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Valve: Research

Impact of Complex Anatomy and Patient Risk Profile in Minimally Invasive Mitral Valve Surgery

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ABSTRACT

BACKGROUND We aimed to assess the impact of complex mitral valve disease and patient risk profile on operative outcomes in the large cohort of the Mini-Mitral International Registry.

METHODS Patients were assigned to categories of complex degenerative mitral valve regurgitation (DMR; bileaflet or anterior mitral leaflet prolapse/flail) and simple DMR (posterior mitral leaflet prolapse/flail). Subgroup analyses was performed in low-risk (EuroSCORE II <8%) and high-risk (EuroSCORE II >8%) cohorts. A logistic regression model was applied to investigate the impact of valve anatomy and patient risk factors on valve repair rate and operative risk.

RESULTS The study cohort consisted of 4524 patients with DMR (complex DMR, 1296; simple DMR, 3228). Valve repair rate was 87.3% and 91% in complex DMR and simple DMR, respectively. Predictors of valve replacement were anterior leaflet prolapse/flail, bileaflet flail, female sex, age, and reoperation, whereas Barlow disease was protective. Clinical results were comparable between complex DMR and simple DMR. On subgroup analyses, high-risk patients showed less satisfactory outcomes with respect to both the valve repair and operative mortality rates.

CONCLUSIONS Our findings suggest that complex DMR can be satisfactorily addressed by minimally invasive techniques. However, whereas complex disease was associated with low operative risk, anterior leaflet lesions and bileaflet flail remain negative predictors of successful valve repair. Conversely, valve repair rate was less satisfactory in high-risk patients, regardless of DMR complexity.

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Minimally invasive mitral valve surgery (MI-MVS) was popularized in the late 1990s and has gradually been recognized as a less traumatic approach than conventional full sternotomy.[1,2] Since its introduction, because of controversy on the versatility to address complex mitral valve disease through a narrow working space and the need for prolonged operative times, the use of MI-MVS has been limited to simple degenerative mitral valve regurgitation (DMR) and simple (low-risk) patients.[3,4] More recently, with improvement in techniques and technologies, complex mitral valve disease as well as complex (high-risk) patients can be addressed. In this study, we evaluated the impact of DMR anatomy and patient complexity on procedural and clinical outcomes in the large cohort of the Mini-Mitral International Registry (MMIR).

PATIENTS AND METHODS

STUDY OUTCOMES. The study outcomes were successful mitral valve repair, operative mortality, and composite major complications (defined as a composite of stroke, myocardial infarction, and dialysis). The outcomes were defined according to the Mitral Valve Academic Research Consortium (MVARC) end point definitions[5] and EuroSCORE II model.[6] Successful mitral valve repair was defined as the absence of mitral regurgitation ≥2+, early reintervention (30 days), and mitral valve prosthesis implantation. Operative mortality was defined as death in the same hospital in which the operation took place, before discharge from the hospital. Stroke included duration of a focal or global neurologic deficit ≥24 hours or <24 hours if available neuroimaging documents a new intracranial or subarachnoid hemorrhage or central nervous system infarction or the neurologic deficit results in death. Myocardial infarction involved either periprocedural (≤48 hours) or spontaneous (>48 hours) myocardial infarction.[5] Dialysis was defined as postoperative acute kidney injury requiring renal replacement therapy.

MMIR. The MMIR is an independent registry enrolling patients at 17 referral heart valve centers in Europe, the United States, Oceania, and Asia. The rationale and methods of MMIR were previously reported.[7] Briefly, the study population was defined as patients undergoing minimally invasive mitral valve operations with all possible indications, using all available approaches and materials. The MMIR database was designed specifically to assess patients with mitral valve disease and patients undergoing MI-MVS. It includes variables on clinical data, risk assessment, surgery-related data, perioperative outcomes, and echocardiographic data. All centers provided data by using the same definitions and assessment measures according to the current European Society of Cardiology or American College of Cardiology/American Heart Association/Heart Rhythm Society guidelines, EuroSCORE II model, and MVARC end point definitions.[5,6,8] The completed data forms were forwarded by the participating MMIR sites to the coordinating center at the Polytechnic University of Marche and reviewed for face validity and completeness.

STUDY COHORT. At the time of this study, 7513 patients were enrolled in the registry. This study population consists of patients with DMR who underwent MI-MVS. Patients with no degenerative disease (rheumatic, functional, endocarditis, and other) and those with concomitant valve stenosis were excluded. Patients were assigned to classes of complex DMR (anterior mitral leaflet [AML] and bileaflet prolapse or flail) and simple DMR (posterior mitral leaflet prolapse or flail). Preoperative, intraoperative, and postoperative outcome variables were compared between the groups. Subgroup comparisons were performed in low-risk (EuroSCORE II <8%) and high-risk (EuroSCORE II >8%) patients.

STATISTICAL ANALYSIS. Continuous variables were expressed as mean ± SD and categorical variables as percentages. Where continuous variables did not follow a normal distribution, the median and interquartile range were reported. In all cases, missing data were not defaulted to negative, and denominators reflect only cases reported. Comparisons of groups were performed with unpaired *t*-test or Mann-Whitney *U* test and χ^2 test. The multivariable association between the type of complex valve lesion (AML prolapse, AML flail, bileaflet prolapse, bileaflet flail) and the study outcomes was assessed by multivariable logistic regression. The models were adjusted for potential confounders selected a priori on the basis of their clinical significance that may directly influence the in-hospital results (age, sex, obesity, chronic lung disease, diabetes, atrial fibrillation, peripheral arteriopathy, cerebrovascular arteriopathy, pulmonary hypertension, renal impairment, reduced left ventricular ejection fraction, New York Heart Association class III-IV, previous cardiac surgery, mitral valve disease cause [fibroelastic deficiency vs Barlow disease vs form fruste], urgent/emergent status, concomitant procedures, center volume). Backward stepwise method was used to build the final models. The results are presented as adjusted odds ratios (ORs) with 95% CIs. Multicollinearity was assessed by the variance inflation factor. The level of significance, α, was set at 5%. Statistical analysis was performed with Statistical Package for Social Sciences version 29.0 (IBM, Chicago, IL).

RESULTS

BASELINE CHARACTERISTICS. From 2015 to 2021, a total of 4524 consecutive patients with DMR were treated by MI-MVS at MMIR centers. Of those, 1296 (28.6%) were described as complex DMR and 3228 (71.4%) as simple DMR. Baseline characteristics according to the type of DMR and patient risk profile are presented in Table 1. Simple DMR was more frequently associated with flail, whereas prolapse and annulus dilation were more frequently observed in complex DMR.

OPERATIVE DATA AND PROCEDURAL OUTCOMES. Operative data are listed in Table 2. The overall repair rate was 91% for simple DMR and 87.3% for complex DMR ($P < .001$), being 91.8% and 88% ($P < .001$), respectively, in the low-risk cohort and 59.8% and 63.6% ($P = .8$) in the high-risk cohort. The most common repair technique was chordal replacement, followed by resection. MVARC technical success rate was 95.6% in complex DMR and 97.2% in simple DMR ($P = .007$).

On multivariable analysis, AML prolapse (OR, 2.87), AML flail (OR, 2.09), bileaflet prolapse (OR, 1.64), and bileaflet flail (OR, 3.36) as well as age, female sex, and reoperation emerged as independent predictors of decreased probability of successful mitral repair. Conversely, Barlow disease was associated with an increased likelihood of repair (OR, 0.35). No association was found between center volume and valve outcome (Table 3).

IN-HOSPITAL RESULTS. In-hospital results are presented in Table 4. The overall mortality (1.2%) and complication rates were similar between simple DMR and complex DMR. Complex DMR repair was more frequently associated with postoperative mild mitral regurgitation, whereas the rates of moderate to severe mitral regurgitation were comparable. After adjustment for confounders, factors of complex DMR did not emerge as predictors of mortality and major complications (Table 5). Subgroup comparisons indicated no difference between simple DMR and complex DMR, in both the low-risk and the high-risk cohort (Table 4).

COMMENT

During the past decades, mitral valve surgery has made great progress with the development of less invasive approaches that better respect thoracic integrity and reduce surgical trauma.[9,10] Although there is consensus that minimally invasive mitral valve repair in low-risk patients with “simple” posterior leaflet prolapse is effective and reproducible, outcomes in patients with complex DMR and higher risk profile are less certain.[11] The institution of the MMIR[7] has enabled a comprehensive report describing the contemporary results in complex DMR and simple DMR. Our findings indicate the following: complex DMR can be satisfactorily addressed by minimally invasive approaches; complex DMR had similar clinical outcomes to simple DMR; bileaflet and AML lesions were associated with an increased risk of valve replacement or unsuccessful valve repair; and high-risk patients were associated with low rate of valve repair regardless of the complexity of valve lesions.

A successful mitral valve repair was achieved in 90.1% of patients even though a considerable number of patients had complex and multiscallop valve lesions, urgent or emergent procedures, and reoperations. In considering only elective primary operations in patients presenting with isolated P2 prolapse/flail, the rate of valve repair increased to 96%. These findings confirm that less invasive approaches ensure the optimal targets in mitral valve repair.[12]

Repairs of AML and bileaflet lesions have traditionally been considered to be more challenging than repair of posterior mitral leaflet, and multiple techniques have been proposed to improve outcomes in patients with complex DMR.[13] In MMIR, complex repairs were more likely to be performed by chordal replacement (78.5% vs 72.6%) and edge-to-edge technique (4.8% vs 1.4%), whereas resection (12.1% vs 20.4%) was more frequently used in simple DMR. Complex repair more frequently required repeated cross-clamping (4.3% vs 2.3%) because of increased initial failed attempt at valve repair. Nevertheless, consistent with data reported by

TABLE 1 Demographics

Characteristics	Overall Cohort			High-Risk Cohort			Low-Risk Cohort		
	Complex Disease (n = 1296)	Simple Disease (n = 3228)	*P* Value	Complex Disease (n = 33)	Simple Disease (n = 87)	*P* Value	Complex Disease (n = 1263)	Simple Disease (n = 3141)	*P* Value
Age, y	61 (51–72)	64 (55–72)	<.001	79 (73.5–81)	76 (69–80)	.2	61 (51–71)	64 (55–72)	<.001
Female	461 (35.6)	1102 (34.1)	.4	15 (45.5)	51 (58.6)	.2	446 (35.3)	1051 (33.5)	.2
NYHA class III–IV	524 (41)	1373 (43)	.2	30 (90.9)	71 (82.6)	.4	494 (39.7)	1302 (41.9)	.2
Diabetes	80 (6.2)	212 (6.6)	.7	3 (9.1)	21 (24.1)	.08	77 (6.1)	191 (6.1)	.9
Obesity (BMI >30 kg/m^2)	136 (10.5)	406 (12.9)	.03	3 (9.1)	12 (13.8)	.8	133 (10.5)	394 (12.8)	.04
Preoperative AF	408 (33.5)	874 (29.5)	.01	17 (60.7)	40 (61.5)	.9	391 (32.9)	834 (28.7)	.01
Dialysis	4 (0.3)	20 (0.6)	.3	1 (3)	5 (5.7)	.9	3 (0.2)	15 (0.5)	.3
Chronic lung disease	90 (6.9)	219 (6.8)	.8	5 (15.2)	16 (18.4)	.8	85 (6.7)	203 (6.5)	.7
Cerebrovascular arteriopathy	20 (1.5)	51 (1.6)	.9	2 (6.1)	10 (11.5)	.5	18 (1.4)	41 (1.3)	.8
Peripheral arteriopathy	19 (1.5)	67 (2.1)	.2	4 (12.1)	20 (23)	.2	15 (1.2)	47 (1.5)	.3
Previous cardiac surgery	37 (2.9)	74 (2.3)	.3	6 (18.2)	28 (32.2)	.2	31 (2.5)	46 (1.5)	.03
Type of valve disease			<.001			.03			<.001
FED	516 (52.6)	1269 (63)		11 (44)	31 (68.8)		505 (52.9)	1238 (62.8)	
Barlow	349 (35.6)	323 (16)		9 (36)	4 (8.9)		340 (35.6)	319 (16.2)	
Forme fruste	116 (11.8)	424 (21)		5 (20)	10 (22.2)		111 (11.6)	414 (21)	
Prolapse	1234 (95.2)	2553 (81.7)	<.001	31 (93.9)	47 (54)	<.001	1203 (95.2)	2514 (82.5)	<.001
Flail	288 (31.3)	842 (37)	<.001	6 (26)	40 (45.9)	.003	282 (31.5)	802 (36.1)	<.001
Mitral annulus dilation	617 (68.3)	1291 (56.7)	<.001	16 (72.7)	28 (53.1)	.2	601 (68.2)	1263 (56.7)	<.001
Pulmonary hypertension	478 (37.8)	1169 (37.4)	.8	26 (81.3)	58 (69)	.2	452 (36.7)	1111 (36.5)	.9
LVEF <50%	178 (13.9)	376 (11.8)	.6	17 (51.5)	27 (31.4)	.06	161 (12.9)	349 (11.2)	.1
Urgency	55 (4.2)	135 (4.2)	.9	7 (21.2)	16 (18.4)	.8	48 (3.8)	119 (3.8)	1
EuroSCORE II, %	1.1 (0.7–1.8)	1.1 (0.7–2)	.6	10.9 (9.2–12.8)	11.7 (8.9–16.8)	.2	1 (0.7–1.7)	1.1 (0.7–1.8)	.8

Categorical variables are presented as number (percentage). Continuous variables are presented as median (interquartile range). AF, atrial fibrillation; BMI, body mass index; FED, fibroelastic deficiency; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association.

TABLE 2 Operative Data

Characteristics	Overall Cohort Complex Disease (n = 1296)	Overall Cohort Simple Disease (n = 3228)	*P* Value	High-Risk Cohort Complex Disease (n = 33)	High-Risk Cohort Simple Disease (n = 87)	*P* Value	Low-Risk Cohort Complex Disease (n = 1263)	Low-Risk Cohort Simple Disease (n = 3141)	*P* Value
Surgical approach			.7			.6			.7
Direct vision	357 (27.5)	832 (25.8)		13 (39.4)	30 (34.5)		344 (27.2)	802 (25.6)	
Video assisted	485 (37.4)	1247 (38.7)		10 (30.3)	22 (25.3)		475 (37.6)	1225 (39.1)	
Totally endoscopic	440 (34)	1111 (34.5)		10 (30.3)	35 (40.2)		430 (34)	1076 (34.3)	
Robotic	14 (1.1)	33 (1)		…	…		14 (1.1)	33 (1.1)	
Conversion to full sternotomy	27 (2.1)	54 (1.7)	.4	4 (12.1)	5 (5.8)	.3	23 (1.8)	49 (1.6)	.5
Arterial cannulation site			.3			.9			.3
Femoral artery	1205 (93)	2974 (94.1)		28 (84.8)	72 (82.8)		1177 (93.2)	2902 (94.4)	
Axillary artery	14 (1.1)	32 (1)		1 (3)	2 (2.3)		13 (1)	30 (1)	
Ascending aorta	70 (5.4)	132 (4.2)		3 (9.1)	9 (10.3)		67(5.3)	123 (4)	
Other	7 (0.5)	22 (0.7)		1 (3)	4 (4.6)		6 (0.5)	18 (0.6)	
Myocardial protection			.4			.6			.3
Cardioplegia	1284 (99.2)	3210 (99.4)		32 (97)	82 (94.3)		1252 (99.2)	3128 (99.6)	
Ventricular fibrillation	10 (0.8)	13 (0.4)		1 (3)	3 (3.4)		9 (0.7)	10 (0.3)	
Beating heart	1 (0.1)	4 (0.1)		…	2 (2.3)		1 (0.1)	2 (0.1)	
Cardioplegia type			.2			.8			<.001
Blood	490 (37.8)	1308 (40.5)		6 (18.2)	21 (24.1)		484 (32)	1294 (44.9)	
Crystalloid	789 (61.3)	1902 (59)		26 (78.8)	63 (72.4)		1023 (67.6)	1579 (54.8)	
Type of surgery			<.001			.8			<.001
Mitral valve repair	1132 (87.3)	2936 (91)		21 (63.6)	52 (59.8)		1111 (88)	2884 (91.8)	
Mitral valve replacement	164 (12.7)	291 (9)		12 (36.4)	35 (40.2)		152 (12)	256 (8.2)	
Replacement due to unsuccessful repair	32 (2.5)	20 (0.6)	<.001	…	1 (1.1)	.2	32 (2.6)	19(0.6)	<.001
Type of valve repair									
Annuloplasty ring	1119 (98.9)	2907 (99.1)	.5	21 (100)	51 (98.1)	.9	1098 (98.8)	2856 (99.1)	.5
Resection	137 (12.1)	588 (20.4)	<.001	1 (4.8)	12 (23.1)	.1	136 (12.2)	576 (20.4)	<.001
Sliding plasty	46 (4.1)	75 (2.6)	.02	1 (4.8)	…	.3	45 (4.1)	75 (2.7)	.002
Artificial chords	889 (78.5)	2016 (72.6)	.001	15 (71.4)	31 (59.6)	.4	874 (78.7)	2075 (72.8)	<.001
Edge to edge	54 (4.8)	39 (1.4)	<.001	…	…	…	54 (4.9)	39 (1.4)	<.001
Concomitant procedure									
Tricuspid surgery	197 (15.2)	377 (11.7)	.005	15 (48.4)	35 (39)	.5	182 (14.4)	342 (10.9)	.003
AF surgery	209 (16.1)	481 (14.9)	.3	6 (18.2)	22 (25.3)	.5	203 (16.1)	459 (14.6)	.2
Aortic valve replacement	15 (1.2)	23 (0.7)	.2	…	1 (1.1)	1	15 (1.2)	22 (0.7)	.1
Thoracic aorta surgery	2 (0.2)	7 (0.2)	1	1 (3)	2 (2.3)	1	1 (0.1)	5 (0.2)	.7
LAA closure	207 (16)	365 (11.3)	<.001	8 (24.2)	14 (16.1)	.3	199 (15.8)	351 (11.2)	<.001
Repeated cross-clamping	56 (4.3)	73 (2.3)	<.001	…	1 (1.1)	1	56 (4.4)	72 (2.3)	<.001
CPB time, min	149 (120–188)	133 (106–169)	<.001	152 (129–180)	152 (125–194)	.9	149 (120–188)	133 (106–169)	<.001
Cross-clamp time, min	95 (73–120)	84 (64–107)	<.001	86 (64–121)	99 (67–123)	.2	95 (73–120)	83 (64–106)	<.001
Technical success	1236 (95.6)	3110 (97.2)	.007	30 (90.9)	78 (92.9)	.7	1206 (95.7)	3032 (97.3)	.007

Categorical variables are presented as number (percentage). Continuous variables are presented as median (interquartile range). AF, atrial fibrillation; CPB, cardiopulmonary bypass; LAA, left atrial appendage.

TABLE 3 Predictors of Mitral Valve Replacement and Unsuccessful Valve Repair

Variable	*P* Value	OR	95% CI
Female	<.001	2.069	1.499–2.855
Age	<.001	1.026	1.013–1.039
Redo	<.001	3.810	1.852–7.084
Cause			
FED (reference)			
Barlow	<.001	0.345	0.212–0.562
Forme fruste	.3	0.816	0.546–1.219
Prolapse			
PML (reference)			
AML	<.001	2.868	1.677–4.095
Bileaflet	.04	1.638	1.004–2.672
Flail			
PML (reference)			
AML flail	.04	2.088	1.021–4.498
Bileaflet flail	.006	3.359	1.410–8.002

AML, anterior mitral leaflet; FED, fibroelastic deficiency; OR, odds ratio; PML, posterior mitral leaflet.

others,[14] the increased repeated cross-clamping did not impair clinical outcomes. Although minimally invasive mitral valve repair was performed across a wide range of pathologic complexities, these affected valve outcomes. The repair rate and the MVARC technical success rate were higher in patients with simple DMR, and the presence of AML and bileaflet lesions was associated with 2- to 3-fold higher risk of valve replacement. However, the rate of valve repair, even in the complex DMR group, compares favorably with that reported in other multicenter registries involving full sternotomy access.[15,16] Thus, complex mitral repair should not be a deterring factor in considering whether a patient can undergo less invasive repair of the mitral valve at referral heart valve centers.

Valve repair outcomes were significantly influenced by the type of valve disease, with Barlow disease being protective against valve replacement. This was mainly related to the better outcome of patients with Barlow disease with AML or bileaflet lesions compared with those with fibroelastic deficiency. In the complex DMR group, the valve repair rate was 96.6%, 83.8%, and 86.2% in patients with Barlow disease, fibroelastic deficiency, and forme fruste, respectively. A possible explanation for this result may also involve the fact that almost 20% of patients with Barlow disease received an annuloplasty-only procedure. As previously reported,[17,18] annuloplasty-only is a simple and reliable solution to address Barlow disease in patients with a symmetric prolapse pattern with a central regurgitation jet. The valve repair rate was significantly influenced by patient risk factors. Age, female sex, and reoperation emerged as strong predictors of valve replacement. In addition, subgroup analysis revealed a less satisfactory repair rate in high-risk patients regardless of the complexity of valve disease. Whereas these results may reflect a surgeon's propensity to opt for an easier and faster procedure in such patients to shorten cross-clamp time[19] and to decrease the risk of repeated cross-clamping, it may also suggest that valve repair may not always be the preferred treatment option in such cases.

Evidence supporting comparable clinical outcomes for simple DMR and complex DMR after conventional—full sternotomy—mitral valve surgery has accumulated in the past years.[20,21] Our study demonstrated similar excellent results for patients with simple DMR and complex DMR receiving less invasive operations. Overall mortality and morbidity rates were very low in both groups, and no association between complex valve lesions and postoperative adverse events was observed (Table 5).

LIMITATIONS. This study has the limitations of any observational registry involving no adjudication of patient inclusion and data collection. Long-term outcomes are currently not sufficiently recorded to include these data in the article. Although the MMIR was specifically designed to minimize patient selection bias by including only tertiary referral centers with extensive experience in minimally invasive and mitral valve surgery and by excluding the learning curve, this bias cannot be ruled out with certainty. Our findings may not reflect management or represent patients treated and observed at community hospitals.

CONCLUSION. Findings from our registry suggest that complex DMR can be satisfactorily addressed by minimally invasive techniques. However, although complex disease was associated with similarly low operative risk compared with simple DMR, AML and bileaflet lesions remain negative predictors of successful valve repair. In MMIR, operative results were less satisfactory in high-risk patients, regardless of DMR complexity. This suggests that the decision to perform minimally invasive mitral valve repair in individual patients should be based primarily on the

TABLE 4 In-Hospital Results

Characteristics	Overall Cohort Complex Disease (n = 1296)	Overall Cohort Simple Disease (n = 3228)	Overall Cohort *P* Value	High-Risk Cohort Complex Disease (n = 33)	High-Risk Cohort Simple Disease (n = 87)	High-Risk Cohort *P* Value	Low-Risk Cohort Complex Disease (n = 1263)	Low-Risk Cohort Simple Disease (n = 3141)	Low-Risk Cohort *P* Value
In-hospital mortality	17 (1.3)	37 (1.1)	.7	3 (9.4)	10 (11.5)	.9	14 (1.1)	27 (0.9)	.5
Stroke	11 (0.89)	34 (1.1)	.6	…	2 (2.3)	1	11 (0.9)	32 (1)	.7
Delirium	64 (5.2)	179 (6)	.4	4 (15.4)	7 (10.8)	.7	60 (5)	172 (5.9)	.3
Ventilation >24 h	99 (8)	199 (6.7)	.05	7 (26.9)	12 (18.5)	.4	92 (7.7)	187 (6.5)	.1
Bleeding (requiring revision)	77 (6)	159 (4.9)	.2	5 (15.6)	5 (5.7)	.1	72 (5.7)	154 (4.9)	.3
New-onset AF	192 (15.8)	514 (17.3)	.2	2 (7.4)	10 (15.4)	.5	290 (16)	504 (17.4)	.3
Definitive PM	24 (1.9)	64 (2)	.8	1 (3.1)	8 (9.2)	.3	23 (1.8)	56 (1.8)	.9
Myocardial infarction	17 (1.3)	28 (0.8)	.3	1 (3.2)	…	.3	16 (1.3)	28 (0.9)	.4
Periprocedural (≤48 h)	16 (1.2)	24 (0.7)		1 (3.2)	…		15 (1.2)	24 (0.8)	
Spontaneous (>48 h)	1 (0.1)	4 (0.1)		…	…		1 (0.1)	4 (0.1)	
Low cardiac output	50 (3.9)	97 (3.1)	.2	5 (16.1)	12 (13.8)	.8	52 (3.4)	78 (2.8)	.2
Acute kidney injury	76 (6.2)	167 (5.6)	.5	4 (14.8)	14 (21.5)	.6	72 (6.1)	153 (5.3)	.3
Dialysis	13 (1.1)	34 (1.1)	1	2 (7.4)	5 (7.7)	1	12 (0.9)	28 (1)	.6
Vascular complications	23 (1.8)	60 (1.9)	.2	2 (6.7)	7 (8.9)	1	21 (1.7)	53 (1.8)	.2
Major	19 (1.6)	41 (1.3)		2 (6.7)	7 (8.9)		17 (1.5)	34 (1.1)	
Minor	4 (0.2)	19 (0.6)		…	…		4 (0.2)	19 (0.7)	
Wound complications	12 (0.9)	49 (1.5)	.2	…	…	…	12 (1)	49 (1.6)	.2
Mitral regurgitation (after repair)			<.001			.4			<.001
Mild	228 (21.5)	400 (15)		6 (35.3)	13 (31)		222 (21.3)	387 (14.7)	
Moderate	20 (1.9)	40 (1.5)		1 (5.9)	…		19 (1.8)	40 (1.5)	
Severe	2 (0.2)	4 (0.1)		1 (2.4)	…		1 (0.2)	4 (0.1)	
Redo for early failure	13 (1)	22 (0.7)	.3	…	3 (3.4)	.6	13 (1)	19 (0.6)	.2
ICU stay, h	23 (19–48)	23 (19–48)	.9	31 (20–60)	26 (20–120)	.8	23 (19–48)	23 (19–48)	.8
Hospital stay, d	8 (6–11)	7 (6–10)	.05	10 (8–16)	12 (7–18)	.4	8 (6–10)	7 (6–10)	.05

Categorical variables are presented as number (percentage). Continuous variables are presented as median (interquartile range). AF, atrial fibrillation; ICU, intensive care unit; PM, pacemaker.

TABLE 5 Adjusted Models for In-Hospital Mortality and Major Complications

	In-Hospital Mortality		Major Complications	
	Adjusted OR (95% CI)	*P* Value	Adjusted OR (95% CI)	*P* Value
AML prolapse	2.3 (0.51-9.72)	.2	2.1 (0.72-5.59)	.3
AML flail	1.2 (0.09-2.22)	.8	1.2 (0.14-3.38)	.2
Bileaflet prolapse	1.4 (0.53-7.12)	.9	1.9 (0.71-7.42)	.5
Bileaflet flail	1.2 (0.89-8.43)	.8	1.1 (0.81-8.24)	.6

AML, anterior mitral leaflet; OR, odds ratio.

patient's risk profile rather than on valve disease complexity.

The MMIR protocol was approved by the Ethics Committees of all participating centers, and patients gave informed consent when required.

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