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Original Article

Left Atrioventricular Valve Regurgitation After Correction of Atrioventricular Septal Defects

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Abstract Purpose : Progressive regurgitation of the left atrioventricular valve (AV) remains a major postoperative problem in the repair of atrioventricular septal defect (AVSD). The aim of this study was to review a case series of AVSD repair and reoperation for significant left AV valve regurgitation from this institution.

Methods : Forty-nine patients underwent initial repair of AVSD between February 1990 and March 2011, and 4 of them underwent reoperation for left AV valve regurgitation. Another 5 patients, who had received initial repair of AVSD before 1990, underwent reoperation of the left AV valve during the same period. This study retrospectively reviewed all cases of AVSD operation, and considered the causes of the left AV valve incompetence, and furthermore addressed how to manage most effectively this problem.

Results : There were 4 early deaths (8.6%) and no late deaths after initial repair of AVSD. No death was observed after reoperation of the left AV valve. Six patients underwent re-repair of left AV valve, but three patients needed prosthetic valve replacement. An additional cleft closure and commissuroplasty were performed on the 6 re-repaired cases. No significant AV valve regurgitation was observed among the 6 re-repaired cases. The actuarial survival was 92% at 10 and 15 years after AVSD repair. Freedom from reoperation of the left AV valve was 81% at 10 and 15 years for the patients who survived the initial repair during the study period. Freedom from significant left AV valve regurgitation was 46% at 10 years for all patients who survived the initial repair during the study period. A partial ring annuloplasty using Gore-Tex graft was applied to the last 2 cases, and this employment yielded encouraging results.

Conclusion : The results were acceptable in terms of the mortality and reoperation free ratio, but the freedom from significant left AV valve regurgitation was disappointing. The outcome of reoperation for significant left AV valve regurgitation was also satisfactory. The application of Gore-Tex graft partial annuloplasty of the left AV valve appears to be a potentially useful and effective treatment modality.

Key words : Atrioventricular septal defect, Left AV valve, Cleft, Annuloplasty

Introduction

The outcome of a surgical correction of atrioventricular septal defects (AVSD) has dramatically improved in terms of the mortality¹⁾²⁾. Nevertheless, reoperation for progressive left atrioventricular (AV) valve regurgitation follow-

ing previous repair of AVSD remains a major postoperative problem^{2)~5)}. The optimal surgical treatment of AVSD includes the management of left AV valve regurgitation.

Although closure of the zone of apposition between the bridging leaflets (cleft) is crucial, significant residual left AV valve regurgitation can progress even if the cleft closure is appropriately done. Additional procedures have been utilized to manage this problem, including De Vega type annuloplasty, commissuroplasty,

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edge-to-edge technique⁶⁾ or patch augmentation of the leaflets⁷⁾. Recently, Kanani⁸⁾ reported the advantage of Gore-Tex band flexible annuloplasty of the left AV valve in re-repair of AVSD.

This report reviews a case series of initial repair of AVSD, significant left AV valve regurgitation after repair, and reoperation of the left AV valve after AVSD repair, and considers the optimal surgical management of the left AV valve.

Patients and methods

Fifty-eight patients underwent 63 operations for initial repair of AVSD or reoperation for the left AV valve between February 1990 and March 2011. A retrospective review was carried out of all cases of AVSD. Data was collected from the hospital records. The mean follow-up time was 8.7 ± 6.3 years. Forty-nine patients underwent an initial repair of AVSD, and 9 patients had reoperation for left AV valve regurgitation during

the study period. Down syndrome was found in 3 of the 9 reoperation cases. Five patients of the 9 reoperation cases underwent initial repair of AVSD during the same period, and 4 patients received initial repair before 1990. Four of these 5 patients, who received an initial repair during the study period, underwent the initial repair before 2000, while one patient underwent the initial repair after 2000. The baseline characteristics of the patients undergoing reoperation for left AV valve are summarized in Table 1. The mean age of the initial repair cases was 13.1 ± 20.2 years, and 28.9 ± 26.1 years for reoperation cases. Complete AVSD was observed in 24 patients (41.4%), partial AVSD in 34 (58.6%). Associated cardiac anomalies were tetralogy of Fallot ($n = 2$; 3.4%), total anomalous pulmonary connection ($n = 1$; 1.7%), and unroofed coronary sinus ($n = 1$; 1.7%). Patient characteristics by type of AVSD were summarized in Table 2.

Table 1 Baseline characteristics of the patients undergoing reoperation for left AV valve

Case number	Gender	Age (year)	Age (year) at initial repair	Type of AVSD	Interval (year) between initial repair and reoperation
1	M	18	13	partial	5
2	F	45	35	partial	10
3	F	5	1	partial	5
4	F	8	0.3	complete	8
5	F	17	0.6	partial	18
6	M	0.25	0.2	complete	0.2
7	F	74	51	partial	23
8	F	62	20	partial	42
9	F	31	1	partial	31

AV, atrioventricular ; AVSD, atrioventricular septal defect

Table 2 Patient characteristics by type of AVSD

Characteristic	Complete AVSD (n=24)	Partial AVSD (n=34)	Total group (n=58)
Age, years, mean \pm SD	2.0 ± 4.6	24.9 ± 24.0	15.3 ± 21.4
Female sex	15 (62.5%)	25 (73.5%)	40 (70.0%)
Down syndrome	12 (50%)	4 (11.8%)	16 (27.6%)
Associated cardiac anomalies	4 (16.7%)	0	4 (6.9%)
Tetralogy of Fallot	2 (8.3%)	0	2 (3.4%)
TAPVD	1 (4.2%)	0	1 (1.7%)
Unroofed coronary sinus	1 (4.2%)	0	1 (1.7%)
TASVD	0	1 (4.2%)	1 (1.7%)

AVSD, atrioventricular septal defect ; AV atrioventricular ; TAPVD, total anomalous pulmonary venous drainage ; TASD, total anomalous systemic venous drainage

Surgical technique (initial operation)

All operations were performed with cardiopulmonary bypass and moderate hypothermia by bicaval cannulation. Complete AVSD was repaired by a two-patch technique, and partial AVSD were repaired by one-patch technique. The left AV valve cleft was closed with interrupted mattress sutures. The cleft was left open or a simple mattress suture was applied at the base of the cleft in some cases ($n = 17$; 34.7%). After 2000, the cleft was left open in only one

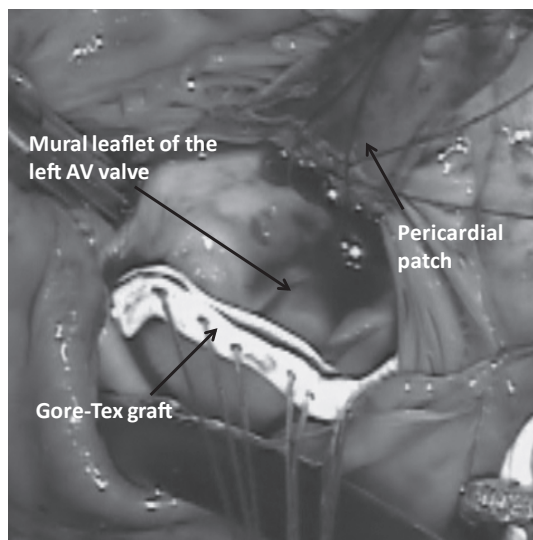


Fig. 1 The photograph shows a half divided 3.5 mm Gore-Tex graft sutured to the parietal part of the left atrioventricular valve. AV, atrioventricular

patient. Several additional techniques were used when there was significant residual regurgitation through the left AV valve following a saline injection test, including Kay type commissuroplasty (in 5 patients), De Vega type annuloplasty (in one patient), edge-to-edge valvuloplasty (in one patient) and Gore-Tex band partial annuloplasty (in 2 patients). The last technique used a thin-walled Gore-Tex graft (W.L. Gore & Associates, Inc., Flagstaff, AZ, USA) of 3.5 mm diameter as a partial ring supporting the parietal portion of the annulus of the left AV valve. A half of a longitudinally divided Gore-Tex graft was used to treat a child (Fig. 1). The graft was sutured to the posterior wall of the annulus using interrupted braided Nespolen so that the annuloplasty band covered both commissures on either side of the mural leaflet. The length of the band was selected so as to reduce the length of the posterior wall of the annulus by 20%. Competence was then confirmed by saline injection.

Surgical technique (re-repair)

All operations were performed through a median re-sternotomy. The left AV valve was approached through the right atrium with an atrial septal patch incision. Several techniques of left AV valve re-repair were used, such as cleft closure, commissuroplasty or annuloplasty. Cleft

Table 3 Operative findings and procedures at reoperation and recent left AV valve regurgitation

Case number	Findings at reoperation	Operative procedures	recent left AVVR
1	annular dilatation	MVR	none
2	Torn chordae, annular dilatation	MVR	none
3	Incomplete cleft closure AL commissure incompetence	cleft closure, commissuroplasty	trivial
4	Incomplete cleft closure AL commissure incompetence	cleft closure, commissuroplasty	none
5	Incomplete cleft closure Bilateral commissure incompetence	cleft closure, commissuroplasty	trivial
6	Incomplete cleft closure AL commissure incompetence	cleft closure, commissuroplasty	trivial
7	leaflet prolapse, annular dilatation	MVR	none
8	Incomplete cleft closure AL commissure hypoplasia	cleft closure	mild
9	Incomplete cleft closure PM commissure hypoplasia	cleft closure, commissuroplasty	trivial

AL, antero-lateral ; PM, postero-medial ; MVR, mitral valve replacement

closure was performed in 6 patients. Annuloplasty was performed in 5 patients (unilateral commissures in 4 patients, bilateral commissures in one patient) (Table 3). Valve replacement with a mechanical prosthesis was performed in 3 patients based on the surgeon's preference.

Statistical Analysis

Data are expressed as the mean with standard deviation. Estimates of survival, freedom from significant left AV valve regurgitation, and freedom from reoperation were determined using the Kaplan-Meier method, with differences between complete AVSD and partial AVSD tested by the log rank test. Statistical significance was established at P less than 0.05.

Results

1. Early and late outcome

There were 4 early deaths (8.3%) after initial repair of AVSD including a 24-year-old female associated with total anomalous pulmonary venous connection. There was no early death following re-operation of the left AV valve. The survival rates of all cases was 92%, 92%, and 92%, 90%, 90%, and 90% in complete AVSD, and 94%, 94%, and 94% in partial AVSD at 5 years, 10 years, and 15 years, respectively (Fig. 2). There was no significant difference in survival at 15 years

between complete AVSD and partial AVSD ($p = 0.65$). There was no death after reoperation for the left AV valve.

2. Significant left AV valve regurgitation after AVSD repair and reoperation for left AV valve regurgitation

Fourteen (28.6%) of the 49 patients, who underwent initial repair during the study period, progressed to more than moderate left AV valve regurgitation. Five of those patients underwent reoperation for left AV valve regurgitation, and 4 additional cases, that underwent initial repair before 1990, underwent reoperation for the left AV valve during the same period. Three of the 9 reoperations were mitral valve replacements (MVRs) and 6 re-repairs were performed. Table 3 shows the findings and procedures at the time of reoperation. Cleft closure was performed in 6 patients; however, cleft closure was completed in 3 of them according to the surgical record.

The estimated freedom from more than moderate left AV valve regurgitation was 84%, 66%, and 48% at 5 years, 10 years, and 15 years respectively (Fig. 3). This rate was 85%, 69%, and 52% in complete type, and 77%, 58%, and 51% in partial type at 5 years, 10 years, and 15 years, respectively (Fig. 3). There was no significant difference in freedom from significant AV valve regurgitation

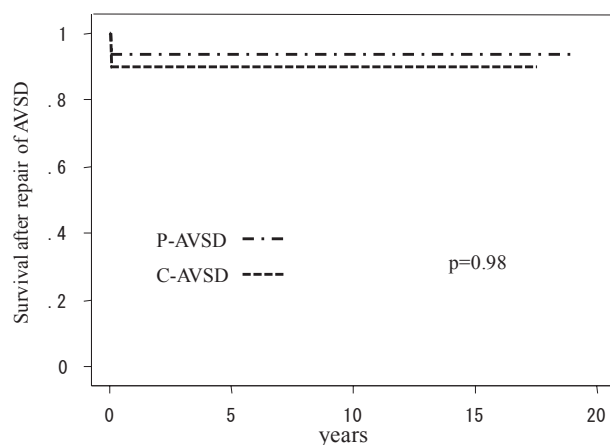


Fig. 2 Actuarial survival after repair of AVSD AVSD, atrioventricular septal defect; P, partial; C, complete

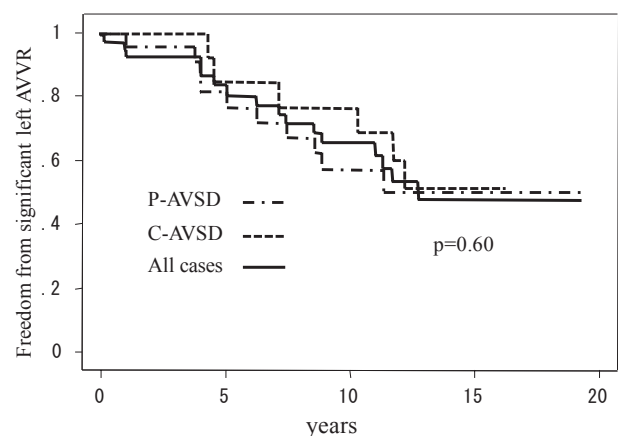


Fig. 3 Freedom from significant left atrioventricular valve regurgitation (AVVR) AVSD, atrioventricular septal defect; P, partial; C, complete

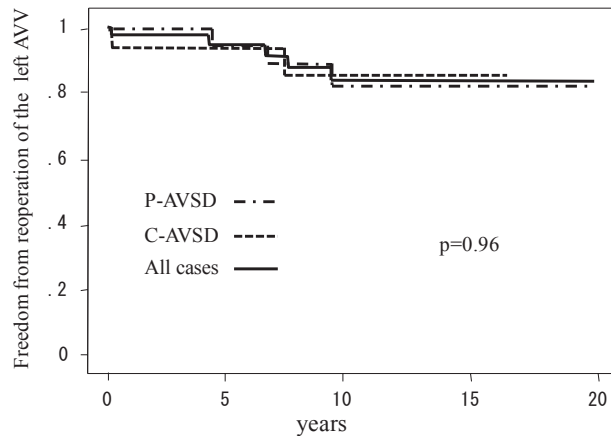


Fig. 4 Freedom from reoperation of the left atrioventricular valve (AVV)
AVSD, atrioventricular septal defect ; P, partial ; C, complete

at 15 years between complete AVSD and partial AVSD ($p = 0.60$). The estimated freedom from reoperation for the left AV valve was 98%, 84%, and 84% for all cases, 94%, 86%, and 86% in complete AVSD, and 95%, 82%, and 82% in partial AVSD at 5 years, 10 years, and 15 years, respectively (Fig. 4). No significant difference was observed in survival at 15 years between complete AVSD and partial AVSD ($p = 0.96$).

3. Gore-Tex band partial ring annuloplasty

A Gore-Tex band partial annuloplasty was applied to the last two cases due to the high incidence of significant left AV valve regurgitation following AVSD repair. One patient was a 54-year-old female with partial AVSD. She had severe left AV valve regurgitation preoperatively. The other was a 4-month-old child with partial AVSD with moderate left AV valve regurgitation. A saline injection test resulted in nearly moderate central valvular regurgitation in both cases following complete closure of the cleft of left AV valve. The saline injection test revealed the excellent competence of the valve after the completion of Gore-Tex band partial annuloplasty. Postoperative color Doppler echocardiography revealed competence of the left AV valve.

Discussion

Although the outcome of surgical management of AVSD has dramatically improved with a decrease in mortality following the initial repair, progressive left AV valve regurgitation remains a major cause of postoperative mortality and morbidity^{2)~5)}. This retrospective study analyzed the outcome of initial repair of AVSD in 49 patients and reoperation for significant left AV valve regurgitation in 9 patients over the last 20 years was analyzed. In-hospital mortality for the entire study population was 8.6%, which is consistent with the previously reported rates⁹⁾¹⁰⁾. This rate has shown dramatic improvement¹⁴⁾. The current series showed no in-hospital death after 1997. Freedom from reoperation of the left AV valve was comparable or superior to the rates of previous reports⁵⁾⁹⁾, as well. However, freedom from significant left AV valve regurgitation was disappointing.

The repair technique for the normal mitral valve seems to have been popularized, standardized and reproducible¹¹⁾. Controversy still remains with regard to the predictability of the technique and durability of the result of left AV valve repair in AVSD when there is a significant regurgitation after closure of the cleft. The left AV valve of AVSD has structural diversity in comparison to the normal mitral valve, such as the annular component, the leaflet and the subvalvular apparatus⁸⁾. Complete closure of the cleft does not always ensure the long term competence of the valve. The current results showed that late left AV valve regurgitation is not uncommon after repair of AVSD has been accomplished utilizing ordinary techniques demonstrated by many authors²⁾³⁾⁵⁾¹²⁾.

The use of a flexible ring in an annuloplasty of the normal mitral valve has resulted in a standard, predictable and reliable technique based on the anatomical and physiological structure of the mitral valve¹³⁾¹⁴⁾. Little attention has been paid to the ring annuloplasty concept in the surgical

management of AVSD probably because of the morphological difference between the mitral valve and the left AV valve of AVSD.

The normal mitral valve annulus is D-shaped¹⁵⁾. The straight border of the “D” consists of aortic-mitral fibrous continuity and both right and left fibrous trigone. This area is relatively inflexible in comparison to the annulus surrounding the mural leaflet, which sometimes lacks well-formed fibrous cords¹⁵⁾.

Although the linear part of “D” never faces the ventricular septum in the normal heart, the counterpart of this part of “D” in AVSD is the portion where both superior and inferior bridging leaflets are artificially fixed to the baffle that separates the atriums and ventricles. Consequently, the linear part of AVSD is considered to be less flexible, and it is not necessary to cover this part by annuloplasty ring anymore. Although we have no experience in using commercially available rings in patient with AVSD, we believe that these rings are not ideal for the repair of left AV valve regurgitation in AVSD patients because they are not designed for the left AV valve of AVSD but instead for the normal mitral valve.

The indications for this technique remains controversial ; however, the Gore-Tex graft partial ring annuloplasty appears to be an important surgical technique when a central or commissural leak is noted by a saline injection test following ordinary repair of the left AV valve of AVSD irrespective of the type of AVSD.

Limitations of this study

This study is limited by its retrospective design and relatively small number of the patients. No detailed surgical record was available in early cases.

Conclusion

The outcome of AVSD repair was acceptable in terms of mortality and freedom from reoperation for significant left AV valve regurgitation.

There was a significant decrease in mortality in the later period of the study. The outcome of reoperation for left AV valve regurgitation was satisfactory. However, the high incidence of significant left AV valve regurgitation was disappointing, and consequently this could result in growing population of candidates for reoperation with time. The employment of Gore-Tex graft reduction ring annuloplasty yielded encouraging results, but this treatment modality still needs to be evaluated in the long term.

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房室中隔欠損症根治術後の左側房室弁逆流

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目的：房室中隔欠損症（AVSD）根治術後の進行性の左側房室弁逆流は、本疾患に対する外科治療における最も重要な問題点である。本研究において、当施設における AVSD 根治術症例術後の左側房室弁逆流、および左側房室弁に対する再手術に検討を加える。

方法：1990 年 1 月から 2011 年 5 月までに 49 例に対し AVSD の根治手術を行い、うち 4 例に左側房室弁に対する再手術を行った。同時期に 1990 年より以前に根治術を受けた 5 例に対し、左側房室弁に対する再手術を行った。本研究では、これらすべての症例に検討を加え、左側房室弁逆流発生の原因を考察し、この問題に対しいかに対処すべきかに言及する。

結果：初回根治術後早期死亡を 4 例（8.6%）に認めたが、遠隔死亡はなかった。再手術後は早期死亡、遠隔死亡とも認めなかった。再手術では、6 例に左側房室弁の再形成を行い、3 例に人工弁置換術を行った。再形成の 6 例において、裂隙の再閉鎖と、交連部における弁輪縫縮術を行った。再形成の 6 例において、有意な左側房室弁逆流の再発を認めていない。AVSD 初回根治術後の累積生存率は 10 年、15 年で 92%であった。初回根治手術生存例における、左側房室弁に対する再手術からの回避率は、10 年、15 年で 81%であった。初回根治術後の有意な左側房室弁逆流からの回避率は 10 年で 46%であった。Gore-Tex グラフトを用いた部分弁輪縫縮術は有用であった。

結語：AVSD に対する初回根治術の成績は、死亡率、再手術回避率の点で満足すべき結果であったが、術後の有意な左側房室弁逆流からの回避率は不満足な結果であった。左側房室弁に対する再手術の成績は満足すべきものであった。Gore-Tex グラフトを用いた部分弁輪縫縮術は、術後左側房室弁逆流発生を減少させる可能性を有する有用な方法であると考えられた。