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To cite this article: Mark A. Merlin, Joslyn Joseph, Janae Hohbein, Navin Ariyaprakai, James Tanis & AmmundEEP Tagore (2019): Out-of-Hospital Transesophageal Echocardiogram for Cardiac Arrest Resuscitation: The Initial Case, Prehospital Emergency Care, DOI: 10.1080/10903127.2019.1604926

To link to this article: https://doi.org/10.1080/10903127.2019.1604926

Accepted author version posted online: 08 Apr 2019.
Published online: 10 May 2019.

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OUT-OF-HOSPITAL TRANSESOPHAGEAL ECHOCARDIOGRAM FOR CARDIAC ARREST RESUSCITATION: THE INITIAL CASE

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ABSTRACT

Objective: The use of transesophageal echocardiogram (TEE) during cardiac arrest in the emergency department (ED) is a newer concept. TEE provides dynamic evaluation of chest compressions and rhythm analysis. Hand placement using external landmarks can result in maximal compression over the aorta, rather than the ventricles of the heart. Methods: We present the initial case of TEE performed in the out of hospital setting in an ambulance to facilitate cardiac arrest resuscitation using a disposable TEE probe. Results: This case is a proof of concept that TEE can be successfully performed and contribute to clinical care of cardiac arrest in the out of hospital setting. Conclusion: Further research needs to be performed to determine the clinical benefit, indications, and curriculum for emergency providers to successfully deliver this potentially valuable resource prior to widespread adoption. Key words: EMS physician; prehospital; transesophageal echocardiogram; cardiac arrest; EMS; paramedics

PREHOSPITAL EMERGENCY CARE 2019;00:000–000

INTRODUCTION

The use of transesophageal echocardiogram (TEE) during cardiac arrest in the emergency department (ED) is a newer concept. TEE provides dynamic evaluation of chest compressions and rhythm analysis. Transthoracic echocardiogram (TTE) is used more commonly but is limited by suboptimal views in patients with a large body habitus and the need to interrupt chest compressions (1). Huiz et al. demonstrated that TTE during cardiac arrest results in prolonged rhythm checks greater than the recommended American Heart Association (AHA) guidelines of 10 seconds (2). Additionally, the AHA recommends hand placement during cardiac arrest to be located over the lower half of the sternum; however, this position may actually lead to compression of the left ventricular outflow track (LVOT), aortic valve, or proximal aorta, resulting in diminished forward flow (1–4). Routine TEE can potentially impact clinical decision making during resuscitation similar to TTE and also allow resuscitation personnel to directly observe and optimize flow across the aortic outflow tract in real time without pausing chest compressions. Here, we present the initial case of TEE performed in the out of hospital setting in an ambulance to facilitate cardiac arrest resuscitation using a disposable TEE probe (imaCor, Garden City, NY).

DEVICE

Utilization of TEE has become more practical since the development of the first disposable probe attachment. Given the unpredictable nature of cardiac arrest, using non-disposable probes that require medical sterilization is neither practical nor cost effective in the emergent setting and, specifically, the out-of-hospital setting.

Compared with conventional TEE, the disposable TEE uses a smaller transducer that can remain in place in a mechanically ventilated patient for up to 72 hours and is suitable for practitioners with less formal training in echocardiography (5). Each probe costs approximately $2,000 and the monitor costs $80,000; however, these costs are rapidly changing as the technology improves. Technology improvement is also anticipated to decrease the size, weight, and portability of the current 35 lb. monitor.

EDUCATION

Our group of Emergency Medical Services (EMS) physicians underwent a 5-hour training program in TEE. All physicians received ultrasound training as part of their emergency medicine residencies including training in echocardiography. None had received prior training in TEE beyond observing the

Received January 30, 2019 from MD1, NJ Statewide EMS Physician Response, Newark, New Jersey (MAM, JJ, JH, NA, JT, AT); Beth Israel Medical Center, Newark, New Jersey (MAM, JJ, JH, NA, JT, AT). Revision received March 31, 2019; accepted for publication April 4, 2019.

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doi:10.1080/10903127.2019.1604926
procedure. The initial 2-hour didactic program was taught by a cardiologist with significant TEE experience. The didactic program consisted of utilization of the monitor and a presentation on the operation of the TEE probe. Additionally, all participants watched a video demonstrating how to connect the probe to the monitor and the basic set up. After the 2-hour lecture, a simulator was used to develop an operational skill set on the disposable probe. Each EMS Physician practiced multiple views for an additional 2 hours. Lastly, everyone was required to watch the operational video again and participate in a bedside TEE. The only indication established for an out of hospital TEE for our group was cardiac arrest with ongoing cardiopulmonary resuscitation (CPR) and intubation. The TEE is not meant to delay on scene time, however the EMS system routinely treats cardiac arrest at the scene. An EMS physician is available at all times for response throughout the state at all times. When the EMS Physician arrived at the scene, CPR was in progress. PEA with a narrow complex tachycardia was noted on the monitor during the first rhythm check after physician arrival. At this time, the TEE was connected and the probe was easily inserted into the patient’s esophagus without interruption of CPR. A 4-chamber cardiac view found adequate movement of the left ventricle with an ejection fraction (EF) of approximately 10–20% with apical and septal hypokinesis (Figures 1–3). Subsequently, 20 µg of epinephrine was administered with a normal saline bolus of 1,000 mL, and CPR was discontinued. This resulted in a return of palpable pulses and a blood pressure of 100/62 mmHg, which was maintained during transport to the hospital. Figure 1 was obtained during cardiac arrest in the back of a moving ambulance.

The patient was admitted to the hospital, status post-return of spontaneous circulation. The TTE performed on the second day of admission revealed no wall motion abnormality with an EF of 40–45%. The patient was admitted to the ICU. She developed rapid atrial fibrillation, aspiration pneumonia, worsening pancytopenia, and fever. She achieved a Cerebral Performance Category Score of 3 but deteriorated rapidly and care was withdrawn on hospital day 4. Prior to withdrawal of care, no additional episodes of cardiac arrest occurred.

**Discussion**

The application of TEE in cardiac arrest was first described by Redberg et al. in 1993 (6). TEE during
CPR is superior to TTE, as it does not require access to the patient’s chest and allows easier acquisition of images during active chest compressions.

Hand placement using external landmarks can result in maximal compression over the aorta, rather than the ventricles of the heart. Giraud et al. published a case report describing the LUCAS-2 device as providing suboptimal chest compressions, likely due to the placement of the device on the patient’s chest (4). TEE can uniquely identify where maximal compression force is occurring and allows for appropriate adjustments to be made.

TEE can also identify shockable rhythms during compressions before they are visible on a monitor. One study evaluating 100 out-of-hospital cardiac arrests demonstrated that 35% of patients initially classified as asystole actually had cardiac contractility identified by echocardiography (7). In our case, TEE placement and imaging resulted in no interruption of chest compressions and differentiated that the patient was in pseudo-PEA with hypotension that resulted in a lack of palpable pulses. This led to appropriate cessation of CPR with infusion of epinephrine bolus and return of spontaneous circulation.

TEE can be learned with minimal training and is well within the scope of practice of resuscitationists (8–12). The American College of Emergency Physicians (ACEP) issued a policy statement in 2017 supporting the use of TEE in cardiac arrest. Increase use of TEE in emergency departments will potentially occur in the next few years (8). Although there is a lack of published literature regarding education for TEE use in the out-of-hospital setting, our training program was able to train physicians with this equipment in 5 hours of education, split between didactic lectures and a TEE simulator. However, all physicians were already credentialed in various hospitals in TTE, having performed a minimum of 25 TTEs each. The competency of out-of-hospital training will have to be evaluated with further research.

Several limitations exist to widespread use of disposable TEE in the out-of-hospital setting. First, the probes and monitor are expensive. Reimbursement for advanced life support is limited and these catheters cost $2,000 each. Reimbursement for advanced life support is not routinely itemized so the cost potentially needs to be placed on the patient or insurance company. Second, robust training programs for out of hospital physicians, nurses, and paramedics need to be developed. None of these providers typically receive education in TEE. Even expert TEE physicians would find deployment of the disposable device a unique experience in a moving ambulance. Third, we need to validate the use of TEE in the out-of-hospital setting. The rise of the popular ResTEE project is evidence of the increasing interest of TEE in emergency care (13). Lastly, a barrier to implementation is the initial requirement that an EMS physician respond.

Based on existing dispatch protocols that favor sensitivity for cardiac arrest over specificity, physician time is expended responding to arrests in which TEE would not be used. This would vary across system dispatch protocols and geographics.

TABLE 1. Time Table

<table>
<thead>
<tr>
<th>Sequence of events in military time</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unresponsiveness</td>
<td>1238</td>
</tr>
<tr>
<td>CPR Started</td>
<td>1239</td>
</tr>
<tr>
<td>Basic Life Support Arrival</td>
<td>1244</td>
</tr>
<tr>
<td>Advanced Life Support Arrival</td>
<td>1249</td>
</tr>
<tr>
<td>Asystole Noted</td>
<td>1249</td>
</tr>
<tr>
<td>PEA Noted</td>
<td>1252</td>
</tr>
<tr>
<td>EMS Physician Arrival</td>
<td>1251</td>
</tr>
<tr>
<td>TEE Inserted</td>
<td>1254</td>
</tr>
<tr>
<td>Epinephrine 20 ug given</td>
<td>1254</td>
</tr>
<tr>
<td>Blood pressure obtained</td>
<td>1256</td>
</tr>
<tr>
<td>CPR Discontinued</td>
<td>1256</td>
</tr>
<tr>
<td>Arrival at Hospital</td>
<td>1312</td>
</tr>
</tbody>
</table>

CPR = cardiopulmonary resuscitation; PEA = pulseless electrical activity; EMS = emergency medical services; TEE = transesophageal echocardiogram.
It remains unknown whether there is a clinical benefit to have EMS physicians or even paramedics, who see patients initially in cardiac arrest, use this modality in the field until further research is performed. While on-scene TEE appeared to change decision making in the field, it may, paradoxically, create more cases of transport and even return of spontaneous circulation (ROSC) without neurologic survival.

CONCLUSION

Utilization of TEE in the emergency setting during cardiac arrest is a newer concept. This is the first reported case and proof of concept that TEE can be successfully performed and contribute to clinical care of cardiac arrest in the out-of-hospital setting. Further research needs to be performed to determine the clinical benefit, indications, and curriculum for emergency providers to successfully deliver this potentially valuable resource prior to widespread adoption.

References