Transesophageal echocardiographic assessment in trauma and critical care

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Cardiac ultrasonography, in particular transesophageal echocardiography (TEE) provides high-quality real-time images of the beating heart and mediastinal structures. The addition of Doppler technology introduces a qualitative and quantitative assessment of blood flow in the heart and vascular structures. Because of its ease of insertion and ready accessibility, TEE has become an important tool in the routine management of critically ill patients, as a monitor in certain operative settings and in the aortic and cardiac evaluation of trauma patients. The rapid assessment of cardiac preload, contractility and valve function are invaluable in patients with acute hemodynamic decompensation in the intensive care unit as well as in the operating room. Because of its ease and portability, the TEE assessment of traumatic aortic injury after blunt chest trauma can be rapidly undertaken even in patients undergoing life-saving procedures. The role of TEE in the surgical and critical care setting will no doubt increase as more people become aware of its potential.

L'échographie cardiaque, et en particulier l'échocardiographie transœsophagienne, produit des images de grande qualité et en temps réel du cœur battant et des structures du médiastin. La technologie Doppler permet d'évaluer aussi qualitativement et quantitativement la circulation sanguine dans le cœur et les structures vasculaires. Parce qu'elle est facile à mettre en place et facile d'accès, l'échographie transœsophagienne est devenue un outil important dans le traitement routinier de patients en état critique, comme moyen de contrôle dans certains contextes opératoires et dans l'évaluation de l'état aortique et cardiaque de patients traumatisés. L'évaluation rapide de la précharge cardiaque, de la contractilité et du fonctionnement des valvules est précieuse chez les patients victimes d'une décompensation hémodynamique aiguë aux soins intensifs, ainsi qu'à la salle d'opération. Comme elle est facile à utiliser et portable, l'échographie transœsophagienne d'évaluation de traumatismes à l'aorte consécutifs à un traumatisme contondant au thorax peut être réalisée rapidement, alors même qu'un patient subit une intervention destinée à lui sauver la vie. L'utilisation de l'échocardiographie transœsophagienne dans des contextes de chirurgie et de soins critiques augmentera certainement à mesure que l'on en connaîtra mieux les possibilités.

Echocardiography provides real-time images of the beating heart and can help guide therapeutic interventions. There are 2 major techniques available to image the heart with ultrasound: transthoracic echocardiography (TTE) and transesophageal echocardiography (TEE). In critical care, TTE has more limited applications. During mechanical ventilation, lung inflation and its position between the heart and the chest wall causes loss of imaging. TEE, however, provides clear and easily accessible pictures of the heart and mediastinal contents through the esophagus and the stomach. It is fast becoming an essential tool in critical care, trauma and in some intraoperative settings. It provides fast, noninvasive assessment of heart function and structure that is complementary and sometimes superior to invasive monitoring. It is an ideal monitoring tool since the probe can be left in situ

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during operative interventions with no loss of image. Several studies have demonstrated a role for TEE in critical care.[1–5] In one study, the treatment was changed in 44% of patients with a pulmonary artery catheter (PAC) in situ as a result of the TEE examination.[3] Likewise, in another study, TEE examination resulted in a change of treatment in 62% of patients.[4] In critically ill patients who were deemed euvolemic by PAC examination, TEE indicated that 45% were not. Indeed, 36% of these patients were found to be hypovolemic and 9% were hypervolemic. TEE supported the finding by PAC examination of normal left ventricular function in only 61% of critically ill patients; the remaining 39% showed hypocontractility on TEE. Therefore, TEE would seem to complement, if not add to, the usual hemodynamic monitoring of critically ill patients.

TEE need not be limited to the heart. An examination of the ascending and descending aorta can be undertaken to evaluate dissections and traumatic disruptions or to assess the severity of vascular disease or dysfunction. Furthermore, both the left and right pleural spaces can be visualized when looking for effusions. Para-aortic masses and consolidated lung can also be identified. In the operating room, TEE can be used as a continuous monitor to evaluate ventricular size and contractility. Changes in size may represent acute preload changes whereas loss of contractility in a particular wall usually represents ischemia.

Standard imaging using echo

The standard images obtained with the TEE probe positioned in the esophagus are the 4- and 5-chamber views. The 4-chamber view includes the left atrium, the left ventricle, the right ventricle and the right atrium. The 5-chamber view is obtained by pulling the probe up slightly to include the left ventricular outflow tract (LVOT). This position will provide clear pictures of the aortic valve, and while rotating the angle of interrogation approximately 40° a cross-section of the aortic valve including the coronary arteries can be seen. Further rotation will show a longitudinal section of the ascending aorta, aortic valve and LVOT. It is not possible to image the distal segment of the ascending aorta and the arch as the left main-stem bronchus blocks these structures. In the 5-chamber view, the mitral valve, left upper pulmonary vein, left atrial appendage, tricuspid valve and interatrial septum can also be evaluated (Fig. 1). The descending aorta can be imaged from the arch to the diaphragm by rotating the probe to the left. Both the right and left pleural spaces along the mediastinum can also be imaged. Pleural effusions can be seen as well as consolidated or collapsed lung.

The probe can be pushed down further into the stomach and flexed superiorly to abut the superior aspect of the stomach and the inferior aspect of the diaphragm. The heart's inferior wall sits on the left hemidiaphragm, providing an excellent opportunity to obtain cross-sections of the left ventricle.

Indications and contraindications

Contraindications to TEE include esophageal or gastric disease. Indeed, gastric perforation has been noted af-

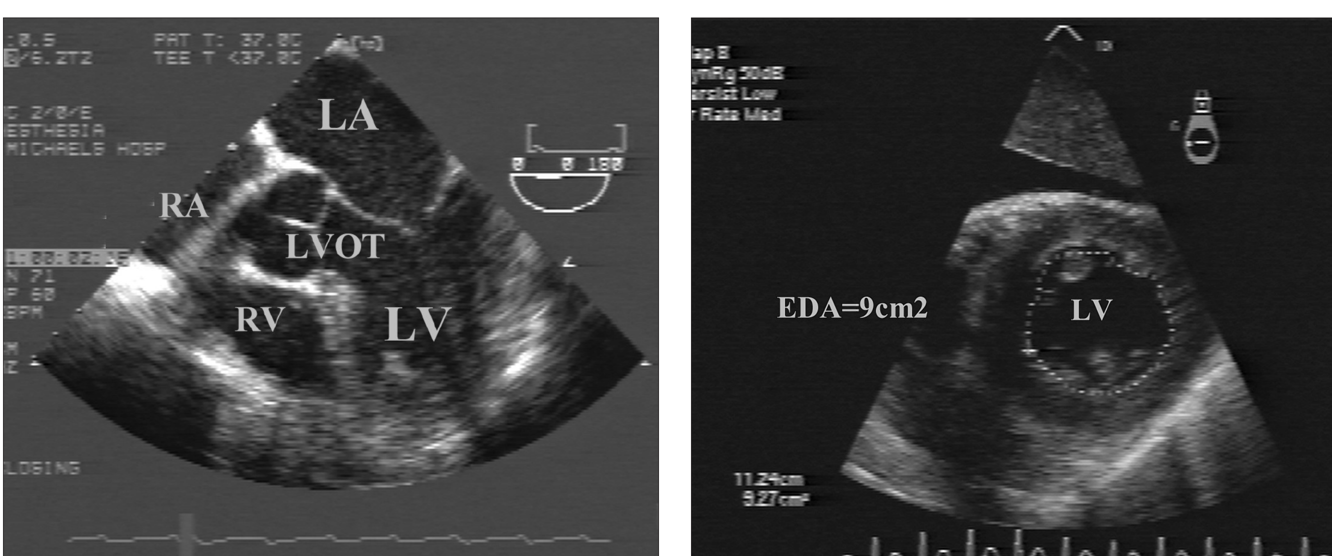

FIG. 1. The 5-chamber view is demonstrated on the left. The image on the right demonstrates the transgastric short-axis view of the left ventricle. The endocardium of the left ventricle has been traced to obtain surface area by planimetry.

ter intraoperative TEE.[6] Patients with a history of gastric ulcer, esophagitis or gastrectomy can undergo TEE as long as the disease is not active or the surgery is not recent. Proven hiatus hernia can make insertion of the probe difficult. Liver cirrhosis severe enough to cause esophageal varices can lead to bleeding on insertion. Probe insertion may require neck manipulation, which may have consequences in patients with disease or injury to the cervical spine. In severe cervical spine disease, the strong angulation of the cervical spine may make insertion difficult. Furthermore, constant pressure by the probe on the posterior pharynx may cause ulcers or necrosis.

The indications for performing TEE are shown in Table I.

Hemodynamic assessment

TEE has become an invaluable tool in the assessment of acute hemodynamic decompensation in critical care and in the operating room. The most common causes include loss of myocardial contractility, hypovolemia and acute valvular disease. It is also useful in routine hemodynamic work-up. Assessment of cardiovascular function by TEE can be divided into 3 major parts: preload, contractility and valve function.

Table I

Indications for the Use of Transesophageal Echocardiography (TEE)

Acute hemodynamic decompensation
Vascular volume
Left and right ventricular function
Valve disease
Pericardial effusion, tamponade
Traumatic injuries
Dissection
Endocarditis
Thrombi, source of embolism

Preload

In ventilated critically ill patients, pulmonary capillary wedge pressures may not accurately reflect the volume status of the patient because ventricular compliance and ventilatory parameters may influence this pressure. The left ventricular end-diastolic area (EDA) and end-systolic area (ESA) in the transgastric midpapillary short axis view can provide a rapid estimate of a patient's volume status. These left ventricular areas can be rapidly calculated by planimetry of the endocardial border (Fig. 1, right).

Patients who have graded volume loss will initially demonstrate a decrease in EDA as well as ESA.[2,7,8] Further decreases result in "kissing" or touching of the papillary muscles in systole. Large volume losses result in obliteration of the left ventricular cavity in systole. Other disorders, however, may give similar findings. In septic shock, for example, a profound depression of systemic vascular resistance results in complete emptying of the left ventricle in systole. An understanding of the patient's underlying pathophysiology is essential for appropriate interpretation. Patients with abnormal left ventricular function present special problems. These patients will have a chronically dilated left ventricle and may demonstrate hypovolemia at higher left ventricular sizes than patients with preexisting normal left ventricular function. Inferring optimal left ventricle size becomes more difficult.

Contractility

TEE provides various ways in which left ventricular systolic function can be assessed. An accurate assessment, however, is complicated by the fact that most available methods are load sensitive and are one-beat measures of contractility. Most of the time a qualitative assessment is performed to estimate ventricular contractility. However, some simple and fast measurements are possible using TEE. The fractional area of contraction, an *estimate* of ejection fraction is the difference in left ventricular surface areas in the midpapillary transgastric short axis view during a single cardiac cycle. This measurement has some limitations, but it can provide a reasonable global estimate of left ventricular function.[9,10] The corrected velocity of circumferential fibre shortening is said to be more preload independent; however, it is cumbersome and time-consuming to calculate.[11,12] Finally, cardiac output can be calculated by Doppler technology which allows measurement of forward flow through the aortic valve.

During myocardial ischemia or after myocardial infarction, the myocardial territory involved will stop contracting. TEE is very sensitive in detecting these changes, but certain limitations can make some assessments difficult. Assessment of wall motion is mostly subjective. Severity is graded from no wall motion abnormality (normal) to akinesis or even dyskinesis. The appearance of a normally contracting wall on TEE is that of motion and thickening. It takes a certain degree of experience to accurately assess wall motion abnormalities.

Valve assessment

Examination of the heart valves is an integral part of the hemodynamic assessment. Valve abnormalities found on echocardiography may be instrumental in defining a cause for hemodynamic decompensation. Valve assessment for incompetence or stenosis requires a high degree of skill and a thorough knowledge of Doppler echocardiography. A morphologic assessment of the mitral, aortic and tricuspid valves is usually performed first. The pulmonary valve is often obscured and cannot be imaged adequately. It is important to note structural changes such as thickening (myxomatous degeneration), calcification, disruptions, flail segments, range of motion and tumours or vegetations. Colour Doppler is used to assess incompetence and readily demonstrates jet size and direction. Doppler is used to assess valvular areas.

Cardiac tamponade

Cardiac tamponade is readily assessed by TEE (Fig. 2). Classic echo signs of tamponade include a fluid collection surrounding the heart, compression of cardiac chambers including diastolic collapse and septal shift into the left ventricle. In some circumstances, echo signs of cardiac tamponade can be very subtle or absent. Large fluid collections need not be present. In trauma or cardiac surgery, clots can also be observed compressing the right atrium, the right ventricle and occasionally the left atrium. Although these clots may be small, their hemodynamic consequence can be profound.

Traumatic aortic injury

The method of choice for evaluating traumatic aortic injury remains angiography. The presence of a widened mediastinum on the chest radiograph in patients who have suffered blunt chest trauma, often leads to angiography. There is, however, a poor predictive value to the chest radiograph diagnosis of traumatic aortic injury that frequently leads to unnecessary angiography.[13,14] Angiography requires the transport of a sometimes hemodynamically unstable patient to a specialized area. The procedure requires on average 70 minutes to perform and may delay definitive therapy of other serious injuries.[15] TEE of traumatic aortic injury, on the other hand, can be performed safely and rapidly (within 10 minutes) at the bedside in the operating room, the emergency room or the intensive care unit.

Acute deceleration injuries usually result in aortic disruption at the ascending aorta or more commonly at the descending aorta 2 to 3 cm distal to the origin of the left subclavian artery. Rarely will the aortic arch be involved. TEE is capable of imaging the ascending and descending aorta with ease. The aortic arch, however, cannot be visualized.

Recent studies have demonstrated a 75% specificity and a 100% sensitivity for TEE in the diagnosis of mediastinal hematomas.[14] Echo signs include an increased distance between the TEE probe and the aorta (more than 3 mm), a double contour aspect of the aortic wall and ultrasound signals between the aorta and the visceral pleura. A mediastinal hematoma, however, does not always imply aortic injury because blood accumulation could be the result of injuries to bony structures or other vessels. Traumatic aortic injury can result in intimal tears with or without dissection. There can also be aortic disruption with false aneurysm formation or transection. Complications of traumatic aortic injury include pericardial tamponade and valvular disruption. All of these are readily identified by TEE.

TEE is very sensitive in examining the intimal surface of the aorta. Indeed, a small intimal disruption that may not be visible on angiography can be seen on TEE. In one study examining aortic dissections, a lower sensitivity for aortography than TEE was found because the angiogram could not identify noncommunicating intimal tears.[16] Signs of aortic injury on TEE with dissection or disruption include: turbulent flow by colour Doppler, dissection flaps, spontaneous echo contrast in the aorta (when blood flow is very low, there is an appearance of "smoke" in a vessel), thrombus or aneurysm.

In many institutions, TEE has become the modality of choice for evaluating traumatic aortic injury. It is quick and can be readily performed in various environments while other lifesaving procedures are under way. It is sensitive in identifying mediastinal hematomas from any cause, aortic intramural injuries and intimal disruptions, which can be missed by angiography. Aortography may still be required when the diagnosis is unclear or when there is a need to examine structures that cannot be seen by TEE, such as the coronary arteries, the aortic arch or other vessels supplying vital organs.

Because of its ready accessibility and ease of transportation, the role of TEE in trauma and critical care and in the operating room continues to increase. It is an invaluable tool in examining cardiac and other mediastinal structures as well as being able to rapidly assess cardiac function. It has gained an increasing role in the assessment of acute hemodynamic decompensation, in aortic evaluation and for intraoperative monitoring. As more people become familiar with TEE, its role will no doubt increase in most hospital settings.

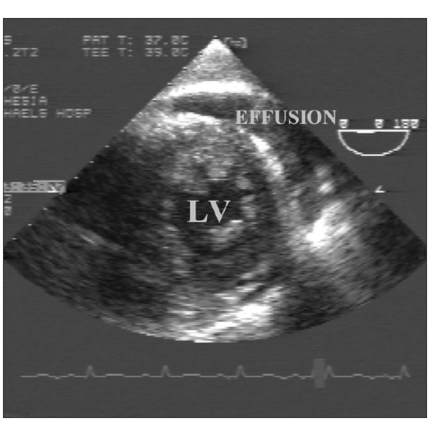

FIG. 2. An example of pericardial effusion in the transgastric short-axis view.

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Section Editor's comment: As can be seen from Dr. Tousignant's report, the role of echocardiography is dramatically expanding. In addition to its familiar role in the diagnosis of blunt aortic injury, I have found it tremendously helpful in the intensive care unit setting in dealing with difficult hemodynamic issues. When colleagues have a keen interest in using this tool in varied settings, access improves, indications widen and relax, and the clinical information provided is pertinent, precise and targeted to specific clinical questions. I would suggest that the support of individuals having such an interest may lead to more rational patient care as they gain added familiarity with the use of echocardiography in this setting.