Genesis of Diastolic Sounds in Mitral Incompetence

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A third heart sound, followed by a diminuendo diastolic murmur, is generally considered a characteristic of all but the most trivial grades of mitral incompetence. The genesis of these physical signs has remained controversial despite many human and animal studies. There are two main schools of thought concerning the origin of these sounds. The first or “extravalvar” school originated in Potain’s treatise on gallop sounds (Potain, 1876). He attributed the origin of the third heart sound to vibration of the ventricular walls resulting from a sudden distension due to the entrance of a large volume of blood. Several other authors have accepted, wholly or partially, this view (Wolferth and Margolies, 1933; Orías and Braun-Menéndez, 1939; Smith, 1944; Kuo et al., 1957). The second or “valvar” school hold that the third sound is related to the anatomic arrangement of the mitral valve curtains, chordae, and papillary muscles. During the rapid inflow of blood into the ventricles at the start of diastole, the left ventricular cavity is suddenly elongated. This exerts traction on the chordae tendineae which, because of their insertion, pull the mitral cusps into the path of the inflowing blood and cause a transient obstruction of the mitral orifice. This partial reclosure of the mitral valve results in the production of these physical signs (Hirschfelder, 1907; Gibson, 1907; Thayer, 1909; Lewis and Dock, 1938; Dock, 1945; Brady and Taubman, 1950; Dock, Grandell, and Taubman, 1955; Fleming, 1969).

The object of this report is to describe a unique situation in the human heart, namely massive mitral incompetence without cusps or chordae tendineae being present, which occurs in mitral incompetence around a prosthetic valve. This situation permits a separation of “valvar” and “extravalvar” elements in the genesis of these sounds. Investigation of this state by phonocardiography and recording the left ventricular apical movements provides convincing evidence that the mitral valve apparatus is essential for the production of the diastolic sounds of mitral incompetence.

SUBJECTS AND METHODS

Three patients, all women, whose ages ranged from 19 to 61 years, form the basis of this study. Two had undergone mitral valve replacement with a Starr-Edwards prosthesis for chronic rheumatic valvular disease, and the third had had a similar operation for spontaneous rupture of a mitral chorda tendinea. All these patients had been in severe congestive cardiac failure for at least 3 months, and were in failure at the time of study.

Cardiac investigations were undertaken for intractable congestive heart failure with minimal signs of valve disorder. In fact, apart from a Grade 3 to 4 apical pansystolic murmur, auscultation of the heart was unremarkable.

Phonocardiograms were recorded using a crystal microphone on photographic paper. The sounds at the mitral area were recorded via a low frequency filter. The severity of mitral incompetence was assessed by left ventricular angiography.

The movements of the left ventricular apex were recorded by means of a bell chest piece connected by a stiff polyethylene tube to a Statham P23Dd transducer. The left ventricular apex was identified by its outward motion in systole as suggested by Mackenzie (1902).

Left atrial pressure was recorded by direct needle puncture at operation.

RESULTS

All 3 patients showed gross mitral incompetence as judged angiographically (Fig. 1) and confirmed at operation.

In no case was a third heart sound or mitral diastolic murmur audible or recordable, though these signs were present before the initial operation for insertion of the prosthetic valve.

Records of left ventricular apical movement before the insertion of the prosthesis (Fig. 2) showed a large peak of outward movement which was associated with a third heart sound and short diastolic murmur. After the development of para-
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FIG. 1.—Left ventricular angiogram showing gross paravalvar mitral incompetence.

FIG. 2.—Apex displacement curve (ADC) and low frequency phonocardiogram recorded from the mitral area (MA) before the insertion of the prosthetic valve showing a prominent third heart sound and third sound peak (3P).

valvar mitral incompetence, this peak, third sound, and diastolic murmur were consistently absent (Fig. 3).

Absence of significant mitral obstruction and rapid equalization of atrioventricular pressures were shown by the development of "stasis" waves on the apex tracing (Fig. 3), and by the shape of the left atrial pressure tracing which showed a precipitous "y" descent and "stasis" waves (Fig. 4).

DISCUSSION

The results of these investigations show that severe mitral incompetence can exist without a third sound or diastolic murmur.

The explanation for these physical signs must thus lie in factors other than purely the movement of large volumes of blood between atrium and ventricle.

The proponents of the extravalvar school have suggested that the vibration of the ventricular walls in response to the sudden entry of a large volume of blood is the cause of the third heart sound. This theory has several drawbacks. First, the third heart sound usually occurs at the beginning of the phase of rapid filling rather than at the end when distension is maximal. Dock (1949) has shown that the left ventricle can be distended to a greater degree in life than that which occurs at the time of the third heart sound. This theory provides no real explanation for the diminuendo diastolic murmur of mitral incompetence, and finally our cases show that gross mitral incompetence can exist without a third sound or diastolic murmur provided there are no cusps or chordae present.

Any explanation of the third sound in mitral in-
The absence of the third sound and third sound peak in patients without chordae tendineae, cusps, and papillary muscles, is good evidence that these structures are essential for the production of both these very closely-related findings. The thesis of the valvar school is that entry of blood causes elongation of the ventricle, the apex moving outwards while the base remains relatively stationary. At a critical degree of distension, the slack in the chordae tendineae is taken up and tension is applied to the valve curtains on the one side and the outward movement of the apex on the other. The tension on the cusps causes partial reclosure of the mitral valve causing the third sound and brief diastolic murmur, and traction on the papillary muscles halts the rapid outward movement of the apex, resulting in the third sound peak.

It can be seen that this critical distensibility will depend on the volume of blood flowing suddenly into the ventricle, the height of the atrial pressure driving it in, and the volume/elasticity characteristics of the ventricular wall. Thus, extravalvar factors do have a part in setting up the environment in which a third sound and mitral flow murmur can occur, but our evidence indicates that it is the valve apparatus that is responsible for the noise itself.

**Summary**

Three cases of gross mitral incompetence around a Starr-Edwards prosthesis were studied by phonocardiography and recording of left ventricular apical movement.

All these patients showed an absence of a third heart sound and the peak of rapid filling associated with this, despite the presence of severe mitral in-
competence. A third sound and third sound peak had been present before the first operation for insertion of a prosthetic valve.

These findings support the theory that the diastolic sounds of mitral incompetence are produced by the valve structures themselves rather than by vibration of the myocardium.

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