

Frequency and Explanation of False Negative Diagnosis of Aortic Dissection by Aortography and Transesophageal Echocardiography

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Objectives. This study was designed to define the frequency and explanation of false negative diagnosis of aortic dissection by aortography and transesophageal echocardiography.

Background. Aortography and transesophageal echocardiography have been widely utilized to diagnose aortic dissection. Previous reports have not fully addressed the reasons why these studies yield false negative results in a large number of patients with aortic dissection.

Methods. Sixty-five consecutive patients with aortic dissection underwent aortography and transesophageal echocardiography. Diagnosis of aortic dissection was confirmed at operation or by computed tomography in all patients.

Results. Biplane transesophageal echocardiograms yielded false negative results in two patients (sensitivity 97% [63 of 65]). Both patients had well localized DeBakey type II aortic dissection. The diagnosis was probably missed because of image interference from the air-filled trachea and mainstem bronchi. In both patients, the dissection was readily identified by aortography.

Aortograms yielded false negative results in 15 patients (sensitivity 77% [50 of 65]); the aortic dissection was type I in 7 patients, type II in 1 and type III in 7. The dissection in all 15 patients was readily identified by transesophageal echocardiography. The missed diagnosis was probably due to a completely thrombosed false lumen or intramural hematoma with noncommunicating dissection in 13 patients and to a large ascending aortic aneurysm with nearly equal flow on both sides of the intimal flap in 2. In no patient was the diagnosis missed by both aortography and transesophageal echocardiography.

Conclusion. Transesophageal echocardiography is an excellent screening tool for aortic dissection. However, it may miss small type II aortic dissections localized to the upper portion of the ascending aorta because of image interference from the air-filled trachea. An intramural hematoma cannot be easily visualized by aortography, and this lesion is the principal reason for false negative aortographic findings.

(*J Am Coll Cardiol* 1995;25:1393-401)

Acute aortic dissection of the thoracic aorta is a life-threatening emergency and requires prompt diagnosis and treatment. Patients with DeBakey type I or type II (Stanford type A) aortic dissection usually require immediate surgery, whereas patients with DeBakey type III dissection (Stanford type B) can generally be managed medically (1-3). Therefore, any diagnostic technique should provide information regarding the presence and type of aortic dissection. Aortography has long been an established diagnostic tool for aortic dissection; however, it has diagnostic shortcomings and may yield false negative results (4). Aortography was found in a large multicenter trial to have a sensitivity of 88% (5). In recent studies

(5-8), transesophageal echocardiography has emerged as a powerful tool for diagnosing aortic dissection with a sensitivity of 97% to 100%, which is higher than that of aortography. Although these studies have reported the sensitivity of aortography and transesophageal echocardiography in diagnosing aortic dissection, there is a paucity of information regarding the reasons for the false negative findings (9,10). In this retrospective study, we attempted to find possible explanations for the false negative diagnosis of aortic dissection by aortography and transesophageal echocardiography in a large number of patients undergoing both tests.

Methods

Patients. We reviewed the data of 65 consecutive patients with aortic dissection who underwent both aortography and transesophageal echocardiography between 1988 and 1993. A diagnosis of aortic dissection was regarded as correct if it was confirmed at operation. In patients, when there was a discrepancy between the aortographic and transesophageal echocardiographic findings and surgical confirmation was not possible (mostly in patients with type III dissection), contrast computed

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Manuscript received September 6, 1994; revised manuscript received December 12, 1994, accepted December 22, 1994.

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Table 1. Clinical, Echocardiographic and Other Diagnostic Data

Pt No.	Age (yr)/ Gender	Risk Factor for Dissection	Transesophageal Echocardiography	Computed Tomographic Scan	Angiogram	Surgical Confirmation of AD	Cause of False Negative Study
False Negative Aortographic Findings							
1	63/M	HBP	Type I AD, Large AA aneurysm, Multiple tears	ND	Negative	Surgically confirmed type I AD	Nearly equal flow in both lumens
2	24/M	Marfan	Type I AD, Large AA aneurysm	ND	Negative	Surgically confirmed type I AD	Nearly equal flow in both lumens (Fig. 10 and 11)
3	63/F	HBP	Type I AD, clotted FL	Type III AD	Negative	Surgically confirmed type I AD	Clotted FL
4	40/F	HBP	Type I AD, clotted FL	Type I AD	? Type III	Surgically confirmed type I AD	Clotted FL (Fig. 5 to 7)
5	49/M	HBP	Type I AD, clotted FL	ND	Negative	Surgically confirmed type I AD	Clotted FL
6	66/F	HBP	Type I AD, clotted FL	Type I AD	Negative	Surgically confirmed type I AD	Clotted FL
7	66/F	HBP	Type I AD, clotted FL	Type I AD	Negative	Medical	Clotted FL
8	62/M	HBP	Type II AD, clotted FL	Negative	Negative	Surgically confirmed type II AD	Clotted FL
9	45/F	HBP	Type III AD, clotted FL	Type III AD	Negative	Medical	Clotted FL (Fig. 8 and 9)
10	78/F	HBP	Type III AD, clotted FL	Type III AD	Negative	Medical	Clotted FL
11	72/F	HBP	Type III AD, clotted FL	Type III AD	Negative	Medical	Clotted FL
12	80/F	HBP	Type III AD, clotted FL	Type III AD	Negative	Medical	Clotted FL
13	62/M	HBP	Type III AD, clotted FL	Type III AD	Negative	Surgically confirmed type III AD	Clotted FL
14	59/F	HBP	Type III AD, clotted FL	Type III AD	Negative	Medical	Clotted FL
15	52/F	—	Type III AD, clotted FL	Type III AD	Negative	Medical	Clotted FL
False Negative Transesophageal Echocardiographic Findings							
16	79/F	HBP, trauma	Negative	Type II AD with hemorrhage around aorta	Type II AD	Medical	Dissection localized to upper segment of aorta
17	79/M	HBP	Negative	ND	Type II AD	Surgically confirmed type II AD	Dissection localized to upper segment of aorta (Fig. 3 and 4)

AA = ascending aorta; AD = aortic dissection; F = female; FL = false lumen; HBP = high blood pressure; M = male; Marfan = Marfan syndrome; ND = not done; Pt = patient.

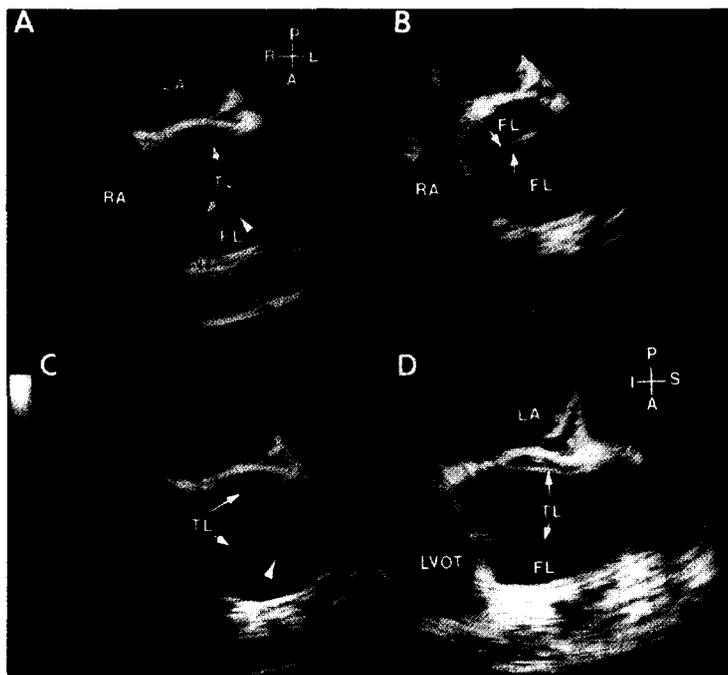
tomographic scanning was used for validation. The extent of dissection was classified as type I, II or III according to the criteria of DeBakey et al. (3). All diagnostic studies were performed within 24 h of each other. In most cases, the operator performing angiography, transesophageal echocardiography or computed tomographic scanning was not aware of the results of the other examinations. In 48 (74%) of 65 patients, there was agreement between the findings of transesophageal echocardiography and aortography. In the remaining 17 patients (26%), there was a discrepancy between the two studies. The false negative findings were obtained by transesophageal echocardiography in 2 patients and by aortography in 15. These 17 patients form the basis of this study (Table 1).

Transesophageal echocardiographic evaluation. Transesophageal echocardiography was performed with a variety of

commercially available echocardiographic imaging systems. The study was performed with the patient in the fasting state, after exclusion of any potential contraindications to esophageal intubation. In emergencies, the study was performed without fasting. All patients received local pharyngeal anesthesia (20% Benzocaine spray) and light sedation (midazolam, 2 to 5 mg intravenously) and there were no complications. The technique of complete transesophageal echocardiographic examination has been described previously (11).

A diagnosis of aortic dissection was made by transesophageal echocardiography if two lumens separated by an intimal flap could be seen within the aorta. If the false lumen was completely thrombosed, central displacement of intimal calcification was considered positive for dissections (5,12). Entry tear was defined as the most proximal site of disruption in the continuity of the intimal flap. An attempt was made to define

Figure 1. Longitudinal plane transesophageal echocardiographic views of the ascending aorta from a 42-year old woman with Marfan syndrome and type I aortic dissection. **A** and **B**, Short-axis images of the ascending aorta in systole and diastole, respectively, showing the intimal flap (**arrows**) entry tear (**arrowhead**) and true (TL) and false lumens (FL). **C**, Color flow image taken during systole, showing the true lumen filled with color flow velocities. Color flow velocities are shown entering at the site of the entrant tear (**arrowhead**) into the anteriorly located false lumen. **D**, Long-axis image of the ascending aorta, showing the distribution of the intimal flap and true and false lumens. A = anterior; I = inferior; L = left; LA = left atrium; LVOT = left ventricular outflow tract; P = posterior; R = right; RA = right atrium; S = superior.



the entrant (primary) and reentrant (secondary) intimal tears by using two-dimensional transesophageal echocardiography, color flow imaging and Doppler techniques. The extent of thrombosis in the false lumen was noted. These studies further

Figure 2. Aortogram showing type I aortic dissection with intimal flap (**arrowheads**) and differential opacification of the true and false lumens. The right coronary artery (RCA) is seen. Abbreviations as in Figure 1.



helped differentiate true and false lumens by showing different intensity and timing of color flow velocities in the two lumens. The intimal flap moved toward the false lumen in systole (Fig. 1).

Aortography. Aortography was performed with the use of percutaneous retrograde arterial catheterization from the common femoral artery. Serial imaging of the ascending aorta, arch and descending thoracic aorta was performed by using 14-in. × 14-in. (36-cm × 36-cm) cut film in the anteroposterior and right posterior oblique projections. An angiographic diagnosis of aortic dissection was established with the identification of an intimal flap or a double lumen (Fig. 2). Indirect angiographic signs of dissection were a compressed true lumen and a severely thickened aortic wall (13,14).

Computed tomographic scan. GE 9800 computed tomographic scanner was used to obtain multiple 10-mm thick slices at 10-mm intervals throughout the chest and upper abdomen, before and after intravenous injection of contrast material. Aortic dissection was diagnosed if two lumens, separated by a flap, could be identified. There was differential contrast density in the true and false lumens. In the case of a completely thrombosed false lumen, no contrast medium was seen in the false lumen. In these cases, marked thickening of the wall of the aorta with medial displacement of the intimal calcification was considered diagnostic of a noncommunicating aortic dissection (15).

Statistical methods. Data were collected during a retrospective chart review. The cases selected for this study are not a random sample of any defined population. The methods used to determine in which cases both diagnostic tests were used is unknown. Sensitivity as used in this article is defined as the proportion of patients with true aortic dissection detected by the test. The 95% confidence intervals for estimating the true population proportion were determined using $P = p \pm 1.96$

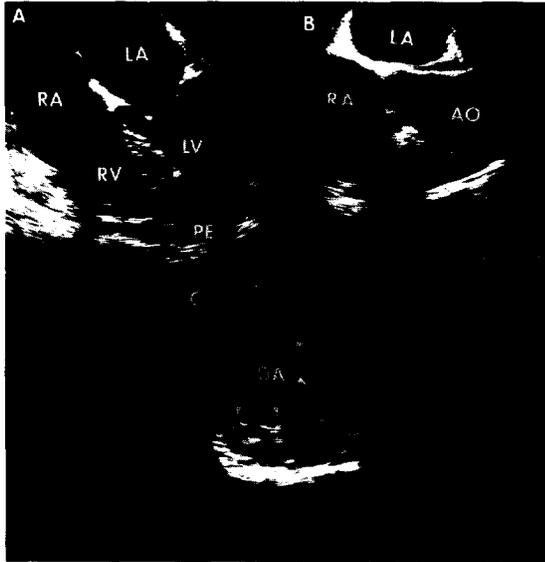


Figure 3. Patient 17. Biplane transesophageal echocardiographic views from a 79-year old man who presented with chest pain. **A**, Four-chamber view with a small pericardial effusion (PE). **B**, View of the ascending aorta (AO), showing no evidence of dissection. **C**, View of the descending aorta (DA), showing laminated clot in the dilated descending thoracic aorta. The inner margin of the clot (**arrowheads**) is not calcified. LV = left ventricle; RV = right ventricle; other abbreviations as in Figure 1.

$[p(1 - p)/n]^{1/2}$, where P = lower and upper bounds of the confidence intervals; p = sample proportion; and n = sample size.

Figure 4. Same patient as in Figure 3. Aortogram showing a localized disruption (**between arrows**) of the upper portion of the ascending aorta. Direct surgical inspection confirmed type II aortic dissection. This diagnosis was missed by biplane transesophageal echocardiography (Fig. 3).



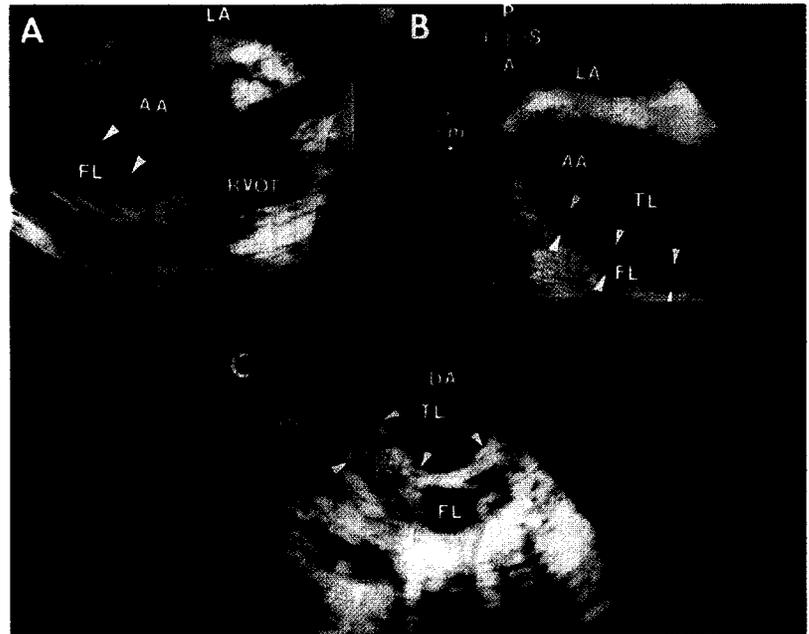
Figure 5. Patient 4. Aortogram from a 40-year old woman with hypertension and chest pain. Aortic wall thickening of the descending aorta (**arrowheads**) suggests type III dissection. However, this patient had type I aortic dissection by transesophageal echocardiography and by direct surgical inspection.

Results

In 17 (26%) of 65 patients, the results of aortography and transesophageal echocardiography were discordant (Table 1). In two patients (one man and one woman, each 79 years old) with type II aortic dissection localized to the inner margin of the distal ascending aorta (Fig. 3 and 4), the diagnosis was missed by biplane transesophageal echocardiographic examination. The diagnosis was confirmed at operation in one patient, and by computed tomographic scan in the other. Transesophageal echocardiography correctly identified the presence and extent of dissection in the remaining 63 patients (sensitivity 97%; 95% confidence interval [CI], 93% to 100%).

Aortography correctly diagnosed the presence and extent of aortic dissection in 50 of 65 patients (sensitivity 77%; 95% CI, 67% to 87%). The diagnosis of aortic dissection was either missed (14 patients) or incorrectly classified (1 patient) by aortogram in 15 patients (5 men, 10 women; mean age 59 years [range of 24 to 80]). There were seven patients with type I dissection (confirmed at operation in six and by computed tomographic scan in one); one patient with type II dissection

Figure 6. Same patient as in Figure 5. Biplane transesophageal echocardiographic views of the ascending (AA) and the descending (DA) aorta. The study shows a type I aortic dissection with a clotted false lumen. Both the short- (A) and the long-axis (B) views of the ascending aorta show thickening of the anterior wall of the ascending aorta as a result of a completely clotted false lumen. C, View of the descending aorta at 35 cm (35) from the incisors. The false lumen is almost completely clotted, but there are areas of echolucency. There is no communication by color flow imaging between the true and the false lumen. RVOT = right ventricular outflow tract; other abbreviations as in Figure 1.



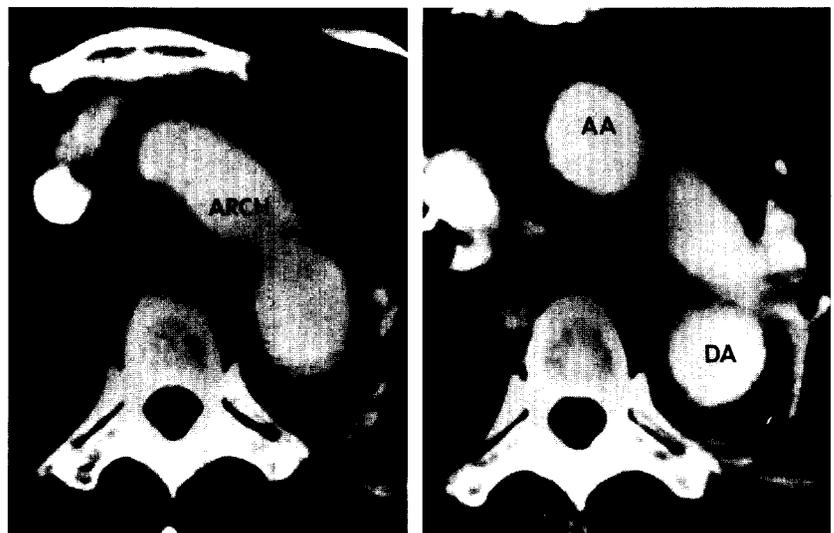
(confirmed at operation), and seven patients with type III dissection (confirmed by computed tomographic scan in all).

In 13 of 15 patients (5 with type I, 1 with type II and 7 with type III aortic dissection), the aortographic findings were incorrect because of a completely thrombosed false lumen (Fig. 5 to 9). These patients may be considered to have had either typical dissection with thrombosis of a false lumen or "medial hematoma" (noncommunicating aortic dissection). In the remaining two patients (both with type I dissection), the aortographic findings were considered negative for dissection because of an intimal flap in a large aneurysm with similar flow on both sides of the flap. (Fig. 10 and 11).

Discussion

Frequency and explanation of false negative aortographic findings. Until recently, aortic root angiography was considered the most definitive diagnostic tool for aortic dissection (13,14). However, some studies (4,10,13,14) have reported limitations and pitfalls of angiography in diagnosing aortic dissection. In a multicenter European cooperative study involving 82 patients, Erbel et al. (5) reported a sensitivity of 88% in diagnosing aortic dissection with aortography. These investigators did not systematically study the reason for the 12% false negative findings in their series but hypothesized that they were most likely due to a completely throm-

Figure 7. Same patient as in Figures 5 and 6. Computed tomographic scans of the aorta. **Left,** Contrast enhancement of the true lumen of the arch. The false lumen is completely clotted (arrows). **Right,** Completely clotted false lumens of the ascending and the descending aorta. Type I aortic dissection was confirmed at operation. Abbreviations as in Figures 1 and 6.



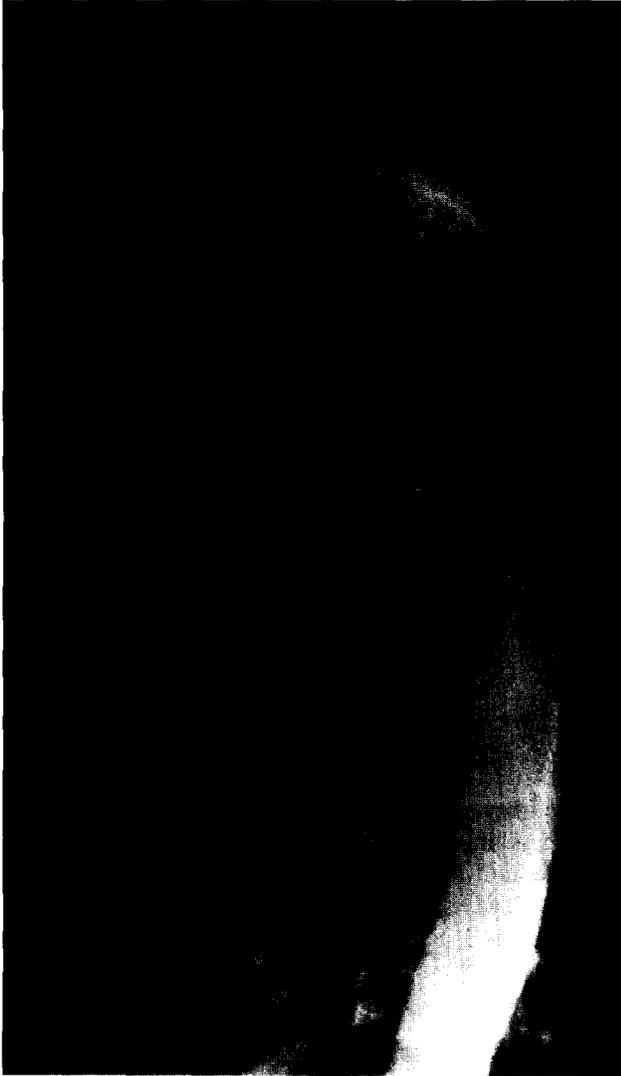


Figure 8. Patient 9. Aortogram from a 45-year old woman with hypertension and chest pain, showing normal opacification of the ascending and the descending aorta. Transesophageal echocardiographic views from this patient (Fig. 9) show type III dissection. Abbreviations as in Figure 3.

bosed false lumen. Mugge et al. (9) studied 22 patients with aortic dissection using transesophageal echocardiography and aortography and found 2 patients with false negative aortographic findings. In one patient the negative finding was due to a completely thrombosed false lumen; in the other it was due to a flap in a large aneurysm with similar flow on each side of the flap.

In our study comprising a large number of patients, the aortogram correctly identified dissection in 50 of 65 patients (sensitivity 77%). In 13 of 15 patients, the false negative finding was thought to be due to a completely thrombosed false lumen or a noncommunicating dissection; in the other 2 patients a large ascending aortic aneurysm with good flow on each side of the intimal flap was considered responsible because these anatomic characteristics made it difficult for differential opacification of the true and false lumens.

Frequency and explanation of false negative transesophageal echocardiographic findings. Several recent studies have shown excellent sensitivity of transesophageal echocardiography in diagnosing aortic dissection. Simon et al. (8) used this study to identify dissection in 32 of 32 patients (sensitivity 100%). Erbel et al. (5) found that it missed the diagnosis of aortic dissection in 1 of 82 patients (sensitivity 99%). When that patient underwent surgical treatment for severe aortic regurgitation, a localized type II dissection was noted. Ballal et al. (6) used transesophageal echocardiography to correctly diagnose aortic dissection in 33 of 34 patients (sensitivity 97%). Their one patient with a false negative result had a localized dissection close to the aortic valve leaflets in a large ascending aortic aneurysm. In our study, transesophageal echocardiography correctly diagnosed dissection in 63 of 65 patients (sensitivity 97%). Both patients with a false negative diagnosis of aortic dissection had a type II dissection localized to the inner margin of the distal ascending aorta. The diagnosis was missed despite the use of biplane transesophageal echocardiography. In such patients, the air-filled trachea interferes with optimal imaging of the distal ascending aorta and proximal portion of the

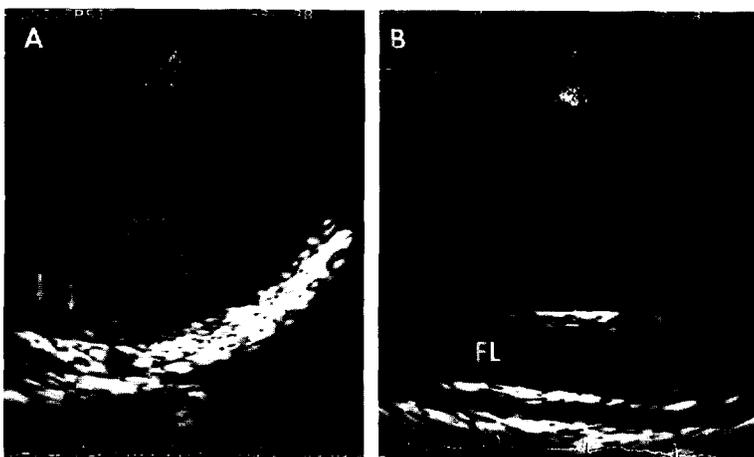


Figure 9. Same patient as in Figure 8. Biplane transesophageal echocardiographic views of the aorta. An intimal flap (arrows) is seen in the arch (A) and descending aorta (B). The false lumen is almost completely clotted, and color flow imaging did not show communication between the two lumens. Calcified intima (arrows) are shown in B. "Skip areas" due to incomplete clotting are noted in A (large arrow) and B (arrowheads). Abbreviations as in Figures 1 and 3.

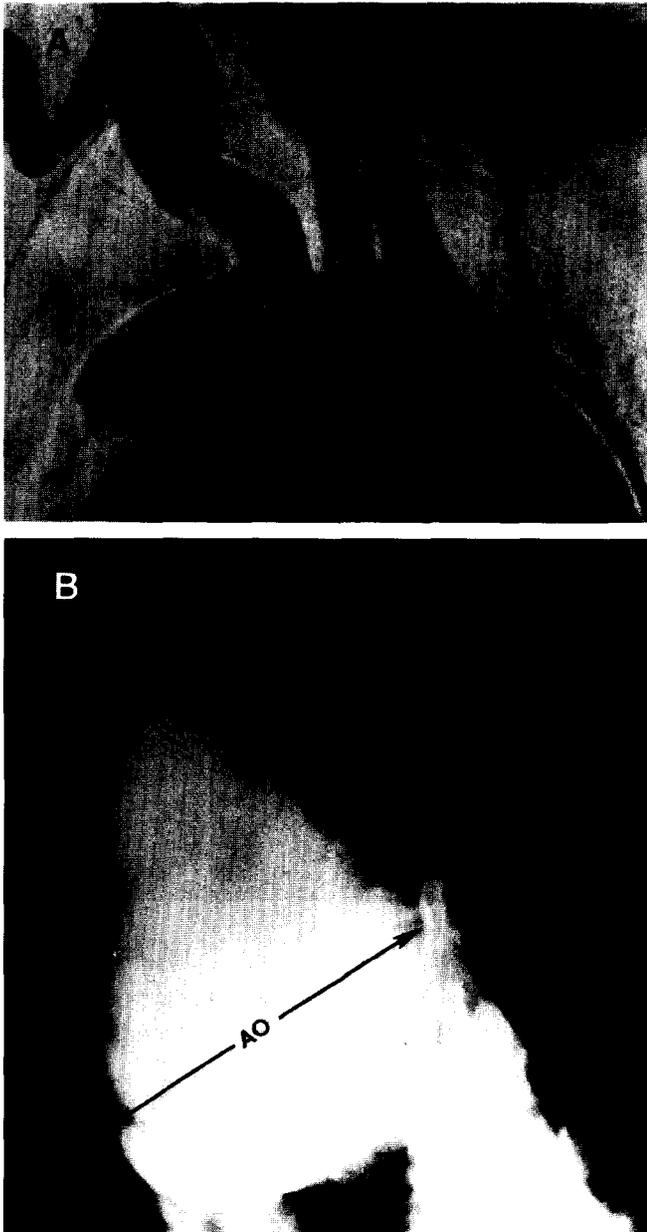


Figure 10. Patient 2. Aortogram from a 24-year old man with Marfan syndrome and surgically confirmed type I dissection. **A**, The arch and the arch vessels show no evidence of intimal flap or dissection. **B**, An extremely large ascending aortic (AO) aneurysm. There is no evidence of an intimal flap or a true and a false lumen on this aortogram. LC = left carotid artery; LS = left subclavian artery; RI = right innominate artery.

arch; ultrasonic resolution of this area may not be possible even with the biplane transesophageal echocardiographic probes. Therefore, dissections limited to this region of the aorta can be missed.

Pathogenesis of aortic dissection and intramural hematoma. The initial event in aortic dissection has long been a point of controversy. Data from multiple studies indicate that

a majority of aortic dissections start after an intimal tear, with a secondary dissection of blood into the media (16). Angiography generally provides diagnostic information in these cases (13,14). Other imaging modalities, including nuclear magnetic resonance imaging (7), contrast computed tomographic scanning (15) and transesophageal echocardiography (5,6,8), provide excellent diagnostic accuracy for this type of communicating dissection.

Entry tears are not present in a minority of patients with aortic dissection (16-18). Gore (17) described aortic dissection without intimal tear in 23 patients, including 6 patients whom he treated. Hirst et al. (18) reviewed the findings in 505 patients with aortic dissection and found no tears in 21 (4%). Wilson and Hutchins (16) found no intimal tears in 21 (13%) of 168 patients with spontaneous dissection studied at necropsy. Dissection without an intimal tear may be explained by spontaneous rupture of vasa vasorum, with hemorrhage into the diseased aortic media.

Krukenberg (19) in 1920 first suggested the rupture of vasa vasorum as a cause of medial hematoma. This medial hemorrhage or hematoma generally occurs in older patients with hypertension. The medial hemorrhage can extend retrograde to involve the ascending aorta or show antero-grade extensions involving the descending aorta. In some patients, this medial hematoma does not establish any communication with the main aortic lumen. In others, secondary tear of the intima can occur, and communication of the media is then established with the main aortic lumen. The medial hematoma stage of aortic dissection without any communication with the main aortic lumen frequently accounts for false negative aortographic findings. When the medial hematoma is large, a thickened aortic wall on aortography may serve as an indirect sign of aortic dissection. This type of noncommunicating dissection can be diagnosed by transesophageal echocardiography (20), contrast computed tomography and magnetic resonance imaging (21).

Serial follow-up studies have reported regression of medial hematoma in some cases (20), whereas in others aortic rupture (20,21) or a typical communicating dissection (20) develops. The dissected channel is generally present in the outer media beneath the adventitia. Pericardial and pleural effusions are common owing to the subadventitial location of the hemorrhage (20,21).

Limitations of transesophageal echocardiography in the diagnosis of intramural hematoma. Intramural hematoma or clotted false lumen should be differentiated from laminated clot in an aortic aneurysm. If the intimal calcification is near the inner margin of the thick wall, an aortic dissection is diagnosed. Additionally, in intramural hematoma or noncommunicating aortic dissection, the clotting is generally not uniform and there are echolucencies or skip areas. (Fig. 6C and 9). In patients with an aortic aneurysm with laminated clot, the innermost margin of the clot is not calcified (Fig. 3C), and calcification is generally present near the peripheral margin of

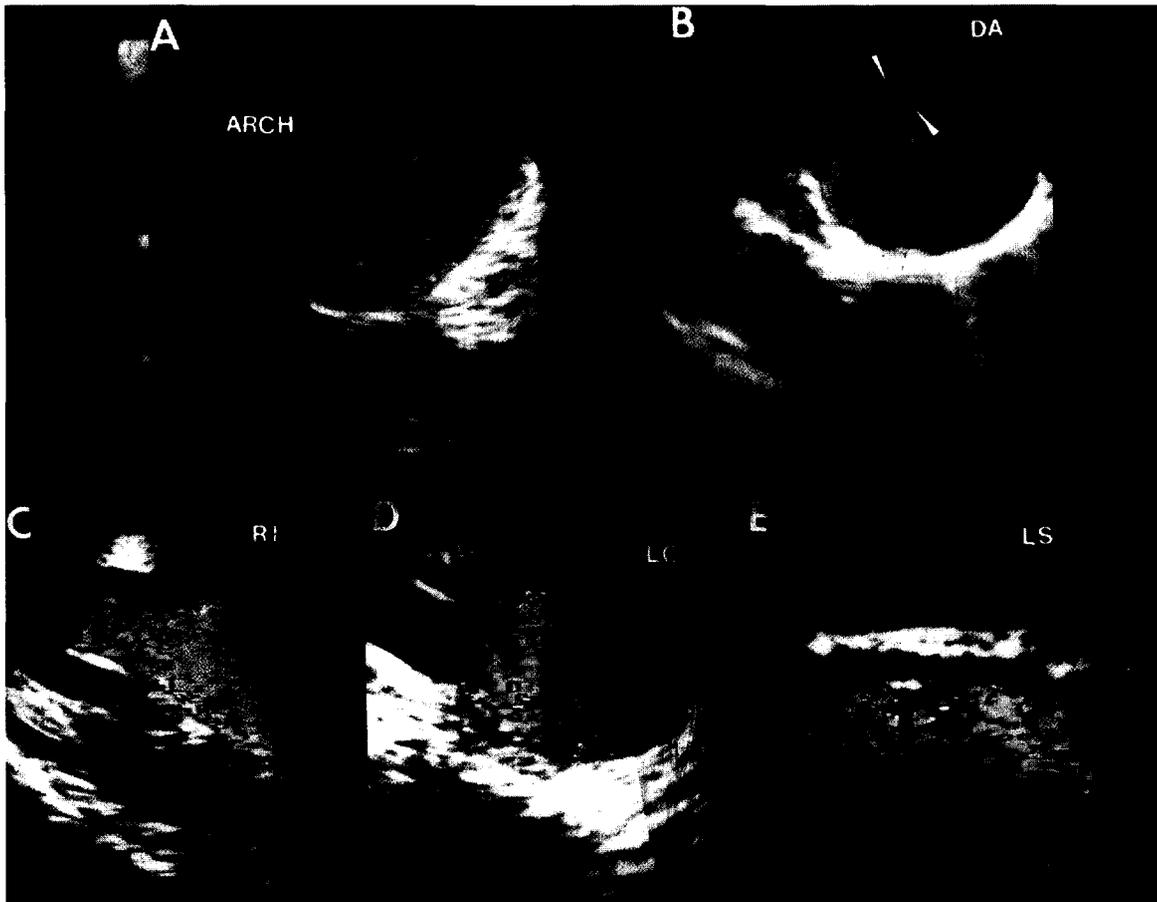


Figure 11. Same patient as in Figure 10. Biplane transesophageal echocardiographic views of the arch (A), descending aorta at 35 cm from the incisors (B), right innominate artery (C), left carotid artery (D) and left subclavian artery (E). All views show the intimal flap (small arrows), true and false lumens in the arch, descending aorta and the arch vessels diagnostic of type I dissection. Note the reentrant tear in the descending aorta (arrowheads) in B. Views in Panels C, D and E were obtained with the longitudinal scanning probe and displayed by using the right-left reorientation switch. Abbreviations as in Figures 1, 3 and 10.

the thick wall. Occasionally, calcification may be noted inside the clot as well.

We gratefully acknowledge the expert secretarial help of Jackie Abboud. We thank Floyd F. Petersen, MPH for assistance with statistical analysis. We also appreciate the services of the Media Services Department at Loma Linda University for their assistance with photography.

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