Echocardiography of Left Ventricular Masses

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SUMMARY The M-mode and two-dimensional real-time echocardiographic findings in 10 patients with left ventricular masses are discussed. Two patients had left ventricular tumors and eight had left ventricular thrombi. In all cases the diagnosis was confirmed by angiography or surgery. The intracavitary and intramural left ventricular tumors were detected both by M-mode and two-dimensional echocardiography. M-mode echocardiography, however, did not detect the left ventricular thrombus in all instances. Two-dimensional echocardiography was able to identify the four large and inhomogeneous left ventricular thrombi but did not clearly identify four cases of smaller mural thrombi. Echocardiographic techniques useful in detection of left ventricular masses are discussed.

ALTHOUGH THE ROLE OF M-MODE echocardiography in the detection of many cardiac tumors is well-established,1-4 experience with tumors of the left ventricle is extremely limited.5-7 The reliability of echocardiography for the detection of left ventricular thrombi has not been assessed. In this paper we present the M-mode and two-dimensional echocardiographic findings of 10 patients with left ventricular masses. The reliability of echocardiography in the diagnosis of left ventricular masses is assessed, and techniques useful in the diagnosis of such lesions and potential sources of interpretive error are discussed.

Materials and Methods

We reviewed the preoperative echocardiographic findings of 15 patients within an 18-month period who underwent ventriculotomy or aneurysmectomy, at which time the absence or presence of thrombus was determined. From this group the M-mode and two-dimensional echocardiographic findings of eight patients with surgically proven left ventricular thrombi are reported. These patients underwent preoperative cardiac catheterization, biplane cineangiography and coronary arteriography. The echocardiographic findings of two patients with documented tumor involvement of the left ventricle are also discussed.

Echocardiographic Studies

All patients were studied with M-mode and two-dimensional real-time echocardiography. All echocardiographic studies were reviewed preoperatively and then retrospectively after the surgical confirmation of the mass. The echocardiograms were done within one month of the subsequent surgery. The M-mode echocardiograms were done on a Smith-Kline Echoline 20A echocardiograph interfaced with an Irex 101 strip chart recorder. The two-dimensional real-time studies were performed with a Varian 3000 wide-angle, 80°, phased-array sector scanner. Both the M-mode and two-dimensional real-time recordings were done with the patient in the supine or 30° left lateral decubitus position. The M-mode echocardiograms were done by positioning the transducer at the fourth or fifth intercostal spaces at the left sternal border and directing the ultrasonic beam in the established manner to obtain a sweep of the left ventricle from apex to base.

The two-dimensional images were obtained in the long axis, or sagittal, plane by directing the echo sweep between the apex and base of the heart. Short axis, or transverse, views were obtained by directing the plane of sweep along a line drawn between the right hip and the left shoulder perpendicular to the long axis of the left ventricle.8 All patients were also studied by apex echocardiography, using the apex four chamber view and the apical frontal view. This
TABLE 1. Clinical, M-Mode and Two-Dimensional Echocardiographic and Angiographic Findings

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Sex</th>
<th>Presentation</th>
<th>Type of LV mass</th>
<th>M-mode echo findings</th>
<th>Two-dimensional echo findings</th>
<th>Angiography</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24</td>
<td>M</td>
<td>Peripheral emboli</td>
<td>Metastatic melanoma</td>
<td>Intracavitary LV mass</td>
<td>Intracavitary LV mass</td>
<td>Not done</td>
</tr>
<tr>
<td>2</td>
<td>28</td>
<td>M</td>
<td>Cerebral emboli; S/P myocardial infarction</td>
<td>2 x 3 cm densely organized thrombus with fresh areas</td>
<td>Aneurysm w/NS multiple fine echoes (dust)</td>
<td>Large apical thrombus</td>
<td>Apical aneurysm with filling defect</td>
</tr>
<tr>
<td>3</td>
<td>32</td>
<td>F</td>
<td>Sudden death</td>
<td>LV hemangioma</td>
<td>Thickened posterior LV wall</td>
<td>Large posterior intramural mass</td>
<td>Large posterior intramural tumor</td>
</tr>
<tr>
<td>4</td>
<td>48</td>
<td>M</td>
<td>Angina; S/P myocardial infarction</td>
<td>Mural thrombus</td>
<td>Normal</td>
<td>Apical aneurysm; no thrombus</td>
<td>Apical aneurysm; no thrombus noted</td>
</tr>
<tr>
<td>5</td>
<td>54</td>
<td>F</td>
<td>S/P myocardial infarction; angina</td>
<td>2 x 2 cm adherent mural thrombus</td>
<td>Normal</td>
<td>Inferior wall hypokinesis; no thrombus noted</td>
<td>Inferior wall hypokinesis; no thrombus noted</td>
</tr>
<tr>
<td>6</td>
<td>56</td>
<td>M</td>
<td>S/P myocardial infarction; angina</td>
<td>2 x 3 cm apical thrombus</td>
<td>Aneurysm</td>
<td>Apical aneurysm with thrombus</td>
<td>Apical aneurysm with thrombus</td>
</tr>
<tr>
<td>7</td>
<td>58</td>
<td>M</td>
<td>S/P myocardial infarction; angina</td>
<td>Mural thrombus</td>
<td>Normal</td>
<td>Inferior apical dyskinesis; no thrombus noted</td>
<td>Apical dyskinesia; no thrombus noted</td>
</tr>
<tr>
<td>8</td>
<td>59</td>
<td>M</td>
<td>S/P myocardial infarction; ↓ LV function</td>
<td>3 x 3 cm variably organized thrombus</td>
<td>↓ LV function; no thrombus noted</td>
<td>Apical aneurysm with thrombus</td>
<td>Apical aneurysm with filling defect</td>
</tr>
<tr>
<td>9</td>
<td>63</td>
<td>M</td>
<td>Angina; S/P myocardial infarction</td>
<td>Mural thrombus</td>
<td>Normal</td>
<td>Aneurysm; no thrombus noted</td>
<td>Aneurysm; no thrombus noted</td>
</tr>
<tr>
<td>10</td>
<td>64</td>
<td>F</td>
<td>Angina; S/P myocardial infarction</td>
<td>4 x 3 variably organized thrombus</td>
<td>Aneurysm w/NS multiple fine echoes (dust)</td>
<td>Large apical aneurysm with filling defect</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: LV = left ventricular; NS = nonspecific.

The technique involves positioning the transducer precisely over the cardiac apex and angulating it in such a way as to visualize simultaneously all four chambers (the four chamber view) and then rotating the transducer 90° clockwise to produce the apex frontal view, or right anterior oblique (RAO) equivalent.

The images were permanently recorded on videotape for future analysis. The illustrations were obtained from Polaroid photographs of stop-action, single-frame scan images made from the videotape recordings. This photographic process results in a reduction of image quality and a loss of the visual appreciation of motion normally present in these phased-array real-time recordings.

Results

Table I summarizes the clinical, angiographic and echocardiographic features of all 10 patients. Patients are listed in order by age.

Left Ventricular Tumors

Two patients with left ventricular tumors were studied. In both cases M-mode and two-dimensional echocardiography resulted in identification of the tumor mass. The M-mode echocardiogram obtained from patient 1 is shown in figure 1. The dense intracavitary echoes representing the tumor are seen in systole as the left ventricle is scanned from the mitral valve to the apex. The two-dimensional apex four chamber view from this same case is illustrated in figure 2. In this systolic stop-frame image the mobile tumor can be identified in the mid-left ventricle. Figure 3 is the apex-to-base M-mode echocardiogram obtained from patient 3, a 32-year-old woman with the blue bleb nevus syndrome with previously known involvement of the liver and gastrointestinal tract. She suffered an episode of sudden death and was studied after resuscitation. The posterior left ventricular myocardium was infiltrated with a tumor, producing the M-mode appearance of a markedly thickened (5–6 cm) left ventricular wall. The small left ventricular cavity and left ventricular outflow tract can be seen from this scan. The two-dimensional echocardiographic features of this case are illustrated in figures 4, 5 and 6. The long and short axis two-dimensional echocardiograms are shown in figures 4 and 5, where the hemangioma can clearly be seen to infiltrate the posterior left ventricular wall. The diastolic frame from the left anterior oblique (LAO) left ventricular angiogram (fig. 7), showing the small left ventricular cavity with encroachment by the tumor, is presented for comparison. The angiographic image is comparable to the short axis view shown in figure 5. Further noninvasive appreciation of this intramural tumor is afforded by the apex four chamber view shown in figure 6, in which the small left ventricular cavity and tumor are clearly seen.

Left Ventricular Thrombi

The M-mode echocardiogram failed to detect the left ventricular thrombus in all cases (table 1),
although in two patients (patients 3 and 10) the non-specific “dust-like” echoes suggestive of a thrombus were noted on retrospective examination. Figure 8 is the M-mode echo from patient 2 in which a large left ventricular apical aneurysm is seen on the sweep of the left ventricle. Nonspecific dust-like echoes within the left ventricle (indicated by arrows) can be seen and possibly originated from the large 2 × 3 cm organized clot removed at the time of surgery. The corresponding RAO left ventricular cineangiogram is shown in figure 9. There is a large aneurysm and filling defect in the left ventricle. The two-dimensional echocardiogram from this same case (fig. 10) shown in the apex four chamber view, illustrates clearly the apical aneurysm and the non-mobile intracavitary echoes which may represent the apical clot. Using the apex views, similar two-dimensional echocardiographic findings were present in the three additional cases in which large and inhomogeneous left ventricular clots were found at surgery (patients 6, 8 and 10). There were no instances of false positive echocardiograms in this series. The left ventricular clots were not seen by two-dimensional echocardiography using the long and short axis views.
FIGURE 3. M-mode sweep of the left ventricle from apex to base from patient 3. Note the markedly thickened posterior left ventricular wall caused by the intramural tumor. Abbreviations: Ao = aorta; LA = left atrium; LV = left ventricle; MV = mitral valve; RV = right ventricle.

Mural Thrombi

Four patients in this series had mural thrombi noted intraoperatively at aneurysmectomy or infarctectomy. M-mode echocardiography failed to suggest the presence of the thrombus in each case. Two-dimensional echocardiography in both the apex and long axis views identified the left ventricular aneurysm when present but did not detect the associated mural thrombus. On retrospective examination of the apex views at high receiver gain setting, findings suggestive of mural thrombus were noted in two cases. Figure 11 (from patient 9) illustrates this finding in the apex frontal view. Dense areas along the endocardium, indicated by the arrows, appeared to correspond to the adherent mural thrombus noted at surgery.

Discussion

Our two cases of left ventricular tumor were easily identified by both M-mode and two-dimensional echocardiography. Figure 1 illustrates that an intra-

FIGURE 4. Two-dimensional echocardiogram long axis view from patient 3. Note the infiltration of tumor into the posterior left ventricular wall. Abbreviations: Ao = aorta; LA = left atrium; LV = left ventricle; S = septum.
A cavity left ventricular tumor can be readily recognized on M-mode echocardiography by the dense echoes appearing within the left ventricular cavity. The mobile nature of the tumor allows for easy separation of it from the left ventricular wall and mitral valve. Real-time, two-dimensional echocardiography allows more dramatic appreciation of the motion of such tumors and permits accurate determination of the point of attachment to the myocardium (fig. 2). An intramural left ventricular tumor, as illustrated by patient 3 and figure 3, can be detected by M-mode echocardiography by the appearance of

cavitary left ventricular tumor from patient 3. The infiltration of tumor into the posterior left ventricular wall is shown. Abbreviations: PM = papillary muscle; RV = right ventricle.

Diastolic stop frame two-dimensional echocardiogram apex four chamber view from patient 3. The apex is at the top of the figure, the base at the bottom. Note the extensive infiltration of the tumor into the posterior left ventricular wall. Abbreviations: LA = left atrium; LV = left ventricle; RA = right atrium; RV = right ventricle; S = septum.
marked thickening of the left ventricular wall. This thickening far exceeds that expected in left ventricular hypertrophy. The encroachment of the tumor upon the left ventricular cavity is apparent with both M-mode and two-dimensional echocardiography (figs. 3–7). Two-dimensional echocardiography allows for viewing of the heart in several planes, and is therefore helpful in clarifying the extent of tumor involvement.
This information is useful in planning possible surgery and permits noninvasive followup.

Echocardiography of Left Ventricular Thrombi

Because left ventricular thrombi commonly occur within ventricular aneurysms and within the setting of acute myocardial infarction, they represent a much more common problem than left ventricular tumors. However, clots are more difficult to detect by echocardiography. This difficulty is evident from the rarity of reports of left atrial clots detected by echocardiography, despite their relatively common occurrence.13-16

Horgan et al. reported a left ventricular thrombus detected by M-mode echocardiography.17 The M-mode features of this case are similar to those found in patients 2 and 10, (fig. 8). Multiple fine echoes are seen

![Figure 9. A diastolic frame from the right anterior oblique (RAO) cineangiogram from patient 2. The arrows indicate the large apical filling defect. Compare with figures 8 and 10.](image1)

![Figure 10. Two-dimensional echocardiogram apex four chamber view with the apex at the top of the figure, the base at the bottom. The large thrombus is noted within the apical aneurysm. Compare with figures 8 and 9. Abbreviations: LV = left ventricle; LA = left atrium; MV = mitral valve; RA = right atrium; S = septum.](image2)
in the area of the left ventricle in which the clot was noted at surgery. We believe, however, that these "dust-like" echoes are nonspecific and may result from myocardial scar or receiver gain artifact.

Two-dimensional echocardiography is somewhat better for detecting left ventricular thrombi. The two-dimensional echocardiogram detected half of the left ventricular thrombi (table 1). The left ventricular thrombi detected in this series by two-dimensional echocardiography were all rather large in size (>2.5 cm). Those that were most distinct were inhomogeneous, i.e., laminated with areas of highly-organized and fresh thrombus. Figure 10 illustrates a representative example of thrombus within an aneurysm of the left ventricle. The thrombus is represented by the dense echoes which are distinct from the aneurysm wall.

In this series, smaller adherent mural thrombi were not reliably detected by either M-mode or two-dimensional echocardiography. In all cases the left ventricular aneurysms were easily identified by two-dimensional echocardiography, but the mural thrombi within them were not. Even when the preoperative echocardiograms were reviewed after the surgical findings were known, mural thrombi could not be clearly identified by this technique. Retrospectively, the normally thin walls of an aneurysm appeared somewhat thicker in the cases with mural thrombi when viewed on the two-dimensional echocardiogram (fig. 11).

Although this finding may provide a clue to the presence of a mural thrombus, we believe it is insufficient to enable a reliable diagnosis.

The apical views (apex four chamber or apex frontal view) represent the two-dimensional views of choice for the detection of left ventricular thrombi. In this series of eight left ventricular thrombi, the standard precordial images along the long and short axis of the left ventricle did not detect a single instance of left ventricular clot, probably because these views do not permit sufficient imaging of the cardiac apex for delineation of abnormal masses. The apical views increase the accuracy of detecting left ventricular thrombi since they allow better visualization of the left ventricular apex.

While two-dimensional echocardiography would appear to be more reliable than M-mode echocardiography for the detection of left ventricular thrombi, it does have technical limitations. A major limitation results from the acoustic properties of clotted blood. Tumors are reliably detected echocardiographically because the acoustic properties of tumor tissue differ from the surrounding blood and muscle, so that an adequate reflective interface is created. The acoustic impedance of recently clotted blood is probably not significantly different from the surrounding blood or endocardium to allow for detection by current clinical echocardiographic instruments. The higher acoustic impedance of more organized thrombi probably ac-

Figure 11. Two-dimensional apex frontal view from patient 9. The apex is at the top of the figure, base at the bottom, inferior wall to the left, anterior wall to the right. The arrows point to a mural thrombus which gives the impression of thickened endocardium within the aneurysmal segment of the left ventricle. Abbreviations: LA = left atrium; LV = left ventricle; MV = mitral valve.
counts for our success in identifying them with two-dimensional echocardiography.

Receiver gain settings are extremely important in all forms of echocardiography, but are especially so with two-dimensional techniques where sharp demarcation of endocardium can be difficult. Obviously, if the gain attenuation is set too high, an intracavitary mass may not be detected. Similarly, with the gain attenuation set too low, a nonexistent mass may appear on the echocardiogram. The proper gain attenuation is especially critical at the apex, where the left ventricular cavity is smaller. With the apical views the left ventricular apex will appear in the near field where the gain attenuation should be set to just allow for visualization of the endocardium. Also, apical masses should be looked for at end-diastole when the heart is at its maximum diameter, so that the normal obliteration of the apical cavity in systole will not be confused with the filling in of the cardiac apex by a thrombus.

Both M-mode and two-dimensional echocardiography should prove to be reliable techniques for the detection of left ventricular tumors. Left ventricular thrombi, however, cannot be detected reliably by M-mode echocardiography.

Although the definition of sensitivity of two-dimensional echocardiography in the detection of thrombi requires a larger patient population, it appears that large left ventricular thrombi may be reliably detected by careful two-dimensional echocardiography.

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References
