Benefits of a dedicated ultrasound education for medical students: A 3 year experience

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Abstract

Objective
An accelerated ultrasound education curriculum was designed specifically for second-year medical students. Our goal was to effectively measure this teaching methodology and to assess the practicality of this concept.

Materials and Methods
After analyzing the existing ultrasound training for medical students, improvements were made to the existing curriculum for 2nd-year students that addressed the drawbacks in ultrasound education, including instrumentation, anatomy, and ultrasound-guided procedures. Prior to exposure to ultrasound education, all students participated in an anonymous quiz to determine and document their baseline knowledge. The ultrasound immersion week included; hands-on education and lectures. Students were divided into small groups with radiologists supervising ultrasound skills on standardized patients and intervention using phantom models.

After the week-long exposure to radiology and ultrasound, students took a post-exposure assessment to evaluate their knowledge. Efficacy of the program was determined by comparing pre and post-exposure test results.

Results
Students from Cohort A and B had a 19% improvement, and Cohort C had a 39% improvement. Pre and Post immersion quiz analysis were validated with statistical testing with a p-value <0.01. A thorough analysis of all three years showed significant improvement among medical students.

Conclusion
The study proved that short, accelerated ultrasound education programs are effective in educating second-year medical students. By the standardized questionnaire, it also demonstrated that there is a significant impact in ultrasound knowledge among students through a week of focused education. Using homemade phantoms promoted
active engagement among students and exhibited the practicality of conducting such a course in any institution.

**Keywords:** Ultrasound education; Medical school; Radiology teaching

**Introduction**

Ultrasound has gained a high ground in recent years in for healthcare diagnosis and treatment, due to its easy availability, portability, and accuracy. For years many physicians have called upon ultrasound because of its wide array of applications in the clinical environment, especially at the bedside. Through a survey of medical schools around the nation in 2014, only 18.6% of medical schools showed that ultrasound education was a priority in their schools.

Ultrasound imaging originally the purview of radiologists, has now evolved to be used in multiple specialties as a point of care and diagnostic tool (Webb *et al.*, 2014). In 2014 Solomon *et al.*, highlighted the importance of ultrasound being a modality of choice and the next generation of physicians being trained and comfortable to use in everyday clinical practice (Solomon & Saldana, 2014). This would require incorporating ultrasound education as a major component of the current medical school curriculum. Bahner lists that one of the biggest barriers to the discrepancy in ultrasound training is the lack of space in the current rigorous medical student curriculum. (Bahner *et al.*, 2014)

Based on our observation, there was a lack of ultrasound education within our institution, especially during the preclinical years. Therefore, we addressed the concern by creating a short and robust ultrasound education training session that can be easily implemented. This change would require additional effort and time to integrate into our existing current second-year medical school curriculum.

**Methods**

The main objective of this course was to create a curriculum for the 2nd year medical students and provide a feasible education session that gives them an introduction to the basics of ultrasound imaging. At our institution, an organized ultrasound education week was conducted toward the end of the second year in medical school and administered consecutively for three years. The study was conducted from years 2014 through 2016, resulting in 3 student cohorts A (second-year students in 2014), B (second-year students in 2015), and C (second-year students in 2016) respectively. The week-long curriculum was designed to cover the basic concepts of ultrasound knobology, progress to anatomy in identifying various organ systems, and finally advance to the skills sessions to scan and perform ultrasound-guided procedures. Data collected and lectures given were part of normal curriculum, therefore IRB approval was given by the institution.

The curriculum was designed to have on average of three hours of lectures and two hours of skills sessions per day. Over a week of four days, the entire course included on average, twelve hours of lectures and eight hours of skills sessions, dedicated to ultrasound and imaging. The schedule had several hours of lecture sessions to emphasize pathological findings using ultrasound; and several hours of skills sessions, where students were able to get hands-on training. The last day was used as an adjunct for students to refine and practice skills they had learned throughout the week.

Didactic lectures were given to all 240 students in a traditional classroom setting. The week-long lecture series was created to cover the following topics: knobology, musculoskeletal ultrasound, vascular ultrasound, ultrasound of abdominal organs, and interventional ultrasound-guided procedures. Lectures and materials presented were kept consistent throughout each year of the ultrasound curriculum.
Students were then broken down into smaller groups to facilitate a better hands-on training session and due to the limited availability of ultrasound machines. Radiology faculty and residents (first-year radiology residents) were assigned as instructors, with a student to instructor ratio of 15:1. Each group had one standardized patient and one homemade phantom gel model. The homemade phantom gel model was created from various ingredients such as gelatin and Metamucil, that would resemble a similar echogenicity and consistency found in pathological diseases to simulate real-world scenarios. It also contained water-filled balloons to represent vessels and organs, while olives and grapes as tissue nodules (Figure 1). The gel model was poured and set in layers to allow for simulation of anatomical structures at varying depths. (Jeanty, 2014)

**Figure 1:** Image of the olive in the gel phantom model during an interventional procedure

The students were instructed on three basic hands-on skill sets: i) to measure organs like the spleen, liver, and kidney, ii) locate arteries like the carotid, femoral, and aorta, and iii) learn the principles of ultrasound-guided cannulation and guided biopsy techniques. Students were encouraged to practice imaging on standardized patients, and ultrasound-guided biopsy and cannulation on the homemade phantom gel model. Over time streaks and puncture tracts become more apparent on the model; however, the gel model was easy to make and relatively inexpensive. Therefore replacement after use was easily manageable.

The students were asked to take a standardized questionnaire, prior to the ultrasound education week that interrogated their baseline knowledge in identifying multiple organ systems with ultrasound. After the completion of the ultrasound immersion week, a similar questionnaire was given to students to measure their improvement in proficiency of identifying multiple organ systems. The pre and post-test were designed such that the material tested in both questionnaires were identical. The difficulty level of both exams was similar if not the same, giving each student a fair chance both times. Answer choices among the pre and post-test questionnaire were randomized to eliminate biases such as short-term recall.

Both tests consisted of 5 multiple choice questions that were developed, based on the concepts reiterated throughout the week of didactic lectures and hands-on training. The topics tested were chosen based on complexity, variable echogenicity, and prevalence in patient presentations. During the tests, the students were shown an ultrasound image with probe orientation for each question and asked to identify the anatomical landmark, such as a gallbladder, aorta, femoral artery, tendon, and liver. The questionnaire was administered anonymously across all three years of the study for a consistent and comparable analysis. In addition to the questionnaire, students were given the opportunity to demonstrate a successful biopsy of a nodule on the gel model.
Finally, at the end of the course, an anonymous satisfaction survey was administered to gain feedback.

**Results**

The sample size, across all three years, included a total of 440 students who took the post-immersion week questionnaire. Passing was defined as scoring above 60%. A cumulative analysis across all three years showed a consistent improvement in medical student understanding and interpretation of ultrasound imaging. Results for individual cohorts are as follows: cohort A had a 39% improvement in pass rate, cohort B had a 36% improvement in pass rate, and cohort C had a 49% improvement in the pass rate. Pre and Post immersion quiz analysis were validated with Fisher's exact t-test and two sample t-test with a statistically significant p-value of <0.01 for each cohort (as seen as in Figure 2).

**Figure 2:** Pass rate of each cohort with associated improvement on post examination

![Pre and Post Immersion week pass rate (>60%)](image)

**ALL 3 YEARS:**

The cumulative statistical analysis was conducted incorporating all the three cohort groups (A, B and C). Pre-test scores, with the Fisher's exact test, had a p-value of 0.02. The post-test scores Fisher's exact test had a p-value of <0.01. The Chi-squared analysis showed an improvement in the pass rate in the cumulative analysis with a p-value of <0.01 (Table 1).

Each cohort is independent of one another but is comparable in all other factors. The students have undergone the same medical education and represent the same diversity of experiences among each cohort. Each cohort was taught the same material, with emphasis on the same basic concepts.
Table 1: Comparison of scores across all three years with associated p-value

Indicates a significant improvement in number of students with passing scores in the post immersion week test.

| Test Scores | Pre-Test | Post-Test |
|-------------|----------|-----------|
| 0.00%       | 9        | 0         |
| 20.00%      | 66       | 5         |
| 40.00%      | 149      | 33        |
| 60.00%      | 178      | 88        |
| 80.00%      | 133      | 171       |
| 100.00%     | 30       | 129       |

P value: 0.02* <0.01*

Conclusion

This immersion week was designed to be a minimalistic course that covered the basics and allowed students to be relatively engaged in a short period of time. With just one immersion week of ultrasound education, students were able to remarkably increase their understanding and interpretation of ultrasound imaging. This course is a simple and effective way to implement ultrasound education in the pre-clinical areas without disrupting the natural flow of other courses and requirements the students have.

Short and focused ultrasound education programs with a series of focused lectures and hands-on training in small groups, proved to be useful and effective in educating second-year medical students in our academic-based institution. The results from the standardized questionnaire demonstrate that it is possible to have a significant impact in ultrasound knowledge among students. The use of homemade phantom models not only promoted active engagement among students but also offers a practical method for hands-on ultrasound-guided interventional procedural training.

Student feedback reiterated the success with positive comments regarding the hands-on-training, especially the incorporation of the gel model. The phantom gel model was specifically designed for multiple students to practice interventional procedures in a low-risk environment with minimal resources.

One of the drawbacks was the limited availability of equipment, during the week of ultrasound education, which was addressed by breaking students into smaller groups. The other feedback from students was the lack of resources available to practice and maintain their ultrasound skills outside of this curriculum. Therefore, students at our institution are given the opportunity to use a computer simulation model at the skills center to practice on their own time.

For consistency and simplicity, the test was limited to only 5 pre and post-test questions that were derived from the core concepts emphasized throughout the week. A potential improvement to the assessment of students should incorporate a highly comprehensive questionnaire that includes but not limited to basic anatomy and common pathological imaging seen in patients.

Future studies should contain an adequate control arm to differentiate the necessity of each aspect of this ultrasound curriculum, with the ultimate goal of increasing the understanding and proficiency among medical students.

Take Home Messages

Learning Objective:
1. Ultrasound education among medical students is possible through a short interventional immersion week.

2. Future physicians will use ultrasound imaging on an increasing basis as a bedside diagnostic tool.

3. An interactive and effective course can be implemented in an already rigorous medical school curriculum with minimal disruption.

**Notes On Contributors**

Saagar Patel – MSIV Medical student at UT Houston McGovern Medical School, Class of 2020. He has worked on the project from implementation to analysis and write up.

Dr. Manickam Kumaravel – Professor, Program director of Medical student education for UT Houston McGovern Medical School Radiology department. He designed and implemented the program.

Girija Rajakumar – Senior program manager for medical student education for the department of diagnostic and interventional radiology. She helped implement, analyze and edit the manuscript.

Dr. Kimberly Brown – UT Houston Radiology resident who helped implement, write and edit the results from the intervention.

Dr. Haitham Awdeh – Associate professor the department of diagnostic and interventional radiology at UT Houston McGovern Medical School.

Dr. Pritish Bawa – Associate professor at the department of diagnostic and interventional radiology at UT Houston McGovern Medical School.

Chunyan Cai – Department statistician at UT Houston McGovern Medical school. She helped with designing the questionnaire and performing the statistical analysis.

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Appendices

None.

Declarations

The author has declared that there are no conflicts of interest.

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Ethics Statement

An IRB was obtained. The reference number for the IRB review at UT Houston Medical School is #HSC-MS-19-0401. Ethics approval was done by McGovern Medical School regarding analytical study of the curriculum. All associated personal have approved and consented to the curriculum.

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