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Can paramedics perform and evaluate a focused echocardiogram during a simulated 10-second pulse check, after a one-day training course?

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Abstract

Aim – To assess whether paramedics can be trained to perform basic echocardiograms in the 10-second pulse check window during a simulated advanced life support (ALS) resuscitation.

Introduction – Cardiac arrest survival in the UK varies between 2% and 12%. Management of cardiac arrests concentrates on the detection of reversible causes, which is limited pre-hospitally due to a lack of equipment. Ultrasound machines are now small enough for pre-hospital use and may assist in the detection of some of these causes. There is currently no evidence to suggest the best methodology or required course duration to train paramedics to use ultrasound, or to indicate whether ultrasound simulation could be beneficial.

Methods – Ten volunteer paramedics were trained to perform focused echocardiograms using handheld ultrasounds and an ultrasound simulator. The training involved six hours of teaching and practical training, at the end of which the participants were assessed using objective structured clinical examinations (OSCEs) on an ultrasound simulator with three different pathologies which were relevant in cardiac arrest management.

Results – Paramedics were able to get a view of the heart during the assessments in 96.7% of the OSCEs, but were only able to accurately recognise the pathologies of the condition in 50%. Overall, the participants demonstrated simulated competence in 46.7% of the OSCEs.

Conclusion – Paramedics can be trained to gain a view of the heart using focused echocardiograms after a one-day course, but are not consistently able to determine the cardiac activity or pathology from the echocardiogram.

Keywords

advanced life support; resuscitation; ultrasound

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Aim

This study aims to assess whether paramedics can be trained to perform basic echocardiograms in the 10-second pulse check window during a simulated advanced life support (ALS) resuscitation.

Introduction

In the UK, the chance of surviving an out of hospital cardiac arrest (OHCA) varies from 2% to 12% depending on the ambulance region (Perkins & Cooke, 2012). The figure in the North East of England stands at only 7% (North East Cardiac Arrest Network, 2012). Management of cardiac arrest patients often prioritises delivering early cardiopulmonary resuscitation and defibrillation of the heart in shockable rhythms – that is, ventricular fibrillation (VF) and pulseless ventricular tachycardia. However, in certain circumstances such as in cases where pulseless electrical activity is the presenting rhythm, management also focuses on the detection of reversible causes. These may be difficult to identify in the pre-hospital environment.

Focused echocardiography is a limited study that can be performed in a short period of time with the aim of identifying cardiac activity and also features of reversible causes, for example a dilated right side of the heart in massive pulmonary embolism or a pericardial effusion causing cardiac tamponade. It may be possible for paramedics to attempt to perform such an echocardiogram during the pause in chest compressions when a rhythm/pulse check is performed during ALS (Resuscitation Council, 2010). Such a limited study has shown that it is feasible for healthcare professionals other than formal echocardiography experts to perform the echocardiogram (Niendorff et al., 2005). An echocardiogram is the performance of an ultrasound scan, which gains a view of the heart; for the purpose of this article echocardiogram is use to describe that particular focused scan, while the term ultrasound is used to describe a wider group of skills and views that can be performed, including echocardiograms.

Focused echocardiography has been found to be diagnostic in the management of cardiac arrest, and to be 99% predictive of survival to discharge (Cureton et al., 2012). The use of ultrasound and focused echocardiograms has been shown in previous studies to allow clinicians to modify their management of cases, leading to improvements in patient outcomes (Breitkreutz et al., 2010; Prosen, Križmarić, Završnik, & Grmec, 2010; Volpicelli, 2011). The use of echocardiograms may also assist in decision-making regarding the termination of futile resuscitation attempts (Aichinger et al., 2012; Salen et al., 2005). Paramedics have shown in previous ultrasound studies that they are capable of learning to perform focused ultrasound scans (Booth et al., 2015; Brooke, Walton, Scutt, Connolly, & Jarman, 2012; Chin et al., 2013). The use of ultrasound machines outside of hospital has previously been limited due to their size and weight. With new, lighter weight models, small portable ultrasounds have been shown by ambulance physicians to be suitable for pre-hospital use, and to improve diagnostic accuracy (Lapostolle et al., 2006).

The purpose of this article is to report upon an observational study of training paramedics to perform a focused echocardiogram during a simulated ALS resuscitation. This study was a joint investigation conducted by North East Ambulance Service (NEAS) NHS Foundation Trust and the North East Medical Ultrasound Society (NEMUS).

The primary research question of this study was:

- Can paramedics perform a focused echocardiogram in a simulated 10-second pulse check during an ALS resuscitation?

The secondary research questions were:

- Can paramedics evaluate a focused echocardiogram, for physiological causes of cardiac arrest, and possible reversible causes, during the 10-second pulse check window of a simulated cardiac arrest, after a one-day training course?
- Can paramedics apply these findings to patient care?
- What are the participating paramedics' views of the potential of ultrasound in their practice?
- Could simulation be of use in paramedic ultrasound education and assessment?

The Health Research Authority (2014) online decision tool was used to assess the requirement for ethical approval for the study. As the study did not involve the participation of any patients, research ethics committee approval was found not to be required. NEAS acted as the sponsor for the study and granted NHS permissions for the participation of the organisation's staff.

Methods

An e-mail was sent out to all 645 paramedics in NEAS asking for expressions of interest to participate in the study. The criteria for inclusion and participation was that the staff member should be a paramedic registered with the Health and Care Professions Council (HCPC) in the UK, that they were outside of their one-year preceptorship period and that they had not taken part in any ultrasound education previously. Twenty paramedics met the criteria for involvement in the study and volunteered to participate, with 10 of those volunteers selected to participate using simple random sampling. Those invited to participate were asked to attend a one-day training course, and were provided with the core/level 1 Royal College of Emergency Medicine (2010) eBook as pre-course learning materials one week prior to the course. The demographics and educational background of the participants were collected to analyse the effects of these on their performance in conducting and interpreting focused echocardiograms.

The one-day programme was taught in January 2015 by a multidisciplinary team made up of emergency medicine consultants, sonographers and a paramedic with experience of performing and teaching focused echocardiograms. The study was conducted using a VSCAN handheld ultrasound manufactured by General Electric (GE), Chicago, IL, USA. The ultrasound simulator was a Vimedix ultrasound simulator from CAE Healthcare, Saint-Laurent, Canada.

The instruction on the day involved a total of six hours of tuition, made up of three hours of classroom based learning, and three hours of practical sessions with an instructor at each station. This duration of didactic and practical training was similar to previous studies into paramedic ultrasound and echocardiograms (Backlund, Bonnett, Faragher, Haukoos, & Kendall, 2010; Brooke et al., 2012; Heegaard et al., 2004, 2010; Unlüer et al., 2011). The instructor to student ratio for practical sessions was 2:5. Participants were rotated through ultrasound stations so that they were able to practice their echocardiograms on each other to gain experience in scanning different body shapes, as well as using the Vimedix ultrasound simulator. The classroom based session introduced the participants to the basics of ultrasound, governance for the use of ultrasound and the questions of why and how ultrasound can be used in the management of cardiac arrests.

VSCAN ultrasounds are only capable of performing B-Mode (Brightness Mode) scans; therefore, candidates were not instructed in the use of M-Mode (Motion Mode) or Doppler modes. As the focus of the study was to assess the ability of the candidates to perform basic echocardiograms, only two views were taught: the subcostal or subxiphoid (SC) view, and the parasternal long axis view (PLAX). These views were chosen as being the most appropriate views for assessing the heart during a cardiac arrest.

The participants were taught to use a systemic approach to interpreting the focused echocardiogram as developed by NEMUS. The system utilises a sequential mnemonic-based system called dimensions, effort, fluid and gradient (DEFG; Supplementary 1). This method allowed the participants to systematically check the dimensions of the heart, assess its movement or global effort, check for fluid surrounding the heart and check the gradients, or flow, through the valves and chambers of the heart.

Following didactic and practical training, the participants were individually tested on the Vimedix ultrasound simulator using three different pathologies that had been covered during the teaching, with candidates being marked against the focused echocardiogram assessment form shown in Supplementary 1. Using the DEFG method for image interpretation, at each objective structured clinical examinations (OSCE) station the candidates were assessed on their ability to gain a view in 10 seconds or less, to correctly identify the pathology of the image, and on whether they would meet the assessment criteria as set by the Royal College of Emergency Medicine (2010) echocardiography in life support (ELS) competency. Each station was assessed by a different faculty member for continuity in the assessment; it also controlled for personality bias. The primary view that participants were asked to demonstrate was an SC view; if they were unable to gain this view first, a PLAX view could be obtained as a secondary alternative.

At each station the participant was timed from the start of the assessment to the point where they were able to attain the view of the heart asked for by the faculty member. They were then asked to identify the pathology found using the DEFG method of interpreting ultrasound images. The results for each OSCE station and study participant were recorded by the faculty member for later analysis. After all the participants had been through the assessments they were asked to complete an anonymous questionnaire (Supplementary 2) regarding their participation in the study and their views on ultrasound having completed the training.

All data were entered into an Excel spreadsheet (Microsoft Corp., Redmond, WA, USA) for analysis, and reported using descriptive statistics. Due to the small sample size, more advanced statistical tests were not required for this study.

Results

Of the 645 paramedics contacted, 20 were available on the day of the study and were willing to take part, representing 3.1% of the paramedic workforce. Of the 20 paramedics who volunteered, 10 were selected randomly to participate in the study. All the participants were male, with a mean age of 45.8 years (range 39–56). The average mean time qualified as a paramedic was 9.3 years (range 4–16). Six (60%) of the participants held an FdSc or BSc (Hons) in paramedic science, the other four (40%) holding the older vocational Institute of Health Care Development (IHCD) paramedic qualification.

With each participant completing three OSCE stations, a total of 30 assessments were conducted. The data from these assessments were then analysed as part of the study. It was found that the participants were able to obtain a cardiac view in 10 seconds or less in 96.7% of assessments. Correct pathology was identified in 50% of assessments, with a simulated level of competence assessment success rate of 46.67%.

The results of the OSCE assessments are shown in Table 1, with the results shown by paramedic education background in Table 2 for comparison.

Following the OSCEs, the participants were asked to complete a feedback form to analyse their learning experience. In this feedback they were asked whether they felt ultrasound would be of value in their practice, if they now felt able to perform a scan in a cardiac arrest and whether they would recommend learning ultrasound skills to their colleagues. The results of these questions are shown in Table 3.

Discussion

The sub-analysis of the results of the three different pathologies shows that the performance of the candidates

Table 1. Results from the objective structured clinical examinations (OSCEs).

Simulated pathology	Able to obtain a view in < 10sec	Correctly recognised pathology	Demonstrated competence
Ventricular fibrillation	100% (n = 10)	20% (n = 2)	10% (n = 1)
Cardiac tamponade/pericardial effusion	100% (n = 10)	70% (n = 7)	80% (n = 8)
Hypodynamic heart	90% (n = 9)	60% (n = 6)	50% (n = 5)
Overall	**96.7% (n = 29)**	**50% (n = 15)**	**46.7% (n = 14)**

Table 2. Results from the objective structured clinical examinations (OSCEs) based on education background.

Education background	Able to obtain a view in < 10 sec	Correctly recognised pathology	Demonstrated competence
Higher education FdSc/BSc (n = 6)	94.3% (n = 17)	44.5% (n = 8)	44.5% (n = 8)
IHCD vocational qualification (n = 4)	100.0% (n = 12)	58.3% (n = 7)	50.0% (n = 6)
Overall (n = 10)	**96.7% (n = 29)**	**50% (n = 15)**	**46.7% (n = 14)**

Table 3. Results of participant questionnaires.

	Yes	Maybe	No
Do you feel that ultrasound would be of value your practice?	100% (n = 10)	0% (n = 0)	0% (n = 0)
Do you feel that you would be able to take an echocardiogram during a cardiac arrest?	90% (n = 9)	10% (n = 1)	0% (n = 0)
Would you recommend a colleague to take an ultrasound course?	100% (n = 10)	0% (n = 0)	0% (n = 0)

was only consistent in that a view was obtained in less than 10 seconds. The ability to correctly recognise the presented pathology differs between the assessments, with large abnormalities being recognised more accurately than smaller ones. Dynamic presentations with movement and activity were also more accurately recognised that less dynamic ones. Although VF was only correctly recognised by 20% of the participants, the incorrect answer given in the other 80% was that of asystole, showing in this study that following a one-day training course the paramedics were unable to differentiate between VF and asystole in a simulated ultrasound image. This result differs from the results obtain by both Booth et al. (2015) and Backlund et al. (2010) in that their participants, after a one-day course, were with a high level of sensitivity able to detect cardiac activity. The assessment methodology may explain this difference, in that the previous studies used live models and video clips while this study utilised high fidelity ultrasound simulation. The consistent error in interpretation may point to limitations in the training or in the candidates' ability to interpret simulated images, which could be corrected in future courses to equip the paramedics to better interpret less dynamic images.

Previous studies of paramedics' ability to perform ultrasound have involved healthy volunteers acting as patients or pre-recorded video loops of scans, with the paramedics' performances being compared with an expert user of ultrasound such as a senior doctor or sonographer (Backlund et al., 2010; Booth et al., 2015; Brooke et al., 2012). Although a recognised research methodology, this method has a number of flaws, in that the scans are being performed on fit, healthy people who present with none of the pathologies that the paramedics are being assessed on or may see in practice. The use of clips does not allow for the paramedic to demonstrate the psychomotor skill of gaining the view required and concurrently interpreting that view. The use of other participants as live models in the study could also lead to bias.

For this study it was decided to use an ultrasound simulator instead of using video clips and live models. This was so that we could also evaluate the use of ultrasound simulators in paramedic research. Simulation allows for various pathologies to be used both as part of the teaching process and for examination. The simulated presentations could be rare, such as cardiac tamponade, or time critical, such as hypovolemia or pulseless electrical activity, which limits the opportunities for learning and competency assessment on actual patients. The use of simulation also allows for each practical training session and the assessment to be standardised (Lewiss, Hoffmann, Beaulieu, & Phelan, 2014). Therefore, the use of simulation prevents variations due to availability, positioning or compliance of the live model(s).

The ability of the participants to gain a view in the 10-second window was comparable with a previous UK study looking at paramedics performing echocardiograms during a 10-second resuscitation window, which reported that a view was achieved in 88% of attempts (Booth et al., 2015). Heegaard et al. (2004) also reported that in their study of aeromedical paramedics and nurses in the US a view was obtained in 95% of cardiac scans.

In this study, although only a small sample, education background does not appear to prevent those educated at levels below higher education from learning the skills and competencies to perform focused echocardiograms, as shown in Table 2. In fact, those without a degree appeared to gain slightly better results in the OSCE than their degree-educated peers. These results suggest that ultrasound, although generally taught at Master's level, can be learned by paramedics without a higher education background.

Although this study and others have demonstrated that paramedics are able to perform ultrasound scans in the pre-hospital environment, there have been no large studies conducted to show if this intervention improves patient outcomes. There are also no large research studies specifically looking into paramedic echocardiograms and its effect on patient care. Two studies with samples of over 100 patients have shown good correlation between the ultrasound scans and interpretation conducted on trauma patients by paramedics pre-hospitally and the diagnosis of those patients in hospital (Heegaard et al., 2010; Unlüer et al., 2011).

Limitations

The limitations of the study are that the sample of paramedics was small with only 10 participants. The sample selected at random was all-male, and thus not representative of the paramedic workforce population; no female paramedics volunteered or were involved as participants in the study. However, the authors do not feel that this would have changed the results or the conclusion of the study. Although the participants were trained to use the VSCAN handheld ultrasound machine, due to the technology the assessments had to be completed on the Vimedix ultrasound simulator, which has a larger, clearer screen than the small handheld ultrasound. The participants were therefore not assessed on the ultrasound machine they received training on nor assessed for competence in using that ultrasound device.

Due to funding limitations it was not possible to reassess the participants at a later date to examine the level of simulated competence at that time, and whether consolidation of learning had occurred. In the study by Booth et al. (2015) it was found that psychomotor performance had decreased in the 10 weeks following the initial ultrasound training, particularly in the participants' ability to gain a parasternal view. It was not possible in this study to assess whether the same decrease in ability would be evident over time.

The questionnaires at the end of the course, although completed anonymously were done straight after the OSCE assessment, which may have affected the participants' responses. The results of the questionnaire may also be influenced by selection bias, since the participants volunteered as they wished to participate in study into paramedic ultrasound use; this interest may have influenced the answers given in the questionnaire.

Conclusion

The results of this study demonstrate that paramedics can be trained to use a focused echocardiogram to obtain a view of the heart during a simulated 10-second pulse check, but are not consistently able to determine the cardiac activity or pathology from the echocardiogram. Future paramedic education for focused echocardiogram needs to be greater than the equivalent of one day's training if those participating are going to be able to consistently demonstrate simulated competence. Paramedics who participated felt capable of obtaining an image after one day's training and felt that ultrasound would be of value in their practice. Further research is required in this area to give a study which is powered enough to provide good statistical evidence of the benefits of paramedic ultrasound and the most effective methods of training.

Ultrasound simulation during this study was found to be a suitable method for ultrasound education, and was found to be suitable for OSCE assessments for paramedics to be able to demonstrate simulated competence of basic echocardiograms. Simulation could help provide ultrasound experience for paramedics where there are limited opportunities for scanning due to training and work environment.

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Conflict of interest

None declared.

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