

# The Safety of Intraoperative Transesophageal Echocardiography: A Case Series of 7200 Cardiac Surgical Patients

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Transesophageal echocardiography (TEE) is an invaluable intraoperative diagnostic monitor that is considered to be relatively safe and noninvasive. Insertion and manipulation of the TEE probe, however, may cause oropharyngeal, esophageal, or gastric trauma. We report the incidence of intraoperative TEE-associated complications in a single-center series of 7200 adult cardiac surgical patients. Information related to intraoperative TEE-associated complications was obtained retrospectively from the intraoperative TEE data form, routine postoperative visits, and cardiac surgical morbidity and mortality data. The overall incidences of TEE-associated morbidity and mortality in the study

population were 0.2% and 0%, respectively. The most common TEE-associated complication was severe odynophagia, which occurred in 0.1% of the study population. Other complications included dental injury (0.03%), endotracheal tube malpositioning (0.03%), upper gastrointestinal hemorrhage (0.03%), and esophageal perforation (0.01%). TEE probe insertion was unsuccessful or contraindicated in 0.18% and 0.5% of the study population, respectively. These data suggest that intraoperative TEE is a relatively safe diagnostic monitor for the management of cardiac surgical patients.

(Anesth Analg 2001;92:1126-30)

**T**ransesophageal echocardiography (TEE) is an invaluable intraoperative diagnostic monitor for management of cardiac surgical patients. A survey of 155 US academic institutions reported that 91% routinely use intraoperative TEE (1). The popularity of TEE is caused by its impact on intraoperative cardiac surgical decision making by providing pertinent information regarding hemodynamic management, cardiac valvular function, and the diagnosis of congenital heart lesions and great vessel pathology (2,3).

TEE is considered to be relatively safe and noninvasive. Insertion and manipulation of the TEE probe, however, may cause oropharyngeal, esophageal, or gastric trauma. In a multicenter survey of 10,419 predominantly conscious adult patients undergoing TEE, a complication rate of 0.18%, including one death, was reported (4). Furthermore, an incidence of 2.4% adverse events associated with TEE was noted in a study

of 1650 pediatric cardiac surgical patients (5). Other investigations have focused primarily on the incidence of dysphagia after intraoperative TEE (6,7). We now describe and report the incidence of intraoperative TEE-associated complications in a single-center series of adult cardiac surgical patients.

## Methods

The study population consisted of 7200 consecutive adult ( $\geq 18$  yr old) cardiac surgical patients in whom intraoperative TEE was performed between 1990 and 1999 at Brigham and Women's Hospital (Boston, Massachusetts). Indications for surgery included coronary artery bypass grafting, valve repair or replacement, congenital heart surgery, procedures on the great vessels, heart transplantation, transmyocardial laser revascularization, and placement of ventricular assist devices.

After obtaining approval from the IRB of Brigham and Women's Hospital, information related to intraoperative TEE-associated complications was obtained retrospectively from the intraoperative TEE data form recorded by the attending anesthesiologist, routine

Accepted for publication December 20, 2000.

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postoperative follow-up visits recorded in a standardized fashion, and cardiac surgical morbidity and mortality data. Reported complications included but were not limited to odynophagia, defined as severe and persistent enough to warrant diagnostic esophagogastroduodenoscopy (EGD); dental injury, defined as a dislodged or loosened tooth noted during TEE probe placement; and clinically significant upper gastrointestinal (UGI) bleeding, defined as the presence of copious bright red blood or "coffee grounds" during orogastric suctioning at the conclusion of the operation. Attribution of a given complication to the intraoperative TEE examination was made at the discretion of the attending anesthesiologist, cardiac surgeon, or both. The number of patients in whom TEE probe insertion was unsuccessful or contraindicated was recorded.

All intraoperative TEE examinations were conducted after the induction of general anesthesia, neuromuscular blockade, and tracheal intubation. Before insertion of the TEE probe, tooth guards were inserted and the gastric contents emptied with an orogastric tube that was then removed. A lubricated biplane or multiplane TEE probe (Acuson Corporation, Mountain View, CA) was then blindly inserted into the esophagus. If blind insertion of the TEE probe was not readily accomplished after one or two attempts, the probe was then inserted by using direct laryngoscopy, or the procedure was abandoned if significant resistance was encountered. All examinations, including interpretation, were performed by attending cardiac anesthesiologists credentialed to perform intraoperative TEE.

## Results

TEE-associated morbidity occurred in 14 (0.2%) of the 7200 patients, without any TEE-associated mortality. Most complications (86%) were caused by oropharyngeal, esophageal, or gastric trauma secondary to TEE probe insertion or manipulation (Table 1).

Seven patients (0.1%) experienced postoperative odynophagia severe enough to warrant diagnostic EGD. Linear esophageal abrasions were discovered in four patients in the upper (1), mid (1), and lower (2) esophagus. In addition, dysphagia was evaluated by a Gastrografin swallow study in one patient. Dental injury, consisting of a dislodged or loosened tooth during TEE probe insertion, was documented in two patients (0.03%). All of the above patients recovered uneventfully and were later discharged from the hospital without further acute complication.

Acute UGI hemorrhage occurred in two patients (0.03%). Both cases were diagnosed at the end of surgery and then confirmed by EGD. There was no evidence of a clinical or laboratory coagulopathy in either

case. One patient had a history of a surgically corrected and asymptomatic Zenker's diverticulum. In both patients, TEE probe insertion and manipulation were uneventful and the intraoperative course benign. However, upon removal of the TEE probe at the end of surgery, >600 mL of fresh blood and "coffee grounds" were noted during orogastric aspiration. In one patient, EGD revealed several linear esophageal erosions and a large contusion at the gastroesophageal (GE) junction consistent with a Mallory-Weiss tear. In the second patient, EGD revealed only erythema and diffuse oozing at the GE junction. Gastric hemorrhage resolved in both patients with conservative, nonsurgical management.

One case (0.01%) of TEE-associated esophageal perforation occurred in an elderly woman undergoing removal of a defective automatic implantable cardioverter-defibrillator. Although TEE probe insertion was not difficult, the acquired images were poor in quality. Two days after the surgical procedure, the patient complained of dyspnea. A right hydro-pneumothorax was diagnosed by chest radiograph, and a Gastrografin swallow study revealed extravasation of contrast entering the right pleural cavity just above the thoracic inlet. The patient subsequently underwent surgery to repair the esophageal perforation and recovered without further acute sequelae.

Arterial desaturation associated with increased peak inspiratory airway pressure during the intraoperative TEE examination occurred in two patients (0.03%). In both patients, the endotracheal tube was inadvertently advanced into the right mainstem bronchus during TEE probe manipulation.

TEE probe insertion was unsuccessful in 13 (0.18%) patients and contraindicated in 35 (0.5%) patients, all with a known medical history of esophageal or gastric pathology (Table 2).

## Discussion

The incidence of TEE-associated complications is in the range of 0%–0.5% (3,4,8,9). The morbidity and mortality of TEE is comparable to UGI endoscopy, which is associated with a complication rate of 0.08%–0.13% and a mortality of 0.004% (4,10,11). In our series, intraoperative TEE was associated with similar rates of morbidity (0.2%) and mortality (0%).

The majority of intraoperative TEE-associated complications in our case series were caused by oropharyngeal, esophageal, or gastric trauma. Direct trauma to the gastrointestinal (GI) tract may be associated with blind insertion and advancement of the probe, the large size of the probe tip relative to the esophagus, the wide range of probe tip flexion and manipulation required to obtain certain images, and the presence of unknown esophageal or gastric pathology.

**Table 1.** Intraoperative TEE-Associated Complications

Complication	No. patients	% All cases (n = 7200)	% All complications (n = 14)
Odynophagia	7	0.10	50
Swallowing abnormality	1	0.01	7
Esophageal abrasions	4	0.06	29
No associated pathology	2	0.03	14
Upper gastrointestinal hemorrhage	2	0.03	14
Esophageal perforation	1	0.01	8
Dental injury	2	0.03	14
Endotracheal tube malposition	2	0.03	14
Total	14	0.20	100

TEE = transesophageal echocardiography.

**Table 2.** Contraindications to TEE Probe Insertion

Contraindication	No. patients	% All contraindications (n = 35)
Oropharyngeal carcinoma	2	6
Esophageal pathology		
Varices	9	26
Stricture	7	20
Diverticulum	1	3
Esophagitis	5	14
Mallory-Weiss tear	1	3
Gastric pathology		
Recent UGI hemorrhage <sup>a</sup>	3	8
Mo. gastric ulcer	4	12
Symptomatic hiatal hernia	2	6
Thoracic aortic aneurysm	1	3
Total	35	100

TEE = transesophageal echocardiography; UGI = upper gastrointestinal.  
<sup>a</sup> Within 3 mo of surgery.

Indirect trauma of the GI tract may be related to excessive or prolonged, continuous pressure at the TEE probe-mucosal interface, resulting in tissue ischemia and necrosis (12). Urbanowicz et al. (13), however, demonstrated the absence of significant esophageal wall pressure (<10 millimeters of mercury) and mucosal injury even with maximal TEE probe tip flexion in an animal model. Alternatively, GI injury may occur secondary to thermal injury produced by piezoelectric crystal vibration at the TEE probe tip or from ultrasound energy absorption by the adjacent tissue (13,14). Although esophageal thermal injury has been reported in patients with severe atherosclerotic cardiovascular disease in whom the esophageal circulation was presumed to be compromised (14), experimental studies in animals have failed to demonstrate any gross anatomic or microscopic evidence of injury directly related to ultrasound energy transmission (15).

Seven patients (0.1%) in our case series complained of severe odynophagia warranting further investigation by EGD or Gastrografin swallow. Dysphagia or evidence of esophageal injury was demonstrated in five (0.07%) of these patients. Although many patients

in our series experienced mild sore throat, only dysphagia accompanied by persistent, severe odynophagia was considered a clinically significant, TEE-associated complication. The reported incidence of swallowing dysfunction in adult patients after cardiac surgery is in the range of 2%–4% (6) and is associated with advanced age, duration of tracheal intubation, the presence of an orogastric tube, cerebral vascular accident, and recurrent laryngeal nerve injury (6,16). An independent correlation between intraoperative TEE and dysphagia has been reported (6,7) but not consistently demonstrated (17,18).

Intraoperative TEE was associated with direct GI trauma in seven cardiac surgical patients (0.1%) in our series, including four esophageal abrasions and one esophageal perforation. Two additional patients (0.03%) experienced significant UGI hemorrhage. The overall incidence of GI complications after cardiac surgery is in the range of 0.7%–2% (18–20). Although direct GI trauma associated with TEE probe insertion and manipulation may contribute to the incidence of postoperative UGI bleeding, factors such as advanced age, perioperative anticoagulant administration, and perioperative visceral hypoperfusion have also been implicated (18).

Esophageal perforation, most likely related to the use of intraoperative TEE, occurred in one patient in our series. Severe pharyngeal or esophageal injury is a rare, but serious, TEE-associated complication that is more likely to occur in difficult TEE probe insertions or in patients with preexisting GI pathology (14). This form of GI trauma usually presents early with hemorrhage (12), subcutaneous emphysema (21), or the appearance of the TEE probe in the surgical field (22).

Contraindications to TEE probe insertion include either signs or symptoms of GI disease (severe dysphagia, odynophagia, reflux, hematemesis) or a history of pathology. Insertion of the TEE probe was contraindicated in 35 patients in our study for reasons similar to those previously cited (3,4,23,24). Patients with hiatal hernias usually tolerate TEE examination without complications, although imaging may be

compromised. TEE was contraindicated in two patients with hiatal hernias in our case series because of the severity of the associated GE reflux. There is controversy in the literature regarding the relative risk of TEE in patients with mild dysphagia in the absence of known esophageal pathology. Routine barium swallow or EGD before TEE probe insertion for all of these patients might be useful, although not necessarily cost-effective. Proceeding with caution and maintaining a low threshold for abandoning the procedure if resistance is encountered during insertion or advancement of the probe may be an acceptable approach, because most of these patients tolerate the procedure without complications (24). The use of intraoperative epicardial and epiaortic probes is also a reasonable alternative when TEE is contraindicated.

Failure to successfully insert or advance the TEE probe occurs in 0.7%–1.9% of sedated adult patients (4,25) and in 0.8% of anesthetized pediatric patients (5). We observed a smaller incidence of failed probe insertion in anesthetized adult patients (0.18%). Explanations for failed TEE probe insertion in awake adults include patient intolerance, operator inexperience, and limiting anatomic variants in the pediatric population. Buckling of the TEE probe tip can also contribute to difficult or failed placements; this occurred during 2.8% of TEE probe insertions in one study of anesthetized patients (25). Because injury to the oropharynx or dysphagia after TEE is often associated with failed insertion or malposition of the probe (12), the procedure should be abandoned if difficulty or resistance is encountered with probe insertion or advancement. In one patient in our case series, insertion of the TEE probe was immediately abandoned after resistance was encountered while attempting to advance the probe into the proximal esophagus. The patient's perioperative course was unremarkable, although he developed recurrent aspiration pneumonia after discharge from the hospital. EGD revealed the presence of a previously unknown Zenker's diverticulum, which required surgical correction.

Many retrospective case series studies, including ours, may underestimate the true incidence of TEE-associated complications. Conservative definitions of clinically significant adverse events, limitations in standardizing the evaluation of patients' subjective complaints, and ascribing truly related complications to other etiologies may all contribute to systematic underreporting. In addition, it is difficult to assess consequences associated with the distraction factor of intraoperative multitasking and patient care while performing intraoperative TEE (26). Intraoperative TEE-associated morbidity may be minimized by avoiding its use in patients with contraindications to GE manipulation, adhering to conservative judgment in abandoning probe insertion when significant resistance is encountered, and maintaining strict vigilance

while continuing to observe and care for patients during the examination.

## References

1. Poterack KA. Who uses transesophageal echocardiography in the operating room? *Anesth Analg* 1995;80:454–8.
2. Savage RM, Lytle BW, Aronson S, et al. Intraoperative echocardiography is indicated in high-risk coronary artery bypass grafting. *Ann Thorac Surg* 1997;64:368–73.
3. Mishra M, Chauhan R, Sharma KK, et al. Real-time intraoperative transesophageal echocardiography: how useful? Experience of 5,016 cases. *J Cardiothorac Vasc Anesth* 1998;12:625–32.
4. Daniel WG, Erbel R, Kasper W, et al. Safety of transesophageal echocardiography: a multicenter survey of 10,419 examinations. *Circulation* 1991;83:817–21.
5. Stevenson JG. Incidence of complications in pediatric transesophageal echocardiography: experience in 1650 cases. *J Am Soc Echocardiogr* 1999;12:527–32.
6. Hogue CWJ, Lappas GD, Creswell LL, et al. Swallowing dysfunction after cardiac operations: associated adverse outcomes and risk factors including intraoperative transesophageal echocardiography. *J Thorac Cardiovasc Surg* 1995;110:517–22.
7. Rousou JA, Tighe DA, Garb JL, et al. Risk of dysphagia after transesophageal echocardiography during cardiac operations. *Ann Thorac Surg* 2000;69:486–9.
8. Seward JB, Khandheria BK, Oh JK, et al. Critical appraisal of transesophageal echocardiography: limitations, pitfalls, and complications. *J Am Soc Echocardiogr* 1992;5:288–305.
9. Khandheria BK. The transesophageal echocardiographic examination: is it safe? *Echocardiography* 1994;11:55–63.
10. Silvis SE, Nebel O, Rogers G, et al. Endoscopic complications: results of the 1974 American Society for Gastrointestinal Endoscopy Survey. *JAMA* 1976;235:928–30.
11. Miller G. Komplikationen bei der Endoskopie des oberen Gastrointestinaltraktes. *Leber Magen Darm* 1987;17:299–304.
12. Savino JS, Hanson CW, Bigelow DC, et al. Oropharyngeal injury after transesophageal echocardiography. *J Cardiothorac Vasc Anesth* 1994;8:76–8.
13. Urbanowicz JH, Kernoff RS, Oppenheim G, et al. Transesophageal echocardiography and its potential for esophageal damage. *Anesthesiology* 1990;72:40–3.
14. Kharasch ED, Sivarajan M. Gastroesophageal perforation after intraoperative transesophageal echocardiography. *Anesthesiology* 1996;85:426–8.
15. O'Shea JP, Southern JF, D'Ambra MN, et al. Effects of prolonged transesophageal echocardiographic imaging and probe manipulation on the esophagus: an echocardiographic-pathologic study. *J Am Coll Cardiol* 1991;17:1426–9.
16. Messina AG, Paranicas M, Fiamengo S, et al. Risk of dysphagia after transesophageal echocardiography. *Am J Cardiol* 1991;67:313–4.
17. Owall A, Stahl L, Settergren G. Incidence of sore throat and patient complaints after intraoperative transesophageal echocardiography during cardiac surgery. *J Cardiothorac Vasc Anesth* 1992;6:15–6.
18. Hulyalkar AR, Ayd JD. Low risk of gastroesophageal injury associated with transesophageal echocardiography during cardiac surgery. *J Cardiothorac Vasc Anesth* 1993;7:175–7.
19. Krasna MJ, Flancaum L, Trooskin SZ, et al. Gastrointestinal complications after cardiac surgery. *Surgery* 1988;104:773–80.
20. Egleston CV, Gorey TF, Wood AE, McGovern EM. Gastrointestinal complications after cardiac surgery. *Ann R Coll Surg Engl* 1993;15:52–6.
21. Badaoui R, Choufane S, Riboulot M, et al. Esophageal perforation after transesophageal echocardiography. *Ann Fr Anesth Reanim* 1994;13:850–2.
22. Spahn DR, Schmid S, Carrel T, et al. Hypopharynx perforation by a transesophageal echocardiography probe. *Anesthesiology* 1995;82:581–3.

23. Fleischer DE, Goldstein SA. Transesophageal echocardiography: what the gastroenterologist thinks the cardiologist should know about endoscopy. *J Am Soc Echocardiogr* 1990;3:428-34.
24. Chan KL, Cohen GI, Sochowski RA, Baird MG. Complications of transesophageal echocardiography in ambulatory adult patients: analysis of 1500 consecutive examinations. *J Am Soc Echocardiogr* 1991;4:577-82.
25. Orihashi K, Sueda T, Matsuura Y, et al. Buckling of transesophageal echocardiography probe: a pitfall at insertion in an anesthetized patient. *Hiroshima J Med Sci* 1993;42:155-7.
26. Weinger MB, Herndon OW, Gaba DM. The effect of electronic record keeping and transesophageal echocardiography on task distribution, workload, and vigilance during cardiac anesthesia. *Anesthesiology* 1997;87:144-55.