Idiopathic Mitral Valve Prolapse
—Analysis by Real-time Two-dimensional Echocardiography—

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Mitral valve prolapse is diagnosed in real-time two-dimensional echocardiograms when there are discrepancies in the coaptation zone of the anterior mitral leaflet and the posterior mitral leaflet. Out of the 100 cases of mitral valve prolapse diagnosed in this way, 65 had prolapsed anterior mitral leaflets, 28 prolapsed posterior mitral leaflets and 7 prolapses of both the anterior and posterior mitral leaflets. In addition to the cases with mitral valve prolapse, 23 cases of ruptured chordae tendineae of the mitral valve, including 15 cases which had undergone surgery, were investigated.

The frequent site of mitral valve prolapse was the posteromedial commissure in the anterior leaflet and the posteromedial and anterolateral commissures in the posterior leaflet. These sites coincide with those where rupture of the chordae tendineae of the mitral valve was apt to occur.

An investigation of the relation between age and mitral valve prolapse showed that the number of cases of prolapsed anterior leaflet did not increase with age, but there was an age-related increase in the number of cases of prolapsed posterior leaflets. It was also found that the degree of the prolapse progressed with age. Many of the cases of ruptured chordae tendineae of the mitral valve were in their forties or fifties, and there appeared to be some relation between the progress of the prolapse and age.

Mitral regurgitant murmurs were recorded on phonocardiograms, and the severer the degree, the wider the range of the prolapse. Mitral regurgitation was more likely to occur in cases of prolapsed posterior leaflets than in those with prolapsed anterior leaflets, even if the degree and the range of the prolapse were mild.

Visualization of the morphology and dynamics of the mitral valve is possible by means of real-time two-dimensional echocardiography. In this paper, a standard for the diagnosis of mitral valve prolapse by real-time two-dimensional echocardiograms are proposed based on the morphological characteristics of idiopathic mitral valve prolapse seen in such echocardiograms. The pathophysiological changes occurring in the prolapsed mitral valve have been analyzed on the basis of this diagnostic standard.

Key Words:
Idiopathic mitral valve prolapse
Two-dimensional echocardiography
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PATIENTS
As the subjects of this study 100 patients, 55
males and 45 females, in whom a sufficient recording could be obtained, were selected from the 113 patients diagnosed as mitral valve prolapse between May, 1978 and October, 1980 by means of real-time two-dimensional echocardiograms. Their ages ranged from 15 to 79 years (average: 41.5). Twenty-three patients (age range: 31 to 72; average: 53.2 years), diagnosed as having ruptured chordae tendineae of the mitral valve by real-time two-dimensional echocardiograms during the same period, were also included in the study. Among these 23 cases (16 males and 7 females) of ruptured chordae tendineae of the mitral valve, 15 underwent surgery and ruptured chordae tendineae were found in 16 locations. Among these 16 ruptures, 13 (81%) could be correctly diagnosed preoperatively by real-time two-dimensional echocardiograms.

Cases of mitral valve prolapse complicated by other heart diseases such as atrial septal defect of secundum type and hypertrophic cardiomyopathy were not included in the present study.

METHODS

Patients were examined in the supine position. Because the area of greatest interest was the mitral valve, all studies were performed with the transducer placed on the anterior chest wall at the level directly anterior to the mitral valve.
Fig.3. Forms used for diagnosis and evaluation of the degree of mitral valve prolapse on real-time two-dimensional echocardiograms. In healthy subjects, there are no discrepancies in the coaptation zone of the anterior and posterior leaflets (AML, PML respectively) of the mitral valve. When there is a discrepancy in the coaptation zone, the case can be diagnosed as mitral valve prolapse. The degree of prolapse can be decided by measuring the distance of this discrepancy. Degree I = discrepancies of 5 mm or less; degree II = discrepancies of 6 to 10 mm; degree III = discrepancies of 11 mm or more.

which was usually in the third or fourth intercostal space near the left of the sternum. Care was especially taken to assure that the mitral valve was positioned in the center of the picture because of the poor resolution around the edges.

The equipments used were commercially available real-time two-dimensional echocardiographs, Toshiba SSH-11A with a 78° phased array system, and Aloka SSD-800 with an 80° phased array system.

*Diagnosis of Mitral Valve Prolapse and Evaluation of the Degree of Prolapse by Real-time Two-dimensional Echocardiography*

Patients were diagnosed as having mitral valve prolapse if discrepancies were found in the coaptation zone between the anterior and posterior leaflets of the mitral valve by real-time two-dimensional echocardiography. Conventionally, mitral valve prolapse was diagnosed by real-time two-dimensional echocardiography in cases where the mitral valve had passed the mitral ring and protruded into the left atrium (Fig.1). However, mid-systolic click and/or late systolic murmur which are characteristic of mitral valve prolapse have been found in phonocardiograms in cases where the mitral valve did not pass beyond the mitral ring. In such cases, discrepancies in the coaptation zone between the anterior and posterior leaflets of the mitral valve

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*Fig.4. Method of obtaining a long axis view of the mitral valve in 3 directions. To determine the location of the prolapse in the mitral valve, echocardiograms of the mitral valve and the subvalvular tissues were observed near the posteromedial commissure (M), in the center (C) and near the anterolateral commissure (L). In this case, prolapse was found near the posteromedial commissure and in the center of the mitral valve, but there was no prolapse near the anterolateral commissure.*

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can be seen in real-time two-dimensional echocardiograms (Fig. 2). Since there are no such discrepancies between the anterior and posterior leaflets of the mitral valve in healthy subjects, cases with such discrepancies in the coaptation zone in real-time two-dimensional echocardiograms can be diagnosed as mitral valve prolapse.2-3

The degree of the mitral valve prolapse was evaluated by measuring the distance of the discrepancy between the anterior and posterior leaflet of the mitral valve. These distances of the discrepancies between the anterior and posterior leaflets of the mitral valve were graded as follows: those within 5 mm (degree I), those from 6 to 10 mm (degree II) and those 11 mm or more (degree III). In the cases in which both the anterior and posterior leaflets protrude into the left atrium, the distance between the mitral ring and the leaflet was measured (Fig. 3).

To determine the location of the prolapse, long axis views of the mitral valve were obtained in 3 directions. First, the leaflet, chordae tendineae and posterior papillary muscle near the posteromedial commissure of the mitral valve were traced. Then the center of the mitral valve was traced with the transducer facing the outer side from the posteromedial commissure. Tracings of the leaflet, chordae tendineae and anterior papillary muscle near the anterolateral commissure were also made with the transducer facing outwards (Fig. 4). By means of this method, it is possible to clarify the location of the prolapse of the mitral valve.

Prolapse coefficients from 1 to 9 were devised in order to evaluate the range and the degree of mitral valve prolapse. This coefficient is expressed as a product of the degree of prolapse and number of locations involved. For example, when a prolapse of degree III (discrepancy of 11 mm or more) was found in 3 locations, i.e., near the posteromedial commissure, in the center and near the anterolateral commissure of the mitral valve, the prolapse coefficient was expressed as 9.

RESULTS

Age Distribution of Mitral Valve Prolapse
Among 100 cases of mitral valve prolapse, 65 cases had prolapse of the anterior mitral leaflet,
Fig. 7. Location of prolapse in cases of prolapsed anterior leaflet. In cases of prolapsed anterior mitral leaflet, the most severe prolapses were found near the posteromedial commissure (PMC) in 37 out of 65 cases. The most severe prolapses were in the center of the valve (C) in 7 cases and near the anterolateral commissure (ALC) in 5 cases.

Fig. 8. Location of prolapse in cases of prolapsed posterior leaflet. In cases of prolapsed posterior mitral leaflet, the most severe prolapses were found near the posteromedial commissure in 10 out of 28 cases. The most severe prolapses were in the center of the valve in 2 cases and near the anterolateral commissure in 7 cases. Prolapsed posterior leaflets are most likely to occur near the posteromedial and anterolateral commissures.
Fig. 9. Location of ruptured chordae tendineae of the mitral valve. Locations (23 cases, 24 locations) of ruptured chordae tendineae of the mitral valve were confirmed in real-time two-dimensional echocardiograms or surgery. Chordal ruptures occurred common near the anterolateral and posteromedial commissures of the posterior leaflet and near the posteromedial commissure of the anterior leaflet. These locations are the same as those where the prolapses are apt to occur. AML = anterior mitral leaflet, PML = posterior mitral leaflet.

Fig. 10. Prolapse coefficients of the anterior leaflet and phonocardiographic findings. The investigation of prolapse coefficients which indicate the degree and extent of the prolapse and phonocardiographic findings showed that mitral regurgitant murmurs appeared with higher prolapse coefficients. Mitral regurgitant murmurs were recorded in all 12 cases with prolapse coefficients of 4 or more. In 20 out of 44 cases with prolapse coefficients of 3 or less, no mitral regurgitant murmur was recorded.

28 of the posterior mitral leaflets and 7 of both the anterior and posterior leaflets. There were no increases in the number of cases of anterior leaflet prolapse with age, but the number of cases of posterior leaflet prolapse tended to increase with age (Fig. 5). When cases with ruptured chordae tendineae of the mitral valve were included, there was a clear tendency of the number of prolapse of the posterior leaflet to increase with age (Fig. 6). Many of the patients with ruptured chordae tendineae were in their forties and fifties.

Fig. 11. Prolapse coefficient of the posterior leaflet and phonocardiographic findings. Mitral regurgitant murmurs were recorded in 15 out of 18 cases with prolapse coefficients of 3 or less. There tended to be more mitral regurgitant murmurs in prolapse of the posterior leaflet than in prolapse of the anterior leaflet.

Location and Degree of Mitral Valve Prolapse

The results of long axis views of the mitral valve in 3 directions permit confirmation of the location of the prolapse, i.e., either being near the posteromedial commissure, in the center or near the anterolateral commissure of the mitral valve. In 37 (57%) of the 65 cases of prolapsed anterior mitral leaflets, the degree of the prolapse became more severe as the prolapse occurred nearer to the posteromedial commissure. There were 7 cases of severe prolapse in the center (11%) and 5 cases of severe prolapse near the anterolateral commissure (8%) (Fig. 7). Among the 28 cases of prolapses of the posterior leaflet, the most severe prolapse occurred near the posteromedial commissure in 10 cases (36%), in the center of the valve in 2 cases (7%) and near the anterolateral commissure in 7 cases (25%) (Fig. 8). Therefore, in the cases of the posterior leaflet, the prolapse tended to be more severe.
near both the anterolateral and posteromedial commissures, while in the case of the anterior leaflet, the prolapse was more apt to occur near the posteromedial commissure.

**Location of Ruptured Chordae Tendineae in Cases of Ruptured Chordae Tendineae of the Mitral Valve**

The location was decided either by surgeon during the operation or by the site of the strongest degree of mitral valve prolapse on a real-time two-dimensional echocardiograms in cases without surgery. The results indicate that the ruptured chordae tendineae were often near the posteromedial commissure of the anterior mitral leaflet and near the posteromedial and anterolateral commissures of the posterior mitral leaflet (Fig. 9). The areas where these ruptures are most apt to occur coincide with those where the mitral valve prolapse is most likely to occur.

**Relation between Prolapse Coefficients and Phonocardiographic Findings**

Phonocardiograms were obtained in 83 out of the 100 cases of mitral valve prolapse. When the relation between the prolapse coefficients, which show the degree and extent of the prolapse, and the phonocardiographic findings was examined, it was found that the cases of prolapsed anterior leaflet with higher prolapse coefficients showed late systolic murmur with or without middysystolic click or pansystolic murmur. In all 12 cases with prolapse coefficients of 4 or more, pansystolic regurgitant murmurs of the mitral valve were recorded. However, in 20 of the 44 cases with prolapse coefficients of 3 or less, no abnormalities were found on the phonocardiograms or there was only a midsystolic click (Fig. 10).

In cases of prolapse of posterior leaflet, 15 of the 18 cases with prolapse coefficients of 3 or less showed mitral regurgitant murmur. This differed from the findings observed in the prolapsed anterior leaflet. In the cases with posterior leaflet prolapse, mitral regurgitant murmur was often recorded even in cases with low prolapse coefficients (Fig. 11).

**DISCUSSION**

Hitherto, there is still no definite standard for diagnosing mitral valve prolapse by real-time two-dimensional echocardiography. This is due to the fact that there are continuous changes of the valve in cases of mitral valve prolapse and also that it is difficult to distinguish the equivocal lesion from the normal variance. In the reports up to now, a method has been proposed to diagnose mitral valve prolapse in the cases where the mitral valve extends into the left atrium beyond the mitral ring. However, there are cases in which the diagnosis can not be ascertained by this method in spite of the presence of a typical midsystolic click and late systolic murmur (Fig. 2). In this paper, it is proposed that mitral valve prolapse be diagnosed on real-time two-dimensional echocardiograms when there are discrepancies in the coaptation zone of the anterior and posterior mitral leaflets. In healthy persons, there are no discrepancies in the coaptation zone between the anterior and posterior leaflets and the presence of such discrepancies on real-time two-dimensional echocardiograms can be considered as abnormal findings. When the distance of the discrepancies of the posterior and anterior mitral valve leaflets is measured, the results can be used to decide the degree of the prolapse. (I: mild, discrepancy of 5 mm or less, II: moderate, discrepancy between 6 and 10 mm, and III: severe, discrepancy of 11 mm or more).

On the basis of this diagnostic standard, the ratio of anterior to posterior leaflet in mitral valve prolapse was 2.3:1, i.e., there were more cases of prolapse of the anterior mitral leaflet. The number of cases of prolapsed anterior leaflet did not tend to increase with age, but there was a tendency to increase with age in the cases of prolapsed posterior leaflet. When cases of ruptured chordae tendineae of the mitral valve were included, a tendency of an increasing occurrence of the prolapsed posterior mitral leaflet with age became clearer.

Concerning the anterior leaflet, the prolapse is most apt to occur near the posteromedial commissure. This is the same site as that found in dogs by Kogure. In dogs, the degree of the mitral valve prolapse tended to become more severe with age, and the accumulation of acid mucopolysaccharide was found to be a histological feature at the site of the prolapse.

The prolapse was most likely to occur near the posteromedial and the anterolateral commissures in the posterior leaflet and near the posteromedial commissure in the anterior leaflet. These areas are the same as those in which ruptured chordae tendineae are most likely to appear. This is very interesting since it suggests the possibility of ruptured chordae tendineae

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occurring as a result of the progress of mitral valve prolapse. Out of 15 cases of ruptured chordae tendineae of the mitral valve which underwent surgery, histological examinations of the resected valves were made in 8 cases. Myxomatous degeneration was found to be severe in 6 cases and moderate in one. There was no myxomatous degeneration in the remaining one case.

The possibility of increasing frequency of mitral valve prolapse with age can be anticipated since the degree of the prolapse becomes more severe with age. The fact that most cases of ruptured chordae tendineae are in their forties and fifties might also support the hypothesis that prolapse progresses with age. The possibility that mitral valve prolapses progress with age and are then followed by ruptured chordae tendineae has already been pointed out by Jeresaty.11

REFERENCES


