PREOPERATIVE EVALUATION OF THE STRUCTURAL LESION
OF THE MITRAL VALVE BY M-MODE SCAN ECHOCARDIOGRAPHY

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M-mode scan echocardiographic studies of the mitral valve were performed in
order to investigate structural architecture of the diseased mitral valve. Structural
lesion of the mitral valve was assessed by the echo-pattern change, an
increase in number or thickness of the diastolic mitral echo complex. The
echo-pattern was classified into 4 grades according to number or thickness of
the mitral echoes. The echo-pattern grade correlated with the degree of the
structural lesion of 21 surgically excised mitral valves. Clinically, the echo-
pattern grade was compared with subsequent operative procedure in 56 cases
with pure or predominant mitral stenosis (42 open commissurotomy, 14 valve
replacement). Grade I or grade II echo-pattern was a good indicator for mitral
commissurotomy. Grade IV pattern was a reliable criterion for valve replace-
ment. Mitral valve replacement should be also considered in cases with grade
III pattern, 38 percent of whom underwent valve replacement. C-E amplitude
of the mitral valve was not a useful parameter in assessing the surgical
procedure. Thus, the echo-pattern obtained by M-mode scan technique
appeared to be of value in planning the surgical approach for patients with pure
or predominant mitral stenosis.

ECHOCARDIOGRAPHY has been demonstrated
by many authors to be a valuable method
in the diagnosis and evaluation of mitral
stenosis. Structural architecture of the mitral
valve, such as fibrous thickening or calcification,
is an additional factor which influences the
surgical decision regarding commissurotomy or
valve replacement. Echocardiography also has
been reported to be of value in assessing this
lesion. However, conventional echocardiography

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Fig.1. Directions of the transducer of the sector scan
(M-mode scan). See text for details.
usually investigates echoes from the limited parts of the mitral valve and does not seem satisfactory for evaluation of the structural lesion of the valve.

Therefore, M-mode scan technique was employed in this study in order to obtain echoes widely from various parts of the mitral valve apparatus. The purpose of this report is to describe the usefulness of this technique in assessing the structural lesion of the mitral valve and in planning the surgical approach, commissurotomy or valve replacement.

METHODS AND MATERIALS

Echocardiographic examinations were performed using Smith-Kline Ekoline 20 with a 2.25 MHz, 0.5 inch transducer. M-mode scan echocardiography was carried out in three directions as shown in Fig.1. Scan A is the sector scan from the aortic root to the mitral chordae along the long axis of the left ventricle. Scan B is the scan along the short axis of the left ventricle at
Structural Mitral Valve Lesion by M-mode Scan Echocardiography

Fig. 3. A representative M-mode scan echocardiogram of the mitral valve from a patient with heavily calcified valve who underwent valve replacement. The technique of M-mode scan is similar as in Fig. 2. The most constantly appearing echo-pattern is multiple parallel echoes which occupy the entire space between the anterior and posterior leaflets. In this case, as it is impossible to identify echoes from each leaflet separately, both leaflets are assumed as grade IV pattern.

the level where echoes from the anterior and posterior leaflets are simultaneously obtained. Scan C is the scan along the short axis at the level of the chordae tendinae. All these echochograms were recorded on polaroid films. Scan A was usually recorded on three films, scan B on two films and scan C on one film as shown in Fig. 2 and Fig. 3.

Structural lesions of the mitral valve were assessed by the echo-pattern change such as number or thickness of the diastolic mitral echo complex (Fig. 4). Single or double diastolic echoes were denoted as grade I. Grade II was defined as 3 to 5 diastolic echoes and echo thickness of 6 mm or less. Grade III was defined when the number of diastolic echoes exceeded 6 or echo thickness over 6 mm except grade IV pattern. Grade IV was denoted when multiple parallel echoes occupied the entire space between the anterior and posterior leaflets. Echo-pattern grade of a given leaflet was described by choosing the pattern which appeared most constantly in a series of echochograms (Fig. 2 and Fig. 3).

For the assessment of the echo-pattern, the sensitivity of the instrument was adjusted so that it was low enough to obliterate the intracavitary echoes but high enough to show the left side of the ventricular septum distinctly. As shown in Fig. 5, a recording obtained at suboptimal gain may mask some echoes. However, higher gain setting does not alter the echo-pattern appreciably.
Fig. 4. Grading of the echo-pattern. The echo-pattern was classified into 4 grades according to number or thickness of the diastolic mitral echo complex. See text for details.

Fig. 5. Effect of instrument sensitivity. The echo from the left side of the ventricular septum is not recorded clearly at suboptimal gain (left panel). Excess gain setting (right panel) results in numerous intracavitary echoes. Optimal recording (center panel) shows the left side of the ventricular septum distinctly and few intracavitary echoes.
Fig. 6. Method for calculation of the density index. According to its density on the X-ray film (left panel), the leaflet was divided into 7 different colored areas using NAC color data system 1200 (right panel). Then the density index was obtained from the following equation: density index = \(1/7 \cdot (a_1 + 2a_2 + 3a_3 \ldots + 7a_7)\), where \(a_1, a_2, a_3 \ldots a_7\) = area of each color in percent.

Fig. 7. Two-dimensional echocardiogram (sagittal cross-section in early diastole) from a patient with mitral stenosis. The posterior leaflet and the tip of the anterior leaflet are observed nearly parallel to the sound beam. AL = anterior leaflet, PL = posterior leaflet, Ao = aorta, LA = left atrium, LV = left ventricle, VS = ventricular septum.

Several conventional mitral echograms were also studied and maximum C-E amplitude of the mitral valve was measured.

In order to study the reliability of the preoperative echo-pattern, 21 patients were selected on whom mitral valve replacement was performed. They included 7 males and 14 females, aged 21 to 54 years. The surgical diagnosis was pure or predominant mitral stenosis in 14 cases, pure or predominant mitral regurgitation in 5 cases and ruptured mitral chordae tendineae in 2 cases. All surgically excised valves were divided into the anterior and posterior leaflets at the commissures and excessive papillary muscle tissue was trimmed. Then radiographs were taken on Kodak RP/M X-Omat films using 34 KV, 20 mA and 1.6 sec X-ray. These films were further analysed by NAC color data system 1200. With this instrument, the leaflet was divided into seven different colored areas according to its radiographic density as shown in Fig. 6 and each area was computed automatically in percent. Then, the density index of each leaflet was calculated as follows:

density index = \(1/7 \cdot (a_1 + 2a_2 + 3a_3 \ldots + 7a_7)\)

where \(a_1, a_2, a_3 \ldots a_7\) = area of each color in percent. In this calculation, the density index is 100 for heavy calcification of the entire leaflet and 0 for back ground.

In order to investigate the relation of the echo-pattern and C-E amplitude of the mitral valve to type of surgery, 56 patients with pure or predominant mitral stenosis were studied. 7 cases were also associated with aortic valvular disease. They included 16 males and 40 females, aged 17 to 54 years. 42 cases of them underwent open mitral commissurotomy and 14 cases underwent mitral valve replacement.

RESULT

Fig. 2 and Fig. 3 show representative M-mode scan echocardiograms of the mitral valve from a patient with mild valvular lesion and from a patient with heavily calcified valve.

Table I shows a relation between the density index of the excised mitral leaflet and the preoperative echo-pattern. In cases with grade IV pattern, both leaflets were assumed to be grade IV, because it was impossible to identify echoes from each leaflet separately (Fig. 3). As for the anterior leaflet, the density index averaged 26 ± 3 for grade I, 31 ± 4 for grade II and 42 ± 9 for grade III and IV. The differences among these three groups were statistically significant. A mean density index of the posterior leaflet was 29 ± 6 in grade I, 36 ± 5 in grade II and 45 ± 10 in grade III and IV. The density index in grade grade III and IV was significantly higher than that in grade I or grade II. Thus the echo-pattern appeared useful in assessing the structural lesion of the mitral leaflets, especially of the anterior leaflet.

Table II shows a relation between the echo-pattern and type of surgery in 56 cases with pure or predominant mitral stenosis. In this study, higher grade in either of the leaflet was considered to be the echo-pattern grade of a given patient. Mitral commissurotomy was possible
in all cases with grade I and 90 percent of cases with grade II. On the other hand, mitral valve replacement was required in all cases with grade IV. Patients with grade III pattern did not dominate a particular operative category. 10 cases (62 percent) in this group underwent mitral commissurotomy, while on the remaining 6 cases (38 percent) valve replacement was carried out.

Table III shows a relation between C-E amplitude of the mitral valve and type of surgery in 56 cases with pure or predominant mitral stenosis. No cases demonstrated valve amplitude of 15 mm or less. There were 5 cases with amplitude of 19 mm or less and one of them underwent valve replacement. The remaining 13 cases with valve replacement showed valve amplitude of 20 mm or more.

From above findings, the echo-pattern seemed valuable in the assignment of the operative category, while C-E amplitude of the mitral valve was not a useful parameter. Grade I or grade II echo-pattern was a good indicator for mitral commissurotomy. Grade IV pattern was a reliable criterion for valve replacement. For patients with grade III pattern, valve replacement should be also considered when planning surgery.

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DISCUSSION

Mitral commissurotomy is the primary surgical procedure of choice for most patients with pure or predominant mitral stenosis. Structural architecture of the stenosed mitral valve is one of the major factors which influence the surgical approach. Therefore, when surgery is indicated in a patient with mitral stenosis, it is important to obtain information regarding the structural changes of the mitral valve such as valvular calcification or fibrous thickening.

Several echocardiographic features have been reported to represent the structural lesion of the mitral valve. Decreased C-E amplitude of the mitral valve has been reported to be the sign of the rigid and distorted valve.\(^\text{1,5,7-15}\) Nanda et al.\(^\text{15}\) described that patients with valve amplitude of 15 mm or less were regularly associated with valve replacement. In the present series, however, no patients showed valve amplitude of 15 mm or less and this parameter did not appear to be of value in the assignment of the operative procedure. As described by Tatemichi\(^\text{14}\) cases with valve amplitude under 15 mm seem to be rare in Japanese.

Echo-strength also has been used as a parameter of structural lesions of the mitral valve.\(^\text{9,14,16}\) However, this parameter seems to have some problems for clinical practice. In the present study, structural lesion was assessed by the echo-pattern changes\(^\text{7,8,15}\) such as number or thickness of the diastolic mitral echo complex. In addition to an increase in echo-strength, structural lesion of the valve would provide an increase in echo sources, which is responsible for thick or multiple mitral echoes. Calcareous deposits in the valve would be the usual cause of the echo-pattern change, while grade IV pattern was observed in one case with severe fibrous thickening.

Nanda et al.\(^\text{15}\) reported the usefulness of the echo-pattern in assessing mitral valve calcification and in planning the surgical approach for patients with mitral stenosis. The echo-pattern described by them partly differs from that in the present study. This would be due to the difference of instruments. Some electrical modifications are made on the original echo in most commercially available instruments\(^\text{7}\) and the echo-pattern might vary to some extent in other instruments. Therefore, it seems necessary to modify the echo-pattern criteria for a given instrument.

It is also important to obtain echoes widely from various parts of the mitral valve apparatus for the evaluation of its structural architecture. In conventional echocardiographic study, it is necessary to record several echograms from the mitral valve apparatus. For this purpose, therefore, it seems more convenient to employ M-mode scan technique. This technique could provide a systematic observation of the mitral valve apparatus and give information about the anatomical relation of the lesion. Thus, it was possible to some extent to estimate the localization and distribution of the structural lesion with M-mode scan technique. In the present study, therefore, the most constantly appearing echo-pattern in a series of echograms was chosen as representing the structural lesion of a given leaflet. In some cases, it was possible to detect the localized heavy calcification. However, the precise diagnosis of localization of the lesion was difficult with this technique, because it did not display the actual anatomical relation of the mitral valve apparatus. M-mode scan technique has several more shortcomings to be discussed. As shown in two dimensional echocardiogram (Fig. 7), the posterior leaflet and the tip of the anterior leaflet appear nearly parallel to the sound beam in most cases with mitral stenosis.\(^\text{17,18}\) Thus, in this direction of the sound beam, thick or multiple echoes would be erroneously obtained. However, as the transducer angle of these false multiple echoes are narrow, it is not usually difficult to identify this technical artifact. In addition, this anatomical relation to the sound beam would be a major cause for less significant correlation between the echo-pattern and density index in the posterior leaflet.

Despite these problems, the echo-pattern reflected structural architecture of the surgically excised mitral leaflets. This would provide the basis for further clinical use of the echo-pattern. The echo-pattern proved valuable in planning the surgical procedure for patients with pure or predominant mitral stenosis. Grade I or grade II echo-pattern was a good indicator for mitral commissurotomy. Grade IV pattern was a reliable criterion for mitral valve replacement. Valve replacement should be also considered for patients with grade III pattern when planning surgery, nearly half of whom underwent valve replacement.

Therefore, it would appear that evaluation of the mitral echo-pattern obtained by M-mode scan technique is of value in assessing the structural
architecture of the mitral valve and in planning the type of surgery for patients with mitral stenosis.

REFERENCES


