Correction of uncomplicated cases of transposition of the great arteries

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In recent years the surgical treatment of transposed great arteries has become one of the standard operations of cardiac surgery. Though exchange of the great arteries has theoretical attractions, the success of re-arrangement of the atrial flow has been so great that this will probably remain the operation of choice for some time yet. The principle of this operation was first described by Albert (1955). Although Senning (1959) was the first to achieve success with this operative approach, its widespread application did not occur until Mustard described his technique in 1964. Other modifications of the principle had been attempted by Creech et al. (1958), Merendino et al. (1957), Shumacker (1961), and Barnard, Shrire, and Beck (1962), but only Barnard’s case had been successful.

Our experience has been with the Mustard operation. Since February 1965 112 cases have had Mustard’s operation at The Hospital for Sick Children, Great Ormond Street. The types of cases are shown in Table 1. Seventy-eight anatomically uncomplicated cases form the largest group and discussion will be limited to these.

Results

Of the 78 simple cases, 10 (13%) died in hospital. The reasons for the deaths are shown in Table 2. The important conclusion is that almost all the causes of death were avoidable. Late deaths have occurred in 7 cases in the entire group of Mustard’s operations (112 cases), but only the last two were in cases of simple transposition of the great arteries, the first five also having ventricular septal defects. However, these delayed deaths do emphasize the danger of arrhythmias (especially atrial flutter) and heart block (Table 3).

Post-operative arrhythmias

The conduction in the first days and weeks after operation is shown in Table 4. The cases are divided into roughly half. In the first 54 cases the incidence of conduction troubles was much greater than subsequently. At this time some minor modifications to Mustard’s operation were made in an attempt to reduce the arrhythmias. It can be seen that sinus

| TABLE 1  Mustard’s operations, February 1965 to May 1970 |
|---|---|
| Transposition of great arteries (simple) | 78 |
| Transposition of great arteries + ventricular septal defect | 21 |
| Transposition of great arteries + ventricular septal defect + pulmonary artery unbanding | 4 |
| Transposition of great arteries + ventricular septal defect + pulmonary stenosis | 7 |
| Transposition of great arteries (complex) | 2 |
| **Total** | **112** |

| TABLE 2  Simple transposition of great arteries: cause of death in hospital in 10 cases |
|---|---|
| Case No. | Cause of death |
| 9 | Superior vena caval obstruction |
| 30 | Pulmonary oedema |
| 33 | Persistent ductus arteriosus tear |
| 42 | ? Induced ventricular fibrillation for long period |
| 44 | ? Induced ventricular fibrillation for long period |
| 60 | Post-operative haemorrhage |
| 61 | Pulmonary vascular disease (R/R, = 1.2/1) |
| 68 | Dacron patch leak |
| 70 | Low output state |
| 111 | Pulmonary vascular disease (R/R, = 2/3) |

| TABLE 3  Mustard’s operations: late deaths in 7 cases |
|---|---|---|
| Age (yr.) | Cause of death | Interval between operation and death (mth.) |
| 5 | Atrial flutter | 6 |
| 4 | Nodal/atrial flutter | 23 |
| 1–10/12 | 3rd degree AV block (late onset) | 30 |
| 4 | 3rd degree AV block | 32 |
| 2 | Measles bronchopneumonia | 11 |
| 1* | Febrile convulsions; inhalation pneumonia | 11 |
| 15* | Pulmonary vascular disease | 7 wk. |

* Simple transposition.
TABLE 4  Mustard's operations: early post-operative rhythm

<table>
<thead>
<tr>
<th>Rhythm</th>
<th>Cases 1-54</th>
<th>Cases 55-112</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sinus</td>
<td>17</td>
<td>40</td>
</tr>
<tr>
<td>Nodal</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>2nd degree AV block</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Complete AV dissociation</td>
<td>7 (5 s)*</td>
<td>10 (5 s)*</td>
</tr>
<tr>
<td>Atrial flutter</td>
<td>5</td>
<td>1 (briefly)</td>
</tr>
</tbody>
</table>

* s = later sinus rhythm.

TABLE 5  Mustard's operations: long term atrial flutter

<table>
<thead>
<tr>
<th></th>
<th>Cases 1-54</th>
<th>Cases 55-112</th>
</tr>
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<tbody>
<tr>
<td>Post-operative atrial flutter (long term)</td>
<td>14</td>
<td>Nil</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 (briefly)</td>
</tr>
</tbody>
</table>

TABLE 6  Mustard's operations: variations in technique

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Variations</th>
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<tr>
<td>2</td>
<td>Atrial septum used as pedicle flap</td>
</tr>
<tr>
<td>4</td>
<td>Superior vena cava cannula to right side</td>
</tr>
<tr>
<td>23,30</td>
<td>Atrial pedicle flap posterior to coronary sinus</td>
</tr>
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<td>47</td>
<td>Prolonged artificial ventricular fibrillation</td>
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<tr>
<td></td>
<td>abandoned</td>
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<tr>
<td>55</td>
<td>Interrupted sutures over atrial conduction paths</td>
</tr>
<tr>
<td>60</td>
<td>Coronary sinus not cut back</td>
</tr>
<tr>
<td>66</td>
<td>Dacron only used for dividing atria</td>
</tr>
<tr>
<td>69</td>
<td>Pericardium and Dacron used for dividing atria</td>
</tr>
</tbody>
</table>

The incidence of atrial flutter has occurred much more frequently in the latter part of the series and nodal rhythm much less commonly. Complete AV dissociation has occurred in a number of cases where sutures have not been placed near the main AV conduction bundle or the AV node, and in a number of these the conduction has later returned to sinus rhythm (see Table 4).

Over a long term atrial flutter developed in a large proportion of the early part of the series, but since further attempts have been made to avoid damage to either the sinus or the AV nodes or to the interatrial conduction pathways the incidence of atrial flutter has been almost abolished (Table 5).

The modifications made to the operation have been almost all designed to reduce the incidence of arrhythmias and are listed in Table 6. The superior vena cava cannula is now placed as far as possible from the sinus node, and when a suture line crosses the presumed position of the interatrial conduction pathways interrupted sutures are used. To avoid damage to the posterior internodal pathway the coronary sinus is no longer cut back, and since Case 66 the patch has been placed well posterior to the coronary sinus allowing this to drain to the pulmonary atrium, but the effect of this is not significant as a cause of systemic desaturation.

The type of operation which has been used in the last 43 cases is shown in Fig. 1. An attempt was made to use Dacron for the whole interatrial division, but this proved unsuccessful in two of three cases, so the technique used thereafter was to employ pericardium for most of the patch except where a narrow strip of Dacron was required – that is, over the inferior vena caval inflow. (In those cases which we have seen at necropsy some time after operation the pericardium

FIG. 1  Diagram showing completed operation. The pericardial patch surrounds the pulmonary veins, and the 'D' shaped patch of Dacron lies over the inferior vena caval orifice.

FIG. 2  Comparison of hospital death with age at operation.
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