Reoperation after failure of mitral valve repair for degenerative disease: A single surgeon experience

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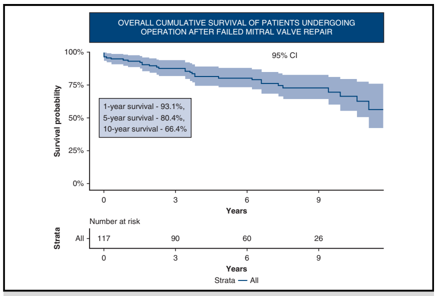
ABSTRACT

Background: With an increasing number of patients undergoing mitral valve repair, more patients are presenting for reoperation. This study aimed to evaluate factors influencing mortality and survival of patients undergoing reoperation for mitral valve surgery after previous mitral valve repair under a single surgeon.

Methods: We retrospectively collected data from 117 patients who underwent reoperation after previous mitral valve repair between 2010 and 2022. We aimed to identify preoperative, operative, and postoperative factors affecting outcomes. The primary outcome was overall survival, and the secondary outcomes included prolonged hospital stay and in-hospital mortality. The mean follow-up was 9.13 ± 10.36 years (median, 6.50 years).

Results: Out of 117 patients, 85 underwent mitral valve replacement (MVR) and 32 underwent mitral valve repair (MVr). The mean age was 64.7 ± 12.7 years (65.5 ± 12.2 years in the MVR group and 62.7 ± 14.0 years in the MVr group), and 66 (56.4%) were men. On a standard multivariate analysis of the overall factors influencing mortality, advanced age was associated with a higher risk of overall mortality (hazard ratio [HR], 1.07; 95% confidence interval [CI], f1.03-1.12; *P* = .001). The urgency of surgical intervention also played a role, with a higher risk of in-hospital mortality in patients undergoing emergency reoperation (HR, 1.55; 95% CI, 1.60-149.05; *P* = .02). Furthermore, the presence of mixed lesions, encompassing both mitral regurgitation and stenosis, was strongly linked to increased overall mortality (HR, 17.09; 95% CI, 4.06-71.94; *P* < .001) and in-hospital mortality (HR, 1.75; 95% CI, 15.83-1925.61; *P* < .001). Infective endocarditis emerged as a prominent risk factor for overall mortality (HR, 992.08; 95% CI, 85.74-11,479.08; *P* < .001) and in-hospital mortality (HR, 5.83; 95% CI, 514.81-65,932.99; *P* < .001). Additionally, chronic obstructive pulmonary disease was associated with a significantly increased risk of overall mortality (HR, 4.3; 95% CI, 1.24-14.97; *P* = .02)

Conclusions: Our single surgeon experience demonstrates that mitral valve reoperation after a previous repair is associated with good outcomes and survival. (JTCVS Open 2023;16:221-33)



Cumulative survival after reoperation for failed mitral valve repair.

CENTRAL MESSAGE

Mitral valve reoperation demonstrates good outcomes and good survival. Factors influencing mortality include older age, urgency of surgery, mixed lesions, and pulmonary disease.

PERSPECTIVE

Mitral valve reoperation after repair is becoming more frequent, and this study provides insight into risk factors and outcomes associated with it. The aim of this study is to inform and improve clinical decision making for this cohort. Further research is needed with a larger cohort to confirm and identify additional risk factors for prolonged hospital stay and mortality.

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Mitral valve repair (MVr) is the established intervention strategy to correct significant mitral regurgitation. But with the increasing frequency of patients undergoing MVr, mitral valve reoperations are becoming more common. The incidence of reoperation after initial MVr failure is estimated as 4.5% to 8% at 10 years,[1] with a linear increase of approximately 0.5% to 1% per year, reducing late survival.[2]

There is a paucity of data on factors that contribute to outcomes and survival after reoperation. Thus, the optimal treatment strategy for an initial failed mitral valve repair remains unclear. Our study aimed to evaluate the

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Abbreviations and Acronyms

COPD = chronic obstructive pulmonary disease
CVA = cerebrovascular accident
ECMO = extracorporeal membrane oxygenation
HR = hazard ratio
IE = infective endocarditis
IQR = interquartile range
LVEF = left ventricular ejection fraction
LVIDD = left ventricular internal diameter in diastole
MR = mitral regurgitation
MS = mitral stenosis
TIA = transient ischemic attack

postoperative outcomes of redo mitral surgery, including prolonged hospital stay, in-hospital mortality, and overall mortality, and risk factors influencing immediate and long-term outcomes.

METHODS

Study Population

This retrospective study was an analysis of adult patients age ≥18 years who underwent redo surgery for mitral valve disease between 2010 and 2022 at Royal Papworth Hospital, Cambridge, United Kingdom. The study included all the patients who underwent reoperation by a single surgeon with either mitral valve replacement (MVR) or re-repair after previous MVr. The majority of patients were from other surgeons or underwent the original operation at other institutions. The median duration of follow-up was 7 years (interquartile range [IQR], 4.9 years), and the maximum follow-up was 12.4 years. Approval from the Institutional Review Board (IRB) or equivalent Ethics Committee of the Royal Papworth Hospital, Cambridge was waived, as this was a retrospective study. Patient written consent for the publication of the study data was waived as well. Figure 1 provides a graphical abstract of the study.

Patient data were collected through electronic patient records. All available preoperative data were reviewed to identify patients' baseline characteristics. Intraoperative data including surgical priority, type of procedure, and concomitant procedure performed, along with cardiopulmonary bypass time and aortic cross-clamp time, were recorded.

Study Endpoints

The primary study endpoint was overall mortality, and the secondary endpoints or postoperative outcomes included prolonged hospital stay and in-hospital mortality. Reoperation was defined as any mitral valve operation, either replacement or repair, on subsequent admissions. Overall death was defined as death from all causes during the follow-up period. Deaths were identified from the National Death Registry. In-hospital mortality was defined as death during admission perioperatively. Prolonged hospital stay was defined as postoperative hospital length of stay >10 days.

Statistical Analysis

Patients' baseline and preoperative characteristics were summarized using appropriate descriptive statistics. Continuous variables were conveyed as mean ± standard deviations for normally distributed data and median and IQR for non-normally distributed data. Categorical variables were presented as proportion and absolute number. Differences between groups were tested using the χ^2 test or Fisher exact test for categorical variables and the Welch unpaired *t* test or Mann-Whitney *U* test for continuous variables, as appropriate. Kaplan-Meier (KM) survival curves were constructed to visualize and evaluate postoperative survival. Univariate and Multivariate Cox proportional hazard regression models were fitted to explore the association between the predictor variables and the overall survival

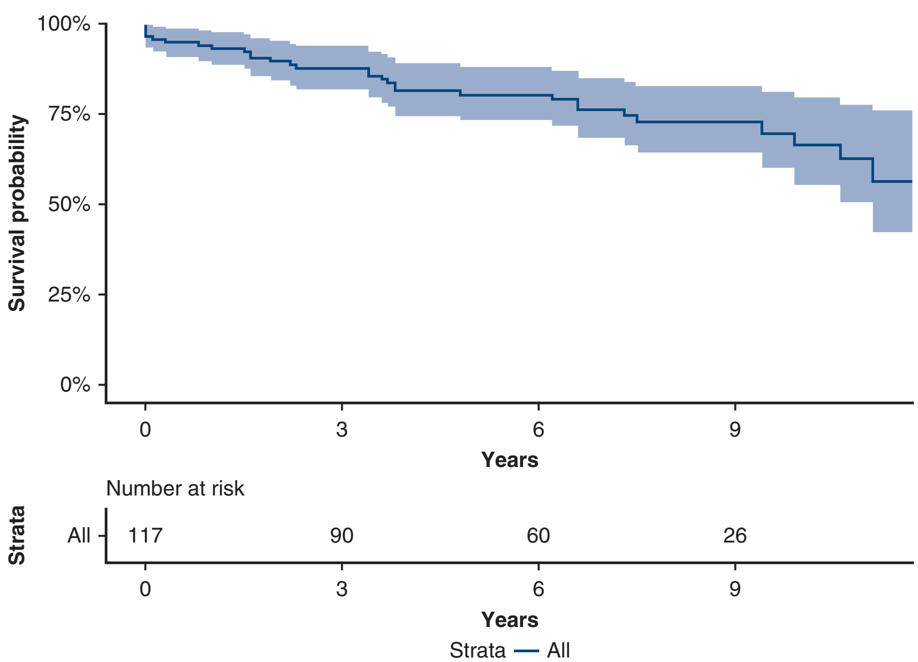

FIGURE 1. Cumulative overall survival over 12 years: 1-year survival, 93.1% (95% confidence interval [*CI*], 88.6%-97.8%); 5-year survival, 80.4% (95% CI, 73.1%-88.3%); 10-year survival, 66.4% (95% CI, 55.4%-79.7%).

outcomes and in-hospital mortality. The level of significance for the analytical models was set at $P = .05$. All statistical analysis was done using R version 4.1.2GUI 1.77 High Sierra build (8007).

RESULTS

Baseline Characteristics

The 117 patients who composed the study cohort included 32 who underwent re-MVr and 85 who underwent MVR. The mean age of the total cohort was 64.7 ± 12.7 years. Mean patient age was younger in the MVR group compared with the MVr group (65.5 ± 12.2 years vs 62.7 ± 14.0 years), although the difference was not statistically significant. The majority of the patients were men (56.4%). More patients were suffering from chronic heart failure in the MVR group (21.4% vs 13.7%; $P = .03$). Other factors, such as age, hypertension, hyperlipidemia, and pulmonary disease, did not differ significantly between the 2 groups. No significant between-group differences in preoperative echocardiographic findings were seen (Table 1).

We evaluated the lesions that led to the redo operation; the most prevalent was posterior leaflet prolapse, affecting 34 patients, followed closely by stenotic, calcified, or thickened leaflets, observed in 24 patients, and anterior mitral leaflet prolapse, seen in 18 patients. Twelve patients had bileaflet prolapse, and 11 patients had a dehisced or detached small ring. Eighteen patients presented with a combination of other associated conditions.

The majority of patients in both the MVR and MVr groups underwent elective surgery (83.5% and 84.4%, respectively). The mean follow-up was 9.13 ± 10.36 years. The median time from initial repair to reoperation was 6.50 (IQR, 10) years in the total cohort, 8.0 (IQR, 11.5) years in the MVr group, and 5 (IQR, 11.5) years in the MVR group. Mitral regurgitation was the most common indication for reoperation in the total cohort and in both reoperation groups. Other indications for reoperation included infective endocarditis, mitral stenosis, and mixed mitral regurgitation and stenosis. Among the patients with mitral regurgitation, 6 had a systolic anterior motion of the mitral valve resulting in left ventricular outflow tract obstruction and 3 had valve hemolysis.

Bioprosthetic valves were used more frequently in the MVR group (78.8%). Aortic valve surgery was the most common concomitant procedure performed in both groups. Mean aortic cross-clamp time and cardiopulmonary bypass time were shorter in the MVR group, but the difference was not statistically significant (94.4 ± 31.8 minutes vs 98.7 ± 22.5 minutes and 133.2 ± 34.4 minutes vs 159.3 ± 79.4 minutes, respectively) (Table E1).

There were no significant differences between the 2 groups in postoperative left ventricular ejection fraction (LVEF), mitral valve function, hospital length of stay, or mortality. Postoperatively, most patients in both groups had normal or mild left ventricular dysfunction (defined as LVEF of 40%-50%) and normal mitral valve function or at most mild regurgitation. Both groups were equally matched in the mean hospital stay (13.8 days for MVR and 12.7 days for re-MVr) (Table E2).

Outcomes of Redo Mitral Surgery

We analyzed the effect of all the variables on our outcomes of interest overall mortality, in-hospital mortality, and prolonged hospital stay by univariate and multivariate analyses. The variables include mean age, sex, time since previous mitral valve repair (in years), surgical priority, indication for surgery, preoperative LVEF, chronic heart failure, hypertension, hyperlipidemia, chronic obstructive pulmonary disease (COPD), asthma, other pulmonary disease, previous cerebrovascular accident (CVA) or transient ischemic attack (TIA), preoperative tricuspid regurgitation, and preoperative left ventricular internal diameter in diastole.

Overall Survival and Mortality

Our analysis showed an overall 1-year survival rate of 93.1%, with a 5-year survival at 80.4% and 10-year survival of 66.4% (Figure 1). There was no significant difference in overall mortality between the MVr group and MVR group (hazard ratio [HR], 0.88; 95% confidence interval [CI], 0.39-1.99; $P = .8$) (Figure 2).

Univariate analysis showed that advanced age (HR, 1.07; 95% CI, 1.03-1.12; $P < .01$) was significantly associated with increased overall mortality, indicating a shorter lifespan in older patients. Reoperation indicated by the presence of mixed lesions (HR, 4.20; 95% CI, 1.23-14.38; $P = .02$) and infective endocarditis (HR, 14.20; 95% CI, 3.14-64.29; $P < .01$) also were associated with significantly higher overall mortality. Although male sex and time since previous surgery were associated with increased mortality, these variables were not statistically significant ($P = .8$ and .2, respectively). There was no difference in mortality by age group analyzed as a categorical variable (Figure E1).

The preoperative comorbidities found to be significantly associated with increased mortality were previous history of CVA/TIA ($P = .03$) and COPD ($P = .003$). Hypertension, hyperlipidemia, asthma, preoperative left ventricular dysfunction, and increased left ventricular internal diastolic diameter were not found to be statistically associated with increased overall mortality. However, as expected, the overall mortality rate was higher in patients who underwent urgent surgery compared to those who had elective surgery ($P = .04$) (Table 2). Prolonged cardiopulmonary bypass time was found to be significantly associated with increased mortality (HR, 1.02; 95% CI, 1.00-1.03; $P = .02$). With each additional minute of bypass time, there was a 2% escalation in the risk of overall mortality. This observation

TABLE 1. Preoperative patient data

Characteristic	MVR	MVr	Total	*P* value*
Total number of patients	85	32	117	
Sex, n (%)				1.00
Male	48 (56.5)	18 (56.3)	66 (56.4)	
Female	37 (43.5)	14 (43.8)	51 (43.6)	
Age, y, mean ± SD	65.5 ± 12.2	62.7 ± 14.0	64.7 ± 12.7	.40
Time to most recent redo MV surgery	8.9 ± 10.7	9.7 ± 9.3	9.13 ± 10.4	.73
Chronic heart failure, n (%)	25 (29.4)	16 (53.3)	41 (35.0)	.03
Hypertension, n (%)	46 (54.1)	11 (34.4)	57 (48.7)	.15
Hyperlipidemia, n (%)	31 (36.5)	6 (18.8)	37 (31.6)	.15
COPD, n (%)	3 (3.5)	1 (3.1)	4 (3.4)	1.00
Asthma, n (%)	11 (12.9)	3 (9.4)	14 (12.0)	1.00
Pulmonary disease, n (%)	15 (17.6)	5 (15.6)	20 (17.1)	1.00
CVA/TIA, n (%)	9 (10.6)	5 (15.6)	14 (12.0)	.52
Tricuspid regurgitation, n (%)	56 (63.5)	20 (57.1)	76 (63.2)	1.00
Preoperative echocardiographic findings				
Tricuspid regurgitation, n (%)				.66
Trace	13 (15.3)	3 (9.4)	16 (13.7)	
Mild	20 (23.5)	8 (22.9)	28 (23.9)	
Moderate	17 (20.0)	5 (15.6)	22 (18.8)	
Severe	5 (5.9)	4 (12.5)	9 (7.7)	
Preoperative LVEF, n (%)				.68
Normal	36 (42.4)	11 (34.4)	47 (40.2)	
Mild	22 (25.9)	11 (34.4)	33 (28.2)	
Moderate	9 (10.6)	1 (3.1)	10 (8.5)	
Severe	3 (3.5)	1 (3.1)	4 (3.4)	
Hyperdynamic	4 (4.7)	1 (3.1)	5 (4.3)	
Preoperative LVIDD, mean ± SD	5.4 ± 0.6	5.6 ± 1.3	5.4 ± 0.7	1.00
Preoperative LVIDD indexed, mean ± SD	2.9 ± 0.7	2.9 ± 0.3	2.9 ± 0.7	.83
Indications, n (%)				.21
Mitral regurgitation	60 (70.6)	27 (84.3)	87 (74.4)	
Mitral stenosis	12 (14.1)	1 (3.1)	13 (11.1)	
MR + MS	4 (4.7)	0	4 (3.4)	
Infective endocarditis	1 (1.2)	1 (3.1)	2 (1.7)	
Infective endocarditis + MR	4 (4.7)	3 (9.4)	7 (6.0)	
Missing			4 (3.4)	
Causes of MVr failure				.06
Anterior leaflet prolapse	14 (16.5)	4 (12.5)	18 (15.4)	
Posterior leaflet prolapse	23 (27.1)	11 (34.4)	34 (29.1)	
Bileaflet leaflet prolapse	6 (7.150)	6 (18.8)	12 (11.1)	
Stenotic or calcified valve lesion	23 (27.1)	1 (3.1)	24 (20.5)	
Ring lesions (small, detached or dehisced)	6 (7.1)	5 (15.6)	11 (9.4)	
Others†	10 (11.8)	4 (12.5)	14 (12.0)	
No documentation	3 (3.5)	1 (3.1)	4 (3.45)	

MVR, Mitral valve replacement; *MVr*, mitral valve repair; *MV*, mitral valve; *COPD*, chronic obstructive pulmonary disease; *CVA*, cerebrovascular accident; *TIA*, transient ischemic attack; *LVEF*, left ventricular ejection fraction; *LVIDD*, left ventricular internal diameter in diastole; *MR*, mitral regurgitation; *MS*, mitral stenosis. **P* values derived from the *t* test, Fisher test, and χ^2 test. †Other causes including orifice dilation (n = 2), ruptured native chords, patient preference (n = 4), abandoned (n = 3), SAM, nil obvious course, left ventricular dilation, poor leaflet coaptation.

underscores the significance of the lesion's severity and the technical complexity involved.

For the multivariate analysis, following adjustment for age, sex, previous history of CVA/TIA and COPD, increased cardiopulmonary bypass time ($P = .003$), patients with mixed lesion (mitral regurgitation and stenosis; $P < .01$), and infective endocarditis ($P < .01$) remained significantly associated with increased mortality (Table 3).

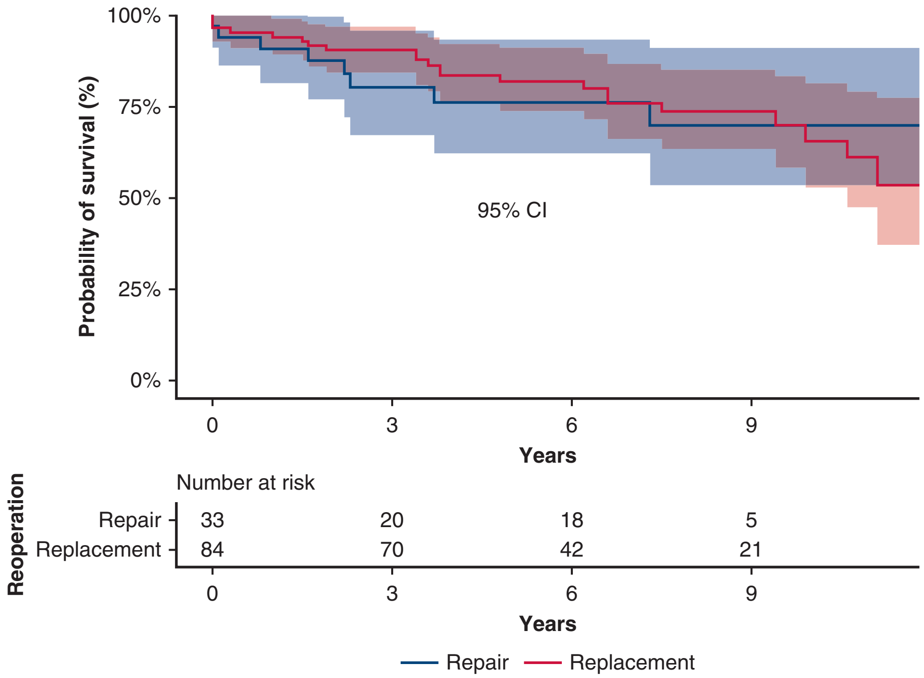

FIGURE 2. Cumulative survival by type of reoperation, replacement versus re-repair (hazard ratio, 0.88; 95% confidence interval, 0.39-1.99).

In-Hospital Mortality

The in-hospital mortality rate was 3.5% for the MVR group and 3.1% for the MVr group (Table E2). An 80-year-old man who underwent tissue MVR developed progressive persistent acidosis as a result of ischemic bowel disease; a computed tomography scan revealed colitis, resulting in subsequent multiorgan failure and death. A 60-year-old man who underwent mitral valve replacement with a size 29 tissue valve experienced right ventricular damage during reopening. Although it was patched, the patient required venoarterial extracorporeal membrane oxygenation (ECMO) and multiple inotropic support postoperatively. He could not be weaned from the support. His right ventricle was exceptionally thin and fragile and tore on gentle retraction from the sternum. A 75-year-old patient who underwent redo MVr with reconstruction of the posterior ventricular wall because of heavy calcification required venoarterial ECMO for support for his failing right ventricle. He was subsequently weaned off the ECMO after 48 hours. One week after the surgery, his right ventricle failed, and recovery was not possible. The fourth patient, an 82-year-old who underwent mitral valve repair with left atrial appendage excision, developed refractory bradycardia with increased vasopressor support postoperatively. Reintubation was required in the face of right heart failure.

Surgical priority and preoperative LVEF each had a borderline association with in-hospital mortality ($P = .06$ and .05, respectively). Cardiopulmonary bypass time showed a significant association with in-hospital mortality (HR, 1.02; 95% CI, 1.00-1.04; $P = .04$); for every 1-minute increase in cardiopulmonary bypass time, there was a 2% increased risk of in-hospital mortality. None of the other variables showed a significant association with in-hospital mortality (Table 4).

In the multivariate analysis for in-hospital mortality, emergency reoperation ($P = .02$), mixed lesion ($P < .001$), infective endocarditis ($P < .001$), and preoperative left ventricular function ($P < .001$) were found to be significantly associated with increased in-hospital mortality (Table 3).

Prolonged Hospital Stay (>10 Days)

Significant differences were found between the 2 groups in mean patient age ($P = .03$), suggesting advanced age as a risk factor for prolonged hospital stay. In this group of patients, no significant differences were found in terms of sex, time from previous mitral valve repair, surgical priority, preoperative LVEF, chronic heart failure, hypertension, hyperlipidemia, COPD, asthma, pulmonary disease, CVA/TIA, tricuspid regurgitation, or preoperative left ventricular internal diameter in diastole (Table 5).

DISCUSSION

Mitral valve repair is the preferred treatment modality for the majority of patients with degenerative mitral valve disease requiring intervention.[3] However, mitral valve repair has an inherent failure rate. The durability of mitral valve repair for degenerative disease is affected by the pathophysiology of mitral regurgitation, with repairs of posterior prolapse showing better results than anterior and bileaflet

TABLE 2. Univariate analysis of variables affecting overall mortality

Variable	Overall mortality		*P* value*	HR	95% CI	*P* value†
	No (N = 87)	Yes (N = 30)				
Baseline characteristics						
Age, y, mean ± SD	62.8 ± 12.5	70.3 ± 11.7	<.01	1.07	1.03-1.12	<.01
Age group, n (%)			.07			.01
21-30 y	1 (1.1)	0 (0)		-	-	-
31-40 y	3 (3.4)	1 (3.3)		1.51	0-iInf	1
41-50 y	12 (13.8)	1 (3.3)		1.38	0-inf	1
51-60 y	19 (21.8)	3 (10.5)		1.46	0-inf	1
61-70 y	26 (29.9)	6 (20.5)		1.48	0-inf	1
71-80 y	20 (23)	15 (50)		1.63	0-inf	1
81-90 y	6 (6.9)	4 (13.3)		1.63	0-inf	1
Sex						
Male	48 (55.2)	18 (60)	.81	-	-	-
Female	39 (44.8)	12 (40)	.81	1.11	0.53-2.32	.8
Time from last MV repair	8.5 ± 10.5	10.8 ± 9.3	.07	1.02	0.99-1.05	.2
Surgical priority			.13			.04
Elective	76 (87.4)	22 (73.3)		-	-	-
Urgent	8 (9.2)	6 (20)		2.33	0.94-5.76	.07
Emergency	3 (3.4)	2 (6.7)		2.59	0.60-11.12	.2
Reoperation type			1.0			
Repair	24 (27.6)	8 (26.7)		-	-	-
Replacement	63 (72.4)	22 (73.3)		0.88	0.39-1.99	.76
Indication for reoperation			.02			
Mitral regurgitation	67 (77.0)	20 (66.7)		-	-	-
Mitral stenosis	11 (12.6)	2 (6.7)		0.67	0.16-2.92	.60
Mixed lesion (MR + MS)	1 (1.1)	3 (10)		4.20	1.23-14.38	.02
Infective endocarditis	0 (0)	2 (6.7)		14.20	3.14-64.29	<.01
Infective endocarditis + MR	6 (6.9)	1 (3.3)		0.70	0.09-5.25	.73
Missing	2 (2.3)	2 (6.7)				
Comorbidities						
Chronic heart failure	16 (18.4)	14 (46.7)	.27	1.44	0.70-3.00	.30
Hypertension	16 (18.4)	14 (46.7)	.88	1.02	0.50-2.10	1.00
Hyperlipidemia	25 (28.7)	12 (40)	.53	1.39	0.67-2.92	.37
COPD	1 (1.1)	3 (10)	.05	6.69	1.95-22.99	.003
Asthma	10 (11.5)	4 (13.3)	.82	1.03	0.36-2.95	.96
Pulmonary disease	15 (17.2)	5 (16.7)	1.0	1.04	0.40-2.72	.94
CVA/TIA	8 (9.2)	6 (20)	.27	2.69	1.08-6.69	.03
Tricuspid regurgitation	50 (57.5)	24 (80)	.10	2.87	0.99-8.31	.05
Preoperative findings						
Preoperative LVEF			.73			
Normal	34 (39.1)	13 (43.3)		-	-	-
Mild	23 (26.4)	10 (33.3)		1.36	0.59-3.12	.47
Moderate	8 (9.2)	2 (6.7)		1.51	0.25-5.21	.86
Severe	4 (4.6)	0 (0)		0.00	0.0-inf	1.00
Hyperdynamic	4 (4.6)	1 (3.3)		1.33	0.17-10.31	.79
Missing	14	4 (13.35)				
Preoperative LVIDD	5.4 ± 0.7	5.3 ± 0.7		0.61	0.18-2.09	.4
Operative data						
CPB time, min, mean ± SD	131.6 ± 27.6	158.0 ± 76.5	.34	1.02	1.00-1.03	.02
Aortic cross-clamp time, min, mean ± SD	94.5 ± 28.3	96.9 ± 36.3	.87	1.01	0.98-1.03	.6

HR, Hazard ratio; *CI*, confidence interval; *MV*, mitral valve; *MR*, mitral regurgitation; *MS*, mitral stenosis; *COPD*, chronic obstructive pulmonary disease; *CVA*, cerebrovascular accident; *TIA*, transient ischemic attack; *LVEF*, left ventricular ejection fraction; *LVIDD*, left ventricular internal diameter in diastole; *CPB*, cardiopulmonary bypass. **P* values derived from the *t* test, Fisher test, and χ^2 test. †*P* values derived from the Cox proportional hazards model.

TABLE 3. Multivariate analysis of variables affecting overall mortality

Variable	Overall mortality		In-hospital mortality	
	HR (95% CI)	*P* value*	HR (95% CI)	*P* value*
Baseline characteristics				
Mean age	1.07 (1.03-1.12)	.001	1.01 (0.92-1.12)	.80
Sex				
Female	-	-	-	
Male	0.95 (0.43-2.01)	.90	0.00 (0-inf)	1.0
Time from last MV repair	1.01 (0.97-1.04)	.69	1.03 (0.92-1.15)	.67
Surgical priority				
Elective	-	-	-	
Urgent	2.27 (0.88-5.81)	.09	4.09 (0.43 -39.3)	.22
Emergency	2.88 (0.65-12.82)	.17	1.55 (1.60-149.05)	.02
Reoperation type				
Repair	-	-	-	
Replacement	0.56 (0.24-1.34)	.20	0.79 (0.08-7.81)	.84
Indication for reoperation				
Mitral regurgitation	-	-	-	
Mitral stenosis	0.32 (0.06-1.63)	.17	0.00 (0-inf)	.99
Mixed lesion (MR + MS)	17.09 (4.06-71.94)	<.001	1.75 (15.83-1925.61)	<.001
Infective endocarditis	992.08 (85.74-11,479.08)	<.001	5.83 (514.81-65,932.99)	<.001
IE + MR	2.45 (0.30-20.26)	.40	0 (0-inf)	.99
Comorbidities				
Chronic heart failure	1.63 (0.76-3.53)	.21	2.75 (0.33-22.78)	.35
Hypertension	1.11 (0.51-2.43)	.79	0.60 (0.08-4.28)	.61
Hyperlipidemia	1.11 (0.51-2.41)	.79	4.42 (0-inf)	.99
COPD	4.3 (1.24-14.97)	.02	0.00 (0-inf)	1.00
Asthma	0.65 (0.21-2.03)	.46	0.00 (0-inf)	.99
Pulmonary disease	1.54 (0.57-4.15)	.40	1.77 (0.18-17.41)	.83
CVA/TIA	2.55 (1.01-6.42)	.05	0.00 (0-inf)	1.00
Tricuspid regurgitation	2.16 (0.72-6.48)	.17	1.50 (0-inf)	.99
Preoperative findings				
Preoperative LVEF				
Normal	-	-	-	
Mild	1.64 (0.67-4.00)	.28	9.65 (8.75-10.65)	<.001
Moderate	1.52 (0.32-7.39)	.60	2.05 (1.86-2.25)	<.001
Severe	7.51 (0.00-inf)	1.00	0.13 (0-inf)	1.0
Hyperdynamic	1.34 (0.16-11.36)	.79	1.43 (1.30-1.58)	<.001
Operative data				
CPB time	1.03 (1.01-1.04)	.003	1.02 (1.00-1.04)	.05
Aortic cross-clamp time	1.01 (0.99-1.04)	.39	0.99 (0.96-1.04)	.96

HR, Hazard ratio; *CI*, confidence interval; *MV*, mitral valve; *MR*, mitral stenosis; *IE*, infective endocarditis; *COPD*, chronic obstructive pulmonary disease; *CVA*, cerebrovascular accident; *TIA*, transient ischemic attack; *LVEF*, left ventricular ejection fraction; *CPB*, cardiopulmonary bypass. **P* values derived from the Cox proportional hazard model.

prolapse repair in most cases.[4] Our study compared replacement and re-repair surgery in patients who had previous mitral valve repair. In our study, the majority of initial mitral valve repairs had been done in other centers by different surgeon. Information regarding indication for initial mitral valve repair was not limited. During the same time period, the index surgeon performed 1147 mitral valve surgeries.

The survival results of the 2007 study by Dumont and colleagues[5] of 188 patients who underwent mitral valve reoperation following an initial repair, were similar to those found in our study. They reported a 10-year survival rate of 62%, which is comparable to the 66.4% found in our study. Also, their in-hospital mortality rate was 4.3% which is comparable to the 3.4% in our study. In their study, all 8 in-hospital deaths occurred in patients who underwent valve replacement; in our study, 3 of the 4 deaths were in replacement patients. Also, Anyanwu and colleagues,[2] in their study of 53 patients who underwent MVr due to nonrheumatic mitral valve disease, reported a 0% in-hospital mortality and good midterm outcomes of valve re-repair. Kilic and colleagues,[6] in their study of 305 patients who underwent reoperation after MVr reported a higher operative

TABLE 4. Analysis of variables affecting in-hospital mortality

Variable	In-hospital mortality No (N = 123)	In-hospital mortality Yes (N = 4)	*P* value*	HR	95% CI	*P* value†
Age, y, mean ± SD	64.6 ± 12.8	67.8 ± 9.7	.76	1.02	0.94-1.11	.63
Sex, n (%)						
Male	62 (50.4)	4 (100)	.13	1.9	0.00-inf	.99
Female	61 (49.6)	0 (0)				
Time from last surgery, y, mean ± SD	9.2 ± 10.3	7.5 ± 8.9	.70	1.01	0.92-1.1	.86
Surgical priority, n (%)			.06			.06
Elective	96 (78.0)	2 (50)		-	-	-
Urgent	13 (10.6)	1 (25)		3.57	0.32-39.37	.29
Emergency	14 (11.4)	1 (25)		10.53	0.95-116.16	.05
Reoperation type, n (%)						
Repair	31 (25.2)	1 (25)		0.89	0.39-1.99	.76
Replacement	82 (74.8)	3 (75)				
Preoperative LVEF, n (%)			.05	10.53	0.95-116.16	.05
Normal	64 (52)	0 (0)		-	-	-
Mild	32 (26.0)	1 (25)		2.82	0-inf	.99
Moderate	9 (7.3)	1 (25)		9.54	0-inf	.99
Severe	4 (3.3)	0 (0)		1.00	0-inf	1.00
Hyperdynamic	4 (3.3)	1 (25)		1.00	0-inf	.99
Missing	0	1 (25)				
Comorbidities, n (%)						
Chronic heart failure	2 (1.6)	2 (50)	.64	1.82	0.26-12.92	.55
Hypertension	2 (1.6)	2 (50)	1.0	1.02	0.14-7.23	.98
Hyperlipidemia	33 (26.8)	4 (100)	.20	1.84	0-inf	.99
COPD	4 (3.3)	0 (0)	1.0	0.00	0-inf	.99
Asthma	14 (11.4)	0 (0)	1.0	0.00	0-inf	.99
Pulmonary disease	19 (15.4)	1 (25)	.56	1.58	0.16-15.17	.69
CVA/TIA	14 (11.4)	0 (0)	1.0	0.00	0-inf	.99
Tricuspid regurgitation	70 (56.9)	4 (50)	.56	0.00	0-inf	.99
Operative data						
CPB time, min, mean ± SD	133.52 ± 34.78	190.67 ± 110.44	<.001	1.02	1.00-1.03	.04
Aortic cross-clamp time, min, mean ± SD	95.03 ± 30.07	97.00 ± 37.0	<.001	1.00	0.96-1.04	.9

HR, Hazard ratio; *CI*, confidence interval; *LVEF*, left ventricular ejection fraction; *COPD*, chronic obstructive pulmonary disease; *CVA*, cerebrovascular accident; *TIA*, transient ischemic attack; *CPB*, cardiopulmonary bypass. **P* values derived from the *t* test, Fisher test, and χ^2 test. †*P* values derived from the Cox proportional hazards model.

mortality rate in patients who underwent MVR compared to those who underwent redo MVr.

Although the rate of in-hospital mortality was higher in patients who received a valve replacement undergoing redo surgery compared to those who received re-repair following an initial repair, the difference was not statistically significant. Factors affecting these outcomes remain to be identified, as in-hospital mortality is more common after redo MVR than after redo MVr. It is likely that in the hands of an experienced mitral valve repair surgeon, this reflects technical difficulty rather than a fault of the new valve.

Numerous studies have explored factors that contribute to the failure of MVrmitral valve repair resulting in the need for reoperation. In our study, systolic anterior motion, valve hemolysis and endocarditis were the predominant factors contributing to the need for repeat surgery. Gillinov and colleagues[7] explored risk factors for late reoperation after MVr, including rheumatic disease, advanced myxomatous changes of both leaflets, prior chordal shortening procedures, failure to place an annuloplasty band or ring, and residual mitral regurgitation at completion of the repair. In our study, posterior leaflet prolapse, retraction or hole (34 patients); stenotic, calcified, or thickened leaflets (24 patients); and anterior mitral leaflet prophase, retraction, or hole (18 patients) were identified as the most common indications for redo surgery. New York Heart Association functional class III or IV and performance of concomitant cardiac procedures were other risk factors for reoperation late after repair.[7] Anyanwu and colleagues[2] reported technical failure as a significant cause of failed mitral valve repairs, accounting for 37% of their cases.

In our study, the presence of mixed lesions and infective endocarditis were found to be associated with higher overall

TABLE 5. Analysis comparing variables affecting prolonged hospital stay

Variable	Prolonged hospital stay (>10 d) (N = 114; 4 missing)		*P* value*
	No (N = 64)	Yes (N = 50)	
Age, y, mean ± SD	62.9 ± 12.7	67.8 ± 11.7	.03
Sex, n (%)			
Male	35 (54.7)	29 (58)	.72
Female	29 (45.3)	21 (42)	
Time from last MVR, y, mean ± SD	9.5 ± 11.8	8.6 ± 8.0	.87
Surgical priority, n (%)			
Elective	54 (84.4)	40 (80)	.50
Urgent	6 (9.4)	8 (16)	
Emergency	3 (4.7)	1 (4)	
Reoperation type, n (%)			.25
Repair	20 (31.3)	10 (20)	
Replacement	44 (68.7)	40 (80)	
Preoperative LVEF, n (%)			
Normal	28 (43.8)	17 (34)	.42
Mild	16 (25)	16 (32)	
Moderate	6 (9.4)	4 (8)	
Severe	2 (3.15)	2 (45)	
Hyperdynamic	1 (1.6)	4 (8)	
Missing	11 (17.2)	7 (14)	
Comorbidities, n (%)			
Chronic heart failure	31 (48.4)	18 (36)	.61
Hypertension	21 (32.8)	28 (56)	.29
Hyperlipidemia	19 (29.7)	17 (34)	.91
COPD	3 (4.7)	1 (2)	.79
Asthma	6 (9.4)	7 (14)	.75
Pulmonary disease	12 (18.8)	7 (14)	.53
CVA/TIA	4 (6.3)	8 (16)	.13
Tricuspid regurgitation	36 (56.3)	35 (70)	.30
Preoperative LVIDD, mean ± SD	5.2 ± 0.8	5.5 ± 0.6	.37
Operative data			
CPB time, min, mean ± SD	141.4 ± 55.8	138.7 ± 38.8	.45
Aortic cross-clamp time, min, mean ± SD	92.3 ± 23.8	98.5 ± 34.3	.47

MVR, Mitral valve replacement; *LVEF*, left ventricular ejection fraction; *COPD*, chronic obstructive pulmonary disease; *CVA*, cerebrovascular accident; *TIA*, transient ischemic attack; *LVIDD*, left ventricular internal diameter in diastole; *CPB*, cardiopulmonary bypass. **P* values derived from the *t* test, Fisher test, and χ^2 test.

mortality. In patients with endocarditis, although there was a difference in overall mortality between the MVr and MBR groups, this difference was not statistically significant ($P = .08$). There was a statistically significant difference in in-hospital mortality between re-repair and replacement group with endocarditis ($P < .001$). In the literature, an initial mitral repair in patients with endocarditis was associated with lower mortality and reoperation rates. For success, all infected tissue must be removed. The presence of mixed stenotic and regurgitant lesions and extensive infective endocarditis are most likely to render repair inappropriate.

Other factors that we found to adversely affect outcomes were increased age, previous transient ischemic attack/stroke, tricuspid regurgitation, chronic obstructive pulmonary disease, and prolonged bypass time. This is similar to the study by Kilic and colleagues,[6] who also identified older age, chronic lung disease, and long cardiopulmonary bypass time as predictors of overall mortality. They also found that diabetes mellitus, chronic kidney disease, peripheral arterial disease, nonelective status, and concomitant coronary artery bypass grafting were predictive of increased overall mortality.[6]

We analyzed the factors associated with in-hospital mortality and prolonged hospital stay after a previous MVr for degenerative disease. We found that advanced age was a major contributor to prolonged hospital stay and in-hospital mortality. This was contrary to the results of a study from the Society of Thoracic Surgeons database examining risk factors for prolonged hospital stay in patients who had undergone redo mitral valve surgery showing that advanced age did not contribute significantly to prolonged hospital stay (odds ratio, 0.99; 95% CI, 0.98-1.00; $P = .07$).[8] Similar

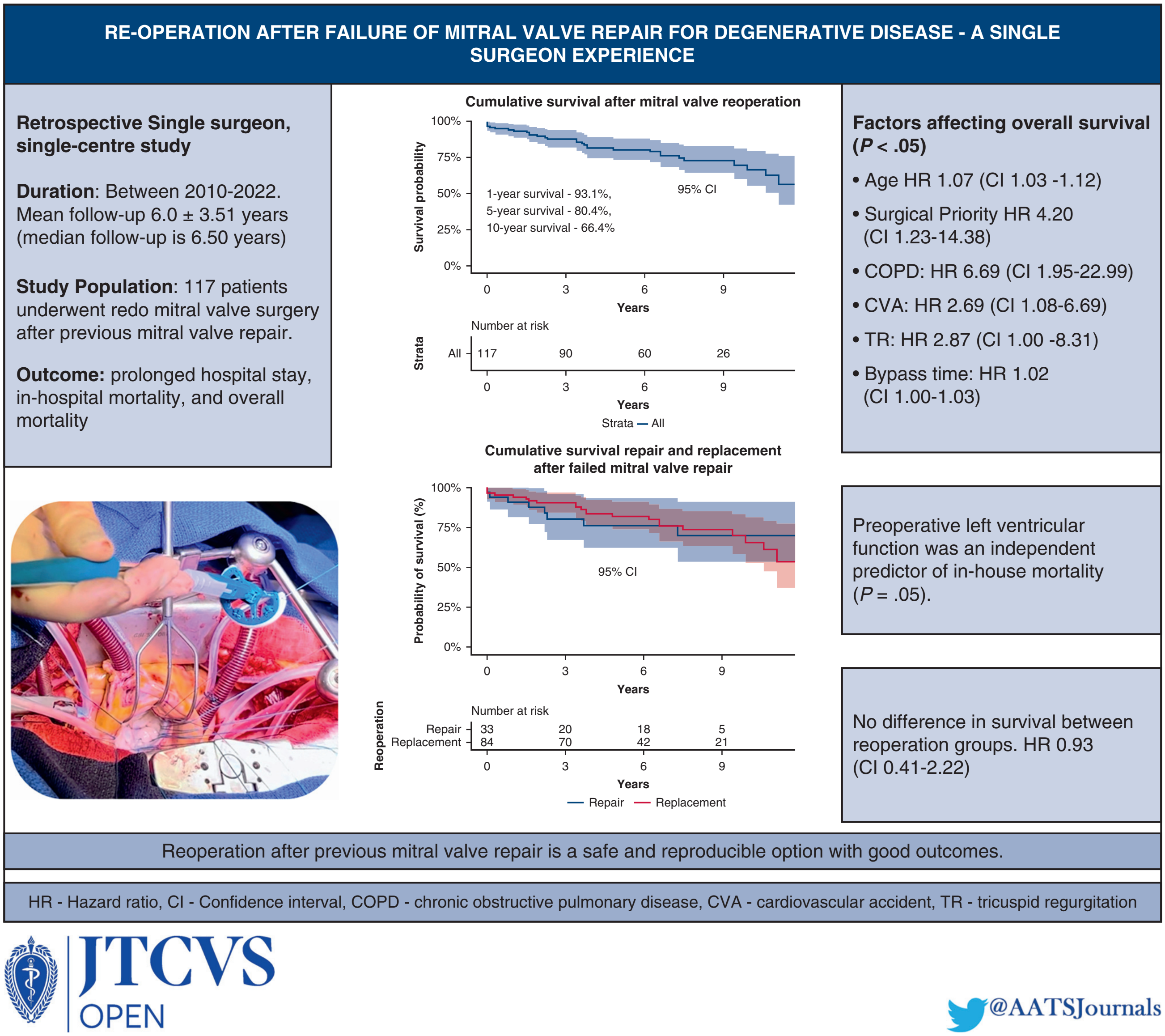

FIGURE 3. Summary: We examined 117 patients who had reoperations after previous mitral valve repair (2010-2022). It aimed to identify factors affecting outcomes, including survival, prolonged hospital stay, and in-hospital mortality, with an average follow-up of 9 years. Advanced age, emergency reoperation, mixed lesions, infective endocarditis, and chronic obstructive pulmonary disease were identified as significant risk factors for mortality. *CI*, Confidence interval; *HR*, hazard ratio; *COPD*, chronic obstructive pulmonary disease; *CVA*, cerebrovascular accident; *TR*, tricuspid regurgitation.

to our results, that study also reported that urgent/emergent status and severe tricuspid insufficiency resulted in significantly prolonged hospitalization. Important factors associated with prolonged hospital stay include cardiogenic shock and the need for a preoperative intra-aortic balloon pump.[8] Gender was not found to be significantly associated with in-hospital mortality and prolonged hospital stay.

Mitral valve replacement and re-repair are both acceptable treatment options in cases of failed MVr.[6] Data from a study by Chikwe and colleagues[9] support the concept of referral to experienced mitral surgeons to improve outcomes in patients with degenerative mitral valve disease. The authors concluded that the number of surgeries performed by a surgeon is a factor affecting both the rate of successful MVr, as well as the likelihood of reoperation and survival.[9] Although some studies have reported that MVr is associated with superior survival, decreased risk of thromboembolism, and better preservation of left ventricular function compared to MVR,[10] this evidence is based on first/initial mitral surgery. When it comes to redo mitral surgery for failure of MVr, both re-repair and replacement are useful alternatives. In our study we have shown that although re-repair may be the best option for most patients, it might not be suitable for everyone, and the treatment strategy needs to be tailored for each individual patient.

CONCLUSIONS

MVr is the treatment of choice for mitral regurgitation. However, if repair fails and mitral valve reoperation is necessary, the results and survival rate depend on several factors. In our study, we found that reoperation after previous MVr is safe and reproducible option with good outcomes (Figure 3). Redo MVr should be attempted when feasible, keeping in mind that the treatment options need to be tailored according to individual patient requirements, and both MVR and re-MVr surgery had good long-term survival.

Webcast

You can watch a Webcast of this AATS meeting presentation by going to: https://www.aats.org/resources/reoperation-after-failure-of-mitral-valve-repair-for-degenerative-disease-a-single-surgeon-experience.

Conflict of Interest Statement

The authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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Key Words: mitral valve repair, reoperation, survival, risk factors

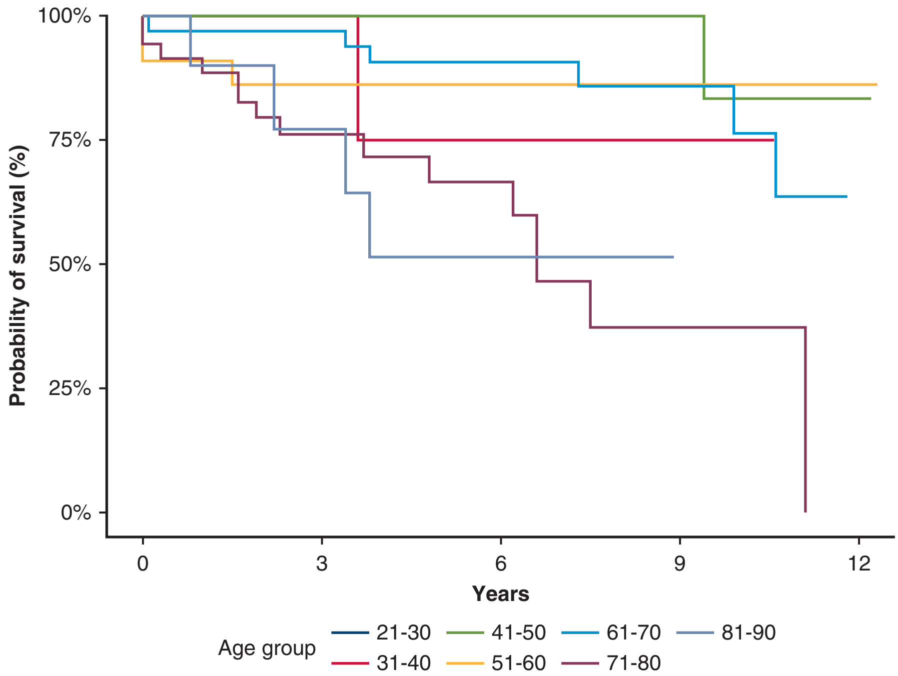

FIGURE E1. Kaplan-Meier survival curve by age group. Age 21-30 years: 5-year survival, 100% (95% confidence interval (*CI*), 100%-100%); age 31-40 years: 10-year survival, 75% (95% CI, 42.6%-100%); age 41-50 years: 10-year survival, 83.3% (95% CI, 58.3%-100%); age 51-60 years: 10-year survival, 86.1% (95% CI, 72.7%-100%); age 61-70 years, 10-year survival, 76.3% (95% CI, 57.8%-100%); age 71-80 years: 10-year survival, 37.2% (95% CI, 19.3%-71.6%).

TABLE E1. Operative data

Parameter	MVR group (N = 85)	Re-MVr group (N = 32)	Total (N = 117)	*P* value*
Surgical priority, n (%)				1.00
Elective	71 (83.5)	27 (84.4)	98 (83.8)	
Urgent	10 (11.8)	4 (12.5)	14 (12.0)	
Emergency	4 (4.7)	1 (3.1)	5 (4.3)	
Type of procedure				
MVR			85 (72.6)	
Tissue, n (%)	67 (78.8)		67 (57.3)	
Mechanical, n (%)	18 (21.2)		18 (15.4)	
Size of replacement, mm, mean ± SD	29 ± 2.1		29 ± 2.1	
Re-MVr		32 (27.4)	32 (27.4)	
Band size of repair, mm, mean ± SD		32 ± 2.7	32 ± 2.7	
Concomitant procedures, n (%)				.56
Tricuspid valve repair/replacement	6 (7.1)	4 (12.5)	10 (8.5)	
Maze procedure	1 (1.2)	0	1 (0.9)	
Left atrial appendage excision	1 (1.2)	1 (3.1)	2 (1.7)	
Aortic valve repair/replacement	11 (12.9)	5 (15.6)	16 (13.7)	
CABG	3 (3.5)	1 (3.1)	4 (3.4)	
CPB time, min, mean ± SD	133.2 ± 34.4	159.3 ± 79.4	138 ± 45.9	.41
Cross-clamp time, min, mean ± SD	94.4 ± 31.8	98.7 ± 22.5	95.2 ± 30.1	.71

MVR, Mitral valve replacement; *MVr*, mitral valve repair; *CABG*, coronary artery bypass grafting; *CPB*, cardiopulmonary bypass. **P* values derived from the *t* test, Fisher test, and χ^2 test.

TABLE E2. Postoperative outcomes

Outcome	MVR group (N = 85)	Re-MVr group (N = 32)	*P* value*
Postoperative echocardiographic findings			
LVEF			.85
Normal	47 (55.3)	18 (56.3)	
Mild	22 (25.9)	11 (34.3)	
Moderate	9 (10.6)	1 (3.1)	
Severe	3 (3.5)	1 (3.1)	
Hyperdynamic	4 (4.7)	1 (3.1)	
Mitral valve function			.65
Normal	65 (76.5)	19 (59.4)	
Trace	8 (9.4)	6 (18.8)	
Mild	9 (10.6)	6 (18.8)	
Moderate	3 (3.5)	1 (3.1)	
Total hospital stay, d, mean SD	13.8 ± 10.4	12.7 ± 7.8	.56
Postoperative hospital stay, d, mean SD	11.4 ± 6.2	10.1 ± 6.1	.36
In-hospital mortality, n (%)	3 (3.5)	1 (3.1)	1.00
Overall mortality, n (%)	22 (25.9)	8 (25)	.99

MVR, Mitral valve replacement; *MVr*, mitral valve repair; *LVEF*, left ventricular ejection fraction. **P* values derived from the *t* test, Fisher test, and χ^2 test.