The Usefulness of Transesophageal Echocardiography During Intraoperative Cardiac Arrest in Noncardiac Surgery

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According to guidelines established by the American Society of Anesthesiologists and the Society of Cardiovascular Anesthesiologists, life-threatening hemodynamic disturbances are classified as a category I indication for the intraoperative use of transesophageal echocardiography (TEE). However, the usefulness of TEE during intraoperative cardiac arrest and its impact on patient management have not been rigorously investigated. Using our departmental TEE database, we identified a population of 22 patients who underwent noncardiac surgical procedures and experienced unexpected intraoperative hemodynamic collapse requiring the initiation of Advanced Cardiac Life Support procedures between the time of induction of general anesthesia and the termination of the surgical procedure. Results of TEE examinations, patient records, detailed operative records, and outcome of patients were reviewed for the utility of TEE to diagnose the etiology of the hemodynamic collapse. Furthermore, the impact on subsequent patient management was evaluated. A primary suspected diagnosis of the underlying pathological process was established in 19 of 22 patients with TEE, including 9 with thromboembolic events, 6 with acute myocardial ischemia, 2 with hypovolemia, and 2 patients with pericardial tamponade. A definitive diagnosis could not be made in 3 patients with TEE. In 18 patients, TEE guided specific management beyond implementation of Advanced Cardiac Life Support protocols, including the addition of surgical procedures in 12 patients. Fourteen patients survived to leave the operating room, and 7 of these patients were eventually discharged from the hospital. Thus, TEE may provide additional diagnostic information in patients with intraoperative cardiac arrest and may directly guide specific, potentially life-saving therapy.

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Transesophageal echocardiography (TEE) is used in 98% of all teaching hospitals in the United States in routine clinical practice (1). In the operating room (OR), it is often used as a routine diagnostic and monitoring tool during open heart surgery, influencing the management in more than one fifth of cases in some series (2). The American Society of Anesthesiologists (ASA) and the Society of Cardiovascular Anesthesiologists have issued guidelines for the intraoperative use of TEE (3). In these guidelines, the presence of life-threatening hemodynamic disturbances is classified as a category I indication for the use of TEE, which is therefore thought to directly contribute to improving outcomes in this clinical scenario. In view of a paucity of scientific data to support this recommendation, its basis relies largely on expert opinion.

TEE reliably produces cardiac images and during cardiopulmonary resuscitation does not interfere with continuing resuscitation efforts as demonstrated in a prior series of patients experiencing cardiac arrest in nonoperative, in-hospital, and out-of-hospital settings (4). Although TEE is immediately available in many ORs, its usefulness as a diagnostic modality during intraoperative cardiac arrest is unknown. Therefore, we investigated a series of 22 patients who experienced unexpected, intraoperative cardiac arrest while undergoing noncardiac surgical procedures to determine usefulness, diagnostic capabilities, and impact of TEE on the management of these patients.

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Methods

The study population consisted of patients who experienced cardiac arrest during noncardiac surgical procedures between January 1995 and May 2005 at the Brigham and Women's Hospital and subsequently underwent a TEE examination during the course of resuscitation at the request of the team caring for the patient. For the purpose of this study, cardiac arrest was defined as absent or ineffective cardiac pump function leading to inadequate circulation that was unexpected and required cardiopulmonary resuscitation according to the Advanced Cardiac Life Support guidelines. Patients who arrived in the operating room after cardiac arrest in locations other than the operating room were not included in this series. Patients were identified using the departmental TEE database. Approval for the retrospective data analysis was obtained from the IRB.

Emergency TEE examinations were performed after patients experienced cardiac arrest as previously defined and Advanced Cardiac Life Support efforts had been started. All TEE examinations were performed using multipanele probes (3 to 7 MHz; Acuson, Mountain View, CA) and were videotaped by cardiac anesthesiologists with extensive experience in the interpretation of perioperative TEE examinations and were correlated with findings recorded during the initial examination.

Surgical operative notes and detailed anesthesia records were reviewed. Data pertaining to age, gender, ASA physical status, indication, and type of surgery were recorded. Written echocardiographic records completed by a cardiac anesthesiologist immediately after the arrest were reviewed. The implementation of further management such as additional surgical procedures or other therapeutic modalities initiated in an attempt to improve patient outcome was recorded. Survival data and postmortem reports were reviewed and findings recorded.

Results

Twenty-two patients (15 male, 7 female) were identified who experienced an intraoperative cardiac arrest during noncardiac surgical procedures and underwent subsequent intraoperative TEE examination. Eight of these patients were scheduled for emergency procedures (Table 1). The initial electrocardiogram recorded during the event was identified as electromechanical dissociation in 9, asystole in 5, bradycardia in 2, ventricular fibrillation in 4, and ventricular tachycardia in 1 of 22 patients. No information on the initial rhythm was found in 1 patient.

A suspected primary diagnosis could be established with TEE in 19 patients (Table 2). The TEE findings
aided in further management in 18 patients, and included the implementation of specific surgical interventions in 12 patients. Diagnosis with TEE revealed signs of myocardial ischemia in 6 patients. Three of these patients underwent emergency coronary artery bypass grafting. One patient received an intra-aortic balloon pump and was treated medically for an acute myocardial infarction (MI). In 9 patients, thromboembolic events of the central vasculature were diagnosed. In 6 patients, thrombi were visualized directly, and in 3 patients, indirect signs of pulmonary emboli (PE) were identified. Four patients underwent emergency pulmonary embolectomy, 1 patient with a left ventricular thrombus underwent a surgical thrombectomy, 2 received cardiopulmonary resuscitation only, and 2 underwent an unsuccessful exploration. In the latter 2 patients only indirect signs of PE were seen on TEE, which, in the absence of other abnormalities consistent with the cardiovascular arrest, led to the decision by the surgeon in charge to proceed with an exploration. Two patients with pericardial tamponade were treated by pericardiotomy. In 2 additional patients, the diagnosis of hypovolemia led to the initiation of vigorous fluid resuscitation.

Fourteen patients survived to leave the OR. Seven of these patients were discharged from the hospital, while the other 7 succumbed shortly after the intraoperative arrest. Postmortem examinations were performed in 3 patients. In one patient the primary diagnosis of PE was confirmed, and in another, right heart dilation was found. TEE showed indirect signs of PE in the latter. No abnormalities were found in a postmortem examination of a patient, in whom left ventricular clots had been surgically evacuated intraoperatively.

**Discussion**

The ASA and Society of Cardiovascular Anesthesiologists guidelines for the use of TEE classify acute,
life-threatening, intraoperative hemodynamic collapse as a class I indication (3). However, the specific impact of TEE on the management of patients during intraoperative hemodynamic collapse and cardiac arrest has not been thoroughly investigated.

The importance of TEE during cardiac arrest was documented in a study by van der Wouw et al. (4), which evaluated its efficacy in 48 patients after in-hospital and out-of-hospital onset cardiac arrest. A diagnosis of the underlying pathological process was made in 31 (64%) of these patients by TEE. The presumptive diagnosis was confirmed in all but 4 patients by other diagnostic modalities (e.g., angiography, postmortem examination) resulting in a sensitivity of 93%, a specificity of 50%, and a positive predictive value of 87%, respectively. Treatment was changed in 31% of all patients after TEE established a preliminary diagnosis. Because of the lack of a control group, a mortality benefit could not be demonstrated in this series. However, despite the lack of outcome data regarding mortality, previous reports underline the potentially beneficial role of TEE in the intraoperative assessment and treatment of hemodynamically unstable patients (5–7). In our series, 14 of 22 patients (64%) survived to leave the OR, and 7 patients (32%) were eventually discharged from the hospital compared with 21% of patients who regained spontaneous circulation and 8% who were discharged from the hospital in the study by van der Wouw et al. (4). This difference may be explained by the immediate availability of therapeutic interventions in the OR to initiate management for the underlying cause of the cardiac arrest.

Although the etiology of cardiac arrest may be difficult to diagnose with continuing resuscitation efforts, TEE is readily available in most hospitals, is relatively noninvasive, and does not interfere with resuscitation efforts. In addition, the utility of TEE for diagnosing the majority of specific cardiovascular abnormalities associated with cardiac arrest, including PE (8,9), myocardial ischemia (10–13), hypovolemia (14–17), and pericardial tamponade (18), have been evaluated and discussed in the literature. Nonetheless, the role of TEE during intraoperative cardiac arrest, including its utility for diagnosing the etiology and its impact on perioperative management, has not been thoroughly investigated. Limitations for the utility of TEE during cardiac arrest may include the relatively short timeframe available to make the difficult distinction between regional wall motion abnormalities associated with acute myocardial ischemia versus an old MI. In addition, an organized rhythm is necessary for evaluation of regional wall motion abnormalities, which may be absent during cardiac arrest. Furthermore, it may be difficult to determine if myocardial ischemia is the cause or the consequence of hypoperfusion during cardiac arrest. Despite these concerns, the literature suggests that episodes of spontaneous rhythm may be sufficient for diagnosis of MI by TEE during cardiac arrest (4).

Similarly, it may be difficult to determine the relevance of intracardiac thrombi, which may be the cause of the hemodynamic collapse or, alternatively, develop after a cardiac arrest as a consequence of a low flow state. Varriale and MacDonald (19) also highlighted the general value of echocardiography in determining the cause of in-hospital cardiac arrest, including its role in the intraoperative environment, and furthermore suggests that TTE may be used in the absence of the availability of TEE. However, TEE may be superior to TTE, as evident by its use in 4 of 20 patients in whom TTE imaging was deemed inadequate. In addition, unlike TTE, TEE does not interfere with resuscitative efforts such as chest compressions.

The present study is limited by the relatively small number of patients and its retrospective analysis. The inclusion of only patients who underwent intraoperative TEE may be a source of bias. The lack of a control group prohibits the determination of the independent impact of TEE on outcome in these patients. However, identifying a matched group of historical controls may be extraordinarily difficult, given the relative infrequency of this event and the multitude of conflicting variables that may impact on outcome after cardiac arrest.

Furthermore, a prospective study design in which patients experiencing cardiac arrest could be randomized to undergo TEE examination or not, would impose significant ethical constraints. These limitations account for the fact that the majority of studies involving intraoperative TEE are published as case series and also that its direct impact on outcome remains at the discretion of expert opinion. Despite these limitations, the use of TEE during cardiac arrest has few disadvantages, and it is safe when used by experienced operators (20).

Thus, the use of TEE may be of value in this setting, and its role during intraoperative cardiac arrest deserves further evaluation.

References


