Myxoma of the Left Atrium
Phonocardiographic Study of Three Cases

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With the advent of open-heart surgery, myxoma of the heart has become one of the curable lesions. The clinical picture associated with this tumor is extremely variable. It may at times simulate mitral stenosis, subacute bacterial endocarditis, or it may present the picture of intractable heart failure.1–6 The establishment of correct preoperative diagnosis is difficult but crucial for the successful outcome of surgery.

Recently three patients with myxoma of the left atrium were studied on the Cardiac Service of General Rose Memorial Hospital. The purpose of this report is to present the auscultatory and phonocardiographic findings in myxoma of the left atrium, which may be of interest and help to the clinician.

Methods

Phonocardiographic studies were performed with the patients in the supine position, by a direct-writing phonocardiographic recorder having a frequency response of 25 to 800 cycles per second (eps).° Built-in filters enabled preferential recording of high- and low-frequency murmurs. Recordings were made at a paper speed of 50 mm. or 100 mm. per second. A simultaneously recorded electrocardiogram was used for timing of murmurs. In some instances the apex beat or the jugular vein tracing was recorded simultaneously with the heart sounds for timing purposes.

Heart sounds were recorded in the four cardinal areas of auscultation: the apex, the tricuspid area, the pulmonic, and the aortic areas. In addition, phonocardiograms were recorded in the fourth interspace to the left of the sternum and in the anterior axillary line in the fifth interspace.

One patient was studied preoperatively only:

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°Mingograph 21c, manufactured by Elema Schönannder, Stockholm, Sweden.

the other two patients were studied both preoperatively and postoperatively. The Q-S1 and S2-os intervals were measured on all tracings. The Q-S1 interval was measured from the beginning of the Q wave on the electrocardiogram to the first major vibration of the first sound on the phonocardiogram. The S2-os interval was measured from the first major vibration of the second sound to the first major vibration of the opening snap (os) of the mitral valve.

Results

Patient K.P. A white woman, 43 years old, was diagnosed on the basis of physical findings and right heart catheterization to have mitral stenosis. During surgery, palpation revealed a normal mitral valve and the presence of a large tumor in the left atrium. The incision was closed with the intention of removing the tumor at a later operation under hypothermia. Postoperatively, however, the patient developed signs of an embolus at the bifurcation of the aorta caused by a part of the tumor, and during embolectomy she died. Autopsy revealed a large myxoma in the left atrium. The heart valves were normal.

Phonocardiographic studies were performed twice during the patient's hospitalization. The first sound was markedly accentuated. The Q-S1 interval was prolonged to 0.08 second (fig. 1). The second sound was normally split in the second interspace. The pulmonic second sound was accentuated in the fourth interspace to the left of the sternum (fig. 1). In the apical area there was a presystolic murmur of medium frequency that waned in intensity from one examination to another and was not affected by the patient's position. A systolic murmur was present along the left sternal border and in the pulmonic area. When the patient was in congestive heart failure, there was a musical systolic murmur in the tricuspid area that became louder on in-
Summary of Auscultatory Findings

<table>
<thead>
<tr>
<th>Patient</th>
<th>First sound, apex</th>
<th>Second sound, pulmonic area</th>
<th>Opening snap</th>
<th>Systolic murmur and location</th>
<th>Presystolic murmur and location</th>
<th>Early diastolic murmur and location</th>
</tr>
</thead>
<tbody>
<tr>
<td>K.P.</td>
<td>Accentuated 4+</td>
<td>Accentuated, split normally</td>
<td>3rd interspace left sternal border</td>
<td>Tricuspid 3+, musical and transient; apex 2+</td>
<td>3+ apex, variable</td>
<td>Pulmonic area 2+</td>
</tr>
<tr>
<td>B.B.</td>
<td>Accentuated 3+</td>
<td>Accentuated, split normally</td>
<td>Anterior axillary line and 3rd interspace left sternal border</td>
<td>Apex 2+, Tricuspid 2+, louder on inspiration</td>
<td>3+ apex and 3+ tricuspid, variable</td>
<td>Pulmonic area 1+</td>
</tr>
<tr>
<td>E.C.</td>
<td>3+</td>
<td>Accentuated, split normally</td>
<td>Entire precordium</td>
<td>Entire precordium 1+</td>
<td>Absent, atrial sound inconstant</td>
<td>Pulmonic area 2+</td>
</tr>
</tbody>
</table>

An extra sound was clearly visible in diastole. It had the auscultatory characteristics of the tricuspid murmur (fig. 1) and as the signs of congestive heart failure receded it disappeared. In the pulmonic area a high-pitched, early diastolic murmur was heard and recorded (fig. 1). This murmur could also be seen in the trace recorded in the fourth interspace to the left of the sternum and at the apex.

Patient K.P. Phonocardiogram, showing wide and accentuated first sound (1), the separated sound (2), systolic (3m), and diastolic (3dm) murmurs. The opening snap (4s) is best recorded in the fourth interspace left sternal border. Speed 50 mm. per second.
Figure 2

Patient K.P. Phonocardiogram recorded in the tricuspid area showing the appearance of a systolic musical murmur (msm) on inspiration. Frequency response 300 cycles per second, paper speed 50 mm. per second.

Table 2

Cardiac Catheterization Data

<table>
<thead>
<tr>
<th>Patient</th>
<th>Before operation S1-os second</th>
<th>After operation S2-os second</th>
<th>Pulmonary artery mm. Hg (mean)</th>
<th>Right ventricle mm. Hg (mean)</th>
<th>Right atrium mm. Hg (mean)</th>
<th>Pulmonary artery wedge mm. Hg (mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K.P.</td>
<td>0.08</td>
<td>0.09 -0.11</td>
<td>65/27 (42)</td>
<td>73/7 (4)</td>
<td>(4) (24)</td>
<td></td>
</tr>
<tr>
<td>B.B.</td>
<td>0.09 0.06</td>
<td>0.055-0.06</td>
<td>65/25 (38)</td>
<td>62/3 (1)</td>
<td>(1) (29)</td>
<td></td>
</tr>
<tr>
<td>E.C.</td>
<td>0.09 0.06</td>
<td>0.11 -0.12</td>
<td>90/35 (55)</td>
<td>95/ (5)</td>
<td>12/3 (7)</td>
<td>(33)</td>
</tr>
</tbody>
</table>

Normal Q-S1 interval = 0.055 second.

of an opening snap, being high-pitched and of short duration. It was best recorded in the fourth interspace to the left of the sternum (fig. 1), but was clearly seen in the tracings recorded in the anterior axillary line in the fifth interspace. The S2-os interval measured 0.09 to 0.11 second.

Patient B.B. A 57-year-old white woman. A tumor of the left atrium was suspected on the basis of history and physical findings. The diagnosis was confirmed by a venous angiocardiogram. Successful removal of the myxoma was performed under hypothermia.

Phonocardiographic tracings were obtained before and after surgery. The first sound at the apex was markedly accentuated (fig. 3). The Q-S1 interval was prolonged and measured 0.09 second. The pulmonic second sound was accentuated and normally split.

Presystolic and systolic murmurs were recorded in the apical and the tricuspid areas (figs. 3 and 4). The presystolic murmur varied in intensity from one examination to another and at times it was inaudible. The systolic murmur increased in intensity with inspiration (fig. 4). A faint, early diastolic, high-pitched murmur was heard in the pulmonic area. An extra sound was present in the anterior axillary line in the fifth intercostal space and the apical area. This sound had the clicking quality of an opening snap. The S2-os interval measured 0.055 to 0.06 second (fig. 3).

One year after successful surgery, the phonocardiographic findings were completely normal. The first apical sound and the pulmonic second sound were of normal intensity. The murmurs and the opening snap had disappeared. The Q-S1 interval was 0.06 second (fig. 6).

Patient E.C. A 57-year-old white man presented a picture of congestive heart failure with dyspnœa, orthopœa, crepitant rales in both lungs, large liver, and dependent edema. Myxoma of the left atrium was suspected on the basis of history and the experience with
two previous patients. Venous angiocardiography showed a filling defect in the left atrium. A large myxoma was successfully removed from the left atrium under hypothermia.

The first sound was markedly accentuated and widened. The Q-S₁ interval was prolonged to 0.09 second. The pulmonic second sound was accentuated and showed narrow splitting on inspiration (fig. 5).

There was no presystolic murmur. A short systolic murmur confined to the early part of systole was recorded in all four cardinal areas of auscultation. A high-pitched, early diastolic murmur was recorded in the fourth left interspace and the pulmonic area. In the former area there was also an inconstant atrial sound (fig. 5).

An extra sound was recorded in early diastole in almost all areas, but it was especially clear in the apical area (fig. 5). This sound lacked the snapping character of an opening snap and had the auscultatory quality of a third heart sound. The S₂-O₅ interval was also longer than in the two other patients and measured 0.11 to 0.12 second. When this sound was simultaneously recorded with a jugular vein tracing, however, it occurred at the peak of the V wave and it was therefore considered to be an opening snap (fig. 5).

A postoperative phonocardiogram 1 year later showed no abnormalities. The first apical and pulmonic second sounds were normal and all murmurs had disappeared. The Q-S₁ interval, however, was still prolonged and measured 0.06 second (fig. 6).

Table 1 summarizes the auscultatory findings.

Discussion

The first sound was markedly accentuated and prolonged in all three patients. The accentuated first sound in the absence of valvular pathology must result from a more forcible valvular closure and, possibly, a greater excursion of the cusps during the closure.³ The pulmonary artery wedge pressure, which reflects the left atrial pressure,⁸ was elevated in all three cases (table 2). The accentuated first sound is, therefore, the result of the high atrioventricular pressure gradient. Another possible factor may be the striking of the cusps against the tumor during closure.

The delayed first sound. The high atrioventricular gradient also accounts for the delay of the first sound. The Q-S₁ interval was prolonged in all three patients (table 2). The elevated left atrial pressure delays the closure of the valve because it takes a longer time for the ventricular pressure to exceed the left atrial pressure.⁹,¹⁰
Accentuation of the pulmonic second sound found in all three patients was due to pulmonary hypertension as shown by cardiac catheterization data (table 2). Other investigators have found fairly good correlation between the height of the pulmonary artery pressure and the intensity of the pulmonic second sound. The amount of splitting of the second sound was within normal limits but was very narrow in patient E.C.

A sound that was considered to be an opening snap of the mitral valve was heard in early diastole in all three patients. In patients K.P. and B.B. this sound had the usual auscultatory characteristics of an opening snap, being fairly high-pitched and snappy in character. In patient E.C. the early diastolic sound was lower in pitch and longer in duration; however, since it was recorded simultaneously with the peak of the V wave, it should be considered an opening snap. The S2–os intervals placed the sound in the range of opening snap rather than that of a third heart sound. It was differentiated from the split pulmonic sound, which has similar auscultatory characteristics to the opening snap, because all three sounds, namely, the split second sound and the opening snap were visible on some records. Furthermore, the split second sound was affected by respiration whereas the opening snap was not.

It is interesting to note that in patient B.B., the opening snap was best heard in the anterior axillary line in the fifth interspace and not in the usual position, the third and fourth

**Figure 4**

Phonocardiogram of patient B.B. showing respiratory variations of the systolic murmur (sm). Notice increased intensity on inspiration, (Insp). Frequency response 300 cycles per second, paper speed 50 mm. per second.

**Figure 5**

Patient E.C. Uppermost tracing recorded at earlike frequency response shows an apical phonocardiogram recorded simultaneously with jugular vein pressure tracing. The opening snap (os) occurs at the peak of the V (v) wave. The two lower tracings recorded at a frequency response of 300 and 50 cycles, show the presence of systolic (sm) and diastolic (dm) murmurs. An atrial sound (as) is recorded in the fourth left interspace. The second sound (2) is narrowly split. Paper speed 50 mm. per second.
interspace to the left of the sternum. In patient E.C. the opening snap had very wide distribution and was heard over the entire precordium.

An opening snap is usually present in patients with mitral stenosis in whom the flexibility of the mitral valve has been preserved. The origin of the opening snap in mitral stenosis has been assumed to depend on (1) the increased left atrial pressure and the resulting forcible opening of the thickened valve, (2) the pathologic changes in the valve, which create a sort of hammock-like deformity and cause the valve to snap open suddenly and produce an audible vibration. When the valve becomes fibroed and calcified and cannot move, the opening snap disappears. Since the mitral valve was normal in all three patients, the opening snap must have been caused solely by the abrupt opening of the valve produced by the high left atrial pressure.

An atrial sound was also occasionally heard in patient E.C. This sound was of low intensity and was very inconstant (fig. 5).

Murmurs. A presystolic murmur was present in two of the three patients. This murmur had the auscultatory quality of the presystolic murmur of mitral stenosis. This is not surprising, since in both myxoma and mitral stenosis the presystolic murmur is produced by a similar mechanism, namely, obstruction to the flow of blood at the mitral valve. The presystolic murmur in our patients, however, varied in intensity from one auscultation to another. This variability of the presystolic murmur is very suggestive of myxoma. Also, of extreme diagnostic importance is the observation that the presystolic and mid-diastolic murmurs were not so loud as would be expected in patients with mitral stenosis with left atrial pressures (or pulmonary artery wedge pressures) of the degree noted.

The systolic musical murmur recorded in patient K.P. on inspiration before the treatment of congestive heart failure was probably due to tricuspid insufficiency resulting from hypertrophy and dilatation of the failing right ventricle.

Summary and Conclusions

The phonocardiographic findings in three patients with myxoma of the left atrium and normal mitral valve are presented.

The obstruction of blood flow through the mitral valve closely simulated mitral stenosis and resulted in a high atrioventricular gradient, a presystolic murmur, an opening snap, pulmonary hypertension (accentuated P₂), and an early high-pitched diastolic murmur (Graham Steel murmur) of pulmonary insufficiency.

Of special significance is the occurrence of an opening snap, which has been considered by many as pathognomonie of mitral stenosis. It is proposed that the opening snap heard in myxoma is due to a high atrioventricular gradient and may occur in the presence of a normal valve.

All phonocardiographic abnormalities disappeared after the successful removal of the myxoma.

References

Experience seems to show that the only kind of hypothesis which can find conclusive scientific support, or sound basis in the phenomena of matter and energy, is a mechanistic hypothesis. Exact and positive knowledge can demonstrate scientifically the truth of no other hypothesis with the finality which characterizes its proof of a mechanistic theory. Hence, so far as it ventures into the field of science at all, a vitalistic theory, when attacked by science, cannot effectually avail itself of the weapons of the assailant, and can never make a powerful counter attack. Its only method consists in a determined resistance, yielding little by little before the advance of positive knowledge and never gaining new territory, nor, except by accident, regaining what it has lost. Where this process is to end; in what respect and how far life is destined ever to remain a scientific riddle, can only be surmised.—Lawrence J. Henderson. The Fitness of the Environment. New York, The Macmillan Co., 1924, p. 283.
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