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Redo surgery for noninfective isolated mitral valve disease: Initial outcome and further follow-up compared to primary surgery

Uwe Speiser MD, PhD[1] | Daniel Pohling MD[2] | Sems-Malte Tugtekin MD, PhD[3] | Efstratios Charitos MD, PhD[4] | Klaus Matschke MD, PhD[3] | Manuel Wilbring MD, PhD[3]

[1]Department of Cardiology, University Heart Center Dresden, Dresden, Germany

[2]Department of Cardiac Anesthesiology, MediClin Heart Center, Coswig, Germany

[3]Department of Cardiac Surgery, University Heart Center Dresden, Dresden, Germany

[4]Department of Cardiac Surgery, Kerckhoff Heart Centre, Bad Nauheim, Germany

Correspondence
Manuel Wilbring, University Heart Center Dresden, Center for Minimally Invasive Cardiac Surgery, Fetscherstrasse 76, 01307 Dresden, Germany.
Email: manuel.wilbring@gmail.com

Abstract

Introduction: Isolated redo-mitral valve replacement (iMVR) is underreported and often mixed up with endocarditis in the present literature. The present study compares first with redo iMVR in noninfective mitral disease.

Patients and Methods: A total of 3821 mitral valve procedures were analyzed. The study was restricted to isolated and noninfective mitral valve replacements done by sternotomy. Finally, 402 patients are included, consisting of 102 redo- and 300 first surgeries. The mean patient's age was 65.9 ± 10.4 years; the mean EuroSCORE II was 3.0 ± 2.2%. Median follow-up was 221 days, ranging up to 9.9 years with a total of 367 patient-years.

Results: Redo's had higher EuroSCORE II (5.1 ± 2.9% vs. 2.3 ± 1.4%; $p < .01$), more atrial fibrillation (31.1% vs. 46.1%; $p = .01$), chronic obstructive pulmonary disease (7.3% vs. 17.6%; $p = .05$), coronary artery disease (7.3% vs. 17.6%; $p = .03$) and more frequently reduced ejection fraction < 30% (3.0% vs. 11.8%; $p = .02$). Main outcomes showed comparable 30-days mortality (first: 4.1%, redo: 6.9%; $p = .813$). Postoperative morbidity of the redo's was associated with increased postoperative bleeding ($p < .01$) resulting in increased transfusions of packed red blood cells and fresh frozen plasma (each $p < .01$), more re-explorations ($p < .01$) and longer primary intensive care unit stay ($p < .01$). Postoperative occurrence of stroke, respiratory or renal failure, and myocardial infarction as well as hospital stay differed not significantly. Estimated 5-years survival was 65.5 ± 12.3% for all patients with no significant differences between the groups. Multivariate logistic regression respiratory failure as relevant for hospital (odds ratio [OR]: 12.3 [1.1–158]; $p = .029$) and stroke (OR: 4.8 [1.1–12.3]; $p = .021$) as relevant for long-term mortality.

Conclusion: iMVR for noninfective reasons is infrequent and rare. Compared to primary surgery, redo's suffer mainly from bleeding-associated morbidity. This does not translate into prolonged hospital stay or inferior immediate or long-term

outcomes. Redo mitral valve replacement can be performed at no significantly increased surgical risk compared with first surgery and the results are particularly not limited by the surgery itself.

KEYWORDS

mitral valve, outcomes, redo, replacement

1 | INTRODUCTION

Mitral valve repair is supposed to be the standard of care for the treatment of mitral valve disease. Nonetheless, mitral valve replacement still is performed frequently, taking an amount of 35.9% of all isolated mitral valve procedures done in 2020 in Germany.[1] Meanwhile, the ideal prosthetic valve, lifetime lasting and free from the need for anticoagulation, still does not exist and surgeons, as well as patients, are forced into a decision between two imperfect options by means of the characteristics of the available substitutes. For those reasons, durability will remain a significant limitation of mitral valve surgery, and accordingly, the need for mitral valve reoperations will persist in the future.

Having upcoming transcatheter solutions for the treatment of failed mitral repair or degenerated mitral prostheses up one's sleeve, nothing here really is known about durability beyond a few years. This restricts transcatheter valve-in-valve or valve-in-ring procedures to a high-risk subgroup.[2–4]

Presently, redo mitral surgery is assumed to have an increased surgical risk. Patients usually are older and gathered more risk-relevant comorbidities during the time since the primary procedure.

But, besides all assumptions, clinical outcomes of isolated noninfective redo mitral surgery consistently are underreported in the present and past literature, and summing up, we do not really know about risk and outcomes compared with primary surgeries.

Indeed, several studies addressed reoperative valve surgery.[5–11] But for real, all of them suffer from severe methodical faults. Most of the available literature does not discern the position of the prosthetic valve, thus dealing more with redo surgery in general. Often, different entities like prosthesis dysfunction, concomitant coronary artery bypass graft, and endocarditis are mixed up, generating inconsistent and noncomparable groups. Finally, yet importantly, some of the available studies are outdated by parts.[5–11]

For those reasons, we initiated the present study to evaluate the contemporary risk of surgical mitral valve replacement during primary or redo surgery. The present study rules out mitral repair, endocarditis, and concomitant procedures.

In doing so, a pure study population is reported to answer the question of whether redo mitral replacement can be done at the same risk compared to primary mitral replacement. Additionally, a follow-up ranging up to 10 years is described.

2 | PATIENTS AND METHODS

2.1 | Ethics statement

Data collection and analyses for the study were approved by the local Institutional Review Board (Ethikkommission an der Technischen Universität Dresden; approval-number EK 298092012). There exists no ethical conflict. Informed consent was obtained. Clinical trial registration was not applicable.

2.2 | Patients and study design

Due to a nearly complete shift to minimally invasive access routes after 2012, the study time period was restricted from 2000 to 2012. During this period, a total of 27,841 patients underwent cardiac surgery. Out of these, 3821 mitral valve procedures were identified and studied retrospectively out of the hospital's database.

After exclusion of endocarditis, history of (h/o) other than isolated mitral replacement in case of redo surgery, mitral repair during the actual surgery, minimally invasive procedures, and combined procedures, 402 patients remained. Within this final study group, 300 patients underwent first and 102 patients underwent redo surgery, constituting the treatment groups. Figure 1 depicts the study design and group generation.

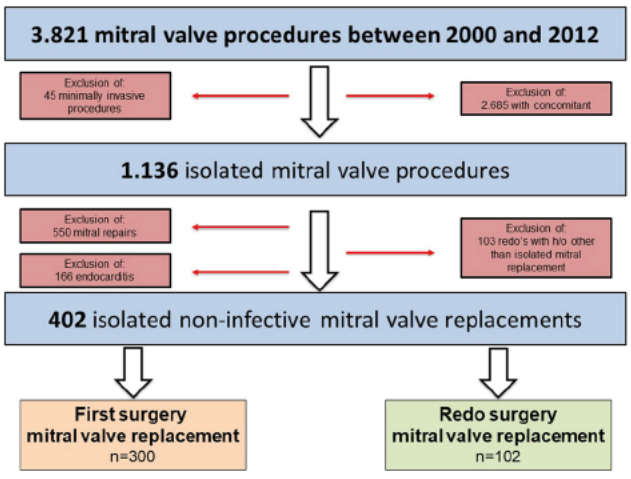

FIGURE 1 Study design and generation of the final study group. The study was restricted to noninfective, isolated mitral valve replacements done by sternotomy

The mean age of the entire study group was 65.9 ± 10.4 years. Computed logistic EuroSCORE II averaged 3.0 ± 2.2%. Median follow-up was 221 days, ranging up to 9.9 years with a total of 367 patients-years of follow-up.

The study was designed as a retrospective data analysis. For those purposes, pre-, intra-, and postoperative items were analyzed out of the hospital database. Follow-up was gained during regular follow-up visits if they were performed at our institution. Follow-up visits included physical examination, transthoracic echocardiography, and laboratory testings and were regularly scheduled for once a year.

2.3 | Surgical technique

The main surgical techniques did not differ between primary and redo surgery. In this study, for both, the median sternotomy was the standard access route according to the inclusion criteria. Extracorporeal circulation was established in a standardized manner, cannulating the aorta in the entry of the arch and bicaval for venous drainage. Three different types of atriotomies were used: (a) Extended vertical transatrial septal approach as described by Guiraudon et al.,[12] (b) standard left atrial access, or (c) standard transseptal approach. The choice of the access route depended on the surgeon's preference. Preservation of the subvalvular apparatus likewise depended on the surgeon's preference and was reported only inconsistently. After mitral replacement and closure of the atriotomy, de-airing was performed using a left ventricular venting line and a needle vent in the aortic root. All procedures were done in normothermia. Cardiac arrest was induced using histidine–tryptophan–ketoglutarate cardioplegia.

2.4 | Study endpoints and statistical analysis

The study endpoints are defined as given below:

a) Primary study points—postoperative mortality:

- hospital mortality and
- mortality during further follow-up.

b) Secondary endpoints—postoperative morbidity:

- prolonged intensive care unit (ICU) stay >24 h;
- duration of hospital stay;
- perioperative stroke;
- perioperative myocardial infarction;
- postoperative respiratory failure with the need for reintubation;
- postoperative renal failure with the need for hemofiltration;
- amount of postoperative bleeding during the first 24 h; and
- need for surgical re-exploration.

For the comparisons of the demographic variables between the two groups, the *t*-test, Mann–Whitney *U* test, or the χ^2 and Fisher's exact test were used where appropriate. To identify predictors of hospital mortality, univariable logistic regression was employed. The following factors were investigated: age, sex, atrial fibrillation, diabetes, pulmonary hypertension, coronary artery disease, chronic kidney disease, dialysis, chronic pulmonary disease, extracardiac arteriopathy, h/o stroke left ventricular ejection fraction (LVEF), postoperative bleeding, re-exploration for bleeding, administration of packed red blood cell (PRBC) and/or fresh frozen plasma (FFP), length of ICU stay, length of hospital stay, postoperative renal failure, postoperative respiratory failure, postoperative stroke or myocardial infarction, low cardiac output syndrome, intra-aortic balloon pump (IABP), wound healing disorder, reoperation, and procedure time.

Variables that showed significant association in the univariable analysis ($p < .1$) entered a multivariable stepwise, bidirectional variable selection process. The final multivariable logistic regression model is displayed in Table 3.

For time-to-event outcomes were investigated using the Kaplan–Meier method. $p < .05$ was considered statistically significant. The statistical analysis was performed using SAS JMP 12.2© (SAS Institute).

3 | RESULTS

3.1 | Baseline characteristics

The main patient baseline characteristics of the entire group are summarized in Table 1. Patient's sex differed significantly with a higher rate of male patients in the redo group (62.7% vs. 38.1%; $p = .01$). The calculated mean EuroSCORE II of 3.0 ± 2.2% in the overall group indicated an intermediate risk constellation. Accordingly, the frequency of relevant comorbidities was high. Patients of the redo group had a higher mean EuroSCORE II (5.1 ± 2.9% vs. 2.3 ± 1.4%; $p < .01$). Furthermore, redo group had a higher incidence of atrial fibrillation (46.2% vs. 31.1%; $p = .01$), more presence of chronic obstructive pulmonary disease (17.6% vs. 7.9%; $p = .05$) and coronary artery disease (17.6% vs. 7.3%; $p = .003$). Significantly reduced left ventricular function was more likely in the redo group (LVEF < 30% 10.3% vs. 3.0%; $p = .02$). The remaining baselines were counterbalanced between both groups.

3.2 | Prior mitral valve surgery in the redo group

First surgery dated back 9.9 ± 7.2 years in mean (median 3 years) and consisted in 54.9% ($n = 56$) of biologic and in 45.1% ($n = 46$) of mechanic substitutes. The decision for mitral valve replacement during primary surgery relied to the surgeon's decision. Documented reasons were mitral stenosis ($n = 86$; 28.7%), prolapse of the anterior mitral leaflet ($n = 64$; 21.3%), large posterior mitral leaflet with echocardiographic systolic anterior motion predictors ($n = 39$; 13.0%), complex pathology estimated to be unsuitable for successful repair ($n = 67$; 22.3%), poor LVEF or tenting height >10 mm ($n = 16$; 5.3%),

TABLE 1 Baseline characteristics

	Entire group (n = 402)		First surgery group (n = 300)		Redo surgery group (n = 102)		
	n	%	n	%	n	%	p
Age (years, mean ± SD)	65.9 ± 10.4		64.2 ± 11.1		68.2 ± 10.0		ns
Male	180	44.8%	114	38.1%	64	62.7%	.01
Atrial fibrillation	127	31.6%	93	31.1%	47	46.1%	.01
Diabetes mellitus type 2	113	28.2%	76	25.3%	21	20.6%	ns
Coronary artery disease	36	8.9%	22	7.3%	18	17.6%	.03
pHT (>60 mmHg)	143	35.6%	106	35.2%	37	36.3%	ns
Chronic renal failure	149	37.1%	106	35.2%	47	46.1%	ns
Dialysis dependent	2	0.5%	1	0.3%	1	0.9%	ns
COPD	33	8.2%	24	7.9%	18	17.6%	.05
Extracardiac arteriopathy	36	9.0%	21	6.9%	11	10.8%	ns
h/o stroke	45	11.2%	32	10.7%	13	12.7%	ns
Normal LVEF	270	67.2%	233	77.8%	46	45.1%	.02
LVEF 30%–50%	107	26.6%	58	19.2%	45	44.1%	
LVEF < 30%	25	6.2%	9	3.0%	11	10.8%	
log EuroSCORE (%)	10.8 ± 8.9		8.1 ± 7.6		25.0 ± 18.2		<.01
EuroSCORE II	3.0 ± 2.2		2.3 ± 1.4		5.1 ± 2.9		<.01

Note: The bold values are the values with a significant p.

Abbreviations: COPD, chronic obstructive pulmonary disease; h/o, history of; LVEF, left ventricular ejection fraction; ns, nonsignificant; pHT, pulmonary hypertension.

failed repair without second pump run (n = 20; 6.7%), and failed repair with second pump run (n = 8; 2.7%).

Modes of failure were structural valve degeneration (n = 56; 54.9%), mechanical valve thrombosis (n = 30, 29.4%), or impaired leaflet motion due to pannus formation (n = 16; 15.7%).

3.3 | Procedural outcome and postoperative course

All patients underwent isolated mitral valve replacement. Mean procedure times averaged 197 ± 90 min in the redo group and were significantly longer, compared with the first surgeries (150 ± 51 min; p = .003). Use of mechanical prostheses (n = 240; 59.7%) and biologic substitutes (n = 162; 40.3%) did not differ significantly between both groups (p = .953). Intraoperatively, two patients died (0.5%), with one patient in each group dying. Reasons for death were atrioventricular disconnection in a case with severely calcified mitral stenosis and one case with a fulminant low cardiac output. Altogether, 20 patients died during the first 30 postoperative days, equaling a 30-days mortality of 5.0% in the entire group. Hereby, hospital mortality differed not significantly between both groups with 7 patients dying in the redo group (6.9%) and 12 patients in the first surgeries group (4.1%; p = .2710). (Figure 2). The estimated 1- and 5-year survival of the entire group was 83.3 (confidence interval [CI] 95 ± 9.3%) and 65.5%

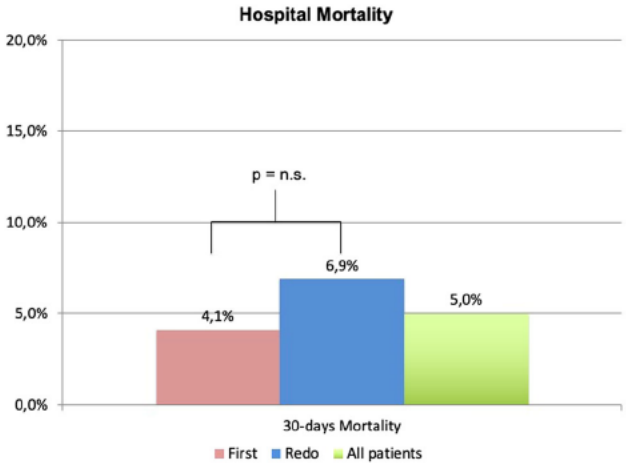

FIGURE 2 Depiction of 30-days mortality. No significant (ns) differences between both groups were detected

(CI 95 ± 12.3%), respectively. During the whole follow-up, which ranged up to 9.9 years, no significant differences concerning survival during follow-up were observed in both groups (Figure 3).

Main differences between both groups were observed concerning postoperative morbidity. Patients of the redo group had higher amount of postoperative bleeding (1311 ± 140 vs. 591 ± 62 ml; p < .001) and accordingly more frequently re-exploration for bleeding

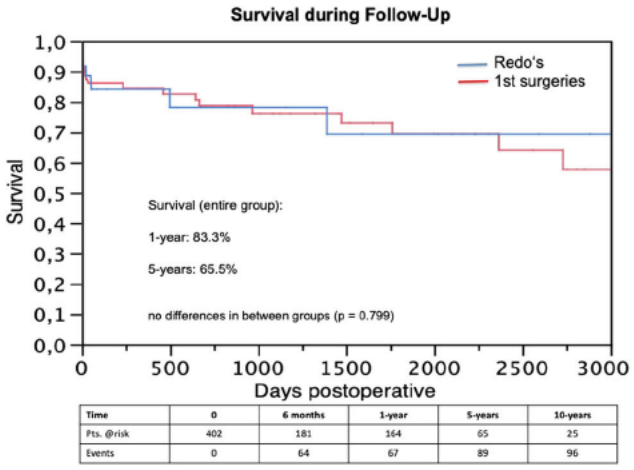

FIGURE 3 Kaplan–Meier Survival curve of first surgery (red line) and redo group (blue). There was no significant difference in long-term survival ($p = .799$)

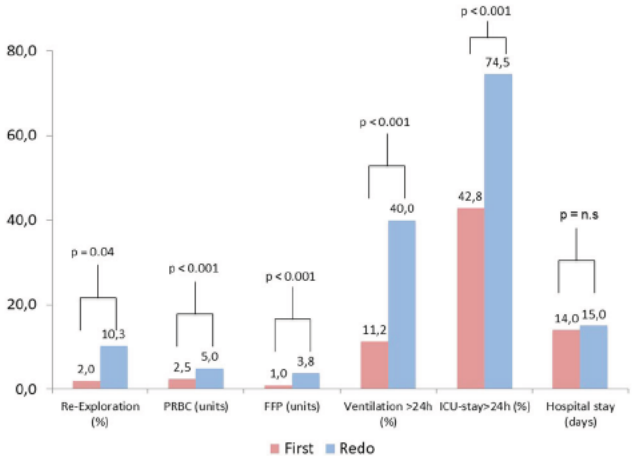

FIGURE 4 Frequencies of significant different postoperative morbidity: which was mainly bleeding associated. This did not translate into a prolonged hospital stay for the redo's. FFP, fresh frozen plasma; ICU, intensive care unit; ns, nonsignificant; PRBC, packed red blood cells

(10.3% vs. 2.0%; $p = .04$), more administration of PRBC (5.0 ± 7.0 vs. 2.5 ± 5.2; $p < .001$) and FFP units (3.8 ± 5.3 vs. 1.0 ± 2.8; $p < .001$). These differences resulted in longer ventilation times (>24 h: 40.0% vs. 11.2%; $p < .001$) and longer primary ICU stay of patients in the redo group (>24 h: 74.5% vs. 42.8%; $p < .001$). Mean hospital stay did not differ significantly between both groups (redo: 15.0 ± 9.0 days and first: 14 ± 8.6 days; $p = .4348$). Figure 4 summarizes these results.

Further postoperative morbidity is depicted in Figure 5. No statistically significant differences were observed between both groups. Most common postoperative morbidity in the entire group consisted of delirium in 11.7% ($n = 47$), renal failure in 8.2% ($n = 33$), and respiratory failure needing reintubation in 3.2% ($n = 13$). Postoperative myocardial infarction was observed in 2.0% ($n = 8$) with six (1.5%) patients needing mechanical circulatory support by

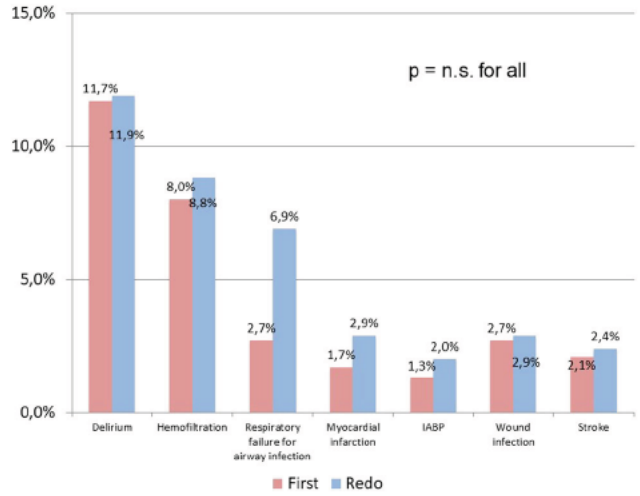

FIGURE 5 Frequencies of nonsignificant (ns) different postoperative morbidity

means of IABP. Further 11 patients (2.7%) suffered from impaired wound healing, needing vacuum-assisted wound therapy.

3.4 | Risk factors for hospital mortality

Univariate analysis revealed age (odds ratio [OR]: 0.95 [0.90–1.00]; $p = .04$), presence of coronary artery disease (OR: 6.2 [2.4–15.4], $p < .01$), h/o prior myocardial infarction (OR: 6.5 [2.05–18.94]; $p < .01$), presence of diabetes (OR: 3.3 [1.3–9.0]; $p = .01$), chronic kidney disease (OR: 2.63 [2.18–3.17]; $p < .01$), postoperative low cardiac output needing IABP (OR: 2.01 [1.24–3.00]; $p < .01$), re-exploration for bleeding (OR: 9.54 [3.11–28.57]; $p < .01$), administration of PRBC or FFP (OR: 3.49 [2.93–4.15]; $p < .01$), prolonged ICU stay >24 h (OR: 2.96 [1.19–8.41]; $p < .01$), respiratory failure needing reintubation (OR: 8.08 [1.60–32.99]; $p < .01$), postoperative stroke (OR: 8.29 [1.08–46.45]; $p < .01$), and postoperative renal failure needing hemofiltration (OR: 6.00 [1.91–17.51]; $p < .01$) as risk factors for hospital mortality in the entire group. For the total group of patients, redo surgery was no risk factor for hospital mortality in univariate analysis (OR: 1.05 [0.93–1.91]; $p =$ ns). We observed no difference regarding mortality between patients with mechanical or biological valve failure as indication for the redo surgery.

After multivariate analysis, only postoperative respiratory failure needing reintubation (OR: [95% CI] = 12.3 [1.1–158]; $p = .04$) remained a significant factor for hospital mortality in the entire group. Table 2 gives a summary.

3.5 | Risk factors for mortality during further follow-up

Univariate analysis was performed for hospital survivors ($n = 382$) and revealed h/o myocardial infarction (OR: 8.17 [2.53–27.94]; $p < .01$),

TABLE 2 Univariate risk factors for hospital mortality and mortality during follow-up

	OR [95% CI]	*p*-value for 30-days mortality		*p*-value for mortality during follow-up
Age	**0.95 [0.90–1.00]**	**.04**	1.05 [0.99–1.13]	ns
CAD	**6.2 [2.4–15.4]**	**<.01**	0.86 [0.37–2.12]	ns
h/o MI	**6.5 [2.05–18.94]**	**<.01**	**8.17 [2.53–27.94]**	**<.01**
Diabetes	**3.3 [1.3–9.0]**	**.01**	1.50 [0.22–29.46]	ns
pHT (<60 mmHg)	1.07 [0.38–2.81]	ns	**6.82 [1.05–133.01]**	**.03**
CKD	**2.63 [2.18–3.17]**	**<.01**	3.97 [0.61–77.34]	ns
IABP	**2.01 [1.24–3.00]**	**<.01**	na	
Re-exploration	**9.54 [3.11–28.57]**	**<.01**	4.7 [0.60–27.4]	ns
PRBC/FFP	**3.49 [2.93–4.15]**	**<.01**	1.01 [0.88–1.12]	ns
Prolonged ICU stay >24 h	**2.96 [1.19–8.41]**	**<.01**	1.44 [0.52–4.07]	ns
Respiratory failure (reintubation)	**8.08 [1.60–32.99]**	**<.01**	na	
Postoperative stroke	**8.29 [1.08–46.45]**	**<.01**	**13.05 [7.67–85.63]**	**<.01**
CVVH	**6.00 [1.91– 17.51]**	**<.01**	**1.88 [0.09–13.30]**	ns
Redo surgery	1.05 [0.93–1.91]	ns	1.01 [0.33–2.86]	ns
Wound infection	1.53 [0.82–4.27]	ns	**1.55 [1.10–10.18]**	**<.01**

Note: The bold values are the values with a significant *p*.
Abbreviations: CAD, coronary artery disease; CI, confidence interval; CKD, chronic kidney disease; CVVH, continuous venovenous hemofiltration; FFP, fresh frozen plasma; h/o, history of; IABP, intra-aortic balloon pump; ICU, intensive care unit; MI, myocardial infarction; na, not applicable; ns, nonsignificant; OR, odds ratio; pHT, pulmonary hypertension; PRBC, packed red blood cells.

pulmonary hypertension (OR: 6.82 [1.05–133.01]; $p < .01$), postoperative stroke (OR: 13.05 [7.67–85.63]; $p < .01$) and wound infection (OR: 1.55 [1.10–10.18]; $p < .01$) as risk factors for mortality during follow-up in the entire group.

After multivariate analysis, only postoperative stroke (OR [95% CI] = 4.8 [1.1–12.3]; $p = .02$) remained a significant factor for mortality during further follow-up. These multivariate findings additionally differed not for both groups.

Redo surgery was neither a risk factor for mortality during follow-up in univariate or multivariate analysis. Table 2 summarizes these findings.

4 | DISCUSSION

The first observation is that redo mitral valve replacement for noninfectious reasons is infrequent and rare. Even in a high-volume center during a 12-year period, in which a population of 27,841 patients underwent cardiac surgery, only 102 patients are eligible according to the inclusion criteria. For those reasons, only little can be reported by the present literature.

McGiffin et al.[13] stated the main consideration is "the competing risks of death without re-replacement and re-replacement before death." For well-based decision-making, profound knowledge about the particular risk of re-operative surgery is essential – but not available in the present literature.[5–11,13–15]

Reoperative surgery certainly is technically more upmarket compared to primary surgery. Pericardial adhesions associate with higher chances of injuring relevant structures. Furthermore, patients facing redo surgery usually are older and have gathered an additional mentionable amount of comorbidities since their first surgery. In line with these hypothetic considerations, a higher EuroSCORE II characterized the patients of the redo compared with the first surgery group in the present study.

However, looking into the present literature, it is nearly unexamined whether these facts translate into inferior outcomes. Most of the presently available studies mix up different valve positions as well as infectious and noninfectious diseases and thus draw a very heterogenic picture of redo valve surgery.[5–11,13–15]

The present study addresses that methodical lack and restricts the inclusion criteria to isolated mitral valve surgery for noninfectious reasons. That generated a very homogeneous study group.

The first mentioned technical aspect potentially can translate into higher surgical mortality. This was not the case in the present series. We observed one patient in each group dying intraoperatively. This is quite low, particularly in the redo group. The literature reports operative mortality, ranging between 1.3% and 17.4% for redo surgery.[5–11,13–15]

The present study included patients at intermediate risk and the observed hospital mortality mainly fits the expected mortality as predicted by the EuroSCORE II. These observations are mainly in line with the findings of other studies.[5–11,13–15] Vohra et al.,[14] e.g.,

TABLE 3 Multivariate risk factors for hospital mortality and mortality during follow-up

	Multivariate for hospital mortality		Multivariate for mortality during follow-up	
	OR [95%CI]	*p*	OR [95% CI]	*p*
Age	0.98 [0.89–1.06]	ns	1.10 [0.75–1.87]	ns
CAD	3.23 [0.45–22.30]	ns	2.48 [0.92–6.87]	ns
h/o MI	7.26 [0.02–1.13]	ns	3.78 [0.58–9.03]	ns
Diabetes	1.23 [0.22–6.21]	ns	1.68 [0.79–3.85]	ns
pHT (<60 mmHg)	1.14 [0.22–5.62]	ns	5.34 [0.95–13.58]	ns
CKD	2.17 [0.45–12.82]	ns	1.85 [0.53–3.47]	ns
IABP	1.27 [0.05–16.87]	ns	2,57 [0.23–24.08]	ns
Re-exploration	5.59 [0.63–54.16]	ns	4.39 [0.69–16.48]	ns
PRBC/FFP	0.97 [0.87–1.08]	ns	0.01 [0.00–637.50]	ns
ICU stay >24 h	1.72 [0.15–18.34]	ns	3.47 [0.36–22.47]	ns
Respiratory failure (infection)	**12.53 [1.31–127.50]**	**.0291**	8.49 [0.74–60.59]	ns
Postop stroke	30.26 [0.89–750.21]	ns	**4.8 [1.1–12.3]**	**.021**
CVVH	4.45 [0.70–29.62]	ns	1.89 [0.35–22.09]	ns
Redo surgeries	1.07 [0.18–6.73]	ns	1.02 [0.21–4.56]	ns
Wound infection	1.01 [0.45–9.27]	ns	3.58 [0.36–6.74]	ns

Note: The bold values are the values with a significant *p*.

Abbreviations: CAD, coronary artery disease; CI, confidence interval; CKD, chronic kidney disease; CVVH, continuous venovenous hemofiltration; FFP, fresh frozen plasma; h/o, history of; IABP, intra-aortic balloon pump; ICU, intensive care unit; MI, myocardial infarction; ns, nonsignificant; pHT, pulmonary hypertension; PRBC, packed red blood cells.

reported hospital mortality of 6.0%, which nearly matches observed hospital mortality in the redo group of the present series. The same is true for the observed mortality in the first surgery group, compared to the results reported by literature.[16]

Interestingly, the nominally higher EuroSCORE II and higher incidence of comorbidities in the redo's did not translate into an inferior long-term survival, which was statistically nonsignificant different for both groups. To our best knowledge, the present series is the only study that provides such a long-term follow-up in the defined patient group. In the current literature, we could not identify a comparable study, dealing with such homogeneous groups—which finally makes subsumption of our observations difficult.

In line with these observations, neither univariate nor multivariate analysis identified redo surgery as a risk factor for hospital or long-term mortality in the present series.

On the contrary, significant differences concerning postoperative morbidity between both groups were observed. Hereby, the source of all evil seems to be increased postoperative bleeding in the redo's—leading to higher rethoracotomy rates, more transfusions, longer ventilation times, and prolonged ICU stay. Nonetheless, this did not translate into a prolonged hospital stay at all. In line with this, the occurrence of other common postoperative morbidities, such as stroke, renal failure, low cardiac output, myocardial infarction, or impaired wound healing was not significantly different between both groups.

Naturally, the risk factors for long-term mortality differed significantly from those for early mortality. In the group of hospital survivors, the single risk factor for mortality during follow-up was the presence of postoperative stroke, which seems to be quite explainable.

In conclusion, the immediate and long-term outcomes of redo-mitral valve surgery are comparable to the results of primary surgeries. Both provide good results with an acceptable amount of postoperative morbidity with respect to the intermediate- or high-risk constellation, respectively.

Nowadays many transcatheter edge-to-edge mitral procedures are performed – but the guidelines give only a recommendation for patients who are judged "inoperable or at high surgical risk."[16] As an alternative for reoperative mitral surgery, transapically performed mitral valve-in-valve or valve-in-ring procedures, an endovascular option exists too, which remains an off-label use of the devices.[2–4] Despite the obvious good immediate results of this relatively new technique, nothing really is known about long-term results, and - additionally, a natural limitation exists in the case of prior mechanical mitral valve replacement. Recently, Alexiou et al.[17] reported 1-year results of transcatheter mitral valve-in-valve (TMViV) and valve-in-ring (TMViR) procedures in 48 patients. Markedly, the hospital mortality was 0%, but 17.4% for TMViV and 36.0% for TMViR after 1 year.[17] One concern they stated was that postinterventional mitral

stenosis and a high rate of mild residual regurgitation (particularly in TMViR) plays a limiting role in the clinical outcomes.[17] Concluding, interventional alternatives do exist. The immediate results reflect absolute safety, but outcomes during further follow-up are scarce but if reported tend to be poor. Not to forget, TMViV and TMViR are an off-label use of the applied products.

For adequate decision-making, good knowledge of the risks of the different treatment options is absolutely needed. For those purposes, the present study was set up and concludingly can report, that the isolated fact "redo surgery" is not adding surgical risk. Having that in mind and with respect to the good clinical results, redo-mitral valve surgery has an unargued right to exist, even in the era of emerging catheter-based valve therapies.

In our point of view, catheter-based procedures – at this point in time – remain reserved for inoperable or high-risk patients. In doubt, the decision-making for or against redo surgery should be heart team-based, relying on the local experience and results of reoperative surgery.

4.1 | Limitations

A potentially major limitation is the tending historical character of the data, including procedures partially performed 10 years ago. Additionally, the present study naturally is limited by the differences in baselines of both groups and its retrospective design.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

ETHICS STATEMENT

The study was approved by the local Institutional Review Board. There exists no ethical conflict. Informed consent was obtained.

ORCID

Manuel Wilbring http://orcid.org/0000-0002-3382-1142

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