Front. Med. 2012, 6(3): 332–337
DOI 10.1007/s11684-012-0212-8

COMMENTARY

Emergent limited perioperative transesophageal echocardiography: should new guidelines exist for limited echocardiography training for anesthesiologists?

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Abstract **Bedside limited echocardiography, or focused cardiac ultrasound, continues to gain popularity in many emergency rooms, intensive care units, and operating rooms as a rapid method of assessing unstable patients. Effective monitoring of cardiovascular function in conditions like cardiac arrest or near-arrest is the crucial step to guide successful resuscitative efforts. Transesophageal echocardiography (TEE) has emerged as one of the preferred cardiac diagnostic and monitoring modalities in the intraoperative setting due to the fact that it is less invasive than many other monitors, is immediately accessible, and allows for continuous real-time monitoring of cardiac function. However, the minimum training requirements needed for the anesthesia provider to obtain the competency, knowledge, and skills for basic certification in perioperative TEE far exceed those developed for other medical specialties. We believe there is an urgent need to develop (1) practical guidelines for emergent perioperative TEE use for anesthesiologists and (2) a requisite educational curriculum to teach the basic skills necessary to aid in the diagnosis and treatment of cardiac arrest or near-arrest scenarios. The measures elucidated in this report summarize the efforts of the Department of Anesthesiology at the University of Florida in establishing the necessary steps to make this process not only practical, but accessible to all trainees. We hope that these collective efforts will provide more trainees the confidence in utilizing TEE to aid in establishing a diagnosis in critical situations.**

Keywords transesophageal echocardiography; curriculum; competency training; hemodynamic instability

Introduction

Ultrasonography encompasses a myriad of applications in state-of-the-art medicine. Focused abdominal sonography for trauma (FAST), for example, has emerged as a key step in many trauma management guidelines, and is currently accepted as the "gold standard" for detection of intra-abdominal bleeding in the hemodynamically unstable patient with blunt abdominal trauma [1]. Additionally, bedside limited echocardiography by emergency physicians (BLEEP), or focused cardiac ultrasound (FOCUS), continues to gain popularity in many emergency rooms, intensive care units, and operating rooms as a rapid method of assessing unstable patients [2,3]. Furthermore, the American Society of Echocardiography (ASE) has issued a joint consensus statement with the American College of Emergency Physicians on FOCUS [4]. Training guidelines for pulmonary critical care-trained intensivists are reportedly forthcoming, and 2-day training programs on critical care echocardiography sponsored by the American College of Chest Physicians offer relevant certification [5].

Received January 27, 2012; accepted June 12, 2012
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Inconsistent training requirements for skill and knowledge of ultrasonography

Hospitalists are utilizing hand-carried echocardiography to guide inpatient decision-making in at least one inpatient facility [6]. While BLE is by no means designed to supplant or achieve equivalency with the varying levels of certification currently offered by the National Board of Echocardiography (NBE), it, nonetheless, provides physicians with an enhanced modality for point-of-care diagnostic monitoring and testing. In fact, a recent publication by Razi *et al.* reported that

internal medicine residents with limited training (20 practice studies) were able to identify left ventricular systolic dysfunction in patients with acute decompensated heart failure with superior accuracy compared with clinical, physical exam, laboratory, and electrocardiographic findings [7].

Advanced cardiovascular life support (ACLS) guidelines have emphasized several key components to improve the outcome of cardiopulmonary resuscitation (CPR). These elements include, but are not limited to, the prevention of cardiac arrest, effective treatment of cardiac arrest, and improved care following restoration of spontaneous circulation after cardiac arrest [8]. Hypovolemia, respiratory failure, and cardiac origins are generally considered the most common perioperative etiologies that cause clinically relevant hemodynamic instability leading to cardiac arrest. Effective monitoring of cardiovascular function in these situations is the crucial step in guiding successful resuscitative efforts.

Transesophageal echocardiography (TEE) has emerged as one of the preferred cardiac diagnostic and monitoring modalities in the intraoperative setting due to the fact that it is less invasive than many other monitors, is immediately accessible, allows for continuous real-time monitoring of cardiac function, and does not typically require violation of the surgical field or the need for significant repositioning [9]. Multiple case reports and case series have claimed that the use of TEE has proven beneficial in clinical decision-making, and successfully altered patients' outcomes during high-risk procedures and in various emergent clinical scenarios [10–16]. Despite the intraoperative use of TEE for cardiac surgery and complex noncardiac surgery, the routine use of TEE in perioperative arrest or near-arrest scenarios has not been established [17–19].

Although ACLS guidelines are designed to accommodate rescuers with and without advanced medical training, they contain no recommendations for the routine use of TEE during CPR [3]. Similarly, the recently described ACLS guidelines, Part 12: Cardiac Arrest in Special Situations, do not incorporate TEE into the routine algorithms despite the fact that they are designed for medical specialists [20]. Several factors may explain the delayed adoption of TEE use in these emergent conditions:

(1) There are few prospective data to support the use of TEE to improve outcomes [9,21];

(2) There are safety concerns about the routine use of TEE due to its semi-invasive nature [22–24];

(3) There is debate concerning the diagnostic accuracy of TEE during chest compressions [9,25];

(4) There is a competency requirement of basic TEE knowledge and skills to interpret positive findings during CPR [9,26].

Although sufficient prospective study data are lacking to support the routine use of TEE for high-risk surgical procedures or emergent clinical conditions, there is ample current literature to suggest that the benefits of TEE outweigh its risks as a "rescue monitoring device" during complex clinical situations [9,17,27–30]. Perhaps it is time to re-visit this unresolved issue from a pragmatic perspective rather than waiting for more evidence-based prospective study results.

Currently, the NBE has two processes available for certification in basic perioperative TEE (PTE). The requirements for certification available via the practice experience pathway to board certified anesthesiologists include 40 h of continuing medical education and 150 echocardiography examinations, in addition to achieving a passing score on the standardized examination administered once a year [31]. Unfortunately, in many anesthesiology practices, these numbers are difficult for dedicated providers to achieve, and may be impossible for all anesthesiologists to obtain due to the limited number of patients being examined annually. As a result, many anesthesiologists find themselves unable to acquire certification and/or hospital credentialing for using TEE as a potentially life-saving tool. This pathway will no longer be offered to anesthesiologists who complete their training after 2016, following which basic PTE certification will only be achievable via the supervised training pathway from an Accreditation Council for Graduate Medical Education-accredited residency program, in which the trainee must document study of 150 echocardiography examinations (of which at least 50 must be performed by the applicant). As perioperative consultants, anesthesiologists are frequently presented with hemodynamic emergencies and primary cardiac events during the perioperative period. Why, then, should anesthesiologists have significantly higher training standards for utilization of echocardiography as a point-of-care diagnostic monitor for these situations?

The comprehensive training guidelines for ultrasound for emergency medicine physicians state that a minimum of 150 ultrasound examinations in "critical" or "life-saving" scenarios should be completed by residents in training within a 2-week (80-h) period of a dedicated ultrasound rotation supervised by the appropriate faculty, along with recommendations for competency assessment of the trainees [32]. This is the recommended training for the 11 core emergency ultrasound applications, but only one of these relates to cardiac ultrasound. For established emergency medicine physicians, a 2- or 3-day course is recommended to cover all 11 applications with 6–8 h of skills laboratory, while for a *single application course*, 3–4 h of didactics is deemed sufficient, with 2–4 h of laboratory training [32].

Proposed curriculum for resident training in echocardiography skills

We believe there is an urgent need to develop (1) guidelines for emergent perioperative TEE use for anesthesiologists and (2) a requisite educational curriculum to teach the basic skills necessary to aid in the diagnosis and treatment of cardiac arrest or near-arrest scenarios. The proposed guidelines and curriculum are based on a merger of the goals of FOCUS in

the symptomatic emergency department patient [4] with an abridged, goal-directed modification of ASE/Society of Cardiovascular Anesthesiologists (SCA) guidelines for a comprehensive TEE examination [33]. At a minimum, these goals should include:

- Assessment for the presence of pericardial effusion.
- Evaluation of global cardiac systolic function.
- Identification of marked right and left ventricular enlargement.
- Identification of aortic stenosis.
- Identification of acute pulmonary thromboembolism or venous air embolism.
- Identification of significant intracardiac shunt.
- Assessment of intravascular volume.
- Guidance of pericardiocentesis when appropriate.
- Confirmation of transvenous pacing wire placement.
- Identification of organized cardiac contractility to aid the clinician in distinguishing between asystole, pulseless electrical activity, and pseudo-pulseless electrical activity.
- Determination of the cardiac etiology of the cardiac arrest or hemodynamic instability.
- Assessment of response to resuscitative efforts, including pharmacologic and electrical maneuvers.

To meet the above proposed educational goals and objectives, we propose a 1–2 days curriculum modeled after the training guidelines for a single ultrasound application course, including a minimum of 3–4 h of didactics and 2–4 h of laboratory training, for obtaining requisite competency in both the knowledge and skills necessary for the safe conduct and interpretation of emergent limited perioperative transesophageal echocardiography (EL-PTE). The curriculum for obtaining this competency training for EL-PTE certification should emphasize the following areas:

- Understanding the indications for and timing of TEE during CPR or cardiovascular crises.
- Acquiring the TEE views necessary to guide the differential diagnosis during assessment of hemodynamically unstable patients.
- Teaching the basic maintenance of equipment, including servicing echocardiography machines, caring for echocardiography probes, cleaning in compliance with infection control guidelines, and maintaining safety issues related to TEE.
- Assessing the trainee, in practice, for competency via multiple simulated patient situations.

The intention behind the EL-PTE is not to obviate the need for the NBE's established certification processes. Rather, the program suggested is intended to establish a mechanism for bringing PTE into the armamentarium of practicing anesthesiologists, as well as create a rational pathway to facilitate motivated anesthesiology residents, fellows, and faculty members to achieve further training, knowledge, and skills as a bridge to basic or advanced PTE certification via the NBE. With the proposed curriculum, the anesthesia provider with such training will not only be able to utilize echocardiography to make diagnoses with confidence for the hemodynamically unstable patient, but it will also aid providers in avoiding false positive findings in an ambiguous diagnosis.

Practical approach in obtaining competency skills for echocardiography

At our institution, we have established the necessary steps to make this process practical as well as accessible:

(1) All trainees interested in obtaining TEE certification are encouraged to secure designated TEE rotation blocks for basic TEE certification (minimal 2 weeks; ideally, 4 weeks) and advanced TEE certification (minimal 8 weeks; ideally, 12 weeks within the year of Accreditation Council for Graduate Medical Education [ACGME]-approved fellowship in adult cardiovascular anesthesia training). At the beginning of their rotation, the responsible faculty members review the goals and objectives with all trainees. (It is essential to review each resident's fundamental knowledge about TEE prior to having each trainee perform a TEE exam on any patient.) The basic information required includes: function of a TEE machine and all pertinent controls (knobology), care of the TEE probe and machine, and TEE safety.

(2) Supervising attending physicians are responsible for teaching each trainee how to perform a safe TEE probe insertion, image acquisition and interpretation, and documentation skills. All TEE examination reports are co-signed by the supervising TEE-certified anesthesiologist.

(3) Simulation software programs, an educational TEE website, and additional TEE reading materials are used to introduce all trainees who are seeking additional learning resources to the basic knowledge of TEE.

(4) A bi-weekly didactic TEE lecture series is aimed at covering the spectrum of knowledge required by the TEE curriculum (Table 1).

(5) A periodic transthoracic echocardiography (TTE) workshop is used to supplement the knowledge and skills of TEE, as well as instruct individuals on basic TTE image acquisition.

(6) Additional TEE image reading sessions (at least monthly) are designed to help the trainee review a variety of complex cases.

(7) It is recommended that each trainee review a total of 15 additional fundamental cases archived in the TEE imaging library with an advanced TEE-certified anesthesiologist. This library of cases is intended to cover the spectrum of knowledge required to make accurate diagnoses of cardiac pathophysiological and hemodynamic derangements during our daily practice (Table 1). We have also incorporated these guidelines into our institution's cardiopulmonary bypass protocol. Specific TEE views were included to expedite the quick diagnosis of the etiology during hemodynamic collapse in the operating room (Table 2).

(8) Additional requirements for TEE certification can be viewed at the NBE website [31].

Table 1 TEE lectures and case library to cover the spectrum of knowledge

TEE lecture series to cover the necessary curriculum	TEE cases to cover the spectral essential knowledge
Fundamental ultrasound principles	Normal TEE exam
TEE machine and knobology	Assessment of volume status
Image acquisition and normal TEE exam	Congestive heart failure and dilated cardiomyopathy
Normal variant and artifact	Ischemic heart disease
Assessment of ventricular systolic function and regional wall motion	Intracardiac shunt
Assessment of ventricular diastolic function	Cardiac mass
Assessment of aortic valvular disease	Aortic stenosis/regurgitation
Assessment of mitral vavular disease	Mitral stenosis/regurgitation
Hemodynamic assessment and calculation	Tricuspid valve disease
Pericardial disease	Pericardial effusion and tamponade
Systolic anterior motion of the mitral valve	Hypertrophic cardiomyopathy and systolic anterior motion
Assessment of aortic disease	Aortic aneurysm and dissection
Endocarditis	Endocarditis
Congenital heart disease	Adult congenital heart disease
Assessment of valvular function	Prosthetic valves

TEE, transesophageal echocardiography.

Table 2 Specific circumstances and TEE views to establish findings

Specific circumstance	Trangastric view	Middle esophageal view	Upper aortic view	Modalities finding
Hypovolemia	Short axis			Obliteration of LV chamber
Myocardial ischemia	Short axis Two chamber	Four chamber Two chamber Long axis		Regional wall motion abnormality Mitral regurgitation
Congestive heart failure	Short axis	Four chamber Two chamber Long axis		Global wall hypokinesis or akinesis
Pericardial effusions	Short axis Two chamber	Four chamber		Echo-free space may contain thrombi, diastolic RV collapse
Pulmonary embolism	Short axis focus on right side heart	Four chamber Right ventricle inflow-outflow	Ascending aortic short axis	RV overload Intracardiac or pulmonary artery thrombi
Intracardiac shunt	Short axis	Four chamber Commissural Bicaval		Atrial or ventricular septal defect or shunt, or fistula detect by color flow Doppler
Aortic dissection		Ascending aortic long axis	Descending aortic short axis Long axis Aortic arch	Intimal flaps on multiple planes Severe aortic regurgitation, pericardial tamponade, RWMA
Unrecognized severe aortic stenosis	Short axis Deep gastric	Aortic valve short axis Long axis		Calcified stenotic aortic valve Left ventricle hypertrophy May accompany with regurgitation
Systolic anterior motion of MV	Short axis Long axis Deep gastric	Four chamber Long axis		Left ventricular hypertrophy Obliteration left ventricle cavity Mitral regurgitation Dynamic aortic stenosis

TEE, transesophageal echocardiography; LV, left ventricle; RV, right ventricle; RWMA, regional wall motion abnormality; MV, mitral valve.

Conclusions

Echocardiography is currently being performed in a limited fashion by physicians from multiple different medical specialties. Currently, the minimum recommendations for training for anesthesiologists to employ perioperative TEE

exceed those of their medical counterparts' training programs in focused cardiac ultrasound. As there are many situations in which TEE can establish diagnoses in life-threatening perioperative emergencies, it is the authors' belief that a new level of training should exist for anesthesiologists expecting to employ emergent limited perioperative TEE. A guideline for EL-PTE is proposed in hopes that these collective efforts will allow more trainees to gain confidence in utilizing PTE to help with their diagnoses in critical situations and, ultimately, to benefit patients.

Acknowledgements

Support for this work was provided through the Department of Anesthesiology at the University of Florida.

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