Transesophageal Echocardiographic Recognition of Subaortic Complications in Aortic Valve Endocarditis

Clinical and Surgical Implications

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Background. Secondary involvement of the mitral-aortic intervalvular fibrosa and the anterior mitral leaflet (subaortic structures) can occur in patients with aortic valve endocarditis. The secondary involvement of these structures occurs as a result of direct extension of the infection from the aortic valve or as a result of an infected aortic regurgitant jet striking the ventricular surfaces of the mitral-aortic intervalvular fibrosa and the anterior mitral leaflet. The abscess of mitral-aortic intervalvular fibrosa can expand to form an aneurysm. Subsequently, this mitral-aortic intervalvular fibrosa aneurysm can develop a perforation and communicate with the left atrium, resulting in the systolic regurgitation of blood from the left ventricular outflow tract into the left atrium. Secondary infection can also occur on the ventricular surface of the anterior mitral leaflet and result in the formation of an aneurysm or perforation of anterior mitral leaflet.

Methods and Results. This study examines the utility of transesophageal echocardiography in the detection of these subaortic complications in 55 consecutive patients with aortic valve endocarditis. A total of 24 patients (44%) had involvement of subaortic structures, including four with an abscess in the mitral-aortic intervalvular fibrosa, four with mitral-aortic intervalvular fibrosa aneurysm, seven with perforation of the mitral-aortic intervalvular fibrosa with communication into the left atrium, two with an aneurysm of the anterior mitral leaflet, and seven with perforation of the anterior mitral leaflet. The transesophageal echocardiographic findings were confirmed at surgery in 20 patients and at necropsy in two. By comparison, transthoracic echocardiography visualized these lesions in five of 24 patients (21%), including none of four with mitral-aortic intervalvular fibrosa abscesses, two of four with mitral-aortic intervalvular fibrosa aneurysms, one of seven with mitral-aortic intervalvular fibrosa perforations, one of two with anterior mitral leaflet aneurysms, and one of seven anterior mitral leaflet perforations. Eccentric mitral regurgitation—type systolic jets were noted in eight additional patients by transthoracic color flow imaging, and this finding suggested the possibility of these unusual subaortic complications. If these patients are included, then transthoracic echocardiography suggested the presence of these subaortic complications in 13 of 24 patients (54%).

Conclusions. The results indicate that 1) involvement of the subaortic structures in patients with aortic valve endocarditis may be more common than previously recognized, 2) patients with aortic valve endocarditis and eccentric jets of mitral regurgitation on transthoracic echocardiography should undergo further evaluation by transesophageal echocardiography to exclude these unusual complications, 3) precise recognition of these complications is of value in the optimal medical and surgical management of these patients, and 4) these complications may be responsible for unexplained congestive heart failure and hemodynamic deterioration in some patients with aortic valve endocarditis. (Circulation 1992;86:353–362)

KEY WORDS • endocarditis • valves • aneurysms, mitral valve • echocardiography

During the last two decades, transthoracic echocardiography (TTE) has been used to detect vegetations and determine the hemodynamic sequelae of valvular damage and prognosis in patients with infective endocarditis.1–5 More recently, transesophageal echocardiography (TEE) has been demonstrated to be superior to TTE in the visualization of vegetations and abscesses associated with endocarditis.6–9

Infection of the aortic valve produces destruction and perforation of the leaflets and results in severe aortic regurgitation.10 Ring abscess and perivalvular regurgitation is frequently noted in patients with prosthetic

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Received January 4, 1991; revision accepted April 6, 1992.
aortic valves. The hemodynamic deterioration in patients with aortic valve endocarditis is generally a result of severe aortic regurgitation and left ventricular failure. Less commonly, the infected aortic regurgitant jet can strike the subaortic structures and produce complications related to the mitral-aortic intervalvular fibrosa (MAIVF) (abscess, aneurysm, and perforation into the left atrium) and the anterior mitral leaflet (AML) (aneurysm and perforation). Early recognition of these subaortic structural complications in patients with aortic valve endocarditis is important for optimal patient management for several reasons: 1) Involvement of the MAIVF and the AML may produce severe mitral regurgitation and hemodynamic collapse in an already ill patient, 2) the presence of severe mitral valve involvement may present with clinical features suggestive of primary mitral valve disease, and 3) these complications can be overlooked at the time of aortic valve replacement when repair or replacement of the mitral valve may also be necessary.

There are few reports of use of TTE\textsuperscript{14–16} and TEE\textsuperscript{17–20} in the identification of these unique secondary complications. Therefore, we undertook a study to assess and compare the value of TTE and TEE approaches in the detection of subaortic structural complications in patients with primary aortic valve endocarditis.

**Methods**

**Study Patients**

Between May 1988 and August 1991, 55 consecutive patients with a diagnosis of aortic valve endocarditis underwent TTE and TEE studies. Aortic valve endocarditis was diagnosed clinically by the presence of persistently positive blood cultures with organisms fre-
Figure 2. Schematic of the long-axis view of the heart and subaortic structures with primary endocarditis of the aortic valve. Panels A through D represent complications of secondary infection of the mitral-aortic intervalvular fibrosa (arrow). Panel A shows mitral-aortic intervalvular fibrosa abscess, panel B shows aneurysm, panel C shows rupture of the aneurysm into the left atrium (arrowhead), and panel D shows rupture of the mitral-aortic intervalvular fibrosa into the left atrium without formation of an aneurysm. Panels E and F show complications resulting from secondary infection of the anterior mitral leaflet. Panel E demonstrates formation of an aneurysm, and panel F shows perforation of the anterior mitral leaflet. AO, aorta; AV, aortic valve; LA, left atrium; LV, left ventricle; MV, mitral valve; V, vegetation.

Echocardiographic Equipment and Examination Techniques

Both TTE and TEE were performed within 24 hours of each other with a variety of commercially available echocardiographic imaging systems. These included Hewlett-Packard 77020AC and Hewlett-Packard Sonos 1000 (transthoracic 2.25-MHz transducer; transesophageal monoplane 5-MHz phased-array probe manufactured by Hewlett-Packard Medical Products Group, Andover, Mass.); Aloka SSD 860 or 870 (transthoracic 2.5-MHz transducer; transesophageal 5-MHz monoplane or biplane probe manufactured by Aloka Company, Tokyo); and ATL Ultramark 7 (transesophageal 2.5-MHz transducer; transesophageal 5-MHz biplane probe manufactured by Advanced Technology Laboratories, Bellevue, Wash.) phased array ultrasound imaging systems equipped with Doppler and color flow capabilities. TTE was performed according to a previously described standardized protocol and scan planes.22 For TEE, patients had fasted for at least 4 hours. Informed consent was obtained from all patients before examination. All patients received local pharyngeal anesthesia (10% Xylocaine spray), and some received light sedation (2–5 mg midazolam i.v.). The technique of complete transesophageal examination has been described previously.23–25 Transesophageal studies were completed within 20 minutes without any complications.

Echocardiographic Definitions

Vegetation was defined as a localized shaggy mass of echoes contiguous with the valve leaflet. The vegetation was further classified as sessile if it was flat and firmly attached to the valve or mobile if a part of the vegetation was pedunculated and demonstrated chaotic or highly mobile motion. A large vegetation was ≥10 mm in length; a small vegetation was <10 mm in length.7 Abscess was defined as an abnormal echo-dense or echo-lucent area within the valvular annulus or perivalvular tissue in the setting of valvular infection confirmed by imaging in more than one tomographic plane.9 Severity of aortic and mitral regurgitation was determined according to the previously described echo-Doppler criteria.26,27

Anatomic Definitions

The various subaortic structures are shown in Figure 1. MAIVF is the junctional interannular zone between the elements of the anterior mitral leaflet and the aortic valve. Infective complications of this zone include abscess, aneurysm, and perforation into the left atrium (Figures 2A–2D). Infective complications of AML include aneurysm and perforation (Figures 2E and 2F).
Results

The clinical characteristics and types of subaortic structural abnormalities for the entire population of 24 patients are summarized in Table 1. There were 23 men and one woman (age, 18–70 years; mean, 43 years). Eleven patients had prosthetic, 10 bicuspid, and one unicusp aortic valve. The remaining two patients, with trileaflet aortic valves, had a history of intravenous drug abuse. Twenty patients were studied during the acute stage and four during the healed stage (months after treatment of acute infection) of aortic valve endocarditis.

TTE did not show vegetations on any of the 11 patients with prosthetic aortic valve endocarditis. TEE showed large mobile vegetations on the leaflets of one patient with a bioprosthetic aortic valve and along the sewing ring in the left ventricular outflow tract in another patient with a Starr-Edwards aortic prosthesis. Of the 13 patients with native aortic valve endocarditis, two patients had small and 10 had large vegetations by TEE. One patient with severe aortic regurgitation and a unicusp aortic valve did not have any identifiable vegetations on the aortic valve by TEE. TTE could identify vegetations in 11 of 14 patients (79%). TEE, however, provided a higher-resolution image of the vegetation in all patients. Vegetations were mobile in 12 patients and sessile in two. The degree of aortic regurgitation was severe in 15 patients, moderate in four, mild in three, and trace in two. The types of infective organisms in the 20 patients with acute infection are summarized in Table 1.

Five different subaortic complications were identified by TEE; their anatomic details and the comparison of the TTE and TEE findings are as follows.

MAIVF abscess. An abscess in the MAIVF was diagnosed by TEE in four patients (Figure 3). TTE could not show this abnormality in any of these patients. Two
TABLE I. Clinical and Echocardiographic Findings (cont)

<table>
<thead>
<tr>
<th>Management</th>
<th>Complications</th>
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<tbody>
<tr>
<td>AVR</td>
<td>None</td>
</tr>
<tr>
<td>AVR</td>
<td>MAIVF perforation, surgery, death</td>
</tr>
<tr>
<td>AVR</td>
<td>MAIVF perforation, surgery</td>
</tr>
<tr>
<td>AVR</td>
<td>Perioperative death</td>
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<td>AVR, repair</td>
<td>None</td>
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<tr>
<td>AVR, repair</td>
<td>None</td>
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<tr>
<td>AVR</td>
<td>Postoperative prosthetic endocarditis</td>
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<tr>
<td>AVR, repair</td>
<td>None</td>
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<tr>
<td>Medical</td>
<td>Death</td>
</tr>
<tr>
<td>AVR, repair</td>
<td>None</td>
</tr>
<tr>
<td>AVR, repair</td>
<td>None</td>
</tr>
<tr>
<td>AVR, repair</td>
<td>Persistent MAIVF perforation</td>
</tr>
<tr>
<td>AVR, repair</td>
<td>Persistent MAIVF perforation</td>
</tr>
<tr>
<td>AVR, repair</td>
<td>Death</td>
</tr>
<tr>
<td>Medical</td>
<td>None</td>
</tr>
<tr>
<td>Medical</td>
<td>Death</td>
</tr>
<tr>
<td>AVR, MV repair</td>
<td>None</td>
</tr>
<tr>
<td>AVR, MV repair</td>
<td>Death</td>
</tr>
<tr>
<td>Medical</td>
<td>None</td>
</tr>
<tr>
<td>AVR, MV repair</td>
<td>None</td>
</tr>
<tr>
<td>AVR, MV repair</td>
<td>Mild MR at repair site</td>
</tr>
<tr>
<td>AVR, MV repair</td>
<td>None</td>
</tr>
<tr>
<td>AVR, MV repair</td>
<td>None</td>
</tr>
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</table>

patients with this lesion had prosthetic and the other two bicuspid aortic valves. Aortic regurgitation was severe in three patients and moderate in one. All four patients underwent aortic valve replacement, and the findings were confirmed at surgery. One patient died in the immediate perioperative period. Two patients developed perforation of the abscess and communication with the left atrium in the postoperative period. One of these patients underwent successful surgical repair, but the other patient died after the second surgery. The remaining one patient is doing well after surgery.

**MAIVF aneurysm.** TEE demonstrated an aneurysm of MAIVF in four patients. TTE was able to visualize this complication in two of four patients (50%). The MAIVF aneurysm showed systolic expansion and diastolic collapse by echocardiography (Figure 4). Two patients had prosthetic aortic valve, one had unicuspid, and one had trileaflet aortic valve with history of intravenous drug abuse. Aortic regurgitation was severe in two and trace in the other two patients. Findings were confirmed at the time of surgery in all four patients. Three patients had aortic valve replacement and repair of this subaortic aneurysm and are doing well after surgery. One patient had aortic valve replacement alone and developed post-operative endocarditis of the prosthetic valve.

**MAIVF perforation into the left atrium.** TEE showed evidence of rupture of the infected MAIVF zone into the left atrium via the formation of aneurysm in two patients (Figure 2C) or directly in five patients (Figure 2D) with systolic shunting of blood from left ventricular outflow tract into the left atrium (Figure 5). This complication produced a clinical picture similar to mitral regurgitation, but the leakage was located above the mitral annulus ("supra-annular mitral regurgitation"). TTE showed anatomic details of this lesion in one of seven patients (14%). In an additional four patients (56%), TTE showed evidence of an eccentric jet of mitral regurgitation from the left ventricular outflow tract (Figure 6). This was a clue for the presence of this complication. Six patients in this group had prosthetic and one had bicuspid aortic valve. The degree of aortic regurgitation was mild in two patients, moderate in one, and severe in four. One patient was managed medically, and the lesion was not confirmed at surgery. One patient died while receiving medical treatment, and the findings were confirmed at necropsy. The other five patients had aortic valve replacement and repair of the perforation. One patient died after surgery, and two had persistent postoperative leakage of blood through the perforation.

**AML aneurysm.** Two patients were noted to have an aneurysm of the AML by TEE (Figure 7). TTE detected this abnormality in one patient with a large AML aneurysm. The other patient had a small aneurysm of the AML that was not seen by TTE. There were, however, small perforations at the summit of the AML aneurysm, and TTE could visualize an eccentric jet of mitral regurgitation originating through the body of the AML suggestive of this lesion. Both of these patients had bicuspid aortic valves. Aortic regurgitation was mild in one and severe in the other. While waiting for surgery, the patient with the large AML aneurysm died of rupture of the aneurysm and massive mitral regurgitation. The second patient underwent successful replacement of the aortic valve and repair of the AML with a pericardial patch.

**AML perforation.** This complication was diagnosed by TEE in seven patients (Figure 8). Direct visualization of the perforation was noted in one of seven patients (14%) by TTE. In another three of seven patients (43%), there was flow acceleration on the ventricular aspect of the AML and an eccentric jet of mitral regurgitation suggestive of this complication. In the other three of seven patients (43%), however, TTE could not provide any clue regarding the presence of this complication. One patient had prosthetic, five bicuspid, and one trileaflet aortic valve with history of intravenous drug abuse. Aortic regurgitation was moderate in two patients and severe in the other five. One patient with a small perforation of the AML was managed medically, and the findings were not confirmed. The findings were confirmed at surgery in the remaining six patients. One patient underwent mitral and aortic valve replacement and died of postoperative sepsis. Two additional patients underwent replacement of aortic and mitral valves and are doing well. The remaining three patients had replacement of aortic and repair of mitral valve; only one of these patients had mild residual mitral regurgitation at the site of repair.
FIGURE 3. Transesophageal four-chamber with aorta (five-chamber) view from a patient with prosthetic aortic valve endocarditis. A large abscess (arrow) is seen in the region of the posterior aortic root; it extends to the subaortic region of mitral-aortic intervalvular fibrosa. Although the anterior mitral leaflet is thin, its base is thickened. AO, aorta; LA, left atrium; LV, left ventricle; MV, mitral valve; RV, right ventricle.

FIGURE 4. Magnified transesophageal five-chamber diastolic (panel A) and systolic (panel B) views from a 34-year-old woman with endocarditis of unicuspid aortic valve (AV). Panel B shows the systolic doming of the AV. Systolic frame clearly shows the aneurysm (AN) in the region of mitral-aortic intervalvular fibrosa between the annuli of the mitral (MV) and aortic valves. This aneurysm communicates (arrow) with the left ventricular outflow tract (LVOT) and shows marked systolic expansion. The diastolic frame (panel A) shows almost complete collapse of the aneurysm (AN). AO, aorta; LA, left atrium; LV, left ventricle.
FIGURE 5. Transesophageal five-chamber view without color (panel A) and with color (panel B) from a patient with prosthetic aortic valve endocarditis. There is echo drop-out or discontinuity at the junction of the base of anterior mitral leaflet (MV) and aortic root (AO) resulting from rupture of the mitral-aortic intervalvular fibrosa. Color flow image (panel B) shows a mosaic-colored systolic jet through this communication into the left atrium (LA) because of systolic shunting of blood from the left ventricular outflow tract to the left atrium. LV, left ventricle.

Discussion

Anatomy of Subaortic Structures

The anterior leaflet of the mitral valve lies in a somewhat medial position, subjacent to the aortic valve.

There is no well-formed fibrous mitral annulus medially, and the AML shows an anatomic continuity with the posterior and left aortic cusps and the aortic root.\textsuperscript{11,12} This junctional zone between the elements of the two

FIGURE 6. Transthoracic apical four-chamber view with apex up and left ventricle (LV) displayed to the viewer's left (panel A) and its schematic (panel B) from a 45-year-old patient with a history of intravenous drug abuse and endocarditis of a Bjork-Shiley aortic prosthesis. A mosaic-colored eccentric jet of mitral regurgitation (arrow) is seen, originating from the region of left ventricular outflow tract (LVOT) directed toward the lateral wall of the left atrium (LA). Although the rupture of the mitral-aortic intervalvular fibrosa is not directly demonstrated on this image, it was confirmed by transesophageal echocardiography and surgery. This type of jet is a clue to this complication. I, inferior; L, left; LA, left atrium; LV, left ventricle; R, right; RA, right atrium; RV, right ventricle; S, superior.
The image shows a page from a medical journal, discussing the formation of an abscess in the left ventricular outflow tract from aortic valve endocarditis. The text explains that the abscess can expand and form an aneurysm of the left ventricular outflow tract. The page includes an illustration of an echocardiogram showing the aneurysm with color flow imaging.

Pathology of Subaortic Structures in Patients With Aortic Valve Endocarditis

Five different subaortic lesions were noted in patients with aortic valve endocarditis. Secondary infection of the mitral valve chordae tendineae has also been reported. This complication was not seen in our series.

MAIVF Abscess. The MAIVF is relatively avascular and offers little resistance to infection. Early infection results in the formation of an abscess. TTE demonstrated this complication in four patients (Figure 3). TTE, however, was negative in all four patients. The abscess in this zone can expand and form an aneurysm of the left ventricular outflow tract, as was seen in one of our patients (patient 8) by serial TEE studies. This abscess or aneurysm can rupture into the left atrium, and TEE is useful for early recognition of this complication. Two patients (patients 2 and 3) developed this complication after aortic valve replacement. Serial TEE studies may detect formation of an aneurysm in this zone, and surgery may be indicated if this zone demonstrates significant expansion (Figure 4) or perforation.

MAIVF Aneurysm. Infection is the most common cause of aneurysm of MAIVF. Blunt chest trauma has also been reported as a cause of this aneurysm. This complication was recognized by TEE in four patients. TTE was able to diagnose this complication correctly in two of four patients (50%). M-mode and two-dimensional echocardiographic features of this aneurysm with characteristic systolic expansion and diastolic collapse have been described previously. TEE studies can be performed serially to determine the progression of this lesion. Surgery would be indicated in an otherwise hemodynamically stable patient who shows evidence of...
progressive enlargement of this aneurysm (Figure 4). Without timely surgical intervention, it can rupture either into the pericardium with acute tamponade or into the left atrium with findings of severe mitral regurgitation.

MAIVF perforation into the left atrium. Rupture of the MAIVF into the pericardial space resulting in acute tamponade and death has been described previously. This particular complication was not seen in any of our patients. By TEE, however, we recognized perforation of the MAIVF into the left atrium directly or through aneurysm of this zone in seven patients (Figure 5). TTE provided direct visualization of this complication in only one of seven patients (14%). Presence of an eccentric jet of systolic flow signal from the region of left ventricular outflow tract (below the aortic annulus) directed toward the lateral left atrial wall was a clue for the presence of this complication in four patients by TTE (Figure 6). Bansal et al reported these transesophageal findings in three patients and Karalis et al in one patient with this lesion; these patients have been included in this series. This complication should be precisely diagnosed before surgery and differentiated from mitral regurgitation caused by perforation of AML or other valvular pathology. Despite preoperative knowledge of the existence of these lesions, surgical repair can be difficult. Five patients underwent surgery for this lesion; there was one perioperative death, and two patients had persistent residual leakage of blood through this perforation into the left atrium. This complication can be overlooked at the time of replacement of the aortic valve because of suboptimal visualization of this zone by the surgeon. This complication requires direct surgical attention and will not be corrected by surgical replacement of the mitral valve; therefore, it must be differentiated from valvular mitral regurgitation.

AML aneurysm. This complication of aortic valve endocarditis has been reported previously by TTE and TEE. Secondary infection on the ventricular surface of the AML can produce an abscess, which may expand to form an aneurysm (Figure 7). Rupture of this aneurysm can produce severe mitral regurgitation and congestive heart failure. Generally, these aneurysms can be repaired with a pericardial patch. If severe destruction of the mitral leaflet tissue is noted, then replacement of the mitral valve may be required.

AML perforation. AML perforation may occur because of infection of the leaflet; it has been described previously by TTE and TEE studies. This was observed in seven patients by TEE (Figure 8) and only in one of seven patients (14%) by TTE. An eccentric systolic jet through the center of the AML with flow acceleration on the ventricular surface was a clue to the presence of this complication in three additional patients. This lesion can generally be repaired, but mitral valve replacement is required if there is evidence of extensive mitral leaflet tissue destruction. This lesion was successfully repaired by surgery in three of six patients.

Limitation of the Study

The majority of the patients in this series were referred to two tertiary care hospitals; therefore, the
study population represents a select group of patients. The fact that the surgeons were aware of the TEE findings before surgery may be considered a limitation. The sensitivity of TEE in detection of these lesions cannot be determined because only patients with positive TEE examinations were included in this study.

Clinical Implications

Secondary infection of the subaortic structures in patients with primary aortic valve endocarditis may be more common than is generally appreciated. Attention should be directed by TTE to the subaortic zone of the MAIVF and the AML in every patient with endocarditis of the aortic valve. Any thickening at the base of the mitral leaflet or the posterior aortic root, especially in the presence of an eccentric mitral regurgitation type of jet by color flow imaging, should alert the clinician to the possibility of these complications. Furthermore, these complications should be suspected in every patient with aortic valve endocarditis with clinical findings of mitral regurgitation or with hemodynamic deterioration without severe aortic regurgitation.

TEE is of great value for the detection, serial follow-up, and determination of the optimal time of surgical intervention in patients with secondary subaortic complications of aortic valve endocarditis. TEE should also be used during surgery to assess the results of repair of these lesions involving the MAIVF and the AML.

Acknowledgments

We gratefully acknowledge the expert secretarial help of Catherine Coin and Brenda Mayne. We also express our gratitude to Jerry Daly and Louise Cecarelli of the Media Services Department at Loma Linda University for their assistance with the illustrations and photography.

References

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Circulation. 1992;86:353-362
doi: 10.1161/01.CIR.86.2.353

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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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:
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