MILITARY MEDICINE

PILOT STUDY TO DETERMINE THE FEASIBILITY OF TRAINING ARMY NATIONAL GUARD MEDICS TO PERFORM FOCUSED CARDIAC ULTRASONOGRAPHY

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ABSTRACT

Objective. To assess the ability of Army National Guard combat medics to perform a limited bedside echocardiography (BE) to determine cardiac activity after a brief training module. **Methods.** Twelve Army National Guard health care specialists trained to the level of emergency medical technician–basic (EMT-B) underwent an educational session consisting of a 5-minute lecture on BE followed by hands-on practical training. After the training session, each medic performed BEs, in either the subxiphoid (SX) or parasternal (PS) location at his or her discretion, on four healthy volunteers. The time required to complete the BE and the anatomic location of the examination (SX vs. PS) was documented. A 3-second video clip representing the best image was recorded for each BE. These clips were subsequently reviewed independently by two of the investigators with experience performing and interpreting BE; each BE was graded on a six-point scale designed for the study, the Cardiac Ultrasound Structural Assessment Scale (CUSAS). A score of 3 or greater was considered to be adequate to assess for the presence of cardiac activity. Where there was disagreement on the CUSAS score, the reviewers viewed the clip together and agreed on a consensus CUSAS score. We calculated the median time to completion and interquartile range (IQR) for each BE, the median CUSAS scores and IQR for examinations performed in the SX and PS locations, and kappa for agreement between the two reviewers on the CUSAS. **Results.** A total of 48 BEs were recorded and reviewed. Thirty-seven of 48 (77%) were obtained in the SX location, and 11 of 48 (23%) were obtained in the PS location. Forty-four of 48 (92%) were scored as a 3 or higher on the CUSAS. Median time to completion of a BE was 5.5 seconds (IQR: 3.7–10.9 seconds). The median CUSAS score in the SX location was 4 (IQR: 4–5), and the median CUSAS score in the PS location was 4 (IQR: 4–4). Weighted kappa for the CUSAS was 0.6. **Conclusion.** With minimal training, the vast majority of the medics in our study were able to rapidly perform a focused BE on live models that was adequate to assess for the presence of cardiac activity.
Key words: emergency medical services; echocardiography; sudden cardiac death; military medicine

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INTRODUCTION

Emergency medical services (EMS) providers have played a major role in the care of cardiac arrest (CA) patients since the early 1960s, when portable defibrillators were first placed on ambulances designated as "mobile coronary care units" in Belfast, Ireland.[1] Despite advances in cardiac and resuscitative care, however, the likelihood of survival after out-of-hospital nontraumatic CA remains extremely low; although estimates vary, survival ranges from 1% to 8%, and is lower if neurologically intact survival is used as the endpoint.[2–6] Survival rates are even worse in patients whose presenting rhythm is asystole, ranging from 0% to 2%.[2,3,7] In the United States, the incidence of out-of-hospital CA is approximately 5.5 per 10,000 population, equating to greater than 150,000 annual cases, and approximately 60% of these are treated by EMS providers.[4,8]

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There has been some interest in identifying factors predictive of poor outcomes for CA victims, and in developing guidelines for the termination of resuscitation efforts for those who are unlikely to benefit.[2,7,9–14] Several studies have demonstrated that survival of CA patients who have no cardiac activity by bedside focused ultrasonography in the emergency department is extremely unlikely.[15–17] However, no studies to date have addressed the role of focused bedside echocardiography (BE) performed by prehospital providers to assess cardiac activity. In addition, no studies have addressed training requirements that would allow prehospital providers to make determinations of cardiac activity. It is conceivable that the absence of cardiac activity as demonstrated by a portable, handheld ultrasound device in the prehospital setting could provide valuable information to identify those patients for whom resuscitation efforts are likely to be futile. Conversely, observable cardiac activity might indicate that continued aggressive resuscitation efforts should be pursued. The goal of the present study was to assess the ability of basic life support (BLS) providers who had undergone a standardized educational module to perform focused BE of sufficient quality to be able to make a determination of the presence of cardiac activity.

METHODS

This study was approved by the Colorado Multiple Institutional Review Board (COMIRB). This was a prospective observational study performed using volunteer Colorado Army National Guard health care specialists (medics) trained to the level of emergency medical technician–basic (EMT-B). Written informed consent was obtained from all study participants using a standardized consent document. The study was conducted during the annual training of a Colorado Army National Guard medical unit. Because of time constraints imposed by the unit's training schedule, all of the didactic and testing components were designed to be completed during a four-hour block of time on a single day. Twelve volunteer medics were recruited for the study. None had any prior experience performing BE. They received a very brief, 5-minute lecture on the basics of ultrasonography and echocardiography. They were then divided into four groups and given a 15-minute hands-on training session in the performance of BE in the subxiphoid (SX) and parasternal long-axis (PS) views. One of the investigators served as the model for the training sessions. There were two instructors, both emergency physicians who had completed residency training in emergency medicine. One was an emergency department (ED) attending physician with extensive experience in emergency ultrasound, credentialed to perform all primary emergency ultrasound applications, including focused echocardiography. The other also had prior extensive experience with emergency ultrasound, and was completing an emergency ultrasound fellowship.

A General Electric LOGIQ Book XP with a 2–3.6-MHz phased-array transducer (General Electric Company, Fairfield, CT) was used for the study. The medics were trained to locate the heart and demonstrate cardiac activity in each of the two views. No detailed instruction was provided with regard to orienting the probe, identifying specific cardiac structures, or adjusting the quality of the image on the ultrasound machine. Only two-dimensional ultrasound imaging was used for the study; Doppler functionality was not taught or used. Each medic was observed performing several examinations until the training investigator was satisfied that the individual understood the task and was able to demonstrate an acceptable cardiac ultrasound examination.

Once the training portion was completed, each medic then performed four echocardiograms on healthy volunteers recruited as models for the study. Each medic was allowed to obtain either an SX or a PS view, whichever he or she judged provided the best image. There was no "coaching" or feedback provided at this stage by the instructors to the medics during image acquisition. At the medic's signal, one of the instructors recorded a 3-second video clip of the echocardiogram onto the hard drive of the ultrasound machine. The time required for the medic to obtain a view that he or she felt adequately demonstrated the presence of cardiac activity was recorded, as was the location of this view (i.e., PS or SX).

The video clips were then reviewed independently by two reviewers experienced in performing and interpreting emergency BE (JLK and BHB), who did not participate in the training and testing portion of the study. The first reviewer was the emergency ultrasound director and emergency ultrasound fellowship director at the originating institution, and the second reviewer was the current emergency ultrasound fellow at the same institution. Both were board-certified in emergency medicine and fully credentialed to perform all basic and advanced emergency ultrasound applications. The reviewers were blinded to the identity of the sonographer and the model (Fig. 1). The reviewers scored the echocardiogram according to a six-point scale prospectively designed for the study, the Cardiac Ultrasound Structural Assessment Scale (CUSAS) (Fig. 2). Where there was disagreement between the two reviewers on the CUSAS score, the clips were played with both reviewers present and a consensus score was agreed upon. Because a CUSAS score of 3 meant that a ventricle had been at least partially visualized, this was used as the minimum required score for a given BE to be considered adequate to make a determination of cardiac ventricular activity.

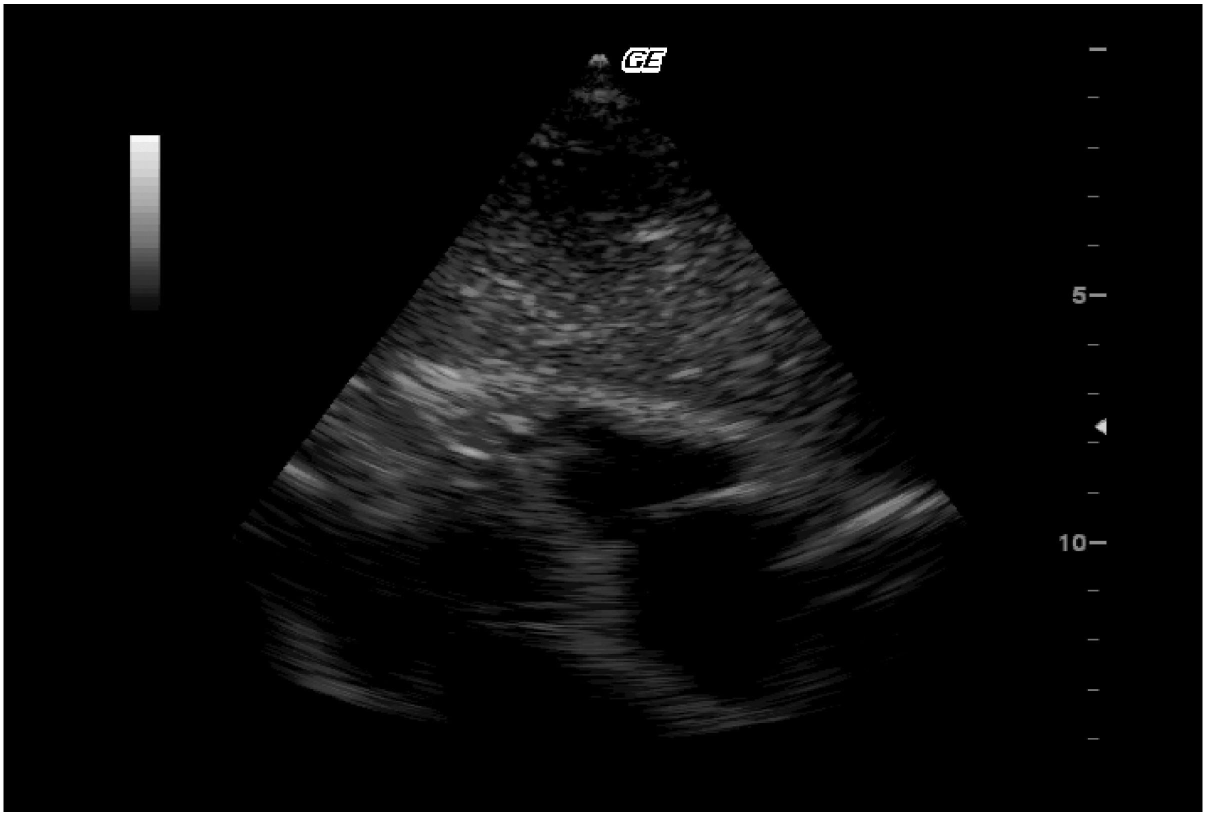

FIGURE 1. Sample still frame from video clips.

Data for each medic, examination number, examination location, time to completion of the examination, and the CUSAS score were entered into an electronic database (Excel, Microsoft Corp., Redmond, WA).

All statistical analyses were performed using Stata Version 10 (StataCorp LP, College Station, TX). No a priori sample size was calculated. We calculated the median time to completion of the BE and the interquartile range (IQR) for this measurement, the median CUSAS score and IQR for the examinations in the PS and SX locations, and the kappa value and 95% confidence interval (CI) for agreement between the two reviewers on the CUSAS. Fisher's exact test was used to evaluate the possibility that there was a statistically significant relationship between the ability or inability to generate an adequate image (CUSAS score ≥3) and the medic performing the examination, the model on whom the examination was performed, or the anatomic location of the examination (i.e., PS or SX).

1	**No myocardium visualized**
2	**Myocardium visualized**
3	**Partial ventricle visualized**
4	**Multiple partial chambers visualized** (including part of at least one ventricle)
5	**Full ventricle visualized**
6	**Multiple full chambers visualized** (including at least one ventricle)

FIGURE 2. The Cardiac Ultrasound Structural Assessment Scale.

RESULTS

Table 1 shows the results. Each medic performed four echocardiograms, thus totaling 48 echocardiograms reviewed. Of the 48 total studies, 44 (92%) were considered adequate to determine the presence or absence of cardiac activity (CUSAS of 3 or greater). Of the 48 studies, 37 (77%) were obtained in the SX location and 11 (23%) were obtained in the PS location.

The median time required for participants to obtain their final image was 5.5 seconds (IQR: 3.7–10.9 seconds). The median CUSAS score in the PS location was 4 (IQR: 4–5), and that in the SX location was also 4 (IQR: 4–4). The kappa value for agreement on the CUSAS score between the two reviewers was 0.62 (95% CI: 0.25–1.00).

There was no statistically significant relationship found between the ability or inability to generate an adequate image and the medic performing the examination, the model on whom the examination was being

TABLE 1. Results of the Study

Medic	Model	Anatomic Location	Time (sec)	CUSAS Value
W1	M1	SX	3.25	4
W1	M2	SX	3.54	4
W1	M3	SX	3.66	4
W1	M4	SX	13.28	4
W2	M2	SX	2.63	3
W2	M3	SX	4.97	4
W2	M4	SX	4.75	3
W2	M5	SX	2.07	4
W3	M1	SX	3.66	4
W3	M3	SX	6.47	2
W3	M4	PS	94.1	4
W3	M5	SX	7.06	3
W4	M1	SX	2.44	4
W4	M2	SX	4.22	1
W4	M3	SX	6.47	5
W4	M4	PS	28.38	6
W5	M1	SX	6.6	4
W5	M2	SX	3.34	5
W5	M3	PS	9.78	2
W5	M4	PS	25.62	6
W6	M1	SX	5.44	4
W6	M2	SX	31.07	4
W6	M3	SX	4.56	4
W6	M4	PS	24.43	4
W7	M1	SX	7.97	4
W7	M2	SX	2.57	4
W7	M3	SX	12.09	4
W7	M4	SX	3.84	4
W8	M1	SX	2.97	5
W8	M2	SX	3.62	6
W8	M3	PA	6.32	4
W8	M4	SX	7.07	4
W9	M1	SX	3.19	4
W9	M2	SX	5.47	6
W9	M3	SX	6.32	4
W9	M4	PS	23.75	5
W10	M1	SX	5.4	6
W10	M2	PS	51.81	4
W10	M3	PS	5.47	4
W10	M4	PS	55.82	4
W11	M1	SX	8.88	4
W11	M2	SX	4.92	4
W11	M3	SX	3.06	5
W11	M5	PS	4.03	4
W12	M1	SX	4.5	4
W12	M2	SX	15.13	4
W12	M3	SX	9	2
W12	M4	SX	27.31	4

CUSAS = Cardiac Ultrasound Structural Assessment Scale; M = model; W = medic; PS = parasternal long-axis; SX = subxiphoid.

performed, or the anatomic location of the examination ($p = 0.23–1.00$).

DISCUSSION

With minimal training, medics in our study were able to perform a limited BE that was adequate to demonstrate cardiac activity more than 90% of the time. It is reasonable to hypothesize that, with more extensive training, this percentage could be increased. It remains unknown, however, whether this information could be incorporated into decision making during prehospital cardiac resuscitation. Studies within the last decade have demonstrated that successful resuscitation is unlikely when myocardial activity is absent by BE. Blaivas and Fox found no survivors among CA patients presenting to the ED who did not have cardiac activity by BE.[15] Salen et al. found significantly lower survival among patients in CA without cardiac activity by BE as compared to those with cardiac activity[13] and, in a subsequent study, found no survivors among CA patients without cardiac activity by BE.[14] If there has been no return of spontaneous circulation with usual protocols and a prehospital-performed BE shows no cardiac activity, perhaps that patient may be pronounced dead at that point in the field rather than undergoing further resuscitative efforts, including transport to the ED. A cost analysis of pronouncement of death in the field versus pronouncement in the hospital for CA patients with low likelihood of survival found lower cost and decreased physician time associated with field pronouncement.[18]

The minimum amount of training required for nonphysicians to adequately perform and interpret focused BE has not been investigated. This has not been definitively established for noncardiologist physicians, either, but estimates can be extrapolated from the existing literature on the subject. A study of emergency medicine residents with variable levels of experience performing bedside ultrasound examination, but without prior experience performing focused BE, found significant improvement in the study subjects' ability to perform and interpret BE after five didactic hours and a one-hour practical session.[19] A study by DeCara et al. of internal medicine residents with no prior experience performing BE used a 20-hour didactic training period followed by the performance of 20 proctored examinations, finding that participants were able to achieve sensitivities approaching those of fully trained echocardiographers. It is worth noting that the DeCara study encompassed echocardiographic evaluation well beyond that of the more focused BE in our study and other studies.[20] A study by Hellmann et al. of internal medicine residents without prior experience in BE found that acceptable competence was attained after 30 minutes of didactic instruction and the supervised performance of 20 to 40 examinations.[21] The wide variability in the length of the didactic sessions used in these studies makes it difficult to suggest an exact optimal duration for the lecture component of the training period, but there seems to be a significant competence threshold that is crossed for BE after performing somewhere between 25 and 50 examinations. The American College of Emergency Physicians currently advocates a four- to eight-hour training session incorporating didactic and practical components, and the performance of 25 to 50 supervised examinations, for emergency physicians to independently perform and interpret focused BE.[22]

A few studies have assessed the feasibility of real-time wireless transmission of echocardiographic images from the prehospital setting to a base station for interpretation by a designated person, such as a base hospital physician, and found that, as long as certain infrastructure requirements are met, this can be achieved.[23–25] This technology might be useful for providing contemporaneous quality assurance review in early phases of implementation of prehospital-performed BE. As ultrasound technology continues to evolve, equipment size has decreased while imaging capability has improved. It is conceivable that ultrasound capability could be incorporated into other standard equipment carried by EMS personnel, such as portable monitors/defibrillators.

The results of this study suggest multiple directions for future research. For example, would more extensive training sessions result in higher-quality images or fewer inadequate studies? Additionally, studies of the effect of using a greater number and diversity of models, studies of the ability of subjects to identify cardiac structures when cardiac activity is absent (perhaps using cadavers), implementation studies to determine the feasibility of prehospital personnel performing BE in field conditions, and outcome studies measuring the impact of the use of this technology by prehospital personnel should be conducted.

Limitations and Future Research

This study used live models; therefore, the ability of study participants to identify cardiac structures when cardiac activity is absent could not be assessed. Although logistically and technically challenging (for example, it would be very difficult to blind subjects in a study using cadavers to simulate asystole), the inclusion of an asystole model by some means in a future study would enable the assessment of the ability of study participants to identify the absence as well as the presence of cardiac activity, which would be important to establish before the scope of practice for prehospital providers could be expanded to include BE.

Our intent was not specifically to determine whether images obtained in one anatomic location (i.e., PS vs. SX) were superior to the other; medics were not required to obtain an image in both locations. We did not find that an image was statistically more likely to be "better," i.e., receive a higher CUSAS score, in one location versus the other. However, relatively few examinations were done in the PS location, and it may be that with greater numbers, or if medics had been required to perform BE in both locations on each model, a statistically significant difference might become apparent.

The models used for this study were healthy volunteers from the National Guard; using models with conditions known to make echocardiography more difficult that may be encountered in the general population, such as obesity, chest wall deformities (e.g., pectus excavatum), or chronic lung disease (e.g., asthma or chronic obstructive pulmonary disease), could potentially alter the results of a similar study.

The number of participants was relatively small, and therefore the possibility of bias related to sample size exists.

Finally, kappa values for the CUSAS score were fair, suggesting that this scoring system as it was conceived has limited utility outside of this study.

Conclusion

Our study demonstrated that, with minimal training, the study participants were able to obtain a cardiac image that would be adequate to demonstrate cardiac activity in the vast majority of cases and could be completed in a relatively short time period.

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