Vectorecardiographic Investigations on the Auricles

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Vectorecardiography demonstrates very clearly the method of auricular activation and shows its spatial development. This is illustrated and discussed in this paper as it occurs in normal subjects, in a patient with an ectopic auricular pacemaker, and in patients with pulmonary heart disease. Changes similar to those seen in patients with cor pulmonale have been observed in dogs after partial occlusion of the pulmonary artery. Remarkable alterations of the auricular vectocardiogram have been seen in patients with mitral heart disease after commissurotomy.

Since there is no final agreement concerning the methods which should be used in vectorecardiography, the vectocardiograms, registered by various investigators, are, therefore not absolutely comparable. In Vienna we use the method of Polzer and Schuhfried.1 By this method the normal auricular vector loops are directed anteriorly and inferiorly. The sense of rotation is counterclockwise in the frontal and horizontal, and clockwise in the sagittal plane. Theoretically, the auricular vectocardiogram may be subdivided into a partial vectocardiogram of the right and a partial vectocardiogram of the left auricle. The isolated vectocardiogram of the right auricle would mainly be directed inferiorly, whereas the isolated left auricular vectocardiogram would be directed mainly to the left, which corresponds to the main direction of activation of the left auricle.

Figure 1 shows the vectocardiogram of a normal subject. On all illustrations a potential of 1 mv. corresponds to a deflection of the vectocardiographic loop of 2 cm.

Vectorcardiograms in Conditions Associated with Auricular Abnormalities

Mitral Stenosis. In mitral stenosis the time of activation of the left auricle is prolonged if the auricle is dilated. Therefore the P waves are notched and broader than normal in leads II and III. The ratio P-Q/I-Q, obtained by the use of standard and esophageal leads, is increased. The atriodiagram for the left auricle shows a bulge. Both these methods have been described elsewhere in detail.3-5

The frontal auricular vectocardiogram often shows a distortion of the loop, corresponding to the deformity of the P waves in standard leads II and III. The horizontal loop likewise shows typical changes. In most cases the vector loop is diphasic. The first part of the vector loop, which is partly produced by the normal right auricle activated alone before the left auricle is activated, is directed anteriorly. The second part, which is related to the dilated left auricle with prolonged activation, is directed posteriorly and shows a clockwise rotation (fig. 2A). In connection with this deviation of the second part of the horizontal vector loop, it is to be noted that the direction of the dilatation of the left auricle is mainly toward the left and posteriorly.

In severe cases of mitral stenosis, the horizontal vector loop is directed entirely posteriorly. It shows a clockwise rotation (fig. 2B). This vectocardiogram was taken from a 52 year-old patient with mitral heart disease of long duration. In this case, the sagittal vectocardiogram also shows very clearly the deviation of the second part of the auricular vector loop in the posterior direction.

We investigated 23 patients with mitral stenosis who underwent commissurotomy. In six cases studied after operation, the auricular vectocardiogram was not altered essentially. In the remaining cases, a distinctive change of the horizontal auricular vectocardiogram occurred: the vector loop, which had been

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**Fig. 1.** M. A., a 25 year-old man. Normal subject.

**Fig. 2A,** E. G., a 23 year-old man with mitral stenosis of a moderate degree. **B,** K. L., a 52 year-old man with mitral stenosis of a severe degree.
directed partly or totally posteriorly before operation, was directed more anteriorly or completely anteriorly after operation. Also, the direction of rotation, which before operation was clockwise in the posteriorly directed part of the vector loop, was changed after operation and showed a counterclockwise rotation. Figure 3A shows such changes in the auricular vectorcardiogram after commissurotomy.

*Left Ventricular Hypertrophy.* Corresponding changes of the auricular vector loop may also be seen but rarely in patients with marked left ventricular hypertrophy and resulting dilatation of the left auricle. The patient of figure 4 is a 49 year-old man, suffering from an obliterative arterial disease and corresponding changes of the coronary vessels. The left ventricle is grossly hypertrophied and the left auricle dilated. The ventricular electrocardiogram and vectorcardiograms show widening of QRS and changes due to enormous left ventricular hypertrophy. The auricular vectorcardiogram in the horizontal plane shows clockwise rotation and marked posterior deviation, similar to the changes observed in cases of severe mitral stenosis.

*Cor Pulmonale.* In patients with pulmonary heart disease, the P waves are prominent and peaked in leads II and III. The right auricle is hypertrophied. Corresponding to the increased bioelectric forces causing the partial right auricular vectorcardiogram, the auricular vector loop is directed mainly inferiorly and anteriorly. This is best shown in the frontal plane. Figure 5A shows the vectorcardiogram registered on a 27 year-old woman who has been suffering from bronchial asthma for five years.

*Pulmonary Stenosis.* We were able to observe

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**Fig. 3.** P. A., a 25 year-old man with mitral stenosis. A, shows preoperative and B, postoperative loops.

**Fig. 4.** M. K., a 49 year-old man with hypertrophy of the left ventricle
Fig. 5. A, K. H., a 27 year-old woman with bronchial asthma. B, H. H., a four year-old boy with pulmonary stenosis.

Fig. 6. Sch. M., a 21 year-old man with an ectopic auricular rhythm

Similar changes in patients with pulmonary stenosis, in which obstruction in the outflow tract of the right ventricle causes a dilatation and hypertrophy of the right auricle. This is responsible for the higher bioelectric potentials in this part of the heart. The auricular vectorcardiogram shows relatively large, peaked loops, which are best shown in the sagittal plane. The vectorcardiogram shown in figure 5B was obtained in a boy 4 years of age.

Animal Experiments. Similar changes of the auricular vector loops were found in animal
experiments. We clamped a portion of the pulmonary artery of the exposed dog hearts and observed a gradual prolongation of the frontal and sagittal vector loops. This development was the result of the higher electric potential which arose in the acutely dilated right auricle.

Ectopic Auricular Pacemaker. Also, in patients with ectopic auricular pacemakers, the direction of the auricular vectorcardiogram is altered characteristically. Figure 6 shows the curves obtained from a 21 year-old man, who showed no evidence of heart disease. The electrocardiogram showed P waves which are directed downwards in leads II, III and aVF. This case is described elsewhere in detail.\(^6\)

The assumption of the existence of a pacemaker situated in the caudal portion of the auricles seemed to be justified. The electrocardiographic pattern is similar to that produced experimentally by Prinzmetal and his co-workers\(^5\) on stimulation of caudal parts of the auricles. The auricular vector loops are deviated upward in the frontal and sagittal plane. The sense of rotation is clockwise in these two planes. The horizontal vectorcardiogram shows a more or less normal pattern. The vectorcardiogram clearly shows that the auricles in this case are activated in a reverse sense.

**Comments and Summary**

The auricular vectorcardiogram is changed characteristically in many instances of pathological disorders of the auricles. A few examples are given in this paper. In cases of mitral stenosis, the altered partial vector of the left auricle is reflected in the pattern of the auricular vectorcardiogram. The horizontal vector loop shows a partial or total deviation posteriorly and a corresponding change of sense of rotation. After commissurotomy, the auricular vectorcardiogram showed, in some of the cases, a pronounced change toward the normal.

It is remarkable that changes similar to those found in patients with severe mitral stenosis have also been observed in a patient with marked left ventricular hypertrophy. The resulting dilatation of the left auricle seems to be responsible for this change of the auricular vectorcardiogram. Possibly the posterior displacement of the auricle by the huge left ventricle also plays a causative role.

In cases of pulmonary heart disease, as well as in cases of pulmonary stenosis, the auricular vector loop is directed anteriorly and prolonged in the caudal direction. This corresponds to the alteration of the partial right auricular vectorcardiogram caused by the dilatation and hypertrophy of the right auricle.

Similar changes have been observed under experimental conditions, when the pulmonary artery has been partially clamped.

In the hearts with ectopic auricular pacemaker, the vectorcardiogram clearly shows the changed conditions of auricular activation, as has been demonstrated in a case of a caudally situated auricular pacemaker.

**Conclusions**

Vectorcardiography offers the opportunity of clearly demonstrating the altered activation of the auricles under various normal and abnormal conditions. A few examples are presented in this paper.

**Summario in Interlingua**

Le vectocardiogramma es caracteristicamente alterate in multe casos de disorders pathologic del auriculas. Le presente reporto discute alicum exemplos illustrative de iste facto. In casos de stenosis mitral, le alterate vector partial del auricula sinistre es reflectite in le configuration del vectocardiogramma auricular. Le spira vectorial horizontal exhibi un partial o total deviation in direction posterior e un cambiamento correspondente del senso rotational. Post commissurotomy, le vectocardiogramma mostra in alicum casos un pronunciate cambiamento verso le configuration normal.

Il es remarcabile que cambiamentos simile a illos incontrate in patientes con sever stenosis mitral ha etiam essite observate in patientes con pronunciate hypertrophia sinistroventricular. Le resultante dilatation del auricula sinistre pare esser responsabile pro iste alteratio del vectocardiogramma auricular. Il es possibile que etiam le displaciamiento del
auricula in direction posterior effectuate per le enorme ventriculo sinistre exerce in iste situation un influentia causal.

In casos de morbo cardiac pulmonar e etiam in cases de stenosis pulmonar, le spira vectorial auricular se dirige in direction anterior e es prolongate verso le cauda. Isto corresponde al alteration del partial vectocardiogramma dexterauricular causate per dilatation e hypertrophia del auricula dextere.

Simile cambiamentos ha essite observate sub conditiones experimental quando le arteria pulmonar es partialmente pinciate.

In cordes con ectopic pacemaker auricular, le vectocardiogramma mostra clarmente le cambiate condition del activation auricular. Isto ha essite demonstrate in un caso de pacemaker auricular situate in le portion caudal del auricula.

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