Ambulatory Follow-up of Aortic Dissection by Transesophageal Two-Dimensional and Color-Coded Doppler Echocardiography

Susanne Mohr-Kahaly, MD, Raimund Erbel, MD, Holger Rennollet, CandMed, Norbert Wittlich, MD, Michael Drexler, MD, Helmut Oelert, MD, and Jürgen Meyer, MD

Follow-up of 18 patients with aortic dissection (five with type I, one with type II, 11 with type III dissection according to DeBakey) by transesophageal, two-dimensional and color-coded Doppler echocardiography showed a persistence of the false lumen in five of seven patients (71%) after surgery and in nine of 11 patients (82%) after medical therapy. In two patients treated with surgery, the dissected part of the aorta had been resected, whereas in two patients treated medically, a progressive and complete obliteration of the false lumen was observed. In the false lumen, thrombus formation was absent in four, localized in four, and progressive in six patients. Flow within the false lumen could be registered in 14 patients, and two distinct flow patterns were differentiated (laminar biphasic flow or slowly circulating flow). Persisting intimal tears were visualized by two-dimensional echocardiography in four patients, whereas color-coded Doppler showed an additional one to three intimal tears in the descending aorta in 10 patients. Flow across these intimal tears was biphasic in 75% of patients; that is, systolic flow was directed from the true to the false lumen with diastolic flow reversal. Unidirectional flow was detected in 25% of the communications, directed in 20% from the true to the false lumen, serving as an entry only and in one (5%) as reentry only. Additional information concerning complications like extension of the dissection (one of 18 patients), localized dilatation of the aorta (two of 18 patients), mediastinal hematoma (one of 18 patients), or aortic regurgitation (three of 18 patients) were detected by this method. Concerning the morphologic findings and the detection of flow characteristics, the transesophageal approach was superior to conventional echocardiography especially in the descending thoracic aorta. Thus, transesophageal two-dimensional and color-coded Doppler echocardiography seems to be an ideal method not only for the easy detection of aortic dissection but also for follow-up. (Circulation 1989;80:24–33)

Adequate therapy of aortic dissection requires information about the site and extent of the dissection and blood flow dynamics within the true and false lumens.1–3 Whether or not the localization of the intimal tears is important for prognosis is controversial.4–7 Since the introduction of effective surgical and medical therapy, the prognosis of patients has been dramatically improved.4,6–9

Recently, the role of angiography as the standard diagnostic procedure in acute dissection has been questioned because less invasive techniques such as echocardiography, computed tomography (CT), and digital subtraction angiography have shown increased clinical reliability.10–20 Echocardiography is the method of choice for diagnosis of aortic dissection because it is less invasive and less expensive than other methods. Transthoracic echocardiography is less reliable in patients with obesity, pulmonary emphysema, or thorax deformation. Visualization of the descending part of the aorta is limited to 70% of the patients.18,21,22

See p 215

Transesophageal echocardiography overcomes these methodologic limitations and is of great diagnostic value because of high-quality cross-sectional images of the ascending and descending thoracic aorta even in patients in shock or on mechanical ventilation.23–30 Surgery without further diagnostic investigation has been performed successfully in emergency cases.30 In combination with color-coded Doppler flow imaging, which superimposes flow information
on two-dimensional echocardiographic images, transse-
sophageal echocardiography provides real time infor-
mation about structure, function, and flow. The
purpose of this study was to analyze aortic structure
and flow dynamics in patients with and without prior
surgery for aortic dissection during follow-up.

Methods

Patients

From April 1985 to February 1988, 41 patients (22
men, 19 women) aged 23–79 years with aortic
dissection proven by angiography, computed tomog-
raphy, or surgery were initially examined by trans-
 thoracic and transesophageal two-dimensional,
pulsed, and color-coded Doppler echocardiogra-
phy. Eight patients died during the acute phase
before surgery or early after surgery. In 11 patients,
follow-up examination could not be performed
because of geographical distance or noncompliance.
Follow-up by repeated transthoracic and transeso-
ophageal echocardiography, as well as abdominal sonog-
raphy and vascular scanning, was possible in 22
patients. Additional transesophageal color-coded
Doppler echocardiography was used in 18 patients
(13 men, five women) aged 23–76 years (mean age,
51.6 years). The results of the repeated transthoracic
and transesophageal two-dimensional and color-
coded Doppler echocardiographic studies are consid-
ered in the present study. The mean follow-up period
was 15.0 months (range, 1–41 months). The aim was
to perform follow-up examinations at 1, 6, and 12
months after the initial diagnosis followed by a once
yearly examination in the absence of complications.
When complications were clinically suspected, addi-
tional studies were performed.

Echocardiographic Instrumentation

Echocardiography. From April 1985 to Decem-
ber 1986, echocardiographic examinations were per-
formed with an electronic sector scanner (CV 6400,
Diasonics, Palo Alto, California) with a 3.5-MHz
phased-array transducer fitted to the distal end of a
conventional 12-mm gastroscope, with the possibil-
ity of M-mode, two-dimensional, and pulsed Doppl-
er registration, which was first introduced by
Hanrath et al. Since January 1987, an echofibroscope (Type ESB-
37SR, Toshiba, Japan) with a 3.75-MHz, 48-
element, phased-array transducer integrated with a
12-mm gastroscope, attached to an electronic sector
scanner (SSH65A, Toshiba) with additional possibil-
ity of two-dimensional color-coded Doppler flow
imaging and a fiberoptic control device was used.
The latter was used during the most recent or in all
follow-up studies. In this system, color-coded flow
patterns are superimposed on real time two-
dimensional echocardiographic images. Velocity data
are coded in red while flow is directed toward and in
blue while flow is directed away from the transducer.

Nonuniformity of velocities in 1 pixel is displayed
by adding green to each color to indicate turbulence
by increased variance. The optimal gain setting was
chosen as the level where maximal color informa-
tion was obtained, just below the level at which
white noise echoes appeared. Transthoracic studies
were performed with a 2.5-MHz phased-array trans-
ducer. All images were recorded on a 1⁄2 in. video
tape with a Panasonic AG-6200 recorder (Japan).

Conventional Echocardiography

and Doppler Examination

Conventional echocardiographic and Doppler
examinations were performed routinely before the
transesophageal procedure in left and right paraster-
nal, apical, supra- sternal, and subcostal transducer
positions.8,21

Preparation and Premedication for
Transesophageal Echocardiographic Studies

Before examination, patients had fasted for a
minimum of 4 hours and had given their informed
consent. The history of the patients had been care-
fully studied to exclude dysphagic disease. In anx-
ious patients, a mild sedation of diazepam 5–10 mg
or an analgesic (buprenorphin 0.3 mg) was admin-
istered intravenously 5–10 minutes before the exam-
ination. In all patients, local anesthesia of the throat
with lidocain spray (Xylocain) was applied.

A routine antibiotic prophylaxis has not been
used up to now because an increased risk of
endocarditis has not been proven for simple endo-
scopic procedures unaccompanied by biopsies.35

Transesophageal Examination Technique

and Echocardiographic Evaluation

Patients were placed in a left lateral decubitus
position, with the head flexed in a midline position.
The tip of the probe is introduced toward the pos-
terior aspect of the tongue. Patients were asked
to swallow while the probe was advanced up to 30
mm into the esophagus.

The transducer is placed behind the left atrium,
and further positioning can be performed by rota-
tion while looking at the cardiac structure on the
video screen. Standardized scan planes are evalu-
ated as described before.26,28,34 The thoracic aorta
can be visualized in horizontal scan planes with the
exception of the upper ascending aorta because of
interposition of the trachea.26,28,33 The proximal
ascending aorta can be scanned up to 3–5 cm from
the aortic valve plane. The descending aorta is
visualized by slight rotation of the transducer at the
level of the left atrium and is followed as distally as
possible, usually several centimeters below the dia-
phragm to the proximal abdominal aorta. Then, the
probe is pulled back slowly up to the aortic arch,
while keeping the cross-sectional view of the aorta
in the center of the sector and while noting the
distance in centimeters from the incisors. During
the initial and follow-up studies, the same standard-
ized scan planes were analyzed for changes in cardiac structure and flow patterns.

The aorta was carefully searched for intimal tears. By two-dimensional echocardiography, an intimal tear was diagnosed when a discontinuity of the dissection membrane with fluttering ends could be visualized. With color-coded Doppler, smaller intimal tears, not visualized by two-dimensional echocardiography were noted when a turbulent jet traversing the dissection membrane was registered. The number of intimal tears was listed, and flow characteristics across these communications were analyzed.

The differentiation between the true and the false lumen was based on M-mode and two-dimensional echocardiography by analysis of the motion of the intimal flap, showing an expansion of the true lumen during systole and compression during diastole.29 As additional indicator for the false lumen, the presence of spontaneous echocardiographic contrast, reflecting prestasis and aggregation of corpuscular blood elements, was noted,29,36,37 as well as the systolic jet direction across the intimal tear.

The diameters of the ascending and descending aorta, as well as those of the false lumen, were evaluated. A ratio of the transverse cross-sectional diameters of the false to the true lumen was calculated at the level of the maximal extent of the false lumen. The existence, distribution, and progression of thrombus formation was determined in a semi-quantitative manner, differentiating between localized thrombosis of the false lumen: segmental thrombus formation without detectable horizontal or vertical progression, progressive thrombosis, that is, an extensive and expanding thrombus formation during follow-up studies, and complete obliteration of the false lumen. Flow patterns, that is, flow direction, velocity, and turbulence, within the true and false lumen were studied during the cardiac cycle with pulsed and color-coded Doppler. For studies of flow timing, M-mode recordings of color-coded Doppler flow signals or pulsed Doppler were used.

We looked especially for complications like pericardial effusion, re-dissection, localized distension of the aorta, and hematoma at the site of surgery, as well as for aortic regurgitation. The latter was diagnosed when diastolic disturbed flow in the left ventricular outflow tract originating from the aortic valve was noted by pulsed and color-coded Doppler. Aortic regurgitation was graded semiquantitatively according to Perry et al38 by measuring the width of the jet within the left ventricular outflow tract.

Results

The clinical data of all patients are listed in Table 1. According to DeBakey’s classification, five patients had type I, one patient had type II, and 12 patients had type III dissection.

Surgical Therapy

Three of five patients with type I, one patient with type II, and one of 12 patients with type III dissection were treated with interposition of a tubular graft. In two of five patients with type I dissection, the ascending aorta was reconstructed. Because of significant aortic regurgitation, four patients (patients 1, 2, 3, 6) had aortic valve replacement, whereas two patients had resuspension of the aortic valve (patients 4 and 5).

Medical Therapy

Eleven patients with type III dissections were treated medically with β-blocking agents and calcium antagonists.

Fate of the False Lumen

In 14 of 18 patients (78%), the false lumen persisted at the last transesophageal follow-up examination (Figure 1), ranging from 1 to 41 months. In two patients (patients 6 and 9), the dissected part of the aorta had been resected during surgery. At follow-up, patient 9 had a localized hematoma around the graft, which was occluded by thrombus formation 1 month later.

In two patients (patients 10 and 12) treated medically, the false lumen was progressively occluded by thrombus formation after 6 and 9 months, respectively (Figure 2). A persistent intimal flap was detected by conventional echocardiography in all patients (n=5) with type I dissection within the aortic arch, but this flap was detected only in four of 11 patients with type III dissection (Table 2).

In 14 patients with a persistent false lumen and in patient 12 before its obliteration, the cross-sectional area or transverse diameter of the false lumen was large or even larger than that of the true lumen (see Table 2).

Flow within the false lumen of the dissected aorta was noted by transesophageal color-coded Doppler in all patients with a persisting false lumen. Although systolic laminar flow was detected in the true lumen, flow within the false lumen occurred later in systole and during diastole. Two characteristic flow patterns were seen. 1) In two of five patients with type I and in four of 12 patients with type III dissection, slightly delayed laminar flow within the false lumen was detected, which was directed distally as in the true lumen during systole with diastolic flow reversal. 2) In three of five patients with type I and in five of 12 patients with type III dissection, slowly circulating flow with a “swirling pattern” was registered. By conventional color-coded Doppler, flow within the false lumen was noted in five patients, but differentiation of flow patterns was not possible (Table 2).

Intimal Tears

By transesophageal two-dimensional echocardiography alone, the identification of intimal tears was possible in four patients (two with type I, two
<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (yr)</th>
<th>Gender</th>
<th>Type</th>
<th>Risk factors</th>
<th>Dissection</th>
<th>Initial diagnostic method</th>
<th>Treatment</th>
<th>Follow-up TEE (mo)</th>
<th>Other findings/complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>27</td>
<td>M</td>
<td>I</td>
<td>Marf, BV, Hyp</td>
<td>Acute</td>
<td>TEE, Surg</td>
<td>Surg AVR P</td>
<td>1, 10, 23, 24, 27, 28, 32, 41</td>
<td>Traumatic redissection, surgery descending aorta</td>
</tr>
<tr>
<td>2</td>
<td>36</td>
<td>F</td>
<td>I</td>
<td>Hyp</td>
<td>Acute</td>
<td>TEE, TTE, Surg</td>
<td>Surg AVR P</td>
<td>2, 7, 12, 16</td>
<td>—</td>
</tr>
<tr>
<td>3</td>
<td>68</td>
<td>F</td>
<td>I</td>
<td>Hyp, AS</td>
<td>Acute</td>
<td>TEE, TTE, Ang, Surg</td>
<td>Surg AVR P</td>
<td>1, 5, 11</td>
<td>—</td>
</tr>
<tr>
<td>4</td>
<td>50</td>
<td>M</td>
<td>I</td>
<td></td>
<td>Acute</td>
<td>TEE, TTE, Surg</td>
<td>Surg AR R</td>
<td>1, 4, 6, 8, 13, 19, 25</td>
<td>Aortic regurgitation, dilatation of aorta, surgery abdominal aorta</td>
</tr>
<tr>
<td>5</td>
<td>54</td>
<td>M</td>
<td>I</td>
<td>Hyp</td>
<td>Acute</td>
<td>TEE, TTE, Surg</td>
<td>Surg AR R</td>
<td>1, 7, 16</td>
<td>Aortic regurgitation, dilatation of aorta</td>
</tr>
<tr>
<td>6</td>
<td>30</td>
<td>F</td>
<td>II</td>
<td>Marf</td>
<td>Chronic</td>
<td>TEE Surg</td>
<td>Surg AVR P</td>
<td>3, 7</td>
<td>—</td>
</tr>
<tr>
<td>7</td>
<td>68</td>
<td>M</td>
<td>III</td>
<td>Hyp, AS</td>
<td>Chronic</td>
<td>TEE, TTE, Ang, CT</td>
<td>Med</td>
<td>1, 2, 21</td>
<td>—</td>
</tr>
<tr>
<td>8</td>
<td>76</td>
<td>M</td>
<td>III</td>
<td>Hyp, AS</td>
<td>Chronic</td>
<td>TEE, Ang, CT</td>
<td>Med</td>
<td>16</td>
<td>Aortic regurgitation</td>
</tr>
<tr>
<td>9</td>
<td>63</td>
<td>M</td>
<td>III</td>
<td>Hyp, AS</td>
<td>Acute</td>
<td>TEE, Ang</td>
<td>Med/Surg P</td>
<td>1, 2, 3, 16</td>
<td>Progressive dilatation of descending aorta, localized hematoma around the graft after surgery Mediastinal hematoma with compression of right ventricle</td>
</tr>
<tr>
<td>10</td>
<td>45</td>
<td>M</td>
<td>III</td>
<td>Hyp</td>
<td>Acute</td>
<td>TEE, CT</td>
<td>Med</td>
<td>1, 6, 16</td>
<td>—</td>
</tr>
<tr>
<td>11</td>
<td>65</td>
<td>M</td>
<td>III</td>
<td>Hyp, AS</td>
<td>Acute</td>
<td>TEE, TTE, Ang, CT</td>
<td>Med</td>
<td>2, 3, 8, 12</td>
<td>—</td>
</tr>
<tr>
<td>12</td>
<td>58</td>
<td>F</td>
<td>III</td>
<td>Hyp, AS</td>
<td>Acute</td>
<td>TEE, TTE, CT</td>
<td>Med</td>
<td>9, 12, 24</td>
<td>—</td>
</tr>
<tr>
<td>13</td>
<td>49</td>
<td>M</td>
<td>III</td>
<td>Hyp, AS</td>
<td>Chronic</td>
<td>TEE, CT</td>
<td>Med</td>
<td>2, 4</td>
<td>—</td>
</tr>
<tr>
<td>14</td>
<td>55</td>
<td>M</td>
<td>III</td>
<td>Hyp</td>
<td>Acute</td>
<td>TEE, TTE, CT</td>
<td>Med</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>15</td>
<td>32</td>
<td>M</td>
<td>III</td>
<td></td>
<td>Acute</td>
<td>TEE, CT</td>
<td>Med</td>
<td>4</td>
<td>—</td>
</tr>
<tr>
<td>16</td>
<td>60</td>
<td>M</td>
<td>III</td>
<td>Hyp, AS</td>
<td>Acute</td>
<td>TEE, TTE, CT</td>
<td>Med</td>
<td>7</td>
<td>—</td>
</tr>
<tr>
<td>17</td>
<td>70</td>
<td>M</td>
<td>III</td>
<td>Hyp</td>
<td>Chronic</td>
<td>TEE, TTE, Ang, CT</td>
<td>Med</td>
<td>20, 33</td>
<td>—</td>
</tr>
<tr>
<td>18</td>
<td>23</td>
<td>F</td>
<td>III</td>
<td>Coarctation</td>
<td>Acute</td>
<td>TEE, Ang, CT</td>
<td>Med</td>
<td>10</td>
<td>—</td>
</tr>
</tbody>
</table>

Type, dissection type according to DeBakey; TTE, transthoracic echocardiography; M, male; F, female; Marf, Marfan's syndrome; BV, bicuspid aortic valve; Hyp, hypertension; AS, atherosclerosis; TEE, transesophageal echocardiography; Ang, angiography; Surg, surgery; AVR, aortic valve replacement; Med, medical therapy; AR, aortic valve reconstruction; P, aortic graft; R, aortic reconstruction; CT, computed tomography.
with type III) with large communications. Additional intimal tears, not visualized by two-dimensional echocardiography were detected by color-coded Doppler in the descending aorta in 10 of 15 patients (67%) with a persisting false lumen or before its obliteration in patient 12. In 15 of 20 communications (75%), flow across the aperture was bidirectional, with flow from the true to the false lumen during systole and diastolic flow reversal (Figures 3, 4). Across five communications, flow was unidirectional, in four directed from the true to the false lumen serving as "entry" only and in one very small one into the opposite direction, serving as reentry only.

In patients with multiple communications (patients 4, 11, 12, 15, 18), flow across the communications differed, showing unidirectional flow in a proximal communication and bidirectional flow across a more distally located intimal tear. Flow across these communications seemed to depend on the size and the instantaneous pressure gradient between both lumina.

By conventional echocardiography and color-coded Doppler, four communications were seen in

![TYPE III DISSECTION](image1)

**FIGURE 1.** Diagram of persistence of the false lumen and extent of thrombus formation in patients treated medically and surgically.

![TYPE III DISSECTION](image2)

**FIGURE 2.** Transesophageal echocardiographic study during acute phase and follow-up in a patient with complete obliteration of the false lumen due to thrombus formation.
<table>
<thead>
<tr>
<th>Patient</th>
<th>Intimal flap</th>
<th>Intimal tears</th>
<th>Flow FL</th>
<th>Thrombus FL</th>
<th>Aortic regurgitation</th>
<th>Other sonographic findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I Asc, Arch</td>
<td>I 1</td>
<td>*</td>
<td>Laminar</td>
<td>–</td>
<td>Dissection abdominal aorta, left carotid artery, innominate artery</td>
</tr>
<tr>
<td>2</td>
<td>I Arch</td>
<td>1 (Abdominal)</td>
<td>–</td>
<td>Swirling</td>
<td>– ++</td>
<td>Dissection abdominal, flow TL abdominal aorta</td>
</tr>
<tr>
<td>3</td>
<td>I Arch</td>
<td>–</td>
<td>–</td>
<td>Swirling</td>
<td>– ++</td>
<td>Dissection abdominal aorta, flow TL</td>
</tr>
<tr>
<td>4</td>
<td>I Arch</td>
<td>1 4</td>
<td>*</td>
<td>Laminar</td>
<td>–</td>
<td>Dissection abdominal aorta, flow TL and FL abdominal</td>
</tr>
<tr>
<td>5</td>
<td>I Arch, Desc</td>
<td>–</td>
<td>1</td>
<td>Swirling desc</td>
<td>–</td>
<td>Moderate Moderate</td>
</tr>
<tr>
<td>6</td>
<td>II – Desc</td>
<td>0</td>
<td>–</td>
<td>–</td>
<td>0</td>
<td>– –</td>
</tr>
<tr>
<td>7</td>
<td>III – Desc</td>
<td>&gt;1</td>
<td>–</td>
<td>Laminar</td>
<td>– +</td>
<td>– –</td>
</tr>
<tr>
<td>8</td>
<td>III – Desc</td>
<td>&gt;1</td>
<td>–</td>
<td>Swirling</td>
<td>– ++</td>
<td>Moderate Moderate Anurysm abdominal aorta</td>
</tr>
<tr>
<td>9</td>
<td>III – –</td>
<td>0</td>
<td>–</td>
<td>–</td>
<td>– (+)</td>
<td>– –</td>
</tr>
<tr>
<td>10</td>
<td>III – –</td>
<td>0</td>
<td>–</td>
<td>–</td>
<td>– ++</td>
<td>– –</td>
</tr>
<tr>
<td>11</td>
<td>III Desc</td>
<td>&gt;1 3 (Abdominal)</td>
<td>*</td>
<td>Laminar</td>
<td>–</td>
<td>– –</td>
</tr>
<tr>
<td>12</td>
<td>III – Desc</td>
<td>&gt;1 2</td>
<td>–</td>
<td>Swirling/++</td>
<td>+ /+++</td>
<td>– –</td>
</tr>
<tr>
<td>13</td>
<td>III – Desc</td>
<td>&gt;1 1</td>
<td>–</td>
<td>Swirling</td>
<td>– ++</td>
<td>– –</td>
</tr>
<tr>
<td>14</td>
<td>III Desc</td>
<td>&gt;1 1</td>
<td>–</td>
<td>Laminar</td>
<td>– ++</td>
<td>– –</td>
</tr>
<tr>
<td>15</td>
<td>III – Desc</td>
<td>&gt;1 3</td>
<td>–</td>
<td>Laminar</td>
<td>–</td>
<td>– –</td>
</tr>
<tr>
<td>16</td>
<td>III Desc</td>
<td>&gt;1 1 (Abdominal)</td>
<td>* (Abdominal) Swirling</td>
<td>–</td>
<td>– –</td>
<td>Dissection abdominal aorta</td>
</tr>
<tr>
<td>17</td>
<td>III Arch, Desc</td>
<td>&gt;1 –</td>
<td>–</td>
<td>Swirling</td>
<td>– ++</td>
<td>Dissection abdominal aorta</td>
</tr>
<tr>
<td>18</td>
<td>III – Desc</td>
<td>&gt;1 2</td>
<td>–</td>
<td>Swirling</td>
<td>–</td>
<td>– –</td>
</tr>
</tbody>
</table>

Type, dissection type according to DeBakey; FL, false lumen; TL, true lumen; TTE, transthoracic echocardiography and Doppler (conventional technique); TEE, transesophageal echocardiography; Asc, ascending aorta; Arch, aorta arch; Desc, descending aorta; –, not visualized; 0, no persistent false lumen; *, flow detected by TTE; thrombus formation: +, localized-segmental; ++, progressive-extensive; ++++, complete obliteration.
the thoracic aorta and two in the abdominal aorta. Flow was bidirectional in these cases (Table 2).

**Thrombus Formation**

Combining the information obtained by transesophageal two-dimensional echocardiography and color-coded Doppler, patients (patients 1, 4, 11, 15) with remaining large communications had laminar flow within the false lumen and no or only localized thrombus formation. However, in patients where the leading intimal tear had been closed during surgery (patients 2, 3, 5) or in those with only small communications (patients 11, 12, 16, 17, 18) in the descending aorta, slowly circulating flow within the false lumen and extensive and progressive thrombus formation was observed. Thrombus formation in the false lumen was not detected by conventional echocardiography.

**Complications**

Follow-up studies showed complications that led to secondary surgical interventions in two of seven patients (28%) primarily treated surgically. Patient 1 had traumatic redissection distal to the graft extending into the descending aorta with a need to replace the proximal descending aorta. Patient 4 had surgery of the abdominal aorta because of progressive distension noted by transesophageal and abdominal scanning and impending perforation. Patient 5 had progressive dilatation of the ascending and descending thoracic aorta and was observed closely at follow-up. Patient 9 developed mediastinal hematoma with compression of the right ventricle shown by transesophageal and transthoracic echocardiography that was treated by ultrasound-guided percutaneous puncture.

Moderate aortic regurgitation was noted in two patients after aortic valve resuspension and in one patient with type III dissection and arteriosclerotic valve disease but did not require surgical intervention. Aortic regurgitation was as well detected in these patients by conventional color-coded Doppler echocardiography (Table 2).

**Discussion**

Transesophageal two-dimensional echocardiography has been shown to be a valuable technique in the detection of aortic dissection because of its independence of the thorax configuration, respiration, and its better visualization of the descending...
thoracic aorta. With the transesophageal approach in combination with transthoracic, sub-costal, and suprasternal echocardiography, the whole aorta can be visualized. For the detection of dissection, this combined echocardiographic examination has been shown to have a higher sensitivity and specificity (>90%) than angiography and computed tomography. Although not completely non-invasive, the procedure is well tolerated by patients. Side effects did not occur in this patient group and are rare as previous studies have shown. To prevent an increase in blood pressure in this particular patient population, the administration of a mild sedative or analgesic is recommended. This study shows that serial evaluations during follow-up are possible on an outpatient basis.

The addition of color-coded Doppler further improves diagnostic possibilities by providing beat-to-beat information on two-dimensional flow distribution within the true and the false lumen as described for the transthoracic and the transesophageal approach in acute dissection. During follow-up, additional intimal tears in the descending thoracic aorta could be detected that were not visualized by transthoracic and transesophageal two-dimensional echocardiography. Transesophageal color-coded Doppler may become the method of choice to detect intimal tears in aortic dissection because the detection rate by angiography has been shown to be only about 50%. Furthermore, the temporal variation of flow across the intimal tears could be analyzed. As already described by Takamoto et al, we detected biphasic flow in 75% of the communications, with systolic flow from the true to the false lumen and diastolic flow reversal. Thus, entry and reentry occurs at the same site during different phases of the heart cycle. Across 25% of the communications, flow was unidirectional, serving as an entry in 20% and as reentry only in 5%.

As has been described in previous angiographic and echocardiographic studies after surgery or medical therapy, a persistence of the false lumen was found in 78% of the patients in whom the false lumen had not been completely resected during surgery. Furthermore, a persistence of flow within the false lumen was shown in all of these patients. This may be explained by the detection of additional intimal tears in the descending aorta not visualized by two-dimensional echocardiography alone. The prognostic implication of a persistence of flow has been described by Dinsmore et al, who found a higher survival rate of 90% in patients with no flow in the
false lumen compared with those with flow in both channels at the initial angiographic study. Further follow-up will show whether this new diagnostic technique can influence surgical management and prognosis.

Two characteristic flow patterns within the false lumen could be shown in this study probably depending on the size of the persisting intimal tears. In about 44% of the patients, those with large remaining communications, biphasic flow was detected in the false lumen with shortly delayed systolic flow directed distally and with diastolic flow reversal. In 56% of the patients with small communications, a slowly circulating flow pattern was found that showed the same motion as spontaneous echocardiographic contrast, which reflects a prestasis of blood.29,36,37

In the group with biphasic flow, no or only localized thrombus formation could be detected, whereas those patients with slowly circulating flow had extensive and progressive thrombus formation that increased with the distance from the communications. These findings have not been described in detail before probably because of the inferior spatial and temporal resolution of other diagnostic procedures. With transthoracic color-coded or pulsed Doppler, bidirectional flow has been described in the true and false lumen of the ascending aorta and the aortic arch in acute dissection.30,36,45,46 In this study, flow could be detected by transthoracic Doppler in five patients in three cases within the aortic arch and in two patients within the abdominal aorta, but no differentiation of flow patterns was possible. The low-intensity signals of slowly circulating flow in the descending thoracic aorta were not recorded by the transthoracic approach probably because of the longer distance between the anterior chest wall and the descending aorta.

Possible technical limitations of the transesophageal approach are that the ascending part of the aortic arch and branch arteries cannot be visualized but can be analyzed by suprasternal two-dimensional and color-coded Doppler echocardiography. Furthermore, flow velocities in the descending aorta may be underestimated because of an approximate 90° angle to flow. However, in aortic dissection, kinking and dilation of the aorta occur so that the transducer is not completely perpendicular to flow and enough Doppler shift occurs that can be detected. Turbulent flow across communications is recorded independently of the Doppler angle to flow.

Concerning the outcome of the patients in this study, secondary surgery was necessary because of complications in two of the patients (28%) primarily treated with surgery. In one patient, an anterior mediastinal hematoma was aspirated by percutaneous puncture. Other investigators have reported secondary surgical interventions during follow-up in 13% of patients with type A dissection.47 Two patients with localized dissection were successfully treated by complete resection of the dissected part of the aorta, whereas complete obliteration of the false lumen after medical therapy alone was observed in two of 11 patients (18%). Spontaneous healing as observed in these patients has been described in only a few patients up to now.48 Moderate aortic regurgitation was noted in two patients after aortic valve resuspension and in one patient with type III dissection unrelated to the dissection, but none required additional surgery.

**Conclusion**

Transeosophageal M-mode, two-dimensional, and color-coded Doppler echocardiography represents not a pleasant but, at least, a well tolerated noninvasive method. It can be performed serially on an ambulatory basis with excellent image quality concerning cardiac structure and flow dynamics in patients with aortic dissection without exposing patients to radiation or contrast agents. It complements the transthoracic echocardiographic methods in the descending thoracic aorta. Follow-up examinations by this method are helpful in the detection of complications leading to secondary surgery or to document the healing process.

**References**


47. Hoshimo T, Ohmoe M, Sakai A: Spontaneous resolution of a dissection of the descending aorta after medical treatment with a β-blocker and a calcium antagonist. Br Heart J 1987;58:82–84


KEY WORDS • surgery • thoracic aorta • aortic dissection • transesophageal two-dimensional echocardiography • color-coded Doppler echocardiography
Ambulatory follow-up of aortic dissection by transesophageal two-dimensional and color-coded Doppler echocardiography.
S Mohr-Kahaly, R Erbel, H Rennollet, N Wittlich, M Drexler, H Oelert and J Meyer

Circulation. 1989;80:24-33
doi: 10.1161/01.CIR.80.1.24

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1989 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/80/1/24

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/