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# Ultrasound in Medical Education: Increasing Awareness for Ultrasound Applications in the Novice Learner

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## Abstract

**Objective:** We aimed to assess understanding and perceived educational benefit of Point of Care Ultrasound (PoCUS) in a surgical setting for 3rd year medical students.

**Design:** We conducted a prospective study evaluating a PoCUS course that comprised of a two-hour session. The session included a pre-test assessment survey, one-hour of didactic lecture, hands-on workshop with an ultrasound simulation machine and live standardized patient, and finally a post-test assessment survey. Students were given the option to return, if desired, for further self-directed learning with an ultrasound simulator after the pilot program.

**Setting:** Sim Central at Texas Tech University Health Sciences Center in Amarillo, TX.

**Participants:** A total of 12 students participated in the course. All students completed a pre-course survey and 11 students completed the post-course survey.

**Results:** Providing educational instruction and resources for PoCUS in a surgical setting has a statistically significant self-reported positive effect on students.

**Conclusion:** All the participants of the study had a strong awareness of the advantages of utilizing Ultrasound (US) in a clinical setting. However, given an opportunity to learn in depth applications of ultrasound technology in a clinical setting, the benefit to medical students emerge.

**Keywords: Education; Ultrasound; Medical students; PoCUS**

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## Introduction

Ultrasound (US) is a fairly inexpensive, non-invasive portable modality used to identify normal anatomy and various abnormalities within the human body. Advances in technology have allowed increased application of ultrasound in everyday clinical practice. Ultrasound now plays a critical role in many medical specialties including obstetrics and gynecology, surgery and emergency medicine. In fact, residency programs value the utility of ultrasound application and most programs seek ways to integrate it into their training programs for improved physician competency [1]. Unfortunately, a wide gap still exists between the clinical applications of ultrasound and its integration into the standard medical education curriculum [1,2]. A significant need for more training including didactics and hands-on modules for learning ultrasound is needed at the medical school level. Although no standard ultrasound curricula currently exist for graduate medical students, we believe early integration of ultrasound education and training through both basic science and clinical clerkships are critical to the evolving future practice of medicine [2,3]. Our pilot program aims to re-acquaint students with ultrasound using guided instruction, hands-on experience and open access to training modules for greater exposure and learning of ultrasound applications.

## Methods

### Study design

We conducted a prospective study to test the hypothesis that a Point of Care Ultrasound (PoCUS) pilot training program with didactics and hands-on training would improve both attitudes and knowledge about ultrasound in surgical settings. In our study, participants served as their own controls. Survey questions and statistical methods were reviewed and approved by Texas Tech University Health Sciences Center Clinical Research Institute. The QI study was approved by the

**Table 1:** A schedule of activities during the Surgical Ultrasound Skills Program. Students were incentivized to attend our program through a door prize raffle.

| Time | Activity |
|---|---|
| 10:00 AM | Welcome + Pre-Test |
| 10:10 AM | Ultrasound-Trauma & Triage |
| 11:00 AM | Introduction to US Mentor System Software |
| 11:15 AM | Explore US Equipment |
| 12:00 PM | Post-Test |

Texas Tech University Health Sciences Center's Quality Improvement Review Board.

### Setting and population

The study was conducted at a semi-rural academic medical center, using an accessible sample of 12 interested 3rd year medical students. Self-selection bias was accounted for by informing students via email from a third-party about the course. Previous exposure to ultrasound was limited to pre-clinical didactics clinically oriented anatomy course where students had only focused exposure to Focused Assessment with Sonography in Trauma (FAST) exam, etc. Didactic training was provided by faculty within the Department of Surgery with expertise in PoCUS. There were no exclusion criteria.

### Intervention and outcome

Participants attended a 2-h session with training faculty. Our session consisted of a pre-test assessment survey, one-hour of didactic lecture, hands-on workshop with an ultrasound simulation machine and live standardized patient, and finally a post-test assessment survey. Students were given the option to return, if desired, for further self-directed learning with ultrasound simulation machine after the pilot program. Course topics covered during the didactic session included FAST/eFAST exam with respective standard views, echocardiography, and abdominal views (Table 1).

The primary outcome was the objective change in awareness and confidence regarding ultrasound in a surgical setting. Our hope was that participants would become more aware of the benefits of ultrasound and increase their future use of ultrasound in their practice of medicine.

### Equipment

The following machines were used during the 2019 workshop: GE NextGen LOGIQ e R7 ultrasound system equipped with standard phased array (3 MHz), linear (12 MHz), and curvilinear (1 to 5 MHz) probes. Simbionix U/S Mentor medical training simulator with a curvilinear and phased array transducer on a male multi-purpose mannequin.

### Statistical analysis

Every student assessment was paired and de-identified before analysis. Eleven completed pre and post-assessments were used in order to assess attitudes. Only 1 participant failed to complete a post-test survey, which was not included in the post-test analysis. Pre and post-test assessment differences for Likert-scaled items were assessed by paired t tests. Significance was determined to be a P-value of $<0.05$.

## Results

The administered survey shows a statistically significant increase in Questions 1 to 4 indicating a change in attitude towards the surgical application of ultrasound ($p=0.009$) and educational benefit of learning ultrasound in a surgical setting ($p=0.0002$). Participants also agreed that our program helped them to understand the applications of ultrasound in a surgical setting ($p=0.002$) and the fundamentals of operating ultrasound as a whole ($p=0.017$). Questions 5-9 did not show any statistical significance as attitudes and confidence for those parameters were already high before the study (median = 5, Questions 5 to 9). Responses for all students were used to calculate results except for 1 participant who failed to complete the post-test assessment.

Participants were also given the opportunity to provide feedback about the program. Comments were overwhelmingly positive with several commenting on the benefits of eFAST instruction which would be applicable to their future practice of medicine. An additional suggestion for future focus of instruction was also mentioned, including a need for a brief lecture on Transvaginal Ultrasound and Transrectal Ultrasound for prostate exams. Overall, students were excited about the surgical ultrasound skills program course as observed with the median rating of 5 for students who completed the post-course survey.

## Discussion

Our program had success in changing attitudes towards the following: "Understanding surgical applications of US", "educational benefits of learning US in a surgical setting", "fundamentals of operating US in a surgical setting" and "applications of US in a surgical setting." Remaining survey questions did not show a

**Table 2:** At the beginning of our session, students completed a 9-item pre-assessment online survey noting their attitudes towards ultrasound. Another 10-item post-assessment online survey was given immediately at the conclusion of the program. The self-assessments were scored on a 5-point Likert scale for each question, with 1 being Strongly Disagree and 5 being Strongly Agree. Outcomes from the survey were reported as minimum and maximum values, group median, etc. The survey was administered using SurveyMonkey, an online survey service.

| | |
|---|---|
| 1. | I understand the surgical applications of ultrasound. |
| 2. | There is an educational benefit of learning ultrasound in a surgical setting. |
| 3. | The fundamentals of operating ultrasound equipment in a surgical setting are clear. |
| 4. | This program will help me understand the applications of ultrasound in a surgical setting. |
| 5. | I feel comfortable collaborating with other healthcare professionals while using ultrasound in a surgical setting. |
| 6. | All medical schools should incorporate ultrasound education into their clinical curriculum. |
| 7. | I plan to incorporate ultrasound into my future clinical practice. |
| 8. | Open access to ultrasound training modules allows me to gain more experience outside of the traditional lecture format. |
| 9. | Using self-directed learning allows me to better enjoy learning about ultrasound in a surgical setting. |
| 10. | Having self-directed learning gives me more opportunities to learn about ultrasound in a time-efficient manner.* |

1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree
*Question 10 was only seen in the post-survey assessment

**Table 3:** Q1-Q5 Descriptive Statistics.

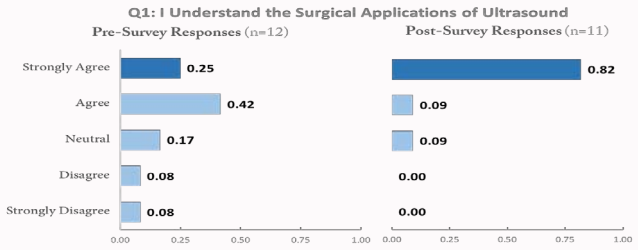
| | Q1 | | Q2 | | Q3 | | Q4 | | Q5 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (Pre-Test) | (Post-Test) | (Pre-Test) | (Post-Test) | (Pre-Test) | (Post-Test) | (Pre-Test) | (Post-Test) | (Pre-Test) | (Post-Test) |
| Min | 1 | 3 | 3 | 4 | 2 | 3 | 1 | 3 | 2 | 4 |
| Max | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Median | 4 | 5 | 5 | 5 | 3.5 | 5 | 3 | 5 | 5 | 5 |
| *P* | 0.009887361 | | 0.000233447 | | 0.002490682 | | 0.01751398 | | 0.177561839 | |

**Table 4:** Q6-Q10 Descriptive Statistics.

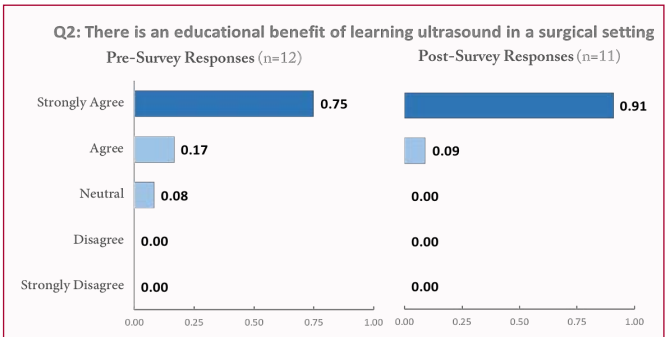
| | Q6 | | Q7 | | Q8 | | Q9 | | Q10 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (Pre-Test) | (Post-Test) | (Pre-Test) | (Post-Test) | (Pre-Test) | (Post-Test) | (Pre-Test) | (Post-Test) | (Pre-Test) | (Post-Test) |
| Min | 3 | 3 | 3 | 4 | 3 | 4 | 3 | 4 | | 4 |
| Max | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | 5 |
| Median | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | 5 |
| *P* | 0.63089169 | | 0.270248341 | | 0.270248341 | | 0.270248341 | | | |

**Figure 1:** Medical students listening to the Ultrasound Trauma & Triage Lecture given by Dr. Shane Harper.

**Figure 2:** Medical students practicing their hands-on skills with our Simbionix U/S Mentor machine.




**Graph 1:** Breakdown of survey responses for Question 1.

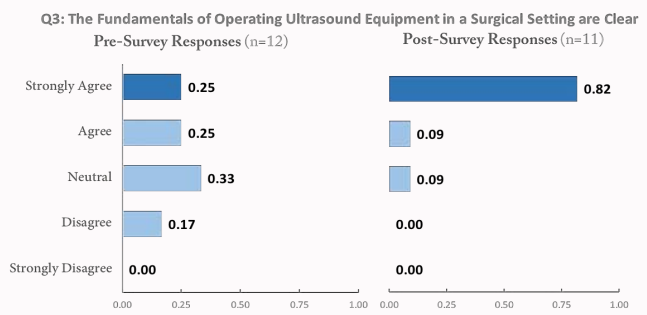



**Graph 2:** Breakdown of survey responses for Question 2.

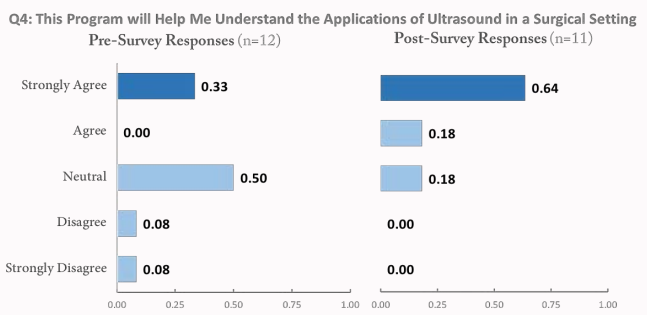
statistical significance possibly demonstrating a previous personal self-awareness and importance of those factors. Overall, the need for further incorporation of ultrasound within the undergraduate medical education seems clear as advantages for integration of ultrasound into the pre-clinical curriculum have previously been confirmed. Specifically, medical students at the University of Colorado School of Medicine responded to a survey saying they felt that US had enhanced their ability to learn anatomy [3]. Thus, the advantages to ultrasound within clinical practice are becoming more apparent.

Based on the data, our students recognize the utility of gaining experience for US outside of the traditional lecture format. We believe allowing access within an environment that respects the time-constraints of a typical medical student while providing support may be an effective way to further incorporate US into the undergraduate medical education.

Funding issues and lack of time within the curricula were frequently cited as barriers to implementation in US training programs. However, a single-center cohort study at the University of Colorado found that first year students required only 6 days within the academic year to learn ultrasound while second year students required 5 days [4,5]. Additionally, time constraints could be solved by allowing students to have initial in-person instructor-guided sessions followed by a flexible schedule to complete simulator guided US modules as previous studies have shown equal effectiveness for simulation curriculum and standard didactic curriculum for learning physiologic principles in ultrasound [6]. Self-guided learning in this sense allows the necessary exposure but retention and acquisition of learned information or demonstration of basic competency remains




**Graph 3:** Breakdown of survey responses for Question 3.




**Graph 4:** Breakdown of survey responses for Question 4.

questionable. One study looked at this parameter and found inability to achieve PoCUS competency for medical learners engaged in self-directed ultrasound simulator training [7]. However, proposed alterations in study design and improvements in technology could still allow for this learning model to become viable.

If resources for training simulators are unavailable, multiple small group sessions could be used to achieve similar results. A study at the Hamilton campus of the Michael G. DeGroote School of Medicine at McMaster University concluded that structured small group teaching sessions were effective in teaching introductory Point of Care Ultrasound (PoCUS) knowledge [8].

Our program was able to incorporate both using a U/S Mentor machine with virtual simulated modules in addition to hands-on training with a live standardized patient. Overall, we believe a combination of both initial small group instructor guided US sessions paired with simulator guided modules interspersed with periodic competency checks would be the most beneficial for student learning.

## Study Limitations

Some limitations of our study should be noted. First, our data comes from a single-center study which focused only on a small number of 3rd year medical students. We admit that including more 3rd years and expanding the study to other 4th year students may have increased our external validity and reliability. Second, with a limited student population, selection bias logically becomes a concern. However, self-selection bias was accounted for by informing students *via* email from a third-party about the course. Finally, survey results are self-reported which may reflect an inherent bias of perceived improvement of understanding and application without actual quantitative results showing that increase.

## Conclusions

Our study was able to effectively demonstrate a self-reported positive effect on students using PoCUS in a surgical setting. This finding highlights the need for US education to be expanded within undergraduate medical education. Main issues with implementation lie in financial constraints and time considerations. Practically speaking, if resources allow, students can use a combination of in-person instructor guided sessions and simulator guided instruction for US learning. Additionally, testing of competency for proper confirmation of acquisition and retention of information is needed.

In conclusion, students already had an awareness of the advantages of ultrasound based on this limited study data. However, given an opportunity for students to learn specific use cases, the benefits to understand the surgical applications of ultrasound emerge.

## Future Directions

Based on the results of the pilot program, we hope to better incorporate ultrasound into the clinical curriculum through a seamless integration into the third-year clerkships. As the pilot program was geared towards using ultrasound in a surgical setting, we believe starting with the Surgery Clerkship would be ideal. Other clerkships with ultrasound applications can also be considered (i.e. Obstetrics and Gynecology and Internal Medicine) as well.

Finally, we hope to conduct a larger more robust study on the integration of ultrasound within the curriculum and track student acquisition and retention of skills via formal and informal testing. This will ensure that every medical student graduates with a minimum baseline of ultrasound knowledge that can be utilized throughout residency and thereafter. Additionally, further studies can elucidate the effects of acquisition and retention of ultrasound knowledge on patient-care outcomes.

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