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Transesophageal echocardiography in the ICU and during noncardiac surgery: Part 1

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***Editor's note:** Since its debut, the "Anesthesiology Rounds" series has covered clinical topics to keep practicing anaesthesiologists informed of the latest developments in various fields. This issue and the next one, entitled "Transesophageal echocardiography in the ICU and during noncardiac surgery, Parts 1 and 2," are no exception. Readers familiar with the series know that we normally devote only one issue to each topic. As an exception, we decided to publish two issues on the same topic because we thought it would be difficult to accurately portray the possibilities of transesophageal echocardiography (TEE) and its indications in the usual format. Unlike previous topics covered by the series, TEE is only used by a minority of clinicians. Therefore, we thought it worthwhile to let the authors develop the topic sufficiently so that readers unacquainted with this technology might realize its importance. I suggest you save this first part of the article so that, when Part 2 appears, you will have the complete text.*

Pierre Drolet, Editor

Perioperative echocardiography primarily involves the use of transesophageal echocardiography (TEE), but also includes all echocardiographic techniques that play diagnostic, monitoring, and supportive roles for various medical and surgical procedures.

The number of medical centres in Quebec where perioperative TEE is practiced by anaesthesiologists has risen from 2, in the early 1990s, to about 11 in 2003. Consequently, interest in the use of TEE is growing. Moreover, 1998 saw the introduction of a perioperative echocardiography competency test for anaesthesiologists administered by the National Board of Echocardiography, and the number of Quebec anaesthesiologists who have passed the test is growing.

The indications for TEE were established by consensus at a 1996 conference of expert anaesthesiologists and cardiologists.[1] These two issues of *Anesthesiology Rounds* assess the level of evidence for the various indications for TEE.

- Category or Level 1 means a case in which the use of TEE is strongly supported by clinical evidence and experts. At this level, we find mitral valve repair and hemodynamic instability where the etiology remains unclear.

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TABLE 1: Indications for transesophageal echocardiography (TEE) during noncardiac surgery (adapted from Thys[1])

Category 1	Supported by the strongest clinical and expert evidence, TEE in this case is frequently useful for improving the clinical outcome, for example: 1. Assessment of hemodynamic instability in the operating room or ICU when the etiology is uncertain or of a valvular or thromboembolic nature and not responding to treatment.
Category 2	Weaker or controversial clinical and expert evidence, TEE may be useful in this case, but the indications are less certain, for example: 1. Perioperative use with patients at risk of coronary syndrome or hemodynamic instability. 2. Detection of an air embolism in patients scheduled for seated-position neurosurgery. 3. Use in patients suspected of cardiac trauma or aortic dissection, rupture, or aneurysm. 4. Assessment of anastomoses during lung grafts. 5. Assessment of extracorporeal circulatory support system (intra-aortic balloon, extracorporeal membrane oxygenation).
Category 3	Little clinical or scientific evidence to support its use; TEE is rarely useful in these cases and the indications are undetermined, for example: 1. Assessment of uncomplicated endocarditis in noncardiac surgery. 2. Embolism monitoring in orthopedic surgery with asymptomatic patients. 3. Assessment of the cardiac impact of pleuropulmonary diseases. 4. Intra-aortic balloon, pulmonary artery catheter, and defibrillator position monitoring.

- Level 2 is supported by less evidence and/or a weaker consensus of experts.
- Level 3 is supported by neither scientific evidence nor experts. The role of TEE in these situations is presently under study. For example, the routine use of TEE in valvular and coronary bypass surgery is Level 2 while its monitoring role in orthopedic surgery comes under Level 3.

In following these recommendations, we demonstrated that the routine use of TEE in heart surgery with 851 patients was more useful in type-1 cases, and medical conduct was modified 28% of the time, compared to 14% in type-2 situations.[2] Further, the impact of TEE was greater in complex (39%) and valvular (19%) surgeries than it was in coronary artery bypass (10%) surgery. In addition, we found that the impact was even greater in the ICU and during noncardiac surgery than it was during heart surgery. In a population of 214 patients, TEE altered medical conduct for 60% of those with Category 1 indications. Yet, TEE was only used selectively and not routinely, which differs from its use in heart surgery.[3]

TEE is increasingly used during noncardiac surgery.[3-6] Such instances include vascular, thoracic, general, and orthopedic surgery, as well as neurosurgery. TEE during noncardiac surgery and in the ICU has been described as altering conduct in 14 ± 7% of cases.[3] With the help of guidelines for the practice of perioperative echocardiography, we will review the role of TEE during noncardiac surgery and in the ICU (Table 1).[1]

CATEGORY 1 INDICATIONS

Assessment of a patient with hemodynamic instability in the operating room or ICU when the etiology is uncertain or of a valvular or thromboembolic nature and not responding to treatment.

One of the most pertinent indications for TEE is its role in rapidly diagnosing the causes of hemodynamic instability. TEE performed by a trained anesthesiologist can determine, in less than 5 minutes, the etiology of hemodynamic instability occurring in the operating or recovery room, or in the ICU.

In dealing with hemodynamic instability, anesthesiologists or intensivists frequently resort to the pulmonary artery catheter. Yet, the reliability of the pulmonary artery catheter as a diagnostic tool during noncardiac surgery[7] and in the ICU[8-10] is drawing increasing criticism. The catheter mainly measures pressure and the clinician assumes that pressures vary in proportion to volumes; however, this pressure-volume relationship is skewed by diastolic dysfunction, heart surgery,[11,12] or mechanical ventilation.[13] Moreover, the performance indicators obtained by the pulmonary artery catheter do not match the contractility indicators derived from analyzing the pressure-volume curve.[14] The interpretation of the data provided by a pulmonary artery catheter can vary substantially among observers[15,16] and the incidence of complications associated with its use is significant.[17,18] Some of these problems can be avoided through the use of Doppler echocardiography that provides information about ventricular volume and estimates pressure. Many studies have shown the superiority of a TEE examination in hemodynamically unstable patients during heart surgery[19,20] and in the ICU.[19,21-35]

We studied 20 consecutive patients who were hemodynamically unstable following heart surgery and monitored by TEE for a period of 4 hours in the ICU.[36] When the patient was admitted to the ICU, the intensivist in charge had to determine the etiology of the hemodynamic instability based on all the information available except for the echocardiographic readings in the operating room and at bedside. Once the intensivist produced a diagnostic hypothesis, the echocardiographic data was provided. This was repeated 2 and then 4 hours later. Moreover, all the hemodynamic and echographic readings were collected, randomized, and reviewed by 5 clinicians (3 intensivists and 2 cardiac surgeons) and 5 echocardiographists (3 anesthesiologists, one cardiologist, and one radiologist). The hemodynamic diagnosis at admission was identical to the echocardiographic diagnosis in 10 out of 20 patients (kappa: 0.33), more so after 2 hours (kappa: 0.47), but less after 4 hours (kappa: 0.28). The study proved that diagnoses based on hemodynamic data varied more than those based on echocardiographic data. This raises a serious problem with the inaccuracy of hemodynamic instability diagnoses in the ICU where such diagnoses are usually based on values obtained from pulmonary artery catheterization. The study supports the role of TEE in the ICU with cases of hemodynamic instability.

In noncardiac surgery, hemodynamic instability can stem from various causes among them: hypovolemia from blood loss or a decline in systemic vascular resistance, myocardial ischemia, pulmonary and systemic thrombosis or air embolism, subvalvular outflow tract obstruction, or right ventricular dysfunction. Tamponade and valvular dysfunction rarely occur during noncardiac surgery. The following sections examine the role of TEE in each of these diagnoses during noncardiac surgery and in the ICU.

Hypovolemia

Hypovolemia or a decline in systemic vascular resistance can be associated with hemodynamic instability. With TEE, this usually appears in a midpapillary transgastric image as a end-systolic obliteration[37] or empty left ventricle. An empty left ventricle, however, can also be found in cases of severe right ventricular failure and left diastolic dysfunction,[36] so this is a sensitive, but nonspecific sign. It has also been demonstrated that the variation in arterial pressure under positive-pressure ventilation is a better indicator of volume response than the measurement of heart cavities.[38] Therefore, TEE would be useful for patients where hypovolemia is suspected, but where there is an inadequate response to volume administration.

Myocardial ischemia and left ventricular dysfunction

The presence or occurrence of a regional wall motion abnormality (RWMA) is one of the echocardiographic signs of myocardial ischemia.[39] Given echocardiography's superior sensitivity for detecting cardiac ischemia compared to the mean arterial pressure/heart rate ratio[40,41] and electrocardiography (ECG),[40,41] it is not surprising that TEE was first used to monitor patients at risk of myocardial ischemia[42,43] or hemodynamic instability, for example, during vascular surgery.

In a study of 50 patients at high risk of myocardial ischemia, 29 of whom underwent vascular surgery, Smith found that TEE detected 4 times as many ischemic episodes as 7-lead ECG. Three patients developed a postoperative infarct. All of these patients had an intraoperative RWMA, and an ST segment abnormality was only detected in one patient. The superior sensitivity of TEE was also observed with 51 high-risk patients who underwent abdominal aorta surgery.[44] During aortic cross-clamping, an exacerbation or new RWMA occurred in 33% of the group and 7 patients developed a postoperative myocardial infarct. All had RWMAs, compared to only one patient in which ST segment abnormalities were detected.[44] However, Eisenberg's study of 285 patients undergoing noncardiac surgery monitored by TEE and 12-lead ECG, failed to establish that the routine use of TEE could identify patients at risk of postoperative ischemic complications.[45] It should be noted that TEE monitoring was limited to a single midpapillary transgastric view. Other studies have found that this approach underestimates the real incidence of ischemia detectible by TEE.[41,46,47]

Left ventricular dysfunction can occur as the result of myocardial ischemia, as well as in other cases such as the brain-heart syndrome observed in neurosurgery and when taking charge of organ donors. Brain-dead patients with advanced subarachnoid hemorrhage can become hemodynamically unstable. These patients can present RWMAs[48] 9% to 23% of the time, with electrocardiographic abnormalities correlated to the severity of the neurological damage,[49,50] without necessarily being associated with a coronary disease.[51] The assessment of cardiogenic shock associated with subarachnoid hemorrhage is important because the postoperative support treatment such as hypertension and hypervolemia cannot be tolerated by some patients with cardiac dysfunction and can lead to a deterioration in pulmonary condition. This cardiac dysfunction has also been described with a number of brain-dead patients and can complicate organ harvesting.

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Note: The conclusion of this article will appear in the next issue of "Anesthesiology Rounds". It covers the remainder of the Category 1 indications, as well as those in Categories 2 and 3.

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Abstract of Interest

Perioperative use of transesophageal echocardiography by anesthesiologists: impact in noncardiac surgery and in the intensive care unit.

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BACKGROUND: The American Society of Anesthesiologists (ASA) has published practice guidelines for the use of perioperative transesophageal echocardiography (TEE) but the role and impact of TEE performed by anesthesiologists outside the cardiac operating room (OR) is still poorly explored. We report our experience in the use of TEE in the noncardiac OR, the recovery room and in the intensive care unit (ICU) in a university hospital, and analyze the impact of TEE on clinical decision making.

METHODS: Two hundred fourteen patients were included and TEE indications were classified prospectively according to the ASA guidelines. The examinations and data sheets were reviewed by two anesthesiologists with advanced training in TEE. For each examination, it was noted if TEE altered the management according to five groups: 1) changing medical therapy; 2) changing surgical therapy; 3) confirmation of a diagnosis; 4) positioning of an intravascular device; and 5) TEE used as a substitute to a pulmonary artery catheter.

RESULTS: Eighty-nine (37%), 67 (31%) and 58 (27%) patients had category I, II and III indications. The impact was more significant in category I where TEE altered therapy 60% of the time compared with 31% and 21% for categories II and III ($P < 0.001$). The most frequent reason for changing management was a modification in medical therapy in 53 instances (45%).

CONCLUSION: Our results confirm a greater impact of TEE performed by anesthesiologists on clinical management for category I compared to category II and III indications in the noncardiac OR surgical setting and in the ICU.

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