Development and Evaluation of Methodologies for Teaching Focused Cardiac Ultrasound Skills to Medical Students

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Background: Handheld ultrasound is emerging as an important tool for point-of-care cardiac assessment. Although cardiac ultrasound skills are traditionally introduced during postgraduate training, the optimal time and methodology to initiate training in focused cardiac ultrasound (FCU) are unknown. The objective of this study was to develop and evaluate a novel curriculum for training medical students in the use of FCU.

Methods: The study was conducted in two phases. In the first phase, 12 first-year medical students underwent FCU training over an 8-week period. In the second phase, 45 third-year medical students were randomized to one of three educational programs. Program 1 consisted of a lecture-based approach with scan training by a sonographer. Program 2 coupled electronic education modules with sonographer scan training. Program 3 was fully self-directed, combining electronic modules with scan training on a high-fidelity ultrasound simulator. Image interpretation skills and scanning technique were evaluated after each program.

Results: First-year medical students were able to modestly improve interpretation ability and acquire limited scanning skills. Third-year medical students exhibited similar improvement in mean examination score for image interpretation whether a lecture-based program or electronic modules was used. Students in the self-directed group using an ultrasound simulator had significantly lower mean quality scores than students taught by sonographers.

Conclusions: Third-year medical students were able to acquire FCU image acquisition and interpretation skills after a novel training program. Self-directed electronic modules are effective for teaching introductory FCU interpretation skills, while expert-guided training is important for developing scanning technique. (J Am Soc Echocardiogr 2014;27:302-9.)

Keywords: Handheld ultrasound, Medical education, Electronic learning, Simulation

Recent developments in ultrasound technology have enabled point-of-care cardiac assessment of patients using portable, handheld ultrasound (HHU) units. The American Society of Echocardiography (ASE) has recognized that these devices are capable of performing focused cardiac ultrasound (FCU) assessments as an adjunct to the physical examination. The ASE has also noted that comprehensive echocardiographic examination requires image acquisition by trained sonographers and image interpretation by skilled echocardiographers.[1] Although the opportunity for widespread use of HHU exists, the appropriate clinical applications of FCU are yet to be clearly defined.

The potential clinical utility of FCU has been well established.[2-8] However, no studies have attempted to elucidate the optimal timing and methodology to educate trainees in the use of FCU. Current research has focused on the application of FCU in clinical settings; published training programs have not been well validated. Several international bodies have recognized the need to train nonexpert imagers; however, a consensus does not exist regarding the most appropriate timing and method of training.[1,9,10] Considering that this technology is available for use in a broad range of settings, a lack of standardized training is concerning.

The majority of studies examining FCU have focused exclusively on the proficiency of attending staff members and postgraduate trainees. There has been comparatively little research focusing on introduction of FCU training during undergraduate medical education. Because medical school is the stage at which fundamental clinical examination skills are introduced, training in FCU may be most effective during this period. Considering the increasing prevalence of

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Abbreviations

A5C = Apical five-chamber

ASE = American Society of Echocardiography

A2C = Apical two-chamber

FCU = Focused cardiac ultrasound

HHU = Handheld ultrasound

LV = Left ventricular

PLX = Parasternal long-axis

PSX = Parasternal short-axis

ultrasound use, competence in sonographic examination may become a core competency required of graduating medical students.

The objective of this study was to develop and evaluate three novel curricula for training medical students in the acquisition and interpretation of FCU. The educational programs were designed to provide students with a basic skill set for the assessment of cardiac patients using an eight-view FCU protocol. The study was conducted in two phases to (1) assess the time at which the introduction of FCU skills would be appropriate and (2) assess the optimal methodology (didactic teaching, electronic modules, or simulation training) to deliver this fundamental knowledge.

METHODS

The study was conducted in two phases. The first phase was designed to establish the feasibility of first-year medical students to acquire FCU interpretation and image acquisition skills. The second phase was conducted in a larger cohort of third-year medical students and investigated different methods of delivering knowledge and skills, including electronic and simulation-based modules. The Queen's University Research Ethics Board approved the study protocols, and written consent was obtained from all participants.

Phase 1

Study Population. Twelve medical students from the Queen's University School of Medicine were recruited to participate in this project during the summer break after their first year of medical education. Students had not completed their core training in cardiology. Exclusion criteria included any preexisting ultrasound or echocardiography experience. No students met these criteria, thus none were excluded. This study was extracurricular, and no compensation, monetary or academic credit, was provided for participation.

HHU Device. The Vscan device (GE Healthcare, Horton, Norway) used in this study consists of a display unit and a broad-bandwidth, phased-array probe (total weight, 390 g). It provides two-dimensional imaging and conventional color flow echocardiographic images. It has limited controls for adjusting image depth and gain. Electronic calipers and a touchpad enable the user to make distance and area measurements. All images can be frozen and scrolled for review, but there is no electrocardiographic gating. Images may be saved in still or video format.

Cardiac Pathologies. Five cardiac pathologies were examined: left ventricular (LV) systolic dysfunction, LV hypertrophy, aortic valve dysfunction (regurgitation and stenosis), mitral valve dysfunction (regurgitation and stenosis), and pericardial effusion (Table 1). The cardiac pathologies were selected on the basis of consensus by three ASE level III echocardiographers at our institution. All FCU images provided to students for assessment depicted abnormalities rated as moderate or severe by ASE level III echocardiographers; this level of pathology was considered representative of clinically relevant abnormalities. Students were not expected to grade pathologies on the basis of severity; assessment of images was based exclusively on identification of the presence of a moderate or severe abnormality.

Table 1 Cardiac pathologies that medical students were taught to recognize and identify

Pathology	Interpretation Method
Aortic valve dysfunction (moderate to severe regurgitation or stenosis)	Abnormal leaflet thickening, mobility Conventional color flow with visual assessment
Mitral valve dysfunction (moderate to severe regurgitation or stenosis)	Conventional color flow with visual assessment
LV hypertrophy (moderate to severe)	Qualitative analysis on the basis of visual estimate of wall thickness
LV systolic dysfunction (moderate to severe)	Visual estimate of LV systolic contractility
Pericardial effusion (moderate to severe)	Visual estimate of pericardial space for presence/absence of effusion

Preintervention Evaluation. Participants underwent an evaluation of FCU interpretation knowledge before commencing the educational intervention. This evaluation consisted of 15 online case-based multiple-choice questions. Each question consisted of a one-line clinical vignette and a video showing an FCU assessment. Participants were then asked to identify the presence of major cardiac pathology if any was present. Three examples of each of the five cardiac pathologies were presented.

Educational Intervention. The educational intervention was created in consultation with National Board of Echocardiography, ASE level III, and FASE certified echocardiographers and American Registry for Diagnostic Medical Sonography certified sonographers. The program was designed to instruct the participants in image acquisition and interpretation of focused cardiac imaging using HHU units.

The educational intervention included instruction in image acquisition using a focused protocol consisting of seven specific views: apical two-chamber (A2C), apical four-chamber, apical five-chamber (A5C), parasternal long-axis (PLX), and parasternal short-axis (PSX) with cuts at the aortic valve, mitral valve, and midchamber left ventricle (PSX-LV). The intervention occurred over an 8-week period with a 2-hour session each week. Each 2-hour session was divided into a didactic and a practical component. The eight didactic lectures focused on instruction surrounding general cardiac anatomy, general cardiac ultrasound, device use, and the five pathologies described in Table 1. All lectures were delivered by ASE level III echocardiographers.

Six 1-hour practical instructional sessions focused on FCU scanning technique. Practical sessions were taught by both ASE level III echocardiographers and American Registry for Diagnostic Medical Sonography certified sonographers. Participants were instructed in the use of the HHU unit and proper sonography technique to improve their image accuracy and quality. Participants worked in pairs