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ORIGINAL RESEARCH

How fast is the focused assessment with sonography for trauma examination learning curve?

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Abstract

Objective: Although accuracy for focused assessment with sonography for trauma (FAST) examination interpretation has been widely reported, the learning curve for FAST interpretation by emergency medicine (EM) residents who are novice to ultrasound has not been well described. The present study's objective was to analyse EM resident FAST interpretation accuracy over 18 months.

Methods: Prospective comparison of EM resident FAST interpretation accuracy for a class of nine EM residents at baseline after initial training, and then every 6 months over 18 months. Accuracy was scored after viewing the same 20 video clip images of the four anatomic views for five FAST examination cases. Three video clips had large anechoic stripe (AS) (>6 mm), four had moderate AS (6 mm ≥ AS ≥ 3 mm), two had small AS (<3 mm), and eleven had no AS (AS = 0 mm). A surgeon with 20 years of ultrasound experience confirmed the video clip interpretations. Data analysis used descriptive statistics with 95% confidence intervals.

Results: For no AS views, EM resident accuracy was 79.8% (70.3–86.9%) baseline, 91.9% (84.2–96.2%) at 12 months, and 92.9% (85.5–96.9%) at 18 months. For small AS views, resident accuracy was 27.8% (10.7–53.6%) baseline, 66.7% (41.2–85.7%) at 12 months, and 72.2% (46.4–89.3%) at 18 months. For large AS views, resident accuracy was 77.8% (57.3–90.6%) baseline, 86.1% (69.7–94.8%) at 12 months, and 100.0% (84.5–100%) at 18 months.

Conclusion: Over 18 months, EM resident FAST interpretation accuracy steadily increased. By 12 months (or 35 examinations), the accuracy of EM residents novice to ultrasound approximated previously reported accuracy rates.

Key words: *education, haemoperitoneum, trauma, ultrasound.*

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Introduction

The focused assessment with sonography for trauma (FAST) examination has become a routinely utilized diagnostic tool for the evaluation of trauma patients at most trauma centres in the USA and around the world.[1] Most USA emergency medicine residency programmes (95% as of 2003) teach bedside ultrasound principles to their residents. The FAST examination is the most commonly performed of these bedside ultrasound examinations.[2] Many studies have demonstrated that when performed by experienced physicians, the FAST examination is highly sensitive and specific for the detection of free intraperitoneal and intrathoracic fluid.[3–10] The American College of Emergency Physicians has recommended as a minimum training criterion that at least 25 ultrasound examinations be performed for a specific indication in order to obtain proficiency.[11] However, limited data exist to support this numerical standard. A description of the learning curve for accurate FAST examination interpretation by emergency medicine residents would provide useful evidence to establish numerical examination standards.

Several studies support the premise that a learning curve exists for non-radiology physicians performing and interpreting the FAST examination. Shackford and colleagues suggested that as few as 10 FAST examinations might be required for physicians to establish competency.[12] Other studies have suggested that 10 examinations might not be sufficient,[13] and that the learning curve might start to flatten at 30 examinations.[14] The learning curve for emergency medicine residents novice to emergency ultrasound has not been previously described. The objective of the present study was to describe the accuracy of FAST examination interpretation, which is the only purely cognitive component of the examination, for emergency medicine residents during a faculty-supervised period of 18 months in order to describe such a learning curve.

Methods

Study design

This prospective, non-randomized, comparative study analysed the FAST examination interpretation accuracy for a class of nine emergency medicine residents (postgraduate years [PGY] 1–3) at baseline after initial training, and then every 6 months over an 18 month span. Baseline initial training involved a 1 day ultrasound instruction course that included 4 h of didactic instruction along with 4 h of hands-on training. This introductory course covered the FAST examination, plus pelvic, abdominal aortic and biliary ultrasound examinations. Formal training was not repeated after the initial session. Hands-on supervision and training by emergency medicine faculty continued during the residents' subsequent ED shifts. The emergency medicine residents in the present study were in their postgraduate years 1–3 and were training to specialize in emergency medicine. The emergency medicine faculty members were all residency-trained emergency physician specialists.

The physicians' competence for image acquisition was not part of the present study. Thus, the present study did not address the acquisition of combined cognitive and motor skills required to achieve satisfactory image capture for interpretation. All subjects interpreted digitized videotape recordings of the same previously acquired FAST examination images, with assessment of the residents' accuracy for interpretation of each image. The present study was approved as exempt by our Institutional Research Ethics Review Board.

Study setting and population

The medical centre hosts an emergency medicine residency (PGY 1–3) with 12 emergency medicine faculty members and 27 residents (9 residents per class). The ED is a level I trauma centre with an annual census of 57 000 patients. The participants of the present study were one class of nine emergency medicine residents.

Study protocol and measurement

Video recordings of the four standard anatomic views for five patients' FAST examinations were interpreted by each resident. For four consecutive sessions, spaced 6 months apart, the same 20 45 s video recordings were viewed by each resident. The video recordings originated from a video home system (VHS) tape of collected FAST examinations. The selected FAST examinations were obtained by one emergency physician specialist who had performed over 250 FAST examinations. These five examinations were downloaded onto a computer hard drive using commercially available digital video creation hardware. The video recordings were then burned onto a CD for review by the emergency medicine residents participating in the study. A Dell 17 inch monitor (1024 × 768 pixels) was utilized for viewing the digitized images.

Images acquired from each of the five patients who served as sources were always interpreted in standard order (pericardial, right upper quadrant, left upper quadrant and suprapubic) for the presence or absence of free fluid. The patient order for viewing of images was randomized.

All five patients had at least one positive finding for free fluid in one of the four FAST views. Among these twenty video recordings, three video clips contained a large-sized anechoic stripe (>6 mm), four had moderate-sized anechoic stripe (≤6 mm but ≥3 mm), and two had small-sized anechoic stripe (<3 mm). The remaining 11 recordings had no anechoic stripe (0 mm). In determining large-, moderate- or small-sized anechoic stripe size, the largest anechoic stripe dimension for each view was measured from the videotape recordings of the FAST examinations. Determination and measurement of the anechoic stripe were made by one of the investigators and an assistant. These criteria were based on recommendations suggested by Tiling *et al.*[15] The anechoic stripe measurements were established prior to review of the videotapes. The presence or absence of an anechoic stripe in each view was confirmed by a general surgeon from Kobe, Japan, with over 20 years of clinical ultrasound experience and who was blinded to all clinical information. In Japan, emergency ultrasound applications and the FAST examination have been utilized since the 1970s, and an ultrasound machine is used as commonly as a stethoscope to assist with patient management. Thus, at the time of our study, this Japanese surgeon had more experience with FAST interpretation than nearly all USA-based radiologists. Accuracy of image interpretation was judged to have occurred when the resident's interpretation matched that established as correct by the investigators and confirmed secondarily by the Japanese surgeon.

Formal 2-D echocardiography (interpreted by attending cardiologists) for pericardial views, abdominal computed tomography (CT) scan of the abdomen/pelvis (interpreted by attending radiologists), and/or exploratory laparotomy (dictated by attending surgeons in the operative note) for the other three FAST views were also used to verify the presence of free fluid for all cases. The operative notes merely confirmed the presence of free intraperitoneal fluid, but were not used to verify the location of the fluid within the peritoneal cavity.

Data analysis

The accuracy (including 95% confidence intervals) of the FAST examination interpretations of the residents was calculated. Sensitivity and specificity were not reported because accuracy was assessed for each view individually. (An image without an anechoic stripe cannot have its sensitivity assessed, and an image with an anechoic stripe cannot have its specificity assessed.) Image interpretations were treated as independent events.

Results

The accuracy of FAST examination interpretations of the nine emergency medicine residents was measured at baseline, 6 months, 12 months and 18 months. These results are listed in Table 1. The mean number (and

Table 1. Accuracy of FAST examination interpretation at baseline, 6 months, 12 months and 18 months for examinations with varying sizes of AS

	Accuracy percentage (95% CI)			
	Baseline	6 months	12 months	18 months
No AS	79.8 (70.3–86.9)	85.9 (77.1–91.8)	91.9 (84.2–96.2)	92.9 (85.5–96.9)
Small AS	27.8 (10.7–53.6)	50.0 (26.8–73.2)	66.7 (41.2–85.7)	72.2 (46.4–89.3)
Medium AS	63.0 (42.5–79.9)	80.6 (63.4–91.2)	86.1 (69.7–94.8)	91.7 (76.4–97.8)
Large AS	77.8 (57.3–90.6)	92.6 (74.2–98.7)	85.2 (65.4–95.2)	100.0 (84.5–100)
Cardiac view	80.0 (64.9–89.9)	86.7 (72.5–94.5)	91.1 (77.9–97.1)	91.1 (77.9–97.1)
RUQ view	77.8 (62.5–88.3)	91.1 (77.9–97.1)	95.6 (83.6–99.2)	95.6 (83.6–99.2)
LUQ view	64.4 (48.7–77.7)	77.8 (62.5–88.3)	80.0 (64.9–89.9)	82.2 (67.4–91.5)
Pelvic view	66.7 (50.9–79.6)	73.3 (57.8–84.9)	82.2 (67.4–91.5)	97.8 (86.8–99.9)
Mean number FAST per EM resident	0	13	35	73

AS, anechoic stripe; CI, confidence intervals; EM, emergency medicine; FAST, focused assessment with sonography for trauma; LUQ, left upper quadrant; RUQ, right upper quadrant.

range) of FAST examinations performed was 0 (0, 0) at baseline, 13 (4, 40) at 5 months, 35 (15, 90) at 12 months and 73 (30, 150) at 18 months. Overall, the residents improved their number of correct interpretations of the FAST examination over the course of the 18 month period. When assessing the results of the four anatomic views of the FAST examination, improvement was observed in all views throughout the 18 month period. The pelvic view had the largest accuracy improvement of all the anatomic views, whereas the smallest accuracy improvement for the four anatomic views was in the left upper quadrant.

Discussion

Over an 18 month period, numerical accuracy rates for emergency medicine resident FAST examination interpretation steadily increased. By the time of the 18 month assessments, for all anechoic stripe sizes assessed, the numerical accuracy rate for correct interpretation lay beyond the upper 95% confidence limit for the data obtained during baseline accuracy assessment. By 12 months (or 35 examinations), emergency medicine resident accuracy approximated previously reported accuracy rates.[3–8] As could be expected, the lowest resident accuracy was observed for views with a small anechoic stripe. A 2006 study examined how anechoic stripe size influences the accuracy of FAST examination interpretation. In that study, emergency medicine residents had statistically significant lower interpretation accuracy when compared with community hospital attending emergency physicians for detecting a small anechoic stripe. This suggested that experience level might be responsible for this difference.[16] After 18 months (or a mean of 73 examinations), emergency medicine resident accuracy for detecting a small anechoic stripe in our study was similar to the community hospital emergency physician accuracy published in this 2006 study.

Several studies have discussed the presence of a learning curve for novice physicians performing the FAST examination. One example is a study by Shackford and colleagues.[12] These investigators found that the error rates of novice FAST examination operators declined significantly after the initial set of 10 FAST examinations.[12] Jang and coworkers conducted a retrospective review of emergency medicine resident performing FAST examinations on patients who presented with abdominal trauma. They analysed the sensitivities and specificities of emergency medicine residents for detecting free fluid on a FAST examination based on the number of prior FAST examinations performed by the resident. Their data did not support the use of 10 examinations as a minimum standard for adequate training. Although they suggested that more extensive training might be necessary to accurately and independently perform and interpret FAST examinations, the determination of the minimum number of examinations was beyond the scope of their study.[13] Another study, utilizing patients who underwent peritoneal dialysis as models for FAST examinations performed by surgeons and radiologists, suggested that the learning curve starts to level out at 30–100 examinations.[14]

To our knowledge, our study is the first to prospectively evaluate the learning curve for interpreting FAST examinations by emergency medicine residents who were novice to emergency ultrasound. Initial formal training consisted of a 1 day ultrasound instruction course that was not repeated during the study period. The residents enrolled in the present study had no prior ultrasound experience. Hands-on supervision and training continued during the residents' ED shifts. This represented real world training in a busy urban ED, and was likely to be similar to the experience of residents trained in other emergency medicine residency programmes. By 12 months, our residents had performed an average of 35 FAST examinations and, by 18 months, had performed an average of 73 FAST examinations. The learning curve for interpreting the FAST examination in our study appeared to flatten between 12 and 18 months, thereby suggesting that between 35 and 70 FAST examinations were necessary to gain proficiency with interpreting the FAST examination.

Well-performed and confidently interpreted FAST examinations hold promise to decrease the utilization of more expensive CT scanning.[17] Our data suggest that financial benefits might accrue to emergency medicine training programs once their residents have performed a sufficient number of FAST examinations.

Limitations

The principal limitation of the present study was the small number of participants. Thus, extrapolation of usable data from the present study is somewhat limited in its scope and application. Increasing the study size would provide a better understanding of accuracy trends noted in our 18 month evaluation.

Image interpretations were treated as independent events in the present study. The participants were judged by their interpretation of four different views from five independent FAST examinations. We believe that this methodology is appropriate because no observer judged all four images of a single FAST scan to have an anechoic stripe present, even though a stripe was noted in one of the four views. However, it is reasonable to consider the possibility that the present study was one of five patients, not 20 images. It is possible that the presence of one large anechoic stripe could bias the observer into looking more thoroughly for other signs of anechoic stripes in the three remaining views. Whether or not the judgement of an anechoic stripe was falsely deemed to be present in other views was not assessed. In addition, had there been a much higher percentage of cases with small anechoic stripes, it could be postulated that it would have led to more false-positive interpretations of the video clips. The resolution of this controversy was not an objective of our study and the sample size was too small to permit meaningful assessment of this potential source of bias. Any follow-up study of this issue should present FAST images from multiple patients in random order. This would better minimize the probability of this source of bias.

A feature of the present study that could be viewed as a potential limitation was that only image interpretation was analysed, as it is a non-motor, purely cognitive skill. The present study did not assess image acquisition, which has both cognitive and motor components. It is common for medical education researchers to partition components of the learning and acquisition of skills in such a manner. Image acquisition for bedside ultrasound examinations might independently have a different learning curve. However, Mandavia and colleagues analysed PGY-2 emergency medicine residents over a 10 month period. Initial training consisted of a 2 day ultrasound instruction course followed by a 10 month study period where the emergency medicine residents performed and were evaluated on seven different bedside ultrasound examinations. Each ultrasound examination was evaluated for technical adequacy and for correct interpretation. In their study, 96% of the ultrasound examinations were considered technically adequate during the 10 month study period following the 2 days of instruction.[18]

The image quality of the FAST examination video recordings was not as sharp as if the FAST examination was being performed in real time at the bedside with a state-of-the-art ultrasound machine and monitor. The video recordings originated from a VHS tape of collected FAST examinations. Selected examinations were downloaded onto a computer hard drive using commercially available digital video creation hardware. The video recordings were then burned onto a CD for review by the emergency physicians participating in the study. Nonetheless, all anatomic landmarks and anechoic stripes could be visualized on the CD.

In our study, the objective was not to compare accuracy rates across the four assessment periods; thus, no statement of probability of a type I error was expressed for these data. Also, the objective of the study was not to determine whether or not a significant difference between assessment periods existed. Therefore, no attempt was made to plan sample size or to characterize beta error rates. The objective of the present study was to describe correct image interpretation rates across time (and across increased experience with the examination) in a cohort of emergency medicine residents, to provide a comparison to currently published recommendations, and to guide further study of this issue. Our data should be considered a pilot study, and the study merits confirmation in a larger cohort.

Conclusion

Over 18 months, the accuracy of a cohort of emergency medicine resident FAST interpretation steadily increased. By 12 months (or a mean of 35 FAST examinations), the interpretation accuracy of emergency medicine residents who were novice to emergency ultrasound approximated previously reported accuracy rates, particularly for images with large or moderate sized anechoic stripes. Further experience (18 months or a mean of 70 FAST examinations) produced better interpretation accuracy for FAST examinations with small-sized anechoic stripes.

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Author contributions

Each author made substantial contributions to the following tasks of the present study: initial conception (OJM); design (OJM, GG); collection of data (OJM);

analysis and interpretation of data (OJM, GG, JGN, SS), writing and revision of paper (OJM, GG, JGN, SS).

Competing interests

None declared.

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