrasound-guided nerve blocks have you performed during your residency?
a.   0   7.1%
b.   1-5   50%
c.   6-10   14.3%
d.   11-20   7.1%
e.   > 20   21.4%

Would you benefit from learning how to obtain ultrasound images on human volunteers?
a.   Yes   100%
b.   No   0%

Would you benefit from learning how to visualize a needle under ultrasound guidance using a simulation model (i.e. gel, gelatin, or tofu model)?
a.   Yes   100%
b.   No   0%

Would you benefit from 1-2 hours of lecture on ultrasound physics and how to use an ultrasound machine as part of the workshop?
a.   Yes   85.7%
b.   No   14.3%

How long should the workshop last?
a.   2-4 hours   31.0%
b.   4-8 hours   33.3%
c.   2 day workshop   35.7%

Would it add to your educational experience to have a pre-test and post-test where you will be asked to identify structures on ultrasound images which are important for performance of a variety of blocks?
a.   Yes   85.7%
b.   No   14.3%

When during residency training would you prefer this workshop to take place?
a.   Early in the CA1 year   4.8%
b.   Late in the CA1 year   31.0%
c.   During CA2 year   16.7%
d.   Early CA3 year   7.1%
e.   During CA1, CA2, and CA3 years (3 workshops total)   40.5%

Please give any suggestions with regards to organization of this workshop.
Multiple suggestions were given.

Appendix B. Imaging and Skills Workshop

SIMULATED STATIONS
 2-4 residents spent 30 minutes in each station.
 One faculty per station

Station 1 – Gel Models
a. 2 gel models with structures that look like vessels and nerves
b. Resident used 22 G nerve block needles to practice needle visualization using in-plane and out-of-plane approach. The goal was to advance the needle and place the tip next to target structures.

Station 2 – Upper Extremity Blocks
Imaging of brachial plexus on human model. Faculty showed each approach separately and all residents got to try the approach and identify structures on the list provided (Table 1).
Interscalene block
Supraclavicular block
Infraclavicular block
Axillary block

Station 3 – Lower Extremity Blocks
Imaging of lower extremity nerve structures on human model. Faculty showed each approach separately and all residents got to try the approach and identify structures on the list provided (Table 1).
Femoral and saphenous blocks
Sciatic block at popliteal fossa

Station 4 - Other Blocks
Imaging of anatomy on human model. Faculty showed each approach separately and all residents got to try the approach and identify structures on the list provided (Table 1).
Neuraxial anatomy
Transversus abdominis plane block

Appendix C. Post Survey

16 out of 20 attendees completed the survey

Would you attend this type of workshop again in the future?
a.   Yes   90.9%
b.   No   0%
c.   Maybe   9.1%

Would you like to more time spent in didactics? (i.e. >2hours)
a.   Yes   18.2%
b.   No   63.6%
c.   Maybe   18.2%

Would you like more time spent in the hands-on portion of the workshop?
a.   Yes   54.5%
b.   No   45.5%
c.   Not sure   0%

How useful was the lecture material?
a.   Very useful   54.5%
b.   Somewhat useful   45.5%
c.   Neutral   0%
d.   Not useful   0%

How useful was the hand-on workshop?
a.   Very useful   100%
b.   Somewhat useful   0%
c.   Neutral   0%
d.   Not useful   0%

How useful were the pre and post tests for your learning?
a.   Very useful   36.4%
b.   Somewhat useful   54.5%
c.   Neutral   9.1%
d.   Not useful   0%

Would you recommend attending this workshop to a colleague?
a.   Yes   100%
b.   No   0%

Would you be interested in attending multiple workshops on this topic during your residency?
a.   Yes   90.9%
b.   No   0%
c.   Not sure   9.1%

Are there any other anesthesia skills you learn during residency that you would like a separate workshop for?

Responses:
Echo, TEE

Any suggestions on how to improve future workshops?
Responses:
Print out lecture material in advance.
More board type questions for each type of block.
Please make more imaging examples available at the stations for comparison purposes.

Acknowledgements

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