Echocardiographic recognition and implications of ventricular hypertrophic trabeculations and aberrant bands

ANDRE KEREN, M.D., MARGARET E. BILLINGHAM, M.B., B.S., AND RICHARD L. POPP, M.D.

ABSTRACT The accuracy of two-dimensional echocardiography in the recognition of aberrant ventricular bands and pathologic trabeculations (hypertrophic, fibrotic, or both) was assessed in 35 patients who underwent cardiac transplantation and pathologic examination. At pathologic study the prevalence of specific intracavitary structures ranged from 28% to 43%. Left ventricular thrombi were found in 12 patients (34%) and right ventricular thrombi in three (9%). Echocardiography accurately defined left ventricular aberrant bands and left ventricular thickened or fibrotic trabeculations. Bands, trabeculations, and thrombi each showed characteristic echocardiographic patterns. In the right ventricle, these structures were recognized, but accurate discrimination among them was not possible by echocardiography. Aberrant bands and pathologic trabeculations mimicked or obscured fresh or organized thrombi in three patients on two-dimensional echocardiography. Left ventricular longitudinal bands and pathologic right ventricular trabeculations obscured the interventricular septal border in four patients; the presence of these abnormalities could lead to the erroneous diagnosis of asymmetric septal hypertrophy on M mode echocardiography. By expressing the accuracy of two-dimensional echocardiography in the recognition of left ventricular anomalous bands, our results support the feasibility of prospective studies to clarify their clinical significance.


LEFT AND RIGHT ventricular aberrant bands have been noted as incidental findings at autopsy.1–4 Recently left ventricular aberrant bands have been recognized in vivo by means of M mode and two-dimensional echocardiography.5–10 In these initial reports the authors recognized left ventricular anomalous bands as potential sources of echocardiographic diagnostic error because they could mimic more important pathologic entities.6, 7, 10, 11 The entities most frequently considered in the differential diagnoses were subaortic membrane, aortic or mitral valve vegetation, flail aortic or mitral valve, pedunculated thrombi or tumors, and aneurysm of the sinus of Valsalva. The prevalence of aberrant left ventricular bands, as recognized by echocardiography, ranges from 0.5% to 50%.5–10 In the approximately 200 cases of aberrant bands reported, pathologic confirmation of the echocardiographic findings was available in only four cases.5–10 Thus the reliability of two-dimensional echocardiography for recognizing left ventricular aberrant bands has not been established.

Although frequently recognized in everyday echocardiographic practice, right ventricular aberrant bands and hypertrophic ventricular trabeculations have not been systematically studied and their two-dimensional echocardiographic characteristics have not been described.

The objectives of this study were (1) to assess the reliability of two-dimensional echocardiography in defining left ventricular and right ventricular aberrant bands and hypertrophic trabeculations and (2) to evaluate objectively the differential diagnostic difficulties that may be encountered in the presence of these cavitary abnormalities. In this study we correlated the echocardiographic and pathologic findings in patients who underwent cardiac transplantation.

Methods

Materials. We reviewed the preoperative two-dimensional echocardiograms and postoperative pathologic findings in the original hearts of 35 patients who underwent cardiac transplantation at our institution. We included in the study only well-
preserved hearts suitable for renewed analysis. Two patients were excluded because of inadequate echocardiograms.

The ages of the patients at the time of heart transplantation ranged from 15 to 51 years (mean 38). There were 12 female and 23 male patients with either ischemic heart disease (n = 13) or congestive cardiomyopathy (n = 22).

Pathologic data. The original pathologic reports were reviewed and the 35 hearts were reexamined by an experienced pathologist (M. E. B.) who was blinded to the results of echocardiographic analysis. Aberrant ventricular bands were defined as stringlike structures with free intracavitary courses, unrelated to the atrioventricular valves, and connected to papillary muscles, ventricular walls, or both. This designation did not include the moderator band, which originates in the right ventricular septal wall from the trabecula septomarginalis and runs an oblique course to the anterior papillary muscle. The position, orientation, and points of insertion of the aberrant bands were recorded.

Hypertrophy of the ventricular trabeculations was defined qualitatively, since there are no data available for the range of normal trabecular size. In this evaluation deviations from the normal trabecular pattern in the left ventricle and right ventricle were considered. For this study a trabeculation differed from an aberrant band by the lack of a free intracavitary course in the former.

The heart specimens were also inspected for presence of intracavitary anomalies such as endocardial fibrosis, ventricular or valvular masses, and mural thrombi.

Echocardiography. Two-dimensional echocardiographic studies were performed 2 to 160 days (64 ± 50) before surgery with a Hewlett Packard model 77020A imaging system and a 2.5 or 3.5 MHz medium or short-focused transducer. All studies included at least the standard parasternal, apical, and subcostal views. Echocardiograms were interpreted independently by two observers.

The echocardiographic diagnosis of aberrant ventricular band was made with the observation of a stringlike structure with free cavity course, unrelated to the atrioventricular valves, and connected to papillary muscles, left ventricular free walls, or both. The insertion points and orientation of the bands in the ventricular cavity were recorded. We also tried to define abnormal trabecular patterns qualitatively as hypertrophic (large, with amplitude similar to myocardium), fibrotic (high intensitiy relative to myocardium), or both. Intracavitary masses such as thrombi or valvular vegetations were not noted. The accuracy of two-dimensional echocardiography in defining right and left ventricular intracavitary structures was expressed by calculating sensitivity, specificity, and predictive accuracy.

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Positive predictive accuracy (%)</th>
<th>Negative predictive accuracy (%)</th>
</tr>
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<tbody>
<tr>
<td>Thick trabeculae</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left ventricle</td>
<td>80 (12/15)</td>
<td>85 (17/20)</td>
<td>80 (12/15)</td>
<td>85 (17/20)</td>
</tr>
<tr>
<td>Right ventricle</td>
<td>60 (6/10)</td>
<td>72 (18/25)</td>
<td>46 (6/13)</td>
<td>81 (18/22)</td>
</tr>
<tr>
<td>Aberrant bands</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left ventricle</td>
<td>85 (11/13)</td>
<td>82 (18/22)</td>
<td>73 (11/15)</td>
<td>90 (18/20)</td>
</tr>
<tr>
<td>Right ventricle</td>
<td>50 (5/10)</td>
<td>72 (18/25)</td>
<td>38 (5/13)</td>
<td>77 (17/22)</td>
</tr>
<tr>
<td>Thrombi</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left ventricle</td>
<td>67 (8/12)</td>
<td>87 (20/23)</td>
<td>73 (8/11)</td>
<td>83 (20/24)</td>
</tr>
</tbody>
</table>

Results

Pathologic data. From the 35 hearts examined, thickened trabeculae were recognized in the right ventricle in 10 (28%) and in the left ventricle in 15 (43%) cases. Aberrant bands were found in the right ventricle in 10 hearts (28%) and in the left ventricle in 13 (37%). Left ventricular thrombi were found in 12 hearts (34%) and right ventricular thrombi in three (9%). All patients with right ventricular thrombi also had left ventricular thrombi. Healed aortic valve vegetations were found in two cases, and myxomatous degeneration of the mitral valve was found in one.

Echocardiography. Data illustrating the accuracy of two-dimensional echocardiography in defining thickened ventricular trabeculations, aberrant ventricular bands, and left ventricular thrombi are displayed in table 1.

Thickened ventricular trabeculations. We classified thickened ventricular trabeculations as hypertrophic, fibrotic, or both (figures 1 and 2). Hypertrophic trabeculations appeared as intracavitary endocardial prominences in the parasternal short-axis or standard apical views (figures 1, A, and 2, A). In the hearts with fibrotic trabeculations the endocardial surface appeared flat on standard echocardiographic views. In the angled apical four-chamber view, however, highlighted randomly oriented linear structures with an interconnected or "honeycomb" appearance were found (figures 1, B, and 2, B). In hearts with both thickened and fibrotic trabeculations the echocardiogram showed a combination of the above findings (figures 1, C, and 2, C).

In the right ventricle hypertrophic trabeculations were less accurately defined (table 1). Both hypertrophic and fibrotic trabeculations appeared either as thick linear structures (figure 1) or randomly oriented structures with "honeycomb" appearance (figure 3).
In two hearts hypertrophic and fibrotic right ventricular trabeculations obscured the septal border on two-dimensional and M mode echocardiograms.

Ventricular aberrant bands. Left ventricular aberrant bands were accurately defined by echocardiography (table 1). The 19 bands found in 13 hearts at pathologic examination followed a transverse (six bands), longitudinal (six bands), or sagittal plane (seven bands). Transverse bands were best recognized either in a parasternal short-axis view or an apical four-chamber view (figure 4). Longitudinal bands were best visualized in a parasternal or apical long-axis view (figure 5). Longitudinal bands were easily recognized on two-dimensional echocardiography, but they were interpreted as the left septal border on M mode studies in two cases. The echocardiographic recognition of the sagittal bands was more difficult. These bands usually appeared in the apical four-chamber view as discrete spots moving with the cardiac cycle. Rotating the transducer into an apical two-chamber or long-axis plane usually permitted the length and orientation of the sagittal bands to be appreciated (figure 6). Three of the four false-positive echocardiographic diagnoses of left ventricular bands (table 1) were associated with prominent apical trabeculations at pathologic examination (figure 5) and an organized apical mural thrombus was present in the fourth case.

Right ventricular bands were usually located in the distal third of the ventricle (figures 3 and 7). Prominent trabeculations in this area made separate recognition of many right ventricular bands difficult (table 1). When aberrant bands and pathologic trabeculations were considered together, echocardiography was also accurate in recognition of intracavitary structures of the right ventricle. With this approach, echocardiographic sensitivity was 72%, specificity was 92%, positive predictive accuracy was 80%, and negative predictive accuracy was 88%.

Ventricular masses. Data illustrating the accuracy of echocardiography in defining left ventricular thrombi in these patients is summarized in table 1. Six of the seven patients with left ventricular thrombi and no other intracavitary abnormalities were correctly recognized. A correct diagnosis of thrombus was made in only two of five hearts with left ventricular thrombi associated with either pathologic trabeculations or ab-
errant bands. Two of three cases of right ventricular thrombi were correctly recognized by echocardiography. In the third case fibrotic trabeculae obscured the apical thrombi (figure 3).

**Discussion**

The echocardiographic recognition of the cavitary structures studied here may have little clinical significance per se, but these abnormalities may be important because of their potential to be mistaken for more important pathologic entities. Nishimura et al. and others hypothesized that difficulties may be encountered in differentiating left ventricular outflow structures from aberrant bands. Asinger et al. described two patients in whom the false-positive echocardiographic diagnosis of left ventricular mural thrombus could be made in the presence of an apical aberrant band or a thick trabecula.

We studied a highly selected patient population to correlate echocardiographic and pathologic findings. This group of cardiac transplant candidates showed a high prevalence of left and right ventricular aberrant bands, pathologic trabeculations, and left ventricular thrombi. On the basis of our experience with these patients, we believe that by means of modern two-dimensional echocardiographic instruments, aberrant bands situated in the left ventricular outflow tract can usually be accurately distinguished from the structures cited by other investigators.

Our results confirm the previous observation that the most important task is to differentiate these intra-cavitary structures from ventricular thrombi. The ac-
Accuracy of echocardiographic diagnosis of left or right ventricular thrombi was poor in cases with additional intracavitary abnormalities. The seven incorrect diagnoses of left ventricular thrombi were associated with aberrant bands or prominent trabeculations in three instances. Fibrotic trabeculations obscured multiple apical right ventricular thrombi in another case (figure 3).

Comparison of pathologic and echocardiographic findings demonstrated that besides aberrant bands and thick trabeculae, fibrotic trabeculae may also play a

FIGURE 4. Transverse left ventricular aberrant band (b) recognized in the parasternal short-axis view (A). Note lack of change in the shape of the band from diastole to systole secondary to poor ventricular contractility. B, The same findings at pathologic examination. Abbreviations as in previous figures.

FIGURE 5. Longitudinal left ventricular aberrant band (b) and single apical trabeculation (Tr) seen in the apical long-axis view (A), apical two-chamber view (B), and at pathologic examination (C). The apical trabeculation was diagnosed erroneously as a second aberrant band by echocardiography. Abbreviations as in previous figures.

FIGURE 6. Sagittal left ventricular band and left ventricular thrombi detected in the apical four-chamber view (A and B) and apical long-axis view (C and D), with pathologic findings (E). This patient also had a right ventricular thrombus and an aberrant band (figure 3). Note the variable location and appearance of the left ventricular band in different views (A, B, and C) and in the same view as the heart shifts position during the cardiac cycle (C and D). Abbreviations as in previous figures.
major role in the echocardiographic misdiagnosis of ventricular thrombi (figures 1 and 3); however, they have a "honeycombed" echocardiographic appearance, made up of randomly oriented linear reflectors. The diagnosis of thrombus in these cases can be made only by demonstrating an echo-dense mass aligned with the ventricular wall, which preserves its shape and position in spite of changes in transducer angulation or position. However, relatively small thrombi may be overlooked in patients with fibrotic trabeculations.

In patients with aberrant bands or a solitary prominent trabecula (figure 5), our experience supports previous observations of echocardiographic differentiation of these structures from thrombi. The diagnosis of aberrant band or thick trabecula should be favored in the presence of an echo-free space on each side of the structure, constant motion pattern of the structure with the cardiac cycle, and normal wall motion adjacent to the mass. In these cardiac transplant recipients, akinesia or hypokinesis of the ventricular wall near these structures was common. In addition to imaging the area of interest from different echocardiographic windows, it was useful if several views were obtained from the same position. By rotating the transducer or changing its angulation, the echocardiographer was able to align the imaging plane with the intracavitary structure. The echo-free space on both sides of the structure thus became apparent (figure 8). However, the cavitary edge of a fresh thrombus may give a similar echocardiographic appearance. We have also observed this in patients with fresh thrombi in the left ventricular cavity (figure 9). The short-term clinical setting, together with the irregular motion pattern of the bandlike structure, the marked curvilinear shape with beat-to-beat variations, and the associated wall

FIGURE 7. Aberrant right ventricular band (b) connecting the anterior (apm) and posterior (ppm) papillary muscles as recognized in the parasternal short-axis (A) and long-axis view (B). The lack of prominent trabecular pattern found at pathologic examination (C) eased the recognition of the band in this case. PE = pericardial effusion. Abbreviations as in previous figures.

FIGURE 8. Differentiation of these prominent apical trabeculations (arrows) from thrombi is aided by rotation and angulation of the transducer in the apical views. For further details, see text. PrV = prosthetic valve. Other abbreviations as in previous figures.

FIGURE 9. Fresh thrombus (Th) (arrows) in a patient with acute myocardial infarction recognized in the apical views on the tenth hospital day. This finding was not present on two previous studies. Note the echo-free space on both sides of the cavitary margin of the thrombus, imparting the appearance of an aberrant band or trabeculation. For further details, see text. Abbreviations as in previous figures.
motion abnormalities usually help in reaching the correct diagnosis of fresh thrombus.

Prominent right ventricular trabeculae were found to obscure the right ventricular/septal border on M mode echocardiography in this and previous studies.16,17 On two-dimensional echocardiography the true septal border was usually easily identified. In cases with both hypertrophic and fibrotic trabeculations, however, many imaging planes were sometimes needed for recognition of the septal margin. Additionally, in some of our patients with longitudinal left ventricular bands aligned with the septum, the left septal border was obscured on M mode echocardiography. These structures may lead to overestimation of the septal thickness and erroneous M mode echocardiographic diagnosis of asymmetric septal hypertrophy.

Our study demonstrated the reliability of two-dimensional echocardiography in recognizing left ventricular aberrant bands and hypertrophic or fibrotic left ventricular trabeculations (table 1). Echocardiography was also useful in recognizing these structures in the right ventricular cavity but was inaccurate in discriminating among them.

The potential role of left ventricular aberrant bands in the generation of transient systolic murmurs and/or ventricular arrhythmias has not been clearly established.2,3,8,10 The accuracy of echocardiography in recognizing left ventricular bands makes it suitable for use in prospective studies to assess the clinical importance of these structures.

References
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