SECTION ON
CARDIOVASCULAR DISEASES

The Electrocardiogram in Atrial Septal Defect*

LEONARD S. DREIFUS, M.D., SHELDON BENDER, M.D.,**
HARRY GOLDBERG, M.D., F.C.C.P. and DANIEL F. DOWNING, M.D., F.C.C.P.
Philadelphia, Pennsylvania

In an effort to determine the mechanism of the predominant pattern in the electrocardiogram in atrial septal defect we have studied tracings of a number of individuals whose condition was treated by surgery. The patient group presented two obvious advantages: 1) in each case the lesion had been anatomically defined, and 2) comparison could be made in the survivors of tracings before and after repair.

Material

Seventy-nine consecutive patients in whom atrioseptopexy1 was performed were considered. The age range was two to 57 years, the majority being adults. Right heart catheterization was performed in all. None had an associated congenital or acquired cardiac abnormality.

Sixty-five had defects of the septum secundum, 14 of the septum primum. In the latter individuals there could be palpated, at operation, no septal tissue above the atrio-ventricular valves. In none of these was significant mitral insufficiency found.

Thirteen patients died during surgery or in the immediate postoperative period. Of these, eight had septum primum defects, five septum secundum defects.

At least one preoperative electrocardiogram of each individual was available. In 57 of the survivors, several tracings were secured during the period of hospitalization, postoperatively and at intervals during the succeeding several months. Twenty-one have been followed for at least two years. Postoperative records of nine patients are not at hand.

Thirty-eight were recatheterized following operation, the interval between surgery and the study varying from two weeks to four years, the average being one year. The data in six of these proved that the defect had not been completely obliterated, a fact suspected by the surgeon at the completion of operation.

Eliminating the electrocardiograms of these six, there remained 51 suitable for comparative study. In 32 no shunt was demonstrable postoperatively; in the remaining 19 the surgeon was certain of complete closure of the defect and there existed clinical evidence of this result in that symptoms disappeared, murmurs were no longer present or were markedly altered and other signs were changed for the better.

*From the Departments of Medicine and Pediatrics and the B'rith Sholom Cardiopulmonary Laboratory, Hahnemann Medical College and Hospital, Philadelphia, Penna.
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In the recatheterized patients, attention was given to right ventricular pressure, right ventricular work and to flow index in the light of the electrocardiographic data obtained.

Results

Normal sinus rhythm was present preoperatively in 70 patients, atrial fibrillation in eight and chronic atrial flutter in one. Postoperatively the fibrillation and flutter persisted. In those with normal sinus rhythm who survived, transient atrial arrhythmias were frequently seen in the immediate postoperative period; in all there was reversion to a normal pattern.

In 29 initial tracings the P wave was normal; in the others it was widened, notched or peaked, with a notably tall or biphasic configuration in V₁ or V₂. Postoperatively, abnormalities were more common but there was no significant pattern of change.

The P-R interval was greater than 0.22 second in 15 preoperatively. Three died. Postoperative tracings of two cannot be found. Of the 10 remaining, the interval was reduced in four, increased in one and unchanged in five. In four patients with normal P-R interval preoperatively there was a slight prolongation postoperatively. The defect was proved to be completely closed in each.

Right axis deviation was present in 77 of the original 79. In two who had septum primum defect there was left axis deviation. It must be

FIGURE 1
stressed that the other 12 with septum primum defect had right axis deviation. Postoperatively, there was a tendency toward a normal electrical axis.

Five basic QRS patterns in V₁ were seen preoperatively: rsR', qR, rR, R and qRs (Fig. 1). When a qR was present in V₁, an rsR' was invariably present in V₂. Careful measurement of the QRS duration in V₂ in these cases made it apparent that the initial r in V₁ was isoelectric. The pattern most frequently encountered was rsR'. This was present in 55 patients (75 per cent). In 17 (21 per cent) a qR and in 5 (2.5 per cent) an rR or R were found. An rS in V₁ and V₂ in two patients was considered normal.

The mean duration of QRS in V₁ before surgery was $0.086 \pm 0.0016$ sec.* (Table 1). The mean amplitude of the R wave was $8.38 \pm 0.23$ mm.* In 51 individuals in whom it was clinically demonstrated or proved by catheterization that the defect had been completely closed, there was a decrease in QRS duration in 54 per cent (mean $0.079 \pm 0.003$ sec.*) and in R wave height in 37 per cent (mean $6.52 \pm 0.047$ mm.*) in tracings secured within a period of two months. During this time an rsR' pattern persisted in 26 of 38 patients in whom it was present preoperatively. In 6 instances the rsR' gave way to an RS. Two with rs were unchanged. An rsR' pattern developed in two who originally had rR. Of the 21 patients

*Standard error of the mean.

**TABLE I—COMPARISON OF ELECTROCARDIOGRAPHIC AND HEMODYNAMIC DATA PRE- AND POSTOPERATIVELY**

<table>
<thead>
<tr>
<th></th>
<th>Preoperative</th>
<th>Postoperative</th>
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</thead>
<tbody>
<tr>
<td><strong>Right Ventricular Work</strong> (Kg./M./Min.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.086</td>
<td>0.079</td>
</tr>
<tr>
<td>*SD</td>
<td>±0.014</td>
<td>±0.018</td>
</tr>
<tr>
<td>†SE</td>
<td>±0.002</td>
<td>±0.003</td>
</tr>
<tr>
<td><strong>Height or R or R' (millimeters)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>8.38</td>
<td>6.52</td>
</tr>
<tr>
<td>SD</td>
<td>±2.07</td>
<td>±3.38</td>
</tr>
<tr>
<td>SE</td>
<td>±0.23</td>
<td>±0.47</td>
</tr>
<tr>
<td><strong>Right Ventricular Pressure</strong> (mm. Hg.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>46.70</td>
<td>21.54</td>
</tr>
<tr>
<td>SD</td>
<td>±2.49</td>
<td>±5.36</td>
</tr>
<tr>
<td>SE</td>
<td>±0.29</td>
<td>±0.92</td>
</tr>
<tr>
<td><strong>Flow Index (P/S)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.95</td>
<td>Closed</td>
</tr>
<tr>
<td>SD</td>
<td>±0.36</td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>±0.05</td>
<td></td>
</tr>
<tr>
<td><strong>Right Ventricular Work</strong> (Kg./M./Min.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.32</td>
<td>0.62</td>
</tr>
<tr>
<td>SD</td>
<td>±1.28</td>
<td>±0.42</td>
</tr>
<tr>
<td>SE</td>
<td>±0.16</td>
<td>±0.09</td>
</tr>
</tbody>
</table>

*SD — Standard deviation.
†SE — Standard error of the mean.
in whom follow-up observation of at least two years has been possible there were only two in whom there was further decrease in duration of QRS. On the other hand, the height of the R in V1 continued to decrease in 13.

The common preoperative pattern in V6 was RS (62 cases, 79 per cent). The S wave was invariably deep and slurred in this group. In eight subjects (10 per cent) rS, and in two (2.5 per cent) R was found. The remaining seven had a qRS, the S wave being deep and slurred in five instances. Postoperatively there was no significant alteration in this lead.

Preoperatively, in the recatheterized group, the mean right ventricular systolic pressure was 42.38 ± 1.27* mm. Hg.; the mean right ventricular work was 2.32 ± 0.16* Kg. M/sec. Following operation the mean pressure fell to 21.5 ± 0.92* mm. Hg. and the right ventricular work to 0.62 ± 0.09* Kg. M/sec. (Table I).

As illustrated in Figures 2 to 4, there was no apparent correlation of QRS configuration or duration or of R wave amplitude in V1 with right ventricular systolic pressure, right ventricular work or flow index. However, in the five instances in which QRS duration was 0.12 sec. or greater, a large flow index was present.

**Comment**

The predominant pattern in this group of patients was rsR', that of delayed conduction in the right ventricle, with or without hypertrophy. For all practical purposes the rR, R and qRs patterns may be considered as rSR' equivalents although they were not so treated statistically.

Within a few days to a week following closure of the atrial septal defect there was a reduction in the QRS duration and a decrease in the amplitude of the R wave in the right precordial leads (Figs. 5-6). Late, follow-up

*Standard error of the mean.
electrocardiograms showed some further reduction in R amplitude with little or no further decrease in QRS duration. In spite of obliteration of the shunt and significant reduction in right ventricular pressure and work, in almost all cases QRS in V1 and V6 resembled the preoperative configuration.

The rsR' pattern in atrial septal defect has been ascribed to various causes. If due to hypertrophy of the crista supraventricularis, how explain its appearance in acute right ventricular overload as in pulmonary embolism? Or following pulmonary valvulotomy which has resulted in pulmonary insufficiency? If due, purely, to diastolic overload of the right ventricle, how explain its presence in such lesions as isolated pulmonary stenosis and others in which there is a systolic overload? And how relate its persistence in our cases even though there was no longer a diastolic overload?

A factor which is certainly potentially common to all of these conditions is dilatation of the right ventricle. Especially in atrial septal defect of significant size one would expect lengthening of myocardial fibers of the right ventricle to allow it to accept the added volume of the shunt. This serves to increase the length of the fibers of the right bundle and conduction time is therefore prolonged. The immediate decrease in QRS duration following closure of an atrial septal defect suggests that the elasticity component of the stretch has disappeared. The persistence of a degree of widening of the complex may be taken to indicate an irreversible or slowly reversible static stretch. The continuing decrease in R amplitude without further decrease in QRS duration in the late follow-up period probably reflects reversion of hypertrophy of right ventricular fibers.

SUMMARY

The predominant right precordial pattern seen in the electrocardiograms of patients with atrial septal defect is rsR'.

Following closure of the defect there is a decrease in QRS duration and in the amplitude of the R wave. In a two year follow-up in this series there was no progressive diminution in QRS duration although the R wave continued to become smaller.

The data indicate that delay in conduction in the right bundle branch system is due to stretching of the right ventricular muscle fibers and should be considered evidence of dilatation of the chamber.

RESUMEN

El cuadro predominante, precordial derecho que se ve en el electrocardiograma de los enfermos con defecto sepal, es rsR'.

Después del cierre del defecto hay un decrecimiento de la duración de QRS y en la amplitud de la onda R. En seguimiento de esta serie por dos años no hubo disminución progresiva de QRS aunque la onda R continuó haciéndose menor.

Los datos indican que el retardo de la conducción del sistema del haz de la rama derecha se debe a estiramiento de las fibras musculares ventriculares derechas y debe ser considerado como evidencia de dilatación de la cámara.

RESUME

Le tracé précardial droit prédominant dans les électrocardiogrammes des malades atteints d'altération de la paroi de l'oreillette est rsR'.

Après disparition de l'altération, il y a une diminution de la durée QRS et de l'amplitude de l'onde R. Dans un contrôle de deux ans portant sur cette série, il n'y eut aucune diminution progressive de la durée QRS bien que l'onde R continue à devenir plus petite.

Ces faits indiquent que le temps de transmission dans le système de bloc de branche droit est dû à l'extension des fibres musculaires du ventricule droit et devrait être considéré comme la preuve de la dilatation de la cavité.
ZUSAMMENFASSUNG

Die vorwiegend rechtsseitige praeordiale Form des EKGs, die man bei Patienten mit Vorhof-Septum-Defekten sieht, ist rsR'.


Die gewonnenen Werte weisen darauf hin, dass eine Verzögerung in der Leitung des rechten Schenkels des Reizleitungssystems die Folge einer Dehnung des Muskelfasern des rechten Ventrikels ist und als Anhaltspunkt für eine Erweiterung der Kammer angesehen werden muss.

REFERENCES


