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Analytical Investigation of the Systolic Murmurs in Mitral Insufficiency and in Aortic Stenosis.

By

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I. Mitral Insufficiency.

Mitral insufficiency has characteristic murmurs, as is well known, in the systolic phase.

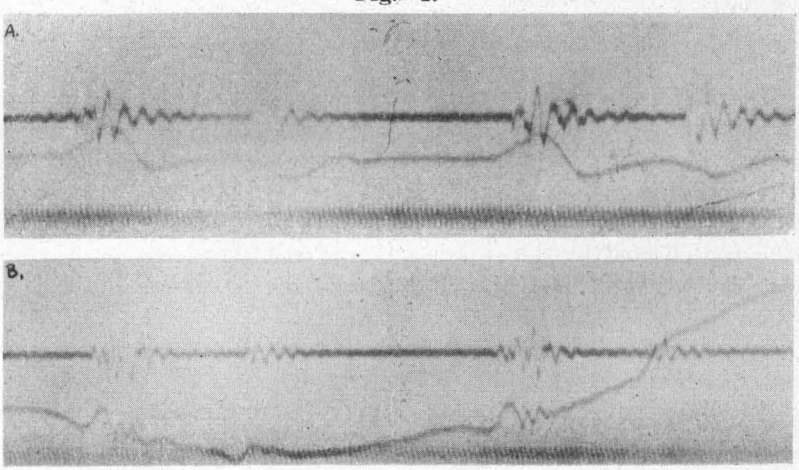
The records A, B, C, and D, shown in figure 1, were obtained from patients who had the intense systolic murmurs characteristic of mitral insufficiency. In those cases the first and the second sounds, which had the normal tone quality were rather clearly audible.

In these records, the three parts of the first sound, — the initial, the principal and the final — are distinguished as clearly as the normal first sound. But it can be noticed by comparing these records with that of the normal shown in figure 2, that very small rapid vibrations are superposed upon the former records. Such vibrations are relatively significant in the final part of each record. The frequency of them was measured and found to be about 100—500 hertz per second.

These small rapid vibrations appearing most conspicuously in the final part of the first sound are characteristic of the murmurs due to mitral insufficiency. In not a few cases, however, these vibrations were rather marked in the whole record of the first sound and continued long after the end of the final part, occupying almost the whole sytole.

This is illustrated by records E, F and G, in figure 3.

Fig. 1.



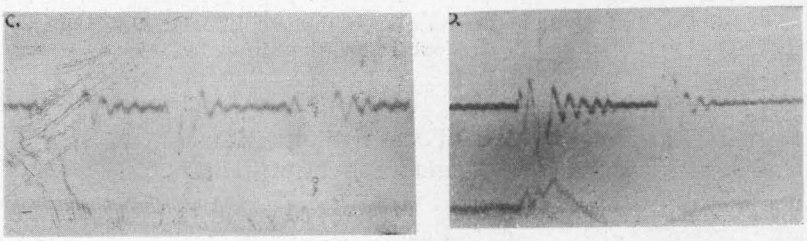


Fig. 2.

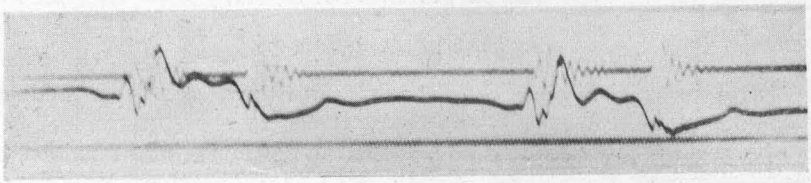
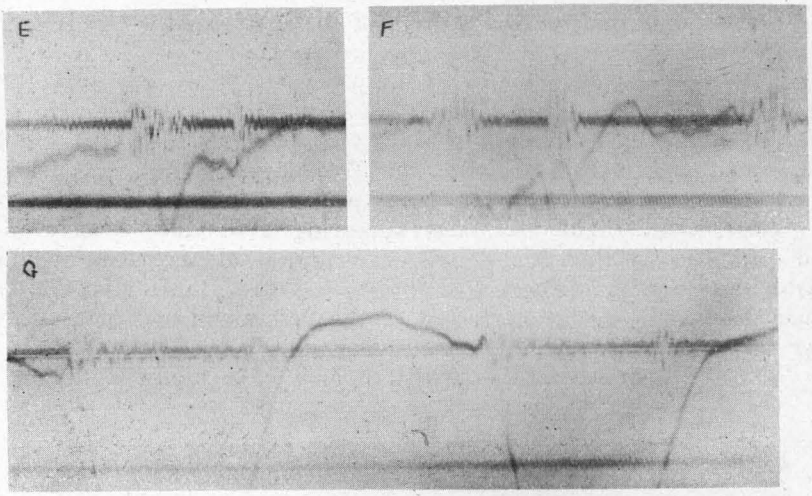


Fig. 3.



The rapid vibrations of the murmurs are more significant and prominent in these records than in the records in figure 1. The first sounds were scarcely audible in these cases on account of the immense intensity of the murmurs. Even in such cases the three parts of the first sound are distinguished clearly, though the final part of each record is more or less complicated by the superposition of relatively significant vibrations due to the murmurs and the vibrations of the murmurs diminish gradually and never show a crescendo form.

Thus, the fundamental form of the normal first sound is not lost even in such cases of mitral insufficiency.

According to the experiments of previous researchers, — the vibrations of the murmurs in mitral insufficiency appear at the beginning of the

ventricular discharge and disappear within a relatively short time, though in some cases such vibrations were observed during the whole period of discharge.

The regurgitation of blood through the mitral orifice, which is considered to be the cause of the murmurs in mitral insufficiency, must occur early in the period of rising tension in the ventricle before the commencement of the ventricular discharge, when the intraventricular pressure exceeds that of the auricle, and continue till the relaxation of the ventricle. The investigators were therefore faced with a problem when the vibrations of the murmurs were found, in the early experiments, after the commencement of the ventricular discharge. There has been a great deal of argument about this problem, but the writer believes that no further discussion is necessary, in as much as the vibrations of the murmurs were found by him to appear in the whole systole. But as it is obvious that the regurgitation must be most vigorous a little after the commencement of the ventricular discharge when the difference in the pressure between the auricle and the ventricle reaches its maximum, the vibrations of the murmurs must be most conspicuous in this period of systole, namely in the final part of the first sound.

Weber observed some cases in which the vibrations of the murmurs were found in the period of diastole, and explained that "—vielleicht sind sie Ausdruck von Wirbeln, die an der narbig veränderten Mitralklappe beim Einströmen des Vorhofblutes entstehen." But these vibrations can not be considered as characteristic of mitral insufficiency.

However, the writer has observed in not a few cases that the initial vibration superposed by small vibrations of the murmurs appeared about 0.02 sec. earlier than the commencement of the apex beat. But these vibrations can not be attributed to the auricular contraction because the commencement of the apical curve is as a rule about 2 or 3 hundredths of a second behind the actual moment of the commencement of the vetricular systole. In fact, such vibrations of the first sound preceding the apex beat were found occasionally in normal cases.

Therefore, it can be said summarily that the record of the murmurs in mitral insufficiency is characterised by small rapid vibrations in the ventricular systole, which appear most conspicuously in the final part of the first sound. The fundamental form of the first sound is not influenced however, by the superposition of such vibrations as they are very small in amplitude.

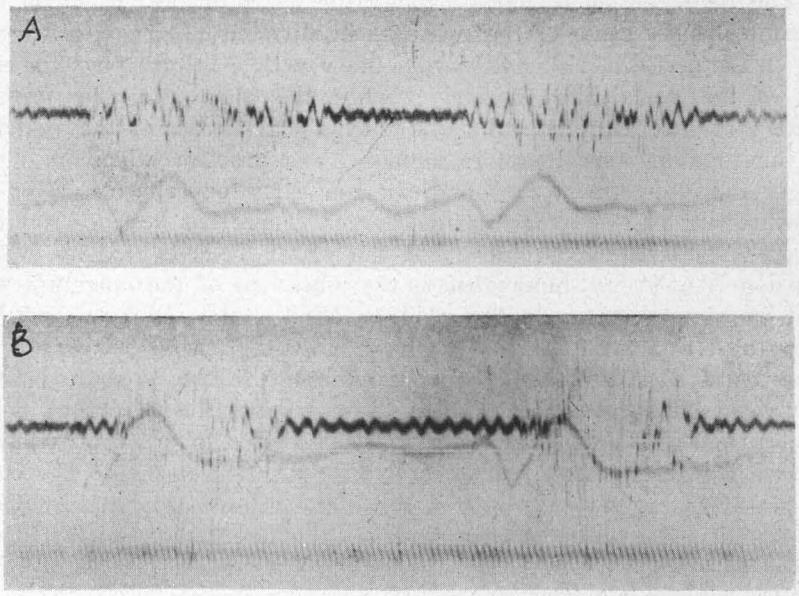
Hence, it can be considered also that the regurgitation through the mitral orifice which causes the murmurs has no influence upon the production of the fundamental vibrations of the normal first sound.

II. Aortic Stenosis.

Aortic stenosis is characterised also by systolic murmurs which can be perceived most significantly in the aortic orifice. But these murmurs

show quite a different appearance in the records from those due to mitral insufficiency.

Fig. 4.



The vibrations due to the systolic murmurs in aortic stenosis were found as a rule in the whole period of the ventricular discharge, and on account of the considerable amplitude of these vibrations, the features of the normal first sound in this period were a good deal affected. But the vibrations occurring in the period before the commencement of the discharge always showed quite the normal form. They occur at the same time as the commencement of the apex beat with the slightest amplitude and thereafter they grow successively in amplitude, and the first section of the principal part just before the commencement of the discharge are distinguished by the superposition of small rapid vibrations. Then there the conspicuous vibrations due to the systolic murmurs occur at the same time as the commenement of the ventricular discharge in place of the second section and the final part. The amplitudes of these vibrations, which are relatively small at the beginning, increase very rapidly and then they diminish again rather gradually, so that the maximum amplitude of the vibrations due to the murmurs is found, not at the commencement of the discharge, but a short time after. Not seldom they were spindle-shaped, showing that they had increased gradually in amplitude and decreasing also gradually, occupying the whole period of the discharge.

This is illustrated by the records in figure 4.

Recently, Groedel has reported that "—der erste Ton fehlt fast vollkommen" in the record of the sound phenomenon in aortic stenosis, and that very rapid vibrations due to the murmurs appear with considerable

amplitude after "beiden sehr niederen ersten Schwingungen, die wir als Ausdruck des ersten Tones auffassen mögen".

But the writer insists that however conspicuous the vibrations of the murmurs may be, and whether the first sound is andible or not, the record of the vibrations of the first sound in the period of rising tension in the ventricle before discharge is not affected by the former. In fact, in the case from which record A, was obtained the interval between the commencement of the apex beat and that of the ventricular discharge is prolonged, to $\frac{8-9}{100}$ sec. (measured), and accordingly, the vibrations of the first sound in the period before the ventricular discharge have a longer duration than normal.

The writer's contention is proved moreover by a comparison of records A and B, which were obtained from the same patient, the auscultation points being those of the apical and the aortic sounds. In record B, (on the aortic arifice), the vibrations of the first sound preceding the murmurs are less significant, while the vibrations due to the murmurs, occurring exactly at the commencement of the ventricular discharge show amplitudes of more remarkable magnitude than those in record A. This fact simply shows that the vibrations due to the murmurs in aortic stenosis always begin after the commencement of the ventricular discharge, that is the vibrations occurring before the ventricular discharge are not affected.

As to the production of such murmur vibrations, many theories have been published by many researchers but none of them can be said to have been substantiated.

It is to be noticed, however, that, these murmur vibrations in aortic stenosis, unlike those in mitral insufficiency not seldom are considerable and that they show their maximum amplitude in a relatively late period of the ventricular discharge when no acoustic vibration is found in the normal case. Or, in other words, the hindrance of the discharge through the aortae effects a considerable deformation of the first sound in the period of discharge, unlike the regurgitation through the mitral orifice, which does not effect any change in the fundamental vibrations of the first sound.

For the explanation of the cause of such a difference, still more comparative investigations of the acoustic phenomenon in various conditions of the heart will be necessary.

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