Usefulness of Transesophageal Echocardiography in Assessment of Aortic Dissection

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Background. The value of transesophageal echocardiography in the assessment of patients with aortic dissection was studied.

Methods and Results. Group 1 (34 patients) represented all patients studied at our institution with this technique in whom aortic dissection was proven by aortography, surgery, or autopsy. Group 2 (27 patients) represented all patients studied with this technique at our institution in whom aortic dissection was excluded by aortography. Transesophageal echocardiography made a correct diagnosis of aortic dissection in 33 of 34 patients (sensitivity, 97%; specificity, 100%). It also correctly demonstrated the type of dissection in all 29 patients with aortographic or surgical proof. On the other hand, computed tomography scanning, performed in 24 of 34 patients in group 1, made a correct diagnosis in only 67% of patients and misclassified the type of dissection in 33%. Transesophageal echocardiography correctly identified involvement of the coronary arteries by aortic dissection in six of seven patients as well as absence of both left and right coronary artery involvement in 10 patients with aortic dissection. This technique was also useful in detecting communications between the true and false lumens, presence of thrombi in the false lumen, and, in two patients, localized dissection rupture with formation of a false aneurysm. In both groups 1 and 2, transesophageal echocardiography correctly identified patients with moderate to severe aortic regurgitation.

Conclusions. Transesophageal echocardiography is very useful in the assessment of aortic dissection. (Circulation 1991;84:1903–1914)

Acute proximal aortic dissection is a life-threatening emergency.¹ The prognosis of patients with aortic dissection has markedly improved in recent years due to prompt diagnosis and the institution of effective medical and surgical therapy.²–⁶ Both the traditional diagnostic gold standard of aortography⁷,⁸ and the frequently used technique of computed tomography (CT)⁹–¹⁴ have well-recognized pitfalls. Two-dimensional echocardiography¹⁵–²² has recently been used in the diagnosis of this entity, but the sensitivity and specificity of this technique in the diagnosis of acute dissection have not been high due to limitations in obtaining adequate images with poor acoustic windows in patients with obesity, emphysema, or chest wall deformity and those on mechanical ventilation.²³ Transesophageal color Doppler echocardiography is a relatively new and safe technology with exciting potential in the evaluation of this life-threatening disorder.²⁴–²⁸ The major advantage of transesophageal echocardiography is the ability to image almost the entire thoracic aorta with no acoustic window impedance.²⁹ Although recent studies²⁴–²⁸ have demonstrated the usefulness of transesophageal echocardiography in the diagnosis of aortic dissection, there has not been anatomic or aortographic confirmation in all cases.²⁵,²⁷,²⁸ In addition, these studies did not assess the severity of associated aortic regurgitation by imaging or color Doppler technique, and the involvement of the coronary arteries by aortic dissection process has not been commented on by previous authors. Comprehensive evaluation of aortic regurgitation and involvement of the coronary arteries with aortic dissection are important considerations when surgical intervention is being assessed.³⁰,³¹
The purpose of the present study is to clarify the role of transesophageal echocardiography in the evaluation of aortic dissection with particular attention to the type of dissection and associated complications that may be present. The usefulness of transesophageal echocardiography in the assessment of the cause and severity of associated aortic regurgitation, the recognition of coronary artery involvement, the detection of thrombi in the nonperfusing lumen, the identification of communication(s) between the perfusing and the nonperfusing lumen, and the value of this technique in the immediate evaluation of the adequacy of surgical repair were studied.

Methods

Study Patients

A total of 61 patients forms the basis of the study, and they were subdivided into two groups. Group 1 (34 patients) comprised all patients studied at our institution with transesophageal echocardiography in whom aortic dissection was proven by aortography and surgery (18), aortography alone (nine), surgery alone (six), or autopsy (one). Group 2 (27 patients) comprised all patients studied at our institution with transesophageal echocardiography in whom absence of aortic dissection was verified by aortography.

Group 1 comprised 20 men and 14 women (age range, 18–79 years; mean age, 56 years). Aortic dissection was diagnosed as acute in 18 patients and chronic in 16, based on whether symptoms were present for less or more than 2 weeks, respectively. The charts of the 34 patients with aortic dissection were retrospectively reviewed for the presence of an acute myocardial infarction defined as an elevation of creatinine kinase with a positive MB fraction and/or the development of new Q waves. Transesophageal echocardiography was done in the awake state in 15 patients, intraoperatively in 16, and in both settings in the remaining three patients.

Group 2 comprised 18 males and 9 females (age range, 13–78 years; mean age, 59 years). Thirteen had aortic aneurysms (11 ascending aorta and two descending aorta), and the remaining 14 had a nonaneurysmal thoracic aorta. With one exception, none of the patients had a clinically suspected aortic dissection. Twenty-one patients underwent intraoperative transesophageal echocardiography, and the remaining six were studied in the awake state.

The clinical findings of patients with and without aortic dissection are summarized in Table 1.

Transesophageal Procedure

Informed consent was obtained from each patient before the study. An Aloka 870 single/biplane, an Interspec 750, a Hewlett-Packard 500 L, or a Sonocor 1000 machine with a 5-MHz transducer was used in the study to obtain transesophageal two-dimensional and color-coded Doppler images. Twenty-two of the 61 patients (36%) had biplane examinations performed using the Aloka biplane transducer. Studies in the awake state were done under light sedation using intravenous diazepam ranging from 1 to 4 mg with the addition of meperidine (25–50 mg) if the patient continued to be restless or uncomfortable. Alternatively, 25–50 mg meperidine and 12.5–25 mg promethazine were given intravenously. Local anesthesia of the pharynx was achieved with Benzocaine 20% spray to suppress the gag reflex.

Intraoperative transesophageal echocardiography was done after the patient was anesthetized and an endotracheal tube was placed. The transesophageal probe was then introduced through the mouth into the esophagus and manipulated to obtain adequate views of the heart, coronary arteries, and thoracic aorta in the standard manner.

Biplane examination was done in 14 patients from group 1 and eight patients from group 2. The aortic root, ascending aorta, aortic arch, and descending thoracic aorta could be viewed using the longitudinal plane in all 22 patients.

Aortic dissection was diagnosed when a consistent linear echo indicative of a dissection flap was seen within the aortic lumen. The location and extent of the dissection flap were used to determine the type of aortic dissection according to the DeBakey classification—Type I if the flap was seen in the ascending and descending thoracic aortae, type II if the flap was confined to the ascending aorta, and type III if the flap was seen only in the descending thoracic aorta.

The coronary arteries were visualized as two parallel lines originating from the aortic lumen in the aortic short-axis plane. Aortic dissection into the coronary arteries was identified whenever the dissection flap was seen to extend from the aortic lumen into the ostium and lumen of the coronary artery. In those without visualized involvement of the coronary arteries, the minimum distance between the dissection flap and the ostium of the uninvolved coronary artery or the nearest visualized coronary artery was measured.

The perfusing or true aortic lumen was differentiated from the false or nonperfusing lumen by noting systolic bulging of the dissection flap toward the nonperfusing lumen or by flow signals moving through a communication from the perfusing lumen into the nonperfusing lumen during systole. Using these criteria, both lumens could be identified in all of our patients.

Communications between the perfusing and nonperfusing lumens were identified if bright mosaic color flow signals were seen traversing from one lumen to the other through a consistent discontinuity or an apparently intact flap, often with an area of localized flow acceleration at its origin.

An intra-aortic thrombus was diagnosed if a bright echo density within the aorta was consistently seen in a segment of the aorta and completely or incompletely occupied the nonperfusing lumen.
Table 1. Clinical, Transesophageal Echocardiographic, and Computed Tomography Scan Findings in Patients With and Without Aortic Dissection

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>Group 1 (patients with aortic dissection proven by aortography and/or surgery or autopsy – 34 patients)</th>
<th>Group 2 (patients with no aortic dissection proven by aortography – 27 patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Six patients died (DeBakey type I, 2; DeBakey type II, 3; DeBakey type III, 1) Five of these were intraoperative deaths due to bleeding (2) or heart failure and hemodynamic deterioration (3). The sixth patient died of renal failure while on medical management (no surgery done).</td>
<td>Aortic aneurysm (13)</td>
</tr>
<tr>
<td></td>
<td><strong>Clinical findings</strong></td>
<td>No aortic aneurysm (14)</td>
</tr>
<tr>
<td></td>
<td>20 men and 14 women</td>
<td>One patient with ascending aortic aneurysm died from ventricular arrhythmia in postoperative period.</td>
</tr>
<tr>
<td></td>
<td>Age range: 18–79 years</td>
<td>18 males and nine females</td>
</tr>
<tr>
<td></td>
<td>Mean age: 56 years</td>
<td>Age range: 13–78 years</td>
</tr>
<tr>
<td></td>
<td>Chest pain or discomfort not suggestive of angina (19)</td>
<td>Mean age: 59 years</td>
</tr>
<tr>
<td></td>
<td>Back pain (6)</td>
<td>Dyspnea at rest or on exertion (13)</td>
</tr>
<tr>
<td></td>
<td>Exertional dyspnea (4)</td>
<td>Chest pain not suggestive of angina (9)</td>
</tr>
<tr>
<td></td>
<td>Jaw pain (3)</td>
<td>Back pain (2)</td>
</tr>
<tr>
<td></td>
<td>Typical angina (2)</td>
<td>Typical angina (2)</td>
</tr>
<tr>
<td></td>
<td>Left neck and arm pain (1)</td>
<td>Exertional syncope (1)</td>
</tr>
<tr>
<td></td>
<td>Epigastric pain (1)</td>
<td>Numbness and thick feeling of the tongue (1)</td>
</tr>
<tr>
<td></td>
<td>Stridor (1)</td>
<td>Hoarseness of voice (1)</td>
</tr>
<tr>
<td></td>
<td>Recurrent fever due to endocarditis (1)</td>
<td>Blunt chest trauma (1)</td>
</tr>
<tr>
<td></td>
<td>Asymptomatic (3)</td>
<td>Coronary artery disease (9)</td>
</tr>
<tr>
<td></td>
<td>Mediastinal widening on chest radiograph (2)</td>
<td>Bacterial endocarditis (3)</td>
</tr>
<tr>
<td></td>
<td>Trauma during cardiac surgery (1)</td>
<td>Rheumatic heart disease (2)</td>
</tr>
<tr>
<td></td>
<td>Hypertensive heart disease (19)</td>
<td>Marfan's syndrome (2)</td>
</tr>
<tr>
<td></td>
<td>Coronary artery disease (17)</td>
<td>Status post replacement of ascending aorta and/or aortic valve (2)</td>
</tr>
<tr>
<td></td>
<td>Status post aortic valve prosthesis (5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Marfan's syndrome (1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>CT scan</strong></td>
<td>Dissection not present (7)</td>
</tr>
<tr>
<td></td>
<td>Dissection present (16)</td>
<td>CT scan not done (20)</td>
</tr>
<tr>
<td></td>
<td>Dissection not present (8)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CT scan not done (10)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>TEE findings</strong></td>
<td>Dissection flap not seen (27)</td>
</tr>
<tr>
<td></td>
<td>Dissection flap seen (33)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dissection flap not seen (1)</td>
<td></td>
</tr>
</tbody>
</table>

CT, computed tomography; TEE, transesophageal echocardiography. Numbers in parentheses represent number of patients.

Aortic regurgitation was diagnosed with color Doppler if mosaic flow signals originating from the aortic valve were seen in the left ventricular outflow tract during diastole. The ratio of the regurgitant jet width immediately beneath the aortic valve to the width of the left ventricular outflow tract at the same level was used to grade aortic regurgitation into mild (1–24%), moderate (25–46%), moderately severe (47–64%), and severe (65% or more) categories.34

Presence or absence of pericardial effusion was assessed in the standard manner and when present was graded as mild, moderate, or large.35

In all patients undergoing intraoperative transesophageal echocardiography, additional recordings were obtained in the postbypass period to assess the aortic and/or coronary artery grafts.

All echocardiograms were recorded on ½-in. Panasonic VHS videotape and reviewed by two independent observers.

Computed Tomography

CT scans were obtained in the standard manner in 24 of the 34 patients in group 1 and seven of the 27 patients in group 2. Fifteen patients had CT of the chest, and 16 had CT of the chest and abdomen. These studies were reviewed independent of the transesophageal echocardiographic findings for the presence and type of aortic dissection.13

Aortography

Aortograms were performed in the standard manner in 29 of 34 patients in group 1 and in all 27
patients in group 2. All aortograms were reviewed independently by an experienced angiographer.

Statistical Analysis

The sensitivity (true-positives divided by true-positives plus false-negatives) and specificity (true-negatives divided by true-negatives plus false-positives) of transesophageal echocardiography, CT, and aortography in the diagnosis of aortic dissection were calculated. The positive (true-positives divided by true-positives plus false-positives) and negative (true-negatives divided by true-negatives plus false-negatives) predictive values of transesophageal echocardiography in the diagnosis of aortic dissection were also calculated.

Results

Transesophageal Echocardiography

There was complete agreement between the two independent observers with regard to all echocardiographic findings.

Group 1. Transesophageal echocardiography correctly made the diagnosis of aortic dissection in 33 of 34 patients (97%) (Figure 1). There was one false-negative study in a patient who had an aneurysm of the ascending aorta. Retrospective review of the one false-negative transesophageal echocardiogram after the diagnosis was confirmed by both aortography and surgery revealed a thin, mobile linear echo very close to the aortic leaflets. This was not, however, consistently seen; therefore, the diagnosis of aortic dissection still could not be made with certainty.

Group 2. Transesophageal echocardiography correctly excluded dissection in all 27 patients.

The sensitivity and specificity of transesophageal echocardiography in the detection of aortic dissection were 97% and 100%, respectively. The positive and negative predictive values were 100% and 96%, respectively.

Classification

Group 1. Transesophageal echocardiography correctly classified aortic dissection in all 29 patients in whom aortographic or surgical proof was available, excluding the patient in whom transesophageal echocardiography missed aortic dissection. This included 11 patients with type I, 10 patients with type II, and eight patients with type III dissection (Table 2). The patient missed by transesophageal echocardiography was found to have a DeBakey type I dissection at surgery. DeBakey type classification was uncertain in four patients because aortography was not done in three patients and was negative for dissection in one patient. Also in these four patients, only the ascending aorta was opened during repair at surgery (three patients), and autopsy results confirmed a dissection of the aortic arch but did not comment on the descending aorta (one patient).

Group 2. No dissection was present or diagnosed by transesophageal echocardiography.

Coronary Artery Involvement

Group 1. The left main and right coronary arteries were visualized in 30 (88%) and 17 (50%) of the 34 patients, respectively. Of seven patients with proven coronary artery involvement by surgery, the dissection flap was clearly seen by transesophageal echocardiography to extend into the ostium and lumen of the coronary artery in six patients (both right and left coronary arteries in three and only right coronary artery in three) (Figure 2). In the seventh patient, the right coronary artery dissection was confirmed by surgery, but transesophageal echocardiography failed to visualize the vessel. Only two of these patients presented with evidence of recent myocardial infarction by electrocardiography and serum enzymes. The remaining patients had no evidence of acute myocardial infarction (Table 3).
In the 27 dissection patients with no coronary artery involvement, the left main coronary artery was visualized in 23 (average length, 1.2 cm from the ostium; length range, 0.6–1.9 cm), and the right main coronary artery was visualized in 11 (average length, 1.2 cm from the ostium; length range, 0.7–2.2 cm). In patients with type I or type II dissection and no coronary artery involvement, the dissection flap was nearer to the left than to the right coronary artery origin in four patients (average minimum distance, 1.3 cm; distance range, 0.1–2.0 cm), and it was nearer to the right coronary artery origin in six patients (average minimum distance, 0.6 cm; distance range, 0.1–1.7 cm). In three patients in whom only the left main coronary artery was visualized, the minimum respective distances of the flap from its origin were 0.1, 2.8, and 3.6 cm.

**Group 2.** The left main and right coronary arteries were visualized in 25 (93%) and 16 (59%) of the patients with average lengths of 1.2 cm (length range, 0.6–1.8 cm) and 0.8 cm (length range, 0.6–1.9 cm), respectively, from the visualized ostium. No patient in this group had evidence of an acute myocardial infarction by serial electrocardiography or enzymes except one, who had an acute inferior myocardial infarction complicated by a ventricular septal rupture.

**Communications**

Communications between the perfusing and non-perfusing lumens as detected by transesophageal echocardiography and their correlations with aortographic and surgical findings are shown in Table 4 (see also Figure 3). The presence of 13 communications identified by transesophageal echocardiography was confirmed at aortography or surgery, whereas an additional 12 communications diagnosed by aortography and/or surgery were not visualized by transesophageal echocardiography. Of particular interest is that 27 communications in 18 patients were diagnosed by transesophageal echocardiography but were not identified at aortography and/or surgery.

**TABLE 2. Transesophageal Echocardiographic Assessment of Type of Aortic Dissection**

<table>
<thead>
<tr>
<th>Aortography/surgery</th>
<th>TEE findings</th>
<th>CT scan findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>DeBakey type I aortic dissection proven by aortography and/or surgery (12)</td>
<td>DeBakey type I (11) No dissection (1)</td>
<td>DeBakey type I (3) DeBakey type II (1) DeBakey type III (1) No evidence of dissection (4) Not done (3)</td>
</tr>
<tr>
<td>DeBakey type II aortic dissection proven by aortography and/or surgery (10)</td>
<td>DeBakey type II (10)</td>
<td>DeBakey type I (2) DeBakey type II (1) DeBakey type III (1) No evidence of dissection (2) Not done (4)</td>
</tr>
<tr>
<td>DeBakey type III aortic dissection proven by aortography and/or surgery (8)</td>
<td>DeBakey type III (8)</td>
<td>DeBakey type III (6) No evidence of dissection (1) Not done (1)</td>
</tr>
</tbody>
</table>

CT, computed tomography; TEE, transesophageal echocardiography. Numbers in parentheses represent number of patients.

**Figure 2.** Transesophageal echocardiogram in aortic dissection. Left panel: Aortic short-axis view obtained in another patient shows extension of dissection flap into lumen of left main coronary artery. Right panel: Five-chamber view showing extension of dissection flap into lumen of right coronary artery (RCA). FL, false lumen; LA, left atrium; LV, left ventricle; RVO, RVOT, right ventricular outflow tract; TL, true lumen.
<table>
<thead>
<tr>
<th>Patient</th>
<th>Clinical findings</th>
<th>TEE findings</th>
<th>Angiographic findings</th>
<th>Surgical findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>54-year-old man, Marfan's syndrome, presented with typical anterolateral myocardial infarction, CABG done for three-vessel disease 10 years ago</td>
<td>LMCA and RCA dissection, 1.9 cm of LMCA and 1.8 cm of RCA visualized from ostia</td>
<td>Totally occluded LMCA and RCA</td>
<td>DeBakey type I, LMCA, RCA, and both saphenous venous graft dissection</td>
</tr>
<tr>
<td>2</td>
<td>49-year-old man, hypertensive, asymptomatic, mediastinal widening on chest radiograph, no evidence of recent acute myocardial infarction by ECG and serum enzymes, CABG done for three-vessel disease 5 years ago</td>
<td>LMCA and RCA dissection, 0.5 cm of LMCA and 1.3 cm of RCA visualized from ostia</td>
<td>No opacification of coronary arteries, 70% stenosis of venous graft to RCA, other grafts not seen</td>
<td>DeBakey type I, LMCA and RCA dissection</td>
</tr>
<tr>
<td>3</td>
<td>18-year-old woman presented with chest discomfort, no evidence of acute myocardial infarction by ECG, serum enzymes not done</td>
<td>LMCA and RCA dissection, 0.9 cm of LMCA and 0.7 cm of RCA visualized from ostia</td>
<td>Only aortogram done, no mention made of coronary artery dissection</td>
<td>DeBakey type I, LMCA and RCA dissection</td>
</tr>
<tr>
<td>4</td>
<td>46-year-old woman, epigastric and back pain, anterior ischemia by ECG, serum enzymes normal</td>
<td>RCA dissection, 0.4 cm of LMCA and 1.7 cm of RCA visualized from ostia, minimum distance of dissection flap from LMCA ostium 0.9 cm</td>
<td>Suspected occlusion of RCA, LMCA arising from nonperfusing lumen on aortogram</td>
<td>DeBakey type I, RCA dissection only</td>
</tr>
<tr>
<td>5</td>
<td>50-year-old man, hypertensive, retrosternal pain, old inferior myocardial infarction by ECG, normal serum enzymes, CABG done for three-vessel disease 2 years ago</td>
<td>RCA dissection, 1.4 cm of LMCA and 1.4 cm of RCA visualized from ostia, minimum distance of dissection flap from LMCA ostium 2.1 cm</td>
<td>Normal LMCA, RCA not selectively visualized, venous and internal mammary grafts patent</td>
<td>DeBakey type I, RCA dissection only</td>
</tr>
<tr>
<td>6</td>
<td>67-year-old woman with acute onset of chest pain and hypotension, ECG showed inferior ST elevation and elevated creatine kinase-MB fraction</td>
<td>RCA dissection, 0.8 cm of LMCA and 1.2 cm of RCA visualized from ostium, minimum distance of dissection flap from LMCA ostium 2.3 cm</td>
<td>Severe stenosis of first septal perforator, proximal and mid RCA, patent venous graft to diagonal and LAD</td>
<td>DeBakey type I, RCA dissection only</td>
</tr>
<tr>
<td>7</td>
<td>72-year-old woman with severe angina, aortic dissection occurred during CABG surgery</td>
<td>0.6 cm of LMCA visualized from ostium, RCA not visualized, minimum distance of dissection flap from LMCA ostium 0.1 cm</td>
<td>Three-vessel coronary artery disease, dilated proximal aorta</td>
<td>DeBakey type II, RCA dissection only</td>
</tr>
</tbody>
</table>

**Thrombi**

Thrombi were detected in the nonperfusing lumen by transesophageal echocardiography in 14 of the 34 patients (five ascending aorta, six descending aorta, two ascending and descending thoracic aorta, and one ascending and descending aorta and arch of the aorta) (Figure 4). Surgical confirmation was obtained in seven of these patients, the presence of a thrombus could not be confirmed in one patient, and the remaining patients did not undergo surgical exploration of the area in question. In addition, transesophageal echocardiography produced a false-negative diagnosis of an ascending aortic thrombus in one patient. Aortographic studies were negative for a thrombus in all except two patients, both of whom had clot in the ascending aorta by transesophageal echocardiography.

In two patients, both with DeBakey type II acute dissection, large false aneurysms containing clot were demonstrated by transesophageal echocardiography and confirmed at surgery (Figure 5). Aortography was negative for false aneurysm in both patients. Both of these patients died intraoperatively—one as a result of hemodynamic deterioration and the other because of poorly controlled bleeding.

**Aortic Regurgitation**

Presence and severity of aortic regurgitation by transesophageal color Doppler and its correlation with angiography as well as its possible mechanism by transesophageal echocardiography are shown in Tables 5 and 6 (see alsoFigures 6 and 7).
Table 4. Transesophageal Echocardiographic Assessment of Communications Between Perfusing and Nonperfusing Lumens

<table>
<thead>
<tr>
<th></th>
<th>Aortic root and proximal ascending aorta</th>
<th>Distal ascending aorta and arch</th>
<th>Descending thoracic aorta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosed by TEE and confirmed by aortography and/or surgery (13)</td>
<td>Seven communications (6)</td>
<td>None</td>
<td>Six communications (4)</td>
</tr>
<tr>
<td>Diagnosed by TEE but not confirmed by aortography and/or surgery (27)</td>
<td>Four communications (3)</td>
<td>Eight communications (6)</td>
<td>15 communications (9)</td>
</tr>
<tr>
<td>Diagnosed by aortography and/or surgery but not by TEE (12)</td>
<td>Seven communications (6)</td>
<td>Four communications (2)</td>
<td>One communication (1)</td>
</tr>
</tbody>
</table>

TEE, transesophageal echocardiography. Numbers in parentheses represent number of patients.

Pericardial Effusion

Group 1. Pericardial effusion (small in three, moderate in four, and large in one) was noted by transesophageal echocardiography in eight patients with aortic dissection and confirmed at surgery in six of them. Two of the eight patients with pericardial effusion noted by transesophageal echocardiography died. Both had serosanguinous effusion, and they died intraoperatively—one as a result of uncontrolled bleeding and the other because of heart failure.

Computed Tomography

Group 1. CT provided a correct diagnosis of aortic dissection in 16 of 24 patients in whom this study was performed and missed the diagnosis in the remaining eight patients (sensitivity, 67%). Regarding the type of dissection, CT correctly identified 10 patients and misclassified five patients (33%) (Table 2).

Group 2. CT was done in seven patients and was negative for aortic dissection in all cases, yielding 100% specificity.

Aortography

A definitive diagnosis of aortic dissection was made by this technique in 27 of 29 patients who had surgically proven dissection (sensitivity, 93%). The remaining two patients were interpreted as showing a false aneurysm and to be negative for aortic dissection. None of the patients in group 2 was diagnosed to have dissection by aortography (specificity, 100%).

Post–Cardiopulmonary Bypass Transesophageal Echocardiography

All thrombi and communications seen before surgery were noted after surgery, except in areas occupied by the grafts. Color flow signals were less prominent in the false or nonperfusing lumen in four patients with type I dissection repair but otherwise were judged to remain unchanged compared with flow signals before surgery in the remaining 15 patients (Figure 8). Eight of the nine Cabrol grafts could be identified by transesophageal echocardiography, and their attachments to the ostium of the left main coronary artery were well visualized (Figure 9).

Discussion

Transesophageal echocardiography has been shown by Erbel et al27 to have a sensitivity of 99% and a specificity of 98% in the diagnosis of dissection of the aorta; however, not all of the patients in this multi-
center study had aortography, surgery, or autopsy to confirm their findings. Hashimoto et al. recently reported the value of transesophageal echocardiography in the detection of the intimal flap, entry sites into the false lumen, the presence of thrombi, aortic regurgitation, and pericardial effusion. Unfortunately, the results in several patients were not verified by the gold-standard technique of aortography or surgery, and the severity of aortic regurgitation was not graded in any of the patients. Detection of coronary artery involvement with aortic dissection by transesophageal echocardiography has not yet been addressed.

<table>
<thead>
<tr>
<th>Severity of Aortic Regurgitation in Patients With Aortic Dissection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aortography</td>
</tr>
<tr>
<td>None (14)</td>
</tr>
<tr>
<td>Grade 1 – mild (4)</td>
</tr>
<tr>
<td>Grade 2 – moderate (3)</td>
</tr>
<tr>
<td>Grade 4 or 5 – severe (5)</td>
</tr>
</tbody>
</table>

None of the patients had moderately severe aortic regurgitation by color Doppler aortography. Numbers in parentheses represent number of patients.
### Table 6. Severity of Aortic Regurgitation in Patients Without Aortic Dissection

<table>
<thead>
<tr>
<th>Aortography</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
<th>Grade 4 or 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>None (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Grade 1 — mild (5)</td>
<td>(5)</td>
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<tr>
<td>Grade 2 — moderate (3)</td>
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<tr>
<td>Grade 3 — moderately severe (3)</td>
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<tr>
<td>Grade 4 or 5 — severe (10)</td>
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</table>

(5) Ascending aortic aneurysm (3), dilated ascending aorta with calcific valve stenosis (1)

(3) Ascending aortic aneurysm with calcific aortic stenosis (1), discrete subaortic stenosis (1), dilated descending aorta with bicuspid stenotic aortic valve (1)

(3) Vegetation on prosthetic aortic valve (1), ascending aortic aneurysm with calcific nonstenotic bicuspid valve (1), dilated ascending aorta with bicuspid stenotic aortic valve (1)

(10) Ascending aortic aneurysm with diastolic noncoaptation of aortic valve leaflets (4), ascending aortic aneurysm (1), dilated ascending aorta with right coronary cusp prolapse (1) and thick and nonstenotic aortic valve (1), left coronary cusp prolapse (2), one associated with nonstenotic calcification of aortic valve leaflets, calcific aortic valve stenosis (1)

Numbers in parentheses represent number of patients.

**Figure 6.** Transesophageal echocardiogram in aortic dissection. Five-chamber view demonstrates mosaic signals filling practically entire left ventricular outflow tract in diastole, indicative of severe aortic regurgitation (AR). AO, aorta; F, dissection flap; LA, left atrium; LV, left ventricle; RV, right ventricle.

**Figure 7.** Transesophageal echocardiogram in aortic dissection. Five-chamber view shows dissection flap (F) impinging (arrowhead) on right coronary cusp of aortic valve (AV) in diastole. FL, false lumen; LA, left atrium; LV, left ventricle; RVO, right ventricular outflow tract.
In the present study, only patients who had confirmatory of their transesophageal echocardiographic findings by aortography, surgery, or autopsy were included. Transesophageal echocardiography was more sensitive than CT scan (97% vs. 67%) in the diagnosis of aortic dissection. Also, there were no false-positive diagnoses by transesophageal echocardiography (100% specificity). A limitation of the present study is that the intraoperative examinations may not be considered truly blinded because the echocardiographer may have had suspicion of the diagnosis and ours was a highly select population. On the other hand, we doubt that prior suspicion of the patient's diagnosis would have influenced the intraoperative transesophageal echocardiography findings, because standard, well-recognized planes were used in all cases. Also, the results were equally good in patients in whom intraoperative transesophageal echocardiography was not performed. These represented 18 of 34 (more than 50%) patients with aortic dissection. Another study limitation is that in a narrow and strict sense, it can be argued that the sensitivity and specificity of transesophageal echocardiography in the diagnosis of aortic dissection can be calculated only if patients with clinically suspected dissection are included. However, a point to be considered is the practical difficulty in doing this because it is well known that a significant percentage of patients with aortic dissection may be asymptomatic or that their symptoms may mimic other conditions, such as myocardial infarction or stroke.

In addition, transesophageal echocardiography correctly classified the DeBakey type of aortic dissection in 29 of 34 patients. Of the remaining five patients, the type of aortic dissection could not be determined with certainty at surgery in three cases and at autopsy in one, and in one patient, the diagnosis was missed by transesophageal echocardiography.

Although the common clinical practice is to distinguish aortic dissection from myocardial infarction as the cause of chest pain, it is not uncommon to find coronary artery involvement in patients with aortic dissection. The incidence of coronary artery involvement in this process has been found in a large review by Hirst et al.37 The involvement of the coronary arteries in patients with proximal aortic dissection is an accepted indication for urgent surgery.30,31 and the present study suggests that transesophageal echocardiography may be useful in its diagnosis. There were no false-positive or false-negative diagnoses in patients in whom the proximal portion of the left or right coronary artery could be visualized. Also of interest was the relation of the intimal flap to the origin of the coronary arteries noted by transesophageal echocardiography in patients who did not have coronary artery involvement. The relation of the proximity of the dissection flap to the origin of the coronary arteries may have prognostic implications, as it would appear more likely to dissect into the coronary artery if it is noted to be close, but further studies are necessary to more fully evaluate this question.

This is the first study that reports the value of transesophageal echocardiographic assessment of the proximal segment of the coronary arteries in patients with aortic dissection. It has previously been noted that coronary artery involvement in patients with aortic dissection may not be associated with positive electrocardiographic changes and that those with electrocardiographic abnormalities indicative of myocardial infarction or ischemia may not have coronary artery involvement by aortic dissection.38,39 The fact that only two of our seven patients with coronary artery involvement had evidence of acute myocardial infarction by enzymes or electrocardiographic criteria supports this prior observation.

**Figure 8.** Transesophageal echocardiogram in aortic dissection. Long-axis view of distal ascending aorta (transverse plane examination) showing prominent flow signals in both true (TL) and false (FL) lumens before surgery (left) and total absence of flow signals in FL after surgery (right), indicative of adequate surgical repair. In other frames, faint color flow signals were noted in FL. F, dissection flap.

**Figure 9.** Transesophageal echocardiogram in aortic dissection. Transverse plane examination. Short-axis view of ascending aorta (AO) in post-cardiopulmonary bypass period demonstrates Cabrol graft (G) and its attachment to left main coronary artery (LMCA). Closely packed, short linear echoes in graft wall represent corrugations in Dacron graft. LA, left atrium.
The diagnosis and quantitation of the severity of aortic regurgitation were easily accomplished with transesophageal color Doppler echocardiography. In the present study, transesophageal echocardiography appeared more sensitive than aortography, as it detected mild aortic regurgitation in 13 patients (eight patients from group 1 and five from group 2) in whom the aortogram was negative. Most important, there was complete agreement between transesophageal echocardiography and aortography in the 15 patients (five from group 1 and 10 from group 2) judged to have severe aortic regurgitation. Transesophageal echocardiography also provided insight into the possible cause of aortic regurgitation, which may assist in the preoperative planning of the surgical procedure to be performed. Possible etiologies of aortic regurgitation in those patients with aortic dissection included dilation/aneurysmal formation of the ascending aorta, thickening of the aortic leaflets, flap impingement on aortic valve leaflets, prolapse of one of the aortic cusps, and prolapse of the dissection flap into the aortic valve orifice or left ventricular outflow tract.

We found transesophageal echocardiography useful in the detection and localization of intra-aortic thrombi and in the evaluation of flow in the true and false lumens. It has been postulated that thrombus formation in the false lumen may be a good prognostic sign.40 The true incidence of thrombus formation in the nonperfusing lumen, however, is not known.

Hematoma posterior to the aorta presumably due to a ruptured aortic wall was observed in two patients by transesophageal echocardiography. This finding carried a bad prognosis because both of these patients died intraoperatively. Biplane examination helped in identifying the extent and relation of the hematoma to the surrounding structures in both of these patients.

Two of the eight patients (25%) with serosanguinous pericardial effusion also died intraoperatively, the mortality of which correlates well with that described by previous authors.30,41

Unfortunately, there was not consistent agreement between transesophageal echocardiography and aortography/surgery in the identification of communications between the true and false lumens. Biplane transesophageal echocardiography has potential in improving visualization of communications, but our experience was too limited to adequately evaluate its sensitivity. Verification of transesophageal echocardiographic findings by aortography and surgery is limited by a number of technical factors, including simultaneous opacification of the true and false lumens and difficulty in localizing small defects in a flaccid aorta at surgery.

In the present study, transesophageal echocardiography proved to be a safe procedure that may be done with facility in both the awake as well as the intraoperative setting. The ability to perform the transesophageal echocardiography examination at the bedsight was particularly advantageous, because our patients were often in the intensive care unit receiving multiple intravenous medications and on monitoring devices, making their transportation to and care in the aortography and CT scanning suites cumbersome and inefficient.

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References


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Usefulness of transesophageal echocardiography in assessment of aortic dissection.
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