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Redo-mitral valve replacement and predictors of operative mortality: A single-institute experience

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Abstract

Background

In spite of improved survival of first-time mitral valve replacement (MVR), operative mortality associated with redo-mitral valve surgery is still higher than that of the primary operation. Consequently, more patients require redo-MVR, and studies investigating the operative outcome with current techniques and prostheses are thus needed.

Patients and methods

This is a nonrandomized prospective study that included 83 patients who underwent redo-MVR with either bioprosthetic or mechanical valves between March 2014 and December 2017 at National Heart Institute. Recorded data were analyzed using the statistical package for social sciences, version 23.0 (IBM SPSS). All preoperative and operative data were analyzed in univariate model to identify predictors of operative mortality and prolonged hospital stay (more than 10 days).

Results

A total of 46 (55.4%) females and 37 (44.5%) males constituted the study population. Overall, 16 (19.3%) patients in this study had ejection fraction below 50%. Indications for reoperation included endocarditis in 38 (45.8%) patients, para-prosthetic leak in 23 (27.7%) patients, structural valve degeneration in 12 (14.4%) patients, and prosthetic valve thrombosis in 10 (12.0%) patients. In-hospital mortality was 11 (13.3%) patients. Mean hospital stay was 13.68 ± 3.87 days (range, 7–22 days). Univariate analysis showed that operative mortality was associated with the left ventricular ejection fraction less than 50% ($P = 0.018$), structural valve degeneration ($P = 0.027$), and total operative time in hours ($P < 0.001$). Similarly, univariate analysis for prolonged hospital stay showed a significant association between it and higher preoperative EuroSCORE ($P = 0.003$).

Conclusion

Repeat MVR can be done safely and with a good overall clinical outcome. Although left ventricular ejection fraction less than 50%, structural valve degeneration, and total operative time in hours are associated with early hospital mortality, higher preoperative EuroSCORE is associated with prolonged hospital stay.

Keywords: Mitral, mortality, predictor, redo

Introduction

Improved survival of first-time mitral valve replacement (MVR) had led to more patients requiring redo-MVR during follow-up. Need for a redo-MVR can be attributed to a multiplicity of reasons, such as structural valve degeneration, thrombosis, endocarditis, and paravalvular leaks. The operative mortality associated with redo-heart valve surgery is higher than that of the primary operation, albeit with some preventable risk factors [1,2].

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Significant advances in prosthesis design, surgical techniques, approaches, and perioperative care had been made to improve redo-surgery outcomes [3]. Moreover, there is a gradual decrease in perioperative risk for redo-valve surgery over

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the past two decades, likely owing to immensely better surgical experience, myocardial protection, and improved patient management and early detection and intervention of valve-related complications [4,5]. However, mortality rates remain higher than first-time valve replacement surgery [2,6].

Studies that investigate the operative morbidity and mortality, survival, and freedom from re-intervention of patients undergoing redo-MVR with current techniques and prostheses are thus needed [4], and there are several studies that have been studying predictors of mortality during reoperative valve surgery [2,6,7]. Therefore, it is important to identify the perioperative variables that are associated with poor outcome in order to offer patients the most appropriate interventions. This study reports a single-center experience with redo-MVR in adult patients and aims to identify factors that contribute to poor outcome.

Patients and methods

Patient population

In this nonrandomized prospective observational study, data from 83 patients, who underwent redo-MVR with either bioprosthetic or mechanical valves between March 2014 and December 2017 at National Heart Institute, were recorded. Patients were excluded if they had undergone alternative MV intervention without replacement (e.g. MV repair, mitral valvuloplasty, and open or closed mitral commissurotomy) in the past. Likewise, renal, hepatic, respiratory failure, and previous cerebrovascular accidents were excluded.

Surgical technique

Intraoperative transesophageal echocardiography was used routinely to assess mitral valve prosthesis before and after implantation. Surgery was undertaken through a redo-median sternotomy, and cardiopulmonary bypass was established via central cannulation (aorto-bicaval). When there was a close proximity of the sternum to the heart evidenced by lateral chest radiograph or computed tomography chest, the femoral vessels were exposed before redo-sternotomy. Myocardial protection was used in the form of antegrade cold crystalloid intermittent cardioplegia (St Thomas solution) and moderate hypothermia (32°C). The left atrium was opened after developing the inter-atrial groove. The old mitral valve prosthesis was explanted, and annulus was debrided. Partial preservation of mitral valve apparatus (leaving posterior valve leaflet intact) was routinely done with enough space for at least 25-mm valve size. A mechanical or bioprosthetic valve was then inserted with horizontal mattress 2/0 ethibond sutures (everting technique). Concomitant procedures included Tvrep and aortic valve replacement (AVR). Tricuspid valve repair was accomplished by passing tapes around vena cavae and fastened them to be able to open right atrium and perform segmental annuloplasty by 3/0 multiple pledgeted prolene suture. AVR was done after redo-MVR by transverse aortotomy followed by explantation of aortic valve, and then implantation of the prosthesis using 2/0 horizontal mattress pledgeted ethibond sutures (everting technique). Closure of cardiac champers, weaning of cardiopulmonary bypass, protamine administration, and hemostasis then followed before patients' closure as per protocol.

Statistical analysis

Recorded data were analyzed using the statistical package for social sciences, version 23.0 (IBM SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean ± SD. Qualitative data were expressed as frequency and percentage. Independent samples *t* test of significance was used when comparing between two means. χ^2 test of significance was used to compare proportions between two qualitative parameters. The confidence interval was set to 95%, and the margin of error accepted was set to 5%. So, the *P* value was considered significant if it was less than or equal to 0.05, highly significant if less than or less than 0.001, and insignificant if more than 0.05. Univariate analysis was done for both hospital mortality and prolonged hospital stay defined as more than 10 days. All preoperative and operative data were analyzed in this model to identify predictors of operative mortality and prolonged hospital stay.

Results

Demographic criteria of the study group are shown in the first table. In this study, the mean age of the whole cohort was 41.66 ± 12.71 years (range, 20–56 years). Overall, 46 (55.4%) females and 37 (44.5%) males constituted the group. The mean additive EuroSCORE was 12 ± 2. A total of 16 (19.3%) patients in this study had ejection fraction below 50%. Moreover, 79 (95.1%) patients had one previous MVR surgery compared with only four (4.8%) patients who had twice previous MVR. Although 54 (65.1%) patients had mechanical valves at first-time MVR, 29 (34.9%) patients had tissue valves. As far as the most common indication for reoperation in our series is concerned, it was the prosthetic valve endocarditis in 38 (45.8%) patients. On the contrary, the least common indication was prosthetic valve thrombosis by 10 (12.0%) patients. Patients had only AVR and TVrep as concomitant procedures with first MVR by 18.1 and 36.1%, respectively. Regarding the presenting hemodynamic pathology, the majority of our patients (62.7%) had mitral regurgitation followed by stenosis (21.7%) and then mixed lesions (15.7%) (Table 1).

The second table demonstrates operative data. In this study, cases were categorized by urgency to elective, urgent, and emergency. Elective cases were 37 (44.6%), urgent cases were 33 (39.8%), and 10 (12%) cases were done on emergency basis. The total operative time in hours was 7.30 ± 1.28 h, with a range of 5–9 h. Cardiopulmonary bypass time mean (m) was 127.03 ± 37.93 m, with a range of 69–182 m. Cross-clamp time mean (m) was 92.65 ± 20.81 m, with a range of 58–122 m. Concomitant procedures were AVR in 25 (30.1%) patients, Tv repair in 21 (25.3%) patients, and both in 15 (18.1%) patients. The mean prosthesis size of the implanted mitral valve was

Table 1: Demographic criteria of the study group

	Total (n=83)
Sex	
Female	46 (55.4)
Male	37 (44.5)
Age (years)	20-56 (41.66±12.71)
LVEF <50%	16 (19.3)
Mean additive EuroSCORE	12±2
Previous MVR	
Once	79 (95.1)
Twice	4 (4.8)
Type of prosthesis at last MVR	
Bioprosthetic	29 (34.9)
Mechanical	54 (65.1)
Time to reoperation (years)	
First-time redo-MVR	2-15 (7.87±3.20)
Second-time redo-MVR	3-11 [6.80±2.86]
NYHA class >II	49 (59.0)
Concomitant procedures performed at the time of 1st MVR	
AVR	15 (18.1)
TVrep	30 (36.1)
Indications for re-operation	
Prosthetic valve endocarditis	38 (45.8)
Paravalvular leak	23 (27.7)
Structural valve degeneration	12 (14.5)
Prosthetic valve thrombosis	10 (12.0)
Hemodynamic pathology	
Mitral regurgitation	52 (62.7)
Mitral stenosis	18 (21.7)
Mixed	13 (15.7)
LAD	59±2.1 mm

Data are presented as mean±SD or as *n* (%). AVR, aortic valve replacement; EuroSCORE, European System for Cardiac Operative Risk Evaluation; LAD, left atrial diameter (mm); LVEF, left ventricular ejection fraction; MVR, mitral valve replacement; NYHA, New York Heart Functional Association; TVrep, tricuspid valve repair.

27.83 ± 2.07. Although 25 (30.1%) patients had tissue valves, 58 (69.9%) had mechanical ones (Table 2).

The early postoperative morbidity and operative mortality is portrayed in Table 3, where the latter in our study was 11 (13.3%) patients. Moreover, five (6.0%) patients were explored for bleeding, 14 (4.8%) patients had permanent pacemaker implantation, six (7.2%) patients had renal failure necessitating hemofiltration, 23 (27.7%) patients had atrial fibrillation, and stroke rate was 3.6%. Mean hospital stay ranged between 7 and 22 days, with a mean of 13.68 ± 3.87 days.

In this study, univariate analysis was done for both hospital mortality and prolonged hospital stay defined as more than 10 days. All preoperative and operative data were analyzed in a univariate model displayed in both Table 4 and Table 5. In Table 4, we found a significant association between hospital mortality and left ventricular ejection fraction (LVEF) less than 50%, structural valve degeneration, and total operative time in hours, where P values were 0.018, 0.027,

Table 2: The operative data of the study group

	Total (n=83)
Priority of surgery	
Elective	37 (44.6)
Urgent	33 (39.8)
Emergency	13 (15.7)
Total operative time (h)	5-9 (7.30±1.28)
Cardiopulmonary bypass time (min)	69-182 (127.03±37.93)
Cross-clamp time (min)	58-122 (92.65±20.81)
Concomitant procedures performed at the time of redo-MVR	
AVR	25 (30.1)
TVrep	21 (25.3)
AVR + TVrep	15 (18.1)
Median prosthesis size (mm)	25-31 (27.83±2.07)
Type of prosthesis at redo-MVR	
Bioprosthetic (%)	25 (30.1)
Mechanical (%)	58 (69.9)

Data are presented as mean±SD or as *n* (%). AVR, aortic valve replacement; MVR, mitral valve replacement; TVrep, tricuspid valve repair.

and less than 0.001, respectively. Causes of death were cardiac (n = 3), cerebrovascular accident (n = 3), sepsis (n = 2), pneumonia (n = 2), and multiorgan dysfunction (n = 1). Again, univariate analysis for prolonged hospital stay is shown in Table 5, where a significant association between it and higher preoperative EuroSCORE (P = 0.003) was found.

Discussion

Despite the fact that recent years have brought a substantial improvement of repeat valve surgery results in terms of both clinical and functional outcomes, repeat valve surgery is a challenge [8]. It is also quite conceivable that the more patients who had MVR survive, the more will be the valve-related complications and perhaps the more need for redo-operations owing to prosthesis failure or valve-related complications. Consequently, we can expect a rise in the number of redo-valve operations. Studies that provide information about clinical and functional outcomes of this type of surgery are therefore required to enrich the surgical knowledge of cardiac surgeons facing this problem as well as improving patients' outcome [4].

Generally speaking, indications for reoperation are many, and they are usually attributed to prosthetic valve-related complications, such as structural valvular degeneration, nonstructural dysfunction, valve thromboembolic complications, bleeding, and endocarditis [5,6,9]. Endocarditis (45.8%) was the most common indications for the redo-operation in our series, which is in contrast with Kothari *et al*.[10] findings who reported pannus formation as the most common cause in 94% of his patients. Others reported pannus formation followed by paravalvular leakage, endocarditis, and thrombosis or thromboembolism as the most common causes [5,6,9]. Other investigators found paravalvular leak was the most common cause for redo-surgeries for mechanical prosthesis [11]. Although valve thrombosis has been directly linked to

anticoagulation use, a direct relationship with the intensity of anticoagulation had not been proved by some studies [12].

Table 3: Early postoperative outcome of the study group

	Total (*n*=83)
Hospital mortality (%)	11 (13.3)
Re-exploration for bleeding	5 (6.0)
Sepsis	13 (15.7)
AF	23 (27.7)
Permanent pacemaker	4 (4.8)
Hemofiltration	6 (7.2)
Cerebrovascular event	3 (3.6)
Mean hospital stay (days)	7-22 (13.68±3.87)

AF, atrial fibrillation.

In line with our results, Vohra *et al.*[4] found that endocarditis was the most common cause of repeat mitral valve surgery. In our study, it was 45.8%, whereas in their study, it was much higher, by more than 6%, than what had been reported in the literature [13,14]. Similarly, others such as Tyers *et al.*[15] had found that endocarditis was a more frequent cause of reoperation particularly in patients with mechanical as compared with those with bioprosthetic valves. Structural valve degeneration occurred in 14.5% of our patients as a third frequent indication for reoperation, which can be attributed to improvements in valve technology, manufacturing, and design.

Perioperative factors affecting hospital mortality are many, and many studies have found different mortality figures for

Table 4: Univariate analysis for hospital mortality

Parameters	In-hospital mortality [*n* (%)]		χ^2/t^a	*P*
	No (*n*=72)	Yes (*n*=11)		
Demographic characteristics				
NYHA >II	40 (55.6)	9 (81.8)	0.015	0.903
Sex				
Female	42 (58.3)	4 (36.4)	1.864	0.172
Male	30 (41.7)	7 (63.6)		
Age (years)	38.32±12.67	41.27±13.32	0.715	0.477
LVEF <50%	11 (15.3)	5 (45.5)	5.584	0.018
Previous MVR once	69 (95.8)	10 (90.9)		
Twice	3 (4.2)	1 (9.1)	0.504	0.478
Bioprosthetic	23 (31.9)	6 (54.5)	2.144	0.143
Mechanical	49 (69.4)	5 (36.4)	2.144	0.143
First-time redo-MVR	7.98±3.32	7.00±1.89	−0.952	0.344
Second-time redo-MVR	3.75±1.37	3.00±0.00	−1.806	0.075
Concomitant procedures performed at the time of previous MVR AVR	12 (16.7)	3 (27.3)	0.725	0.395
TVrep	28 (38.9)	2 (18.2)	1.773	0.183
Prosthetic valve endocarditis	36 (50.0)	2 (18.2)	1.750	0.186
Paravalvular leak	20 (27.8)	3 (27.3)	0.001	0.975
Structural valve degeneration	8 (11.1)	4 (36.4)	4.920	0.027
Prosthetic valve thrombosis	8 (11.1)	2 (18.2)	0.450	0.502
Hemodynamic pathology				
Mitral regurgitation	45 (62.5)	7 (63.6)	0.005	0.944
Mitral stenosis	16 (22.2)	2 (18.2)	0.092	0.762
Mixed	11 (15.3)	2 (18.2)	0.061	0.805
Operative data				
Elective	32 (44.4)	5 (45.5)	0.004	0.950
Urgent	30 (41.7)	3 (27.3)	0.825	0.364
Emergency	10 (9.7)	3 (27.3)	1.294	0.255
Total operative time	6.25±1.18	7.80±1.17	4.062	< 0.001
Cardiopulmonary bypass time	125.38±37.88	139.82±37.59	1.179	0.242
Cross-clamp time	93.12±20.89	88.70±20.72	−0.654	0.515
Concomitant procedures AVR	23 (31.9)	2 (18.2)	0.859	0.354
TVrep	20 (27.8)	1 (9.1)	1.763	0.184
AVR + TVrep	12 (16.7)	3 (27.3)	0.725	0.395
LAD				
Median prosthesis size	27.85±2.06	27.91±2.43	0.088	0.930
Bioprosthetic	24 (33.3)	5 (45.5)	0.617	0.432
Mechanical	48 (66.7)	6 (54.5)	0.617	0.432

AVR, aortic valve replacement; LAD, left atrial diameter; LVEF, left ventricular ejection fraction; MVR, mitral valve replacement; NYHA, New York Heart Functional Class; TVrep, tricuspid valve repair. at, independent sample *t* test. χ^2, χ^2 test. $P<0.05$ significant. $P>0.05$ nonsignificant.

Table 5: Univariate analysis for prolonged hospital stay (>10 days)

Parameters	Prolonged hospital stay >10 days		χ^2/t^a	*P*
	Yes (*n*=55)	No (*n*=28)		
Demographic characteristics				
NYHA >II	35 (63.6)	14 (50.0)	1.427	0.232
Sex				
Female	33 (60.0)	13 (46.4)	1.383	0.240
Male	22 (40.0)	15 (53.6)		
Age (years)	40.29±14.53	36.72±9.18	−1.183	0.240
EuroScore	12.11±3.23	10.02±2.14	−3.091	0.003
LVEF <50%	11 (20.0)	5 (17.8)	0.055	0.815
Previous MVR once	52 (94.5)	27 (96.4)	0.143	0.705
Twice	3 (5.5)	1 (3.6)		
Bioprosthetic	23 (41.8)	6 (21.4)	3.393	0.065
Mechanical	26 (61.8)	28 (71.4)	0.754	0.385
First-time redo-MVR	8.08±3.03	7.38±3.26	−0.970	0.335
Second-time redo-MVR	4.67±1.53	4.00±1.41	−1.936	0.056
Concomitant procedures performed at the time of previous MVR AVR	11 (20.0)	4 (14.3)	0.409	0.522
TVrep	17 (30.9)	13 (46.4)	1.936	0.164
Prosthetic valve endocarditis	20 (41.8)	18 (53.6)	1.033	0.309
Paravalvular leak	12 (21.8)	11 (39.3)	2.826	0.093
Structural valve degeneration	10 (18.2)	2 (7.1)	1.828	0.176
Prosthetic valve thrombosis	5 (9.1)	5 (17.9)	1.346	0.246
Hemodynamic pathology mitral regurgitation	32 (58.2)	20 (71.4)	1.391	0.238
Mitral stenosis	10 (18.2)	8 (28.6)	1.179	0.278
Mixed	8 (14.5)	5 (17.9)	0.154	0.695
Operative data				
Elective	21 (38.2)	16 (57.1)	2.700	0.100
Urgent	22 (40.0)	11 (39.3)	0.004	0.950
Emergency	7 (12.7)	3 (10.7)	0.071	0.790
Total operative time	7.61±1.36	7.23±1.18	−0.711	0.479
Cardiopulmonary bypass time	126.70±39.02	128.08±37.14	0.155	0.877
Cross-clamp time	94.78±20.47	88.73±20.83	−1.266	0.209
Concomitant procedures AVR	16 (29.1)	9 (32.1)	0.082	0.775
TVrep	12 (21.8)	9 (32.1)	1.260	0.262
AVR + TVrep	11 (20.0)	4 (14.3)	0.409	0.522
Median prosthesis size	27.96±2.09	27.62±2.06	−0.704	0.483
Bioprosthetic	19 (34.5)	6 (21.4)	1.517	0.218
Mechanical	32 (58.2)	20 (71.4)	1.391	0.238

AVR, aortic valve replacement; LVEF, left ventricular ejection fraction; MVR, mitral valve replacement; NYHA, New York Heart Functional Association; TVrep, tricuspid valve repair. at, independent sample *t* test. χ^2, χ^2 test. *P*<0.05 significant. *P*>0.05 nonsignificant.

redo-valve surgeries, such as Jones study in 2001, who reported an overall mortality figure of 8.6%, which compared well with Gillinov *et al*.[16] and Niederhauser *et al*. [17], who found an operative mortality of 8.6 and 8.8%, respectively. Jones *et al*.[5] also did show that mortality was higher for those patients requiring reoperation for a prosthetic valve than after mitral valve repair or valvuloplasty. So reports of up to 30% mortality in the literature now have declined to 5–6% [5,6,9,18]. In some studies, early mortality had been associated with older age [5,7,19], female sex [20], advanced New York Heart Functional Association (NYHA) class [20,21], low LVEF (<35), increased left ventricular end-diastolic diameter (>50 mm), pulmonary edema, urgent operations [7,14,20], concomitant procedures [5,21], and previous myocardial infarction [14].

Kothari *et al*.[10] found that redo-surgeries for valve thrombosis with NYHA class of I–II compared favorably with routine redo-operations (10%) whereas valve thrombosis with hemodynamic instability and/or higher NYHA class had significantly higher mortality (45%). NYHA functional class IV was also a risk factor in short-term survival as mentioned by Akay *et al*. [20]. This was not found in our finding, and NYHA more than II was neither associated with hospital mortality nor prolonged length of stay.

We have to consider, on comparing with others, that some studies did not discriminate between the anatomical position of the valve, with results regularly being mixed for aortic, mitral, and tricuspid valve replacements [22]. Perhaps, another factor to consider is that some studies had also included

patients who previously underwent MV procedures other than replacement (e.g. MV repair and mitral valvuloplasty) [16].

In our study, hospital mortality was 13.3%, which is concordant with the literature [5,7,14], despite the fact that 73.5% of our patients had concomitant procedures. Interestingly, in Jounes study, operative mortality was higher for a mechanical valve compared with a tissue valve at all valve positions, which agrees with the findings of Tyers *et al*. [15], Magilligan *et al*. [23], and Bortolotti *et al*. [24]. Nevertheless, there are some authors, like us, who found no difference [25,26].

Neither sex nor age affected operative mortality in our series. Ejiofor *et al*.[27] did not find sex as a risk factor for operative mortality in opposite to what had been reported by Lytle *et al*. [25], who found that female sex had an increased mortality risk for redo-aortic valve, and Akins *et al*. [8], who found that male sex had an increased mortality risk for any redo-valve surgery at any given position. Again, age was not a significant risk factor in the univariate analysis of our study similar to some studies [28]. In contrary, some authors reported older age as a risk factor [25].

Some authors also found a correlation between the degree of urgency of the reoperation and operative mortality. Thus, nonelective operation was found as a predictor of mortality by Wei-Guo Ma, who attributed high mortality of 28.6% in emergency redo patients to poor general condition, worsened cardiac function, and inappropriately sufficient preoperative preparation. Therefore, he suggested that emergency reoperation, being a lifesaving procedure, should be the only exemption from not preparing the patient properly [29]. De Almeida Brandão *et al*.[30] reported a hospital mortality of 10.9% for emergency redo cases, which is similar to findings of Sampath Kumar *et al*.[31] (11%). Overall operative mortality was found to be 8.4% in elective redo-mitral operations by Beghi *et al.* [32], which is very similar to Wauthy *et al*.[33] (8%). In our study, we did not find emergency operation as a significant risk factor in operative mortality, understandably because of small number of patients who were done on emergency basis [10 (12%) cases only]. In the study by Akins *et al*. [8], 38% of the operations were nonelective and 44% required another concurrent cardiac procedure, and they concluded that best results were achieved when the valve replacement is done for a failed bioprosthesis electively and without the requirement for concurrent procedures. In several other reports, acute bacterial endocarditis was identified as a predictor of hospital mortality [21,24,25]. In our series, endocarditis was not a significant predictor of hospital mortality.

In concordance with some authors, we found significant postoperative complications after redo-MVR such as supraventricular arrhythmias, sepsis, acute renal failure requiring renal replacement therapy, and stroke [4]. In our study, 19.3% of the patients had LV dysfunction and mean additive EuroSCORE was 12 ± 2. Univariate analysis revealed an association between postoperative complications and higher additive EuroSCORE. We also found that the LVEF less than 50% was an independent predictor of operative mortality in the short term. This is the reason why some authors recommend early intervention before irreversible myocardial damage and/or deteriorating LV function, and consequently, higher inherent surgical risk [20,34]. Prolonged hospital stay is not well described in the studies investigating redo-MVR [21,22]. In this study, we found a correlation between higher preoperative EuroSCORE and prolonged hospital stay (P = 0.003). It is also quite conceivable that this is strongly linked to the early postoperative course and the occurrence of complications.

Conclusion

Repeat MVR can be done safely and with a good overall clinical outcome. We insist on early intervention before ventricular dysfunction occurs with its deleterious effects on the outcome of the redo surgery. Although LVEF less than 50%, structural valve degeneration, and total operative time in hours are associated with early hospital mortality, higher preoperative EuroSCORE is associated with prolonged hospital stay.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Limitations

This study has a number of limitations: first, the relatively small number of patients and the lack of late follow-up; second, selection bias cannot be excluded which can affect the outcome; third, in particular, information was not always available regarding details of valve prostheses used in initial valve replacement; fourth, we did not look at left atrial diameter and its effect on outcome; and finally, details of anticoagulation management after the initial procedure were also not clear, such as the target international normalized ratio (INR), the frequency of INR measurements, and especially the INR values before the occurrence of valve dysfunction.

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Conflicts of interest

There are no conflicts of interest.

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