Diagnosis of Aortic Root Dissection by Echocardiography

By Navin C. Nanda, M.D., Raymond Gramiak, M.D., and Pravin M. Shah, M.D.

SUMMARY

Six patients with aortic root dissection confirmed by angiography, surgery, or autopsy were studied by echocardiography. All showed marked parallel widening of the anterior (16 to 21 mm) and/or posterior (10 to 13 mm) aortic walls together with enlargement of the aortic root image. (Normal mean aortic wall thickness 5.7 mm, SD 1.2; aortic valve disease patients 6.7 mm, SD 1.5.) In five patients slender aortic valve cusps were recorded moving to the periphery of the inner lumen in systole and not extending to the outer lumen. This finding is useful in excluding calcification of the aortic valve which may produce confusing multiple echoes within the aortic root. Two patients showed 8 to 20 mm variations in the width of the aortic image with slight change in the direction of the transducer indicating that the dissecting hematoma was not uniform in thickness. Other associated findings on the echogram seen in three patients included the demonstration of pericardial fluid collection and mitral diastolic flutter suggestive of aortic regurgitation. Demonstration of enlargement of the aortic root with marked parallel widening of anterior and/or posterior walls appears to be specific for aortic root involvement in dissecting aneurysm of the aorta.

Additional Indexing Words:
Aortic wall thickness Aortic root enlargement Aortic dissecting aneurysm
Catheter in right ventricle Aortic valve disease Ultrasound

Dissecting aneurysm has long been recognized as a highly lethal form of aortic disease. Recent advances in medical and surgical management of this disease have resulted in considerable improvement in the outlook and prognosis.1-6 Since untreated dissecting aneurysms are rapidly fatal in 60 to 90% of the cases,7, 8 it is imperative that an early and accurate diagnosis be made so that treatment may be initiated as rapidly as possible. The diagnosis by clinical methods and by plain chest film roentgenography9 sometimes presents difficulties. By far the most definitive method of diagnosis is intravenous or retrograde aortography. However, this is nondiagnostic in a certain proportion of cases with dissecting aneurysm.10 A safe, noninvasive, nonionizing technique like echocardiography which can be used even at the bedside would be especially welcome if it could contribute to the diagnosis of this condition. The purpose of this report is to describe echocardiographic findings in patients with proven aortic root dissection.

Materials and Methods

Six patients who had aortic root involvement in dissecting aneurysm of the aorta, confirmed by angiography, surgery, or autopsy, were studied by echocardiography. Table 1 summarizes their clinical data.

All ultrasonic examinations were carried out using a commercially available echograph (Picker) and a 2.0 megacycle transducer. Continuous recordings were made on 35 mm film by means of a Fairchild oscilloscope record camera and a dual-beam oscilloscope operating as a slave. Aortic root echoes were obtained by a method previously described.11 The mitral valve was first located from a left parasternal position, utilizing the third or fourth intercostal space. Medial and cephalic rotation of the transducer from the mitral valve position passes the beam through the aortic root, outlining the walls and the valve cusps within. The transducer was angled slightly in various directions and any changes in the width of the aortic root image produced by this maneuver were recorded.

In each patient the width of the aortic root was measured in mm from the outer limits of the dominant...
AORTIC ROOT DISSECTION AND ULTRASOUND

Clinical Findings in the Present Study

<table>
<thead>
<tr>
<th>No.</th>
<th>Patient</th>
<th>Age &amp; Sex</th>
<th>Main symptom</th>
<th>Diagnosis confirmed by</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>W.J.</td>
<td>59 M</td>
<td>Chest pain</td>
<td>Surgery</td>
<td>Died during surgery</td>
</tr>
<tr>
<td>2</td>
<td>A.S.</td>
<td>51 F</td>
<td>Chest pain</td>
<td>Autopsy</td>
<td>Death from cardiac tamponade</td>
</tr>
<tr>
<td>3</td>
<td>H.M.</td>
<td>56 M</td>
<td>Heart failure</td>
<td>Aortogram</td>
<td>Alive and well*</td>
</tr>
<tr>
<td>4</td>
<td>F.K.</td>
<td>57 M</td>
<td>Chest pain</td>
<td>Aortogram</td>
<td>Death from cardiac tamponade</td>
</tr>
<tr>
<td>5</td>
<td>J.D.</td>
<td>59 M</td>
<td>Heart failure</td>
<td>Surgery</td>
<td>Alive and well**</td>
</tr>
<tr>
<td>6</td>
<td>E.P.</td>
<td>76 F</td>
<td>Chest pain</td>
<td>Autopsy</td>
<td>Death from cardiac tamponade</td>
</tr>
</tbody>
</table>

*3 year follow-up
**recently operated

echo configuration of the wall at the end of systole (fig. 1). Wall thickness was similarly determined from the outer limit of the major echo to the inner aspect of the lesser component. When technical limitations precluded separation of wall components, the width of the conglomerate echo representing the aortic root margin was used. These parameters were compared to similar measurements obtained from a previous study conducted in normal persons and patients with aortic valve disease. The first three cases in the present study were examined by the same equipment used to generate the data in the previous study. Changes of equipment to a newer model revealed no obvious differences in wall thickness measurements. The ultrasonic technique used in all examinations was similar. Time-varied gain was adjusted to equalize the intensity of the major echoes emanating from the anterior and posterior aortic margins. No suppression of the near structures was used. Sensitivity was regulated to record cusp echoes, which are of approximately the same intensity as those of the inner aortic margins in dissection. Aortic valve cusp echoes were studied for the character of motion pattern and for evidence of thickening. Mitral valve echograms were analyzed for presence of diastolic flutter and prominent "a" waves. The heart walls were studied for evidence of pericardial fluid.

Results

The ultrasonic findings in the present study are summarized in table 2. All patients in this study showed enlargement of the aortic root. The measured outer diameter of the aortic image varied from 42 to 53 mm. The mean width of the aortic root in the normal heart is 35 mm, so 4.2 (table 3). The most striking echocardiographic finding proved to be marked widening of both anterior and posterior aortic walls which occurred in four of the patients studied (fig. 2). Increased thickness of only one aortic wall was present in the remaining two cases. In Case 2 the widening was localized to the anterior wall, the site of dissection demonstrated at autopsy (fig. 3). The other case with localized echocardiographic abnormality (Case 5) showed widening of the posterior aortic wall which was found at surgery to correspond to a small dissecting hematoma in that area. The anterior wall in this case was normal (fig. 4). The extent of aortic wall thickening as measured by echocardiography was striking when the values obtained are compared to normals and patients suffering from aortic valve disease. In the dissection group anterior wall involvement produced images which ranged from 16 to 21 mm in width while posterior wall

![Figure 1](image)

**Figure 1**

Schematic representation of an aortic root echocardiogram in a patient with aortic root dissection. The small double-headed arrows indicate the thickness of the dissecting hematoma while the large arrows show the width of the aortic root image measured at end systole. D = width of the dissecting hematoma; AO = aorta; RESP = respiration; PHONO = phonocardiogram; ECG = electrocardiogram; S₁ = first heart sound; S₂ = second heart sound.
involvement produced 10 to 13 mm wide walls. The results of a previous study from our laboratory (summarized in table 3) demonstrated the mean aortic wall thickness to be 5.7 mm (± 1.2) in normal individuals and 6.7 mm (± 1.5) in patients with aortic valve disease.12

An important diagnostic aspect of the image of the widened wall is the parallelism that is maintained between the inner and outer limits throughout the cardiac cycle. The outer component of the thickened wall was usually represented by a heavier line than the inner margin. Some variation was present in the appearance of the space between the margins of the thickened wall. Solid lines, speckling or mottling, as well as absence of any echoes were observed. Some patients exhibited more than one pattern of echoes within the

Table 2

<table>
<thead>
<tr>
<th>Patient</th>
<th>Width mm</th>
<th>Ant. wall thickness mm</th>
<th>Post. wall thickness mm</th>
<th>Aortic valve cusps</th>
</tr>
</thead>
<tbody>
<tr>
<td>W. J.</td>
<td>46</td>
<td>16</td>
<td>13</td>
<td>Normal</td>
</tr>
<tr>
<td>A. S.</td>
<td>51</td>
<td>21</td>
<td>4</td>
<td>Normal</td>
</tr>
<tr>
<td>H. M.</td>
<td>42</td>
<td>16</td>
<td>10</td>
<td>Normal</td>
</tr>
<tr>
<td>F. K.</td>
<td>53</td>
<td>20</td>
<td>11</td>
<td>Normal</td>
</tr>
<tr>
<td>J. D.</td>
<td>47</td>
<td>4</td>
<td>10</td>
<td>Thickened</td>
</tr>
<tr>
<td>E. P.</td>
<td>43</td>
<td>17</td>
<td>10</td>
<td>Not well seen</td>
</tr>
</tbody>
</table>

The figure at the head of each grouping represents the mean numerical value for that category. The quantity in brackets is the standard deviation, while N denotes the number of observations. Although the mean values and standard deviations are expressed to the first decimal, measurement in individual cases is accurate only within 1 mm.

Table 3

<table>
<thead>
<tr>
<th>Patient</th>
<th>Width mm</th>
<th>Wall thickness mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>35.0</td>
<td>5.7</td>
</tr>
<tr>
<td>(4.2)</td>
<td>(1.2)</td>
<td></td>
</tr>
<tr>
<td>Heart Disease</td>
<td>35.8</td>
<td>5.7</td>
</tr>
<tr>
<td>(Normal Aortic Valve)</td>
<td>(5.5)</td>
<td>(1.5)</td>
</tr>
<tr>
<td>Aortic Stenosis</td>
<td>37.0</td>
<td>6.7</td>
</tr>
<tr>
<td>(5.1)</td>
<td>(1.5)</td>
<td></td>
</tr>
<tr>
<td>Aortic Insufficiency</td>
<td>40.4</td>
<td>6.0</td>
</tr>
<tr>
<td>(6.7)</td>
<td>(1.1)</td>
<td></td>
</tr>
<tr>
<td>N 44</td>
<td>N 45</td>
<td></td>
</tr>
<tr>
<td>N 41</td>
<td>N 42</td>
<td></td>
</tr>
<tr>
<td>N 12</td>
<td>N 13</td>
<td></td>
</tr>
<tr>
<td>N 14</td>
<td>N 14</td>
<td></td>
</tr>
</tbody>
</table>

The figures in brackets represent the mean numerical values for that category. The quantity in brackets is the standard deviation, while N denotes the number of observations. Although the mean values and standard deviations are expressed to the first decimal, measurement in individual cases is accurate only within 1 mm.

*Abstracted from a previous study from our laboratory.12 widen wall with small changes in transducer angulation or instrument sensitivity.

In all but one of our patients, slender valve cusps moved to the periphery of the inner lumen in systole and did not extend to the outer lumen. One patient (Case 5) showed some evidence of thickening of valve cusps and in another thin leaflets were identified, but their motion pattern was not well demonstrated.

Slight variation in the direction of the sonic beam during recording produced changes in the width of the aortic root image in two patients. These ranged from 8 to 20 mm in magnitude. In the remaining patients little or no change (less than 5 mm) could be demonstrated in the width of the aortic root during beam angulation.

Echocardiographic evidence of aortic regurgitation was present in three patients. This consisted of fine oscillations of the mitral valve in diastole13 together with prominent "a" waves. Three patients showed evidence of large pericardial fluid collections on the echocardiogram.

Discussion

The role of echocardiography in the diagnosis and evaluation of various forms of heart disease has been well established.14-19 It is harmless, noninvasive, and can be used as a bedside investigation even in seriously ill patients. Previous studies from this laboratory11, 12 have demonstrated the feasibility of studying the aortic root by echocardiography and have also validated the anatomic components of the root using indocyanine green dye during cardiac catheterization.

The echocardiographic findings which enabled us to make a definitive diagnosis of aortic root dissection in our cases were: a) enlargement of the aortic root (42 mm or more), b) marked widening (16 to 21 mm) of the anterior wall of the aorta at the root level and/or a wide separation of the posterior aortic wall (10 to 13 mm), and c)
maintenance of parallelism between the separated margins of the walls in every patient. In addition, preservation of normal motion pattern of aortic valve cusps was observed in all but one.

Echograms of two patients also showed marked variations in the width of the aortic root image with slight change in the direction of the transducer. This was thought to be related to the nonuniform thickness of the dissecting hematoma.

The ultrasonic diagnosis was made retrospectively in three of the cases studied. In the remaining three, the diagnosis was suggested from the echocardiographic examination prior to aortography or when the aortogram was inconclusive.

Associated findings on the echogram could be of value to the clinician. Demonstration of pericardial fluid collections by echocardiography may indicate that the dissection has ruptured into the pericardial sac. Echograms of three of our patients showed large anterior and posterior pericardial spaces and in all of them the dissection was found to have ruptured into the pericardial cavity at autopsy. Mitral diastolic flutter and large “a” waves suggestive of aortic regurgitation were observed in three cases. Appearance of these in patients with dissecting aneurysm could be another clue of aortic root involvement leading to aortic incompetence.

Recently a case has been described in which the presence of dissecting aneurysm found at angiography was first suggested by an ultrasound recording from the aortic root. The ultrasonic studies demonstrated widening of the anterior and posterior aortic walls shown as four, rather than two, simultaneously pulsating structures, delineating the true and false lumen.20

Differential Diagnosis

Certain conditions have to be considered in the differential diagnosis of this entity.

Dilatation of the aortic root commonly seen in aortic valvular lesions and in aneurysms of the ascending aorta produces a wide aortic root image on the echocardiogram. However, images of normal width are obtained from the anterior and posterior aortic walls.

It may be difficult to make the diagnosis of aortic root dissection in the presence of calcific aortic valve disease. In this condition multilayered echoes within the aortic lumen may be seen and these may give an erroneous appearance of widening of anterior and/or posterior walls of the aorta (fig. 5).
Case 2. The arrows show the limits of widening of the anterior wall of the aortic root. In the upper panel, valve cusp motion can be seen limited by the inner margin of the dissection. Note that the posterior wall shows normal thickness. In the lower panel, the beam was moved during recording and demonstrates a marked change in the width of the aortic root. This patient showed a localized hematoma involving the anterior wall while the posterior wall was normal.
Figure 5

Echocardiograms from two patients with extensive calcific aortic valve disease and no evidence of dissection. The presence of thick multilayered echoes within the aortic root may simulate widening of the aortic walls.

These echoes, which are produced by deposits of calcium in the aortic valve, however, are usually thicker than those produced by aortic walls and should be easily recognized. Moreover, the valve leaflet motion may be restricted or there may be no recognizable cusp motion. Therefore, it is important to attempt to document aortic leaflets with little or no structural thickening and showing normal motion in the inner lumen before confidently making the diagnosis of aortic root dissection. Occasionally, one can suspect aortic root dissection even in the presence of aortic valve disease. Case 5 illustrates this (fig. 4). Even though aortic root echoes show some evidence of valve thickening, the valve elements produce discontinuous or nonlinear images. At surgery, a small intimal tear which had resulted in the formation of a pouch posteriorly near the noncoronary cusp was found. Thus, aortic dissection can be diagnosed in some patients with aortic valve disease if the cusp motion is not unduly restricted and the valve not heavily calcified.

Echograms of patients in the Coronary Care Unit with a Swan-Ganz catheter in the pulmonary artery or of patients in whom a pacing catheter has dislodged from the apex of the right ventricle and is floating in the outflow tract may show a strong echo anterior to the aorta. The catheter echo may closely follow the movement patterns of the aortic root and may be mistaken as the outer margin of the anterior wall (fig. 6). Multiple echocardiographic recordings showing the catheter moving asynchronously with the aortic root or demonstration of a similar catheter echo in the right ventricular cavity when recording the mitral valve usually clarifies the diagnosis.

Apparent thickening or widening of the posterior wall may be seen in some conditions. Presence of fluid in the transverse sinus of the pericardium can give a double contour to the posterior aortic wall\(^\text{19}\) (fig. 7). However, the two contours tend to be nonparallel. In aortic root dissection, parallelism between the separated walls is maintained. Occa-

Figure 4

Case 5. Echocardiogram demonstrates separation of the posterior aortic wall as indicated by the arrows. The width of the anterior wall is not increased. Valve elements show evidence of thickening.
Echoes from a Swan-Ganz catheter (C) closely follow the movement of the anterior wall of the aorta (left). Another recording from the same patient made a few seconds later shows the catheter moving asynchronously with the aortic root. The nonparallelism of the images helps to rule out dissection.

The panel on the left was recorded from a patient with a large pericardial effusion and shows non-parallel widening of the posterior margin of the aortic root, probably due to fluid in the transverse sinus of the pericardium. On the right, a non-parallel linear echo (origin is obscure) is seen behind the aortic root in the left atrial cavity. Note that the posterior aortic wall is clearly shown to be of normal width and that the added “line” does not have the motion pattern of the aortic wall.
sionally, one echoes "lines" in the left atrium (fig. 7). They also tend to be nonparallel to the posterior aortic margin and are generally seen deep in the left atrial cavity. These echoes could be arising from the walls of the pulmonary veins at their insertion into the left atrium.

Demonstration of an enlarged aortic root with marked parallel widening of anterior and/or posterior walls appears to have diagnostic value for aortic root involvement in dissecting aneurysm of the aorta. We have so far not seen this combination of findings in any other condition. Widening of either anterior or posterior aortic wall in the presence of extensive calcific aortic valve disease should be viewed with caution. False positive diagnoses of aortic root dissection can be avoided by strict adherence to the diagnostic criteria, especially maintenance of parallelism of the widened image of the wall, a stronger echo from the outer limit of the wall as compared to the inner margin, and demonstration of normal aortic valve cusps. Although the present study is not a prospective one, to date no false positive diagnoses have been made. One patient with a suggestive echocardiogram and chest pain has not undergone aortography because of his precarious clinical condition, although clinical findings support the diagnosis of dissection. We are aware of no negative examinations in patients proved to have aortic root dissection, though a dissection limited to a lateral wall, theoretically, could be missed by this method. While the number of cases we have studied utilizing the echocardiographic method is not large, it is evident that this noninvasive technique is useful in the diagnosis of dissection involving the aortic root.

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