Comparison of M-mode and Cross-sectional Echocardiography in Infective Endocarditis

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SUMMARY Cross-sectional and M-mode echocardiograms were performed on 23 consecutive patients with infective endocarditis. Both M-mode and cross-sectional echocardiography identified vegetations in 18 patients, 10 of whom required valve replacement within 1 month of presentation. Cross-sectional echocardiography alone identified a vegetation in one patient with a prosthetic valve. Neither technique identified vegetations in five instances. The size and shape of a vegetation on cross-sectional echocardiography did not accurately predict the need for early valve replacement or the incidence of major peripheral emboli.

THE DIRECT, NONINVASIVE visualization of valvular vegetations by means of echocardiography has been an exciting development in the evaluation of patients who have infective endocarditis. Using a single beam of ultrasound, it is possible to recognize the characteristically coarse, irregular echoes of a valvular vegetation on M-mode echocardiography. However, vegetations cannot be identified with this technique in all patients who have active endocarditis. M-mode echocardiography probably identifies only vegetations that are greater than 2 mm in diameter, and tends to visualize vegetations in patients who have more advanced disease. Many patients whose vegetations can be visualized with M-mode echocardiography require early valve replacement for intratable heart failure.

Cross-sectional or two-dimensional echocardiography has gained widespread popularity. This technique provides real-time, two-dimensional tomographic images of the heart and allows spatial resolution of intracardiac structures in the lateral as well as axial dimension. Cross-sectional echocardiography can also be used to identify valvular vegetations, and may provide more useful information about the size, shape and mobility of a vegetation than does M-mode echocardiography. This study was undertaken to compare the features of M-mode and cross-sectional echocardiography in patients with infective endocarditis.

Materials and Methods

M-mode and cross-sectional echocardiograms obtained from 23 consecutive patients with well-documented, active infective endocarditis were examined. All patients had strong clinical evidence of active endocarditis, including the presence of fever, an organic heart murmur and bacteremia or fungemia. Endocarditis was also documented by pathologic examination of the involved valve in 11 of these 23 patients. Seven patients were female, and 15 were male; their average age was 38 years (range 19–63 years). The organisms causing endocarditis were staphylococcus aureus in 11 patients, streptococcus viridans in six, streptococcus sanguis in one, alpha hemolytic streptococcus in one, peptostreptococcus in one, streptococcus mutans in one, hemophilus influenza in one and candida tropicalis in one.

M-mode echocardiograms were performed with a commercially available ultrasonoscope (Smith-Kline Instruments, Sunnyvale, California) and a 2.25-MHz ultrasound transducer focused at 7.5 cm. Patients were examined in both the supine and left lateral positions. Multiple transducer angulations were used to examine the heart from all available echocardiographic windows, including subxiphoid and apical positions, as well as multiple areas along the left sternal border. Examinations were recorded with a fiberoptic strip chart recorder; the ultrasound transducer was directed sequentially through adjacent intracardiac structures during recording.

Cross-sectional echocardiograms were performed in all 23 patients using a commercially available, 30° mechanical sector scanner (Smith-Kline Instruments, Sunnyvale, California). Four patients were also examined with an 82° mechanical sector scanner (Smith-Kline Instruments, Sunnyvale, California) and one was also examined with a wide-angle, electronic, phased-array instrument (Varian Associates, Palo Alto, California). Patients were examined in both the supine and left lateral positions, and the heart was visualized with multiple transducer positions from all available echocardiographic windows. Cross-sectional echocardiograms were recorded on videotape for later analysis in real-time, slow-motion and stop-frame formats. M-mode and cross-sectional echocardiograms were performed within 1 week of each other in all cases, and generally on the same day.

Two observers independently examined the echocardiographic records and then compared the features of each echocardiographic technique with the clinical presentations of individual patients. Vegetations were defined on M-mode echocardiography as
coarse, irregular, "shaggy" echoes attached to the valve leaflets but not impairing their motion. Vegetations were defined on cross-sectional echocardiography, and an attempt was made to characterize the size, shape and mobility of the mass. Size was estimated qualitatively on a scale of 0 - 3: 0 — not seen, 1 — small, 2 — moderate size, and 3 — large. Precise measurement of a vegetation was not attempted. Vegetations seen on cross-sectional echocardiography were also classified as sessile or pedunculated. Vegetations that appeared elongated and finger-like and had motion independent of the valve leaflet were said to be pedunculated. Vegetations that appeared more flat and globular and moved in unison with the valve leaflets were said to be sessile.

In addition to applying general diagnostic criteria, we specifically reviewed M-mode echocardiograms for the presence of premature mitral valve closure indicating acute severe aortic regurgitation, and for diastolic fluttering of the aortic valve or chaotic motion of the mitral valve, suggesting fenestration or flailing of the leaflets.

The two observers agreed without major discrepancies concerning the echocardiographic findings in all 23 patients. The clinical record of each patient was then examined to confirm the diagnostic criteria for endocarditis and to determine outcome. A patient was said to have undergone early valve replacement if surgery were performed within 1 month of presentation. The primary indication for valve replacement in each case was severe heart failure unresponsive to digitalis and diuretics.

Results
Vegetations were identified on both M-mode and cross-sectional echocardiography in 18 of the 23 patients (78%). No vegetations were seen on either M-mode or cross-sectional echocardiography in four patients. In one patient, aortic vegetations were correctly identified by both M-mode and cross-sectional echocardiography, but small mitral vegetations observed at surgery were not identified with either technique. In one patient who had prosthetic valve endocarditis, vegetations were seen on cross-sectional echocardiography but could not be identified on M-mode echocardiography. Of the 18 patients who had vegetations on both M-mode and cross-sectional echocardiography, eight had vegetations on the aortic valve, seven had vegetations on the mitral valve and three had vegetations on the tricuspid valve.

A typical example of an aortic valve vegetation is shown in figures 1 and 2. In figure 1, the M-mode echocardiogram exhibits the characteristic coarse, irregular echoes of a vegetation. The mass of echoes produced by the vegetation can be seen attached to the valve leaflet during diastole. During systole, the valve opens normally and the vegetation is carried out of view. In other views, the aortic valve leaflets could be seen to flutter rapidly during diastole, suggesting disruption or fenestration of the leaflets. Representative frames of the cross-sectional echocardiogram performed on this patient are shown in figure 2. In the diastolic frame, the mass of echoes produced by the vegetation is seen attached to the valve leaflet. A frame from early systole shows the valve leaflets and the attached vegetation moving toward an open position adjacent to the aortic walls. The vegetation in this patient appeared round and globular and moved in conjunction with the valve leaflets. This vegetation was classified as sessile and 3+, or large.

Figures 3 and 4 show a 3+, sessile mitral vegetation. On the cross-sectional echocardiograms (fig. 3), a large globular mass of echoes is attached to the mitral valve. The vegetation is also readily identified on the M-mode echocardiogram (fig. 4). During diastole, the coarse, irregular echoes typifying a vegetation can be seen attached to the mitral valve.

Of the 18 patients whose vegetations were visualized on both M-mode and cross-sectional echocardiography, 10 required valve replacement for severe heart failure within 1 month of presentation, and one patient died shortly after admission. Valve replacement was also required in the one patient with prosthetic valve endocarditis whose vegetations were seen only on cross-sectional echocardiography. In contrast, the clinical course was relatively benign in the four patients without echocardiographically visible vegetations. All survived with antibiotic treatment alone (mean follow-up 30 weeks, range 8–70 weeks), and none had significant heart failure or embolic events.
Figure 2. Long-axis, cross-sectional echocardiogram of a large, sessile, aortic valve vegetation. AVL = aortic valve leaflet; LV = left ventricle; LA = left atrium; AO = aorta; VEG = vegetation.

Table 1 correlates the cross-sectional echocardiographic appearance of the vegetations with the clinical outcome. One of the three patients with tricuspid vegetations required early valve replacement. The vegetation in this patient was quite large, but sessile. The two patients surviving with medical therapy had small, sessile vegetations.

Six of the eight patients with aortic vegetations required early valve replacement. One of the two patients surviving without valve replacement had a large, sessile vegetation; the other had a moderate-sized, pedunculated vegetation. There was no clear-cut relationship between the size and shape of the vegetation and the need for early valve replacement. Two patients with aortic vegetations had premature mitral valve closure on M-mode echocardiography, and both required early valve replacement. Five patients had diastolic fluttering of the aortic valve on M-mode echocardiography, consistent with fenestration; two required early valve replacement.

Four of the seven patients with mitral vegetations required early valve replacement. Again, no definite relationship between the size of the vegetation and the need for valve replacement was shown. Two patients had chaotic motion of the mitral valve on M-mode echocardiography, consistent with flailing of the valve leaflets; both required early valve replacement.

The incidence of major embolic events is related to the size and shape of the vegetations in table 2. All three patients with tricuspid endocarditis had evidence of septic pulmonary emboli. Two had small vegetations on cross-sectional echocardiography, one had a large vegetation. None of the vegetations were pedunculated.

Of the four patients with major systemic emboli, two had aortic vegetations and two had mitral vegetations. All four suffered strokes with significant neurologic impairment. Two also had femoral artery
Table 1.

<table>
<thead>
<tr>
<th>Valve Involved</th>
<th>n</th>
<th>Surgery or death</th>
<th>Medical Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Size</td>
<td>Shape</td>
</tr>
<tr>
<td>Tricuspid</td>
<td>3</td>
<td>1</td>
<td>3+</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>8</td>
<td>1</td>
<td>3+</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1</td>
<td>3+</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2+</td>
<td></td>
</tr>
<tr>
<td>Total</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mitral</td>
<td>7</td>
<td>1</td>
<td>2+</td>
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<td></td>
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<tr>
<td></td>
<td>1</td>
<td>3+</td>
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<tr>
<td>Total</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Prosthetic</td>
<td>1</td>
<td>1</td>
<td>2+</td>
</tr>
</tbody>
</table>

Abbreviations: 1+ = small; 2+ = moderate; 3+ = large; S = sessile; P = pedunculated.

Figure 4. M-mode echocardiogram showing the typical shaggy echoes of a vegetation attached to the mitral valve. RV = right ventricle; IVS = interventricular septum; VEG = vegetation; AML = anterior mitral leaflet; PML = posterior mitral leaflet; PW = posterior wall.

occlusion and one had an acute splenic infarction. Both patients with mitral vegetations who had large peripheral emboli had 3+ vegetations. One patient with aortic vegetations and stroke had a 3+ sessile vegetation. The other patient had a 2+ (moderate-sized) pedunculated vegetation. After the stroke, the vegetation appeared much smaller and no longer prolapsed freely into the left ventricular outflow tract.

A change in the cross-sectional echocardiographic appearance of the vegetation was seen after peripheral embolization in two of these four patients. The M-mode echocardiogram was appreciably changed after embolization in one patient. Both patients who had aortic vegetations and peripheral emboli survived without early valve replacement, and one patient with mitral vegetation and peripheral emboli died.

Seven of the 18 patients whose vegetations were visualized on both M-mode and cross-sectional echocardiography survived without requiring early valve replacement. This group of patients has been followed for an average of 50 weeks after presentation.

Table 2.

<table>
<thead>
<tr>
<th>Valve Involved</th>
<th>Size of vegetation</th>
<th>Shape of vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>1+</td>
</tr>
<tr>
<td>Tricuspid</td>
<td>With emboli 3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Without emboli</td>
<td>0</td>
</tr>
<tr>
<td>Aortic</td>
<td>With emboli 2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Without emboli</td>
<td>6</td>
</tr>
<tr>
<td>Mitral</td>
<td>With emboli 2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Without emboli</td>
<td>5</td>
</tr>
</tbody>
</table>

Abbreviations: 1+ = small; 2+ = moderate; 3+ = large.
(range 10–108 weeks). Three of these seven had mild heart failure controlled with digitalis and diuretics during their acute illnesses and two suffered strokes. One patient with an aortic vegetation and one patient with a mitral vegetation have been scheduled for elective valve replacement.

Discussion

In this series of 23 patients with active infective endocarditis, vegetations were visualized by cross-sectional echocardiography in 19 patients. M-mode echocardiography identified vegetations in 18 patients. Only in one patient who had prosthetic valvular endocarditis did cross-sectional echocardiography detect a vegetation that could not be adequately identified on M-mode echocardiography. Based on this limited series of patients, we conclude that M-mode and cross-sectional echocardiography are equally sensitive in detecting vegetations attached to native cardiac valves. Although M-mode echocardiography identified vegetations in all three of our patients with tricuspid endocarditis, it is probably easier to visualize the tricuspid valve with cross-sectional echocardiography, particularly in the absence of right ventricular dilatation. Large numbers of patients with early endocarditis involving a previously normal valve need to be examined to document this potential advantage of cross-sectional echocardiography. This series contains only one patient with prosthetic valve endocarditis. The superior spatial orientation of cross-sectional echocardiography did permit recognition of a vegetation in this case, while the M-mode echocardiogram was inconclusive. Additional experience is necessary to adequately assess the role of echocardiography in detecting prosthetic valvular vegetations.

Both M-mode and cross-sectional echocardiography failed to identify vegetations in five patients. In one of these patients, aortic vegetations were correctly identified by both techniques, but small mitral vegetations not identified echocardiographically were observed at the time of aortic valve replacement. Each of the remaining four patients met strict criteria for the clinical diagnosis of endocarditis, but all were successfully treated with antibiotics, and anatomic confirmation of the presence of vegetations was not available. We conclude from these data that neither M-mode nor cross-sectional echocardiography can exclude a diagnosis of endocarditis. Presumably, vegetations in some patients are too small to be resolved by the echocardiographic technique. Severe valve destruction with resultant heart failure was not seen in patients who had no echocardiographically identifiable vegetations.

In contrast, 12 of the 19 patients who had vegetations visualized on echocardiography required valve replacement for severe, intractable heart failure within 1 month of presentation. Thus, the presence of vegetations on echocardiography tends to be associated with severe valve destruction. However, seven of the 19 patients with vegetations on echocardiography survived without requiring early valve replacement. Clearly, the presence of a vegetation on echocardiography is not in itself an indication for valve replacement, but this information should be integrated with other available clinical data when planning a patient’s treatment.

Four of the 15 patients who had echocardiographically visible vegetations on the aortic or mitral valves suffered major peripheral emboli. One of these patients died as a result of severe valve disruption, but three patients survived without surgery and sustained only mild or moderate permanent neurologic impairment. Although the presence of echocardiographically visible vegetations on the aortic or mitral valve is probably associated with an increased risk of peripheral embolization, we did not observe any unequivocal echocardiographic predictors of embolization. Valve replacement to prevent embolization of a vegetation is a drastic measure that should not be recommended until further experience has been gained. The presence of severe, intractable heart failure continues to be the primary indication for emergency valve replacement.

Twelve of the 23 patients in this series either died or required early valve replacement. This unusually high incidence of advanced endocarditis reflects the fact that these patients presented to a tertiary referral hospital. The incidence of echocardiographically identifiable vegetations may be smaller in patients with endocarditis admitted to community hospitals. Although we have occasionally visualized vegetations using echocardiography in patients with previously unsuspected endocarditis or negative blood cultures, echocardiography in no way reduces the requirement for traditional clinical vigilance in the early diagnosis or suspicion of bacterial endocarditis.

Although it did not appear to be more sensitive than M-mode echocardiography in detecting vegetations on native valves, cross-sectional echocardiography did provide superior spatial orientation and allowed better appreciation of the size and shape of a vegetation. However, estimation of the size and shape of a vegetation did not permit precise anticipation of clinical outcome in this series. Although it would retain that larger vegetations would be associated with more severe heart failure and that pedunculated vegetations would be more likely to be associated with peripheral embolization, these features were not exclusively predictive. Some patients with only moderate-sized vegetations required valve replacement and patients with sessile vegetations had strokes.

In addition to identifying vegetations, M-mode echocardiography in this group of patients provided valuable information that was not readily available from cross-sectional echocardiography. In particular, early closure of the mitral valve in the presence of acute aortic regurgitation is an ominous prognostic finding regardless of the size and shape of the aortic vegetation. This observation is best made with M-mode echocardiography. Similarly, high-frequency diastolic fluttering of the aortic valve, which suggests disruption or fenestration of the cusps, is best seen with the M-mode technique.
We conclude that a combination of M-mode and cross-sectional echocardiography can be extremely useful in the evaluation of patients with infective endocarditis. When properly performed, both techniques appear equally sensitive in visualizing vegetations on native valves. Since each technique has advantages and limitations, they should be used together rather than separately in evaluating patients with endocarditis. Neither M-mode nor cross-sectional echocardiography can exclude the presence of vegetations. Both M-mode and cross-sectional echocardiography tend to identify vegetations in patients with more advanced disease, but the presence of a vegetation on echocardiography does not in itself indicate a need for early valve replacement.

The cross-sectional echocardiographic appearance of valvular vegetations is often quite dramatic and frightening. This information has not previously been available to the clinician and should be used cautiously in conjunction with other, more conventional diagnostic information. Although cross-sectional echocardiography vividly displays the size and motion characteristics of a vegetation, the precise clinical implications of these findings need to be established. We do not now recommend valve replacement based solely on the echocardiographic appearance of a vegetation.

References
Comparison of M-mode and cross-sectional echocardiography in infective endocarditis.
L S Wann, C C Hallam, J C Dillon, A E Weyman and H Feigenbaum

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