Results of one-and-a-half-patch technique for repair of complete atrioventricular septal defect with a large ventricular component

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Abstract

OBJECTIVES: Management of complete atrioventricular (AV) septal defect (CAVSD) with a large ventricular component (>1 cm) remains controversial. The purpose of this study was to assess the feasibility of the one-and-a-half-patch technique in repairing this lesion.

METHODS: This was a retrospective review of patients undergoing surgical repair of CAVSD with a large ventricular component (>1 cm). Of the 51 patients who were identified in our database (2005–13), 18 underwent the two-patch repair, 12 underwent the modified single-patch repair and 21 underwent the one-and-a-half-patch repair. The CAVSD was combined with tetralogy of Fallot (TOF) in 3 patients and with double-outlet right ventricle (DORV) and pulmonary stenosis (PS) in two individuals in the one-and-a-half-patch group.

RESULTS: There were two hospital deaths in the two-patch group, but no deaths in the other two groups. The modified single-patch procedure was associated with the shortest myocardial ischaemic and cardiopulmonary bypass (CPB) times, the two-patch procedure was associated with the longest times and the 1.5-patch procedure times were intermediate. Median follow-up was 35 months (41.6 ± 27.2 months). There were no reoperations in the 1.5-patch group while reintervention was required for 1 patient in the two-patch group (P = 0.252) and 3 patients in the modified single-patch group (P = 0.017). The function of the reconstituted AV valves improved after operation in the 1.5-patch group. No patient in these three groups developed subsequent left ventricular outflow tract obstruction.

CONCLUSIONS: The 1.5-patch technique is an attractive clinical option. It produces acceptable mid-term results comparable with two conventional techniques in patients with similarly sized ventricular component.

Keywords: Congenital heart disease • Complete atrioventricular septal defect • Surgical repair

INTRODUCTION

Complete atrioventricular (AV) septal defect (CAVSD) caused by failure of formation of the vestibular spine is a complicated lesion accounting for nearly 3% of congenital cardiac malformations [1]. Several established techniques coexist to achieve the current excellent surgical outcomes of CAVSD repair: the one-patch (Rastelli), the two-patch and the modified single-patch procedures [2–7]. The latter two procedures have become more widely adopted in recent years [8]. The two-patch technique was introduced to avoid dividing the common leaflets. It helps to minimize the risk of left ventricular outflow tract obstruction (LVOTO) and allows for more selective adjustment of the height of the ventricular septal defect (VSD), but at the expense of increased complexity [8]. Modified single patch is an attractive procedure because it shortens cross-clamp and bypass times. Another main advantage of not using a VSD patch is that the left AV valve (LAVV) area of coaptation is increased [9]. However, theoretical concern remains that subsequent LVOTO, the distortion of valve leaflets and increased tension between the common AV valve and the ventricular septum crest will be of consequence if the ventricular component is too large (>1 cm), contributing to the increased reoperation rate [10–12].

Lacour-Gayet et al. [13] and Backer et al. [14] recommended a direct closure of the restrictive communication under the inferior bridging leaflet (IBL), with the residual large defect under the superior bridging leaflet (SBL) being closed by a patch. Karl et al. [6] even used this technique in repairing CAVSD patients combined with tetralogy of Fallot (TOF). Since 2010, we have successfully performed repair in all consecutive patients with CAVSD and a large ventricular component (>1 cm) by using the one-and-a-half-patch technique.

METHODS

Patients were identified by retrospective review of the institutional cardiothoracic surgical database of Shanghai Children’s Medical Center (SCMC). This review was approved by the Ethics Committee of SCMC. Of 51 consecutive repairs of CAVSDs with large ventricular components in infants and children between
January 2005 and April 2013, 18 used the two-patch technique (Group II) before 2008, 12 employed the modified single-patch technique (Group III) between 2008 and 2010, and 21 have used the 1.5-patch technique (Group I) since 2010. There were 31 males (61%) and 20 females (39%). The preoperative demographics are summarized in Table 1. During the study period, there were no other major changes in operative technique or perfusion strategy and all of the operations were performed by one surgeon. However, it should be noted that all of the 1.5-patch patients were more recent, which might bias the results. Associated lesions included patent ductus arteriosus (PDA, n = 18), patent foramen ovale (PFO, n = 36), additional muscular VSD (n = 1), subvalvar aortic stenosis (n = 1), persistent left superior vena cava to coronary sinus (n = 8), TOF (n = 5) and double-outlet right ventricle (DORV) + pulmonary stenosis (PS) (n = 4).

Echocardiography was performed in all the patients. Preoperative VSD size was measured from the crest of the ventricular septum to the common AV valve at end-diastole through the apical four-chamber view. The ventricular component was defined as large if the size was over 1 cm.

Surgical technique

Intraoperative observation of the anatomical relationship between the defect under the IBL and the location of the deepest point of the ventricular component. Intraoperatively, we inspected the morphological characteristics and size of the ventricular component of the septal deficiency (scoop). The deepest point of the scoop was principally beneath the SBL (Type I) in 28 patients (55%) and was approximately centrally located (Type II) in the other 23 patients (45%). The interventricular communication beneath the IBL was usually restrictive or non-existent in Type I defects, whereas it was moderate or large in Type II defects.

One-and-a-half-patch repair

Through a median sternotomy, glutaraldehyde-preserved autologous pericardium was prepared for closure of both primum and ventricular component. If the PDA existed, it was ligated before standard aorto-bicaval cardiopulmonary bypass (CPB) was established. The procedures were performed under mild hypothermia. Myocardial protection was provided with cold 4:1 blood cardioplegia administered every 30 min during the ischaemic time. The edges were retracted with stay sutures for exposure through a right atriotomy. The common AV valve was floated with saline to mark sites for the reapproximation of the SBLs and IBLs. We kept the preservation of bridging leaflets in all of our series. An autologous glutaraldehyde-treated pericardial patch whose size was a little bit smaller than the defect under the SBL was used to obliterate the superior component of the defect. The defect under the posterior common valve was directly closed by suturing the IBL to the right side of the crest of the ventricular septum whatever the size: at the mid-portion of the common AV valve marked by the stitch, one double-armed 5-0/6-0 Prolene suture with Telfon pledget was placed on the right ventricular aspect of the septum, to avoid injury in the main left bundle branch, passing through the IBL and through another trimmed autologous pericardial patch, which was used to close the primum component. Thus, the AV valve tissue was sandwiched between the ventricular endocardium and the pericardial patch (Fig. 1). The coronary sinus was routinely retained in the right atrium. The zone of apposition (LAVV cleft) was closed with a series of interrupted Prolene sutures. The PFO was directly closed if present. After weaning from CPB, modified ultrafiltration was normally applied.

Two-patch and modified single-patch repair

All procedures were performed with standard CPB as described above. In the two-patch group, a Dacron patch or Gore-Tex patch was used to close the ventricular component of the defect and a trimmed autologous glutaraldehyde-treated pericardial patch was used to close the primum component. In the modified single-patch group, the bridging leaflets of the common valve and the pericardial patch, which was used to close the primum component, were anchored together to eliminate the ventricular septal component. Greater detail about these procedures is provided in several references [3-5, 7].

Statistical analysis

Data were collected on standardized forms and analysed with a statistical software package (Statistical Package for Social Scien-
ces, version 18.0; SPSS, Inc., Chicago, IL, USA). All results were expressed as mean ± standard deviation. The significance of differences among the three groups was assessed by using two-sided unpaired Student's t-test and Fisher's exact test. Probability values of less than 0.05 were considered statistically significant. Kaplan–Meier analysis was used to estimate survival and freedom from reoperation.

RESULTS

AV valve competence, residual VSD and LVOTO were carefully evaluated by intraoperative transesophageal echocardiography (TEE) after weaning from CPB. No immediate LVOTO or residual VSD was found in any patient. Second pump and cross-clamp times were added in 2 patients because additional posterior mitral annuloplasty was required in 1 patient in the two-patch group and 1 patient in the modified single-patch group due to moderate–severe LAVV regurgitation noted on TEE, which was then reduced to mild–moderate grade. The function of the LAVV and right AV valve in the other patients were satisfactory, defined as at most moderate regurgitation. In the 1.5-patch group, the function of the reconstituted LAVV had improved in 5 patients with CAVSD combined with TOF or DORV + PS, including 2 with severe regurgitation that fell to moderate, one with moderate-to-severe and 2 with moderate regurgitation falling to mild.

The mean cross-clamp and CPB times in the 1.5-patch group were shorter than in the two-patch group by 18.8 and 23.6 min, respectively. However, they were longer than in the modified single-patch group by 15.6 and 15.9 min. Inotropic support with dopamine hydrochloride was administered in all patients and milrinone in 42 patients (82%) in the cardiac care unit (CCU). There was no difference in the length of CCU stay or duration of ventilatory support time among the three groups. In-hospital results are listed in Table 2. In the two-patch group, 2 patients (surgical age: 10 and 11 months) died in the CCU of low cardiac output syndrome and pneumonia. These 2 patients had unremitting congestive heart failure and had received medical treatment in the pediatric intensive care unit preoperatively. Another patient in the two-patch group required reoperation for closure of a recurrent VSD 10 days after the first operation due to suture dehiscence at the base of the posterior bridging leaflet tissue. Patients in the other two groups had no 30-day mortality and no reoperation during hospitalization after initial operation.

Mean follow-up was 41.6 ± 27.2 months, and the echocardiographic data are given in Table 3. Among 3 children who underwent the modified single-patch repair, two required reoperations for a residual VSD (one defect was located near the base of the SBL and the other was near the base of the IBL) and one required reoperation for worsening LAVV regurgitation (a tear was found in the base of SBL that caused more than moderate regurgitation). Kaplan–Meier analysis of survival and freedom from reintervention as compared with none after the other two kinds of repair, as shown in Fig. 2. Another patient in the two-patch group developed moderate-to-severe LAVV regurgitation. Considering the patient’s absence of clinical

<table>
<thead>
<tr>
<th>Complication</th>
<th>Group I (n = 21)</th>
<th>Group II (n = 18)</th>
<th>Group III (n = 12)</th>
<th>P-value (I vs II)</th>
<th>P-value (I vs III)</th>
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<tbody>
<tr>
<td>CPB time (min)</td>
<td>113.88 ± 11.10</td>
<td>137.50 ± 12.32</td>
<td>98.00 ± 7.25</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
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<tr>
<td>Aortic clamp time (min)</td>
<td>86.47 ± 8.78</td>
<td>105.28 ± 7.99</td>
<td>70.92 ± 3.26</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
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<tr>
<td>CCU stay (days)</td>
<td>5.19 ± 1.97</td>
<td>4.94 ± 1.80</td>
<td>5.25 ± 1.91</td>
<td>0.688</td>
<td>0.933</td>
</tr>
<tr>
<td>Hospital stay (days)</td>
<td>10.19 ± 2.04</td>
<td>11.26 ± 2.37</td>
<td>10.50 ± 2.46</td>
<td>0.481</td>
<td>0.393</td>
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<tr>
<td>Duration of ventilation (h)</td>
<td>45.31 ± 15.46</td>
<td>46.19 ± 22.54</td>
<td>45.17 ± 20.88</td>
<td>0.886</td>
<td>0.982</td>
</tr>
<tr>
<td>Hydropericardium</td>
<td>0 (0%)</td>
<td>1 (6%)</td>
<td>1 (8%)</td>
<td>0.462</td>
<td>0.364</td>
</tr>
<tr>
<td>LCOS</td>
<td>1 (5%)</td>
<td>3 (17%)</td>
<td>1 (8%)</td>
<td>0.318</td>
<td>1.000</td>
</tr>
<tr>
<td>Postoperative early death</td>
<td>0 (0%)</td>
<td>2 (11%)</td>
<td>0 (0%)</td>
<td>0.462</td>
<td>NS</td>
</tr>
<tr>
<td>Immediate LVOTO</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Postoperative residual VSD</td>
<td>0 (0%)</td>
<td>1 (6%)</td>
<td>0 (0%)</td>
<td>0.462</td>
<td>NS</td>
</tr>
<tr>
<td>AV block incidence</td>
<td>0 (0%)</td>
<td>2 (11%)</td>
<td>1 (8%)</td>
<td>0.206</td>
<td>0.364</td>
</tr>
</tbody>
</table>

LVOTO: left ventricular outlet obstruction; CPB: cardiopulmonary bypass; AV Block: atrioventricular block; NS: not significant; CCU: cardiac care unit; LCOS: low cardiac output syndrome; VSD: ventricular septal defect.
symptoms and acceptable cardiac function, we continued to observe him. One patient (AVSD/TOF) in the 1.5-patch group and the other (AVSD/TOF) in the two-patch group developed left PS (estimated peak instantaneous gradients of 34 and 52 mmHg) at 4 and 6 months postoperatively. Among the three groups, no clinically significant LVOTO occurred and no prosthetic valve replacements were performed.

DISCUSSION

Surgical repair of CAVSD with a large ventricular component (>1 cm) using the two-patch and modified single-patch procedures have been reported with good results [3, 5–7, 13]. In our experience, correction of this lesion using a 1.5-patch technique produced results comparable with the two conventional techniques. There was no difference in hospital results, degree of left or right AV valve insufﬁciency, degree of LVOTO or late mortality among the three groups. Mean ischaemic and CPB times for the 1.5-patch group were shorter than in the two-patch group, but longer than in the modiﬁed single-patch group. Although some may question that the differences between the 1.5-patch group and the two-patch group were minor and may not translate into clinically important differences, the comparatively good postoperative outcomes are encouraging.

LAVV regurgitation and residual VSD generated a relatively large proportion of reintervention in our series. Three children (two for residual VSD and one for LAVV regurgitation) who underwent the modiﬁed single-patch procedure and one child (for residual VSD) who underwent the two-patch procedure required reoperation. The most frequent sites of suture dehiscence were near the base of the SBL and IBL. The modiﬁed single-patch technique is much more broadly applicable than initially thought; however, its use remains controversial when the size of ventricular component is over 1 cm and the available leaflet tissue is somewhat limited [8]. There are two stresses placed on the lower zone of approximation of the inferior and superior bridging leaflets: leaflet to leaflet and leaflet to ventricular crest. As the size of ventricular component increases, the dual strain effect substantially enhances, which leads to residual VSDs and valve incompetence. The 1.5-patch procedure serves to prevent undue tension subsequent to the repair and enables good valve function after the operation. Although the early overall incidence of reintervention was signiﬁcantly lower in the 1.5-patch group than in the modiﬁed single-patch group, those differences could be confounded due to the single-institute experience, small population and relatively short follow-up time. However, the 1.5-patch method appears to offer an attractive approach to the correction of CAVSD with a large ventricular component.

The LVOT in CAVSD is intrinsically narrow and some patients are prone to develop clinically important LVOTO, which occurs as a postoperative complication in about 3–7% of the patient.

Table 3: Follow-up outcomes

<table>
<thead>
<tr>
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<th>Group I (n = 21)</th>
<th>Group II (n = 16)</th>
<th>Group III (n = 12)</th>
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<tbody>
<tr>
<td>Follow-up age (months)</td>
<td>27.67 ± 2.61</td>
<td>61.00 ± 8.75</td>
<td>40.08 ± 5.56</td>
</tr>
<tr>
<td>LVOT (velocity) (m/s)</td>
<td>1.00 ± 0.14</td>
<td>0.98 ± 0.22</td>
<td>1.15 ± 0.33</td>
</tr>
<tr>
<td>LAVV (%)/RAVV (%) regurgitation</td>
<td></td>
<td></td>
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<tr>
<td>Class I</td>
<td>5 (24)/13 (62)</td>
<td>6 (38)/11 (69)</td>
<td>3 (25)/5 (42)</td>
</tr>
<tr>
<td>Class II</td>
<td>16 (76)/8 (38)</td>
<td>9 (56)/5 (31)</td>
<td>9 (75)/7 (58)</td>
</tr>
<tr>
<td>Class III</td>
<td>0 (0)/0 (0)</td>
<td>1 (60)/0 (0)</td>
<td>0 (0)/0 (0)</td>
</tr>
<tr>
<td>LAVV annulus (cm)</td>
<td>1.67 ± 0.17</td>
<td>1.75 ± 0.36</td>
<td>1.72 ± 0.22</td>
</tr>
<tr>
<td>RAVV annulus (cm)</td>
<td>1.42 ± 0.31</td>
<td>1.58 ± 0.26</td>
<td>1.61 ± 0.18</td>
</tr>
<tr>
<td>Small residual VSD</td>
<td>1 (5%)</td>
<td>0 (0%)</td>
<td>1 (8%)</td>
</tr>
<tr>
<td>LAVV thickening</td>
<td>6 (29%)</td>
<td>5 (31%)</td>
<td>3 (25%)</td>
</tr>
<tr>
<td>AV block</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
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</table>

Small residual VSD: the defect size was less than 2 mm. The degree of LAVV and RAVV regurgitation was graded on the ratio of the colour Doppler jet to the area of the atrium; Class I: less than mild regurgitation; Class II: between mild and moderate regurgitation; Class III: more than moderate regurgitation.

LAVV: left atrioventricular valve; LVOT: left ventricular outflow tract; AV: atrioventricular; LCOS: low cardiac output syndrome; VSD: ventricular septal defect.

Figure 2: (A) Survival rate of the three groups; (B) freedom from cardiac reintervention of the three groups.
population [8, 15, 16]. Although the development of the subsequent obstruction can be multifactorial, the diameter of the outflow tract is the most significant variable that is directly affected by surgical manoeuvres. In some CAVSD lesions, the defect beneath the SBL extends to the LVOT and this antero-superior border of the defect constitutes a substantial portion of the immediate subaortic region and middle part of the outflow tract, which aggravates its narrowness [17, 18]. Such pathological and morphometric evaluation leads us to believe that using the patch to repair the superior ventricular defect component can relieve the inherently narrow LVOT and reduces the potential obstruction. Before 2008, the two-patch procedure was usually accomplished in our centre by using an autologous pericardial patch to close the primum component and a Gore-Tex or Dacron patch to close the large ventricular septal defect. The synthetic patch may promote the narrowness owing to the increased rigidity in posterior wall of LVOT and flow turbulence during systolic contraction [5, 8, 13]. No synthetic material patch is used in the 1.5-patch technique, which decreases the risk for potential fibrotic obstruction in the LVOT. As for CAVSD patients combined with TOF or DORV, the only outlet for the left ventricle is the space between the bridging leaflets and the ventricular septal crest. Hence, a comma-shaped autologous glutaraldehyde-treated pericardial patch under the SBL increases the LVOT diameter and, thereby, decreases the risk of subsequent LVOTO. The defect under the IBL is actually associated with inlet portion so that it is safe to anchor the IBL to the crest directly, irrespective of its size.

Study limitation

Firstly, this study was a retrospective review so that it is subject to selection bias due to the heterogeneity of the patients. In addition, there may be some historical bias as the 1.5-patch patients were operated in a slightly more recent era. Secondly, this single-centre series included a relatively small group of patients and number of events, limiting statistical power with which to make certain comparisons. A larger series with a randomized design and reconfirmation by other surgeons are required for more definitive conclusions. Thirdly, due to the specifics of our health system, most patients consulted doctors at an older age and greater body weight compared with those in other centres. They did not undergo cardiac catheterization. These factors could have impacted postoperative morbidity and mortality. Finally, although the immediate and median outcomes of this procedure are acceptable, further observation is needed in order to draw more definitive conclusions.

CONCLUSION

In conclusion, the 1.5-patch procedure, by applying a small patch only superiorly to close the VSD, serves to provide acceptable valve competence and reduce the risk of subsequent LVOTO. Although further observation is required, the satisfactory mid-term results from this technique are encouraging.

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