December 1983:1219–23

DIAGNOSTIC TECHNIQUES

# Mitral Valve Prolapse: Comparative Value of M-Mode, Two-Dimensional and Doppler Echocardiography

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**M-mode, two-dimensional and Doppler echocardiography were used to assess the comparative value of each in the detection of clinically diagnosed mitral valve prolapse; 125 consecutive patients with a mid- to late systolic click, with or without a late systolic murmur, were included. There were 46 men and 79 women; their mean age was 42 years. M-mode echocardiography detected 62 of 125 cases (sensitivity 50%). Two-dimensional echocardiography was positive in 85 cases (sensitivity 68%) and 90 cases were detected with Doppler echocardiography (sensitivity 72%). When all three techniques were combined, 116 cases were correctly diagnosed (total echographic sensitivity 93%). The relative insensitivity of the M-mode technique and the additive value of two-dimensional and Doppler echocardiography in the detection of auscultatory mitral prolapse are emphasized.**

Reid (1) in 1961 and Barlow et al. (2) in 1963 proposed a mitral valve origin for the mid-systolic click. Since that time, mitral valve prolapse has been recognized as a clinical entity with a mid- to late systolic click, with or without a late systolic murmur, as its major auscultatory finding (3–8). Thus far, there has been no unanimity of opinion regarding diagnostic criteria for this disorder utilizing various invasive and noninvasive procedures (3–8). In 1970 and 1971, echocardiographic features of mitral valve prolapse were first described (9–11). However, subsequent studies (12–17) revealed a variable sensitivity and specificity of this method. Two-dimensional echocardiography has added to the diagnostic capability of ultrasound; however, the sensitivity of this technique has not been defined in this disorder (18–20). More recently (21–24), Doppler echocardiography has been employed but its usefulness in mitral valve prolapse is yet to be evaluated. We, therefore, prospectively studied the relative value of the three available echocardiographic techniques to define sensitivity and specificity of each in the diagnosis of mitral valve prolapse.

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## Methods

**Patient selection.** One hundred twenty-five consecutive patients who had auscultatory evidence (confirmed by two independent cardiologists) of mitral valve prolapse, that is, mid- to late systolic click, with or without a late systolic murmur, were studied. The mean age of this group of patients was 42 years (range 16 to 73). There were 46 men and 79 women. The click was variable in respect to the first heart sound, as demonstrated by physiologic maneuvers, such as standing and squatting. Of these 125 patients, 81 (65%) also had a systolic murmur associated with the click. All the patients had technically acceptable quality M-mode, two-dimensional and Doppler studies. These patients had no evidence of cardiac wall motion abnormalities by echocardiography. Other conditions that may be associated with mitral valve prolapse, such as atrial septal defect or hypertrophic cardiomyopathy, were also excluded by clinical examination and by other noninvasive techniques, including echocardiography. In order to assess the specificity of M-mode, two-dimensional and Doppler techniques, 30 other patients who had neither clinical nor angiographic evidence of mitral valve prolapse were also studied.

**Echocardiographic examination.** An M-mode echocardiogram was performed in a routine fashion with the transducer placed on the chest wall perpendicular to the mitral valve. Several scans were obtained from the aortic root to the left ventricular apex.



0735-1097/83/$3.00

JACC Vol 2, No. 6
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Two-dimensional echocardiograms were obtained in both the parasternal long-axis and apical four chamber views. The Doppler studies were performed either with a single crystal Doppler Scanner (two-thirds of the cases) or by a combined two-dimensional and Doppler (Duplex) scanner (one-third of the cases).

The transducer was placed one to three interspaces lower than that used for M-mode recording. Often, the transducer was directed from the left ventricular apex toward the mitral valve so as to project the beam as parallel to the mitral flow as possible. The sample volume was placed posterior to the mitral valve and this area was carefully searched from different angles. Both audio and spectral signals were recorded on videotape for subsequent analysis. The spectral sound signals were also registered on a strip chart recorder.

**Analysis of data.** After reviewing the records, two independent observers, who did not know the clinical status of the subjects, agreed on the diagnosis of mitral valve prolapse according to the following criteria (equivocal records were reported as negative):

*M-mode echocardiography.* 1) Mid- to late systolic prolapse: 2 mm CD segment depression (mitral closure to mitral opening points). 2) Pansystolic prolapse: 3 mm CD segment depression.

*Two-dimensional echocardiography.* Posterior or superior systolic displacement of the mitral valve from the level of the mitral anulus (long-axis or four chamber views, or both) (Fig. 1).

*Doppler echocardiography.* Mid- to late systolic flow signal posterior to the mitral valve (Fig. 2).

## Results

**Sensitivity.** In 9 of the 125 patients mitral valve prolapse was not detected by any of the echocardiographic techniques (overall echographic sensitivity of 93%). The relative value of the three echocardiographic techniques was then analyzed. The M-mode technique correctly detected 62 cases (sensitivity 50%). Two-dimensional echocardiography was positive in 85 cases (sensitivity 68%) and 90 cases were correctly detected with the Doppler technique (sensitivity 72%). The combination of either the two-dimensional or Doppler technique with M-mode echocardiography significantly increased the sensitivity (Table 1). When all three techniques were combined, 116 of the original 125 cases were accurately diagnosed (sensitivity 93%). The sensitivity of one technique when the other two were negative was 4% (6 cases) for M-mode, 13% (16 cases) for two-dimensional and 16% (20 cases) for Doppler echocardiography.

**Specificity.** In the 30 patients who had neither auscultatory nor left ventricular angiographic evidence of mitral valve prolapse, Doppler echocardiography detected prolapse in two cases and two-dimensional and M-mode techniques detected prolapse in one case each, suggesting a specificity of 93 and 97%, respectively.

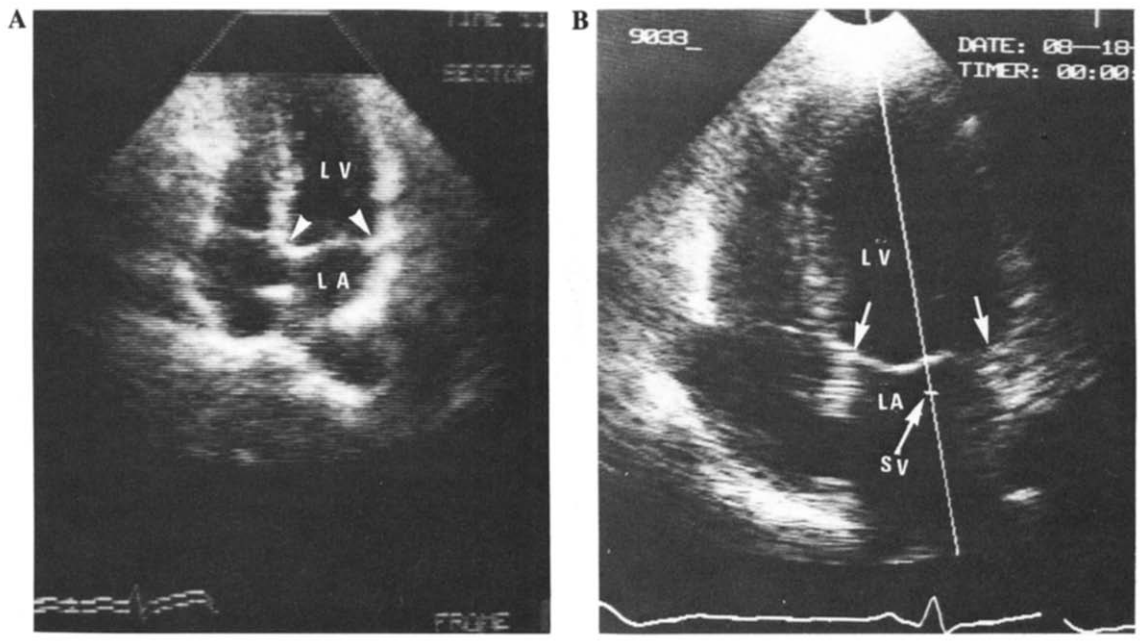


**Figure 1.** Two-dimensional echocardiograms, four chamber view. **A,** Normal. Coaptation of the normal mitral leaflets during systole is at the level of the mitral anulus (**arrows**) or slightly toward the left ventricle (LV). LA = left atrium. **B,** Mitral valve prolapse. The anterior mitral leaflet is displaced posteriorly toward the left atrium (LA) from the level of the mitral anulus, defined by drawing an imaginary line at the tips of the two **arrows.** The Doppler cursor line is shown to pass through the mitral valve. Sample volume (SV) on the cursor is shown by a **dot**.

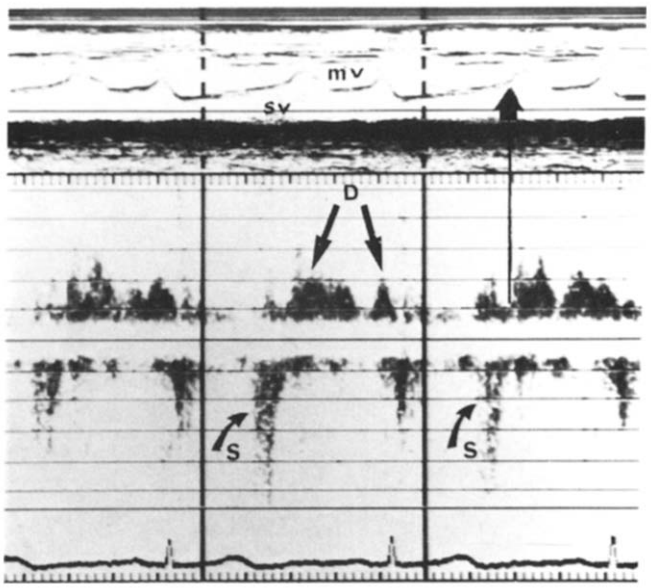


**Figure 2.** Mitral valve flow in mitral prolapse. The M-mode record of the anterior mitral leaflet (mv) is shown at the **top**, with the sample volume (sv) posterior to it. Normal mitral diastolic biphasic flow is indicated by two **straight arrows** (D). Late systolic negative flow (away from the anteriorly located transducer) is shown by two **curved arrows** (S). The timing of onset of ventricular diastole is indicated by the opening motion of the mitral valve (**arrowhead**).

## Discussion

This study was limited to patients who had auscultatory evidence of mitral valve prolapse. No attempt was made to document a mid- to late systolic click or late systolic murmur, or both, by phonocardiography as, in our experience, the yield of recording these by the latter method is relatively low. Other conditions that may be associated with mitral prolapse, such as atrial septal defect or hypertrophic cardiomyopathy, were excluded by means of noninvasive studies. Thus, all the patients appeared to have primary mitral valve prolapse.

**M-mode echocardiography.** The sensitivity of M-mode echocardiography in the detection of mitral prolapse in previous studies (25–28) ranged from 54 to 82%, with left ventricular angiography or midsystolic click, or both, as the standard. A lower yield has been reported (29) in the elderly. In our study, in a relatively heterogeneous age group, the detection rate (50%) by this technique was quite low.

**Table 1.** Sensitivity of M-mode (M), Two-Dimensional (2D) and Doppler (D) Echocardiography in 125 Cases of Mitral Valve Prolapse

| Technique | Cases | |
|---|---|---|
| | no. | % |
| M | 62 | 50 |
| 2D | 85 | 68 |
| Doppler | 90 | 72 |
| M + 2D | 96 | 77 |
| M + D | 100 | 80 |
| 2D + D | 111 | 89 |
| M + 2D + D | 116 | 93 |

*Various causes of false positive and false negative diagnoses of mitral valve prolapse by M-mode scan include* (13,30,31): 1) a too high or too low chest wall transducer position; 2) failure to record both leaflets of the mitral valve; and 3) not properly scanning from the aortic root to the apex, with special attention to the atrioventricular junctional level where the yield of detection appears to be higher. All of these pitfalls were carefully avoided in this study. Because relative lack of specificity has been reported (31) for pansystolic prolapse by M-mode echocardiography, this diagnosis was accepted only if recordings were obtained from a perpendicular transducer chest position and if the pansystolic prolapse was 3 mm or more from the level of the CD segment. Of 62 cases of prolapse detected by M-mode technique in this study, 7 were pansystolic. An overall low sensitivity of M-mode echocardiography, taking into consideration the technical problems, needs to be reaffirmed because this method alone is used in many institutions. In a recent report (32), a significant number of patients with clinical mitral valve prolapse, who had a normal supine M-mode echocardiogram, were found to have mitral prolapse by repeating the M-mode study in a standing position. However, a much higher rate of false positive identification of mitral valve prolapse also occurred with the latter maneuver.

**Two-dimensional echocardiography.** This technique has been suggested as superior to M-mode echocardiography, but its sensitivity in prolapse has not been defined (18–20). The normal mitral valve coapts during systole at the level of the mitral anulus or slightly inferiorly (toward the left ventricular cavity) (Fig. 1A). Gilbert et al. (19) and Morganroth et al. (20) accepted the diagnosis of mitral valve prolapse if the mitral leaflets bowed superiorly or posteriorly toward the left atrium from the level of the mitral anulus. Gilbert et al. used angiography as a standard while Morganroth et al. in their retrospective study did not have information regarding auscultation or angiography. In our prospective study using auscultation as the standard, the sensitivity of two-dimensional echocardiography was found to be significantly higher (68 vs. 50%) than that of M-mode study. Both long-axis and four chamber views were used in this study. In the 85 cases of mitral valve prolapse detected by two-dimensional technique, the long-axis view was positive in 44 (52%) and the four chamber view was positive in 70 (82%). Similar findings were reported in another study (20).

We also found that prolapse of the anterior mitral leaflet was significantly more common than that of the posterior leaflet, as seen in the four chamber view. It should be emphasized that the four chamber view is recorded in such a way that the atrioventricular axis is vertical on the screen

resulting in a horizontal presentation of the mitral anulus. Tilting of the chambers off the vertical axis, foreshortening of the left atrium, or views in between the long- and short-axis might create a false appearance of mitral prolapse or it might not be detected even though it is present.

**Doppler echocardiography.** This method has been used to detect mitral regurgitation in known cases (22,23) of mitral prolapse, but it has not been used to detect prolapse itself. We found that the mid- to late systolic flow signal posterior to the mitral valve was quite sensitive (72%) and highly specific (93%) for prolapse detected by auscultation. Many patients in this study did not have clinical or angiographic evidence of mitral insufficiency. It is possible that the vibration of the prolapsed portion of the mitral valve may occur (33), rather than mitral regurgitation, creating a mid- to late systolic Doppler signal. However, the signal is registered more as a flow rather than as a vibration of a solid structure and it may be that "blood flow in systole" does indeed occur but remains within the prolapsed scallop rather than entering the cavity of the left atrium and, therefore, can go undetected as mitral regurgitation by usual means. The flow signal associated with mitral valve prolapse was enhanced by handgrip if the heart rate increased. This maneuver is known to result in accentuation of the click-murmur of mitral valve prolapse. When mitral prolapse was associated with regurgitation, the systolic flow signal was prolonged, similar to that noted in mitral insufficiency from any other cause. However, there was usually a mid- to late systolic accentuation of the flow when it was secondary to prolapse.

Thus, the Doppler method appears to present an advantage in the detection of associated mitral regurgitation that may be helpful in identifying a subset of patients more at risk for complications (22). Furthermore, in technically difficult patients in whom the four chamber view was not adequately recorded or evidence of mitral valve prolapse was only borderline, Doppler echocardiography helped support such a diagnosis. Because the flow signal is localized to the prolapsed scallop, a careful search from different beam positions is necessary in order not to miss the characteristic signal.

**Implications.** The sensitivity of each of the ultrasonic techniques in detecting auscultatory proven prolapse in our study was relatively low, especially for M-mode echocardiography. It is possible that many of our patients had a rather small prolapse (only 65% were associated with a systolic murmur) that, although causing a systolic click, was still not significant enough to be recorded by ultrasound. Because different cardiac windows are employed by these echocardiographic techniques, it is easy to see why individual sensitivities may differ and why a combined modality would be more helpful in detecting mitral valve prolapse.

Whether mitral valve prolapse, which is suspected on clinical grounds and confirmed by echocardiography has a significance other than prolapse detected by auscultation alone or echocardiography alone remains unknown. At present, the physician who employs echocardiography in his diagnostic procedures should appreciate the relative merits of each of the described techniques as well as their complementary role when used for the detection of mitral valve prolapse.

We acknowledge the technical assistance of Marty Allen and Allan Fraser in this study.

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