FOCUSED CARDIAC ULTRASOUND TRAINING: HOW MUCH IS ENOUGH?

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Abstract—Background: Focused transthoracic echocardiography (F-TTE) is an important tool to assess hemodynamically unstable patients in the Emergency Department. Although its scope has been defined by the American College of Emergency Physicians, more research is needed to define an optimal F-TTE training program, including assessment of proficiency. Objective: The goal of this study was to determine the effectiveness of current standards in post-residency training to reach proficiency in F-TTE. Methods: Fourteen staff Emergency Physicians were enrolled in a standardized teaching curriculum specifically designed to meet the 2008 American College of Emergency Physicians’ guidelines for general ultrasound training applied to echocardiography. This training program consisted of 6 h of didactics and 6 h of scanning training, followed by independent scanning over a 5-month period. Acquisition of echocardiographic knowledge was assessed by an online pre- and post-test. At the conclusion of the study, a hands-on skills test assessed the trainees’ ability to perform and interpret F-TTE. Results: Ninety percent of trainees passed the written post-test. Two views, the parasternal long and short axis, were easily obtainable, regardless of the level of training or the number of ultrasounds completed. Other views were more difficult to master, but strong trends toward increased competency were evident after 10 h of mixed didactic and scan-

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introducing training and > 45 ultrasounds. Conclusions: A short, 12-h didactic training in F-TTE provided proficiency in image interpretation and in obtaining adequate images from the parasternal window. More extensive training is needed to master the apical and subcostal windows in a timely manner. Published by Elsevier Inc.

Keywords—bedside echocardiography; emergency ultrasound; limited bedside cardiac echocardiography

INTRODUCTION

Bedside ultrasound is part of the core Emergency Medicine residency curriculum, but there are few studies on training requirements and proficiency standards in bedside ultrasound. One group studied the learning curve of ultrasound screening for cholecystitis. They concluded that 25 proctored ultrasounds seemed an adequate number to reach proficiency in this application (1). However, this kind of validated look at proficiency standards is the exception rather than the rule. Guidelines have been issued by the American College of Emergency Physicians. For physicians interested in learning focused bedside ultrasound after graduation, the recommendation was to complete 4 to 8 h of didactics and skills training, followed by a minimum of 25 documented and reviewed ultrasound examinations (2).

In this study, we specifically looked at focused transthoracic echocardiography (F-TTE). Its scope in the
Emergency Department has been defined as the semi-quantitative evaluation of left and right ventricular function, pericardial effusion, and volume status (size and respiratory variations of the inferior vena cava [IVC]) (3). Despite the existence of many F-TTE courses, the type and amount of training needed to acquire this skill set has not been studied. After creating a standardized teaching protocol that met American College of Emergency Physicians recommendations, we set out to determine whether postgraduate Emergency Physicians could accurately acquire and interpret F-TTE examinations.

**METHODS**

**Participants**

The participants were a group of board-certified Emergency Physicians working as attending physicians at our institution, a high-volume academic center, with a wide range of experience in general bedside ultrasound. The same instructor, a cardiologist board certified in echocardiography with a specialization in point-of-care echocardiography, was in charge of giving the didactic lectures and scanning training to all participants. Three bedside ultrasound devices (M-Turbo®; SonoSite Inc., Bothell, WA) were in open access to the physicians.

**Description of the Training Program**

Training was divided into the following parts: didactic teaching and scanning training. The didactic lectures consisted mainly of images and echocardiography videos. They were organized in a series of three weekly 2-h lectures. The lectures were also accessible online to avoid scheduling conflicts.

After completion of the didactic training, each participant was scheduled for three 2-h sessions of “one-on-one” hands-on scanning training. The aim of these sessions was to learn how to best acquire each F-TTE view. Five transthoracic views were taught: 1) parasternal long axis view (PSL); 2) parasternal short axis view at the level of the papillary muscle (PSS); 3) apical 4 chamber view (A4C); 4) subcostal 4 chamber view (S4C); and 5) evaluation of the IVC from the subcostal view.

After the initial training, the participants were encouraged to perform and record independent echocardiographic examinations. The number of ultrasounds completed was recorded, with a goal of 50 studies in 5 months. All ultrasounds were reviewed by the instructor and feedback was given throughout the study period. Toward the end of the study period, an optional troubleshooting session with the instructor was offered.

**Evaluation of Participants’ Proficiency**

Each participant’s progression in ultrasound knowledge was evaluated with a written pre- and post-test, consisting of a Web-based multiple-choice test. The pre- and post-tests were similar in content and difficulty, and were designed to assess theoretical echocardiographic knowledge (e.g., orientation of the transducer for each view, description of structures in each view) and image interpretation.

The participants’ scanning skills were assessed at the end of the study by performance of an F-TTE on a single normal male volunteer, whose cardiac anatomy and ultrasound windows were determined by the instructor to be easily obtained. Participants were evaluated on the time to acquire each view in the following order: PSL, PSS, A4C, S4C, and IVC. Optimal time was considered to be \( \leq 120 \, \text{s} \) for each image acquisition, with 5-min maximum time per view. The participants were allowed to position the patient as they wished to obtain the best view. All views were possible to acquire from the starting position with the mock patient supine, arms at his side. When the participant was satisfied with the view obtained, he or she signaled the instructor, who would either agree or tell him or her to keep trying. No guidance or help from the instructor was allowed. When the view was considered adequate by the instructor, time was recorded and reset for the next view.

**Level of Training**

Lectures and scanning training sessions were treated equally, for a total possible number of seven 2-h teaching sessions (three didactic lectures, three hands-on training sessions, and one optional review session). The number of ultrasounds completed and the number of training sessions attended were evaluated as predictors of the ability to acquire each of the seven views within the 2-min periods. For analyses, the scanning test times, as well as the change in pre- and post-test scores, were assessed and implemented in REDcap (research electronic data capture) hosted at Stanford University (4). The study was granted exemption by our institutional review board committee.

**RESULTS**

Fourteen staff physicians volunteered to participate in this study. Their experience in bedside ultrasound varied widely from none (one physician) to graduate-level training in ultrasound (three physicians).

**Level of Training Attained**

The average level of training was 4.6 sessions (9.2 h) per participant, out of a maximum of 7 proposed (14 h). The
average number of ultrasounds completed per trainee was 28 (range 10–53). The average number of ultrasounds done under the direct supervision of the instructor was 8 (range 3–13) per trainee.

**Evaluation of Ultrasound Knowledge**

Of those who took both the pre-test and post-test (n = 10), the average pre-test written score was 68.9%. Nine trainees (90%) reached the post-test predetermined passing score of 85%. The average post-test written score was 87.3%. This 18.4% improvement difference in mean scores was statistically significant on a paired t-test (p < 0.0018) (Figure 1).

**Evaluation of Scanning Skills**

Each view was evaluated separately; the results are displayed in Tables 1 and 2. In each view, the number of participants who could obtain the view in ≤120 s is stratified by their level of training in Table 1, and the number of ultrasounds completed in Table 2. PSL and PSS were the easiest views to obtain at virtually all levels of training and number of ultrasounds completed; 85% of all participants were able to achieve acceptable images in <120 s. A4C was a difficult view to obtain, with only 57% of participants able to get the view within the 2-min time limit. S4C was achieved by 70% of trainees in the same time frame. For A4C and S4C, a trend toward improvement was shown over 45 studies completed. IVC was the most difficult view to obtain, with a success rate <50%, and showed no trend toward improvement regardless of stratification type.

**DISCUSSION**

Although the scope of F-TTE has been defined, there is still an important need for standardization of training and evaluation of proficiency (2,3). We created a standardized teaching protocol to determine whether it was applicable to practicing Emergency Physicians and to assess the trainees’ proficiency in F-TTE.

To evaluate trainees’ proficiency in F-TTE, we used time as an assessment variable, because the time to obtain adequate images is directly related to scanning skills and experience, and can affect survival in unstable patients (5). We used a 120-s time limit per view, adding up to a total of 10 min maximum for the acquisition of the five views. Although this time limit might be debatable, we believed that 10 min would be the maximum time allotted to dedicated bedside echocardiography in true emergency settings.

The parasternal views (PSL and PSS) were the easiest views to obtain at virtually all levels of training and number of ultrasounds completed. This may be explained by the presence of reliable landmarks with limited inter-patient or position variability. A4C and S4C views were more difficult to obtain, due to the variable location of the apical and subcostal windows, depending on the patient’s position, respiratory movements, and body habitus. Our training did not allow trainees to master these views, but a trend toward improvement was shown at >45 studies completed. Based on our findings, we believe

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IVC = inferior vena cava; PSL = parasternal long axis; PSS = parasternal short axis.
that the emphasis of F-TTE training should be placed on the parasternal window.

The relative difficulty in obtaining an adequate IVC view for more than half of the participants was an unexpected finding. Because this view is important to assess patients’ volume status and is also taught in noncardiac ultrasound courses, we expected that it would have already been mastered by the physicians with previous ultrasound training. Possible explanations for this finding include the relative difficulty of this particular view in our volunteer, overestimation of the participants’ prior experience, confusion of image acquisition and interpretation when taught from an abdominal vs. echocardiographic orientation, or different expectations of image quality (only one evaluator used).

Because it is difficult to reproduce abnormal F-TTE findings to test a large number of trainees, we developed a Web-based interpretation test. The trainees’ scores improved significantly between the pre- and post-test, demonstrating the efficacy of the training program for images interpretation.

We evaluated the trainees’ skills a few months after the initial training, after the time they were encouraged to practice as much as possible. The objective of this time window was to reproduce real-life conditions, taking into account motivation and possible decay of knowledge over time. Our findings reinforced the importance of access to continuous training and regular assessment of proficiency that has been stressed in recent literature (2,3,6).

Limitations

Because, to the best of our knowledge, this is the first study to assess proficiency in F-TTE in postgraduate emergency physicians, we could not rely on previous assessment methods. Choosing time as a variable was a novel approach and we believe it introduced a concept that has significant clinical relevance, despite the fact that it may not have been used in this context before. Our physician participant pool varied widely in their ultrasound training before our standardized protocol. This might have affected the hours of training attended as well as outcomes. In theory, highly trained participants would skew the results toward fewer training sessions needed to reach proficiency, but that was not the case. Another limitation could have been that the views were taught from a cardiologist orientation with transthoracic presets as opposed to the classic Emergency Medicine abdominal presets which could have affected learning curve for those with previous training.

CONCLUSIONS

In this study, we showed that F-TTE theory and image interpretation could be acquired after a short training course. Technical skills in acquiring the parasternal views were well within the grasp of emergency physicians with the current level of recommended training. The apical and subcostal views were more difficult to master and more training seemed to be needed for these views. Additional studies are needed to further investigate the scanning learning curve to help define optimal training in F-TTE.

REFERENCES

ARTICLE SUMMARY

1. Why is this topic important?
Cardiac ultrasound is an important skill set for Emergency Physicians. Its scope has been defined in recent guidelines, but a proficiency testing method and the optimal amount of specific training needed are still to be determined, specifically for postgraduate training.

2. What does this study attempt to show?
This study examined the echocardiography skills obtained by postgraduate Emergency Physicians after completion of a standardized echocardiography training curriculum, which met American College of Emergency Physicians 2008 guidelines.

3. What are the key findings?
A standardized training in focused transthoracic echocardiography provided proficiency in images interpretation and in obtaining adequate images from the parasternal window. More extensive training than suggested in the American College of Emergency Physicians guidelines (minimum of 25 documented and reviewed cases) would be needed to master the apical and subcostal windows in a timely manner.

4. How is patient care impacted?
This study is oriented toward physicians’ ultrasound education and does not directly impact patient care. However, it underlines the need for optimization of postgraduate training in cardiac ultrasound and the importance of assessing scanning proficiency.