Safety of Transesophageal Echocardiography
A Multicenter Survey of 10,419 Examinations

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**Background.** During the past few years, transesophageal echocardiography (TEE) has been increasingly used in clinical cardiology; data concerning the practicability and safety of the technique, however, are rare.

**Methods and Results.** This report analyzes the experience of 15 European centers performing TEE studies for at least 1 year. At the time of this survey, 10,419 TEE examinations had been attempted or performed in these institutions. These TEE examinations were carried out by 54 physicians, 53.7% of whom had been trained in endoscopic techniques. Within the same time period, 160,431 precordial echocardiographic examinations were performed in the 15 institutions; the ratio between TEE and transthoracic studies averaged 9.03±6.4% (range of the 15 centers, 1.4–23.6%). Of the 10,419 patients, 9,240 (88.7%) were conscious inpatients or outpatients at the time of the TEE examination; the vast majority of the conscious patients did not receive intravenous sedation before TEE. In 201 cases (1.9%), insertion of the TEE probe was unsuccessfully attempted because of a lack of patient cooperation and/or operator experience (98.5%) or because of anatomical reasons (1.5%). In 90 of 10,218 TEE studies (0.88%) with successful probe insertion, the examination had to be interrupted because of the patient’s intolerance of the echoscope (65 cases); because of pulmonary (eight cases), cardiac (eight cases), or bleeding complications (two cases); or for other reasons (seven cases). One of the bleeding complications resulted from a malignant lung tumor with esophageal infiltration and was fatal (mortality rate, 0.009%).

**Conclusions.** This multicenter survey documents that TEE studies are associated with an acceptable low risk when used by experienced operators under proper safety conditions.

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During the past few years, transesophageal echocardiography (TEE) has rapidly become accepted as a valuable complementary technique to conventional transthoracic echocardiography. Imaging of the heart via the esophagus provides an unobstructed view of cardiac structures and the great vessels and allows the use of higher-frequency transducers, which results in improved image quality. Furthermore, this technique allows anatomical interrogation of cardiac regions that are difficult to detect by precordial ultrasound. Consequently, TEE improves diagnostic information in various cardiovascular diseases compared with conventional transthoracic echocardiography.

In contrast to conventional echocardiography, TEE is a semi-invasive procedure. The examination may be associated with some discomfort for the patient, and the procedure is not free of risk. Because of these concerns, some physicians may be hesitant to perform TEE studies.

Because TEE examinations are performed with an ultrasound transducer mounted at the tip of a modified gastroscope, the risk of this procedure may be...
comparable to routine gastroscopy. Safety aspects of conventional endoscopic procedures are well documented. However, compared with routine endoscopy, TEE studies are performed under circumstances that may increase risk: TEE examinations are usually carried out 1) by cardiologists with no or limited experience in endoscopic techniques or 2) in patients with more severe cardiac diseases, and 3) without an optical control during probe insertion and manipulation in the esophagus.

Only a few studies have systematically analyzed the risk of TEE. To obtain reliable data on various safety and practicability aspects, we performed a multicenter survey including 15 European institutions that use this technique on a routine day-to-day diagnostic basis in clinical cardiology.

Methods

The centers contributing to this study were selected by the initiating institution (Hannover Medical School) between June 1988 and February 1989. The selection criteria were that 1) adult TEE had to be a routine procedure for at least 1 year and 2) detailed records of patients studied by TEE had to be available, including any types of problems, side effects, and complications related to TEE.

Data were collected on the basis of a detailed questionnaire covering the following topics. When did the particular institution start performing TEE examinations, what was the total number of TEE studies performed, and how many transthoracic echocardiographic examinations were performed in the same time period? How many operators had performed these TEE studies, were TEE examinations performed only by physicians or also by technicians, and how many of the operators were trained in conventional endoscopic techniques before they started performing TEE? How many patients were conscious at the time of the TEE examination, what were the ages of the youngest and oldest patients studied at the particular institution, and was a transthoracic echocardiographic study performed before TEE? Details regarding certain technical aspects were queried, namely, type of ultrasound machines used, minimum fasting time, necessity of an esophagoscopy or barium swallow test before the TEE examination, premedication, antibiotic prophylaxis, intravenous line before and during the TEE study, patient’s body position during insertion of the TEE probe, and time of the placement of the bite guard (before or after probe insertion). What kind of disease was considered a contraindication for a TEE study in the various institutions, and how long was the estimated average time needed for a routine TEE study (time of the TEE probe in the esophagus)? In how many patients was the insertion of the TEE probe attempted but not possible, and what were the reasons for the unsuccessful attempt? In how many patients was the TEE study interrupted before completion, what were the reasons for the interruption, and were there any other complications observed during or after the TEE examination?

Results

Patients, Number of Transesophageal Echocardiography Examinations, and Operators

Based on the selection criteria, the data of 15 divisions of cardiology of European institutions were evaluated. TEE was first performed in 1982 in one center, 1983 in three centers, 1984 in three centers, 1985 in one center, 1986 in three centers, 1987 in three centers, and 1988 in one center. At the time of this survey, 10,419 TEE examinations had been performed. The number of TEE studies per center ranged between 106 and 2,977 (average, 694±780), with more than 500 studies having been performed at five institutions. In the same period of time, a total of 160,431 transthoracic studies were carried out. The average ratio of TEE to transthoracic studies was 9.03±6.4% (range, 1.4–23.6%; 11 centers, <10%). At the time of the TEE examinations, 9,240 of the 10,419 patients (88.7%) were conscious inpatients or outpatients. The remaining 1,179 patients underwent TEE examination in the operating room or during mechanical ventilation in the intensive care unit. The age of the patients ranged from 9 to 84 years.

TEE studies were performed only by physicians. Fifty-four percent (29 of 54) of the physicians had had previous training in routine endoscopy. There were only three centers in which none of the physicians performing the TEE studies had had endoscopic training; in these three centers, the first series of TEE examinations was performed with the help of a gastroenterologist.

Transesophageal Echocardiography Technique

TEE studies were performed in the echocardiography laboratory, the emergency department, on regular wards, in intensive care units, and in the operating room using commercially available equipment. In seven centers, TEE probes with an incorporated optical channel were used; however, in only four centers, the possibility of optical control was used in selected patients (suspected esophageal disease and difficulties of probe insertion). No center requested an endoscopic examination of the esophagus or a barium swallow test on a routine basis before the TEE study. In conscious patients, minimum fasting time before the TEE study was 3 hours in one center, 4 hours in 10 centers, and more than 4 hours (5–9 hours) in four centers. In all centers, a transthoracic echocardiographic examination was performed before TEE.

After verbal (12 centers) or written (three centers) informed consent by the patient was received, dentures were removed. Local pharyngeal anesthesia was administered in all except one institution. In only four centers, an intravenous line was placed in all
patients before the TEE study. The remaining centers determined intravenous line placement on the basis of individual risk. Intravenous sedation was routinely administered in one center. The other institutions used mild intravenous sedation in selected patients only (e.g., patients with suspected aortic dissection or high levels of anxiety). Three centers used no sedation. Agents used for sedation were diazepam (10 centers), midazolam hydrochloride (three centers), and buprenorphine hydrochloride (one center). Thirteen centers introduced the TEE probe with the patient in a left lateral decubitus position, and two centers performed this procedure in a right lateral or sitting position. The bite guard was placed after probe insertion in eight institutions and before it in seven centers. Estimated average time for a TEE study (i.e., time between probe insertion and completion of the examination) was less than 10 minutes in six centers, less than 15 minutes in seven centers, and less than 20 minutes in two centers.

During the TEE study, a one-lead electrocardiogram was monitored continuously in all patients and all institutions. Emergency equipment including a cardioverter was available within minutes in all centers but within the same room in which the TEE study was performed in only six centers. The diseases or conditions considered contraindications for a TEE examination were esophageal diverticulum (13 centers), esophageal varices (10 centers), diseases like AIDS, esophageal tumor, or stenosis, or a patient after therapeutic thoracic radiation (five centers). Effective anticoagulation was not a contraindication in any of the contributing institutions.

When data were collected, endocarditis prophylaxis was applied in selected “high-risk” patients (especially those with prosthetic valves) in only two centers. Three centers used a condom type of sheath that covered the TEE probe (one center for all patients, and two centers for selected patients—e.g., AIDS, hepatitis).

Unsuccessful Attempt of Transesophageal Echocardiography Probe Insertion

In 201 of the 10,419 TEE examinations (1.9%), insertion of the TEE probe was unsuccessfully attempted. In 198 studies (98.5% of the 201 cases), failure of probe insertion was a result of a lack of patient cooperation and/or operator experience. In the remaining three cases, there were anatomical reasons—a tracheostoma (one patient) or an esophageal diverticulum (two patients). In the four centers that had performed only 200 TEE examinations or less, failure of probe insertion averaged 3.9±3.2% compared with 1.4±0.9% in institutions with an experience of more than 200 procedures (p<0.05).

Side Effects and Reasons for Transesophageal Echocardiography Study Interruption

In 90 of the 10,218 TEE examinations with successful probe insertion (0.88%), TEE studies had to be interrupted, as listed in Table 1. In the majority of cases (65 of 90 patients), interruption was due to patient’s intolerance of the esophageal probe. In five patients, studies were interrupted because of vomiting and in two other cases because of a defective TEE probe. Significant complications occurred in 18 of the 10,218 examinations (0.18%). These consisted of pulmonary etiology (bronchospasm or hypoxia) in eight patients, cardiac etiology (nonsustained ventricular tachycardia, transient atrial fibrillation, third-degree atrioventricular block, angina pectoris) in eight patients, and minor pharyngeal bleeding in one patient. In these 17 patients, side effects resolved spontaneously after withdrawal of the TEE probe. In the remaining one patient, however, TEE examination resulted in a severe hematemesis that resolved spontaneously within a few minutes after withdrawal of the TEE probe. The patient underwent emergency esophagoscopy examination, which revealed an esophageal tumor. During this esophagoscopy procedure, there was again a severe esophageal bleeding. The patient died before any surgical intervention. At autopsy, a large malignant lung tumor penetrating into the esophagus was found.

Discussion

Complications of Transesophageal Echocardiography

This multicenter study demonstrates that the rate of complications associated with TEE is low. Pulmonary, cardiac, or bleeding complications necessitating interruption of the TEE examination were observed in 0.18% of cases. Death occurred in one of 10,218 studies (0.0098%). This complication rate is in a range comparable to the 0.08–0.13% complication rates reported in large series (more than 200,000) of patients undergoing gastroesophascopy examinations, with a mortality rate of approximately 0.004%.5,7

<table>
<thead>
<tr>
<th>Table 1. Reasons for TEE Study Interruption Before Completion (90 of 10,218 Examinations [88%] With Successful TEE Probe Insertion)</th>
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<tr>
<td><strong>Intolerance of TEE probe</strong></td>
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<tr>
<td><strong>Pulmonary complications</strong></td>
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<td>Bronchospasm</td>
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<td>Hypoxia</td>
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<td><strong>Cardiac complications</strong></td>
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<td>Nonsustained ventricular tachycardia</td>
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<td>Transient atrial fibrillation</td>
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<td>Third-degree atrioventricular block</td>
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<td>Severe angina pectoris</td>
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<tr>
<td><strong>Bleeding complications</strong></td>
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<tr>
<td>Minor pharyngeal bleeding</td>
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<tr>
<td>Severe hematemesis due to malignant tumor; death on same day</td>
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<tr>
<td><strong>Others</strong></td>
</tr>
<tr>
<td>Vomiting</td>
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<td>TEE probe defect</td>
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TEE, transesophageal echocardiography.
The data of the present multicenter study support previous reports with a small number of patients documenting a low risk of TEE. Engberding et al\textsuperscript{10} studied changes in blood pressure and heart rate in 44 consecutive patients undergoing TEE without previous intravenous sedation. The investigators measured only a mild increase in blood pressure and heart rate after insertion of the TEE probe; one patient showed ventricular premature beats during the examination. Geibel et al\textsuperscript{10} performed 24-hour Holter monitoring and blood pressure measurements in 54 unsedated patients during TEE. In 77\% of the patients, average systolic blood pressure increased from 125 to 141 mm Hg; 22\% showed a decrease from 122 to 115 mm Hg during the examination. One patient developed an intermittent second-degree atrioventricular block (type II) during the TEE study, which disappeared immediately after the procedure. Otherwise, there were no increases in complexity or severity of supraventricular or ventricular arrhythmias in any patient.

One death after a TEE examination has been reported from the Mayo Clinic\textsuperscript{13}: a 64-year-old obese woman with type II diabetes had an acute fatal episode of respiratory distress 5–10 minutes after a complete TEE study and removal of the TEE probe. Before TEE, the patient had received intravenous sedation (1.5 mg midazolam hydrochloride). At autopsy, the esophagus was normal, but the myocardium showed infiltration with lymphocytes (myocarditis). Arrhythmia was the presumed mechanism of death.

Although cardiopulmonary complications associated with TEE are rare (16 of 10,218, or 0.16\%, examinations in this survey), it is the policy of the contributing institutions of the present study to perform TEE only under continuous electrocardiographic monitoring and in facilities that allow prompt cardiopulmonary resuscitation. In addition, a pulse oximeter may be useful in early detection of hypoxemia.

Two patients in the present study developed bleeding complications induced by TEE that necessitated interruption of the examination. One of these two patients died on the day of the TEE study. The cause of death was a malignant lung tumor penetrating into the esophagus that was lacerated by the TEE probe. In two other patients, probe insertion was not possible because of a diverticulum not known at the time of the examination. After this survey was completed, we became aware of an additional patient with a serious bleeding complication indirectly induced by TEE (Dr. Curtius, University Clinic, Cologne, Germany, personal communication). A 61-year-old woman with a thrombosed mitral valve prosthesis diagnosed by TEE was treated with thrombolytic therapy immediately after the TEE examination. Because of incomplete thrombus resolution, a second thrombolytic regimen was administered about 30 hours later. Four hours after initiation of the second thrombolytic attempt, the patient developed hemothorax and shock. Emergency surgery detected a large intramural hematoma of the esophagus that had ruptured into the thorax. The patient survived without further complications. The esophageal bleeding was thought to be a result of minor esophageal lesions caused by the TEE probe.

Esophageal lacerations induced by TEE probe manipulations are rare.\textsuperscript{14,15} The risk, however, is increased in patients with esophageal diseases (e.g., esophageal varices, diverticulum, tumors, and stenoses). Most of the contributing centers of this survey considered these disorders at least a relative contraindication for a TEE examination. We recommend that the operator never use force to introduce the TEE probe and that, in cases with suspected esophageal diseases, an esophagoscopy or barium radiographic examination should precede the TEE study. If one of the above-mentioned esophageal disorders is known, the decision to perform a TEE study depends on a careful risk-benefit consideration. In addition, fibrinolytic therapy immediately following a TEE examination may be associated with an increased risk of bleeding.

Patient Tolerance of Transesophageal Echocardiography

In 201 attempted TEE studies, the operator failed to introduce the TEE probe. In 198 cases, this was because of a lack of patient cooperation or insufficient expertise of the operating physician. Compared with centers performing more than 200 TEE studies, the significantly higher failure rate of probe insertion in institutions with a total experience of 200 TEE examinations or less indicates that there is a learning curve for most physicians beginning to perform TEE procedures. Intolerance of the probe was also the reason in 65 of 9,240 conscious patients (0.7\%) to interrupt the examination. This rate of probe intolerance is low, especially because the vast majority of conscious patients underwent TEE without intravenous sedation.

Sedation may be necessary in anxious patients and should be administered in those with diseases where an inappropriate blood pressure increase has to be avoided (e.g., aortic dissection). The disadvantage of an intravenous sedation is an increased risk for respiratory arrest and aspiration pneumonia, as shown in endoscopic studies.\textsuperscript{7} Furthermore, sedated outpatients need supervision for a certain period of time, which may present logistical problems in many laboratories.

Patient tolerance of a TEE examination was also studied by de Belder et al\textsuperscript{12} using a detailed questionnaire. Of 204 consecutive patients, 79\% found the procedure to be tolerable or only mildly unpleasant; younger patients did not tolerate the study as well as older patients. When asked whether they would prefer to be sedated, 83\% of outpatients and 73\% of inpatients preferred to be unsedated. Only one institution of this survey used intravenous sedation in all patients; the remaining 14 centers avoided sedation in the vast majority of patients.
Antibiotic Prophylaxis

The need for antibiotic prophylaxis before TEE is still controversial. The American Heart Association guidelines on endocarditis prophylaxis recommend antibiotic prophylaxis before upper gastrointestinal endoscopy when the procedure is associated with biopsy; upper gastrointestinal endoscopy without biopsy is considered a procedure to which endocarditis has subsequently developed "rarely, if ever." Concerning patients with "prosthetic heart valves and those with surgically constructed systemic-pulmonary shunts," these recommendations state that "it may be prudent to administer prophylactic antibiotics for these low-risk procedures to such patients."16

When the data of this survey were collected, only two centers administered antibiotic prophylaxis to patients with prosthetic valves. Recent studies recommend or do not recommend antibiotic prophylaxis. To the best of our knowledge, no patient in this survey developed infective endocarditis as a direct consequence of a TEE examination. In a series of 100 patients undergoing TEE at the Hannover Medical School, positive blood cultures were found in only two cases (coagulase-negative Staphylococcus and Propionibacterium; P. Nikutta et al, unpublished observation); both were considered contaminants. At the Hannover Medical School, antibiotic prophylaxis is therefore not administered routinely before TEE to high-risk patients; however, the opinion is not universal in the 15 centers contributing to this survey.

Implications and Recommendations

The results of this multicenter survey document that TEE can be performed at a low risk. However, the technique is semi-invasive, and in every individual patient, a benefit-risk calculation should precede the use of TEE. TEE studies should be performed only by physicians. Operators who are not familiar with endoscopic techniques should be trained by colleagues experienced in TEE or endoscopy. Contraindications have to be carefully taken into consideration. In unclear clinical situations, an esophagoscopy or barium radiograph of the esophagus should precede the TEE study. Issues such as antibiotic prophylaxis and intravenous sedation are still controversial. Overall, the results of this survey justify the use of TEE as a complementary technique in patients in whom conventional transthoracic echocardiography results in insufficient diagnostic information.

References


Key Words • echocardiography, transesophageal • safety
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