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A general Critical Care Ultrasonography workshop: results of a novel Web-based learning program combined with simulation-based hands-on training☆,☆☆

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Abstract

Purpose: The aim of this study was to facilitate attainment of Critical Care Ultrasonography (CCUS) competence.

Materials and Methods: We developed a Web-based learning program followed by simulation-based hands-on training in noncardiac CCUS for novice learners. We administered knowledge and skills tests before and after the workshop and conducted surveys on confidence levels using a 10-point Likert scale. Knowledge tests were conducted online, and skills tests were video-captured for evaluation.

Results: Sixteen physicians participated in a 4-hour combined vascular and thoracic CCUS workshop, and 23 in a 2-hour abdominal CCUS workshop. In the combined vascular and thoracic workshop, the mean (SD) pre-workshop and post-workshop knowledge scores were 24 (4) and 33 (5), respectively, out of 43 ($P < .001$). The pre-workshop and post-workshop skill scores were 15 (5) and 23 (2), out of 28 ($P < .001$). In the abdominal workshop, the pre-workshop and post-workshop knowledge scores were 11 (3) and 18 (2), out of 20 ($P < .001$). The pre-workshop and post-workshop skill scores were 6 (3) and 15 (2), out of 16 ($P < .001$). Learners' confidence increased significantly in both workshops ($P < .001$).

Conclusions: Our novel hybrid educational workshop on general CCUS significantly improved knowledge, skills, and confidence levels. Our flexibly scheduled module can be a practical option for the busy intensivist.

1. Introduction

Critical care ultrasonography (CCUS) has evolved into a valuable adjunct to the clinical examination. Several reports demonstrate the usefulness of CCUS in making accurate clinical diagnoses and changing the patient care plan [1-5]. The growing opinion in the critical care community is that

Abbreviations: ACCP, American College of Chest Physicians; CCUS, critical care ultrasonography; FAST, focused abdominal sonography for trauma; ICU, intensive care unit; SRLF, Société de Réanimation de Langue Française.

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intensive care unit (ICU) practitioners should routinely perform and interpret CCUS at the bedside as a physical examination tool. The American College of Chest Physicians (ACCP) and La Société de Réanimation de Langue Française (SRLF) recently published a competency statement on CCUS [6]. An international experts statement has proposed that general CCUS be mandatory in the curriculum of ICU physicians [7]. Several studies on physician education in CCUS have demonstrated that physicians can successfully perform and interpret CCUS after a short, structured training program [8-11]. However, barriers still exist to the development of standardized CCUS curricula, mainly because of inflexible trainee and practicing physician schedules, lack of proficient faculty, and the length of training necessary to reach mastery and ensure patient safety [12,13]. Previous reports have suggested the potential integration of simulation-based education and video-based or Web-based learning into ultrasonography education for overcoming these barriers [12,14]. However, evidence for the effectiveness of a multimedia approach in CCUS has been scarce, except in ultrasound-guided central line insertion [15-19].

We created a novel educational workshop targeted to novice learners of CCUS consisting of a Web-based learning program followed by hands-on training with standardized patients and mannequins in a simulation center. We hypothesized that our multimedia approach would allow busy ICU practitioners to acquire and improve their knowledge and examination skills for noncardiac general CCUS (vascular, thoracic, and abdominal CCUS) in an efficient manner. We measured participants' knowledge, technical skill, and confidence level before and after the workshop to determine the efficacy of our workshop.

2. Methods

The study was conducted in an academic teaching hospital, Mayo Clinic in Rochester, Minnesota, during the academic year 2009 to 2010 . The Mayo Clinic Institutional Review Board approved the study (Study ID 09-004867). We developed a novel, multimedia, simulation-based workshop on noncardiac general CCUS for novice learners. The workshop was divided into 2 separate sessions: the first included vascular and thoracic CCUS training, and the second included abdominal CCUS training. During these workshops, learners were encouraged to use CCUS as a screening tool to enhance their physical examination but never as a definite diagnostic modality. Suspicious findings required confirmation by trained specialists.

2.1. Vascular and thoracic CCUS workshop

For the combined vascular and thoracic CCUS workshop, participants were first asked to take a Web-based pre-workshop knowledge test consisting of 43 multiple-choice questions on basic CCUS background and image interpretation. They were also asked to complete a survey regarding their previous clinical experience with CCUS. After the knowledge test, a series of four 30-minute Web-based didactic lectures (2 hours total) was provided to the participants, who were allowed to review the lectures as many times as they wished. Lectures covered the topics outlined in the recent ACCP/SRLF statement [6], including but not limited to ultrasound physics; use of the instrument; ultrasound-guided central line insertion, detection of deep vein thrombosis, and thoracic examination of pleura, lung parenchyma, diaphragm, and pleural effusion (Appendix 1: Sample lecture). Lectures also included video demonstrations and examples of normal and abnormal CCUS images. These educational materials were created and uploaded to the Mayo Clinic Intranet with the support of our institution's simulation center and the media support service.

Participants were scheduled to undergo a hands-on training session in our multidisciplinary simulation center 1 week after they were granted access to the Web-based lectures. Immediately before the actual training, participants had a 15-minute interactive class with instructors, followed by a pre-workshop skills test. During the scenario-based skills test, the participants were given 4 tasks to complete (Appendix 2), each within 5 minutes. The skills testing was video-captured for later evaluation and scoring by 2 independent reviewers blinded to the examinee's experience and pre-workshop and post-workshop status. The skill scores were calculated on the basis of a 28-item predetermined checklist (Appendix 2). The checklist included items for evaluating the trainees' performance and adequacy of the ultrasound images obtained.

After the pre-workshop skills test, a 1-hour training session on vascular examination in standardized patients and mannequins was conducted at 2 stations. Thoracic examination training was similarly conducted. To maximize the participants' hands-on experience, the trainee-to-instructor ratio was 2:1. Each station had a specific training objective, and participants rotated among the 4 stations every 30 minutes (Fig. 1A). The 4 different stations focused on (1) visualization of the central veins and peripheral arteries; techniques to locate and cannulate the vessels were reviewed using a simulator mannequin (Blue Phantom, Redmond, WA); (2) Scanning of the lower extremity venous system; (3) thoracic ultrasonography of the anterior and lateral chest; and (4) examination of the diaphragm and detection of pleural effusion. A portable ultrasound machine (MicroMaxx; SonoSite, Inc, Bothell, WA) with appropriate transducers (HFL 38, L25e, C60e, and P17) was used at each station. Examples of normal and abnormal images were reviewed during the session, depending on the educational needs of the trainees.

After the hands-on training, a short debriefing and interactive discussion was held. The participants received additional feedback regarding their performance on machine