Two-dimensional Echocardiographic Findings in Right-sided Infective Endocarditis

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SUMMARY M-mode and two-dimensional echocardiograms were recorded in 12 narcotic addicts who had right-sided infective endocarditis. The two-dimensional echocardiogram showed vegetations in 10 patients (nine tricuspid and one pulmonic), while the M-mode echocardiogram was positive in six (five tricuspid and one pulmonic). The use of multiple transducer positions resulted in better visualization of the valves and appeared to be an important reason for the large number of positive two-dimensional echocardiograms. Echocardiographic findings were also available after completion of antibiotic therapy in seven of 10 patients. Of these seven patients, the vegetation appeared unchanged in three, diminished in size in three and was no longer visualized in one. No patient required valve replacement. Two-dimensional echocardiography using a wide-angle sector scanner appears to offer distinct advantages over the standard M-mode technique in evaluating patients with right-sided infective endocarditis.

THE INCIDENCE of right-sided infective endocarditis has increased markedly in recent years, particularly in persons with a history of intravenous drug abuse.1-4 Echocardiographic findings in right-sided endocarditis have been described,5,6 but have received less attention than those in the left-sided endocarditis.7,8 This is in part due to the relative difficulty in recording the tricuspid and pulmonic valves by M-mode echocardiography, especially in the absence of right ventricular dilatation.9

Recently, the availability of two-dimensional echocardiography has permitted more complete visualization of the tricuspid leaflets. Using a real-time, two-dimensional, phased-array, wide-angle sector scanner, we attempted to examine the tricuspid and pulmonic valves in a series of narcotic addicts with clinically diagnosed right-sided endocarditis. In this communication we describe the two-dimensional echocardiographic findings in 10 patients with right-sided infective endocarditis. The importance of multiple transducer positions, comparisons with M-mode findings and changes in morphology of the vegetations after therapy are all considered in the present study.

Materials and Methods

From June through December 1978, right-sided infective endocarditis was diagnosed clinically in 12 narcotic addicts hospitalized at the Morris J. Bernstein Institute of Beth Israel Medical Center. The diagnosis of right-sided endocarditis depended upon the presence of each of the following: a history of recent intravenous drug abuse, fever greater than 101°F and three or more positive blood cultures.12,13 In addition, it was required that the patient have a murmur consistent with tricuspid insufficiency (a blowing systolic murmur along the lower left sternal border that became more intense with inspiration) or radiographic findings compatible with pulmonary embolization. Ten of these patients had right-sided valvular vegetations (nine tricuspid and one pulmonic) visualized on two-dimensional echocardiography and constitute the patient population for the present study. There were eight males and two females, ages 23-59 years (average 33 years). Pertinent clinical data are summarized in table 1.
Echocardiograms were recorded within 72 hours of admission to the hospital. The M-mode examination preceded the two-dimensional study. Seven of the 10 patients also underwent repeat echocardiographic examinations 5–6 weeks later, just before discharge. In these seven patients, the clinical and radiographic findings were reviewed to determine if evidence of new pulmonary emboli appeared during hospitalization.

M-mode echocardiograms were performed by an experienced technician using a Unirad series 100 ultrasonoscope interfaced with a Honeywell 1856A strip-chart recorder. Recordings were made with the patient in the supine or left lateral decubitus position. The transducer was placed in the third, fourth or fifth intercostal space just to the left of the sternum using previously described techniques. In patient 2, the M-mode echocardiogram was repeated after the two-dimensional examination with the transducer in the subxiphoid position.

Two-dimensional echocardiograms were performed by a physician using a commercially available, real-time, 32-element, phased-array, wide-angle (80°) sector scanner (Varian Associates). Images were permanently recorded on videotape and Polaroid photographs were made of stop-action frame images. This produces some degradation of image quality and loss of appreciation of motion of cardiac structures that are ordinarily present in real-time recordings.

Examinations were performed with the patient in the supine or left lateral decubitus position. One or more transducer positions were used in each patient to record echoes from the tricuspid leaflets. The transducer was initially placed in the third or fourth left intercostal space with the ultrasonic beam parallel to the long axis of the left ventricle. By tilting the transducer inferomedially, a long-axis view of the right atrium and right ventricle was obtained and echoes from the anterior and posterior tricuspid leaflets were recorded. Rotating the transducer 90° resulted in a cross section perpendicular to the long axis of the heart. Slight superior angulation of the transducer from this position produced a cross-sectional image at the level of the aortic root and permitted visualization of the anterior tricuspid leaflet. Additional slight superior angulation enabled us to record the pulmonic valve. Keeping the transducer in the same interspace or occasionally one interspace lower and tilting it medially and slightly inferiorly allowed the ultrasound beam to pass through the outflow tracts of both ventricles and permitted visualization of the anterior and septal tricuspid leaflets. The apical four-chamber view was obtained by placing the transducer at the point of maximal impulse and directing the ultrasound beam toward the base of the heart in a plane parallel to the long axis of the left ventricle and perpendicular to the interventricular septum. This enabled echoes to be recorded from the anterior and septal tricuspid leaflets. The subxiphoid four-chamber view was obtained with the transducer in the subxiphoid position slightly to the right of the midline pointing superiorly toward a point between the suprasternal notch and the left supraclavicular fossa, with the plane of the ultrasound beam perpendicular to the interventricular septum. The anterior and septal tricuspid leaflets could be visualized in this view.

No patient required surgery because of a right-sided valvular lesion. Patient 7 had an aortic valve vegetation with severe aortic insufficiency and underwent aortic valve replacement approximately 3 months after completion of antibiotic therapy.

**Results**

**Two-dimensional vs M-mode Findings**

Among the 12 patients with a clinical diagnosis of right-sided endocarditis, two-dimensional echocardiography showed vegetations in 10 (nine tricuspid and one pulmonic), while M-mode studies revealed vegetations in six patients (five tricuspid and one pulmonic). Echocardiograms from patient 4, whose vegetation was seen only on the two-dimensional study, are shown in figure 1. The two patients con-
considered to have negative two-dimensional echocardiograms both had typical clinical findings of tricuspid endocarditis. In one, the tricuspid valve was well visualized by multiple transducer positions but appeared normal; in the other, obesity and emphysema prevented an adequate study from being obtained. There were six patients in whom M-mode studies failed to show vegetations. In four, portions of the anterior tricuspid leaflet were recorded but did not reveal any abnormalities, and in two, the tricuspid valve was not visualized at all. In one patient whose tricuspid valve was not visualized, a two-dimensional study from the subxiphoid position showed a vegetation on the septal leaflet of the tricuspid valve (fig. 2). An M-mode examination from the subxiphoid area was attempted in this patient but was unsuccessful in visualizing the tricuspid valve. In no patient was the M-mode positive and the two-dimensional echocardiogram negative for tricuspid vegetations.

Two-dimensional Echocardiographic Patterns of Right-sided Vegetations

The vegetative lesions appeared to have several features in common, regardless of size, transducer position or site of involvement. The vegetations were extremely mobile, rapidly oscillating dense masses, appearing in some patients as a diffuse mass of echoes involving the entire leaflet and in others as a polypoid lesion attached to one of the valve leaflets (fig. 3). The vegetations attached to the tricuspid leaflets at various points, appearing to adhere to the atrial surface of the involved leaflet in two patients, to the tip of the leaflet in two and to the ventricular surface in one; in five patients there was diffuse involvement of the entire leaflet.

One patient, a 24-year-old male, was felt to have pulmonic valve endocarditis. An early diastolic murmur that was loudest in the second left intercostal space was present on physical examination. Two-dimensional and M-mode echocardiographic findings in this patient are shown in figure 4.
Serial Changes in Two-dimensional Echocardiograms and Associated Clinical Findings

Seven of the 10 patients with vegetations on the initial two-dimensional echocardiogram were restudied before discharge. Of these seven patients, six had vegetative lesions when reexamined. All patients were afebrile, asymptomatic and had completed a full course of antibiotic therapy at the time of the repeat echocardiogram. Of the six patients with tricuspid endocarditis, the vegetation was unchanged in three, appeared diminished in size in two (fig. 5) and was no longer visualized in one (fig. 6). In the patient with involvement of the pulmonic valve, the vegetation appeared to show a minimal decrease in size, but in contrast to the smooth-bordered, globular mass present initially, the follow-up study revealed thickened, irregular, somewhat less dense, rapidly oscillating echoes. These findings were interpreted as showing a small decrease in the size of the vegetation, along with destruction of valvular tissue. Unfortunately, due to degradation of the image produced by stop-action, single-frame photographs, this could only be appreciated on the real-time videotape recordings.

In the six patients with vegetations noted on follow-up study, the pleuritic chest pain present on admission disappeared by the fifth hospital day. Radiographic abnormalities consistent with pulmonary emboli also showed progressive resolution and in none of these patients did new pulmonary infiltrates appear once antibiotic therapy was initiated. The hospital course of the patient in whom the vegetation was no longer visualized at the time of discharge differed somewhat. His pleuritic chest pain remained severe for approximately 3 weeks before finally subsiding. He also had new pulmonary infiltrates consistent with pulmonary emboli during the second week in the hospital. Although the follow-up echocardiogram no

Figure 4. Left) Cross section through the aortic root (Ao) and the pulmonary artery (PA) in patient 6. A globular vegetation (V) is present on the pulmonic valve. Right) An M-mode study reveals multiple shaggy echoes on the pulmonic valve in systole and diastole, indicating a vegetation. A = anterior; P = posterior; R = right; L = left; LA = left atrium.

Figure 5. A) Cross-sectional view from patient 1 at the level of the right and left ventricular outflow tracts showing a large vegetation (V) on the anterior tricuspid leaflet. B) M-mode echocardiogram showing a vegetation on the anterior tricuspid leaflet. C) Same cross-sectional plane as in panel A, but 6 weeks later. The vegetation is smaller. A = anterior; P = posterior; R = right; L = left; RVO = right ventricular outflow tract; LVO = left ventricular outflow tract; MV = mitral valve; RA = right atrium; VS = ventricular septum.
longer showed a vegetation on the tricuspid valve, we could not determine whether this was the result of antibiotic therapy or secondary to embolization, because 3 weeks elapsed between the clinical evidence of embolization and the echocardiogram. This patient also had a vegetation on the aortic valve and underwent aortic valve replacement 3 months later because of severe aortic insufficiency. The tricuspid valve was examined at surgery and no vegetations were seen.

**Discussion**

M-mode echocardiography is an established noninvasive technique for evaluating patients with infective endocarditis. Vegetations as well as hemodynamic sequelae and other complications may be recognized, but the technique has a relatively low sensitivity and the size and morphology of valvular vegetations cannot be estimated. Right-sided endocarditis may present additional diagnostic problems because the tricuspid valve ordinarily is incompletely visualized unless there is right ventricular dilatation. Echoes that are recorded are usually limited to a segment of the anterior leaflet in systole and the rapid opening motion early in diastole. Echoes from the pulmonic valve may be even more difficult to record. Two-dimensional echocardiography using a wide-angle sector scan may help to eliminate these shortcomings. In the present study, the two-dimensional echocardiogram showed valvular vegetations in 10 of 12 patients with clinically diagnosed right-sided endocarditis, while the M-mode study was positive in only six of 12 patients. Although the number of patients is small, these findings suggest that two-dimensional echocardiography may be more sensitive than M-mode echocardiography in diagnosing right-sided valvular infections. Preliminary observations by other investigators support these observations. Despite these encouraging findings, however, the value of two-dimensional echocardiography as a screening procedure in patients with suspected endocarditis remains to be established.

The importance of using multiple transducer positions to record echoes from the tricuspid valve requires further emphasis. With this approach we were able to visualize the tricuspid leaflets in 11 of 12 patients. This degree of success is ordinarily not achieved in adults when the M-mode technique is used. No single cross-sectional view was superior to the others, and often the vegetation was clearly visualized in one cross-sectional plane but not in another. This may be related to the angle at which the ultrasound beam strikes the vegetation. The more perpendicular the ultrasound beam is to the structure being examined, the greater the amount of sound reflected and the more easily the structure recorded. Further, the wide sector arc may more readily allow visualization of a retrosternal structure such as the tricuspid valve.

Observations by a number of investigators, as well as experience in our own institution, have indicated that when vegetations are seen on the M-mode echocardiogram the prognosis with medical therapy may be poor and valve replacement is frequently necessary. These findings apparently do not apply to patients with right-sided endocarditis. None of our patients required surgery. However, in view of the small number of patients and the lack of long-term follow-up, further information is still necessary to clarify this observation.

We anticipate that two-dimensional echocardiography will provide information concerning the effect of medical therapy on the rate of resolution of valvular vegetations. In the present study, only one of seven patients in whom serial studies were available showed a complete disappearance of the vegetation after completion of therapy. Although the clinical course in this latter patient differed from that of others in that he continued to show evidence of pulmonary emboli for several weeks after initiation of therapy, we do not know whether the disappearance of the vegetation was due to embolization or represented a response to antibiotic therapy. In the other six, the vegetations were still present despite evidence of clinical and bacteriologic cure, although in three patients, the vegetations appeared smaller. Serial observations over a much longer period are necessary to determine the outcome on two-dimensional
Two-dimensional echocardiography of valvular vegetations treated medically.

Infective endocarditis involving the pulmonic valve is relatively rare and usually diagnosed only at autopsy.\textsuperscript{2, 28} Occasionally it is suspected on clinical grounds\textsuperscript{29} or detected by echocardiography.\textsuperscript{30} In the present study, one patient had a pulmonic valve vegetation on both M-mode and two-dimensional echocardiograms. A loud diastolic murmur of pulmonic regurgitation was present. Serial two-dimensional echocardiograms showed the valve border becoming more irregular and oscillating more rapidly, findings thought to indicate progressive valvular destruction. When discharged, the patient’s exercise tolerance was normal, although he still had a loud diastolic murmur and a markedly abnormal pulmonic valve echo.

Although the two-dimensional echocardiogram is extremely useful in evaluating patients with valvular vegetations, several possible sources of error exist. These can usually be minimized if careful technique is used. One of the most important potential problems involves the use of proper gain settings. Using a phased-array instrument to study the stenotic mitral valve orifice area, Martin et al.\textsuperscript{31} showed that incorrect gain settings could lead to false estimates of the size of the structure being examined. Their observations are relevant in patients being evaluated for the presence of vegetative lesions, particularly when serial echocardiograms are being obtained to determine if the size of the lesion has changed. If the gain settings on the instrument are too low, image dropout may occur and the vegetation may appear smaller than it is or even be missed entirely. On the other hand, excessively high gain settings will cause images to appear brighter and larger than the actual size. In addition, the borders of the vegetation may become indistinct and actually appear to overlap with adjacent valvular tissue, making the echocardiogram difficult to interpret. In general, the best resolution can be obtained by adjusting the gain setting to the minimal level needed to record the echoes of interest.

Another potential source of error involves estimating the size of valvular vegetations displayed in the far field. Increasing beam width may produce loss of azimuthal resolution in the far field, causing images to appear falsely large. This is unlikely when the transducer is positioned along the left sternal border, but should be taken into consideration when the valvular structures are imaged from the cardiac apex or the subxiphoid position because they are farther from the transducer and may be displayed in the far field.

Other valvular lesions may be confused with vegetations. In patients with valvular calcification, myxomatous degeneration or fibrotic valves, increased echoes resembling valvular vegetations may be recorded. Careful adjustment of gain settings, as well as the absence of an extremely mobile, rapidly oscillating appearance, should differentiate these abnormalities from vegetative lesions. Unfortunately, we were unable to distinguish between active and healed vegetations. Although we had no opportunity for surgical correlation in the present study, Gilbert et al.\textsuperscript{30} using a two-dimensional, phased-array system, were unable to detect vegetations of 2–3 mm later found at surgery or autopsy. Finally, there are a few patients in whom a technically adequate echocardiogram cannot be recorded because of poor penetration of the ultrasonic beam due to interposed lung tissue or an unusual chest wall configuration.

Two-dimensional echocardiography appears to offer more information than standard M-mode echocardiography in patients with right-sided endocarditis. The most notable benefit in the present study was an increased sensitivity in detecting tricuspid vegetations, which resulted from better visualization of the tricuspid leaflets than with the M-mode system. Using two-dimensional echocardiography, we were better able to estimate lesion size and detect serial changes in the morphology of vegetations in patients treated medically.

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