Initial Experience with a Disposable Transesophageal Echocardiography Monitoring System during Therapeutic Hypothermia following out of Hospital Cardiac Arrest

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Citation

Abstract
Objective: This investigation summarizes the initial clinical experience of trained echocardiographers who utilized a miniaturized disposable monoplane transesophageal echocardiography (TEE) system in patients undergoing therapeutic hypothermia following out of hospital cardiac arrest. Design: A retrospective, single-center, observational study. Setting: A tertiary care university hospital. Patients: We retrospectively reviewed the medical records of 13 consecutive patients undergoing therapeutic hypothermia following out of hospital cardiac arrest in which a disposable monoplane TEE probe was placed to observe myocardial recovery and potentially guide hemodynamic optimization. Measurements and Main Results: A total of 40 imaging sessions were performed. The success rate for obtaining the mid-esophageal four chamber and the transgastric mid-papillary short axis views were 92.5% and 100% respectively. Endocardial border definition was adequate in 90% of imaging sessions to measure left ventricular end diastolic and systolic areas enabling calculation of fractional area of change. Assessment of right ventricular function was possible in 92.5% of imaging sessions. A significant number of imaging sessions (12/40, 30%) provided information that clarified the patient’s biventricular function in the setting of ambiguous invasive pressure monitoring measurements. Conclusions: Acquisition of a mid esophageal four chamber and transgastric mid papillary view was possible with the miniaturized disposable TEE probe in the vast majority of imaging sessions. This information enabled the qualitative assessment of right ventricular function, measurement of left ventricular end systolic, and diastolic area with a high degree of success in patients during therapeutic hypothermia following cardiac arrest. The authors postulate that serial assessment of biventricular function and filling with serial TEE imaging provides information that cannot be reliably inferred from other advanced hemodynamic monitoring devices in routine clinical practice.

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INTRODUCTION
Therapeutic hypothermia is an important evidence-based and cost effective therapy following resuscitation from out-of-hospital non-traumatic cardiac arrest [1]. Following resuscitation, practice guidelines recommend early hemodynamic optimization, however specific goals of resuscitation including central venous pressure, mean arterial pressure, mixed venous oxygen saturation, hematocrit, lactate, urine output, and oxygen delivery index are not supported by prospective evaluation [2].

Echocardiography and cardiac output monitoring are recognized advanced monitoring tools to guide hemodynamic optimization in this patient population [2,3]. Recent literature has called into question the accuracy of cardiac output monitoring techniques during hemodynamic instability [4-6]. Practice guidelines generally favor TEE rather than transthoracic echocardiography in mechanically ventilated patients [7]. The challenges of using conventional TEE systems to monitor cardiac function and filling in the ICU setting have been previously described [8]. The ClariTEE™ (Imacor, Uniondale, NY), a miniaturized disposable monoplane TEE probe is approved by the United States Food and Drug Administration to monitor cardiac function and filling for up to 72 hours in mechanically ventilated patients. The initial clinical experience of trained echocardiographer’s who utilized this disposable TEE system in 13 patients undergoing therapeutic hypothermia following
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out-of-hospital cardiac arrest is described.

MATERIALS AND METHODS

This retrospective review was performed after the creation of an Institutional Review Board approved registry of patients undergoing therapeutic hypothermia following out-of-hospital cardiac arrest. Inclusion criteria for the hypothermia protocol included patients over the age of 18 years, estimated time from cardiac arrest to return of spontaneous circulation of less than 60 minutes, unresponsiveness to verbal commands, and ability to initiate the hypothermia protocol within 6-12 hours of return of spontaneous circulation. Exclusion criteria included known pregnancy, initial temperature less than 34°C, known terminal illness, recent major head trauma or traumatic arrest, drug-induced coma and a pathologic bleeding diathesis or ongoing bleeding.

Initial cooling techniques included external ice packs and cold crystalloid infusions while the definitive cooling technique was external gel pad heat exchange with the Arctic Sun 2000 system (Medivance Inc, Louisville, Co). Patients were cooled to target bladder/rectal temperatures of 32-34°C for 24 hours and then rewarmed according to protocol. Standardized sedation, neuromuscular blockade, and mechanical ventilation protocols were followed. Arterial blood pressure was monitored in all patients while central venous and pulmonary artery pressures were measured in some patients.

The ClariTEE™ probes were purchased from the vendor as part of a formal institutional quality assessment program and were placed in 13 consecutive patients undergoing therapeutic hypothermia after arrival to the Intensive Care Unit. There were no contraindications to TEE probe placement. All echocardiographic images were confirmed and interpreted by an intensivist/cardiothoracic anesthesiologist certified in Advanced Perioperative Transesophageal Echocardiography by the National Board of Echocardiography. The imaging sessions were performed to assess biventricular function and filling in the setting of ambiguous invasive hemodynamic pressure measurements.

RESULTS

40 imaging sessions were performed in 13 patients following induction of hypothermia. There were no complications from using the disposable TEE imaging system. Table 1 lists the specific echocardiographic observations during four-hour increments for the first forty hours of the ICU admission. Attempts to obtain a mid esophageal four chamber and transgastric mid papillary short axis view were made during each imaging session. The echocardiographers were able to successfully obtain these views in 37 (92%) and 40 (100%) imaging sessions, respectively. Endocardial border definition was adequate in the transgastric mid papillary short axis view to trace left ventricular end systolic and diastolic area in 36 (90%) of the imaging sessions. Qualitative assessment of right ventricular function was possible in 37 (92.5%) imaging sessions from the mid esophageal four chamber view. This was inferred from the motion of the lateral tricuspid annulus, right ventricular free wall thickening, motion of the Interventricular septum, and right ventricular diameter relative to the left ventricle. Left ventricular regional wall motion abnormalities were observed during 16 (40%) imaging sessions primarily in the transgastric mid papillary short axis view.

Echocardiographic assessment of ventricular filling included measurement of left ventricular end diastolic area, right ventricular filling as visualized in the mid esophageal four chamber view, and the shape of the interventricular septum in the transgastric mid papillary short axis view. As shown in Figure 1, we observed a significant incidence of right ventricular dysfunction in the setting of unconcerning central venous pressure measurements. In 12 imaging sessions the echocardiographic assessment of biventricular filling and function was not consistent with right heart invasive pressure measurements and interventions aimed to optimize hemodynamic conditions for myocardial recovery based on the aforementioned ambiguous right heart pressure readings were not undertaken.

Figure 1

Figure 1: Right ventricular function and corresponding central venous pressure

Figure 1 Legend:

Figure 1 plots observed right ventricular function against the corresponding central venous pressure at the time of the
imaging session. The data was extracted from 11 of the 13 patients that had central venous pressure monitoring in place during at least one imaging session. There is no correlation between right ventricular dysfunction and central venous pressure.

Figure 2
Table 1. Echocardiographic Observations with the ClariTEE™ probe during Therapeutic Hypothermia

Table 1. Displays the echocardiographic observations made with the ClariTEE probe in 13 patients who underwent therapeutic hypothermia following out of hospital cardiac arrest. An imaging session is defined as the attempt to acquire a mid esophageal four-chamber view and a transgastric mid papillary short axis view. Abbreviations: LVEDA = Left Ventricular End Diastolic Area, ME = Mid Esophageal, TG = Transgastric, pap = papillary, SAX = Short Axis, FAC = Fractional Area of Change, RWMA = Regional Wall Motion Abnormalities

DISCUSSION
The utility of echocardiography in the intensive care unit is well-documented and given that usable images were obtained in nearly all patients without complication further investigation examining the impact of this technology on patient outcomes may be warranted [7]. Traditionally, echocardiography is regarded as a static diagnostic modality rather than as a monitoring technique, and echocardiography services have been constructed around this premise. During therapeutic hypothermia, myocardial recovery is a dynamic process that may be adversely affected by interventions aimed at optimizing indirect measures of cardiac function and filling, such as invasive right heart pressure monitoring, stroke-volume variability, mixed venous oxygen saturation, and cardiac output monitoring. The ability to visualize directly the changes in biventricular filling and function in response to therapy (medication, dialysis, blood product transfusion, etc.) or the potential response to therapy such as a fluid responsiveness maneuver (leg lift, table tilt test) may be desirable to clinicians charged with caring for the critically ill. For example in one patient during hypothermia with expected natriuresis intravascular volume replacement may be indicated however presence of right ventricular dysfunction was an indication to withhold intravascular volume replacement out of concern that right ventricular failure may result from volume administration. As rewarming commenced and biventricular function improved intravascular volume was replaced while monitoring right ventricular function.

Factors limiting the routine use of TEE as a monitoring tool in mechanically ventilated patients fall into three categories: cost, patient safety, and physician training. The cost of the ClariTEE™ probe is approximately 1000 dollars US. There is no need for a sterilization system that conventional TEE probes require with incurred costs. Further, most healthcare systems cannot afford conventional TEE probes for every intensive care unit bed. While TEE is generally considered a safe modality, there is no data regarding the safety of frequent probe insertions or leaving a conventional TEE probe in a patient unsupervised for a prolonged period [9]. Adequate training in echocardiography is the greatest barrier to the routine use of TEE as a monitoring tool in the intensive care unit. The “2-view” monoplane TEE exam described in this manuscript likely requires less expertise to perform and interpret compared to a complete multiplane TEE exam. However, prospective investigation is needed to examine what training requirements are needed to correctly obtain and interpret this “2-view” monoplane TEE exam.

CONCLUSION
In 13 patients undergoing therapeutic hypothermia following out of hospital cardiac arrest, trained echocardiographers were able to use this disposable TEE probe to acquire the mid esophageal four chamber and transgastric mid papillary short axis views with a high degree of success. Endocardial border definition was adequate 90% of the time to calculate left ventricular fractional area of change. Disposable monoplane TEE probes enable direct assessment of biventricular function and filling in the setting of therapeutic hypothermia following resuscitation from cardiac arrest that cannot be inferred from other routinely utilized hemodynamic monitors.

CONFLICTS OF INTEREST STATEMENT
Drs. Bick and Wagner and have taught echocardiography courses in which the administrative costs were supported by educational grants from Imacor and Sonosite. Drs. Schaff and McPherson have no conflicts of interest to report.
References


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