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Timing of focused cardiac ultrasound during advanced life support – A prospective clinical study☆

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ABSTRACT

Introduction: Focused cardiac ultrasound can potentially identify reversible causes of cardiac arrest during advanced life support (ALS), but data on the timing of image acquisition are lacking. This study aimed to compare the quality of images obtained during rhythm analysis, bag-mask ventilations, and chest compressions.
Methods: Adult patients in cardiac arrest were prospectively included during 23 months at a Danish community hospital. Physicians who had completed basic ultrasound training performed subcostal focused cardiac ultrasound during rhythm analysis, bag-mask ventilations, and chest compressions. Image quality was categorised as either useful for interpretation or not. Two echocardiography experts rated images useful for interpretation if all the following characteristics could be determined: 1) right ventricle larger than left ventricle, 2) pericardial fluid, and 3) collapsing ventricles.
Results: Images were obtained from 60 of 114 patients undergoing ALS. A higher proportion of the images obtained during rhythm analysis and bag-mask ventilations were useful for interpretation when compared with chest compressions (rhythm analysis vs chest compressions: OR 2.2 (95%CI 1.3–3.8), P = 0.005; bag mask ventilations vs chest compressions: OR 2.0 (95%CI 1.1–3.7), P = 0.03). There was no difference between images obtained during rhythm analysis and bag-mask ventilations (OR 1.1 (95%CI 0.6–2.0), P = 0.74).
Conclusion: The quality of focused cardiac ultrasound images obtained during rhythm analysis and bag-mask ventilations was superior to that of images obtained during chest compressions. There was no difference in the quality of images obtained during rhythm analysis and bag-mask ventilations. Bag-mask ventilations may constitute an overlooked opportunity for image acquisition during ALS.

Introduction

International resuscitation guidelines stipulate that focused cardiac ultrasound has potential to identify reversible causes of cardiac arrest during advanced life support (ALS) [1,2]. The International Liaison Committee on Resuscitation ALS Task Force state that there is inadequate evidence to evaluate whether cardiac ultrasound is of benefit during ALS and recommends that ultrasound should not interfere with the ALS algorithm [3]. This poses a challenge to ultrasound image acquisition.

Previous studies have demonstrated that focused cardiac ultrasound can be obtained during either a rhythm analysis or a separate interruption in chest compressions, if both are extended for up to 10 s [4,5]. The quality of images obtained during other phases of the ALS algorithm, i.e. during bag-mask ventilations or chest compressions, has not been investigated. In patients with spontaneous circulation, a deep inspiration enhances image quality when the ultrasound transducer is in a subcostal position [6]. The same could apply during bag-mask ventilations in patients undergoing

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resuscitation, but there may not be sufficient time for transducer adjustment and positive pressure ventilation may compromise image quality by causing lung-shadowing. During chest compressions, there is ample time to adjust the ultrasound transducer, but movement of the thorax may compromise image quality.

The aim of this study was to compare the quality of focused cardiac ultrasound images obtained during rhythm analysis, bag-mask ventilations, and chest compressions.

We hypothesised that the quality of images obtained during rhythm analysis is superior to that of images obtained during bag-mask ventilations and chest compressions.

Methods

Study design and setting

In this prospective, observational study, patients were included from February 16, 2015 to December 31, 2016 in a Danish community hospital (Regional Hospital Randers, Denmark, catchment area: ~230,000 inhabitants, annual admissions: ~36,500 patients). Acute and elective medical and surgical patients are treated at the hospital.

Ethics

The hospital resuscitation committee approved the study. The ethics committee of the Central Denmark Region regarded the study as a quality assurance project and waived approval and informed consent.

The resuscitation team was informed that no intended action was to be interrupted, delayed, or omitted because of ultrasound image acquisition, especially not defibrillation and chest compressions. The physicians performing ultrasonography were instructed to convey any ultrasonography information that they believed should influence treatment of the patient to the resuscitation team.

Participants

Focused cardiac ultrasound was performed on consecutive patients (≥18 years) undergoing ALS, by physicians who were either anaesthesiology registrars in their final year of training or consultant anaesthesiologists, 24 h a day during the study period.

Focused cardiac ultrasound education

The use of focused cardiac ultrasound in the Department of Anaesthesiology, Regional Hospital Randers was implemented by a previously described educational program in fall 2012 [7]. Briefly, the training consisted of a commercial available e-learning (usabcd.org, Aarhus, Denmark), a one-day hands-on course, and 10 supervised focused cardiac ultrasound examinations of patients with spontaneous circulation. After the fall of 2012, new members of the staff were trained according to the systematic educational program, if they had not previously completed training in focused cardiac ultrasound on a similar level. For this study, additional education in the form of a lecture and simulation based training in obtaining focused cardiac ultrasound images during ALS was conducted in 3-h sessions with groups of two to five physicians.

Image acquisition

When the resuscitation team was activated, the anaesthesiologist brought the ultrasound apparatus to the location of cardiac arrest. All examinations were performed using a portable ultrasound apparatus (Vivid i, GE Healthcare, Little Chalfont, UK) with an MS3 phased array transducer. The apparatus was pre-set to a depth of 18 cm and recording of 5-s ultrasound loops. A commercial cart designed for the ultrasound apparatus was used (SafeLock Cart, GE Healthcare, Little Chalfont, UK).

Subcostal ultrasound imaging was performed during rhythm analysis, bag-mask ventilations, and chest compressions, during the ALS algorithm [1]. The anaesthesiologists were instructed to save at least one loop during each of the three phases but could save up to 10 per patient. During focused cardiac ultrasound, a form was completed to mark the ALS phase in which each image was obtained.

Focused cardiac ultrasound was not performed, if 1) resuscitation was terminated or return of spontaneous circulation (ROSC) was achieved before the arrival of the ultrasound apparatus, 2) the anaesthesiologist was involved in other tasks related to the resuscitation of the patient, or 3) the anaesthesiologist was occupied with other medical emergencies at the hospital.

Study endpoints

The primary study endpoint was the proportion of images useful for interpretation as assessed by twoechocardiography experts (CAF, RRN) certified by the Danish Society of Cardiology. An image was rated useful for interpretation if the experts assessed that the quality of the image was sufficient to determine the presence of all the following predefined ultrasound characteristics: 1) right ventricle larger than the left ventricle (yes/no), 2) pericardial fluid present (yes/no), and 3) collapsing ventricles present (yes/no). If one or more of these characteristics could not be determined, the image was rated not useful for interpretation. The echocardiography experts were blinded to both the patient and phase of acquisition and reviewed images in a randomised order using a computer equipped with EchoPAC™ (GE Healthcare, Little Chalfont, UK).

As a secondary endpoint, the senior anaesthesiologists evaluated images using the same method as the echocardiography experts. They used the screen of the ultrasound apparatus and were not blinded to the phase in which images were obtained. Other secondary endpoints were 1) the presence of ultrasound characteristics (right ventricle larger than left, pericardial fluid, collapsing ventricles) assessed by the experts, given sufficient image quality, 2) whether pericardial fluid was assessed by the experts to measure more than 1 cm from the epicardium to the parietal pericardium, 3) primary causes of cardiac arrest among the included patients.

Other data collection

Based on reviews of electronic hospital patient records, a board-certified specialist in intensive care medicine determined presumed causes of cardiac arrest per the Hs and Ts mnemonic [3]. Other data extracted from the patient record included: age, weight, height, comorbidity, whether the patient achieved ROSC, and survival to discharge. Time to first ultrasound image was calculated as the difference between time of hospital resuscitation team activation and first saved ultrasound image. The duration of the resuscitation attempt was obtained from a national Danish in-hospital cardiac arrest database (DANARREST) [8].

Statistical methods

Logistic regression was used to examine the association between the proportion of images useful for interpretation and the ALS phase in which images were obtained (rhythm analysis, bag-mask ventilations, or chest compressions) taking clustering by patient into account. The sequence in which images were obtained in each patient was included in the logistic regression model in the following categories: image 1–3, 4–6, or 7–10. Also included in the