



Original Article

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Evaluation of mid-term outcomes of partial and intermediate atrioventricular canal defect surgery

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Abstract

Background: The risk factors for reoperation and mortality after partial and intermediate atrioventricular canal defect repair are unclear. This study assessed the mid-term outcomes and risk factors for reoperation and mortality after partial and intermediate atrioventricular canal defect surgery. **Methods:** Ninety-seven patients who underwent primary repair of intermediate (n = 45) or partial (n = 52) atrioventricular canal defect between 2005 and 2019 were included in this single-centre study. **Results:** The median age was 5 years (2.7–8.9 years). The median follow-up time was 32 months (1.6–90.8 months). The estimated freedom from reoperation at 1, 5, and 10 years was 97%, 91%, and 73%, respectively.

In multivariable analyses, post-operative left atrioventricular valve regurgitation of grade II or higher (odds ratio [OR]: 5.3, 95% confidence interval [CI]: 1.8–15.5, $p = 0.01$) and post-operative residual intracardiac shunt (OR: 11.6, 95% CI: 1.6–85.8, $p = 0.02$) were risk factors for reoperation.

In multivariable analyses, perioperative reoperation (OR: 93.4, 95% CI: 3.9–218.7, $p = 0.01$) and the need for right atrioventricular valve repair (OR: 11.2, 95% CI: 1.0–123.3, $p = 0.04$) were risk factors for mortality. Mortality was higher in patients under 2.6 years of age. **Conclusion:** For patients undergoing repair of partial or intermediate atrioventricular canal defect, those with post-operative left atrioventricular valve regurgitation of grade II or higher and post-operative residual intracardiac shunt have an increased reoperation risk. Higher mortality can be expected after a perioperative reoperation, and in patients requiring right atrioventricular valve repair during the index procedure.

Introduction

Partial and intermediate atrioventricular canal defects are on the spectrum of atrioventricular canal defects.¹

The results of the surgical repair of intermediate and partial atrioventricular canal defect have improved.^{2–4} In-hospital mortality has decreased to 1%, with reported mortality rates ranging from 0.8% to 5%.^{2,5–11} Left atrioventricular valve regurgitation is the primary indication for reoperation.^{4,5,12} The reoperation rate due to left atrioventricular valve regurgitation ranges from 3.4% to 18.5%.^{2,5–11} Left atrioventricular valve anomaly and higher post-operative grade of left atrioventricular valve regurgitation have been reported as risk factors for reoperation.^{4,5,11} And, reoperation for left atrioventricular valve regurgitation has been identified as an independent risk factor for mortality.⁴ Although the effect of left atrioventricular valve regurgitation on mortality and reoperation has been shown in previous studies,^{4,5,12} there are conflicting results regarding the effect of patient age.^{5,11,12} This study aimed to present our experience with partial and intermediate atrioventricular canal defect repair and to determine the risk factors affecting the reoperation rate and mortality.

Materials and methods

This single-centre retrospective study was approved by the Dr Siyami Ersek Thoracic and Cardiovascular Surgery Research and Training Hospital institutional review board (05.02.2021/E-28001928-604.01.01-53). All patients were informed about the planned surgical procedure, and consent forms were obtained from all patients detailing that the hospital data could be used for any scientific purpose. Between 2005 and 2019, 97 patients underwent biventricular repair of partial or intermediate atrioventricular canal defect. All demographic, inpatient, and outpatient

clinical data were collected retrospectively from the hospital medical records. The hospitals where patients were followed up were contacted for patients living at a distance. Partial and intermediate atrioventricular canal defect were defined according to the Congenital Heart Surgery Nomenclature and Database Project.¹

Surgical technique

Exposure was through a right atriotomy. Line of coaptation and evaluation of valves were done by injection of cold saline into the ventricles. Cleft closure was performed in all patients using 5–0 or 6–0 prolene. Kay annuloplasty was done if there was a central leak due to annular dilation. The ventricular septal defect was closed by using a pledgeted suture or by using a polytetrafluoroethylene patch. Left atrioventricular valve size was checked by using a Hegar dilator appropriate for a Z score of 0. The right atrioventricular valve was checked by another dose of cold saline injection. Right atrioventricular valve regurgitation was addressed by valvuloplasty, annuloplasty, or cleft closure.

Echocardiographic definitions and measurements

Transthoracic echocardiographic evaluation was used for left atrioventricular valve regurgitation grading (Grade 0: no, trivial; Grade 1: mild; Grade 2: moderate; Grade 3: moderate to severe; Grade 4: severe). A gradient of >20 mmHg in left ventricular outflow tract obstruction was defined as significant stenosis.

Study endpoint

Overall mortality and reoperation were the endpoints of this study. Perioperative reoperation and mortality were defined as occurring in the hospital or within 30 days after discharge. Late reoperation and mortality were defined as occurring more than 30 days after discharge. The aim of this study was to determine the risk factors affecting the reoperation rate and mortality. Consequently, data from patients who underwent left atrioventricular valve replacement were excluded from the final follow-up analysis.

Statistics

Statistical analyses were performed using IBM SPSS Statistics Software Version 21 (SPSS Inc., Chicago, IL, USA). Continuous data are presented as median and interquartile range, and categorical data are presented as n (%). Intergroup comparisons of continuous data were made using the Mann–Whitney *U* test. Chi-square or Fisher's exact tests were used as appropriate for categorical variables. Multivariable analyses were performed using binary logistic regression. Freedom from reoperation was estimated using Kaplan–Meier analysis. Receiver operating characteristics curve analyses were carried out to search for a cut-off age predicting mortality. A *p* < 0.05 was accepted as significant.

Results

Demographics and preoperative data are shown in Table 1, while post-operative data are shown in Table 2. Post-operatively, 92 (94.8%) patients were discharged from the hospital. Among these 92 patients, discharge echocardiography revealed that, left atrioventricular valve regurgitation grade decreased compared to that recorded preoperatively in 30 (32.6%) patients. Out of these 30 patients, 17 (17/30 = 56.7%) had intermediate atrioventricular canal defect, and 13 (13/30 = 43.3%) had partial atrioventricular

Table 1. Demographics and preoperative echocardiographic findings

Variable		Total N:97 (% or IQR)
Age (years)		5 (2.7–8.9)
AVCD type	P-AVCD	52 (53.6)
	I-AVCD	45 (46.4)
Gender	Female	54 (55.7)
	Male	43 (44.3)
LAVR grade	Grade 0	11 (11.3)
	Grade 1	55 (56.7)
	Grade 2	23 (23.7)
	Grade 3	5 (5.2)
	Grade 4	3 (3.1)
> Grade 2 LAVR		31 (31.9)
RAVVR grade	Grade 0	17 (17.5)
	Grade 1	57 (58.8)
	Grade 2	15 (15.5)
	Grade 3	5 (5.2)
	Grade 4	3 (3.1)

AVCD = atrioventricular canal defect; I-AVCD = intermediate atrioventricular canal defect; IQR = interquartile range; LAVR = left atrioventricular valve regurgitation; P-AVCD = partial atrioventricular canal defect; RAVR = right atrioventricular valve regurgitation.

canal defect. The left atrioventricular valve regurgitation grade did not change in 49 (53.3%) patients. Of these 49 patients, 32 (32/49 = 65.3%) had partial atrioventricular canal defect, and 17 (17/49 = 34.7%) had intermediate atrioventricular canal defect. Left atrioventricular valve regurgitation grade increased in 13 (14.1%) patients. Of these 13 patients, six (6/13 = 46.2%) had partial atrioventricular canal defect, and seven (7/13 = 53.8%) had intermediate atrioventricular canal defect. Changes in the grade of left atrioventricular valve regurgitation at the post-operative and latest follow-up period are shown in Figure 1. Preoperatively, 31 (32%) patients had grade II or higher left atrioventricular valve regurgitation. Post-operatively, 15 (16.3%) patients had grade II or higher left atrioventricular valve regurgitation. At the latest follow-up, the rate of grade II or higher left atrioventricular valve regurgitation was 20.5% (18 patients). Latest left atrioventricular valve regurgitation grades are shown in Table 3.

Reoperation

Two patients underwent reoperation in the perioperative period. In one of these patients, the left atrioventricular valve was replaced, and this patient died on post-operative-day 25 due to sepsis. The other patient underwent left atrioventricular valve valvuloplasty. Ten (10.9%) of the 92 hospital survivors required reoperation during follow-up. The median age was 3.5 years (interquartile range: 2–12.5) at the time of reoperation. The median duration for reoperation from the time of the index operation was 32 months (interquartile range: 2–91). The reoperation procedures are shown in Figure 2. Of the reoperation patients, seven patients had grade IV left atrioventricular valve regurgitation, one had grade II left atrioventricular valve regurgitation, and two patients had grade I left atrioventricular valve regurgitation before the reoperation. Of these 10 reoperation patients, two had grade IV right

Table 2. Operative and post-operative data

Variable (operative)		Total N:97 (%)
Additional valve procedures		34 (35)
	LAV annuloplasty	16 (16.5)
	RAV annuloplasty	8 (8.2)
	RAV cleft repair/valvuloplasty	18 (18.5)
Variable (Post-operative)		N:92 (% or IQR)
Post-operative LAVR grade	Grade 0	11 (11.9)
	Grade 1	66 (71.7)
	Grade 2	12 (13.1)
	Grade 3	3 (3.2)
	Grade 4	0
Post-operative \geq Grade 2 LAVR		15 (16.3)
Post-operative RAVR grade	Grade 0	40 (43.5)
	Grade 1	47 (51.1)
	Grade 2	4 (4.3)
	Grade 3	1 (1.1)
Post-operative alteration in LAVR grade *	No change	49 (53.3)
	Increase	13 (14.1)
	Decrease	30 (32.6)
Post-operative hospitalisation (days), (median)		6 (5-10)
Perioperative reoperation		2 (2.1)
Reoperation		10 (10.3)
In-hospital mortality		5 (5.2)
Late mortality		1 (1.1)
Reoperation for LAVR		7 (7.2)
Reoperation for other than LAVR		3 (3.1)
LAVR grade prior to the reoperation (10 patients)		
	Grade 1	2 (20)
	Grade 2	1 (10)
	Grade 4	7 (70)
RAVR grade prior to the reoperation (10 patients)	Grade 1	4 (40)
	Grade 2	4 (40)
	Grade 4	2 (20)
Redo interval (months), (median)		32 (2-91)

*Excluding the replacement patients.

atrioventricular valve regurgitation, four had grade II right atrioventricular valve regurgitation, and four had grade I right atrioventricular valve regurgitation before reoperation. The grade of regurgitation before reoperation is shown in Table 2. Estimated freedom from reoperation at 1, 5, and 10 years was 97%, 91%, and

73%, respectively. The Kaplan–Meier curve for freedom from reoperation is shown in Figure 3. The comparison of reoperation and no-reoperation patients is shown in Table 4 along with the multivariable risk factor analysis for overall reoperations.

The distribution of individuals with left atrioventricular valve regurgitation lower than grade II in the preoperative period and those with left atrioventricular valve regurgitation equal to or higher than grade II in the preoperative period, according to post-operative left atrioventricular valve regurgitation grades, and reoperation, is shown in Figure 4. In addition to overall reoperation risk factors, univariable analyses revealed preoperative grade II or higher left atrioventricular valve regurgitation ($p=0.032$), post-operative grade II or higher left atrioventricular valve regurgitation ($p=0.001$), and perioperative reoperation ($p=0.013$) as risk factors for reoperation for left atrioventricular valve regurgitation. According to the multivariable analyses, post-operative grade II or higher left atrioventricular valve regurgitation (OR: 23.6, 95% CI: 2.5–227.3, $p=0.006$) was a risk factor for reoperation.

Follow-up

The median follow-up time was 32 months (interquartile range: 1.6–90.8 months).

Grading of left and right atrioventricular valve regurgitation at latest follow-up are shown in Table 3. During the follow-up period, the left atrioventricular valve regurgitation grade increased in 21 (23.9%) patients. Nine out of 21 had partial atrioventricular canal defect, and 12 had intermediate atrioventricular canal defect. Seven of these 21 patients underwent reoperation for left atrioventricular valve regurgitation during follow-up. Four of these seven patients underwent left atrioventricular valve replacement. Left atrioventricular valve replacement patients had grade IV regurgitation before reoperation. One of these replacement patients died perioperatively. One patient underwent right atrioventricular valve replacement. Excluding the reoperation patients, left atrioventricular valve regurgitation grade decreased in 6 (6.5%) patients compared to the post-operative echocardiography findings. There were no changes in the grade of left atrioventricular valve regurgitation in 65 (73.8%) patients. At latest follow-up, 18 patients (20.5%) had grade II or higher left atrioventricular valve regurgitation compared to 31 (31.9%) patients preoperatively. One patient is being followed due to subaortic stenosis, three patients are being followed for small residual atrial septal defect, and four patients are being followed for restrictive ventricular septal defect

Mortality

The in-hospital mortality rate was 5.2% (five patients). The median age of these patients was 0.8 years (interquartile range: 0.6–1.9) compared to 5.1 years (interquartile range: 3.8–9.4) for hospital survivors ($p=0.01$). The rate of late mortality was 1.1% (one patient). The ages of the patients who died perioperatively were 2.5 years, 10 months, 22 months, 6 months, 7 months, 10 months, 22 months, and 2.5 years, respectively. Causes of death were infective endocarditis ($n=1$), ventricular fibrillation ($n=1$), left atrioventricular valve regurgitation due to acute-onset cleft separation and resulting in cardiac arrest with possible air embolism related to cardiac arrest ($n=1$), and sepsis ($n=1$). After redo surgery for left atrioventricular valve replacement, late mortality happened in a patient two months after the index procedure due to thrombosis of the mechanical valve. Univariable analyses identified the need for additional valve repair other than left atrioventricular valve cleft ($p=0.01$), post-operative grade II or higher left atrioventricular

Table 3. The latest follow-up left atrioventricular valve regurgitation and right atrioventricular valve regurgitation grades in comparison to the preoperative grades

Variable		N:88 (%)	p-value
Latest LAVVR grade*	Grade 0	11 (12.5)	0.305
	Grade 1	59 (67)	
	Grade 2	16 (18.2)	
	Grade 3	1 (1.1)	
	Grade 4	1 (1.1)	
Latest RAVVR grade	Grade 0	32 (36.4)	0.03
	Grade 1	50 (56.8)	
	Grade 2	4 (4.5)	
	Grade 3	1 (1.1)	
	Grade 4	1 (1.1)	

*Excluding left atrioventricular valve replacement patients.

valve regurgitation, post-operative right atrioventricular valve regurgitation higher than grade I ($p=0.04$), and age ($p=0.01$) as risk factors for in-hospital mortality. The multivariable risk factor analysis for mortality is shown in Table 5.

The mortality rate was higher in younger patients. Age was not in the multivariable analysis model. Receiver operating characteristics curve analyses revealed that with a sensitivity of 1 and specificity of 0.82, the cut-off level for age was 2.6 years while the area under the curve was 0.915 (95% CI, 0.842–0.988; $p=0.002$). The receiver operating characteristics curve is shown in Figure 5.

Discussion

Mortality following repair of partial or intermediate atrioventricular canal defect has been reported to be between 1% and 5%.^{2,5–11} In this study, the in-hospital mortality rate was 5.2%, and the late mortality rate was 1.1%. For these patients, the literature conflicts regarding the correlation between age at the time of operation and mortality and reoperation. Buratto et al. found higher age at partial atrioventricular canal defect repair as a predictor of better long-term survival in their study of 249 partial atrioventricular canal defect patients with a median age of 2.9 (interquartile range: 1.4–5.1) years.¹¹ Mery et al. supported these findings in their extensive series of 265 partial and intermediate atrioventricular canal defect patients and showed that infants were at a higher risk of reoperation.⁵ On the other hand, Sfyridis et al. observed improved survival in intermediate atrioventricular canal defect patients with an operative age lower than 3 months and

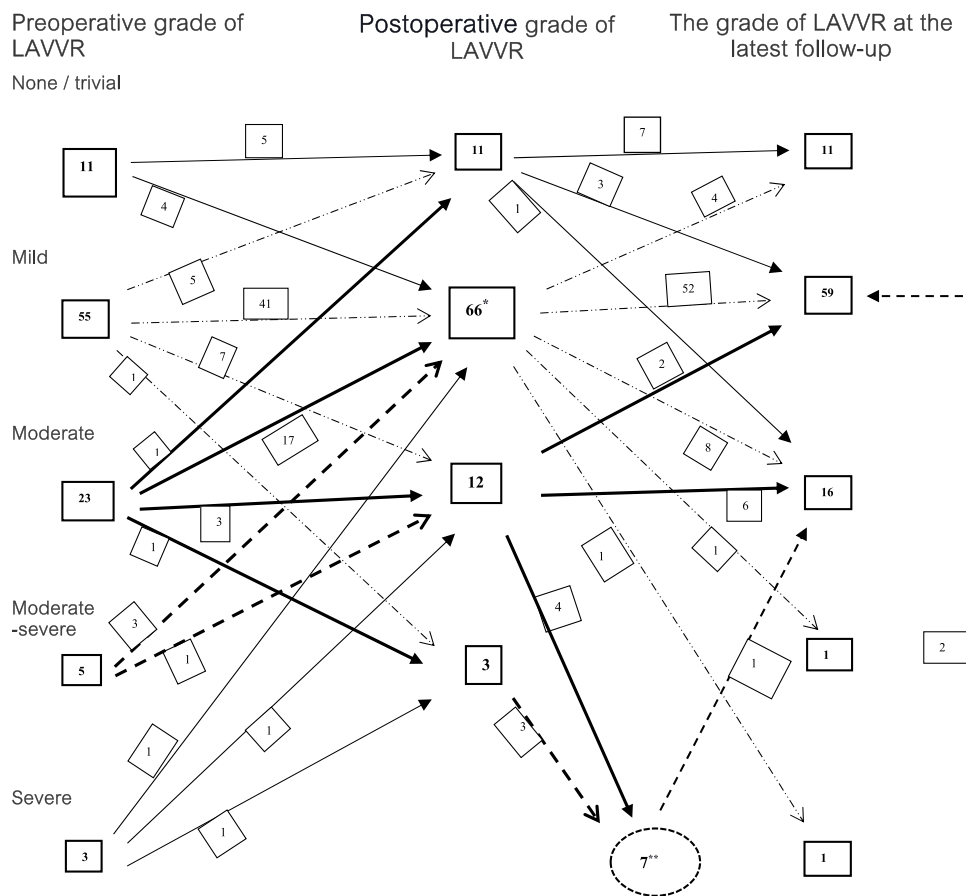


Figure 1. The alterations of the grade of LAVVR at the preoperative, the post-operative, and the latest follow-up period. * the grade of LAVVR increased from mild to moderate during the follow-up period. The dominant lesion for the redo surgery was residual ASD. LAVVR repair was also performed. ** during the follow-up period, four of the grade II LAVVR and three of the grade III LAVVR increased to grade IV LAVVR. Four of these patients underwent LAVV replacement. One of the LAV replacement patients died. The grade of regurgitation of these four patients is not shown in the figure. Three of the grade IV LAVVR patients underwent LAVV repair. One of these patients had Grade 2 and two of them had Grade 1 LAVVR at their latest follow-up. LAVVR = left atrioventricular valve regurgitation.

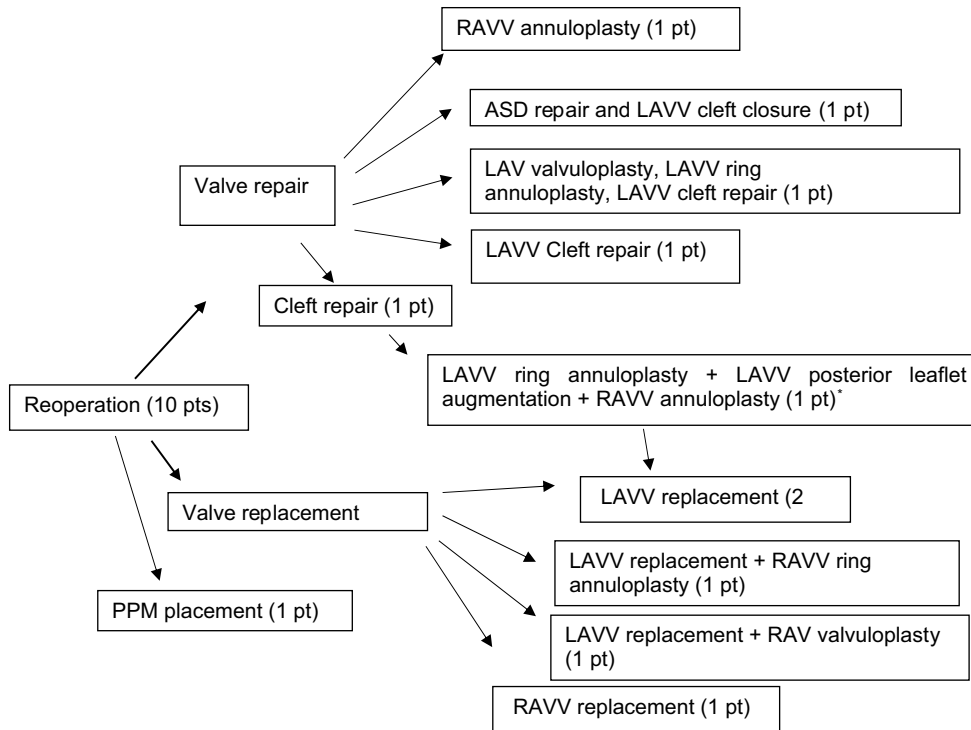


Figure 2. Reoperation procedures. *The patient underwent LAVVR during the follow-up period. ASD = atrial septal defect, LAV; left atrioventricular; LAVV = left atrioventricular valve; LAVVR = left atrioventricular valve regurgitation, RAVV = right atrioventricular valve; PPM = permanent pacemaker.

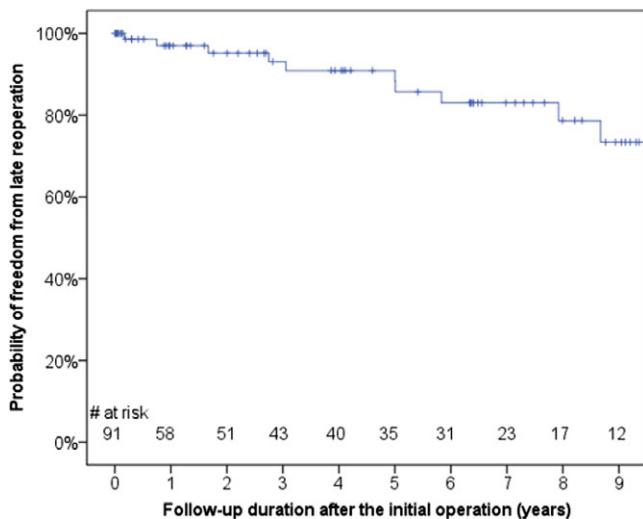


Figure 3. Kaplan–Meier curve for freedom from reoperation.

partial atrioventricular canal defect patients with an operative age under 2 years.¹² In the current study, mortality was higher in partial or intermediate atrioventricular canal defect patients younger than 2.6 years.

Perioperative reoperation was an independent risk factor for in-hospital mortality. Both patients who were reoperated on in the perioperative period were reoperated on for left atrioventricular valve regurgitation. According to univariable analyses, although post-operative left atrioventricular valve insufficiency affects mortality, this was not demonstrated in multivariable analyses. Therefore, we attribute perioperative reoperation as being associated with the poor condition of the patients before reoperation and to the effects of cardiopulmonary bypass performed immediately after the index procedure. Interestingly,

a need for right atrioventricular valve cleft closure or valvuloplasty was found to affect the in-hospital mortality rate. Since post-operative right atrioventricular valve insufficiency is not an in-hospital mortality risk factor, we cannot comment on this finding further.

After partial or intermediate atrioventricular canal defect primary repair in large series, the reoperation rate varies between 11.4% and 21%.^{4–6,11} In these series, the follow-up period ranged from 60 months to 25 years. In this series, the reoperation rate was 10.3%. The fact that this rate is lower in this study may be due to the shorter follow-up period of 32 months compared to other clinical series. Previous studies have shown that left atrioventricular valve regurgitation is the most common cause of overall reoperations.^{2,5,12} In our study group, left atrioventricular valve regurgitation was the most frequent indication for reoperation (seven of 10 [70%] patients). It is known that post-operative grade II or higher left atrioventricular valve regurgitation is associated with an increased reoperation rate for left atrioventricular valve regurgitation.¹¹ The results of this study support this finding. Post-operative grade II or higher left atrioventricular valve regurgitation was also found to be a risk factor for overall reoperations. The rate of preoperative, post-operative, and follow-up grade II or higher left atrioventricular valve regurgitation was 31.9%, 16.3%, and 19.3%, respectively. Cleft or leaflet dehiscence is the primary mechanism for regurgitation, but annulus enlargement and chordae elongation are the other causes of insufficiency.¹³ In this study, among eight out of nine reoperation patients, it was observed that cleft sutures were opened or the leaflet was separated from the annulus. The thin leaflet tissue was frequently torn at the sewing line of the cleft or the thinner point of the leaflet due to excessive tension. For decreasing the tension on the suture line, a cleft repair can be performed using pericardium-supported sutures, or a leaflet can be expanded by placing an autologous pericardium patch between the cleft edges. Although its effect on the reoperation rates was not statistically significant, adding an

Table 4. The risk factor analysis for reoperation

Variable		Reoperation (-) n (%)	Reoperation (+)n (%)	p-value, OR (95% CI)
Gender (female/male)	Female	50 57.5%	4 40%	
	Male	37 42.5%	6 60%	
Type of AVCD	I-AVCD	39 44.8%	6 60%	
	P-AVCD	48 55.2%	4 40%	
Preoperative LAVVR	Grade 0	10 11.5%	1 10%	
	Grade 1	53 60.9%	2 20%	
	Grade 2	18 20.7%	5 50%	
	Grade 3	4 4.6%	1 10%	
	Grade 4	2 2.3%	1 10%	
Preoperative > Grade 2 LAVVR	0	63 72.4%	3 30%	
	1	24 27.6%	7 70%	
Preoperative RAWVR	0	16 18.4%	1 0%	
	1	52 59.7%	5 50%	
	2	13 14.9%	2 20%	
	3	3 3.5%	2 20%	
	4	3 3.5%	0 0%	
Additional valve repair	0	55 63.2%	8 80%	
	1	32 36.8%	2 20%	
LAVV annuloplasty	0	73 83.9%	8 80%	
	1	14 16.1%	2 20%	
RAWV annuloplasty	0	82 94.3%	7 70%	
	1	5 5.7%	3 30%	
RAWV cleft repair or valvuloplasty	0	70 80.5%	9 90%	
	1	17 19.5%	1 10%	
Post-operative LAVVR	Grade 0	10 12.2%	1 10%	
	Grade 1	63 76.8%	3 30%	
	Grade 2	8 9.8%	4 40%	
	Grade 3	1 1.2%	2 20%	
	Grade 4	0 0%	0 0%	
Post-operative > Grade 2 LAVVR	0	73 89%	4 30%	0.01, 5.3 (1.8–15.5)
	1	9 11%	6 60%	
Post-operative RAWVR	Grade 0	38 46.3%	2 11.1%	
	Grade 1	41 50%	6 66.7%	
	Grade 2	2 2.4%	2 22.2%	
	Grade 4	1 1.2%	0 0%	
Post-operative alteration in LAVVR grade	No change	46 56.1%	3 33.3%	
	Increase	9 11%	4 33.3%	
	Decrease	27 32.9%	3 33.3%	
Residual ASD / VSD	0	75 91.5%	7 70%	
	1	7 8.5%	3 30%	0.02, 11.6 (1.6–85.8)

ASD = atrial septal defect; AVCD = atrioventricular canal defect; I-AVCD = intermediate atrioventricular canal defect; IQR = interquartile range; LAVV = left atrioventricular valve; LAVVR = left atrioventricular valve regurgitation; P-AVCD = partial atrioventricular canal defect; RAWV = right atrioventricular valve, RAWVR = right atrioventricular valve regurgitation; VSD = ventricular septal defect.

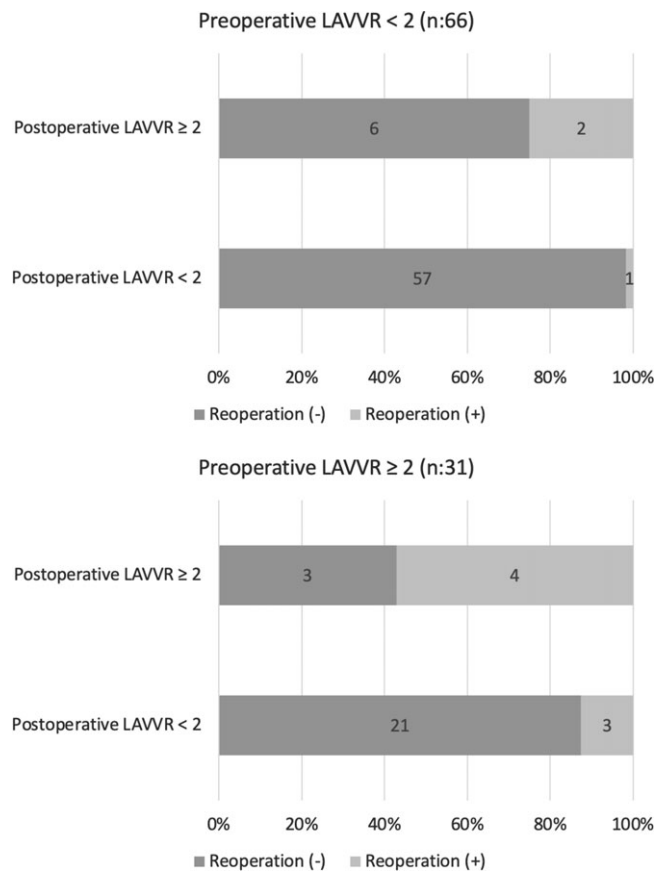


Figure 4. The distribution of patients according to the preoperative and post-operative left atrioventricular valve regurgitation grades. LAVVR = left atrioventricular valve regurgitation.

annuloplasty to the left atrioventricular valve cleft repair can reduce the tension on the cleft sutures by preventing dilation of the annulus and tearing of the sutures. In this study, seven (8.6%) of 81 patients who did not receive left atrioventricular valve annuloplasty underwent reoperation for left atrioventricular valve regurgitation. Among 16 patients who had left atrioventricular valve annuloplasty, one (6.2%) patient underwent perioperative reoperation. None of the 15 left atrioventricular valve annuloplasty patients required reoperation for left atrioventricular valve regurgitation.

The second most common reason for reoperation after atrioventricular canal defect surgery is left ventricular outflow tract obstruction.^{7,14} Mery *et al.*, in their series of 265 partial and intermediate atrioventricular canal defect patients, reported a 7% left ventricular outflow tract reoperation rate at 10 years of follow-up.⁵ Similarly, Buratto *et al.* reported a 6% reoperation rate due to left ventricular outflow tract stenosis at 15.1 ± 9.8 years of follow-up.¹¹ In our study, only one patient had subaortic stenosis at the latest follow-up echocardiography. In this study, we attribute lower left ventricular outflow tract reoperation rates to shorter follow-up times than in the series mentioned above, and we think that left ventricular outflow tract-related intervention will be required in the subsequent follow-up period. The incidence of residual atrial septal defect or ventricular septal

defect has been reported as 0% to 11%.^{4,7,8,11,15} In this study, six patients had residual atrial septal defect of different sizes, while four patients had restrictive ventricular septal defect. Residual atrial septal defect can be seen due to the separation of the patch due to superficial bites in order not to cause a block in the conduction system. Residual ventricular septal defect is caused by tiny leaks passing through the stitches placed in thickened tissues formed due to longstanding turbulence secondary to restrictive flow. Small residual ventricular septal defects can be followed up due to the possibility of spontaneous closure.¹⁶ In our study, one patient had reoperation due to the need for cleft repair and residual atrial septal closure, while the remaining patients with residual intracardiac shunts were followed up. In this study, a residual atrial septal defect or ventricular septal defect, another risk factor for overall reoperations, might show its effect as increased volume or pressure load further increasing atrioventricular valve regurgitation and worsening the clinical picture. If there is no accompanying valve failure, an insignificant atrial septal defect or ventricular septal defect might not directly affect the reoperation rate. The fact that none of the patients in this series were reoperated on for isolated atrial septal defect or ventricular septal defect supports this idea. There are different findings on the effect of timing of surgery on reoperation rates. Delvin *et al.* classified and examined 86 patients in their series as quartiles, that is, 0–0.75 years of age, 0.75–1.5 years of age, 1.5–3.75 years of age, and over 3.75 years of age. In their series, patients underwent partial atrioventricular canal defect repair at a median age of 1.5 years. The authors recommended surgery before two years of age, as there was no significant difference between age groups in terms of reoperation, late atrioventricular valve regurgitation, or stenosis.¹⁷ In the series from Minich *et al.*, significant left atrioventricular valve regurgitation occurred 6 months after the surgery in eight of nine children repaired between ages 4 and 7 years compared with 11 of 50 repaired at less than 4 years or later than 7 years of age.⁸ Regarding the extensive series from Texas Children's Hospital and Mayo Clinic, a repair later in life might be reasonable if the patient is stable on medical therapy.^{5,18} Although age was not found to be a risk factor for reoperation in our study, our clinical practice is to perform the surgery later in life to benefit from leaflet tissue that is more resistant to tension so long the patient uses low-dose medication. The retrospective and single institutional nature were the main limitations of the study. Since echocardiographic images of many patients were not available, evaluations were made based on reports. Valve pathologies could not be examined in detail since some surgery notes did not specify the valve structures.

Conclusion

For patients undergoing repair of partial or intermediate atrioventricular canal defect, high post-operative grade of left atrioventricular valve regurgitation and residual atrial septal defect or ventricular septal defect are independent risk factors for reoperation. An increase in in-hospital mortality can be expected after a perioperative reoperation, right atrioventricular valve cleft repair/valvuloplasty performed during the index procedure, and partial or intermediate atrioventricular canal defect repair surgery performed in patients under 2.6 years of age.

Table 5. Risk factor analysis for mortality

Variable		Mortality (-), n (%)	Mortality (+), n (%)	p-value, OR (95% CI)
Age (year)		5.1 (IQR: 3.8-9.4)	0.8 (IQR: 0.6-1.9)	<0.01
Gender (female/male)	Female	51 55.4%	3 60.0%	
	Male	41 44.6%	2 40.0%	
Type of AVCD	I-AVCD	41 44.6%	4 80.0%	
	P-AVCD	51 55.4%	1 20.0%	
Preoperative LAVVR	Grade 0	9 9.8%	2 40.0%	
	Grade 1	54 58.7%	1 20.0%	
	Grade 2	22 23.9%	1 20.0%	
	Grade 3	4 4.3%	1 20.0%	
	Grade 4	3 3.3%	0 0%	
Preoperative > Grade 2 LAVVR	0	63 68.5%	3 60.0%	
	1	29 31.5%	2 40.0%	
Preoperative RAWVR	0	16 17.4%	1 20.0%	
	1	56 60.9%	1 20.0%	
	2	14 15.2%	1 20.0%	
	3	4 4.3%	1 20.0%	
	4	2 2.2%	1 20.0%	
Additional valve repair	0	63 68.5%	0 0%	
	1	29 31.5%	5 100.0%	
LAVV annuloplasty	0	77 83.7%	4 80.0%	
	1	15 16.3%	1 20.0%	
RAWV annuloplasty	0	85 92.4%	4 80.0%	
	1	7 7.6%	1 20.0%	
RAWV cleft repair or valvuloplasty	0	77 83.7%	2 40.0%	0.04, 11.2 (1.0-123.3)
	1	15 16.3%	3 60.0%	
Post-operative LAVVR	Grade 0	11 11.9%	0 0%	
	Grade 1	66 71.7%	1 20.0%	
	Grade 2	12 13.2%	3 60.0%	
	Grade 3	3 2.2%	1 20.0%	
	Grade 4	0 0%	0 0%	
Post-operative > Grade 2 LAVVR	0	76 83.5%	1 20.0%	
	1	15 16.5%	4 80.0%	
Post-operative RAWVR	Grade 0	40 45.1%	0 0%	
	Grade 1	43 48.4%	4 80.0%	
	Grade 2	3 4.4%	1 20.0%	
	Grade 4	1 2.2%	0 0%	
Post-operative alteration in LAVVR grade	No change	49 53.3%	1 20.0%	
	Increase	13 14.1%	2 40.0%	
	Decrease	30 32.6%	1 20.0%	
Residual ASD / VSD	0	82 89.1%	5 100.0%	
	1	10 10.9%	0 0%	
Perioperative reoperation	0	91 98.9%	3 60.0%	0.01, 93.4 (3.9-218.7)
	1	1 1.1%	2 40.0%	

ASD = atrial septal defect; AVCD = atrioventricular canal defect; I-AVCD = intermediate atrioventricular canal defect; IQR = interquartile range; LAVV = left atrioventricular valve; LAVVR = left atrioventricular valve regurgitation; P-AVCD = partial atrioventricular canal defect; RAWV = right atrioventricular valve, RAWVR = right atrioventricular valve regurgitation; VSD = ventricular septal defect.

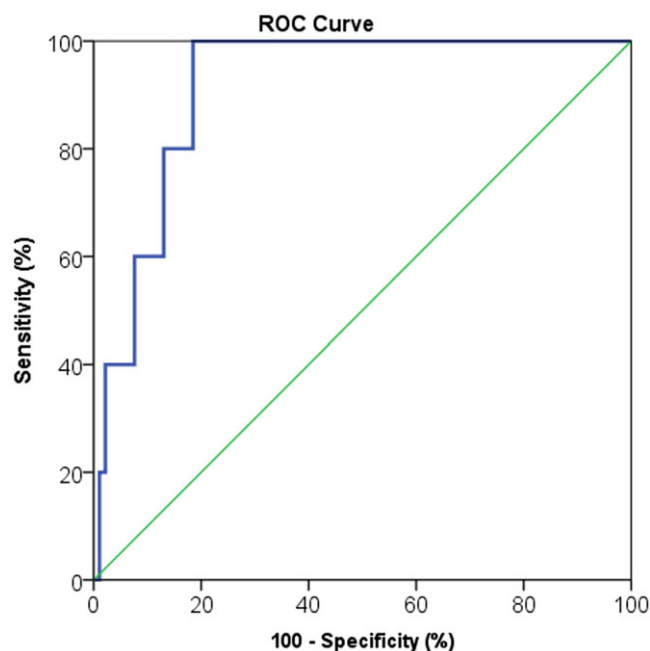


Figure 5. Receiver operating characteristics curve analyses of age for mortality.

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