Use of Echocardiography in Patients with Prolapsed Mitral Valve

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SUMMARY
The echocardiographic findings are described for five patients who had the prolapsed mitral valve syndrome, proven by cardiac catheterization and angiocardiography. In all five patients, the echocardiograms demonstrated posterior displacement of the posterior mitral leaflet during systole. In four of the patients there was also posterior displacement of the anterior leaflet. Four of the five patients had mitral insufficiency, demonstrated by cineangiography. These four patients demonstrated echocardiographic separation of the anterior and posterior leaflets of the mitral valve in late systole. The fifth patient did not show this separation, and she had no mitral insufficiency by selective cineangiography. Two patients were given amyl nitrite during the echocardiographic examination, and the echogram showed earlier separation of the anterior and posterior leaflets as well as lengthening of the murmur. Echocardiography should be a very useful noninvasive, yet direct, method for diagnosing, studying, and following patients with prolapse of the mitral valve.

Additional Indexing Words:
Ultrasound cardiography Late systolic click syndrome Ballooned mitral valve
Mitral insufficiency Billowed mitral valve

Prolapsed mitral valve, also known as the late systolic click syndrome or the billowed or ballooned mitral valve, has generated a great deal of interest in the cardiac literature. For years, people with late systolic murmurs and clicks were looked upon as cardiologic curiosities, but recently evidence has come forth that this syndrome may not be entirely benign. Since the prolapsed mitral valve syndrome is proving to be an important clinical entity, a simple, yet specific technique for diagnosing and following patients with this disease should prove to be very useful.

Echocardiography provides a noninvasive means of visualizing both leaflets of the mitral valve. Several investigators have substantiated the identity of the anterior mitral echo. The origin of the posterior leaflet was confirmed by a recent study using intracardiac injection of indocyanine green dye. This study was designed to see whether the prolapsing mitral leaflets could be detected by use of ultrasound.

Methods
Five patients, all females, ranging in age from 17 to 47 years, were evaluated at the Indiana University Medical Center for late systolic murmurs and clicks. All patients had phonocardiographic studies and underwent diagnostic right and left heart catheterization with selective cineangiocardiology. Each patient had an echocardiographic examination by an Ekoline 20 Mark II echograph with a 2.25 MHz, one-half inch diameter transducer with a repetition rate of 1,000 per second. The echograms were recorded either by a Polaroid photograph directly off the oscilloscope or via an Electronics for Medicine...
multichannel strip chart recorder. The patients' anterior and posterior leaflets of the mitral valve were visualized by previously described techniques for visualization of the anterior leaflet of the mitral valve. Frequently the posterior leaflet was recorded best if the transducer were directed a little more laterally and inferiorly than usual. All patients were examined in the recumbent position. One patient was examined in both the recumbent and upright positions. Two of the five patients were given amyl nitrite during the echocardiographic examination.

Results
All five patients had mid- or late systolic clicks. Four patients had late systolic murmurs. The fifth patient had no apical systolic murmur, only an early systolic ejection murmur along the left sternal border. The left ventricular angiograms on all five patients demonstrated prolapse of the posterior leaflet of the mitral valve toward the left atrium during ventricular systole. The four patients with the late systolic murmurs demonstrated various degrees of mitral insufficiency. The patient without a late systolic murmur had no mitral insufficiency.

Figure 1 is a normal mitral valve echogram in a patient with an atrial septal defect and an angiographically proven normal mitral valve. The echogram demonstrates both the anterior and posterior leaflets of the mitral valve. Both leaflets come together in early systole and stay together throughout systole, during which time there is a gradual anterior motion of both leaflets.

Figure 2 is a Polaroid echogram of one of the five patients with a prolapsed mitral valve. The corresponding strip chart recording of the same patient is shown in figure 3A. In this patient, both the anterior and posterior leaflets come together early in systole. However, in the latter half of systole both leaflets, especially the posterior (figs. 2 and 3A), move posteriorly toward the left atrium.
Figure 3

(A) Simultaneous electrocardiogram, phonocardiogram, and echocardiogram of the same patient as in figure 2. The posterior displacement of the posterior leaflet (arrow) and the separation of the two leaflets coincide with a midsystolic click and the onset of a late systolic murmur recorded on the phonocardiogram.

(B) Recording from the same patient after inhalation of amyl nitrite. The murmur is now longer and separation of the leaflets occurs much earlier in systole (arrow).

Figure 4 is a drawing comparing the normal anterior and posterior mitral valve echogram with one in a patient with a prolapsed mitral valve. The diastolic motion of the valve leaflets is similar in both situations. The differences occur during ventricular systole. Both leaflets of the normal valve come together with the onset of systole and rise gradually upwards towards the transducer. With a prolapsed mitral valve, the onset of systole is normal; however, in midsystole the echoes from both leaflets begin to move downward or posteriorly towards the left atrium. In the illustration, the posterior leaflet moves more than the anterior leaflet and there is separation of the two echoes. The leaflets move back towards each other just before the onset of diastole.

In figure 3A a simultaneous phonocardiogram shows a late systolic murmur preceded by a small midsystolic click. The click occurs as the leaflets are moving posteriorly, while the murmur coincides with the separation of the leaflets. This patient was given amyl nitrite, and the echocardiographic and phonocardiographic findings are seen in figure 3B. The posterior displacement and separation of the posterior mitral leaflet begin sooner and last longer than during the control tracing. This change in the echocardiogram correlates with the lengthening of the murmur on the phonocardiogram.

All five patients demonstrated a posterior displacement of the posterior leaflet similar to that demonstrated in figures 2 and 3A. In one patient there was no posterior displacement of
mitral valve. Such an examination should be valuable in the diagnosis of individual patients with this disease, and it should enhance our understanding of this fascinating condition. The etiology and prognosis of patients with prolapsed mitral valve have come under recent investigation. This syndrome was thought to be entirely benign, but lately the prognosis has been questioned. Marked mitral insufficiency, arrhythmia,7, 11 abnormal electrocardiograms,8 and even sudden death7, 9 have been reported among these patients. Unfortunately much of the evidence compiled concerning this disease is based on indirect rather than direct evidence. Many physicians feel that since these patients are usually asymptomatic and since the disease is benign, cardiac catheterization is not justified. As a result, reliance has been placed on indirect phonocardiographic findings. Unfortunately there are other possible causes for late systolic murmurs and systolic clicks besides prolapsed leaflets.9 Thus, a more specific, noninvasive method of assessment of this disease should be of value.

As noted in this study, the dominant echocardiographic finding is in the posterior mitral leaflet. The abnormality is less marked and may be absent in the anterior mitral valve echo gram. Although the mitral valve has been studied with ultrasound by numerous investigators,11-14 little attention has been given to the posterior leaflet, thus possibly explaining why posterior displacement of the mitral valve echoes during systole has not been reported previously. In a review of our own 6-year experience with echocardiography, we could not find this echographic sign in any condition other than prolapse of the mitral valve. Thus, the echocardiographic findings seem to be quite specific.

An obvious advantage of any noninvasive test, such as echocardiography, is that serial examinations can be obtained at will for observation of the natural evolution of the disease. Since the natural history of this condition is uncertain, long-term serial examinations should help to shed some light on this problem. In addition, acute studies, such as

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**Discussion**

The results of this study indicate that echocardiography provides a direct yet noninvasive method of detection of a prolapsed mitral valve. In this patient the anterior mitral valve echo was normal. In the patient who had no late systolic murmur and no angiographic mitral insufficiency, both anterior and posterior leaflets moved together throughout systole, and no separation could be recorded. Both patients who were given amyl nitrite showed earlier posterior displacement of the posterior leaflet and an earlier onset of the systolic murmur, as demonstrated in figure 3B. The echograms from the one patient who was studied in both the supine and upright positions did not change.

**Figure 4**

A diagram of the anterior and posterior mitral valve echoes in the normal individual and in a patient with prolapsed mitral valve.
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the two done in this paper with amyl nitrite, are now feasible for the study of the functional anatomy of this diseased mitral valve, thus making it possible to record the effects of physiologic or pharmacologic stresses on mitral valve motion.

The finding of separation of the anterior and posterior leaflets in those patients with mitral insufficiency is intriguing for several reasons. First, the finding correlated very well with the murmur which is presumably due to the mitral insufficiency. This echocardiographic finding is also consistent with the reported explanation for the mitral insufficiency in patients with hypertrophic subaortic stenosis. In these patients the anterior leaflet has a late systolic bulge anteriorly rather than posteriorly. Some investigators feel that this anterior displacement is the mechanism for the mitral insufficiency in these patients. In addition, similar types of leaflet separation may prove to be useful in the evaluation of patients with other forms of mitral insufficiency.

As with all echocardiographic techniques, there are always some technical limitations which must be appreciated. Patients who are obese or who have emphysema are frequently very difficult to examine with ultrasound. The posterior leaflet may be particularly difficult to record in some of these individuals. Fortunately this disease entity generally occurs in young adults. This type of individual is usually an excellent candidate for echocardiographic study; for example, all five of our patients had technically good echograms.

In conclusion, echocardiography should prove to be a very useful tool in detecting, studying, and following patients with prolapsed mitral leaflets.

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