The Apexcardiogram in Patients with Systolic Prolapse of the Mitral Valve

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Fifteen patients with the clinical and phonocardiographic finding of a nonejection click initiating a late systolic murmur had apexcardiograms (ACG) performed. In every case, the inward motion of the apex normally inscribed between aortic valve opening and closure was interrupted by either a notch or a second systolic wave, the onset of which occurred at the time of the click. This ACG finding was associated with a double apical systolic impulse in some patients. Therefore, systolic prolapse of the mitral valve has to be excluded from other conditions that cause a double apical impulse.

Material and Methods

Fifteen patients, each of whom was demonstrated on phonocardiogram to have a mid-systolic click initiating a late systolic murmur, were studied. Eight of these 15 patients had diagnostic cardiac catheterization and angiography. In all cases so studied, the resting cardiac index was within normal limits as were all intracardiac and intravascular pressures. In every case, a selective cineangiogram of the left ventricle revealed systolic prolapse of a portion of the mitral valve with mild to moderate mitral regurgitation.

The apexcardiograms were recorded carefully from the point of maximum apical impulse with the patients in the supine or left lateral position with the use of a pulse wave linear crystal microphone (Hewlett-Packard No. 374) which was attached to a small metal funnel pickup (maximum internal diameter 1.5 cm) by a piece of rubber tubing 10 centimeters in length. The apexcardiogram, electrocardiogram and phonocardiogram were recorded simultaneously on photographic paper at speeds of 75 to 200 mm per second using a four-channel Hewlett-Packard recorder model No. 564.

Results

A mid-systolic click, which occurred after the onset of the upstroke of the carotid pulse and the E point of the apexcardiogram (ACG), was recorded in all 15 patients. In every case, the click initiated a late systolic murmur which extended to or just beyond aortic valve closure. The ACG in all 15 patients showed an interruption of the descent from the E point by a positive systolic deflection (Fig 1-3). The side of the second systolic deflection varied greatly, both between patients and from time to time in the same patient. In every case, the point of interruption of the inward motion of the apex was

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FIGURE 1. Phonocardiogram (PCG) and apexcardiogram (ACG) of a 32-year-old woman with angiographically proved systolic prolapse of the mitral valve. CT is the indirect carotid tracing. The interruption of the downward descent from the E point is interrupted by a second positive systolic deflection. The onset of this deflection coincides in time with the mid-systolic click (c).

FIGURE 2. A 23-year-old nurse without cardiac symptoms. The contour of the apexcardiogram (ACG) is similar to that of the indirect carotid tracing (CT). A=aortic component of second sound; P=pulmonic component of second sound; DN=dicrotic notch; E and O points of apexcardiogram represent time of aortic and mitral valve opening respectively. A late systolic murmur is initiated by a midsystolic click (c) which occurs at the nadir of the dip in the apexcardiogram that separates the first and second systolic waves.

FIGURE 3. A 25-year-old man without cardiac symptoms. ACG=apexcardiogram; PA=phonocardiogram from pulmonary area; APEX=phonocardiogram recorded at apex; L3=standard electrocardiogram lead 3.

oberved to coincide exactly in time with the occurrence of the systolic click. The appearance of this phenomenon varied from that of a notch in the downstroke following the E point similar to the dicrotic notch of an arterial pulse tracing to that of a large second systolic wave. There was no apparent correlation between the loudness of the click or murmur and the configuration of the ACG. The summit of the second systolic wave never surpassed the E point. When the midsystolic click was moved to an earlier position in systole by a vasoactive drug or maneuver designed to reduce left ventricular volume (inhaletion of amyl nitrate or adoption of the erect position), the notch or onset of the second systolic wave was observed to similarly change position and remain exactly coincidental in time with the click (Fig 4).

DISCUSSION

Nonejection systolic clicks and late systolic murmurs have, in the past, been considered to be of extracardiac origin. In recent years, however, intracardiac phonocardiography has demonstrated the mitral valvular origin of many nonejection clicks and late systolic murmurs and left ventriculography in such cases has consistently revealed systolic prolapse of one or both leaflets of the mitral valve with late systolic mitral regurgitation. In our patients the second systolic wave of the ACG occurred precisely at the same time as the midsystolic click. Further, whenever the position of the click was moved to an earlier part of systole, the second systolic wave also moved with the click. Therefore, it is very likely that the second systolic wave on the ACG is related to mitral valve prolapse.

In 1963, Benchimol and Dimond described an apexcardiogram similar in form to that we are describing which was recorded from a patient with
APEXCARDIOGRAM IN SYSTOLIC PROLAPSE OF MITRAL VALVE

Figure 4. A 35-year-old woman without cardiac symptoms proved by left ventriculography to have systolic prolapse of the mitral valve. ACG = apexcardiogram; 1 = first heart sound; 2 = second heart sound; C = midsystolic click; R = R wave of electrocardiogram; E and O points of apexcardiogram representing time of aortic and mitral valve opening respectively. Both the midsystolic click and the onset of the second systolic wave are seen to move earlier in systole and remain coincidental when the patient adopts the upright position.

A late systolic murmur initiated by a midsystolic click. However, they thought this ACG abnormality was due to adhesive pericarditis. The occurrence of a peaked systolic retraction preceding a second positive systolic deflection in the ACG of patients with the billowing posterior leaflet syndrome was mentioned briefly by Kesteloot and VanHoute in 1965 who found it to be present in five cases. This finding has not, however, gained much recognition. A bifid systolic apical impulse was recently reported in a single patient with proved mitral valve prolapse by Stapleton and Groves. In their case, kinetocardiography demonstrated the peak of the second systolic wave (rather than its onset) to be coincident with the midsystolic click. However, in all our patients, the onset of the second systolic wave was coincident with the midsystolic click.

The apexcardiogram has been useful in the correlation of the findings on palpation of the apical impulse with the pathophysiology of many hemodynamic disturbances. Diastolic and preejection components of the ACG have been shown to have a definite temporal relationship to hemodynamic events within the left ventricle and changes in the configuration of the tracing have been correlated with various disease entities. That portion of the ACG inscribed during left ventricular ejection has been the subject of considerably lesser interest. The normal ACG shows a rapid descent from the E point, the rate of the descent falling off to form a "shoulder" in the latter part of systole. A second outward deflection or late systolic bulge is only occasionally recorded in normal subjects, particularly if it is recorded at the periphery of the apical impulse, whereas it was recorded in all our patients with mitral valve prolapse at the maximum apical impulse. Moreover, when the midsystolic click is moved earlier in systole by reducing left ventricular volume, interruption of the inward motion of the apex occurs earlier in systole and the usual late systolic shoulder or bulge is seen to occupy the later portion of the ejection phase (Fig 4). The second systolic wave on the ACG has also been recorded in idiopathic hypertrophic subaortic stenosis and in aortic stenosis and insufficiency. The explanation of this finding on the ACG of patients with mitral valve prolapse is unknown. It may be related to a change in wall tension secondary to a change in left ventricular volume or chamber geometry or it may represent a movement of the cardiohemic system resulting from the motion of the prolapsing mitral valve.

In some of these patients, the phenomenon under discussion was detected clinically and was usually interpreted as a double apical impulse. A double apical impulse can be associated with a prominent rapid filling or atrial wave. In such cases, the additional impulse is diastolic in timing. A double apical impulse with both impulses occurring in systole has been described in idiopathic hypertrophic subaortic stenosis, myocardial infarction, angina pectoris and left ventricular aneurysm. Therefore, mitral valve prolapse has to be distinguished from these conditions when a double apical impulse is present.

References
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The Favorite Flower of Linnaeus (1707-1778)

The twinflower or linnaea was Linnaeus' favorite flower, and to it he gave his own name (Linnaea borealis). At Hammerby, his country home in Sweden, one can see his tea service decorated with a border of these dangling pink bells. A portrait of this great taxonomist who devised the system of scientific names which we all use shows him holding one of the delicate plants in his hand. The twinflower, growing throughout the boreal forests of the world, is equally at home in Sweden, New England, or our Northwest.

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