THE CAUSATIVE MECHANISMS OF MITRAL VALVE PROLAPSE IN PROGRESSIVE MUSCULAR DYSTROPHY IN REFERENCE TO THORAX AND THORACIC SPINE DEFORMITIES AND LEFT VENTRICULAR DYSFUNCTION.

Yoshimitsu Yazawa, M.D., Eiji Ohtaki, M.D., Tsuneo Nagai, M.D.
Senji Hayashi, M.D., Osamu Hosokawa, M.D., Kenichi Watanabe, M.D.
Akira Shibata, M.D., and Naoyuki Takasawa, M.D.*

The causative mechanisms of mitral valve prolapse (MVP) were evaluated in 58 patients with progressive muscular dystrophy (PMD). Two possible causes, 1) left ventricular (LV) dysfunction and 2) thoracic spine and thorax deformities were assessed. Patients were classified into three groups by echocardiographic findings. Group 1: 31 patients without MVP, group 2: 11 patients with MVP confirmed only by M-mode echocardiogram, group 3: 16 patients with MVP confirmed by both two-diemnsional and M-mode echocardiograms.

LV functions evaluated by systolic time intervals and fractional shortening showed no significant differences among the three groups.

Scoliosis of the thoracic spine was not related to the incidence of MVP. Lordotic or straight spines were found in 32.3%, 100%, 93.8% of cases in group 1, group 2 and group 3, respectively, and the incidences of MVP in cases with kyphosis, straight spine and lordosis were 4.8%, 66.7% and 77.8%, respectively.

The shape of the thorax as evaluated by the ratio of anteroposterior internal diameter to transverse diameter was more flattened in groups 2 and 3 than in group 1.

From these results, we concluded that LV dysfunction was not related to the incidence of MVP and that the lordotic or straight spine and the flattened thorax were supposed to be the major factors in the occurrence of MVP in PMD.

Mitral valve prolapse (MVP) is frequently seen in patients with progressive muscular dystrophy (PMD)1–6. The etiology of MVP has also been studied in PMD. Left ventricular asynergy and dysfunction of the papillary muscle due to the degeneration and fibrosis of the left ventricular myocardium and papillary muscles have already been reported as the main causes2–4.

In PMD, deformities of the thorax and thoracic spine are known to progress gradually. It is quite possible that these thorax and thoracic spine deformities exert an influence on the cardiopulmonary function.

It has also been reported that MVP is very fre-
quently observed in cases with general connective tissue disorders showing variable deformities of the body. In these cases the presence of simultaneous histologic changes in the mitral valve and its supporting tissue is considered to be the cause of MVP.

It is unlikely that the cause of MVP is identical in all cases, and, particularly in cases with severe deformities in the skeleton and thorax, like PMD, in which the influence of the thoracic spine and thoracic deformities on the heart may be great. However, as far as we know, there has been no report dealing with how the form and degree of deformities of the thoracic spine and thorax are connected with the development of MVP.

The purpose of this study is to clarify the roles of two possible causes of MVP in PMD, that is, (1) left ventricular dysfunction evaluated according to the severity of the degeneration of the left ventricular myocardium and papillary muscles, and (2) the shape and degree of thorax and thoracic spine deformities.

MATERIALS AND METHODS

The subjects were 58 patients with PMD comprising 49 cases of the Duchenne type, 8 of congenital muscular dystrophy and 1 of the fascio-humero-scapular type. The average age was 16 years (7-26 years), with 57 male and 1 female patients.

Real-time, two-dimensional echocardiograms and M-mode echocardiograms were recorded on video tape and a stripchart using an echocardiograph (SSH-11A, Toshiba Co.) The recording was conducted with the patient in the supine or semi-left lateral position. To observe the presence of MVP, a long-axis view of the left ventricle through the mitral valve was obtained, and the sectional plane was turned medially first and then laterally till the anterior and posterior commissures. M-mode echocardiograms of the mitral valve were recorded simultaneously.

The diagnosis of MVP was made when both or either of the anterior or posterior leaflet of the mitral valve was seen protruding into the left atrium beyond the mitral ring in the systolic period on the real-time, two-dimensional echocardiogram, or, when the mitral valve showed a backward movement in the latter half of the systolic period or a pansystolic backward movement exceeding 3 mm on the M-mode echocardiogram.

The function of the left ventricle was evaluated by the fractional shortening calculated from the M-mode echocardiogram, and by the ratio of the pre-ejection period to the ejection time (PEP/ET) of the left ventricle, calculated from the carotid artery pulse which was recorded simultaneously.

As for the chest X-ray films, a frontal picture (A-P view) and a lateral picture were taken with the patient in the supine and in the left or right lateral position and with the respiration withheld.

In order to assess the deformity of the thoracic spine from the frontal view, the degree of scoliosis expressed as an angle proposed by Cobb was measured. In addition, the degree of shift of the thoracic spine evaluated as the ratio of the distance from the midline to the thoracic spine on the horizontal line passing through the upper margin of the diaphragm, divided by the transverse diameter of the thorax (Fig. 1). Using the lateral picture of the chest, the shape of the thoracic spine was classified into kyphosis, straight spine and lordosis groups.

To evaluate the deformity of the thorax, the anteroposterior diameter of the thorax from the inside of the sternum to the anterior margin of the eighth thoracic vertebra was divided by the

1) Form of thoracic spine
   (1) by A-P view
       Scoliosis
       Cobb’s method
       Shift of thoracic spine
       c/a

   (2) by lateral view
       Kyphosis
       Straight spine
       Lordosis

2) Form of thorax
   Flattening ratio of thorax
   b/a

Fig.1. Method of measurement by chest X-ray film. Scoliosis of the thoracic spine is measured with Cobb’s method in the frontal (A-P) view. The shift of the thoracic spine (c/a) is determined at the level of the 8th thoracic vertebra. The form of the thoracic spine is classified into lordosis, straight spine and kyphosis in the lateral view. The degree of flattening of the thorax is evaluated by a ratio of anteroposterior internal diameter to the transverse internal diameter (b/a) of the thorax.

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Fig. 2. A real-time, two-dimensional echocardiogram (left), and a M-mode echocardiogram (right) of a 14 year old male. left: Both anterior and posterior leaflets of the mitral valve showed prolapse beyond the mitral ring (black arrow). right: Pansystolic bowing of the mitral valve was observed. LV = left ventricle; Ao = Aorta; LA = left atrium; RV = right ventricle.

Fig. 3. Comparison of the fractional shortening among the groups. No statistically significant difference was observed between the groups.

Fig. 4. Comparison of the systolic time intervals among the groups. No statistically significant difference was observed between the groups.

The patients were classified into three groups on the basis of echocardiographic findings: Group 1 (G1); 31 cases who showed no MVP on the echocardiograms, Group 2 (G2); 11 cases who showed findings of MVP on the M-mode echocardiograms but were not confirmed by the real-time, two-dimensional echocardiograms, Group 3 (G3); 16 cases who showed prolapse of both or either of the anterior or posterior leaflet of the mitral valve on the real-time, two-dimensional echocardiograms and findings of MVP on the M-mode echocardiograms.

The student t test was used to compare differences between group means in each parameter.

RESULTS
A real-time, two-dimensional echocardiogram

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and a M-mode echocardiogram of a 14 year old male with MVP is demonstrated. He showed a flattened thorax with a straight spine (Fig. 2).

1. MVP and the left ventricular function.

Fractional shortening showed no statistically significant difference between the three groups (G1: 23.1 ± 11.7%, G2: 22.5 ± 12.5%, G3: 26.7 ± 9.2%). A low fractional shortening of 10% or less, was found in 6 cases in group 1, but only in 2 cases in group 2 and in none in group 3 (Fig. 3).

Left ventricular function evaluated by PEP/ET showed no statistically significant difference among the three groups (G1: 0.398 ± 0.129, G2: 0.400 ± 0.118, G3: 0.385 ± 0.071). Cases showing severe left ventricular dysfunction were more numerous in group 1 than in groups 2 and 3 (Fig. 4).

2. MVP and deformities of the thoracic spine and thorax.

The incidence of MVP was studied with regard to the grade of thoracic scoliosis (Fig. 5). Many cases with MVP were found at low-degree scoliosis.

The incidence of each form of thoracic spine among the cases of mitral valve prolapse (left), and among the cases without prolapse (right). The relationship between prolapse and lordosis or straight spine is clearly seen.

Fig.8. Comparison of the groups as to the degree of the flattening of the thorax. Groups 2 and 3 showed high-degree flattening of the thorax compared with group 1.

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Fig. 9. Relationship between the degree of flattening of the thorax and the shift of the thoracic spine to the right or left from the center. There is difference in the degree of flattening between group 1 and groups 2, 3 but no difference in the degree of shift between the groups.

(G1) were 67.7%, 19.4% and 12.9%, respectively.

The degree of flattening of the thorax was compared among the groups (G1: 41.6 ± 6.4%, G2: 28.8 ± 7.2%, G3: 23.4 ± 7.5%, Fig. 8). In groups 2 and 3 as compared with group 1, the thorax was significantly flattened, reflecting a marked anteriorly bent thoracic spine. The relations of the degree of shift of the thoracic spine to the right or left, the degree of flattening of the thorax and the incidence of MVP are shown in Fig. 9. Group 1 and group 2 could be divided clearly into two, one upward (G1) and the other downward (G2 and G3) as the degree of flattening of the thorax changed, but no relation was observed between the incidence of MVP and the direction or degree of the shift of the thoracic spine.

DISCUSSION

The incidence of MVP in PMD has been reported to be high, being 25% to 55%3 In this study, it was 27.6% for MVP confirmed by the real-time, two-dimensional echocardiography and 19.0% for MVP observed on the M-mode echocardiography but not confirmed by the real-time, two-dimensional echocardiography. When these were collated, the incidence reached 46.6%.

The reports published previously on MVP seen in PMD are mostly those studies using M-mode echocardiography and few are using real-time, two-dimensional echocardiography. Hirata et al.17 have reported PMD cases who showed a systolic backward movement of the mitral valve on the M-mode echocardiogram but did not show prolapse on the real-time, two-dimensional echocardiography. The results of our study were similar, there being 11 cases in whom no significant MVP was detected by real-time, two-dimensional echocardiography but a systolic backward movement of the mitral valve was observed on M-mode echocardiograms. This may indicate that the pansystolic bowing of the mitral valve was resulted from the abnormal motion of the mitral valve as they had suggested, and that the diagnostic criteria of MVP we used in M-mode echocardiography were not adequate enough for the diagnosis of MVP. On the contrary, it may be that the real-time, two-dimensional echocardiography is less sensitive in finding a subtle prolapse of the mitral valve. Although we admit the existence of these problems, the diagnosis of MVP by real-time, two-dimensional echocardiography, imperfect as it is, is still the most useful and reliable among the diagnostic methods now available. Accordingly, it is possible that cases who showed a systolic backward movement of the mitral valve which was due to causes other than prolapse were included in the group classified as MVP patients. Many researchers have already pointed out that the systolic backward movement (particularly the pansystolic backward movement) as the criterion for MVP using the M-mode echocardiography is not completely reliable for diagnosing diseases other than PMD18-21.

There have been reports that deformities of the thoracic spine and thorax are related to the development of MVP in diseases other than PMD7-11,23 However, no established theory on the causal relationship between the two has been presented. Salmon et al.8 have suggested that abnormalities of the connective tissue of the whole body and mucoid degeneration of the valvular tissue coexist congenitally, and give rise to the development of deformities of the thoracic spine and thorax complicated with MVP. They have also maintained that direct pressure to the heart is not the major cause of MVP, although it could account for MVP in a limited number of cases.

Bon Tempo et al.9 have observed that there are many cases with thoracic spine and thorax deformities among patients with systolic click-
late systolic murmur syndrome, a type of MVP, and have mentioned congenital and developmental abnormality of the connective tissue as the common cause.

Many authors have reported about PMD complicated with MVP but there has been no report dealing with the causal relationship between the thorax and thoracic spine deformities and MVP. According to the results of our present study, there was a distinct correlation between the extent and the form of thorax and thoracic spine deformities and the incidence of MVP. However, the degree of scoliosis of the thoracic spine and the extent of shift of the thoracic spine to the right or left showed no relationship to the incidence of MVP, but it was demonstrated that the anteriorly bent or shifted thoracic spine (lordosis or straight spine) is significantly related to the development of MVP.

Assuming that there are some abnormalities in the connective tissue and supporting tissue in PMD and that these are common causes in the development of MVP and deformities of the thoracic spine and thorax, this provides no explanation of the results that the development of MVP is significantly correlated with the anteriorly bent thoracic spine but not to the degree of scoliosis or the shift of the thoracic spine to right or left. Therefore, it is possible that the deformities of the thoracic spine and thorax, and particularly the forward bending of the thoracic spine and the concomitant flattening of the thorax produced direct pressure on the heart which resulted in changes in the shape and hemodynamics of the heart in PMD and that MVP was one of the phenomena reflecting these results.

After studying autopsied cases, Sanyal et al. have proposed that the development of MVP in PMD is not due to histological changes in the mitral leaflet, mitral ring and chorda tendinea but to dysfunction of the papillary muscle or abnormal contraction of the left ventricular wall, all of which resulted from the degeneration of the papillary muscles and the left ventricular myocardium. They have also suggested that deformity of the thorax and cardiac enlargement may play a part in the etiology of MVP, but have not published data to substantiate this.

Dysfunction of the papillary muscle is not commonly reported as the cause of MVP and mitral insufficiency and, in contrast, many reports have shown a low incidence of such abnormalities in papillary muscle dysfunction.

Abnormal contraction of the left ventricular wall is also mentioned as one of the causes of MVP. However, MVP is found in a limited number of cases despite there being many diseases with abnormal contraction of the left ventricle. This hypothesis alone fails to provide a satisfactory explanation.

According to our results on the cardiac function, the development of MVP was not directly related to the degree of depression of the left ventricular function and many cases with severe left ventricular dysfunction were found in the group free of MVP. Therefore, the impairment of the myocardium and the cardiac function cannot be directly linked to the development of MVP on the basis of our results. Granted that degeneration of the papillary muscle and the left ventricular myocardium do not progress in the same manner, dysfunction of the papillary muscle and abnormal contraction of the left ventricular wall are bound to present themselves more conspicuously in cases with severely depressed cardiac function. Considering these facts together with our data on the degree of depression of the cardiac function and the incidence of MVP, it is not likely that dysfunction of the papillary muscle and abnormal contraction of the left ventricular wall are the main causes of MVP in PMD.

The idea that MVP develops due to the same cause and mechanism in all cases is unreasonable and it is surmised that the factors involved differ from one case to another, and the results of our study seem to suggest that the thorax and thoracic spine deformities rather than the dysfunction of papillary muscle or the abnormality of contraction of the left ventricular wall are related more closely to the development of MVP in PMD.

REFERENCES

4. REEVES W, GRIGGS R, NANDA NC, THOMSON K, GRAMIKA R: Echocardiographic evaluation of

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