The Vectorcardiogram and Electrocardiogram in Persistent Common Atrioventricular Canal

By Jonas Beregovich, M.D., Selvyn Bleifer, M.D., Ephraim Donoso, M.D., and Arthur Grishman, M.D.

The electrocardiogram and vectorcardiogram are of great aid in differentiating atrial septal defect of the secundum type from the ostium-primum type. In the latter condition there is left axis deviation in the scalar electrocardiogram and superior orientation of the QRS vector in the sagittal and frontal planes. There are relatively few congenital lesions that lead to the same degree of axis deviation and superior orientation of the QRS vector.

The importance of accurate anatomic differentiation preoperatively between the ostium primum and secundum types of atrial septal defects cannot be overemphasized. The ostium secundum type is technically the most simple intracardiac communication to repair and is amenable to several operative technics such as the atrial well, hypothermia, and pump oxygenator bypass. The persistent common atrioventricular canal is more difficult to repair and the surgical procedure requires direct vision for correction of all the malformations.\(^1\), \(^2\)

In the last few years, the pathologic studies of Wakai and Edwards,\(^3\) and Campbell and Missen,\(^4\) have clarified the anatomic features of this malformation in which, besides the low atrial septal defect, there may be a cleft in either or both atrioventricular valves, as well as a defect in the membranous portion of the ventricular septum. Another common finding is the occurrence of combined ventricular hypertrophy.

The differentiation of the 2 types of defects on clinical and hemodynamic grounds alone is often difficult. Several authors\(^5\)–\(^8\) have described electrocardiographic findings that have proved to be reliable for this differentiation. Toscano-Barbosa et al.,\(^5\) also called attention to a rather characteristic vectorcardiographic pattern, which they described only for the frontal plane.

The purpose of this communication is to present our vectorcardiographic and electrocardiographic experience in a group of cases of persistent common atrioventricular canal.

Material and Method

The material is comprised of 18 patients studied at The Mount Sinai Hospital from 1955 to 1959. Selection was made on the basis of a complete history, physical examination, chest x-rays, electrocardiograms, and vectorcardiograms. Right heart catheterization was performed in every instance. In 2 patients selective angioangiography was performed. The dye was injected into the left ventricle and regurgitation into the left or right atrium or right ventricle was demonstrated. In another 7 patients, anatomic confirmation of a persistent common atrioventricular canal was subsequently obtained at operation.

There were 10 female and 8 male subjects in our series, with ages ranging from 2\(\frac{1}{2}\) to 42 years.

Routine 12-lead electrocardiograms were obtained with the direct writing Technicor or Sanborn Viso-Cardiette. Simultaneous leads and double paper speed (50 mm./sec.) were used in several instances.

The vectorcardiograms were obtained with the Sanborn Vector System and Viso-scope. The cube method of electrode placement was used.\(^9\) The horizontal, sagittal, and frontal planes of the vectorcardiogram were analyzed for spatial orientation, configuration, and direction of inscription of the QRS and T loops.

When applicable, the criteria used for the electrocardiographic diagnosis of right ventricular hypertrophy were those of Sokolow and Lyon,\(^10\) Goodwin,\(^11\) Milnor,\(^12\) and Barker and Valeneia.\(^13\) For left ventricular hypertrophy those of Sokolow and Lyon\(^14\) or Pagnoni and Goodwin\(^15\) were used. Combined ventricular hypertrophy was considered to be present if the criteria of Beregovich et al. were satisfied.\(^16\)

The vectorcardiographic diagnosis of right, left,
Table 1

Electrocardiographic and Vectorcardiographic Observations in Eighteen Cases of Common Atrioventricular Canal

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(Explanation of abbreviations on bottom of opposite page)
and combined ventricular hypertrophy, based on studies made in this laboratory,9, 16, 17 could not be satisfactorily applied in these cases.

Results
Vectorcardiograms (Table 1)
A constant finding was superior orientation of the QRS loop in the frontal and sagittal planes. A small initial segment may be directed inferiorly, but by far the largest portion of the QRS loop was superiorly oriented.

In the frontal plane, the QRS loop was directly superior or slightly displaced to the left in 15 cases (fig. 1), and somewhat displaced to the right in 3 cases (fig. 2). The sense of rotation was counterclockwise in all but 1 tracing, in which the loop was a figure-of-eight (case 12).

In the sagittal plane the QRS loop was superiorly and anteriorly oriented in 16 cases, superior and somewhat posterior in 2. The sense of rotation was variable.

In the horizontal plane the QRS loop showed no consistent pattern. There were loops similar to those described for right ventricular hypertrophy in 13 cases (nos. 1 to 13), the orientation being anterior, to the right, and clockwise (figs. 1 and 2). When the loop had a figure-of-eight configuration, the terminal limb was always clockwise (fig. 3).

In 3 other cases (nos. 14-16) the QRS loop in the horizontal plane was similar to that described for right bundle-branch block, with the initial portion of the loop normally oriented, but with a terminal segment anterior, to the right, and slowly inscribed. The terminal limb of this segment was clockwise in rotation (fig. 4).

In 1 case (no. 18) (fig. 5) the QRS loop in the horizontal plane was within normal limits, and the remaining case (no. 17) showed an unusual loop that could not be classified.

The T loop, in general, was discordant or at an angular deviation from the main area of the QRS loop.

Electrocardiograms (Table 1)
There was a sinus rhythm in all 18 cases; however, in 11 electrocardiograms the P-R intervals were prolonged for the heart rate and age.18 Left axis deviation was observed in 14 cases, and this group coincides with those whose frontal plane vectorcardiogram was superior or slightly displaced to the left (fig. 3). In the 4 remaining cases (nos. 10–13) a concordant S pattern was found in the standard leads. This group corresponded to those with a superior and rightward displaced QRS loop in the frontal plane (fig. 2).

In 11 electrocardiograms there was a RSR' pattern in V1 (figs. 3 and 4). However, rR', Rs, rS, qR, or QS patterns in V1 were also observed (figs. 1 to 5). An RSR' pattern in the right precordial leads was not considered sufficient evidence for a diagnosis of right bundle-branch block in this group of patients because the vectorcardiogram does not always show a conduction delay.

On the basis of electrocardiographic criteria, a diagnosis of combined ventricular hypertrophy was made in 9 cases (nos. 1–7, 9, 16) (fig. 3). In the 4 patients with a concordant S pattern (nos. 10–13), right ventricular hypertrophy was diagnosed (fig. 2); and in the 5 remaining cases (nos. 8, 14, 15, 17, 18), the diagnosis was left ventricular hypertrophy (fig. 5).

Intracardiac Pressures
Moderate to marked elevation of right ventricular and pulmonary artery pressures was a frequent finding. Right ventricular pressures of 45 mm. Hg or more were observed in 10 cases.

RVH: Right ventricular hypertrophy.
LVH: Left ventricular hypertrophy.
RAE: Right atrial enlargement.
LAE: Left atrial enlargement.
?: Questionable diagnosis.
Cond. S.: Concordant S pattern.
Rot: Rotation.

Table 1

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<tr>
<th>RVH</th>
<th>LVH</th>
<th>RAE</th>
<th>LAE</th>
<th>?</th>
<th>Cond. S.</th>
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Figure 1

R.L., case 1. The QRS loop is superiorly oriented in the sagittal and frontal planes. Note leftward displacement of the QRS loop in the frontal plane and counterclockwise rotation; in the horizontal plane, anterior displacement and clockwise rotation of the QRS loop. Left axis deviation and an rR' pattern in V1 are shown in the electrocardiogram.
Figure 2

P.L., case 10. There is superior orientation of the QRS loop, which is displaced to the right in the frontal plane. There is a concordant S pattern in the standard leads of the electrocardiogram. An rR' pattern is present in V1.
Figure 3
B.R., case 7. (The diagnosis was confirmed by selective angiocardiology and surgical correction.) There is superior orientation of the QRS loop in the sagittal and frontal planes with counterclockwise rotation in the frontal plane. The horizontal plane shows a figure-of-eight pattern. Electrocardiogram shows first-degree atioventricular block, left axis deviation, and RSR′ pattern in V₁.
T.B., case 11. There is superior orientation of the QRS loop in the frontal and sagittal planes. The terminal limb is slightly delayed. In the horizontal plane the terminal segment is anterior and to the right, resembling the configuration of right bundle-branch block. Electrocardiogram shows left axis deviation and an rSR' pattern in V₁.
K.A., case 18. (Diagnosis proved at operation.) There is superior orientation of the QRS loop in the sagittal and frontal planes. The horizontal plane QRS loop, however, is normal. Electrocardiogram shows left axis deviation, first-degree atrioventricular block, and an rS pattern in V1.
COMMON ATRIOVENTRICULAR CANAL

No correlation existed, however, between right-sided pressures obtained at catheterization and the vectorcardiographic or electrocardiographic patterns.

Discussion

Several clinical and hemodynamic points are suggestive but not diagnostic of a persistent common atroventricular canal. Marked cardiomegaly, an apical thrill, murmurs of mitral or tricuspid regurgitation, cyanosis, or evidence of pulmonary hypertension leads one to suspect such a possibility when the remainder of the clinical picture is that of an atrial septal defect.4,19

From catheterization studies it has been learned8,20 that the following findings also favor the presence of a persistent common atroventricular canal type of defect: (1) a low position of the catheter when the defect is crossed; (2) entrance of the catheter from the right atrium directly into the left ventricle; (3) left-to-right shunt at the right atrial level and occasionally an additional oxygen step-up in the right ventricle; (4) a high incidence of marked right ventricular and pulmonary artery hypertension; (5) left ventriculography demonstrating regurgitation of dye from the left ventricle to the right atrium.21

These findings are not pathognomonic, and the clinical diagnosis remains a difficult one.

The electrocardiogram and vectorcardiogram have proved to be the greatest single aid to the clinician.

The diagnostic value of the electrocardiogram was generally confirmed in our series, and in many cases the electrocardiograms was similar to those described previously.5-7 Normal sinus rhythm, frequent occurrence of first-degree atrioventricular block, left axis deviation or occasionally a concordant S pattern in the standard leads, and an RSR' pattern in V1 were the most outstanding electrocardiographic findings. These features are by no means constant, however. A variety of other electrocardiographic patterns was observed in V1; and with application of strict criteria, a diagnosis of either combined, right, or left ventricular hypertrophy could be made in all cases.

Similar electrocardiograms, with left axis deviation, have been observed in other congenital malformations such as ventricular septal defects16 (fig. 6) and tricuspid atresia. The frontal plane vectorcardiogram in these cases is different, however; it shows a leftward displacement of the QRS loop, but its major portion is not superiorly oriented but is rather inferiorly or horizontally displaced.

The vectorcardiogram shows very constant characteristics in persistent common atroventricular canal. The outstanding features are superior orientation of the QRS loop in the frontal and sagittal planes, and counterclockwise rotation of the QRS loop in the frontal plane. A small difference in the displacement of the QRS loop in the frontal plane accounted for either a leftward or rightward loop which was insignificant vectorially, but electrocardiographically caused a marked change. When there was leftward displacement of the QRS loop, left axis deviation was observed, and with rightward displacement a concordant S pattern resulted.

The horizontal plane QRS loop configuration, in this particular group, seems to be less valuable as an aid in the diagnosis. Slight differences in displacement of the superiorly oriented electrical forces, account for the variability in the horizontal plane projection, and for different QRS loop patterns.

In some cases a terminal slowing appears of the QRS loop somewhat beyond that seen in normal subjects. Distinct from right bundle-branch block, it remains within the general contour of the QRS loop and does not appear as a separate segment (at least in the frontal and sagittal planes). Since in the cases of persistent common atroventricular canal the QRS loop is superiorly oriented, its terminal segment likewise has a perpendicular orientation (fig. 4). Very occasionally almost the entire centripetal limb is slowed. There was no consistent relationship to the duration of the QRS complexes, although with pronounced terminal slowing, increased QRS in-
Figure 6

M.D., a 9-year-old girl with a ventricular septal defect. There is leftward displacement of the QRS loop in the frontal plane but a significant portion of the loop is inferior in the sagittal and frontal plane. There is a figure-of-eight loop anteriorly displaced in the horizontal plane. Electrocardiogram shows left axis deviation and an RSR’ pattern in V1.
Figure 7

R.F., a 17-year-old patient with an ostium secundum type defect, subsequently confirmed at operation. The vectorcardiogram shows inferior orientation of the QRS loop in the sagittal and frontal planes. The QRS loop is inscribed clockwise in the frontal plane. There is also clockwise rotation and anterior displacement of the QRS loop in the horizontal plane. Electrocardiogram shows right axis deviation and an rSR' pattern in V1.
Vectorcardiogram of an elderly patient with coronary atherosclerosis. Note similarity to the patterns illustrated in cases of AV-canal defects. The QRS loop is superiorly oriented. In this case there is terminal conduction delay. Electrocardiogram (double paper speed) shows left axis deviation and an rSR' pattern in V1.

Figure 8

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tervals were more likely to be encountered. The spatial orientation and gradual transition from the main QRS loop, set it apart from right bundle-branch block of the Wilson type, where the terminal, slowed segment is a sharply delineated appendage to the main QRS loop and invariably oriented to the right, anteriorly, and essentially within the horizontal plane.

The significance of the superior orientation of the vectocardiogram is not known. It is tempting to assume that this is caused by combined ventricular hypertrophy, since pathologically this is a frequent finding. It is not justifiable with our present knowledge, however, to make such a statement. It is just as likely to be due to a difference in the course of ventricular activation, since the defect is so intimately related to the conducting system. For this reason, we have avoided making specific vectocardiographic diagnosis, and we have preferred merely to describe the morphologic configuration. This may also apply to the use of electrocardiographic criteria for the identification of right, left, or combined ventricular hypertrophy in the vectocardiogram of this group of patients.

The vectocardiogram is quite different from those observed in the ostium secundum type of defect22 (fig. 7) and serves as an excellent aid in the differential diagnosis.

In our experience the only instance in which a similar vectocardiographic pattern is observed occurs in old patients with left ventricular hypertrophy and coronary disease:23 superior orientation with conduction delay in the second half of the QRS loop is observed (fig. 8). The electrocardiogram might be interpreted as right bundle-branch block with left axis deviation. The differences in age and clinical findings are such that confusion rarely exists. When a vectocardiographic pattern similar to that described above is observed in a patient with congenital heart disease, one must strongly consider the probability of persistent common atrioventricular canal.

**Summary**

The vectocardiogram and electrocardiogram in 18 cases of persistent common atrioventricular canal have been described.

Vectocardiographically superior orientation of the QRS sE loop as seen in the sagittal and frontal planes and counterclockwise rotation of the QRS sE loop in the frontal plane were constant findings. In the horizontal plane a variety of different QRS sE loop configurations were observed.

Electrocardiographically the most frequent findings were first degree AV block, left axis deviation or concordant S pattern, and RSR' pattern in V1, although other configurations were also observed.

The significance of the superior orientation is discussed and the usefulness of the vectocardiogram in the clinical diagnosis of persistent common atrioventricular canal is pointed out.

**Acknowledgment**

We wish to express our appreciation to Dr. Alvin J. Gordon, head of the cardiac catheterization team, who so kindly allowed us to use the catheterization data, and to Miss Ruth Jaspan, whose assistance in this study was invaluable.

**Summario in Interlingua**

Es describite le veceto- e electrocardiogrammas in 18 casos de persistente canal atrioventricular commum.

In le vectocardioogrammas, orientation superior del ansa QRS sE (viste le planos sagittal e frontal) e rotation sinistrose del ansa QRS sE in le plano frontal eseva constantiones constante. In le plano horizontal, un varietate de differente configurationes del ansa QRS sE eseva observate.

In le electrocardiogrammas, le constantaciones le plus frequente eseva bloco atrioventricular del prime grado, deviation axial sinistrose o concordante patrono S, e patrono RSR' in V1, sed altere configurationes eseva etiam observate.

Le signification del orientation superior es discutite. Es signalate le utilitate del vectocardiogramma in le diagnose clinic de persistente canal atrioventricular commun.

**References**


The Vectorcardiogram and Electrocardiogram in Persistent Common Atrioventricular Canal

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