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Long-term outcomes of mitral valve annuloplasty versus subvalvular sparing replacement for severe ischemic mitral regurgitation

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Abstract

Background: *Although practice guidelines recommend surgery for patients with severe chronic ischemic mitral regurgitation (CIMR), they do not specify whether to repair or replace the mitral valve. The purpose of this study was to evaluate the long-term outcomes in patients with severe CIMR undergoing mitral valve annuloplasty (MVA) versus subvalvular sparing mitral valve replacement (MVR).*

Methods: *392 consecutive patients who underwent MVA or subvalvular sparing MVR for treatment of severe CIMR were retrospectively reviewed.*

Results: *After adjustment for baseline differences with multivariable regression analysis at 53 months follow-up (interquartile range, 34–81 months), there was no significant difference between the two groups for risk of major adverse cardiac or cerebrovascular events (MACCE), cardiac death, or all-cause death. Propensity score matching extracted 77 pairs. During the follow-up, compared with the MVR group, both the left atrium and left ventricle end-diastolic diameter were markedly larger ($p = 0.013$ and $p = 0.033$, respectively), and the incidence of mitral regurgitation recurrence was significantly higher in the MVA group ($p < 0.001$). No significant difference was observed between the two propensity score-matched groups in composite in-hospital outcomes, overall survival, freedom from cardiac death or MACCE, except subvalvular sparing MVR was associated with a lower incidence of hospitalization for heart failure than MVA ($p = 0.015$).*

Conclusions: *Subvalvular sparing MVR is a suitable management of patients with severe CIMR, it is more favorable to ventricular remodeling and is associated with a lower incidence of hospitalization for heart failure than MVA.* (Cardiol J 2019; 26, 3: 265–274)

Key words: chronic ischemic mitral regurgitation, mitral valve annuloplast, subvalvular sparing mitral valve replacement, coronary artery bypass grafting

Introduction

Chronic ischemic mitral regurgitation (CIMR) is common and is associated with worse long-term survival and functional status [1]. It is generally agreed that severe mitral regurgitation (MR) requires mitral valve intervention, but the optimal management of patients with severe CIMR, specifically the choice between mitral valve annuloplasty (MVA) and mitral valve replacement (MVR), has long been debated [2–5]. To date, there are no prospective randomized trials evaluating

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the long-term outcomes of MVA versus MVR for severe CIMR, while published series have provided a wide range of results for long-term outcomes. Considering the different conclusions which might have been derived from heterogeneity of patient cohorts and methods of treatment, the present study is a long-term design and propensity score (PS) matched analysis to evaluate the effectiveness of MVA versus sub-valvular sparing MVR for severe CIMR.

Methods

Patients and study design

This study was approved by the Human Research Ethics Committee of the Fuwai Hospital and was performed in accordance with the Declaration of Helsinki and approved guidelines. CIMR was defined by coronary angiographic and echocardiographic findings according to accepted criteria, i.e., 1) MR occurring more than 16 days after myocardial infarction; 2) type I/IIIb leaflet dysfunction following Carpentier's classification; and 3) 70% or greater stenosis of at least one coronary artery, with wall motion abnormalities of the corresponding left ventricular (LV) segment [3].

Between January 2003 and December 2014, a total of 1040 patients with CIMR were hospitalized to undergo coronary artery bypass grafting (CABG) combined with MVA or MVR. From the initial cohort, 642 patients were excluded for various reasons [3], i.e., 1) Preoperative MR ≤ 2+, congenital valvular heart disease, rheumatic or degenerative valvular disease, infective endocarditis, presence of aortic valve regurgitation or stenosis, emergency surgery, repeat operation; or 2) Performance of other procedures, such as LV reconstruction/reshaping, partial band/pericardial annuloplasty, or procedures other than mitral ring annuloplasty for treatment. Moreover, the patients who underwent MVR without preserving the subvalvular apparatus were excluded. In addition, 6 were lost to follow-up. Thus, the final study cohort comprised 392 patients: 306 (78.1%) patients underwent MVA whereas 86 (21.9%) underwent subvalvular sparing MVR.

Baseline patient characteristics, echocardiography data, operative data, and surgical techniques were collected from the division of cardiovascular surgery database and individual medical records. Patients were followed up through the internet or by telephone interview and outpatient department records.

Surgical technique

All surgical procedures were performed with standard bypass techniques through median sternotomy by senior surgeons with a special interest in mitral valve surgery. The decision to perform MVA or subvalvular sparing MVR was at the surgeon's discretion. Downsizing ring annuloplasty (2 sizes) was used in all patients subjected to MVA. The ring size was determined by measurements of the intertrigonal distance and anterior leaflet height. Intraoperative transesophageal echocardiography was routinely used. A successful MVA was defined as a leaflet coaptation of ≥ 0.8 cm and MR ≤ 1 at transesophageal echocardiography performed at the end of cardiopulmonary bypass [3, 6]. Subvalvular apparatus were preserved when performing MVR, including posterior leaflet preservation, posterior and partial anterior leaflet preservation and both leaflet preservation. The decision to perform which kind of procedure was at the surgeon's discretion according to situational conditions. The posterior mitral valve leaflet was left intact in all patients undergoing MVR. In 8 of patients undergoing MVR, the middle portion of the anterior leaflet was resected and the remaining leaflet tissue was plicated with individual valve sutures. In 23 patients undergoing MVR, the anterior leaflet of the valve was partly or completely detached from the mitral annulus and divided in the middle at the 12 o'clock position, and the leftward portion of the anterior leaftlet was plicated to the anterolateral commissure with a pledgetted 4–0 polypropylene suture. The rightward a portion of the anterior mitral leaflet was similarly plicated to the posteromedial commissure. Complete revascularization was achieved in all patients with arterial conduits or saphenous vein grafts. All patients received the same perioperative care and medical therapy according to guidelines.

Echocardiography

Two-dimensional and Doppler transthoracic echocardiography examinations were performed before operations and at pre-discharge for all patients. MR was classified as mild (grade 1+), moderate (grade 2+), or severe (grades 3+ and 4+) [7]. LV inferior basal wall motion abnormality (BWMA) includes hypokinesia, dyskinesis and aneurysm. Echocardiographic criteria for aneurysm were evidence of thinning and localized LV dilation or distortion. Dyskinesis was the presence of outward displacement of the LV wall during systole [8, 9].

Statistical analysis

All statistical analyses were performed by SPSS version 20 (IBM SPSS Inc., Chicago, IL), SAS software version 9.2 (SAS Institute) and Graph Pad Prism release 5 (Graph Pad Software Inc., La Jolla, Calif) statistical packages. All reported p values are two sided, and values of $p < 0.05$ were considered to indicate statistical significance. Continuous data are shown as mean ± standard deviation. The Student t test was used to measure the differences for variables with a normal distribution and equal variances. The Wilcoxon rank sum test was used for non-normally distributed variables. Categorical data are displayed as frequencies and percentages and comparisons were made with χ^2 tests (Fisher exact tests if appropriate). A stepwise multivariable Cox proportional hazards model was developed to determine the independent risk factors. Variables with a p value less than 0.10 in the univariate analyses were entered into multivariable models. Differences in risk-adjusted, long-term rates of study outcomes among patients who underwent different surgical procedures were assessed by the use of multivariable Cox proportional hazards regression with adjustment for all patient-level variables in Table 1. Cumulative event rates were calculated using a Kaplan-Meier method, and different event curves of outcomes were compared using a log-rank test.

To reduce the impact of treatment selection bias and potential confounding in the observational study, rigorous adjustment for baseline differences by use of propensity score matching was performed [10]. A PS representing the probability of having subvalvular sparing MVR as opposed to MVA was calculated for each patient by using a non-parsimonious multivariable logistic regression model. Variables used in the model are shown in Table 1. Pairs of patients with MVA and sub-valvular sparing MVR were matched using calipers of width 0.2 standard deviations of logit of the PS [11]. Model discrimination was assessed with C statistics, and model calibration was assessed with Hosmer-Lemeshow statistics. Finally, 77 pairs of patients were matched to obtain risk-adjusted outcome comparisons between the two groups.

Results

Patient characteristics

The demographic, clinical and procedural data of patients who underwent MVA and subvalvular sparing MVR before and after PS matching are illustrated in Table 1. Before matching, patients who underwent subvalvular sparing MVR were older, with a worse mitral regurgitation grade and better left ventricular ejection fraction (EF).

Three kinds of complete symmetric rings were used in the present study, with the median size of 28 mm (interquartile range, 28–29 mm): Duran Ancore (Medtronic, Santa Ana, CA), Carpentier-Edwards Physio ring I (Edwards Lifesciences, Irvine, CA), Carpentier-Edwards Physio ring II (Edwards Lifesciences, Irvine, CA). There were seven types of prosthetic valves, with a median size of 27 mm (interquartile range, 27–29 mm). The rate of bioprosthesis was 46.5% (40/86). Three types of bioprostheses were used (n = 40): Mosaic (Medtronic, Santa Ana, CA), Carpentier-Edwards Perimount (Edwards Lifesciences, Irvine, CA) and Hancock II (Medtronic, Santa Ana, CA). Four types of mechanical valves were used (n = 46): Medtronic Open Pivot (Medtronic, Minneapolis, MN), On-X valve (On-X Life Technology, Austin, TX), CarboMedics Mechanical (Sorin-CarboMedics Inc, Italia, S.r.l) and St. Jude valve (St. Jude Medical, Minneapolis, MN). Subvalvular apparatus were preserved when performing MVR, with posterior leaflet preservation in 55 (64.0%) patients, posterior and partial anterior leaflet preservation in 8 (9.3%) patients, and both leaflets preservation in 23 (26.7%) patients.

Follow-up and outcomes

The clinical follow-up was closed on January 1, 2017. The median follow-up was 53 months (interquartile range, 34–81 months) with a completion rate of 98.5% (392/398) in the overall cohort. During follow-up, 62 (15.8%) patients died, of whom 53 (13.5%) died of a cardiac cause. The overall survival rates at 5 and 10 years were 86.6% and 52.9%, respectively. Freedom from cardiac death at 5 and 10 years were 88.1% and 63.9%, respectively.

After adjustment for baseline differences with Cox proportional hazard model analysis, there was no significant difference between MVA and subvalvular sparing MVR in risks of major adverse cardiac or cerebrovascular events (MACCE: cardiac death, repeat revascularization and myocardial infarction, stroke, subsequent mitral valve surgery, or hospitalization for heart failure), cardiac death, or overall death (for MACCE: $p = 0.063$; for cardiac death: $p = 0.549$; and for overall death: $p = 0.759$) (Table 2).

Risk factor analysis

Multivariable analysis showed that age and preoperative EF were independent predictors of overall death (for age: hazard ratio [HR], 1.03; 95%

Table 1. Baseline demographic and clinical characteristics of patients depending on surgical proced ure.

	Overall patient			Pairs matched by PS			Standardized difference
	MVA (n = 306)	MVR (n = 86)	P	MVA (n = 77)	MVR (n = 77)	P	
Age [years]	59.27 ± 8.46	62.05 ± 9.18	0.009	61.81 ± 7.64	61.64 ± 9.05	0.901	–0.018
Sex (male)*	248 (81.0%)	65 (75.6%)	0.264	64 (83.1%)	61 (79.2%)	0.536	–0.028
Body surface area [m^2]*	1.79 ± 0.18	1.75 ± 0.17	0.079	1.79 ± 0.16	1.76 ± 0.17	0.316	–0.166
Diabetes*	73 (23.9%)	16 (18.6%)	0.304	19 (24.7%)	15 (19.5%)	0.437	–0.133
Hypertension*	159 (52.0%)	45 (52.3%)	0.952	45 (58.4%)	40 (51.9%)	0.418	–0.129
Hyperlipidemia*	124 (40.5%)	36 (41.9%)	0.824	29 (37.7%)	32 (41.6%)	0.621	0.025
COPD*	21 (6.9%)	6 (7.0%)	0.971	6 (7.8%)	3 (3.9%)	0.298	–0.142
History of PCI*	39 (12.7%)	11 (12.8%)	0.991	6 (7.8%)	10 (13.0%)	0.291	0.155
History of heart failure*	162 (52.9%)	46 (53.5%)	0.928	45 (58.4%)	41 (53.2%)	0.516	–0.144
History of stroke*	28 (9.2%)	10 (11.6%)	0.493	8 (10.4%)	10 (13.0%)	0.616	0.015
Ventricular arrhythmia*	17 (5.6%)	4 (4.7%)	0.742	5 (6.5%)	4 (5.2%)	0.731	–
Atrial fibrillation*	38 (12.4%)	7 (8.1%)	0.271	13 (16.9%)	6 (7.8%)	0.086	–0.190
LV aneurysm*	33 (10.8%)	3 (3.5%)	0.038	4 (5.2%)	3 (3.9%)	0.698	–0.034
Unstable angina*	58 (19.0%)	13 (15.1%)	0.414	16 (20.8%)	12 (15.6%)	0.403	–0.144
NYHA functional class (I–IV)*	2.59 ± 0.60	2.60 ± 0.64	0.824	2.60 ± 0.54	2.60 ± 0.63	> 0.999	–0.001
Left main CAD*	60 (19.6%)	12 (14.0%)	0.232	17 (22.1%)	10 (13.0%)	0.138	–0.177
EF [%]*	51.45 ± 11.96	55.87 ± 10.13	0.001	54.42 ± 11.42	55.22 ± 9.87	0.640	0.080
LVEDD [mm]*	58.82 ± 6.57	58.38 ± 6.24	0.580	59.30 ± 6.25	58.51 ± 6.11	0.427	–0.127
LA [mm]*	43.24 ± 6.01	43.95 ± 7.46	0.359	44.48 ± 6.54	43.68 ± 7.53	0.480	–0.108
Grade of MR:*			< 0.001			0.684	–0.059
3+	279 (91.2%)	64 (74.4%)		61 (79.2%)	63 (81.8%)		
4+	27 (8.8%%)	22 (25.6%)		16 (20.8%%)	14 (18.2%%)		
Pulmonary hypertension*	29 (9.5%)	18 (20.9%)	0.004	9 (11.7%)	15 (19.5%)	0.183	–
BWMA*	176 (57.5%)	49 (57.0%)	0.929	42 (54.5%)	44 (57.1%)	0.746	0.052
CABG:							
LIMA*	261 (85.3%)	70 (81.4%)	0.378	65 (84.4%)	62 (80.5%)	0.525	–0.095
Radial artery*	2 (0.7%)	2 (2.3%)	0.216	0 (0.0%)	2 (2.6%)		
Grafts/patient*	2.63 ± 0.84	2.57 ± 0.68	0.464	2.69 ± 0.89	2.57 ± 0.68	0.361	–0.172
Distal anastomoses/patient*	3.12 ± 1.12	2.93 ± 1.00	0.146	3.01 ± 1.12	2.95 ± 1.01	0.706	–0.065

→

Table 1. (cont.). Baseline demographic and clinical characteristics of patients depending on surgical proced ure.

	Overall patient			Pairs matched by PS			Standardized difference
	MVA (n = 306)	MVR (n = 86)	P	MVA (n = 77)	MVR (n = 77)	P	
Distal anastomoses:			0.381			0.987	
LAD	283 (92.5%)	71 (82.6%)		70 (90.9%)	65 (84.4%)		
Diagonal	143 (46.7%)	29 (33.7%)		33 (42.9%)	28 (36.4%)		
LCx system	270 (88.2%)	72 (83.7%)		62 (80.5%)	64 (83.1%)		
Intermediate	26 (8.5%)	12 (14.0%)		8 (10.4%)	9 (11.7%)		
RCA	53 (17.3%)	14 (16.3%)		12 (15.6%)	12 (15.6%)		
PDA	167 (54.6%)	51 (59.3%)		48 (62.3%)	49 (63.6%)		
Concomitant procedure:							
Tricuspid annuloplasty*	24 (7.8%)	19 (22.1%)	< 0.001	13 (16.9%)	17 (22.1%)	0.416	0.124
Modified maze procedure	2 (0.6%)	0 (0.0%)	–	0 (0.0%)	0 (0.0%)	–	
ACC time	103 (85–125%)	113 (88–134%)	0.041	106 (85–123%)	115 (87–135%)	0.111	–
CPB time	146 (123–181%)	166 (126–187%)	0.063	144 (124–182%	167 (129–187%)	0.227	–
Postoperative IABP	18 (5.9%)	4 (4.7%)	0.654	3 (3.9%)	3 (3.9%)	> 0.999	–
Duration of intubation [h]; median (IQR)	21 (15–30)	22 (16–38)	0.119	19 (15–30)	21 (16–37%)	0.190	–
Duration of ICU [h]; median (IQR)	70 (41–93)	84 (43–114)	0.081	69 (41–90)	83 (43–112%)	0.159	–

*Indicates variables entered into logistic regression for propensity score matching; PS — propensity score; MVA — mitral valve annuloplasty; MVR — mitral valve replacement; COPD — chronic obstructive pulmonary disease; PCI — percutaneous coronary intervention; LV — left ventricular; NYHA — New York Heart Association functional class; CAD — coronary artery disease; EF — left ventricular ejection fraction; LVEDD — left ventricular end-diastolic dimension; LA — left atrial dimension; MR — mitral regurgitation; BWMA — left ventricular inferior basal wall motion abnormality; CABG — coronary artery bypass graft; LIMA — left internal mammary artery; LAD — left anterior descending coronary artery; LCx — left circumflex coronary artery; RCA — right coronary artery; PDA — posterior descending artery; ACC — aortic cross-clamp; CPB — cardiopulmonary bypass; IABP — intra-aortic balloon pump; IQR — interquartile range; ICU — intensive care unit

Table 2. Long-term outcomes according to different surgical procedures in the overall population.

	MVA	MVR	Adjusted HR[#] (95% CI)	P
All patients	306	86		
Cardiac death	41 (13.4%)	12 (14.0%)	1.25 (0.60–2.62)	0.549
Overall death	50 (16.3%)	12 (14.0%)	0.90 (0.44–1.82)	0.759
MACCE	82 (26.8%)	14 (16.3%)	0.55 (0.29–1.03)	0.063

[#]Multivariable Cox proportional hazard analysis was used with adjustment for all patient-level variables (Indicated by*) in Table 1. The HRs were reported for MVA with MVR as reference; HR — hazard ratio; CI — confidence interval; MACCE — major adverse cardiac and cerebrovascular event; MVA — mitral valve annuloplasty; MVR — mitral valve replacement.

Table 3. Cox proportional hazard analysis for overall death and major adverse cardiac and cerebrovascular event (MACCE) at long-term follow-up.

Predictors	Univariable		Multivariable	
	P	HR (95% CI)	P	HR (95% CI)
Predictors of overall death:				
Surgical procedures*	0.895	0.96 (0.51–1.80)	0.997	
Age	0.032	1.03 (1.01–1.07)	0.030	1.03 (1.01–1.07)
EF	< 0.001	0.96 (0.94–0.98)	< 0.001	0.96 (0.94–0.98)
Grafts/patient	0.045	1.41 (1.01–1.96)	0.243	
Anastomoses/patient	0.083	1.24 (0.97–1.57)	0.351	
Predictors of MACCE:				
Surgical procedures*	0.119	0.64 (0.36–1.12)	0.260	
Age	0.031	1.03 (1.00–1.05)	0.055	
History of heart failure	0.010	1.72 (1.14–2.60)	0.337	
Ventricular arrhythmia	0.028	2.17 (1.09–4.31)	0.064	
EF	< 0.001	0.95 (0.94–0.97)	< 0.001	0.96 (0.94–0.97)
BWMA	0.004	1.88 (1.23–2.87)	0.357	
Left ventricular aneurysm	0.066	1.77 (0.96–3.25)	0.823	
Grafts/patient	<0.001	1.66 (1.25–2.20)	0.012	1.48 (1.11–1.97)
Anastomoses/patient	0.004	1.33 (1.10–1.61)	0.875	

*Indicates mitral valve annuloplasty or replacement; HR — hazard ratio; CI — confdence interval; EF — left ventricular ejection fraction; BWMA — left ventricular inferior basal wall motion abnormality

confidence interval [CI] 1.01–1.07, p = 0.030; and for EF: HR 0.96; 95% CI 0.94–0.98, p < 0.001), while the number of grafts and preoperative EF were independent predictors of MACCE (for the number of grafts: HR 1.48; 95% CI 1.11–1.97, p = 0.012; and for EF: HR 0.96; 95% CI 0.94–0.97, p < 0.001). Of note, the choice of MVA or subvalvular sparing MVR was not a significant predictor of late overall death or MACCE (p = 0.997 and p = 0.260, respectively) (Table 3).

Results of propensity score matching analysis

After PS matching, 77 pairs were extracted by 1:1 manner using nearest neighbor matching without replacement. Late deaths occurred in 29 patients, including 26 cardiac deaths. The 5- and 10-year overall survival rates were 80.9% and 55.8%, respectively. The 5- and 10-year freedom from cardiac death rates were 82.5% and 62.1%, respectively. There were no differences in preoperative and operative characteristics between the PS-matched patients (Table 1). The incidences of composite in-hospital outcomes (stroke, reoperation for bleeding, application of intra-aortic balloon pump and acute renal failure) were similar between the two PS-matched groups (Table 4). During follow-up, compared with the MVR group, both the left atrium and left ventricle end-diastolic diameter were markedly larger (p = 0.013 and p = 0.033, respectively), and the incidence of MR

Table 4. Early clinical outcomes of propensity score-matched patients.

Variables	MVA (n = 77)	MVR (n = 77)	P
Composite in-hospital outcome	9	15	0.183
In-hospital mortality	1 (1.3%)	2 (2.6%)	0.556
Complications:	8 (10.4%)	13 (16.9%)	0.240
Stroke	0 (0%)	0 (0%)	–
Reoperation for bleeding	1 (1.3%)	3 (3.9%)	0.300
Postoperative IABP	3 (3.9%)	3 (3.9%)	> 0.999
Respiratory complication	3 (2.5%)	5 (7.4%)	0.138
Acute renal failure	1 (1.3%)	2 (2.6%)	0.556

MVA — mitral valve annuloplasty; MVR — mitral valve replacement; IABP — intra-aortic balloon pump

Table 5. Perioperative and follow-up echocardiographic results of propensity score-matched patients.

Variables	MVA (n = 77)			MVR (n = 77)		
	Preoperative	Postoperative	Follow-up	Preoperative	Postoperative	Follow-up
EF [%]	54.42 ± 11.42	52.81 ± 8.68	52.29 ± 8.23	55.22 ± 9.87	52.62 ± 8.62	51.95 ± 9.58
LVEDD mid-ventricle [mm]	59.30 ± 6.25	51.02 ± 6.61	55.91 ± 5.23	58.51 ± 6.11	51.32 ± 8.25	53.75 ± 6.99*
LA [mm]	44.48 ± 6.54	38.32 ± 4.76	45.34 ± 5.82	43.68 ± 7.53	39.34 ± 7.66	42.76 ± 6.25*
Mitral regurgitation:	–	–	41 (53.25%)	–		2 (2.60%)*
Moderate	–	–	32 (41.56%)	–		2 (2.60%)
Severe	–	–	9 (11.69%)	–		0 (0%)
Periprosthetic leak	–	–	–	–		1 (1.30%)

*p < 0.05 vs. MVA; MVA — mitral valve annuloplasty; MVR — mitral valve replacement; EF — left ventricular ejection fraction; LVEDD — left ventricular end-diastolic dimension; LA — left atrial dimension

recurrence was significantly higher in the MVA group ($p < 0.001$) (Table 5). There were no significant differences in overall survival, freedom from cardiac death or MACCE between the two groups (all $p > 0.05$), except for a higher incidence of hospitalization for heart failure in the PS-matched MVA group than in the subvalvular sparing MVR group ($p = 0.015$) (Fig. 1).

Discussion

According to practice guidelines, both MVA and MVR are recommended treatments for correction of severe ischemic MR [12]. However, an optimal surgical approach to treatment of severe ischemic MR remains controversial. Clinical studies have suggested that repair is associated with lower perioperative morbidity and mortality but has a higher risk of recurrence, which confers with a predisposition to atrial fibrillation, heart failure, and readmission, whereas replacement provides higher perioperative mortality but better long-term correction with a lower risk of recurrence [13–15]. When MVR is required, chordal sparing is the preferred technique. Okita et al. [16] and David et al. [17] reported that the subvalvular apparatus preservation results in improved LV function and enhanced survival. Preservation of the mitral subvalvular apparatus led to better postoperative LV function and survival than those after apparatus removal.

In the present study, no difference was observed in the incidences of early mortality or postoperative complications between the two PS-matched groups. Published literature provides a wide range of results in terms of early outcomes. Several recent experiences found no significant difference between the two surgical managements, this is in accordance with the present observations [2, 18], whereas several studies showed that mitral valve repair is associated with lower operative mortality and postoperative complications [19, 20].

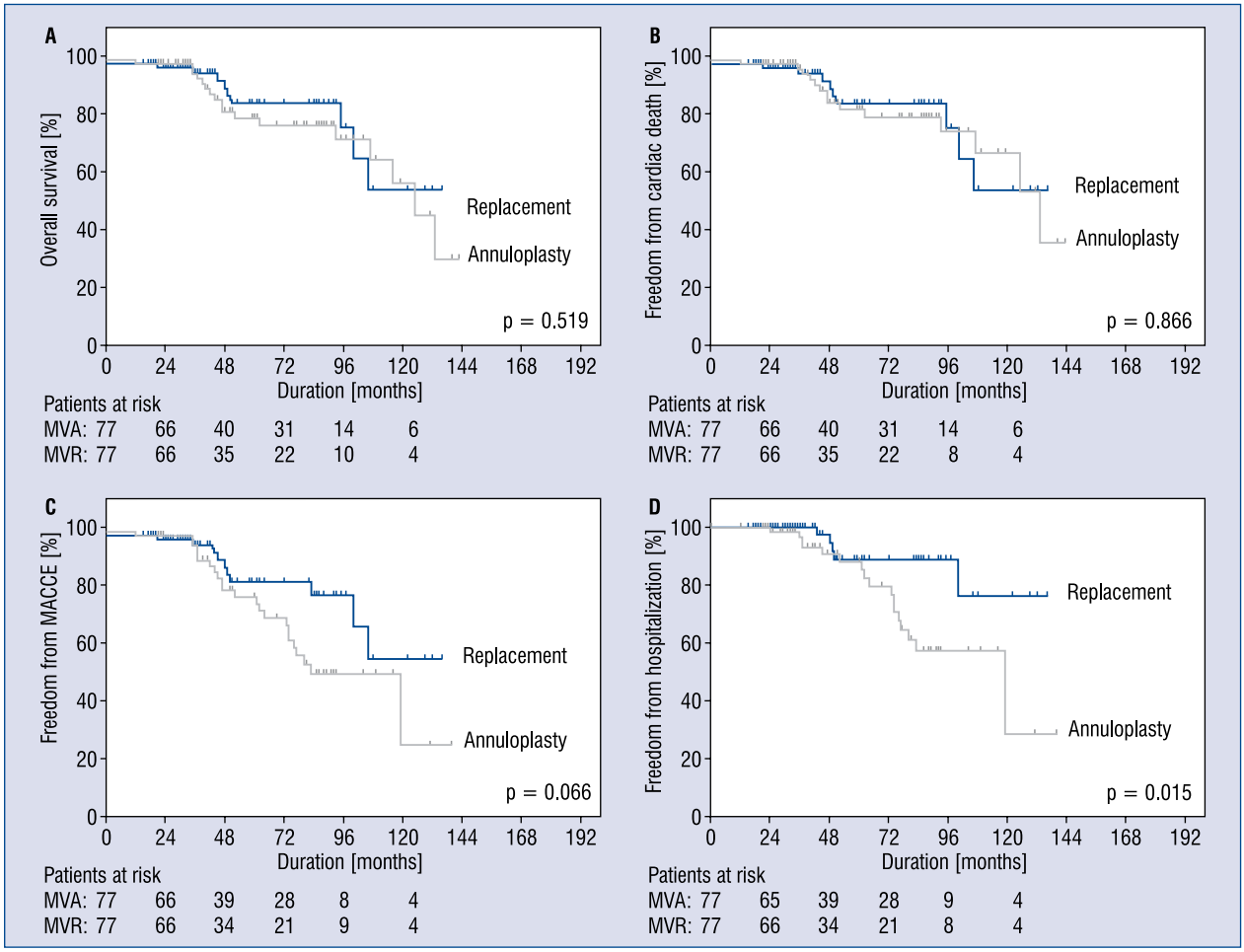

Figure 1. Kaplan-Meier curves for (**A**) overall survival (**B**) freedom from cardiac death (**C**) freedom from MACCE and (**D**) freedom from hospitalization for heart failure in 1:1 propensity score-matched mitral valve annuloplasty group (gray lines) and mitral valve replacement group (black lines); MACCE — major adverse cardiac and cerebrovascular event (cardiac death, repeat revascularization and myocardial infarction, stroke, subsequent mitral valve surgery, or hospitalization for heart failure); MVA — mitral valve annuloplasty; MVR — mitral valve replacement.

After adjustment for baseline differences with Cox proportional hazard model analysis, the present long-term observational study showed no substantial difference between the two managements of risk for MACCE, cardiac death, or overall death. Moreover, PS matching analysis also showed similar results. Follow-up echocardiographic results of PS-matched patients showed that, compared with the MVR group, both the left atrium and left ventricle end-diastolic diameter were markedly larger, and the incidence of MR recurrence was significantly higher in the MVA group. MVR provides a considerably more durable correction of MR than MVA [2, 19], which may have a beneficial effect on long-term outcomes. However, this effect must be weighed against any potential adverse consequences of a prosthetic valve, such as long-term thromboembolism, endocarditis, and structural valve deterioration [2]. The trial conducted by Goldstein et al. [2] showed that, at 2 years after either MVA or MVR for severe ischemic MR, there were no significant between-group differences with respect to LV reverse remodeling, however, the rates of MR recurrence were significantly higher in the MVA group than in the subvalvular sparing MVR group (58.8% vs. 3.8%, $p < 0.001$), related to heart failure and cardiovascular admissions [2]. Another important study carried out by Lorusso et al. [3] showed that 8-year survival was 81.6% ± 2.8% vs. 79.6% ± ± 4.8% in MVA and MVR, respectively ($p = 0.42$). Cohn et al. [21] reported a 5-year survival of 56% and 91.5% in MVA and MVR, respectively, whereas a meta-analysis showed that the relative long-term

risk of death was 35% higher in the MVR group than in the repair group [22].

Such differing conclusions might have been derived from the heterogeneity of patient cohorts. Therefore, in the present study, only patients undergoing MVA or MVR with complete myocardial revascularization were included, without congenital valvular heart disease, rheumatic valvular disease, infective endocarditis, presence of aortic valve regurgitation or stenosis, or having received other procedures. Moreover, the patients who underwent MVR without preserving the subvalvular apparatus were excluded. In addition, a propensity score model was constructed to minimize effects Limitation of confounding variables which ensured the reliability of study results.

Limitations of the study

First, this study reports retrospective data from a single center and is subject to all the limitations inherent to this design. The small study sample might have led to type II statistical errors. An appropriately powered, randomized, controlled trial evaluating the optimal management of CIMR would be useful inconfirming these results. Second, pre-, intra-, and postoperative information about the exact mechanisms and characteristics of MR were not available for all patients. For this reason, the objectives of this study were early and late outcomes. Third, selection bias should be introduced at the time of decision to perform surgical approaches because the decision to perform MVR or MVA may be related to the complexity of the patient and experience of the surgeon. To minimize the effects of selection bias, a propensity score model was constructed. Fourth, because of the 12 year inclusion time, there were three types of rings and seven types of prosthetic valves which could affect heterogeneity of the study. Another limitation is that, although this study assesses surgical approaches to the mitral valve, no detailed information was available regarding medical therapy at follow-up. However, with guideline-directed medical therapy by cardiologists, who had received systematic and standardized clinical training, the potential bias of therapy between groups is expected to be minimized.

Conclusions

The present study indicates that subvalvular sparing MVR was more favorable to ventricular remodeling and associated with a lower incidence of hospitalization for heart failure than MVA at follow-up. Therefore, subvalvular sparing MVR appears to be a suitable management for patients with CIMR undergoing mitral valve surgery and CABG. An appropriately powered, randomized, controlled trial evaluating the optimal management of CIMR would be useful in confirming the present results.

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