Mitral Commissurotomy versus Replacement
Preoperative Evaluation by Echocardiography

By Navin C. Nanda, M.D., Raymond Gramiak, M.D., Pravin M. Shah, M.D., and James A. DeWeese, M.D.

SUMMARY
Echocardiographic studies of the mitral valve were performed in 57 patients with pure or predominant mitral stenosis who subsequently underwent surgery (30 commissurotomy, 27 valve replacement). Mitral valve calcification was graded heavy (thick, conglomerate echoes), light (multiple, discrete linear echoes) or none (thin, single or duplicate signals). Valve mobility, measured as the excursion from the systolic closed position to the fully opened position in diastole, was classified as normal (20 mm or over), restricted (16–19 mm) or poor (15 mm or less). Absence of mitral valve calcification was the most useful echocardiographic indicator for commissurotomy (18 of 19 cases). The most reliable criteria for valve replacement were heavy valve calcification (11 of 11 cases) and poor cusp mobility (11 of 11 cases). The poor mobility group included 3 patients with heavily calcified valves. Thus 37 of 57 cases (65%) could be reliably categorized regarding the type of surgery performed using these three parameters. The remaining echocardiographic parameters (normal mobility, restricted mobility and light calcification) were less valuable in the assignment of the operative category. Echocardiographic assessment of mitral valve calcification and mobility appears to be of value in planning the surgical approach in patients with pure or predominant mitral stenosis.

Additional Indexing Words:
Mitral stenosis
Mitral valve prosthesis
Ultrasound
Mitral valve calcification
Mitral valve mobility

STRUCTURAL architecture and pliability of the cusps of the stenosed mitral valve, the condition of the subvalvar apparatus and the degree of associated incompetence are the major factors which influence the surgical decision regarding commissurotomy or valve replacement. Preoperatively these are routinely studied by physical examination and by radiological techniques. Calcification is assessed by conventional fluoroscopy while mobility requires selective angiocardiography. Ultrasound has also been used in the evaluation of these parameters in patients with mitral valve disease. Its harmless, noninvasive nature has made it attractive in this application. The ultrasonically determined amplitude of the mitral valve movement has in general shown good agreement with the operative assessment of valve mobility. Criteria for assessing mitral valve calcification by ultrasound have been previously reported from this laboratory and these have correlated well with findings observed at surgery. The purpose of this report is to describe our experience in assessing the usefulness of the echocardiographic evaluation of both mitral valve calcification and mobility in planning the surgical approach in patients with pure or predominant mitral stenosis.

Materials and Methods
Fifty-seven patients with mitral stenosis were studied preoperatively by echocardiography. Forty-five were female, 12 were male. Their ages ranged from 19 to 65 years, the mean age being 43 years. Forty-seven patients had pure mitral stenosis with no clinical evidence of associated mitral incompetence. The remaining ten patients, in whom an apical pansystolic murmur was heard, had mild mitral incompetence by angiography and this was confirmed subsequently at surgery. Patients with significant associated diseases of other valves as well as patients with clinically evident ischemic or myopathic heart disease were excluded from the study. Thirty patients underwent commissurotomy (18 closed, 12 open) while the remaining 27 required valve replacement.

All ultrasonic examinations were carried out using a commercially available echograph (Picker) and a 2 MHz collimated transducer. Continuous records were made on 35 mm film by means of a Fairchild oscilloscope camera and a dual beam oscilloscope operating as a slave. Mitral valve echograms were obtained by placing the transducer in the anterior 3rd or 4th left intercostal space and directing the
beam posteriorly and slightly medially. Mitral valve records were obtained from different transducer positions. The mitral valve amplitude was measured in mm from the closed position at the outset of systole to the fully opened position in diastole (fig. 1). For each patient several recordings (more than 100 beats) were studied and the maximum amplitude noted consistently was taken. Valves with amplitudes of 20 mm or more were considered to have normal mobility while lesser amplitudes, ranging between 16 and 19 mm denoted restricted mobility. Poor mobility of the valve was indicated by amplitudes of 15 mm or less. Calcification was graded heavy when thick, conglomerate echoes were observed in diastole, and light if it consisted of tiered, multiple linear echoes duplicating the mitral valve motion pattern. Thin, single or duplicate diastolic echoes from the mitral leaflets denoted a nonealcedified valve (fig. 2).

For the assessment of mitral valve calcification, 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. The time-varied gain and the reject knobs were not used. Marked variations in the sensitivity settings can result in apparent changes in the character of the mitral valve echoes (fig. 3). Grading calcification quantitatively in a more accurate manner on the basis of the exact number of echoes returning from the diseased mitral valve would have made the assessment more prone to subjective interpretations. Hence only a semiquantitative estimation using two broad categories of severity of calcification was performed.

At surgery the valves were carefully examined by palpation in all patients. With open procedures, direct visual inspection was also carried out. Valves containing small focal areas or flecks of calcium either localized or scattered in the valve substance were considered to have light calcification. Large circumscribed or diffuse calcareous deposits in the valve were categorized as heavy calcification. Valves which did not contain palpable or visible calcification also showed minimal fibrous thickening and underwent valvotomy except for one patient whose valve was replaced because the chordae tendineae were found to be unduly shortened and thickened. Valves demonstrating light calcification also showed slight to moderate degrees of thickening due to fibrosis. Extensive fibrosis was not present in any patient in this group. Commissurotomies were performed if light calcification was palpable or visible in the cusp tissue but did not involve the commissures. Only anterior commissurotomies were performed in instances where the posterior commissure was lightly calcified. The valve was excised if light calcification was detected in the region of the anterior commissure even if the leaflets were only slightly thickened. Thus, the distribution of calcium in the mitral valve influenced the choice of the surgical procedure in the light calcification group. Valves with heavy calcification also showed extensive fibrosis and these were all replaced. All the excised valves (27 cases) were examined pathologically and confirmed the surgical findings regarding the degree and distribution of calcification.

Results

The results of the present study are summarized in tables 1 and 2, and figure 4. Eighteen of 19 patients demonstrating no evidence of mitral valve calcification as judged by the ultrasonic method underwent commissurotomy. Patients presenting with ultrasonic criteria for light calcification (27 cases) did not dominate a particular operative category. Some of the

Figure 2

Echocardiographic criteria for estimation of mitral valve calcification. In the absence of leaflet calcification (upper panel), valve echoes are thin and regularly comprised of one or two linear signals. In the presence of light calcification (middle panel) multiple and discrete echo sources can be elicited in the valve. Heavy calcification (lower panel) results in thick, conglomerate patterns without separation of individual linear components.

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Mitral Valves were considered suitable for commissurotomy by the surgeon (12 cases) while in the remaining 15 cases valve replacement was carried out. On the other hand, all the 11 patients with echocardiographic evidence indicative of heavy deposits of calcium in the mitral leaflets required valve replacement (Table 1).

Ultrasonic evidence of good valve mobility was less impressive as an indicator of commissurotomy. Twenty-three of 28 patients with valve amplitudes of 20 mm or over underwent valvotomy. However, this procedure was not deemed feasible in the remaining five patients with normal valve mobility, four of whom had evidence of valve calcification. Mitral prostheses were inserted in 11 of 18 patients showing restricted valve motion (amplitudes of excursion 16-19 mm); commissurotomy was performed in the remaining 7 patients, in whom the valve was noncalcified in one and lightly calcified in six. Poor mitral valve mobility as evidenced by an amplitude of movement of 15 mm or less was regularly associated with valve replacement (Table 2).

Absence of valvular calcification was the most useful echocardiographic indicator for commissurotomy (18/19 cases). The most reliable criteria for valve replacement were heavy valve calcification (11/11 cases) and poor cusp mobility (11/11 cases). The poor mobility group included three patients with advanced valve calcification while the rest had lightly calcified valves. Thus, 37 of 57 cases (65%) were accurately categorized for the type of surgery by application of these three echocardiographic criteria with only one error (Fig. 4). The remaining echocardiographic parameters (normal mobility, restricted mobility and light calcification), individually or in combination, were less valuable in the assignment of the operative category. Application of these criteria would have resulted in the misclassification of a large number of patients.

Discussion

Many aspects of mitral valve disease, including the identification and evaluation of severity of mitral stenosis, have been studied by echocardiography. It also provides a simple, nontraumatic, nonionizing technique for detecting the presence of mitral valve calcification (Joyner et al.) as well as assessing it in a semiquantitative manner. In our experience, mitral valve recordings done at a sensitivity setting which does not obliterate echoes from the left side of the ventricular septum are adequate for evaluation of mitral valve calcification in a given patient. Small changes in gain do not significantly alter the character of echoes emanating from the mitral valve. Recordings obtained at suboptimal gain may mask light

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<td><strong>Ultrasound Evaluation of Mitral Valve Calcification and Type of Surgery</strong></td>
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<th>Type of operation</th>
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<td></td>
<td>Commissurotomy</td>
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<td>None (19 cases)</td>
<td>18</td>
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<td>Light (27 cases)</td>
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<td>Heavy (11 cases)</td>
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<td><strong>Mitral Valve Mobility by Ultrasound and Type of Surgery</strong></td>
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<th>Mobility by ultrasound</th>
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<td>Normal (20 mm or over)</td>
<td>23</td>
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<td>(28 cases)</td>
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<td>Restricted (16-19 mm)</td>
<td>7</td>
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<td>(18 cases)</td>
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<td>Poor (15 mm or less)</td>
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calcification. A considerable decrease in sensitivity is required to mask the thick echoes obtained from a heavily calcified mitral valve. Also, very high gain settings resulting in numerous intracavitary echoes are usually needed to appreciably alter the width of the thin echo produced by the noncalcified valve. In patients with surgically proven lightly calcified mitral valves, multiple, discrete linear echoes paralleling the movement pattern of the valve probably result from numerous interfaces presented by small areas of calcification in the mitral leaflets. Larger calcareous deposits, either circumscribed or more generalized, result in thick, conglomerate echo complexes. The presence of multiple echoes generated by calcification in the mitral valve make it difficult to reliably distinguish posterior cusp echoes from those produced by the anterior leaflet. One patient in the present study with a heavily calcified posterior leaflet and a noncalcified, pliable anterior cusp (demonstrated at surgery) exhibited an easily recognizable echocardiographic pattern (fig. 5).

Using optimal sensitivity settings as defined, minimal fibrosis present in the noncalcified valves in this study did not result in heavy or multiple echoes. Lightly calcified valves regularly produced multiple, tiered diastolic signals even though the associated fibrotic thickening varied from slight to moderate in degree. It would thus appear unlikely that multiple or conglomerate echoes are produced by mild fibrosis. All valves with marked degrees of fibrosis also had heavy calcific deposits and it was not possible to determine whether the great amount of fibrosis contributed to some extent to the generation of thick, conglomerate echoes observed in these patients.

Demonstration of calcifications by different roentgenologic methods such as tomography or cinefluoroscopy gives valuable information regarding the condition of the mitral valve. However, it may be difficult to establish whether the calcium deposits are situated in the leaflets or in the annulus, and the latter location often does not affect the mobility of the cusps. On the other hand, echoes are obtained directly from the individual mitral leaflets by the ultrasonic technique.

The amplitude of movement of the mitral valve measured on the echogram represents the displacement of the valve cusp from the closed to the open position. The normal range is 20 to 33 mm with an average of 27 mm. Many factors affect the mobility of the stenosed mitral valve. Reduced mobility may be due to the fusion of commissures, fibrous and/or calcific thickening of the cusps, fusion and shortening of the subvalvar apparatus or a combination of these factors in various degrees. This may explain the wide range of valve amplitudes observed in patients belonging to the same calcification category. In one study, the mitral valve amplitudes varied from 10 to 20 mm in patients with cinefluoroscopic and surgical evidence of heavy valve calcification. Despite this wide range of values the mean value for the heavily calcified valve group was significantly lower when compared to the groups with less severe calcification or no calcification.

Mitral valvotomy continues to be the operation of choice for pure or predominant mitral stenosis. Despite a progressive reduction in the operative mortality for valve replacement and continued improvement in prosthetic design, work done so far does not
suggest that valve replacement is the primary surgical procedure of choice for most patients with uncomplicated mitral stenosis. The operative risk of valve replacement is greater than that of valvotomy. Also, prosthetic valves introduce the added risk of late complications including thromboembolic phenomena, perianular leaks, hemolysis and ball variance. Thus, valvotomy seems indicated for a majority of patients with mitral stenosis and should be attempted whenever feasible. Whether valvotomy should be done as an open or closed procedure is still controversial. The open technique has been gaining popularity in recent years. It allows careful dissection of the commissures as well as the subvalvular apparatus, particularly in the splitting of the papillary muscles, which is sometimes necessary to ensure an adequate opening. However, although the risk of cardiopulmonary bypass is small, it is by no means negligible and consequently closed commissurotomy is preferred where feasible.

When surgery is considered in a patient with pure or predominant mitral stenosis, the practical importance of obtaining information regarding the presence and severity of valvular calcification and the degree of valve mobility increases. The pure commissural type of mitral stenosis in which there is fusion of the commissures and little involvement of cusps with preservation of adequate leaflet mobility offers the best target for conservative surgical approach. The cuspal type in which severe fibrocalkic disease of the valve cusps has transformed them into stiff, rigid structures incapable of adequate movement would not be benefited by simple commissurotomy but would need valve replacement. Between these two extremes the choice of operation requires most careful consideration. It is in this group that the surgeon needs to carefully inspect the mitral valve apparatus to determine whether or not valvotomy would result in adequate clinical and hemodynamic improvement. In the presence of light valve calcification valvotomy may produce satisfactory results and delay the need for valve replacement.

In the present study echocardiographic evidence of absence of calcification in the mitral valve was the most reliable indicator for mitral commissurotomy. A closed procedure may be considered in this group of patients. Those patients with echocardiographic detection of heavy valve calcification or poor cusp mobility regularly underwent valve replacement. In the light calcification group, commissurotomy was performed in over half of patients (12 out of 19 cases) who had restricted or normal valve mobility. The mitral valve, in this category, deserves a careful examination by the surgeon under direct vision regarding suitability for commissurotomy.

It would appear that echocardiographic evaluation of valve calcification and mobility is of value in planning the type of surgery for patients with pure or predominant mitral stenosis.

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N C Nanda, R Gramiak, P M Shaah and J A DeWese

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