Fonocardiografie. Betekenis voor de diagnostiek van enige aangeboren en verworven hartgebreken

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SUMMARY

Chapter I.

In a short historical survey special attention is given to the studies of *Einthoven,* which are the bases of modern phonocardiography.

In the discussion about human hearing the possibility of concentration on fixed frequency areas is stressed. "Ear like" or "gehörsähnliche" phonocardiography does not exist.

In this investigation we applied "selective phonocardiography". Five so-called "high-pass" filters, found on emperical grounds by *Maass* and *Weber*, were used in our apparatus. The frequency characteristics are shown in fig. 3.

Chapter II.

In seven patients with a severe pulmonary stenosis (pressure gradient between pulmonary artery and right ventricle more than 75 mm mercury) and in six patients with a moderate or slight pulmonary stenosis phonocardiographic studies were performed (table I). In all cases the murmur started immediately after the end of the first sound and was diamond shaped. The maximum of the murmur was found in the first half of the systole in the slight and moderate cases. In the severe cases however the maximum was reached in the second half of the systole.

The murmur ended in slight and moderate stenosis before the second sound (fig. 4); in severe stenoses the end lies after the aortic component of the second sound (fig. 5).

The components of the second sound are separated by more than 0.07 sec. in severe stenoses.

An auricular sound appeared in filter Mm_1 and higher in cases with a pressure gradient of more than 100 mm mercury between the pulmonary artery and right ventricle (fig. 6). A systolic click was found in a case with a slight pulmonary stenosis (fig. 7 and fig. 8).

B. Phonocariographic studies were performed in seven patients with a tetralogy of Fallot. Five of these had a large right-to-left shunt. In two cases a small shunt was found (table II). A diamond shaped systolic murmur was registered in the third or fourth left interspace.

The maximum, of the murmur was reached in the middle of the systole. The murmur ended before the aortic component of the second sound in the cases with a marked right-to-left shunt.

In two patients with a small right-to-left shunt the murmur ended after the aortic component of the second sound (fig. 11, 12, 13).

These two patients had an acyanotic tetralogy of Fallot.

Five patients, two of which had a moderate elevation of the systolic pressure gradient between the pulmonary artery and right ventricle, had a splitting of the second sound with an interval exceeding 0.07 sec. This was also found in a patient with a marked right-to-left shunt (patient R. P. (2) fig. 10).

An auricular sound was registered in three patients one of which had a pressure gradient between the pulmonary artery and right ventricle of only 60 mm mercury.

C. In seven patients with a trilogy of Fallot the phonocardiographic findings were similar to those observed in cases with a pure pulmonary stenosis.

D. Two patients with a pentalogy of Fallot are described in table IV. The murmur reached its maximum in both cases in the third left interspace. The phonocardiogram of patient A. C. (2) (fig. 17) was similar to that found in cases with a tetralogy of Fallot.

In the phonocardiogram of patient A. V. (1) a systolic click (fig. 18) occurred 0.10 sec. after the beginning of the first sound. The murmur was holosystolic and showed no special features.

Addendum: The phonocardiograms of five patients with idiopathic dilatation of the pulmonary artery were shown in table V and VI. There was a holosystolic, often somewhat descrescendo, murmur, that changed with every systole (fig. 19).

In two patients the second sound was split. A systolic "click" was seen in two patients (fig. 20 and 21).

In one patient we observed a dilatation of the pulmonary artery and a systolic pressure gradient between the pulmonary artery and the right ventricle of 15 mm mercury. The phonocardiogram showed the characteristic features described above (fig. 24).

The phonocardiogram however of a patient with a slight pulmonary stenosis (pressure gradient between pulmonary artery and right ventricle 17 mm mercury), but without dilatation of the pulmonary artery (fig. 25 and 26) showed the characteristic features observed in the pure pulmonary stenosis. We are inclined to think that the first patient has an idiopathic dilatation of the pulmonary artery with a relative pulmonary stenosis due to the idiopathic dilatation of the pulmonary artery.

It seems probable that the phonocardiogram enables us to distinguish between idiopathic dilatation of the pulmonary artery and stenotic changes of the pulmonary valves associated with a marked dilatation of the pulmonary artery and a small systolic pressure gradient between the pulmonary artery and the right ventricle.

Chapter III.

Fifteen patients with aortic stenosis are divided on the basis of the clinical findings in severe, moderate and slight stenosis (table VII). When the stenosis was slight the murmur reached its maximum before the middle of the interval between the first and second sound, and ended 0.04 sec. or more before the second sound (fig. 27).

In severe stenosis the maximum of the murmur occurred in the middle between the first and second sound or later, while it ended 0.02 sec. or less before the second sound (fig. 28).

In patient J. E. (fig. 29) a reversal of the aortic and pulmonary component of the second sound was observed.

In 8 patients with a broad ascending aorta a systolic click was found (fig. 30).

In the sphygmographic examination special attention was paid to the calculation of the cresttime of the sphygmogram of the carotid artery. That is the time in seconds between the starting point of the ascending leg of the pulse wave and the highest point of the main wave. This time can be expressed as a percentage of the total pulse cycle (systolic and diastolic). In slight aortic stenosis the cresttime was 19 per cent or less, while in severe stenosis the cresttime exceeded 27 per cent (fig. 32).

Chapter IV.

In twenty out of twenty-five patients with mitral stenosis it was possible to check the phonocardiographic findings at operation (table VIII).

When the first sound was loud and an opening snap was present, the surgeon always found more or less flexible mitral valves. This made it possible to perform a satisfactory commissurotomy. It is possible however that the surgeon observes a minor degree of calcification in the margins of the leaves.

A normal or soft first sound was always associated with the absence of the opening snap. In these cases the surgeon often found stiff valves with an extensive calcification. The valves resembled a calcified diaphragm with a small unchangeable orifice, which usually produced regurgitation.

The difference between (Q (ECG) - first sound) and (second sound-opening snap), converted for a preceeding R-R cyclus of 0,8 sec., as proposed by *Wells,* was correlated with the size of the mitral ostium as found by the surgeon or as calculated with the formula of *Gorlin* (fig. 38). It appeared that there is between —1½ and +5 an approximately linear relationship between the calculated difference and the size of the mitral orifice, when this is smaller than 1½ square cm. If the orifice is more than 2 square cm no relationship could be detected. This is in accordance with the findings of *Lewis,* who found that a normal flow is possible through a mitral office large than 2,5 square cm, without elevation of the pressure in the left atrium.

When a systolic murmur was found, that ended before the middle of the period between the first and second sound, the surgeon did not find regurgitation.

When the phonocardiogram showed holosystolic murmurs, marked regurgitation was always detected at operation. An opening snap is always absent in these cases and the first sound is normal or soft. Than a third sound may be observed (fig. 39). The diastolic murmur was frequently praesystolic, in seven cases praesystolic crescendo and poststolic decrescendo, often beginning some time after the second sound (fig. 40).

Chapter V.

In ten patients with a coarctatio aortae phonocardiographic investigations were made. In some patients complicating cardiac abnormalities (ventricular septal defect, patent ductus Botalli) existed.

The murmurs not due to these complicating lesions could be divided into two groups:

A. murmurs starting immediately after the first sound;
B. murmurs beginning some time after the end of the first sound.

Ad. A. It is clear that a murmur, starting immediately after the first sound is not produced in the coarctation. Its origin must be close to the heart in the ascending aorta and or the valves. It was found that the murmurs registered in the second right or left interspace all started immediately after the first sound and must have their origin in the aortic valves or the aortic wall. The shape was either diamond like or uncharacteristic. These murmurs always ended before the second sound (fig. 41). In all these cases the characteristic sphygmogram, described by *Donzelot,* was found. The cresttime was 18—20 per cent, that is slightly prolonged.

Ad B. The other murmurs, which are registered in front and at the back of the thorax, all started some time after the first sound and were diamond shaped. The maximum was reached on an average of 0.04 sec. after the summit of the sphygmogram of the carotid artery. The end was in most cases reached after the second sound. A murmur that reaches its maximum after the summit of the sphygmogram of the carotid artery does not originate from the coarctation itself, because at that moment the pressure in the aorta at the level of the coarctation is also already diminished.

A murmur, which reaches its maximum so late must arise from those arteries, in which the pulse wave is also retarded, that is in the collaterals. Between the beginning and the end of these murmurs existed a considerable fall of the pressure in the sphygmogram of the carotid artery. These murmurs, which we therefore described as "murmurs in the collaterals" were usually picked up in places where we could feel the pulsations of a collateral vessel. When the resection preparations were studied the coarctation appeared in many cases to be so narrow that it is hard to imagine that a stream of blood, sufficient to cause a registrable murmur could pass through the stenosis.

The localisation of the coarctation in the middle of the thorax explains why a murmur originating from the coarctation has great difficulties in reaching the thoraxwall. Transmission of the murmur in the direction of the stream does not change the situation because this concerns only the descending aorta. This is mainly filled through the collaterals and the stream is usually slow. The collaterals originate from the aorta before the coarctation and do not contribute to the transmission of the murmur. The localisation of the collaterals was parasternal in front of the thorax from the third to the sixth right or left interspace and at the back along the borders of the scapula, especially on the left side.

These observations do not agree with the opinion, that murmurs, heard in front or at the back of the thorax, usually arise from the coarctation.