Cross-Sectional Echocardiographic Observations on the Mechanism of Preservation of the Opening Snap in Calcific Mitral Stenosis*

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Cross-sectional echocardiography (CSE) was performed on 19 patients with mitral stenosis (MS). Nine patients (group 1) had little or no mitral valve (MV) calcification; ten patients (group 2) had heavy MV calcification. An opening snap was present in each of the patients in group 1. Of the group 2 patients, five (group 2A) had an opening snap and five (group 2B) did not. CSE in the long axis revealed in group 1 patients a mobile MV with sharp anterior arching of the anterior leaflet in early diastole; in group 2A, dense echoes suggestive of calcification were noted near the tip of the MV, while the body of the leaflet was relatively thin and it arched anteriorly sharply in early diastole; and in group 2B, dense echoes were noted at the tip and body of the MV with reduction in mobility of the valve, and the sharp anterior arching of the anterior leaflet in early diastole was absent. Preservation of the OS in calcific MS depends on the distribution of calcification. Heavy calcification confined to the tip of the MV allows the anterior leaflet to arch anteriorly in early diastole, allowing preservation of the OS, whereas heavy calcification of the tip and body of the MV reduces the pliability of the valve with consequent disappearance of the OS.

The opening snap is a useful auscultatory feature of mitral stenosis. The presence of an opening snap indicates that the anterior leaflet of the mitral valve is supple. Although calcification of the mitral valve may cause the opening snap to disappear, previous observers have noted that the opening snap may be preserved in 50 to 60 percent of patients with relatively heavy mitral valve calcification. The reason why the opening snap disappears in some patients and is preserved in others with calcific mitral stenosis has been unclear. To explain the preservation of the opening snap in calcific mitral stenosis, we performed cross-sectional echocardiograms to study the pattern of motion of the mitral valve and the distribution of calcification in 19 patients with mitral stenosis.

Materials and Methods

Nineteen patients with mitral stenosis were studied. The presence of mitral stenosis was confirmed by cardiac catheterization in all cases. Two patients had undergone mitral valvotomy at the time of the study. Their ages ranged from 36 to 63 years, and 19 were men. The presence of mitral valve calcification was determined by fluoroscopy and echocardiography. Mitral valve calcification on fluoroscopy was designated as heavy, light, or absent.

Cross-sectional echocardiography was performed with a SKI 30* mechanical sector scanner or a wide-angle phased array sector scanner (Toshiba Sonolayagraph). The aortic root and mitral valve were visualized in the long axis according to previously described methods. This allowed the assessment of the presence or absence of calcification of the mitral valve, the distribution of calcification, and the mobility of the valve.

The presence of an opening snap was assessed by auscultation and phonocardiography. When performing the echocardiogram, the transducer was placed at a point where the opening snap was best audible (usually just lateral to the left sternal border). The phonocardiogram and an M-mode echocardiogram of the mitral valve (obtained at the point of maximum excursion of the valve) were performed simultaneously at a paper speed of 100 mm/sec. In those patients who had echocardiography performed with a phased array wide-angle sector scanner (five patients in group 1 and four in group 2), a cursor was placed at the point of maximum anterior arching of the anterior leaflet in diastole, and an M-mode echocardiogram obtained with the phonocardiogram (Fig 1).

Results

Nine patients (group 1) had little or no calcifica-
Dilation of the mitral valve. An opening snap was heard and recorded in all nine patients. The cross-sectional echocardiogram in the long axis view showed good mobility of the valve, with sharp anterior arching of the anterior leaflet in early diastole (Fig 2). The opening snap coincided with the point of maximum early diastolic opening of the mitral valve on the M-mode echocardiogram in all patients.

Ten patients had heavy calcification of the mitral valve (group 2). Five of them (group 2A) had an opening snap, and the opening snap was absent in five (group 2B). In group 2A, cross-sectional echocardiography in the long axis view revealed multiple dense echoes suggestive of heavy calcification near the tip of the mitral valve. The body of the anterior mitral leaflet was relatively thin (comparable to that in noncalcified valves), and it demonstrated sharp anterior arching in early diastole (Fig 3). Patients in group 2B had uniform thick dense echoes suggestive of heavy calcification of the tip and body of the valve, and the sharp early diastolic anterior arching of the anterior leaflet was not present (Fig 4).

**DISCUSSION**

The opening snap is an important auscultatory feature of mitral stenosis. The absence of an opening snap in a patient with mitral stenosis usually implies the presence of heavy calcification of the mitral valve, although an absent opening snap may also occur when (1) mitral regurgitation is the predomi-
nant lesion, (2) mitral stenosis is extremely mild, or (3) severe aortic regurgitation or stenosis is present. In those patients who had an opening snap in our study, this sound coincided with the maximum early diastolic opening of the mitral valve on the M-mode echocardiogram. When the cross-sectional echocardiogram was performed with a phased array sector scanner, the corresponding M-mode echocardiogram was obtained by placing a cursor at the point of maximum anterior arching of the anterior mitral leaflet. Thus, the opening snap coincides with the maximum arching of the anterior mitral leaflet in diastole. This observation suggests that the opening snap is either the result of sudden anterior arching of the anterior mitral leaflet or, more likely, the anterior arching of the leaflet allows a sizeable volume of blood to enter the mitral funnel, and the sudden deceleration of blood flow at the end of the anterior arching of the leaflet results in a sound, which is the opening snap.

We observed that those patients with calcific mitral stenosis in whom an opening snap was audible had calcification confined to the region of the tip of the valve, which allowed the body of the anterior mitral leaflet to arch anteriorly in early diastole, with consequent production of an opening snap. The patients with calcific mitral stenosis who had no opening snap were noted to have calcification of the tip and the body of the anterior mitral leaflet, with consequent reduction in pliability of the leaflet so that the conditions required for production of an opening snap, ie, entry of a sizeable volume of blood into the mitral funnel and sudden deceleration of blood flow, were absent. None of our patients in group 2B had dominant mitral regurgitation or severe aortic valve disease to account for disappearance of the opening snap on that basis. Although dense fibrosis of the mitral valve may mimic calcification on the echocardiogram, the presence of calcification on fluoroscopy in our patients suggests that the dense echoes observed were probably due to mitral valve calcification.

Our observations raise a question as to the usefulness of detecting the presence of an opening snap in

**Figure 3.** Cross-sectional echocardiogram in long axis view showing a diastolic frame. Tip of anterior mitral leaflet (left) shows multiple dense echoes suggestive of calcification, while body (B) of leaflet is thin and is convex anteriorly. AML = Anterior mitral leaflet; LA = Left atrium.

**Figure 4.** Cross-sectional echocardiogram from patient with calcific mitral stenosis showing a diastolic frame. Multiple dense echoes at tip and body (B) of anterior mitral leaflet (AML), indicating presence of extensive calcification. LA = Left atrium; IVS = Interventricular septum.
predicting the suitability of a stenotic valve for mitral valvotomy. Patients with heavy calcification near the tip of the mitral valve and a well-preserved opening snap are probably not suitable candidates for mitral valvotomy. Thus, the mere presence of an opening snap does not necessarily imply that a patient with a stenotic mitral valve is a candidate for mitral valvotomy. It should be emphasized that the cross-sectional echocardiogram is useful in evaluating patients for mitral valvotomy.

Previous observers have noted that an opening snap may be present in 50 to 60 percent of patients with heavy calcification of the mitral valve. Our echocardiographic data provide an explanation for the mechanism of preservation of the opening snap. It should be noted that a small percentage of patients, especially children, with noncalcific pure mitral stenosis may have absent opening snaps. It is conceivable that in those patients extensive fibrosis of the tip and body of the anterior leaflet may reduce the pliability of the valve and prevent sudden anterior arching of the leaflet in early diastole.

REFERENCES
2. Tavel ME. Clinical phonocardiography and external pulse recording. Chicago: Year Book Medical Publishers, 1972, p 91

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The Department of Radiology, Duke University Medical Center, will present a five-day postgraduate course at the Kona Surf Resort Hotel on the island of Hawaii, February 23-27. Program chairman is Dr. Carl E. Ravin. For information, contact the Department of Radiology, Duke University Medical Center, Box 3808, Durham, North Carolina 27710.

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