The double switch procedure for anatomical repair of congenitally corrected transposition of the great arteries in infants and children


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Aims To assess outcomes of anatomical repair (double switch procedure) in infants and children with congenitally corrected transposition of the great arteries.

Methods and results Between September 1993 and August 1996, 17 patients with congenitally corrected transposition underwent surgery at UCSF. Anatomical repair was performed in 11 of these patients, at ages ranging from 4-8 months to 7-8 years (median 3-2 years). The remaining six patients did not undergo anatomical repair due to unfavourable anatomy (n=2), prior conduit repair (n=2), biventricular dysfunction (n=1), and isolated complete atrioventricular block (n=1). The 11 patients who underwent anatomical repair make up the study group for the present report. All 11 patients had a malalignment ventricular septal defect, while pulmonary outflow tract obstruction was present in nine patients and significant tricuspid valve pathology or dysfunction was present in five. Anatomical repair was achieved with a Senning (n=7) or a Mustard (n=4) procedure combined with an arterial switch operation plus ventricular septal defect closure (n=4), or a Rastelli procedure with left ventricle to aortic baffle and right ventricle to pulmonary artery conduit (n=7). There was one early death and no patients developed surgical complete atrioventricular block. At a median follow-up of 22 months, there were no late deaths. Two patients required a total of three late reoperations, and all patients were asymptomatic on no cardiac medication. Follow-up echocardiography revealed normal biventricular function in all patients.

Conclusions Anatomical repair of corrected transposition can be achieved with low rates of early mortality and surgical heart block, and favourable mid-term results. Long-term follow-up will be necessary to determine if the double switch approach improves the natural history of corrected transposition when compared to less aggressive surgical approaches that leave the right ventricle in the systemic circulation.

Key Words: Atrioventricular discordance, ventriculo-arterial discordance, Rastelli procedure, arterial switch operation, Senning operation, Mustard operation.

Introduction

Until recently, the standard surgical approach to congenitally corrected transposition of the great arteries (corrected transposition) has been simply to repair the associated lesions, which are common and most often include ventricular septal defect, tricuspid valve anomalies or insufficiency, and pulmonary stenosis or atresia[1-7]. In this approach, the right ventricle is allowed to remain as the systemic pumping chamber. Much of the data regarding ventricular function in isolated corrected transposition and corrected transposition following intracardiac repair of associated defects is inconclusive regarding the ability of the morphologically right systemic ventricle to tolerate the pressure load of the systemic circulation. However, a number of studies have demonstrated depressed right ventricular function in corrected transposition, especially during exercise[6-13]. Similarly, as long-term follow-up has become available for patients after atrial level repair of simple transposition of the great arteries, heightened concerns have arisen regarding the chronic performance of the right ventricle in the systemic circulation[14-18]. These concerns, along with the frequent dysfunction of the systemic tricuspid valve in corrected transposition,
have prompted a number of surgeons to undertake anatomical repair of corrected transposition, in which an atrial switch procedure (Senning or Mustard) is combined with either an arterial (arterial switch) or ventricular (Rastelli) level repair. At UCSF, we have been performing anatomical correction in selected patients with corrected transposition since September 1993. In the present report, we review our experience with 11 patients who have undergone anatomical repair of corrected transposition since this time.

**Methods**

**Definitions**

Anatomical structures are referred to in terms of their morphological characteristics, unless otherwise specified. Thus, for example, the morphologically right functionally systemic atrioventricular valve in patients with unoperated congenitally corrected transposition is referred to in the present report as the tricuspid valve. Similarly, semilunar valves and great vessels following their morphological characteristics, unless otherwise specified. Thus, for example, the morphologically right functionally systemic atrioventricular valve in patients with unoperated congenitally corrected transposition is referred to in the present report as the tricuspid valve.

**Patients and operative techniques**

During the 3 year period between September 1993 and August 1996, 17 patients with corrected transposition underwent surgery at UCSF. Patients with corrected transposition who had other abnormalities that precluded biventricular repair were excluded. In six of these patients, anatomical repair was not performed because of unfavourable anatomy for an arterial switch or Rastelli procedure (n=2), previous left ventricle to pulmonary artery conduit repair (n=2), biventricular dysfunction (n=1), and complete heart block with no associated defects (n=1). Details of these patients and operative procedures are summarized in Table 1. A double switch procedure was originally planned in two of these patients, pending surgical exploration. On inspection, one of these patients (patient 16, who had pulmonary hypertension) was found to have chordal attachments of both atrioventricular valves to the rim of the septal defect, which was small and posteriorly located. In order to perform a Rastelli baffle, it would have been necessary to enlarge the septal defect to the extent that atrioventricular valve integrity would have been compromised and complete heart block would have been a likely consequence. In addition, the pulmonary valve was bicuspid and mildly regurgitant, ruling out an arterial switch. In the other patient (patient 17), attachments of the tricuspid valve to the septal crest and muscular left ventricular outflow tract obstruction precluded a Rastelli tunnel, while an arterial switch was out of the question due to a severely dysplastic and stenotic pulmonary valve.

The other 11 patients, aged 4-8 months to 7-8 years (median 3-2 years), underwent anatomical correction with a double switch procedure (Table 2). All 11 patients had a malalignment ventricular septal defect, nine had either pulmonary stenosis (n=5) or atresia (n=4), five had significant tricuspid valve pathology or dysfunction, and five had juxtaposition of the cardiac apex and venae cavae (apicocaval juxtaposition). Six patients had undergone one or more previous procedures, including systemic to pulmonary shunts in the four patients with pulmonary atresia and one patient with severe pulmonary stenosis, pulmonary artery banding (patient 6), aortic coarctation repair (patient 8), and bidirectional cavopulmonary shunt (patients 10 and 11).

In these 11 patients, atrial switch was performed with either a Senning (n=7) or a Mustard (n=4) procedure. The internal or external Senning baffle was augmented with a patch of fresh or glutaraldehyde fixed autologous pericardium in four patients (patients 1, 2, 6, 7), and with in situ autologous pericardium in two patients (patients 8 and 9). The right atrial free wall was augmented in two patients who underwent a Mustard atrial switch (patients 3 and 10). In two patients, one with situs solitus (patient 11) and one with situs inversus (patient 10), the Mustard procedure was modified because of the presence of a previously performed bidirectional cavopulmonary shunt, so that only the inferior vena cava was baffled to the tricuspid valve (Fig. 1).

The atrial switch was combined with an arterial switch procedure in four patients, with patch closure of the ventricular septal defect. In three of these patients, standard coronary transfer techniques were performed. In the other patient (patient 6), the commissures of the pulmonary and aortic valves were not aligned, the left coronary artery arose directly opposite the neo-aorta, and the right coronary arose anteriorly, a long distance from the neo-aorta. Thus, Aubert's technique was applied, with construction of a baffle from the neo-aorta to the coronary orifices through a surgically created aortopulmonary window. In the seven patients who did not undergo an arterial switch procedure, ventriculoarterial discordance was corrected with a Rastelli procedure, in which the left ventricle was baffled to the aorta through the ventricular septal defect and the right ventricle was connected to the pulmonary artery with a cryopreserved aortic allograft conduit (n=6) or a right ventricular outflow tract patch with subvalvar muscle resection (n=1). Conduit placement varied according to the individual patient's anatomy, but was generally at a lateral angle in order to minimize the chance of sternal compression. The ventricular septal defect was enlarged in two Rastelli patients by removing a wedge of muscle from the superior-anterior aspect of the defect. In all patients, the ventricular septal patch or left ventricle to aorta baffle was sutured to the right side of the ventricular septum in order to avoid the conduction axis.

Additional procedures performed are listed in Table 2. Total perfusion time ranged from 196 to 356 min (median 269 min), and aortic cross-clamp time ranged from 136 to 249 min (median 188 min). Circulatory arrest was not employed.

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### Table 1 Diagnostic and surgical details of patients undergoing procedures other than double switch for corrected transposition

<table>
<thead>
<tr>
<th>Patients</th>
<th>Age (years)</th>
<th>Segmental anatomy</th>
<th>VSD</th>
<th>Pulmonary outflow</th>
<th>Tricuspid valve</th>
<th>Surgery</th>
<th>Reason double switch not performed</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>26-8</td>
<td>(I,D,D)*</td>
<td>Yes</td>
<td>PA, s/p LV-PArt conduit</td>
<td>Mild TR</td>
<td>Conduit removal, LV-PArt conduit patch augmentation, VSD and ASD closure</td>
<td>Previous conduit repair</td>
<td>None</td>
</tr>
<tr>
<td>13</td>
<td>22-7</td>
<td>(S,L,L)</td>
<td>Yes</td>
<td>PA, s/p LV-PArt conduit</td>
<td>Normal</td>
<td>Conduit replacement (24 mm Ao)*, LPA augmentation, ASD closure</td>
<td>Previous conduit repair</td>
<td>None</td>
</tr>
<tr>
<td>14</td>
<td>1-8</td>
<td>(S,L,L)</td>
<td>No</td>
<td>Normal</td>
<td>Normal</td>
<td>Unipolar epicardial pacemaker placement</td>
<td>CAVB only — no defects</td>
<td>None</td>
</tr>
<tr>
<td>15</td>
<td>39-2</td>
<td>(S,L,L)</td>
<td>No</td>
<td>Normal</td>
<td>Severe TR</td>
<td>Tricuspid valve replacement (33 mm St. Jude)</td>
<td>Bioventricular dysfunction</td>
<td>None</td>
</tr>
<tr>
<td>16</td>
<td>5-4</td>
<td>(S,L,L)*</td>
<td>Yes</td>
<td>subPS, small conus</td>
<td>Attached to septal crest, trace TR</td>
<td>VSD closure</td>
<td>Unfavourable anatomy</td>
<td>None</td>
</tr>
<tr>
<td>17</td>
<td>4-2</td>
<td>(S,L,L)</td>
<td>Yes</td>
<td>severe PS, thickened dysplastic valve</td>
<td>Attached to septal crest</td>
<td>VSD closure, LV-PArt homograft (21 mm Ao)*, pulmonary artery ligation and division</td>
<td>Unfavourable anatomy</td>
<td>None</td>
</tr>
</tbody>
</table>

*Indicates patients with apicocaval juxtaposition. †Indicates size and type of allograft conduit used.

(I,D,D), (S,L,L)=segmental anatomy; Ao=aorta; ASD+Satral septal defect; CAVB=complete atrioventricular block; JET=junctional ectopic tachycardia; LV-PArt=left ventricle to pulmonary artery; PA=pulmonary atresia; PAB=pulmonary artery band; PS=pulmonary stenosis; T/D=take-down; TR=tricuspid regurgitation; TS=tricuspid stenosis; VSD=ventricular septal defect (malalignment).
<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (years)</th>
<th>Segmental anatomy</th>
<th>VSD</th>
<th>Pulmonary outflow</th>
<th>Tricuspid valve</th>
<th>Surgery</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-1</td>
<td>(S,L,L)</td>
<td>Yes</td>
<td>PS</td>
<td>TR/TS</td>
<td>Senning+Rastelli (18 mm Ao), VSD enlargement, resect supravalvar tricuspid ring</td>
<td>Effusions</td>
</tr>
<tr>
<td>2</td>
<td>0.4</td>
<td>(S,L,L)</td>
<td>Yes</td>
<td>Normal</td>
<td>Mild TR</td>
<td>Senning+ASO, VSD closure</td>
<td>JET</td>
</tr>
<tr>
<td>3</td>
<td>7.0</td>
<td>(I,D,D)*</td>
<td>Yes</td>
<td>Severe PS</td>
<td>Normal</td>
<td>Mustard+Rastelli (23 mm Ao), VSD enlargement, T/D shunt</td>
<td>Cortical watershed infarcts</td>
</tr>
<tr>
<td>4</td>
<td>0.4</td>
<td>(A,L,L)*</td>
<td>Yes</td>
<td>subPS</td>
<td>Normal</td>
<td>Mustard+Rastelli, resect subpulmonary muscle, VSD closure</td>
<td>JET</td>
</tr>
<tr>
<td>5</td>
<td>0.4</td>
<td>(S,L,L)</td>
<td>Yes</td>
<td>PS</td>
<td>Attached to septal crest</td>
<td>Senning+ASO, VSD closure</td>
<td>JET, effusions</td>
</tr>
<tr>
<td>6</td>
<td>3.2</td>
<td>(S,L,L)</td>
<td>Yes</td>
<td>PAB</td>
<td>Ebstein's, severe TR</td>
<td>Senning+ASO (Aubert procedure), VSD closure, T/D PAB</td>
<td>None</td>
</tr>
<tr>
<td>7</td>
<td>4-2</td>
<td>(S,L,L)</td>
<td>Yes</td>
<td>PA</td>
<td>Normal</td>
<td>Senning+Rastelli (23 mm Ao), T/D shunts</td>
<td>Effusions</td>
</tr>
<tr>
<td>8</td>
<td>1-1</td>
<td>(S,L,L)</td>
<td>Yes</td>
<td>subPS</td>
<td>Mild TR</td>
<td>Senning+ASO, VSD closure</td>
<td>Effusions</td>
</tr>
<tr>
<td>9</td>
<td>5.8</td>
<td>(S,L,L)</td>
<td>Yes</td>
<td>PA</td>
<td>Normal</td>
<td>Senning+Rastelli (21 mm Ao), resect subpulmonary muscle, T/D shunts</td>
<td>None</td>
</tr>
<tr>
<td>10</td>
<td>7-8</td>
<td>(I,D,D)*</td>
<td>Yes</td>
<td>PA</td>
<td>Normal</td>
<td>Modified Mustard+Rastelli (20 mm Ao), resect subpulmonary muscle</td>
<td>None</td>
</tr>
<tr>
<td>11</td>
<td>7-4</td>
<td>(S,L,L)*</td>
<td>Yes</td>
<td>PA</td>
<td>Normal</td>
<td>Modified Mustard+Rastelli (23 mm Ao), T/D shunts</td>
<td>Effusions</td>
</tr>
</tbody>
</table>

*Indicates patients with apicocaval juxtaposition. †Indicates size and type of allograft conduit used.
(I,D,D), (S,L,L), (A,L,L) = segmental anatomy; Ao = aorta; ASO = arterial switch operation; JET = junctional ectopic tachycardia; PA = pulmonary atresia; PAB = pulmonary artery band; PS = pulmonary stenosis; T/D = take-down; TR = tricuspid regurgitation; TS = tricuspid stenosis; VSD = ventricular septal defect (malalignment).
Figure 1. Diagram of double switch repair in patient 10, whose anatomy is situs inversus (I,D,D) with apicocaval juxtaposition. This patient had previously undergone bi-directional cavopulmonary shunt, with anastomosis of the superior vena cava (SVC) to the pulmonary artery (PA). The modified Mustard intraatrial baffle (MM) directs inferior vena caval (IVC) return to the tricuspid valve and morphological right ventricle (RV), and does not encompass the SVC orifice. An allograft valved conduit (C) is used to connect the RV to the PA. The modified Mustard baffle allows ample room for drainage of pulmonary venous blood to the morphological left ventricle (LV) via the mitral valve. The Rastelli baffle (RB), which is sutured to the right ventricular aspect of the septum, directs LV blood through the ventricular septal defect to the aorta (Ao).

Results

There was one early death among the 11 double switch patients. This patient 6, who had undergone Senning repair and an arterial switch, with Aubert's procedure instead of simple coronary transfer. The cause of death was multi-organ failure and brain death secondary to mediastinal haemorrhage and cardiac tamponade (Table 2). Other postoperative complications are summarized in Table 2. In six patients, the chest was left open because of extensive myocardial oedema or persistent bleeding following prolonged cardiopulmonary bypass and cardioplegic arrest. Echocardiographic examination was performed in the intensive care unit between 1 and 7 days postoperatively. Duration of ventilator support ranged from 1 to 9 days (median: 5 days), and postoperative hospital stay ranged from 8 to 49 days (median: 14 days).

At follow-up ranging from 1 to 34 months (median: 22 months), there were no deaths. Two patients had undergone a total of three reoperations. One patient underwent reoperation for (1) Rastelli baffle obstruction 8 months post-repair, with patch augmentation of the intraventricular baffle and resection of obstructing muscle bundles, and for (2) replacement of the right ventricle to pulmonary artery conduit 24 months post-operatively. Another patient underwent reoperation 11 months after double switch to relieve right ventricular outflow tract obstruction and right ventricular aneurysm (with a peak right ventricular pressure of 80 mmHg and a peak left ventricular pressure of 98 mmHg), with right ventricular myectomy, transannular patch, and pulmonary artery augmentation. On most recent follow-up echocardiography, all 10 patients had normal biventricular function, one patient had mild bilateral atrioventricular valvar insufficiency, one patient had mild mitral insufficiency, and one patient mild aortic insufficiency. No patients were taking any cardiac medications and all were in New York Heart Association class I.

Discussion

Selection of patients for anatomical repair

Over the past several years a number of centres have reported favourable results with anatomical repair for congenitally corrected transposition. Most surgeons who perform the double switch procedure do not recommend this approach in all patients with corrected transposition, but primarily in patients with systemic right ventricular or tricuspid valvar dysfunction. Clearly, it is these patients in whom anatomical repair offers the greatest immediate benefit, in the form of improved systemic ventricular and atrioventricular valvar function. However, the double switch procedure may prove to be the treatment of choice in most patients with corrected transposition. While there is no evidence yet that anatomical repair will improve chronic ventricular function in patients without a compromised right ventricle, the data of Imaj et al. suggest that mid-term systemic ventricular performance in patients with a double switch may be somewhat better than in patients who have undergone conventional repair. Similarly, though long-term data are not available, a double switch may be effective not only in the presence of tricuspid regurgitation, but also in preventing regurgitation in patients with tricuspid valvar anomalies that are likely to lead to dysfunction.

In general, we prefer to perform anatomical repair in all patients with corrected transposition and no contraindications, including those with intact systemic right ventricular and tricuspid valvar function. This approach is based largely on the literature regarding...
right ventricular failure and tricuspid dysfunction late after atrial repair of simple transposition\(^{[14-18]}\) and our own experience with such patients (unpublished data). However, we realize that the double switch procedure is not the optimal approach in all patients with corrected transposition and two adequate ventricles. The relatively high incidence of native pulmonary outflow tract pathology in corrected transposition\(^{[29]}\) leaves many patients unsuitable for an arterial switch procedure. Likewise, construction of a left ventricle to aorta baffle can be complicated by an unfavourably sized or located ventricular septal defect, which may be difficult to enlarge due to the anterior position of the conduction axis in corrected transposition when viewed from the left-sided right ventricle\(^{[28]}\). Similarly, intraventricular baffle techniques may be difficult in the presence of anomalous atrioventricular valves, especially with chordae that attach to the septal crest. A combination of these factors prevented us from performing a double switch procedure in two of our recent patients (patients 16 and 17).

**Selection of surgical components for anatomical repair**

Even when there is no contraindication to anatomical repair, it is important to select the proper components for the atrial and ventricular/arterial switch procedures. The one death in our series of anatomical repair was the patient in whom an arterial switch with the Aubert procedure was performed. Although the coronaries and the Aubert repair could not be clearly implicated in the patient’s demise, the poor outcome highlights the potential importance of coronary artery anatomy in selecting patients for double switch repair of corrected transposition. As recently reported by McKay et al\(^{[23]}\), the semilunar valve commissures are frequently malaligned in corrected transposition, resulting in coronary arteries that are sometimes poorly situated for transfer. Because the native pulmonary artery is usually deeply seated between the atrioventricular valves, it is generally possible to implant the coronaries above the sinotubular junction and avoid any problem with commissures at the point of implantation. However, this was not the case in our patient, who had non-aligned semilunar valve commissures and a left coronary artery originating directly opposite the neo-aorta (native pulmonary artery). In this patient, the right coronary also arose anteriorly and it would have been necessary to turn this coronary back on itself in order to make the transfer. Anomalous coronary anatomy is not necessarily a contraindication to anatomical repair, but in retrospect this patient may have been better served with a Rastelli procedure.

Probably the major shortcoming of the double switch procedure is that it includes a Senning or Mustard atrial switch, which may be complicated by venoatrial obstruction\(^{[30,31]}\) or supraventricular arrhythmias\(^{[32,33]}\). This might be particularly problematic in patients with corrected transposition and apicocaval juxtaposition, as was found to be the case in the series reported by Yagihara et al\(^{[24]}\). However, there are options that might help reduce the frequency of such complications. In our two most recent double switch procedures, performed in patients who had previously undergone a bidirectional cavopulmonary shunt, the atrial switch component was a modified Mustard procedure in which the intra-atrial baffle was not extended to incorporate the orifice of the superior vena cava. As a result, the atrial suture line was significantly less than with a standard Mustard or a Senning, and the region of the sinoatrial node was completely avoided. These modifications will probably reduce the likelihood of some of the more common electrophysiological complications of the Mustard operation\(^{[33]}\). In addition, not extending the patch to the superior vena cava allowed more room for the pulmonary venous pathway. This is likely to minimize the potential for venoatrial obstruction\(^{[30]}\) especially in patients with apicocaval juxtaposition, which was the case with the two patients in our series who underwent this modification. We (unpublished data) and others\(^{[34]}\) have found the bidirectional cavopulmonary shunt to function well as an auxiliary procedure in the biventricular repair of a variety of congenital heart defects. Though the cavopulmonary shunt had been previously performed in our two patients, this procedure may be a useful addition to the double switch operation in certain circumstances, such as patients with double-outlet right ventricle and a small right ventricle or pulmonary outflow tract, patients with apicocaval juxtaposition, or as a means of avoiding potential atrial complications. On the other hand, there are also possible drawbacks to the use of a bidirectional cavopulmonary shunt in patients with corrected transposition. Because transection of the superior vena cava eliminates the standard access pathway for transvenous pacemaker placement, the management of complete atrioventricular block in patients with corrected transposition and bidirectional cavopulmonary shunt will be more complicated than when a cavopulmonary shunt is not present. We decided to leave the cavopulmonary shunt in both of our patients in whom this procedure had previously been performed, but it is too early to determine whether this is preferable to reconstructing the superior cavoatrial connection.

**Anatomical repair vs conventional repair**

The optimal means of comparing anatomical and conventional repair of corrected transposition would be a randomized clinical trial. However, given the individualized nature of these complex repairs, such a trial is unlikely to be performed. In comparing the literature on the two approaches, it seems clear that outcomes are comparable, and perhaps even better with anatomical repair. There have been five hospital deaths (9%) among the 56 patients reported in the literature to have undergone double switch repair, including the present report\(^{[6,18-24]}\). These results are not noticeably different.
from outcomes in patients undergoing less aggressive repair in which the right ventricle is left in the systemic circulation (4–18%). One of the major technical advantages of anatomical repair is that, because the morphological right ventricle is switched to its natural role in the pulmonary circulation, the ventricular septal defect may be closed either through a right ventriculotomy (in cases of Rastelli repair) or through the neo-pulmonary valve (in cases of arterial switch). This allows more ready accessibility to the right ventricular aspect of the septum than do traditional techniques, which is important from the point of view of avoiding the conduction tissues\textsuperscript{19,26,27}. Though it has become standard procedure to place the patch on the right side of the septum with conventional repair as well, surgical heart block remains a significant problem with such an approach\textsuperscript{14–7,23,24}. In contrast, only two cases of surgical heart block have been reported among the 56 patients in the double switch literature\textsuperscript{6,18–24}, including no cases in our 11 patients. Aside from surgical heart block, however, it might be expected that there will be greater surgical morbidity after the double switch procedure, which generally requires extended periods of cardiopulmonary bypass and cardioplegic arrest. Five of our 11 patients required chest tube drainage of effusions for longer than 7 days, three had a transient junctional rhythm, and one suffered bilateral cortical watershed infarcts. All of these problems had resolved by the time of discharge, and there were no demonstrable differences in post-hospital condition between double switch and non-double switch patients.

Conclusions

We and others have described a variety of approaches to anatomical repair of corrected transposition, in patients with the full range of anatomical variations, including situs solitus, situs inversus, situs ambiguous, and with the usual and juxtaposed apicocaval relationships\textsuperscript{18–24}. The natural history of the right ventricle in patients with corrected transposition is not fully understood, largely because of the unknown number of patients who are asymptomatic and do not have associated defects that require intervention. As a result, the denominator is unclear. Though the evidence is strong that the right ventricle does not hold up well in patients with simple transposition and a Senning or Mustard repair\textsuperscript{14–18}, it is debatable whether this accurately reflects the situation with corrected transposition\textsuperscript{111}. As more data become available regarding outcomes following double switch procedures in patients with various anatomical diagnoses, it may be possible to determine subsets of patients in whom anatomical repair is indicated or contraindicated, or circumstances in which particular modifications, such as the addition of a cavopulmonary shunt, may be more appropriate. Regardless, long-term follow-up will be necessary to determine if the double switch approach favourably influences the natural history of corrected transposition when compared to less aggressive surgical approaches in which the right ventricle and tricuspid valve remain in the systemic circulation.

References

\textsuperscript{[9]} Graham TP, Parrish MD, Boucek RJ \textit{et al.} Assessment of ventricular size and function in congenitally corrected transposition of the great arteries. Am J Cardiol 1983; 51: 244–51.


