Value and limitations of cross-sectional echocardiography in the diagnosis of myocardial aneurysm[1]

Sherif El-Tobgi, M.D.
Ernesto E. Salcedo, M.D.
Floyd D. Loop, M.D.

Cross-sectional echocardiography has been proposed as a useful technique for the diagnosis of ventricular aneurysm. To evaluate and compare its ability to differentiate aneurysm from mural scar, echocardiograms and ventriculograms were obtained in 54 patients. Thirty-seven of these patients subsequently underwent cardiac surgery and 17 had resection of a ventricular aneurysm. Diagnosis at surgery of true aneurysm versus mural scar was used to compare the accuracy of the two diagnostic techniques. Ventriculography correctly identified 16 of 17 patients (94%) who proved to have ventricular aneurysm at surgery; false-positive diagnosis was made in 3 of 37 patients (8%). Cross-sectional echocardiography was accurate in 13 of 17 cases of ventricular aneurysm (76%) and in 13 of 15 patients with anteroapical aneurysm (87%). The 2 cases of diaphragmatic ventricular aneurysm were mistaken for mural scar. A false-positive diagnosis was observed in 8%. We conclude that cross-sectional echocardiography is slightly less sensitive than ventriculography in the diagnosis of left ventricular aneurysm; both methods have a similar specificity. Echocardiography may be useful in complementing the angiographic diagnosis.

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Changes in structure and function of the left ventricle in coronary heart disease are important because of therapeutic and prognostic implications. Myocardial aneurysm is a common complication amenable to surgical treatment. Although the diagnosis is usually established by ventriculography, the differentiation between true fibrous aneurysm and mural scar may not be resolved until surgery is performed.[1] Although resection of an aneurysm is universally

[1] Departments of Cardiology (S. E.-T., E. E. S.) and Thoracic and Cardiovascular Surgery (F. D. L.), The Cleveland Clinic Foundation. Submitted for publication Nov. 1982; accepted Feb. 1983.

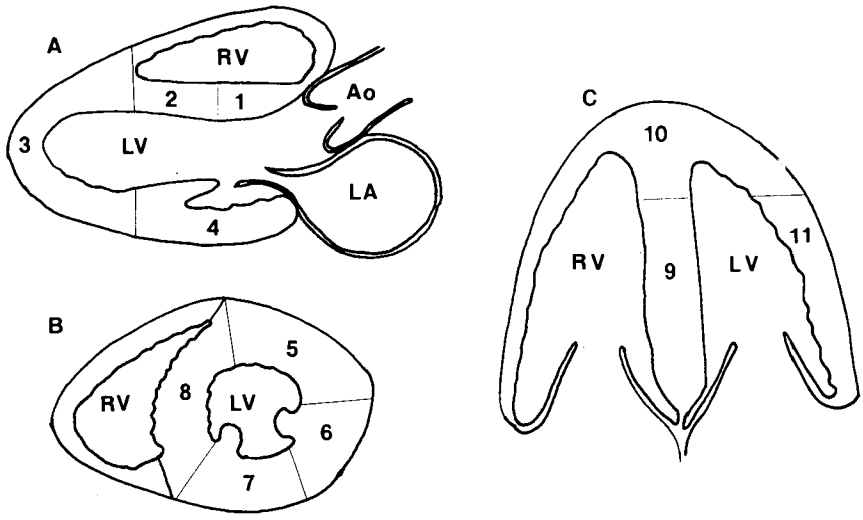

Figure 1. Schematic diagram of left ventricular wall segments in various echocardiographic views: A. Long-axis parasternal: 1. proximal septum, 2. distal septum, 3. apical, 4. diaphragmatic.
B. Short axis: 5. anterolateral, 6. posterolateral, 7. diaphragmatic, 8. septum.
C. Apical four-chamber: 9. septum, 10. apical, 11. lateral.

accepted, excision of a scar is a controversial procedure.[2–4] Furthermore, aneurysmectomy may be the only indication for surgery in patients who do not require bypass grafts, and accurate methods of preoperative diagnosis may save needless surgery.

Although recent reports have described cross-sectional echocardiography in the diagnosis of myocardial aneurysm,[5,6] it is not clear whether this technique can reliably differentiate a true aneurysm from a mural scar. The purposes of this study were (1) to establish the diagnostic criteria of myocardial aneurysm and mural scar by cross-sectional echocardiography in order to determine their differentiation, and (2) to compare the accuracy of cross-sectional echocardiography and ventriculography in the diagnosis of myocardial aneurysm.

Methods

Patients

The study included 54 patients who underwent cardiac catheterization and cross-sectional echocardiography for suspected coronary heart disease. The patients included a small group with normal ventricles and a larger group with either myocardial scar or aneurysm following remote myocardial infarction. Cross-sectional echocardiography was performed within 24 hours of cardiac catheterization. Echocardiograms were interpreted by two investigators who reviewed the videotape recordings without knowledge of angiographic results. There were 45 men and 9 women aged 26 to 80 years. Ventriculography and coronary arteriography (Sones technique) showed that 9 patients had normal hearts, 44 had coronary atherosclerosis, and one had post-traumatic ventricular aneurysm.

Left ventriculography

All patients had two consecutive ventriculograms in the 30 degree right anterior oblique projection and 60 degree left anterior oblique projection, which were recorded on 35-mm film at a speed of 30 frames/sec. Three segments of the left ventricle (apex, anterolateral, and diaphragmatic) were evaluated in both projections, and two segments (septum and posterolateral) in the left anterior oblique projection. The diagnosis of mural scar was based on segmental abnormal wall motion as described in classical angiographic terms: hypokinesia, akinesia, or dyskinesia.[7] A ventricular aneurysm was defined as a discrete sac that bulged paradoxically or remained akinetic during systole.

Cross-sectional echocardiography

Recordings were obtained with the patient in the left lateral decubitus position with the use of a real-time phased-array sector scanner (Varian

3000). The images were obtained with a 32-element transducer and stored on a videotape recorder at 30 frames/sec with a 21-cm field. An attempt was made to record the following views in all patients: short axis at the mitral and papillary muscle levels, long-axis parasternal view, and apical four-chamber.

The left ventricle was schematically divided into 11 segments in the various echocardiographic views, which were compared to the corresponding angiographic segments (*Fig. 1*). The percentage of patients who had adequate images of each myocardial segment is shown in *Table 1*. Although the apical segment was recorded in the long-axis parasternal view in all patients with a normal ventricle, it was difficult to record in most patients with abnormal ventricles. In these patients, therefore, the detection of apical abnormalities depended entirely on the interpretation of the apical four-chamber view. Each segment was analyzed for abnormal wall motion, thickness of myocardium, and abnormal contour. Abnormal segmental wall motion was defined as impairment of systolic inward motion and/or systolic thickening of myocardium. This was classified as hypokinetic, akinetic, or dyskinetic, similar to the angiographic definition. Myocardial thickness was evaluated in comparison to the other ventricular segments. An abnormal segmental contour was defined as a discrete protrusion from the ventricular outline which persisted during both diastole and systole.

Myocardial aneurysm

On the apical four-chamber view, an anteroapical aneurysm appeared as a saccular protrusion involving the apex, the distal interventricular septum, and in some cases the distal lateral wall (*Fig. 2*). During systole its walls either expanded paradoxically or appeared akinetic. In every case, the myocardium was markedly thinned out as compared to the other segments and often an abrupt thinning of septal myocardium was observed. Large aneurysms were separated from the basal contracting segments by a hinge point, which was accentuated during systole by the active inward motion of the latter (*Fig. 2*).

Cardiac surgery

Following the diagnostic studies, 37 patients underwent coronary artery bypass surgery and 17 had resection of a myocardial aneurysm (15 anteroapical, 2 diaphragmatic). At surgery only a true aneurysm, described as a well-demarcated, thin-walled, fibrous sac, was considered resectable. This is in contrast to a myocardial scar composed of mixed viable muscle and fibrous tissue that has poorly defined borders and does not bulge beyond the surface of the surrounding myocardium. The surgeon's definition of an aneurysm versus a scar was used as a standard to compare the diagnostic accuracy of ventriculography and echocardiography.

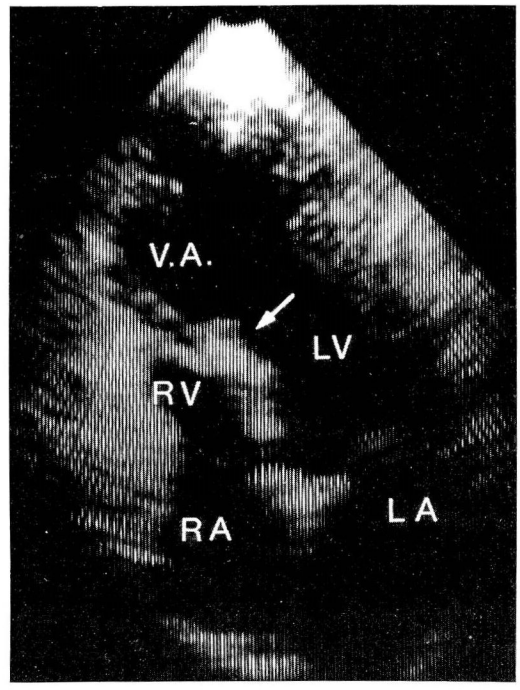

Figure 2. Apical four-chamber view showing a large apical ventricular aneurysm (*V.A.*) during systole. The contour of the ventricle is abnormal. An arrow indicates the hinge point on the septal wall separating the aneurysm from the remainder of the left ventricle (*LV*). *RV* = right ventricle, *RA* = right atrium, *LA* = left atrium.

Results

Thirty-seven patients had cardiac surgery and 9 normal subjects underwent diagnostic studies.

Left ventriculography

Angiographic diagnosis was correct in 16 of 17 patients (94%) who proved to have a true fibrous aneurysm at surgery (*Table 2*). False-positive diagnosis was made in 3 of 37 patients (8%).

Echocardiographic diagnosis of myocardial aneurysm was correct in 13 of 17 cases (76%) verified at surgery (*Table 1*). Whereas the 2 cases

Table 1. Percentage of satisfactory echocardiographic recordings of each left ventricular segment in 54 patients

Left ventricular segment	Percent satisfactory recording
1	98
2	94
3	22
4	96
5	92
6	92
7	92
8	92
9	100
10	100
11	100

of diaphragmatic aneurysm (*Fig. 3*) were mistaken for a mural scar, the diagnosis of anteroapical aneurysm was accurate in 13 of 15 cases (87%). Of the 13 true fibrous aneurysms correctly identified by echocardiography, 11 showed dyskinesia and 2 had akinetic walls. All 9 normal subjects had normal symmetrical left ventricular wall motion on the echocardiograms.

Mural scar (*Fig. 4*)

Fifty-seven abnormal segments were identified in 20 patients with angiographic evidence of asynergy. All showed abnormal wall motion (hypokinesia in 39, akinesia in 14, and dyskinesia in 4, and some degree of myocardial thinning was apparent in 14 segments. A scar was mistaken for aneurysm by echocardiography in 3 of the 37 patients who underwent surgery (8% false-positive).

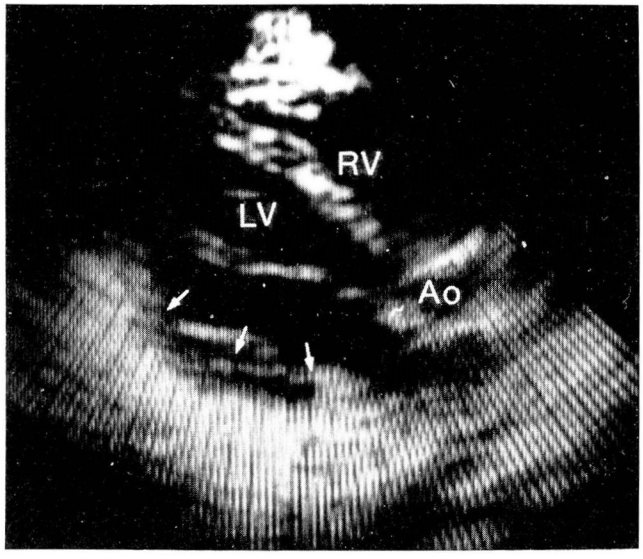

Figure 3. Long-axis view in diastole. The scalloped area on the inferior wall represents a diaphragmatic aneurysm (arrowheads). Diagnosis was made only retrospectively, since a scar can produce a similar abnormality of left ventricular contour in this view. *LV* = left ventricle, *RV* = right ventricle, *Ao* = aorta.

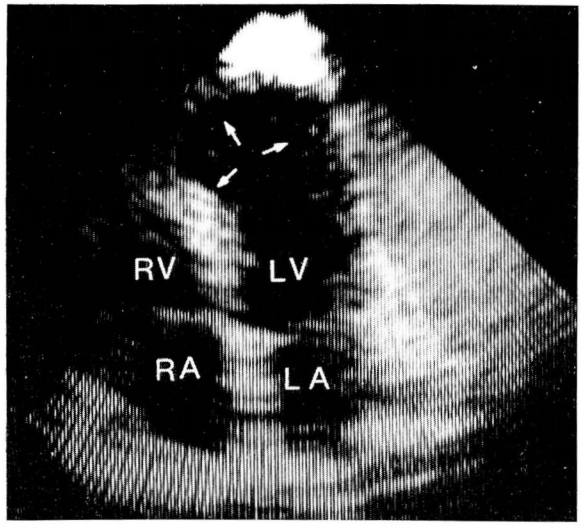

Figure 4. Systolic frame of an apical four-chamber view showing apical scar (top arrow). The two other small arrows point to the endocardium on the lateral and septal walls, which demonstrate systolic thickening. Conversely, the region of the scar is abnormally thinned out. The general contour of the ventricle is preserved. *LV* = left ventricle, *RV* = right ventricle, *LA* = left atrium, *RA*= right atrium.

Discussion

Coronary atherosclerosis eventually results in destruction of viable myocardium and replacement by nonfunctioning scar tissue. This process may be partial or complete, and may result in a mural scar composed of mixed viable muscle and fibrous tissue, or in a myocardial aneurysm. The latter is a well-demarcated, thin-walled fibrous sac formed entirely of scar tissue.[2,3] Because of these unique features, aneurysmectomy became rapidly accepted as a standard surgical procedure and was found to improve myocardial function

Table 2. Comparison of ventriculography and cross-sectional echocardiography in the diagnosis of ventricular aneurysm resected at surgery

	No. cases	Ventriculography	Cross-sectional echocardiography
All cases	17	16 (94%)	13 (76%)
Anteroapical	15	14 (93%)	13 (87%)
Diaphragmatic	2	2	0

and prolong survival.[3,8,9] However, resection of a mural scar remains controversial[2,4] and is associated with less satisfying results.[10] Effectiveness of surgical treatment emphasizes the importance of proper diagnosis. Studies have demonstrated the inadequacy of conventional clinical means for detection of myocardial aneurysm.[11–13] Left ventriculography continues to be an essential prerequisite for clinical diagnosis.[2,14] However, a mural scar is not infrequently mistaken for an aneurysm with this technique.[15,16] In one study,[1] as many as one third of the patients with angiographic diagnosis of myocardial aneurysm did not have a true resectable aneurysm at surgery.

Recently, cross-sectional echocardiography was found useful in the evaluation of the left ventricle,[17] detection and localization of asynergy,[18,19] and diagnosis of myocardial aneurysm.[5,6] As with previous studies,[6] we found that the apical four-chamber view is the most useful projection for detection of anteroapical aneurysms. Although in these cases the parasternal long-axis view may show thinning and dyskinesia of the distal interventricular septum, and/or the distal diaphragmatic wall, it often failed to reveal the entire outline of the aneurysm. This can be explained by the recognized difficulty of recording the apical segment in this view, particularly when the left ventricle is dilated.[5,6] We found that the diagnosis of true fibrous aneurysm depends on the concomitant presence of: (1) dyskinesia or akinesia; (2) marked thinning of myocardium; and (3) abnormal segmental contour. A mural scar, on the other hand, was characterized by (1) hypokinesia, akinesia, or dyskinesia, with or without (2) myocardial thinning. Applying these criteria, echocardiography was slightly less sensitive than ventriculography (86% versus 94%) in the detection of anteroapical aneurysm, and both had a similar incidence of false-positive diagnosis (8%).

These echocardiographic criteria correspond closely to the surgical and pathological description of a true fibrous aneurysm. Marked thinning of the myocardium conforms with the classic pathological observation that the wall of a fibrous aneurysm usually averages 0.5–5 mm in thickness.[11,20] We found that it was easier to detect myocardial thinning by cross-sectional echocardiography than by ventriculography, which is conceivable since the latter outlines only the ventricular cavity. Although Froehlich et al[1] predicted that cross-sectional echocardiography would provide a more accurate means for differentiation between scar and aneurysm because of better definition of wall thickness, quantitation of the degree of thinning is difficult and some scars appear significantly thinned out on the echocardiogram. Unlike Chiang et al,[6] who described dyskinesia in all their cases of myocardial aneurysm, we observed akinetic walls in 2 of 13 cases resected at surgery. Contrary to popular belief, not all aneurysms exhibit dyskinesia on ventriculography; some appear akinetic, as can be shown by superimposition of the ventricular silhouettes in diastole and systole.[8,14] In these 2 patients, the aneurysms were found to have akinetic walls on the ventriculograms as well. Similarly, paradoxical motion is not always seen at surgery, and its absence does not exclude the surgical diagnosis of a ventricular aneurysm.[2,3] Akinesia was ascribed to splinting of the aneurysm walls by thrombus, calcification, or tough adhesions.[21] On the other hand, the angiographic appearance of dyskinesia is not pathognomonic of ventricular aneurysm, since it can be associated with partial scar and even with ischemic normal myocardium.[15]

Since both scar and aneurysm may present with dyskinesia or akinesia, as well as myocardial thinning, differentiation depends upon detection of abnormal contour. We agree with Weyman et al,[5] who define an aneurysm as an interruption of the normal contour of the ventricle which persists during both diastole and systole. However, determination of abnormal contour in diastole may not always be easy,[1] particularly when the left ventricle is markedly dilated. Thus, overreading of abnormal contour resulted in false-positive diagnosis by echocardiography in 3 of our cases. In 2 of these cases, an aneurysm was also incorrectly diagnosed during ventriculography. Conversely, failure to detect an abnormal segmental contour resulted in cases of diaphragmatic aneurysm being mistaken for mural scar by echocardiographic examination. However, we have not routinely employed the apical two-chamber view to examine the diaphragmatic wall of the ventricle, and it is possible that this could have improved our ability to detect these aneurysms.

Cross-sectional echocardiography revealed better definition of the thickness of the myocardium and more accurate assessment of the thickness and motion of the entire interventricular septum than ventriculography. The septum, which is often involved in anteroapical aneurysms, is usually overlapped by other ventricular walls during

angiographic examination. However, with echocardiography we failed to obtain adequate recordings in some patients (14% in this study), and had difficulty differentiating inferior wall aneurysms from scars, at least by the methods we used. Both techniques are limited to a two-dimensional silhouette image and would be expected to be less accurate in detecting systolic expansion than a technique capable of describing and measuring changes in volume. Furthermore, since the difference between extensive segmental scarring and a true fibrous aneurysm is only quantitative, it is unlikely that either of these techniques would be capable of perfectly distinguishing the two conditions.

In conclusion, cross-sectional echocardiography compares favorably with ventriculography in the diagnosis of anteroapical myocardial aneurysm and its differentiation from a mural scar. It may be used to complement the angiographic diagnosis. Multiple apical views are probably required to improve the echocardiographic detection of diaphragmatic aneurysms.

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