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Original Article

# A Prospective Evaluation of Point of Care Ultrasound Teaching in Switzerland

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## Abstract

**Context:** As the utility of point-of-care ultrasound (POCUS) continues to expand in the medical field, there is a need for effective educational methods. In Switzerland, medical education follows the European model and lasts 6 years, focusing on preclinical training during the first 2 years. No previous studies have evaluated the optimal time for teaching ultrasound in European medical education. **Aims:** The aim of this study is to provide ultrasound training to medical students in Switzerland at varying times during their clinical training to determine if the level of training plays a role in their ability to comprehend and to apply basic POCUS skills. **Methods:** We performed an observational study utilizing a convenience sample of Swiss medical students between July 11, 2016 and August 6, 2016. They were taught a 2-day POCUS course by five American-trained 1st-year medical students. Following this course, students were evaluated with written and clinical examination. **Results:** 100 Swiss medical students were enrolled in the study. A total of 59 of these students were early clinical students, and 41 students were late clinical students. A two-tailed *t*-test was performed and demonstrated that the late clinical students performed better than the early clinical students on the written assessment; however, no difference was found in clinical skill. **Conclusion:** Our data suggest that Swiss medical students can learn and perform POCUS after a 2-day instructional taught by trained 1st-year American medical students. No difference was found between students in early clinical training and late clinical training for the ability to perform POCUS.

**Keywords:** Medical education, Switzerland, ultrasound teaching

## Introduction

Point-of-care ultrasound (POCUS) has emerged as a cost-effective, minimally invasive imaging modality. It has a wide array of practical uses across a breadth of medical specialties, and it has been suggested that ultrasound is included in all standard physical examinations to aid physicians in their diagnoses.[1-3] In addition, including ultrasound in medical education has been shown to later boost physicians' confidence in performing bedside examinations.[4] As the utility of POCUS continues to expand in the medical field, there is an increasing need for effective educational methods to teach medical students the necessary skill set to master POCUS.

Previous studies have shown variable success and implementation in teaching curriculums.[5-7] Bahner *et al*. demonstrated that the integration of ultrasound into curricula is highly variable and is in need of standardization.[8] A comprehensive study of ultrasound education at Wayne State University has shown that medical students had positive experiences and better outcomes with the inclusion of ultrasound in their medical education.[9] In addition, a 2010 study conducted by surgeons and medical researchers in the United Kingdom demonstrated that the focused assessment with sonography in trauma (FAST) scan can be effectively taught to inexperienced medical students with significant success.[10] Although the benefit of including ultrasound education in the medical school curriculum has been well established, there

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has been limited research as to the most effective time to teach POCUS during medical students' training.[11] There have been various curriculum models proposed; however, the various cost and benefits of these differing models have not fully been assessed.[12] Furthermore, the model of peer-to-peer teaching has not been fully evaluated.

In Switzerland, medical education follows the European model and lasts 6 years, focusing on preclinical training during the first 2 years, and focusing on clinical training thereafter. Currently, medical education in Switzerland is devoid of any ultrasound training despite recommendations by the European Federation of Societies for Ultrasound in Medicine and Biology.[13] This environment allows comparing ultrasound education between Swiss medical students given ultrasound training in the early clinical training period (year 3/4) as compared to during the late clinical training period (year 5/6). The aim of this study is to determine if 1st-year American medical students with minimal ultrasound training can teach ultrasound to medical students in Switzerland at varying times during their clinical training. A secondary objective is to determine if the level of training plays a role in their ability to comprehend and apply basic POCUS skills.

## Methods

### Study design

We performed an observational study utilizing a convenience sample of volunteer Swiss medical students between July 11, 2016 and August 6, 2016. All students provided written consent for the study. No financial compensation was provided for participation. The study was approved by the site Institutional Review Board. The study took place at the University of Basel Medical School at the hospital's training site.

### Study protocol

We recruited five American-trained 1st-year medical students who consented for study enrollment. All students had completed an entire 1st year of medical education which included human physiology, human anatomy, and basic ultrasound. Before initiation of study enrollment, each student needed to demonstrate the ability to obtain the four required cardiac views including parasternal long-axis view, parasternal short-axis view, apical four-chamber view, and subxiphoid view. Students were required to pass a certification exam given by the institution's POCUS director. Students also needed to be able to identify anatomy for the remainder of the FAST scan including the hepatorenal recess, splenorenal recess, and bladder views.[14] We asked these instructors to demonstrate an ability to identify all important structures of the FAST scan to be considered qualified to teach POCUS. We performed both instruction and image acquisition using four SonoSite NanoMaxx (SonoSite Inc, Bothell WA) ultrasound machines. Each ultrasound machine was equipped with a phased array probe operating at a frequency of 1–5 MHz.

### Intervention

We gave Swiss medical students at various levels of training the opportunity to voluntarily enroll in the study as an elective learning course in addition to their curriculum. All Swiss medical students were offered the opportunity to enroll in the study through an e-mail to the entire student body. The students were separated into two groups. The first group consisted of 3rd and 4th-year Swiss medical students. These students had completed basic science courses as well as basic anatomy but had minimal clinical exposure. The second group of students included 5th- and 6th-year medical students. These students had completed all basic science requirements and were involved in clinical elective rotations. All students in this category had completed internal medicine, general surgery, pediatrics, and emergency medicine.

Students who enrolled in the study were required to take part in a 2-day ultrasound training workshop. We held a total of four ultrasound training sessions. Each training session began with a written pretest, which was then followed by a 1-hr classroom lecture, designed to prepare the students for their hands-on training sessions. A board-certified Swiss Emergency Physician with ultrasound training was present to ensure the accuracy of training and answer any questions. For the hands-on training, we divided the students into groups of four and completed a hands-on pre-test to obtain all components of a FAST examination with a 5-min time limit each.

### Ultrasound curriculum

The initial training session began with a 30-min instructional lecture on ultrasound technical handling (termed "knobology"). Next, students underwent a 60-min instructional lecture on the FAST examination, basic cardiac anatomy. Examples of normal anatomy and pathology were shown in leach lecture. Following didactic instructions, all participants practiced hands-on FAST ultrasound techniques under the direct supervision of one of the medical student instructors for 90-min duration. Instruction began with hepatorenal views followed by splenorenal, cardiac, and bladder views. The remainder of the instructional time was spent practicing POCUS techniques which included image acquisition and image optimization. Techniques included modifications in gain, depth, and image quality. Following instruction, the final hour and a half of the 2-day workshop were spent performing both a written and hands-on posttest. All scans were performed on healthy volunteers. All students were given the same written assessment of general ultrasound use and instructed to perform a practical hands-on demonstration of FAST and cardiac ultrasound examinations before and after the teaching session. Assessment was made in real time, and the students' scores were recorded on standardized data collection sheets. Images were saved on the portable ultrasound machines, and image accuracy was confirmed by the blinded board-certified Swiss Emergency Physician with ultrasound training. Competency was defined as scoring >70% on the examinations.

### Data collection and statistics

All POCUS images and videos were recorded to evaluate the students' ultrasound skills. These images were then reviewed and graded based on appropriate probe selection, orientation, image quality, and accuracy of image interpretation. After grading images and compiling scores, images and videos were erased. Researchers stratified the data from the pre- and post-tests based on the years of medical training (Group 1: students in years 3 and 4; Group 2: students in year 5 and 6). Researchers used this information to determine the averages for the pre- and post-test scores of the groups to determine the effectiveness of the workshop. The improvement in mean written and practical examination scores was analyzed with a two-tailed *t*-test for comparison of pre- and post-clinical year students using a $P = 0.025$ to determine significance. The posttest means of all the groups were then compared to determine which group was able to most effectively learn from the workshop. A one-way ANOVA test was used for this portion of the analysis, using a $P = 0.05$ to determine significance. To determine the students' scores during the pre- and post-test assessments, a scoring rubric was used to quantify performance. The scoring rubric is shown in Figures 1 and 2.

## Results

A total of 100 Swiss medical students were enrolled in the study. 59 of these students were Group 1 (year 3/4), and 41 students were in Group 2 (year 5/6) [Table 1]. A two-tailed *t*-test was performed and demonstrated that the late clinical students (year 5/6) performed marginally better than the early clinical students (year 3/4) on the written assessment both before and after the teaching sessions ($P < 0.025$). This was the only significant difference found in between the groups at any point in the study. Maximum score for the written test was 15.

For the hands-on practical assessment of the cardiac and FAST bedside examination, both early and late clinical groups did not show significant differences in performances before or after the teaching session [Table 2]. After the teaching session, the late clinical students scored an average of 11.74 points

**Table 1: Illustration of written test before 2-day point of care ultrasound course and after 2-day point of care ultrasound course for early and late clinical Swiss students**

| | Subjects | Written test | |
|---|---|---|---|
| | | Preteaching average | Postteaching average |
| Late clinical | 41 | 11.09 | 13.68 |
| Early clinical | 59 | 9.07 | 12.59 |
| *P* | | 0.00014 | 0.00032 |

Maximum score is 15

Student ID: _____ Date: _____

**University of California, Irvine**

**School of Medicine**

Evaluating Effectiveness of Teaching Methods and Timing in Ultrasound Education at the University of Basel School of Medicine

**Practical Exam: Cardiac Ultrasound**

**Each item in the numbered checklist is worth 1 point.**

**Step 0: Choose the correct probe.**

**Parasternal Long**

- 1. Identify Right Ventricle
- 2. Identify Left Ventricle
- 3. Identify Mitral Valve
- 4. Identify Aortic Valve
- 5. Identify Interventricular Septum

**Parasternal Short**

- 6. Identify Aortic Valve
- 7. Identify Mitral Valve
- 8. Identify Papillary Muscles/Chordae Tendinae

**Subxiphoid**

- 9. Identify 4 chambers of heart and apex.
- 10. Identify pericardium.
- 11. Point out where fluid would be if pericardial effusion.

**Apical 4 Chamber**

- 12. Identify 4 Chambers
- 13. Identify Pericardium

Student Score: _____/ 13___

**Figure 1:** Practical examination: Cardiac ultrasound

**Table 2: Illustration of cardiac and focused assessment with sonography in trauma ultrasound skills before and after 2 day point of care ultrasound course**

| Year | Subjects | Cardiac skills | | FAST skills | |
|---|---|---|---|---|---|
| | | Preteaching | Postteaching | Preteaching | Postteaching |
| Late clinical | 41 | 0.5 | 11.74 | 1.62 | 9.5 |
| Early clinical | 59 | 0.98 | 11.19 | 1.07 | 9.09 |
| *P* | | 0.056 | 0.2 | 0.08 | 0.1 |

Please note that maximum score is 13 for cardiac ultrasound and 14 for FAST ultrasound. FAST: Focused assessment with sonography in trauma

Student ID: _____ Date: _____

**University of California, Irvine**

**School of Medicine**

Evaluating Effectiveness of Teaching Methods and Timing in Ultrasound Education at the University of Basel School of Medicine

**Practical Exam: FAST Ultrasound**

**Each item in the numbered checklist is worth 1 point.**

**Step 0: Choose the correct probe.**

**Right Upper Quadrant:**

- 1. Identify Liver
- 2. Identify Diaphragm.
- 3. Point out mirror image artifact
- 4. Identify right kidney
- 5. Identify Morrison's pouch/border between liver and kidney.

**Cardiac (Subxiphoid View):**

- 6. Identify 4 chambers of heart and apex.
- 7. Identify pericardium.
- 8. Point out where fluid would be if pericardial effusion.

**Left Upper Quadrant:**

- 9. Identify spleen.
- 10. Identify left kidney.
- 11. Point out where fluid would be if hemoperitoneum.

**Suprapubic (Sagittal/Transverse Views):**

- 12. Identify bladder in sagittal view.
- 13. Point out where potential free fluid would be in sagittal view.
- 14. Repeat steps 12 and 13 in transverse view.

Student Score: _____/ 14___

**Figure 2:** Practical examination: Focused assessment with sonography in trauma ultrasound

(out of a maximum 13) for the cardiac examination and 9.5 (out of a maximum 14) points for the FAST examination. The early clinical students averaged 11.19 points for the cardiac examination and 9.09 points for the FAST examination after the teaching session. While both groups individually improved significantly from their presession baseline scores, the final scores were exceedingly similar.

## Discussion

The main findings of our study were that POCUS can be taught to medical students in a peer to peer fashion and that there is no difference in knowledge acquisition between early clinical students and late clinical students. The study evaluated a large sample size of Swiss medical students with no prior formal education with English competency trained by American 1st-year medical students. While it may seem that later clinical students would perform better in the practical assessment of FAST and cardiac bedside ultrasound, we were unable to determine any significant difference between the performance of students in early or late clinical training. Both groups improved significantly, however.

Ultimately, both groups scored well enough to indicate competency in the FAST and cardiac ultrasound examinations (Group 1: FAST = 9.09/14, cardiac = 11.19/13; Group 2: FAST = 9.5/14, cardiac = 11.74/13). This suggests that students in their early clinical training can effectively learn FAST and cardiac bedside POCUS as effectively as their counterparts in late clinical training, indicating that ultrasound can be incorporated into medical education at whichever time is most convenient for each school's curriculum. Their similar increases in pre- to post-test score indicate that they acquired a comparable amount of knowledge over the 2-day workshop, and the similarity of their final scores indicate that both groups were equally able to achieve a high level of competency of the scans.

In the written assessment, we found that students in late clinical training outperformed students in the early clinical years in both the pre-and post-tests. We attributed this finding to the higher probability that students with late clinical training have additional medical education and clinical experience which gives them a larger base of knowledge to draw on for the written test, which was multiple choice. That being said, a written test is not as good an indicator of ultrasound ability as a practical one, but has the advantage of a knowledge focus.

This apparent equality in ability of early and late clinical Swiss medical students to learn POCUS could be very useful for determining at which time point to incorporate ultrasound education into American medical school curricula. The value of integrating ultrasound POCUS into undergraduate medical education is being increasingly recognized, and given the need for national guidelines in American ultrasound education, this study aims to determine when would be the most effective time to learn POCUS.[5,6,15-17] While there are some studies that illustrate the use of peer-to-peer educational programs in medical school, there are relatively few studies on medical students teaching ultrasound to other medical students.[18,19] Further investigation is needed into this concept. Potential future studies could include an assessment of long-term retention of the skills and knowledge obtained, to find differences between students of different levels of experience. If there is a difference, the most appropriate time point to start ultrasound education could better further characterized.

### Limitations

This study has several limitations. First, there are many differences in curriculum models between Swiss and American medical schools. Swiss medical school contains pre-clinical years, then early and late medical, educational

years. Thus, this difference may affect the performance of Swiss preclinical students and make these conclusions less generalizable to American preclinical students. This model has appeared to be effective with Swiss medical students. It is unclear if similar results would be achieved in other European countries. In addition, it is unclear if there would have been better knowledge acquisition if expert sonographers were used to each ultrasound. Long-term knowledge was not formally tested in this study. Additional studies must be performed to determine the minimum amount of training required to be an instructor and the retention rate of ultrasound knowledge.

## Conclusion

Our data suggest that Swiss medical students can learn and perform cardiac and FAST ultrasound after a 2-day instructional course taught by trained 1st-year American medical students. In addition, no difference was found between students in their early clinical training and late clinical training for the ability to perform and to interpret FAST and cardiac POCUS.

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### Conflicts of interest

There are no conflicts of interest.

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