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Original Article

Development of the ultrasonography learning model for undergraduate medical students: A case study of the Faculty of Medicine, Burapha University

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Abstract

Background: Ultrasound technology is generally considered to be reliable and widely used by physicians today. Therefore, given the efficacy and popularity of the technology, the need for quality ultrasound education is evident. Ultrasound training for undergraduate medical students has been increasingly incorporated into school curriculums, but the teaching methods can vary significantly among medical schools. Among many different choices, one effective teaching model was proposed which added hands-on ultrasound experience on live patients that was supervised by radiologists in the last clinical year.

Methods: A 2-week radiology elective course was offered for 6th-year medical students at Burapha University Hospital, Chonburi, Thailand in the academic year 2014. Fourteen medical students participated in the elective course. Additionally, students who chose radiology as their elective were provided an ultrasound experience on live patients in real-life clinical settings. All 6th-year medical students then completed a 25-ultrasound image quiz, and completed a questionnaire at the end of the academic year. The ultrasound test scores were compared between the elective and nonelective students. The students' background characteristics were determined by a grade point average and the ultrasound experience was determined by the number of scans. These were collected, and analyzed to establish their relationship with the ultrasound test scores. The students' opinions were also surveyed.

Results: Fourteen medical students participated in the elective course. The ultrasound test scores in the elective group were significantly higher than those in the nonelective group ($p = 0.013$). The students' background characteristics and ultrasound experience had no significant relationship with the ultrasound test scores.

Conclusion: By adding hands-on ultrasound experience using live patients proctored by radiologists for final year medical students, in the space of 2 weeks, an effective ultrasound learning model for undergraduate medical students can be provided. This model should be considered in the curricular design.

Keywords: education; medical students; ultrasound background

1. Introduction

Ultrasound (US) technology has been rapidly developed insofar now that it generally produces good image quality and a user-friendly modality. Presently, it is a diagnostic mainstay among many physicians, and the utilization of US by

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physicians other than radiologists for specific purposes is called focused US or point-of-care US (PoCUS). Focused Assessment with Sonography for Trauma (FAST) performed by a surgeon has proven to have a high level of accuracy[1] and has been incorporated into the Advanced Trauma Life Support (ATLS) course for doctors.[2] Due to the many advantages of US, the American Academy of Emergency Medicine has a policy statement that ultrasound should be integrated into the core curriculum of undergraduate medical education.[3] Sixty-two percent of medical schools in the United States have already incorporated US education into the medical school curriculum.[4] Unfortunately, approximately one-fourth of interns reported that they never performed bedside US during their medical school education.[5] In Thailand, US education has been incorporated into the medical curriculum since 2012.[6] There are a number of articles examining various models of US education for medical students,[7–9] but there has been no consensus to date as to where and how it should be optimally integrated into the curriculum. In 2014, an article from the United States proposed a national ultrasound curriculum for medical students and suggested that a US curriculum be incorporated both vertically and horizontally.[10]

In our country, undergraduate medical school is divided into 3 preclinical years and 3 clinical years. Radiology is included in the undergraduate program of all medical schools, mostly in the clinical years, either the 4th year or the 5th year, depending on the institution. The medical school at Burapha University has been open since 1984, and is located in an urban area of Eastern Thailand, enrolling 32 students per year. The radiology curriculum is taught by radiologists in the 4th year, and US is a part of the standard radiology course subject matter. The US session includes 30 minutes of lectures on US knobology, US scan technique and examples of US images, and a 1-hour hands-on opportunity to practice US scanning skills by using their classroom colleagues as models under the supervision of radiology staff. Following the radiology curriculum, the students might have US exposure in informal training proctored by interns or emergency staff during their clinical rotations.

This study aimed to: (1) test the ultrasonography learning model that is incorporated into the 6th-year medical curriculum; (2) assess the factors that impact US knowledge; and (3) draw out the students' opinions regarding US training.

2. Methods

2.1. Study design

We used a retrospective cohort design to test our hypothesis that the US test scores taken by 6th-year medical students who participated in a 2-week radiology elective were not statistically different, compared with those students who had not taken the elective. A questionnaire was used to survey the demographic variables, US experience, and opinions regarding US education. This study was approved by our Institutional Review Board of Ethics Committee, No. 32/2558, and informed consent was verbally obtained from each participant.

2.2. Setting

The study was conducted at the university-based hospital, where annually ~ 2000 US examinations are performed. During the 2014 academic year, a 2-week radiology elective was offered to the 6th-year medical students. The students who participated in this course received hands-on US experience with patients in a clinical setting at the radiology department, which was proctored by radiology staff. A Toshiba Aplio, XG SSA-790A, US machine (Toshiba, Osaka, Japan) equipped with a 7–12 MHz linear-array transducer and a 3–7 MHz curvilinear transducer was used for all scanning. However, the number of US examinations conducted was by chance, and according to routine patient treatment requirements in the department.

2.3. Testing

The course was concluded with an US quiz that tested the image interpretation ability of each student, followed by a questionnaire at the end of the academic year. The quiz consisted of 25 US images of true negative, true positive, and nondiagnostic images. There were seven normal US anatomy views (Morison's pouch, GB, spleen, bladder, aorta, lung, and subxiphoid view of the heart), four FAST scan views of fluid (Morison's pouch, perisplenic space, cul-de-sac, and pericardial effusion), four abnormal right upper quadrant US images (acute cholecystitis, CBD dilatation, hydronephrosis, and renal stone), two left and right lung base views for pleural effusion, two abnormal bowel images (hypertrophic pyloric stenosis, and acute appendicitis), one abdominal aortic aneurysm, one thyroid nodule, one breast nodule and three nondiagnostic images. An example of an US image and question is shown in Fig. 1.

Additionally, student opinions regarding the US training were surveyed using a tailored questionnaire. A 5-point Likert scale (1 = strongly disagree, and 5 = strongly agree) was used to assess the students' opinions. We also collected information regarding the US experience and competency for each student

Fig. 1. Example of ultrasound question.
* Question 1: Quality of this image, Answer: Interpretable, nondiagnostic.
* Question 2: Tell the anatomic landmark, Answer: .....
* Question 3: Interpret .....

as determined by the number of US scans conducted, coupled with the students' performance background as determined by grade point average (GPA).

2.4. Statistical analysis

The outcomes of the US test scores were reported using the mean and standard deviation (SD) of the groups. Independent *t* test was used to compare the US test scores between the elective and nonelective groups. The association between the number of US scans (≤ 10 and > 10) and the US test scores (< 39 and ≥ 39) was assessed using Chi-square calculation. The relationship between the students' background characteristics, measured in terms of GPA and the US test scores, was determined by Pearson's correlation. A p value < 0.05 was assumed to be significant. The students' opinions were reported as the percentage of students' agreeing or disagreeing. The data were analyzed by use of SPSS version 17 (SPSS Inc., Chicago, IL, USA).

3. Results

At the end of the academic year, all of the students completed an US quiz and a questionnaire. A total of 14 6th-year medical students voluntary participated in a 2-week elective radiology course, discretely divided into one to three students per rotation. The overall mean score was 39.3, with a standard deviation (SD) of 9.1. The mean elective student US test score was significantly higher than the mean nonelective student score ($p < 0.05$), as shown in Table 1. The students were classified into two groups, above and below mean score, to explore the significance of US experience, which was ascertained by the number of US scans conducted. It was shown that the number of US scans has no statistically significant effect on the US test score, as demonstrated in Table 2. Furthermore, there was no difference in US test scores between students with a high performance background compared with low performance backgrounds ($r = 0.184$, $p = 0.313$), according to their GPA.

Answers provided by students on the questionnaire showed that: (1) 97% of students strongly agreed or agreed that US training enhanced their medical education; (2) 97% of students strongly agreed or agreed that US scans on positive patients were significant; (3) 94% (31/33) of students were of the opinion that US education should start during the clinical year, and just two students believed that it should start during the internship at the postgraduate level; (4) 100% of elective students strongly agreed or agreed that US training taught by radiology department was better than the other departments; and (5) 100% of elective students have used US more frequently in their practices after they finished the elective radiology course.

Table 1
Mean US test scores between elective students and nonelective students.

	Mean score	SD	*p*
Elective students	43.7	7.7	0.013*
Nonelective students	35.8	8.8	

SD = standard deviation; US = ultrasound; * = statistical significance.

Table 2
Correlation between number of cases and US test score.

	$n = 32$	US test score		*p*
		< 39 ($n = 13$)	≥ 39 ($n = 19$)	
Cases ≤ 10	22 (68.8)	7 (53.8)	15 (78.9)	0.132
Cases > 10	10 (31.3)	6 (46.2)	4 (21.1)	

Data are presented as *n* (%).
US = ultrasound.

4. Discussion

Our US teaching model is to add hands-on US experience using live patients proctored by radiology staff in the last undergraduate year. In only 2-weeks of training, radiology elective students show significantly higher US test scores than nonelective students, regardless of their background performances or previous US experience. This study suggests that the training had substantial impact on US knowledge independent of background which is further supported by an article indicating there is no significant difference between the posttest scores of medical students and emergency medicine residents after a standardized bedside US curriculum.[11] In addition, another article reported that the majority of the 3rd-year and 5th-year medical students without prior US experience could complete a full FAST scan displaying an adequate level of performance in under 6 minutes after 5 hours of training.[8] However, there are several models of US education for medical students that have been reported.[11–13] Some studies provided US education in preclinical years and yielded a high level of student performance.[14] Several other studies incorporated US into the clinical years,[7,9,15] whereas other studies incorporated US education vertically during both the preclinical and clinical years.[12,16] In our opinion, practical US training on live patients in the last clinical year match to the year-group skill sets, and students have demonstrated a rapid proficiency in learning US skills. The length of US training varied in the literature; Mandavia et al[17] suggested a 16-hour course as an introductory foundation, whereas Blackstock et al[11] presented a 3-hour hands-on training session, and Gogalniceanu et al[8] used a 5-hour course which included a 2-hour hands-on session.

The suitable number of proctored US examinations necessary to give students sufficient US skills remains subject to debate. However, most of the literature involves postgraduate training[18–22] with very few articles focusing on US education at the undergraduate level. An article from Spain which included a small number of medical students reported that 12 medical students who received a 15-hour training program with supervised practice in 20 patients correctly identified abdominal views with > 90% accuracy.[23] However, their study did not include any comparison group. Our study demonstrated that the number of US examinations has no significant

effect on the US test score. Though in our study, we only tested image interpretation skill, and the number of positive patients was not collected separately. In the future, studies that include image acquisition, interpretation skills, and the number of positive patients may show a different outcome.

Some studies used an US simulator as a teaching model.[9,24] Parks et al[9] demonstrated that medical students without previous formal US training achieved a degree of competency in simulated PoCUS after a short training period using a PoCUS simulator. However, an US simulator allows students unrestricted access to practice their US skills. However, the cost to obtain such a US simulator is expensive in our country, and therefore not available in our hospital. In addition, the proficient use of US in a real-life clinical setting is more difficult than in a simulated setting. We believe that proctored US in a positive patient is important. This is in accordance with our survey, which showed that most of our students strongly agreed that US scans on positive patients were significant.

Long-term retention of knowledge and competency is also an important factor. Noble et al[25] reported that proctored US training significantly improved knowledge and higher knowledge retention 6 months after the exam was completed, and 10 months, according to another article.[17] To track image accuracy over time, an ultrasound digital portfolio may be useful to document the student's US longitudinal experience.[24]

Most of the respondents provided positive opinions regarding US education, and all of the radiology elective students had used US more frequently after they finished the elective radiology course. This may have an impact on the improvement of patient care. Almost all of our students agreed that US training should begin in medical school in accordance with other studies.[5,26]

Our study had several limitations. As we all know, US competency comprises two parts, which includes image acquisition and image interpretation. However, we did not evaluate the acquisition skills. In this study, only image recognition and diagnostic ability were assessed. Although the results that were obtained are convincing, further study with a more complete quality assessment are suggested for future study. All participants were volunteers that enrolled in the radiology elective course. There was selection bias, but it would have been difficult to avoid. We used clinical scanning in the radiology department as a teaching model, and therefore the number and variability of US cases could not be controlled. Thus, the extent of US knowledge obtained by each student was different. Therefore, the use of more standardized patients will help to improve the accuracy of the measured outcomes. Our study was conducted in a university using a small number of students as study participants. Consequently, our experience with this model may not be generalized to other universities with larger groups of students, which requires more instructors and equipment. However, Article 1 in the literature suggested training senior medical students as peer instructors for a combined ultrasound/physical exam curriculum.[27]

In conclusion, it has been shown that US can be an effective and valuable tool for physicians. In the past, undergraduate level US training as part of a medical education has been proven useful. Direct hands-on US experience on positive live patients is a valuable part of a student's medical education. Currently, there is no consensus regarding formal US training at the medical student level, and this study presents an effective model of US training during the last clinical year. US education for undergraduate students should be promoted. However, adequate equipment and sufficient staffing are necessary to more successfully integrate formal US teaching into an undergraduate curriculum.

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