Conduction Disturbances in Patent Ductus Arteriosus

A Study of 200 Cases before and after Surgery with Determination of the P-R Index

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The electrocardiographic features of patent ductus arteriosus (PDA) are now well defined, and this knowledge helps both in the diagnosis of this entity and in determining the hemodynamic conditions through the different stages of its clinical course.

In a recent review of 500 cases with first-degree atrioventricular (AV) block we found a relatively large number of PDA patients with this conduction disturbance. This association has seldom been mentioned in the literature and was a surprising finding. The possibility of a simple coincidence was at first considered.

The purpose of this study was to clarify this particular electrocardiographic aspect of PDA, but it soon became apparent that AV conduction improved significantly after surgical closure of the defect, another unexpected finding. Therefore, special attention was paid to the postoperative follow-up of the disturbances encountered.

At the same time the incidence of other conduction disturbances and their postoperative evolution in this malformation was noted.

Material and Method

We studied 200 records of patients with PDA who were submitted to surgery at the Instituto Nacional de Cardiología de Mexico. We did not include cases with associated cardiopathies nor those who had received drugs that might affect the conduction in the heart during the period of the study (digitalis, quinidine, procaainamid). The electrocardiograms before and after operation were recorded by an amplifier type of electrocardiograph (Sanborn Cardiette). In every case the last preoperative and all the postoperative tracings were studied. In relation to the latter, unless otherwise specified, we refer to the last available postoperative tracing.

The duration of the P-R interval was measured according to standard procedures. A magnifying glass was used in order to eliminate as far as possible the "errors of measurement." The observed values were compared to normal standards. As there was marked variability in heart rates and in ages of the patients, the absolute values of the P-R interval were seldom valid for a comparative study of AV conduction time; this inadequacy was overcome by using the P-R index. This index is obtained by establishing the P-R/P-R, ratio, in which the numerator is the P-R interval, as measured from the tracing, and the denominator is the upper limit of normal, according to Ashman and Hull's tables.

The P-R index, by integrating in one simple formula the absolute value of the P-R interval with the factors of age and heart rate, allows a quantitative appreciation of AV conduction. It also enables one to follow the evolution of the disturbances in the same patient and to compare different groups of patients. First-degree AV block exists when the P-R index exceeds unity and its intensity is in direct relation to the value of the index above 1.00.

The diagnosis of bundle-branch block was made according to the criterion of Sodi-Pallares.

Results

Table 1 gives the age and sex of the studied patients. The youngest patient was 1 year old and the oldest was 35. The average age was 9.8 years.

Sinus rhythm was found in all the cases except one in which nodal rhythm was present.

In 199 cases with sinus rhythm the mean

*Arithmetical mean.
P-R index was 0.85. No significant variations of the mean P-R index were found in relation to the level of the pulmonary pressure (fig. 1). Twenty-one cases (10.5 per cent) of first-degree AV block were found (P-R index above 1.00). The most severe block had an index of 1.25. The mean P-R index for this group was 1.09.

Postoperative changes in AV conduction were studied in 147 cases. The mean P-R index in this group was 0.86, and it changed to 0.79 after surgery. There was a significant improvement in AV conduction both in patients with AV block and in those with no apparent disturbance in conduction (figs. 2 and 3).

In 14 cases of first-degree AV block with available postoperative tracings, the block disappeared in 11 instances (79 per cent) and decreased in severity in one (from 1.11 to 1.05). In one case there was no change, and in one the AV block increased (from 1.02 to 1.05).

In 133 cases in which the diagnosis of AV block was not made, the P-R index decreased in 82 (62 per cent), remained unchanged in 23 (17 per cent), and increased in 28 (21 per cent).

Figure 4 and table 2 show the cases divided according to the preoperative P-R index; it is evident that the improvement of the AV conduction is greater when the preoperative P-R index is higher.

The improvement in AV conduction occurred within days after surgery. In 40 cases tracings were obtained between the first and the tenth days postoperatively. In 30 of them (75 per cent) the P-R index decreased, it increased in one and remained unchanged in nine. The mean P-R index changed from 0.92 to 0.84 in this group. These findings are in agreement with the results obtained for the whole series. In some cases the AV conduction improved even more with the passage of time.

Six cases (3 per cent) of incomplete right bundle-branch block and five (2.5 per cent) with incomplete left bundle-branch block were found. These disturbances did not change after surgery.

Discussion

The existence of AV conduction disturbances in PDA is not well known in the lit-
Figure 2

Some examples of postoperative changes in AV conduction in cases of PDA with first-degree AV block (lead II). Below each tracing the corresponding P-R index is given. A. Tracings prior to surgery. B. Tracings after surgery. The time interval between the operation and the tracing is specified in parentheses.

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Some examples of postoperative changes in AV conduction in cases of PDA without first-degree AV block (lead II). Below each tracing the corresponding P-R index is given. A. Tracings prior to surgery. B. Tracings after surgery. The time interval between the operation and the tracing is specified in parentheses.

Mean P-R index in PDA before and after surgery. The cases are grouped according to their preoperative values. A. Cases with preoperative P-R index below 0.81 (62 cases). B. Cases with preoperative P-R index between 0.81 and 0.90 (53 cases). C. Cases with preoperative P-R index between 0.91 and 1.00 (18 cases). D. Cases with first-degree AV block—preoperative P-R index above 1.00 (14 cases). E. Total group (147 cases).

Temperature, even though Taussig\textsuperscript{9} mentioned that slight prolongation of AV conduction time is common in this malformation. The present study indicates that disturbances of AV conduction are, in fact, frequent in PDA. The 10.5 per cent incidence of first-degree AV block in this entity, although lower than in atrioventricular cushion defects\textsuperscript{10} and in atrial septal defects,\textsuperscript{11-13} is practically the same as that observed in ventricular septal defect.\textsuperscript{14, 15} This last finding is of some importance. Up to this time it was thought in this department that the presence of first-degree AV block favored the diagnosis of ventricular septal defect when the electrocardiographic tracings were otherwise compatible with both ventricular septal defect and patent ductus arteriosus.\textsuperscript{16} Our findings do not support this opinion.

The high incidence of first-degree AV block in PDA is not the only manifestation of AV conduction disturbances in this malformation. Such blocks, in PDA, probably express a severe disturbance of AV conduction and are present in a relatively small number of cases. In the remainder, the conduction disturbance

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Table 2

Cases grouped according to the Preoperative Values of Their P-R Index

<table>
<thead>
<tr>
<th>Preoperative P-R index</th>
<th>No. of cases</th>
<th>Decrease No. of cases %</th>
<th>Increase No. of cases %</th>
<th>No change No. of cases %</th>
<th>Mean P-R index Preop.</th>
<th>Postop.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 0.81</td>
<td>62</td>
<td>33 53</td>
<td>18 29</td>
<td>11 18</td>
<td>0.74</td>
<td>0.73</td>
</tr>
<tr>
<td>0.81-0.90</td>
<td>53</td>
<td>34 65</td>
<td>10 19</td>
<td>9 16</td>
<td>0.86</td>
<td>0.79</td>
</tr>
<tr>
<td>0.91-1.00</td>
<td>18</td>
<td>15 83</td>
<td>. . .</td>
<td>. . .</td>
<td>0.96</td>
<td>0.86</td>
</tr>
<tr>
<td>Above 1.00</td>
<td>14</td>
<td>12 86</td>
<td>1 7</td>
<td>1 7</td>
<td>1.09</td>
<td>0.90</td>
</tr>
<tr>
<td>Total group</td>
<td>147</td>
<td>94 64</td>
<td>29 19</td>
<td>24 17</td>
<td>0.86</td>
<td>0.79</td>
</tr>
</tbody>
</table>

is manifested only by high values of P-R index, although it is still below 1.00, which is considered to be the upper limit of normal.

The results of a recent statistical study of the P-R index in normal subjects and in various congenital cardiopathies support this thesis well. While the mean P-R index in normal persons was 0.75, the average in a group of 50 PDA patients was considerably higher, namely, 0.86, a figure which is practically identical with that found in our present series: 0.85. This difference in the mean values of P-R index in normal subjects and in PDA patients was submitted to analysis and found to be statistically significant. On the other hand, there is a striking difference in the distribution of the P-R index in healthy subjects as compared to PDA patients. It can be seen in figure 5 that in normal subjects the P-R index was above 0.78 in only 32 per cent of the cases, while this percentage rises to 64 per cent in PDA. In contrast, in 34 per cent of healthy subjects the P-R index was below 0.72, while this value was found in only 8 per cent of PDA patients. The values 0.72 and 0.78 were obtained by calculating the confidence limits for the mean P-R index in normal subjects.

However, the most important argument in favor of our viewpoint results from the study of the postoperative changes in AV conduction. Not only did a high percentage (79 per cent) of first-degree AV block disappear, but there was also a significant decrease in the P-R index in other cases and particularly in those with relatively high preoperative values (table 2 and fig. 4). It would appear that a large number of cases with high values of the P-R index, although still below 1.00, actually have first-degree AV block, undiagnosed by the usual criteria. Similar findings were encountered in a study before and after surgery of the P-R index in atrial septal defect.

The improvement of AV conduction, observed so soon after surgical correction of this malformation, suggests that the disturbances should not be attributed to a "primary" anatomic factor, either congenital or acquired. It seems more logical to relate it to the hemodynamic conditions existing before the operation and corrected by it. We have not found any reference suggesting relationship between hemodynamic conditions and AV conduction. Nevertheless, our findings strongly suggest that such a relationship exists.

The hemodynamic conditions of PDA are well known. In summary, they depend on two main factors: the magnitude of the left-to-right shunt and the magnitude of the pulmonary resistance. These two factors are usually inversely related. It was considered interesting to try to find out which of these two factors plays a role in AV conduction disturbances of PDA.

Because catheterization is performed in PDA only in a small number of cases, we were unable to study directly the relationship between these factors and AV conduction. There is some indirect evidence, however, which would appear to allow us to rule out the pulmonary resistance as a factor of importance.

First, it can be observed (table 2) that the percentage of cases in which the AV conduction improved after the operation (64 per cent) is indeed larger than the percentage of cases (36 per cent) in which a high pulmo-
occurred within days, and this favors the opinion that it is related, in some way, to the interruption of the left-to-right shunt and not to the decrease in pulmonary pressure and pulmonary resistance, as these two are known to occur more slowly.19,20

Summary
A study of conduction disturbances in 200 patients with patent ductus arteriosus was carried out.

The atrioventricular (AV) conduction was found generally disturbed as compared with normal cases. A significant delay in AV conduction was demonstrated by the high incidence (10.5 per cent) of first-degree AV block, by the elevated percentage of high values of the P-R index and by a high mean P-R index in the whole series (0.85 versus 0.75 in normal subjects).

After surgery a significant improvement in AV conduction was noted. First-degree AV block disappeared in 79 per cent of the cases, and in some instances the block decreased in intensity. In cases without diagnosis of AV block the improvement, as manifested by the diminution of the P-R index, was observed in 62 per cent of the cases. The improvement in AV conduction was greater in those groups with higher preoperative P-R index. The impression was that a large number of cases with high values of the P-R index, although still below the upper limit of normal (1.00), actually have first-degree AV block, undiagnosed by the usual criteria. The mean P-R index after surgery for the whole group was 0.79.

It was suggested that the AV conduction disturbances in patent ductus arteriosus are related, in some way, to the hemodynamic conditions of this entity and particularly to the left-to-right shunt between aorta and pulmonary artery.

Six cases (3 per cent) of incomplete right bundle-branch block and five (2.5 per cent) of incomplete left bundle-branch block were found. These disturbances did not change after surgery.
Acknowledgment
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