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Transesophageal echocardiography in the ICU and during noncardiac surgery: Part 2

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***Editor's note:** As an exception, this issue of Anesthesiology Rounds is a continuation of the previous (June/July) issue. The combination of the two issues provides a complete article on the use of transesophageal echocardiography in noncardiac surgery.*

Pierre Drolet, Editor

As presented in the previous issue of *Anesthesiology Rounds*, the indications for transesophageal echocardiography (TEE) fall into three categories. Category 1 indications have the strongest support from clinical evidence and expert practitioners. In these cases, TEE is often useful for improving the clinical prognosis, eg, *for assessing hemodynamic instability in the operating room or ICU when the etiology is uncertain, or when the instability stems from valvular or thromboembolic diseases and is unresponsive to treatment.* This issue discusses other Category 1 indications (see the previous issue) in which TEE may be useful from a diagnostic perspective or to orient or verify the effectiveness of therapeutic procedures. This issue also presents Category 2 and 3 indications where there is less support for TEE use, but where this diagnostic test may be helpful.

CATEGORY 1 INDICATIONS (CONTINUED FROM PART 1)

Pulmonary thrombotic or gas embolism

A pulmonary embolism that occurs during noncardiac surgery may be due to various mechanisms. Orthopedic surgery has the highest risk of such complications. Hypoxia, hemodynamic instability, and cardiac arrest may complicate 0.02% to 0.5% of hip arthroplasty surgeries.[1] In orthopedic surgery of the leg, the incidence of fat or thrombotic embolism is 100% with a tourniquet.[2,3] This figure drops to 83% when a tourniquet is not used.[4] Two types of emboli have been described and classified (Figure 1). Small emboli may occur at any time during the procedure, whereas larger ones are primarily encountered after the tourniquet is released, though they may occur even when it is inflated.[5,6] The hemodynamic instability associated with the occurrence of an embolism depends on the size of the particles,[3,6] the duration of the embolism, the percentage of right atrium that is occu-

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FIGURE 1: Classification of emboli during orthopedic surgery. **A.** Grade 0: few or slight presence of emboli. **B.** Grade 1: a cascade of fine emboli. **C.** Grade 2: combinations of fine emboli (<5 mm). **D.** Grade 3: fine emboli combined with emboli >5 mm or serpiginous (with permission)[9].

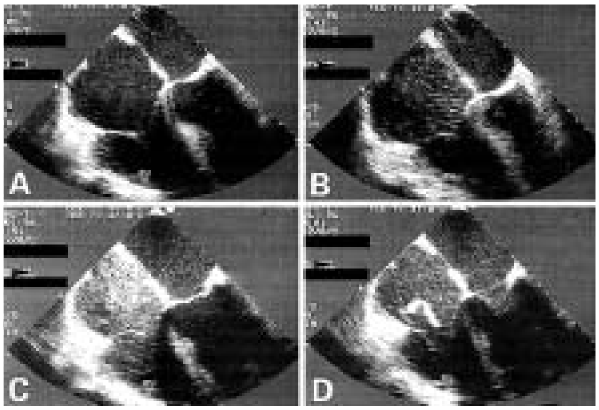
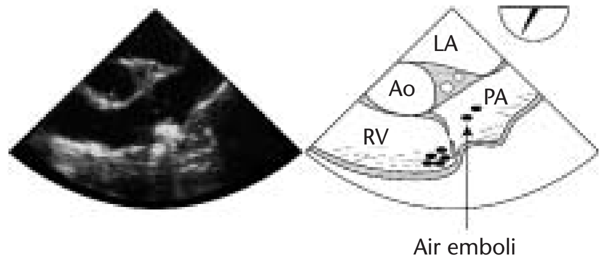


FIGURE 2: A 46-year-old female patient undergoing spinal surgery in a ventral position with intraoperative shock. The TEE is inserted once the patient has been repositioned on her back, and reveals air in the RV outflow tract and a hyperdense collection in front of the anterior leaflet of the pulmonary valve.



Ao = aorta, PA = pulmonary artery, RV = right ventricle, LA = left atrium.

pied, and underlying cardiac function.[7] TEE may be useful to more accurately assess the ability of the right ventricle to tolerate this type of procedure. Femoral catheter aspiration of the embolic material suggests that thrombi rather than fat or cement create these emboli.[3] These emboli can also be detected in the left atrium of patients without a patent foramen ovale (PFO).[8] A significant reduction in the incidence of emboli was observed after the surgical technique was modified.[7,9] Monitoring with TEE has been described in other types of orthopedic surgical procedures, such as lumbar spinal surgery, in which embolic events were observed in 80% of cases.[10] The pulmonary thromboemboli associated with hemodynamic instability in the ICU represents another instance where TEE can facilitate a more accurate diagnosis and guide treatment.

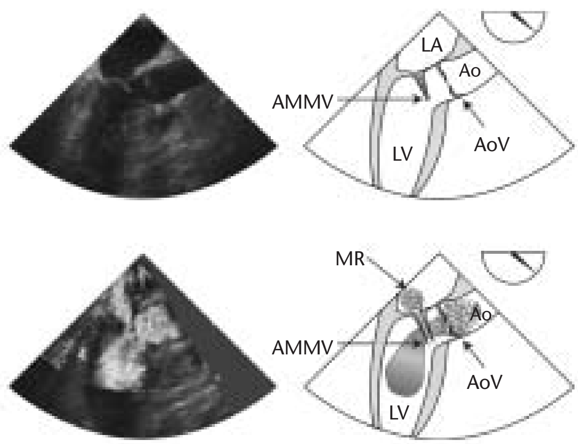
A gas embolism is another type of emboli that may occur during various surgical procedures. Its presence necessitates the creation of a venous breach under sub-atmospheric pressure. In a patient undergoing cervical spine surgery in the ventral position, we have observed hemodynamic instability secondary to an air embolism confirmed by TEE (Figure 2). This finding has also been observed in various studies.[11,12] Other types of orthopedic surgery, including shoulder arthroscopy, are also associated with this complication.[13] Air emboli and their consequences have been described in lobectomies[14] and chest trauma cases.[15,16] General surgical, gynecological, and orthopedic laparoscopies may be associated with the occurrence of CO_2 gas emboli. TEE and Doppler examination are the most sensitive diagnostic methods for detecting gas emboli. Derouin et al found gas emboli in 11 of 16 patents (69%) undergoing laparoscopic surgery,[17] yet, less than 1% were symptomatic.[18,19] An air embolism can have disastrous consequences and, by obstructing the pulmonary vascular bed, may cause pulmonary hypertension and right ventricular failure as well as bronchospasm and pulmonary edema by releasing cytokines and activating neutrophils.[20]

Moreover, with a PFO, which is found in >20% of the adult population, a paradoxical embolism may occur with myocardial, cerebral, muscular, and visceral ischemia. Paradoxical air emboli have been described in various types of noncardiac surgeries, including neurosurgeries, chest, orthopedic, heart, and transplant surgeries.[21] In addition, hypoxia may be associated with the presence of a PFO and a left-to-right shunt in patients under mechanical ventalation. Preoperative detection of the PFO is recommended (Level 2) in patients at high risk of air embolism, depending on the type of procedure (see below).

Subvalvular obstruction

A subvalvular obstruction is an insidious cause of instability and is found in 5%-10% of hemody-

FIGURE 3: Obstruction of the LV outflow tract by the anterior mitral valve leaflet in a 38-year-old male in the ICU, in septic shock and very hemodynamically unstable. The obstruction was associated with mitral regurgitation. Use of a beta-blocker was associated with an improvement in the hemodynamic condition and disappearance of the mitral regurgitation.



Ao = aorta, AMMV = anterior motion of the mitral valve, LA = left atrium, MR = mitral regurgitation, AoV = aortic valve, LV = left ventricle.

namically unstable patients.[22-24] A subvalvular gradient may develop in the presence of a hyperdynamic empty left ventricle, with or without left ventricular hypertrophy, and involve the anterior mitral leaflet in the left ventricular outflow tract. This is often associated with mitral regurgitation. The hemodynamic manifestations of this condition may mimic ischemic mitral regurgitation and lead to the observation of a heart murmur, tachycardia, hypotension, high filling pressures, and the appearance of a V-wave in the pulmonary capillary wedge pressure tracing. In these conditions, the treatment is opposite to that for mitral regurgitation and involves administering fluid, increasing the outflow resistance, and slowing the heart rate. Inotropics or intra-aortic balloon are absolutely contraindicated and will exacerbate the subvalvular obstruction. This condition is difficult to diagnose without a TEE (Figure 3).

Right ventricular dysfunction

Right ventricular (RV) dysfunction is frequently associated with hemodynamic instability after heart surgery and has a poor prognosis.[25,26] It can also occur following chest trauma[27] and with sepsis.[28] RV dysfunction is difficult to diagnose in the ICU when relying on hemodynamic criteria.[29] In noncardiac surgery, it may occur during thoracic surgery, especially lung transplantation, and its occurrence is a sign to the surgeon that extracorporeal support may be necessary. TEE makes it possible to determine the etiology of hemodynamic instability during lung transplantation and differentiate, for example, RV dysfunction from a subvalvular obstruction.[30] RV dysfunction may also accompany overly aggressive fluid resuscitation. Some patients in hemorrhagic shock remain or become increasingly unstable when resuscitation is overly aggressive. In this situation, a TEE reveals RV dilation associated with a decrease in the size of the left ventricle due to interaction via the pericardium and the interventricular septum. Thus, TEE makes it possible to monitor fluid resuscitation and avoid overly aggressive treatment that may exacerbate the pre-existing RV failure.

Valvular dysfunction

Mitral valve dysfunction may occur with myocardial ischemia or a subvalvular obstruction. The etiology of the regurgitation determines the treatment. Acute aortic regurgitation may occur when there is an aortic dissection and, in this case, TEE is essential for determining the entry point and other related complications (tamponade, coronary artery dissection, pleural effusion). Finally, while tricuspid regurgitation is rarely an isolated cause of hemodynamic instability, it often accompanies RV failure.

Cardiac tamponade

Tamponade is usually a complication of heart surgery and may occur insidiously with regional rather than circumferential compression. In such instances, the classic signs of tamponade will not be observed.[31,32] Tamponade may also complicate the insertion of central venous access and pacemakers.

CATEGORY 2 INDICATIONS

Category 2 indications for TEE have weaker or more controversial support from clinical evidence and experts than those in Category 1. In these situations, TEE may be helpful, but the indications are less definite. Some of these indications are discussed below.

Perioperative use in patients at risk of a coronary syndrome or hemodynamic instability

TEE may be useful for monitoring patients undergoing vascular surgery, yet it is difficult to identify exactly which patients are most likely to benefit. For example, in patients with a left bundle branch block, ECG monitoring is less likely to detect myocardial ischemia, whereas TEE can display ischemic episodes.[33] Patients with valvular heart disease are more likely to have TEE discover an anomaly leading to modifications in their medical or surgical therapy. TEE monitoring can be useful for patients with pulmonary hypertension awaiting thoracic surgery, notably to assess left[34] and right ventricular function, as well as rule-out a PFO[35] and pulmonary embolism.

Air embolism detection in patients having neurosurgery in the sitting position

The risk of an air embolism during this type of procedure is estimated to be between 25% and 100%.[36,37] In a prospective study of 62 patients, Papadopoulos found air emboli in 76% of posterior fossa surgeries (Group 1) and 25% of cervical laminectomies (Group 2). The incidence of PFO in the two groups was 23% and 10%, respectively.[38] Ruling-out a PFO is strongly recommended before any surgery in the sitting position, and its presence contraindicates this position due to the risk of air and paradoxical emboli.[21,39]

Use with patients suspected of heart trauma or aortic dissection, rupture, or aneurysm

In this case, an unsuspected RV dysfunction and the presence of an asymptomatic aortic pathology can alter the medical and surgical treatment.

Anastomosis assessment in lung transplantation

TEE is used during lung transplantation to assess RV function during anastomosis of the transplanted lung, especially in patients with pulmonary hypertension. It is also used to locate arterial or venous stenosis at the end of the procedure.[40-44]

Assessment of the extracorporeal circulatory support system (intra-aortic balloon, extracorporeal membrane oxygenator)

In this particular case, with heart surgery or in the ICU, TEE can be used to ensure the proper position of arterial and venous cannula with no need for immediate radiological support.

CATEGORY 3 INDICATIONS

Category 3 indications show little clinical or scientific evidence to support the routine use of TEE. In these cases, TEE is rarely useful and its indications are undefined. Some of the Category 3 indications for TEE are described below.

Assessment of uncomplicated endocarditis in noncardiac surgery and the cardiac impact of pleuropulmonary diseases.

These assessments can be done by the cardiologist prior to surgery.

Embolism monitoring in orthopedic surgery

(This is discussed above.)

Intra-aortic balloon, pulmonary artery catheter, and defibrillator position monitoring

These last applications can be used when the patient is intubated and on a ventilatory support. TEE is rarely used for these indications unless, for example, the patient becomes hemodynamically unstable during the procedure and a cardiac tamponade is suspected.

LIMITATIONS OF TRANSESOPHAGEAL ECHOCARDIOGRAPHY

TEE has its limitations. Certain cardiac structures such as the ascending aorta cannot be seen in the area anterior to the left main bronchus. A TEE examination is relatively safe, but complications related to its use, such as injury to the oropharyngeal region, esophageal perforations, and death, have been reported. A study of 7,200 heart-surgery patients revealed a 0.2% incidence of morbidity and 0% mortality.[45] This incidence is far less than the complications associated with the pulmonary artery catheter. One major problem lies in the misinterpretation of the TEE imagery that can lead to perioperative procedures with no benefit for the patient. It is clear that the safe, optimal use of TEE necessitates initial training and continuing education.[46]

CONCLUSION

In brief, perioperative echocardiography includes TEE as well as other echocardiographic procedures that anesthesiolgists now use and will increasingly employ in both cardiac and noncardiac surgery, as well as in the ICU. These applications go beyond the bounds of heart surgery. Given its increasingly widespread use, the impact of TEE on morbidity and mortality will be difficult to determine with randomized studies. Cost-benefit analysis, however, tends to support the beneficial role of this technology.[47,48]

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