Utility of Echocardiography in the Diagnosis of Aortic Dissection Involving the Ascending Aorta*

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We report our prospective experience with sensitivity, specificity, predictive values and efficiency of echocardiography in diagnosing AD involving the ascending aorta (type A). We studied two groups of patients with both echocardiography and aortography. Group 1 was made up by 46 consecutive patients with clinical suspicion of AD. Type A AD was confirmed in 23 cases. Group 2 was comprised of 509 adult patients who had been studied during the same period with both aortography and echocardiography (including 46 patients from group 1); prevalence of type A AD in this group was 4.9 percent. We conclude that the diagnostic usefulness of echocardiography in patients with suspected type A AD is limited by its moderate sensitivity and predictive positive value. Aortography remains the major step in diagnosis. Within these limitations, echocardiography is useful in confirmation of clinical suspicion if all three main echocardiographic signs are present (predictive positive value: 100 percent). (Chest 1989; 95:124-29)

NPV = predictive value of negative test.

The practical value of echocardiography in the diagnosis of AD is still unclear, though much information is already available. The effectiveness of a diagnostic test depends on test sensitivity, test specificity and prevalence of the disease for which the test is being done. If the prevalence of the disease in the population at hand is known, predictive values of the test can be evaluated, as defined by Bayes' theorem. We report our prospective experience about sensitivity, specificity, predictive values and efficiency of echocardiography in diagnosing AD involving the ascending aorta, type A AD according to the classification of Daily et al. We studied two groups of patients with different disease prevalence. The first group was made up of 46 consecutive cases in which the clinical suspicion of AD was high. Type A AD was confirmed in 23 patients (prevalence of the disease: 50 percent). All patients underwent aortography, which we consider the gold standard in diagnosing AD. This group is useful to calculate the test sensitivity, that is, the percentage of patients with the disease who had a positive test. The second group was made up of all 509 unselected consecutive adult patients studied during the same period, with both aortography and good quality complete echocardiography (prevalence of type A AD: 4.9 percent). This group is useful to calculate the test specificity, that is, the percentage of patients without disease who had a negative test.

We wish to stress that we are not concerned with

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Materials and Methods

Echocardiography

Echocardiograms were performed by standard techniques, using a Picker 80 CI an Aloka SSD-500 echo systems. Ascending aorta and aortic arch were thoroughly scanned in all cases through multiple windows, including left and right parasternal, apical, suprasternal, right and left supravacuicular windows.

We evaluated the following three main echocardiographic signs of AD: (1) enlargement of the aortic root (end-systolic diameter greater than 42 mm2); (2) widening of the aortic walls: 16 to 21 mm for the anterior wall and 10 to 13 mm for the posterior one; (3) intimal flap, a variable length echo, that separates true and false lumen, well differentiated from aortic wall, provided with a peculiar motion, clearly evident in more than one section (Fig 1).

Aortography

We used either the percutaneous approach of the Seldinger techniques through the femoral artery or the arteriotomy of the brachial artery. Aortography was performed in multiple projections, most commonly 60° left anterior oblique projection, to image the aortic root and the arch, and posteroanterior projection, to image the descending aorta. In all the cases of type A AD, we found the presence of direct signs, ie, intimal flap, double lumina and often intimal tear (Fig 1).

According to the classification of Daily et al. based on ascending aorta involvement as the main prognostic clue, we distinguished all dissections in type A, if the ascending aorta was involved, and type B, if it was not involved.
FIGURE 1. Two-dimensional long-axis (A) and short-axis (B) views of the aorta. The intimal flap (arrows) separates the false from the true lumen.

Evaluation of the Diagnostic Usefulness of the Test

Sensitivity is TP/TP + FN × 100, specificity is TN/TN + FP × 100, predictive value of the positive test (PPV) is TP/TP + FP × 100, predictive value of the negative test is TN/TN + FN × 100, efficiency is TP + TN/all the cases × 100.

Patients

Group 1 included 46 consecutive patients who were clinically suspected of having AD. They were admitted to our hospital from May 1981 to June 1987. Type A AD was diagnosed in 23 patients (Table 1). This group also included 12 patients with a type B AD, without ascending aorta involvement (Table 1), and 11 patients who were suspected of having the disease based on clinical and echocardiographic evidence but who did not have AD as shown by aortography (Table 2). We chose to include in the first group patients with type B AD because it is difficult to confirm or to exclude ascending aorta involvement on clinical grounds alone. Furthermore, in most of the patients with type B AD, echocardiographic exclusion of ascending aorta dissection is a true-negative finding. In fact, ascending aorta was normal at echocardiography in ten out of 12 type B AD cases. Only two patients with Marfan syndrome, annulo-aortic ectasia, aortic regurgitation and type B AD showed aortic root dilatation and increased wall thickening on echocardiography. In these two patients, the ascending aorta was not involved by the dissecting hematoma, as documented by angiography and surgery.

Group 2 included all the 509 consecutive unselected adult patients who underwent, during the same period, both aortography and echocardiography. Catheterization was performed for valve disease in 302 cases, for coronary artery disease in 129, for congenital heart
Table 1 — Main Clinical Findings in Patients with AD

<table>
<thead>
<tr>
<th>Clinical Data</th>
<th>Type A Dissection (23 Patients)</th>
<th>Type B Dissection (12 Patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>44-82 (mean, 62)</td>
<td>34-78 (mean, 50)</td>
</tr>
<tr>
<td>Sex</td>
<td>M 22, F 1</td>
<td>M 10, F 2</td>
</tr>
<tr>
<td>Predisposing disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preexisting hypertension</td>
<td>20, 8</td>
<td></td>
</tr>
<tr>
<td>Marfan syndrome</td>
<td>0, 2</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>3, 2</td>
<td></td>
</tr>
<tr>
<td>Main symptoms and signs</td>
<td></td>
<td></td>
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<tr>
<td>Typical pain</td>
<td>19, 7</td>
<td></td>
</tr>
<tr>
<td>Atypical pain</td>
<td>4, 5</td>
<td></td>
</tr>
<tr>
<td>Syncope</td>
<td>2, 1</td>
<td></td>
</tr>
<tr>
<td>Pulmonary edema</td>
<td>2, 0</td>
<td></td>
</tr>
<tr>
<td>Aortic insufficiency</td>
<td>15, 2</td>
<td></td>
</tr>
<tr>
<td>Pulse loss</td>
<td>13, 4</td>
<td></td>
</tr>
<tr>
<td>Pericardial effusion</td>
<td>11, 0</td>
<td></td>
</tr>
<tr>
<td>Pleural effusion</td>
<td>2, 0</td>
<td></td>
</tr>
<tr>
<td>Anuria</td>
<td>2, 0</td>
<td></td>
</tr>
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</table>

*Two patients with Marfan syndrome, annulo-aortic ectasia, aortic insufficiency and type B AD not involving the ascending aorta.

disease in 24 and for cardiomyopathy in six. The 23 cases of type A AD, the 12 cases of type B AD and the 11 false-positive ones, described in the first group, were included as well. Furthermore a chronic type A AD, not diagnosed during the acute phase, was detected in two patients. In one patient, the diagnosis was made one year after an incorrect diagnosis of aortic valve disease with angina pectoris. In the other patient, the acute phase was painless. The patient experienced symptoms due to aneurysmal evolution with progressive enlargement of the ascending aorta. In both patients, there were an increased thickness of the aortic wall and an enlargement of the aortic root. These signs, though not correctly interpreted in the acute phase, were considered true-positives of group 2.

RESULTS

Sensitivity, PPV and Efficiency of Echocardiography in a Group Suspected of Having AD

Group 1 represents a group with high prevalence of type A AD (50 percent). We observed an echocardiographic intimal flap in 13 out of 23 patients with type A AD, aortic root dilatation in 21 out of 23 and thickening of the aortic wall in 18 out of 23 (Table 3).

Aortic root enlargement had high sensitivity (91 percent) but moderate PPV (64 percent) and efficiency (70 percent). Aortic wall thickening had lower sensitivity (78 percent) and higher PPV (75 percent) and efficiency (76 percent). Intimal flap had very low sensitivity (56 percent); its PPV and efficiency were

Table 2 — Main Clinical and Echocardiographic Findings in the 11 Patients Suspected of Having AD Not Confirmed at Aortography*

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Age (yr)</th>
<th>Sex</th>
<th>Predisposing Disease</th>
<th>Chest Pain</th>
<th>Aortic Insufficiency</th>
<th>Pericardial Rub</th>
<th>Pulse Loss</th>
<th>Enlargement of the Aortic Root</th>
<th>Widening of the Aortic Valve</th>
<th>Intimal Flap</th>
<th>Diagnosis</th>
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<tbody>
<tr>
<td>1</td>
<td>52</td>
<td>M</td>
<td>Hypertension</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>Pericarditis</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>F</td>
<td>Hypertension</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>Pericarditis</td>
</tr>
<tr>
<td>3</td>
<td>47</td>
<td>M</td>
<td>Hypertension</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>Angina Pectoris</td>
</tr>
<tr>
<td>4</td>
<td>42</td>
<td>M</td>
<td>. . .</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>Angina Pectoris</td>
</tr>
<tr>
<td>5</td>
<td>62</td>
<td>F</td>
<td>Hypertension</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>Pulmonary embolism with paradoxical embolism</td>
</tr>
<tr>
<td>6</td>
<td>77</td>
<td>F</td>
<td>. . .</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>Pericarditis</td>
</tr>
<tr>
<td>7</td>
<td>52</td>
<td>F</td>
<td>Hypertension</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>Chest pain of unknown etiology</td>
</tr>
<tr>
<td>8</td>
<td>79</td>
<td>M</td>
<td>Hypertension</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>Aneurysm of abdominal aorta without dissection</td>
</tr>
<tr>
<td>9</td>
<td>72</td>
<td>M</td>
<td>Hypertension</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>0</td>
<td>+</td>
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<tr>
<td>10</td>
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<td>+</td>
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<td>+</td>
<td>0</td>
<td>+</td>
<td>Chest pain of unknown etiology</td>
</tr>
<tr>
<td>11</td>
<td>78</td>
<td>M</td>
<td>Hypertension</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>Pericarditis</td>
</tr>
</tbody>
</table>

* +, present; 0, absent.

Echocardiography in Aortic Dissection (Enia et al)
62 and 61 percent, respectively. The simultaneous presence of these three echocardiographic findings had a sensitivity as low as 48 percent but PPV was 100 percent (no false-positives) and efficiency was 74 percent.

**Specificity, Predictive Values and Efficiency of Echocardiography in an Unselected Group with Lower Risk of AD**

In this group of 509 patients, the prevalence of type A AD was 4.9 percent. To the group 1 false-positive echocardiographic signs (Table 2), three more patients with false-positive intimal flap, 123 with aortic dilatation and 51 with aortic wall thickening were added (Table 4).

Specificity of dilatated aortic root in this unselected group was moderate (72 percent), PPV was 15 percent, negative predictive value was high (99 percent) and efficiency was 73 percent. Aortic wall thickening specificity, PPV, negative predictive value and efficiency were 89, 27, 99 and 88 percent, respectively. Intimal flap had the highest specificity (98 percent); PPV, negative predictive value and efficiency were 54, 97 and 97 percent, respectively.

**DISCUSSION**

The central role of echocardiography in diagnosing AD is generally agreed upon. In some cases, it is suggested that the diagnosis should be based only on echocardiography and further tests, such as aortography, avoided. Such a crucial decision cannot be accepted uncritically.

**Sensitivity**

Aortic dissection is an emergency condition, but no more a desperate one, as far as timely and rational medical and/or surgical treatment is provided. Early diagnosis is mandatory and a high sensitivity test is needed since false-negative diagnosis badly affects prognosis, delaying treatment. Actually every diagnostic test must be compared with aortography, whose sensitivity is 90 to 98 percent.12,13

The data about sensitivity of echocardiography in diagnosing AD are conflicting. The intimal flap, a key sign, is reported to have a good (80 to 100 percent), just fair (67 percent) or even low (14 percent) sensitivity. In our series, among patients with clinical suspicion of disease (group 1), sensitivity and PPV of intimal flap are low (56 and 62 percent). In the same clinical context, aortic root dilatation has better sensitivity (91 percent) but moderate PPV (64 percent), so that the risk of a false-positive diagnosis remains. Aortic wall thickening has just fair sensitivity (78 percent) and PPV (75 percent).

**Specificity**

There is general agreement about specificity of echocardiography in diagnosing AD (reported values of 88 to 96 percent). This good specificity is confirmed in our study of 509 unselected patients, where specificity values of echocardiographic intimal flap, aortic wall thickening and aortic root dilatation are 98, 89 and 72 percent, respectively.

**PPV**

The PPV is generally considered high: 72 to 92 percent. As in all diagnostic tests, PPV varies according to the prevalence of the disease. In our series, the PPV of AD echocardiographic signs (aortic root dilatation, wall thickening, intimal flap) shifts from 15, 27 and 54 percent in the low prevalence group to 64, 75 and 62 percent, respectively, in the high prevalence group. This finding is of definite clinical relevance. In a patient with a clinical pattern evoking acute AD, the finding, for example, of aortic wall thickening on an echocardiogram has a PPV of 75...
percent. This poses the urgent indication to aortography. The same echocardiographic sign in a patient with no obvious clinical suggestion of AD (for instance during a routine clinical and echocardiographic evaluation) has a much lower PPV (27 percent) and does not imply the need for invasive study.

Efficiency

In the first group, the efficiency of the test is moderate (61 to 74 percent) as it reflects its low sensitivity. Since specificity is good, efficiency of the test is higher in the second group (73 to 97 percent). Unfortunately, specificity compared with sensitivity is of poor value in the emergency diagnostic approach.

Causes of False-Positives

Aortic root dilatation and aortic wall thickening may be encountered in several conditions in the absence of AD.\(^{7,8}\) It is interesting to note that the prevalence of these findings in patients without AD is almost the same in the two groups. Aortic root dilatation is present in 26 percent of the cases in the first group (12 patients out of 46) and in 26 percent of the cases in the second group (133 patients out of 509). Aortic wall thickening is present in 13 percent of the cases in the first group (six patients out of 46) and in 11 percent of the cases in the second group (55 patients out of 509).

The prevalence of false-positive intimal flap is not well known. In our series, the false-positive rate is quite different between the two groups: 17 percent in the first (eight out of 46) and 2 percent (11 out of 509) in the second. Two explanations are possible: (1) The clinical picture may be a major challenge for the examiner to detect even minor abnormalities, thus determining a higher false-positive rate. (2) In the first group, there is a much higher prevalence of clinical conditions mimicking an intimal flap. An atherosclerotic plaque may determine the presence of non-parallel aortic echoes.\(^{2,14}\) A pericardial effusion with fluid leakage into the transverse sinus, or with an enlargement of the superior vena cava, which passes close to the aortic wall, may cause a false impression of aortic wall thickening and/or intimal flap.\(^{15,16}\) Actually in the first group of patients with false-positive diagnosis of AD (Table 2) we found a high prevalence of pericardial effusion (four out of 11) and one case of pulmonary embolism.

Causes of False Negatives

In only two out of 23 patients with type A AD, aortic root dilatation was not detected. This can be accounted for by the uncommon dislodgement of the dissecting hematoma toward the lumen of the aorta rather than outward.

In five out of 23 patients with type A AD, abnormal thickening of aortic wall was not detected. These false-negatives may be due to a limited extension of the hematoma and/or to a peculiar spiral pattern, hardly imaged on echocardiography.

In ten out of 23 patients with type A AD, we did not identify an intimal flap as an echo of variable length, well-differentiated from the aortic wall, provided with peculiar motion and clearly evident in more than one echocardiographic section. This may be due to a peculiar localization not easily detected by echocardiography. It also should be stressed that the aortic wall thickening, present in 78 percent of our patients with type A AD, does represent the false lumen, \textit{ie}, the dissecting channel. Thus, it also could be maintained that, when echocardiography shows the false lumen as aortic wall thickening, it detects at the same time the intimal flap as the inner boundary of the dissecting channel, which separates the false from the true lumen. Obviously this sign may lack the peculiar oscillatory motion pattern, which is conventionally required to diagnose an echocardiographic intimal flap. Consequently, an intimal flap by strict echocardiographic definition is present in 56 percent of our patient, by broader definition it is present in as many as 78 percent of our cases (specifically in all the cases with increased aortic wall thickness). Even so, however, this echocardiographic sign of AD cannot be compared in sensitivity to aortography.

Conclusion

In our experience, the diagnostic usefulness of echocardiography in patients with suspected type A AD is limited by its moderate sensitivity and PPV. The major step in diagnosis of AD still remains aortography. Furthermore, aortography provides useful information for the surgeon: intimal tear sites may be defined; extent of dissection can be determined; presence of aortic insufficiency can be assessed and aortic branch involvement may be evaluated. New hope for reliable noninvasive diagnosis is provided by computed tomography,\(^{17}\) magnetic resonance imaging,\(^{18}\) Doppler ultrasound\(^{4}\) and color-flow imaging,\(^{19,20}\) although the utility of these tests, compared with aortography, has not been carefully calculated.

With these limitations, however, echocardiography is useful in obtaining a clear-cut confirmation of a clinically suspected case if all the three main echocardiographic signs are simultaneously present (11 patients; PPV = 100 percent). In these cases, with a typical clinical picture and a complete echocardiographic pattern, diagnosis is considered so sure as to justify emergency surgery in critical ill patients without previous aortography.

References