M-mode Echocardiography in the Evaluation of Patients for Aneurysmectomy

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SUMMARY In order to determine whether echocardiography could be useful in predicting surgical mortality of aneurysmectomy, preoperative condensed M-mode echocardiographic scans were taken from both mid (standard position) and low (nearer apex) intercostal spaces and/or from the subxiphoid area in eighteen patients who were sent to surgery for aneurysmectomy. Eleven of the eighteen patients survived aneurysmectomy. All eleven had mid left ventricular dimensions less than 3.3 cm/$m^2$ and low dimensions of 3.8 cm/$m^2$ or less. Of the seven patients who died, the mid and low left ventricular dimensions exceeded 3.3 cm/$m^2$ and 3.8 cm/$m^2$, respectively, with one exception. The combination of abnormal mitral valve closure, a dilated mid dimension and lack of normal motion in opposing wall segments was only seen in six nonsurvivors. Echocardiography can provide information concerning the state of the left ventricle in patients with ventricular aneurysms and these findings may be helpful in predicting surgical mortality for aneurysmectomy.

THE INCIDENCE of left ventricular aneurysm has been reported to be from 3.5% to as high as 38% in patients surviving myocardial infarction. Many reports indicate that an aneurysm may markedly shorten a patient's life span, and surgical intervention is being used increasingly for symptomatic patients. One of the major limitations of surgical therapy is the problem of leaving enough normally contracting myocardium after removing a large aneurysm.

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transducer focused at 7.5 cm was used. The transducer was placed in the intercostal space along the left sternal border in which the transducer was perpendicular to the mitral valve. A mid dimension was obtained in this standard position through the body of the left ventricle as has been previously described. The transducer was then moved down one to two interspaces and laterally approximately one inch to a more apical position and another slow scan from the aorta to the apex was obtained. In this position a low left ventricular dimension was obtained through the more apical area of the heart at the level of the papillary muscles. Both mid and low dimensions were measured at the peak of the simultaneous electrocardiographic R wave. Figure 1A and B demonstrates positions of the transducer on the chest in the mid and low positions. The exact transducer placement on the chest was somewhat dependent on whether the heart was vertically or horizontally oriented. Figure 2A is the type of M-mode scan obtained with the transducer along the left sternal border and in the mid position. It is possible to tell that the echogram is from the mid position because the anterior wall of the aorta is about the same distance from the transducer as is the interventricular septum. When the transducer is moved slightly laterally and down one interspace to a low position, a recording as in figure 2B is obtained. Note how much further the aorta is from the transducer compared with 2A. The aortic position helps to identify this echogram as one obtained with the transducer in a low interspace.

If unable to obtain satisfactory mid and low recordings with the transducer along the left sternal border, the transducer was then placed in the subxiphoid position and the mid dimension was obtained as previously described. The transducer was then directed toward the apex by angling it laterally toward the patient's left shoulder (fig. 3) and a low dimension was obtained. A normal M-mode scan from a subxiphoid position is seen in figure 4. In the subxiphoid position the mid and low dimensions were measured from the same tracing since the transducer angulation was much less than that necessary with the left sternal border approach and should cause less distortion.

All four dimensions could not be recorded in every patient due to variations in body habitus, chest configuration and location of the diaphragm. In many cases if the standard left sternal border examinations were adequate, the subxiphoid

FIGURE 1. Schematic drawings of the position of the transducers in the anterior position in A and the lateral view in B. Transducer position T₁ corresponds to the mid dimension and T₂ to the low dimension. CW = chest wall; R = rib; ARV = anterior right ventricular wall; RV = right ventricular cavity; IVS = interventricular septum; LV = left ventricular cavity; PPM = posterior papillary muscle; PLV = posterior left ventricular wall; AMV = anterior mitral valve; PML = posterior mitral valve; LA = left atrium; AO = aorta.

FIGURE 2. A) Condensed M-mode scan from the third intercostal space (3rd ICS) demonstrating the aorta (AO), left atrium (LA), left side of the septum (LS), endocardium (EN), and the mid dimension (Md). Normal wall motion is noted. In B a condensed scan taken from the 4th ICS, Ld being the low dimension. Note that the wall motion is still normal and that the aorta compared to A is further away from the anterior chest wall consistent with a low scan.
Approach was not attempted. Both left sternal and subxiphoid dimensions were obtained in only seven of the 18 patients. Wall motion was evaluated in each of the four locations when present and was classified as normal, flat, reduced, exaggerated or paradoxical. Reduced septal motion was defined as a systolic amplitude below 3 mm; septal motion was exaggerated when the amplitude exceeded 8 mm. The amplitude of systolic motion of the posterior wall was reduced when endocardial motion was below 8 mm and exaggerated if greater than 16 mm.

Abnormal mitral valve closure was used as an indicator of an elevated left ventricular end-diastolic pressure (LVEDP) as previously described. Mitral valve closure was considered abnormal when the electrocardiographic P-R interval exceeded the echocardiographic mitral valve A-C interval by 0.06 sec or less. A paper speed of at least 25 mm/sec was used when evaluating mitral valve closure.

The decision for surgery was determined independently of the echocardiographic examination and was based on clinical information, cineangiograms and the results of cardiac catheterization.

Results

Surgical Mortality

Eleven of the eighteen patients subjected to surgery for removal of a ventricular aneurysm survived surgery. Seven did not. These seven died at the time of surgery or during the immediate postoperative period. All seven deaths were thought to be cardiac in origin. Five survivors and three non-survivors underwent coronary bypass grafting procedures at the time of ventricular aneurysmectomy.

Echocardiographic Measurement

The echocardiographic findings are listed in table 1. In 17 of 18 patients with resectable aneurysms the low left ven-
tricular dimension exceeded the mid dimension echocardiographically. Figure 5A and B contains echograms taken from the mid and low intercostal spaces in a patient who had a ventricular aneurysm. In this patient the low dimension exceeds the mid dimension. All eleven of the patients who survived surgery had mid left ventricular dimensions less than 3.3 cm/m² and low dimensions less than 3.8 cm/m². The mid left ventricular dimension exceeded 3.3 cm/m² in all seven patients who died; in six of the seven patients the low dimension exceeded 3.8 cm/m².

Normal or excessive motion of both the interventricular septum and the posterior left ventricular wall was recorded in eight of the eleven survivors but in none of the nonsurvivors. Figure 5A and B shows normal wall motion at the base of the heart. As the ultrasound beam approaches the cardiac apex, wall motion decreases. Figure 6 is a subxiphoid echogram from a patient with a ventricular aneurysm. On the left the mid basilar dimension is recorded. Septal and posterior wall motion becomes reduced as the transducer is swept toward the apex (right side of echogram). The low apical dimension is also greater than at the base consistent with the diagnosis of a ventricular aneurysm. One patient who was a nonsurvivor had abnormal septal motion consistent with left bundle branch block.

Abnormal mitral valve closure indicative of an elevated LVEDP occurred in six nonsurvivors and in two survivors. The combination of abnormal mitral valve closure, dilated mid dimensions and abnormal motion in one of the two opposing left ventricular walls was seen in six of seven nonsurvivors.

**Discussion**

Aneurysmectomy can be a very beneficial surgical procedure in the properly selected patient. Successful surgical therapy can lead to relief of heart failure, angina, systemic emboli and occasionally arrhythmias. To find the proper patient for this surgical procedure, one must first

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**TABLE 1. Echocardiographic Findings**

<table>
<thead>
<tr>
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<th>Other surgery</th>
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**Abbreviations:** BG = bypass surgery; VSD = ventricular septal defect repair; 0 = no surgery but aneurysmectomy; S = survived; D = dead; N = normal wall motion; LBBB = left bundle branch block; A = abnormal wall motion; I = increased wall motion; IVS = septum; PW = posterior wall; Md = mid dimension; Ld = low dimension; MN = mitral valve notching consistent with elevated LVEDP.

**FIGURE 5.** An abnormal echogram from a patient with a ventricular aneurysm. In A note that the septal and posterior wall motion is normal initially but tends to decrease both in the septum and the posterior wall as the transducer is swept toward the apex. B is a low condensed scan which demonstrates a wider apical dimension than seen at the 3rd ICS.
identify that patient who has an aneurysm which may be contributing to his clinical problems and then must determine whether or not the risk of surgery is acceptable.\(^6\)\(^-\)\(^10\)

Although many physicians think of an aneurysm in terms of wall motion, the distinguishing feature on angiography is the bulging of part of the LV wall away from the relatively smooth perimeter of the left ventriculogram. The contour of the ventricular wall is abnormal. Wall motion within the aneurysm is usually abnormal but this does not distinguish an aneurysm from other conditions associated with abnormal wall motion. In all of the patients selected for this study the diagnosis of an aneurysm was made angiographically where a distinctive bulge was observed.

One of the questions that might be asked is whether or not echocardiography can detect the presence of an aneurysm. In all of the patients in this study except one the apical echocardiographic dimension was larger than the mid dimension which would suggest that this is a constant and possibly diagnostic finding in a ventricular aneurysm. However, this study was not designed specifically to answer this question. A much larger experience looking at patients with coronary artery disease and no aneurysm would be necessary to be certain that a larger apical dimension is in fact diagnostic of a ventricular aneurysm.

The principal question to which this study was directed was whether or not M-mode echocardiography could provide sufficient information concerning the overall status of the left ventricle to be able to judge a patient's suitability for aneurysnecomy. The principal method for evaluating patients with ventricular aneurysms both for the diagnosis and for the assessment of suitability for surgery is left ventricular cineangiography.\(^6\)\(^-\)\(^10\) Many investigators have used angiographic ejection fractions to assess myocardial performance and the risk of coronary artery surgery including aneurysnecomy. The ejection fraction can be very misleading in the presence of a large ventricular aneurysm. The aneurysm itself may represent such a large area of the ventricular angiographic silhouette that the amount of normally contracting ventricle may be underestimated. In addition, occasionally a very large ventricular aneurysm may obscure the basal portion of the left ventricle on the cineangiogram.

In attempting to evaluate suitability for aneurysnecomy the basal portion is important since it is the area least likely to be involved with the aneurysmal process and is the myocardium which will have to maintain adequate cardiac output once the aneurysm is removed. Echocardiography provides an opportunity to study this critical area at the base of the left ventricle. Because echocardiography depends on reflected ultrasonic information and not on superimposed shadows as with roentgenographic techniques such as angiography, the echocardiographic examination of the basal portion of the left ventricle is not obscured by the shadow of the large ventricular aneurysm. We have seen several cases where the echocardiogram demonstrated normally contracting muscle in the region of the mid ventricle which could not be appreciated on angiography because that area was hidden by a large aneurysm.

Results of this study indicate that echocardiographic information about the left ventricle may help predict surgical risk for aneurysnecomy. As one might predict, where there is dilatation and abnormal wall motion at the base of the heart and mitral valve motion indicative of an elevated LVEDP, surgical risk is considerably higher.

The findings of left ventricular dilatation combined with abnormal mitral valve closure have also been shown to predict hospital mortality in patients with acute myocardial infarction.\(^19\) Both of these studies demonstrate that echocardiography may evaluate important parameters of left ventricular function even though it does not examine all parts of the left ventricle and cannot provide reliable ejection fractions.

As with all echocardiographic applications, one must be cognizant of the technical limitations as well as the obvious clinical advantages. Patients with coronary artery disease are often difficult to examine echocardiographically. Adequate echocardiograms could not be obtained in 15% of our patients with ventricular aneurysms; these patients were not included in the study. The M-mode scanning technique can also give a distorted impression of wall motion depending upon whether or not the segment being examined is perpendicular to the ultrasonic beam. Figure 7A shows a patient's condensed scan from the fourth interspace; as the beam reaches the apex, posterior wall motion looks reduced. Figure 7B is a scan from the same patient in 7A, in which the transducer was in a low position. From this position, posterior wall motion does not appear to be reduced, suggesting that the decreased motion in figure 7A may be due to angulation. It is important to be aware of this problem and to avoid steep angulation of the beam with relation to the cardiac walls. It is better to obtain echoes from as many interspaces as possible. It has been pointed out by previous investigators that distortion of ventricular dimension can also occur depending upon the location of the transducer.\(^20\)

It would be ideal to obtain both mid and apical dimensions along the left sternal border as well as from the subxiphoid approach in every patient but this is not technically possible; in one of our patients only echoes from the subxiphoid area could be recorded. In patients with symmetrically contracting ventricles there has been good correlation between the subxiphoid and left sternal border echocardiographic measurements. It is obvious that in a

**Figure 6.** A subxiphoid echogram sweeping from the base on the left to a more apical position on the right in a patient with a ventricular aneurysm. Note wall motion is normal in the basal area with a dimension of 5 cm; as the transducer sweeps toward the apex there is decreasing anterior and posterior wall motion and dilatation of the cavity to 6 cm.
markedly distorted ventricle with an aneurysm, the subxiphoid and left sternal border measurements may differ. On the other hand the critical measurements in this study are made near the base of the heart which should be less involved with the asymmetry than the more apical portion of the ventricle.

Despite technical difficulties it was possible to obtain satisfactory echocardiographic data from 85% of our patients with ventricular aneurysm and the resulting information indicates that it may be very helpful in managing these patients. An obvious potential use for this technique would be in the screening of patients with proven or suspected ventricular aneurysm. One may be able to assess the risk of aneurysmectomy even prior to ventricular angiogram. In addition echocardiography might be a useful supplement to ventricular angiography, especially in the presence of a large ventricular aneurysm where part of the basilar portion of the ventricle is obscured. With possible changes in technique or instrumentation additional reliable information should become available, and with further clinical experience we should be able to better interpret this information for the management of individual patients.

References

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