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Robotic mitral valve repair: A single center experience over a 7-year period

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Abstract

Background: We report the clinical and echocardiographic results of our experience in robotic mitral valve repair over a 7-year period. The outcomes of the earliest and the latest patients will be compared.

Methods: Between March 2012 and October 2019, 226 patients underwent robotic mitral valve repair for severe mitral regurgitation in a single institution. The first 113 patients (Group 1) were operated between March 2012 and September 2015 and the last 113 patients (Group 2) between October 2015 and October 2019. Conventional techniques employed in open surgery were used. Clinical and echographic follow-up were 96.0% and 94.2% complete, respectively.

Results: Successful mitral repair was achieved in all cases with no hospital mortality. The overall survival rate was 92.7 ± 2.8% and 91.0 ± 3.2% at 3 and 7 years, respectively, with no in between groups difference ($p = 0.513$). The overall freedom from mitral reoperation was 97.4 ± 1.2% at 3 and 7 years and was similar in both groups ($p = 0.276$). Freedom from mitral regurgitation Grade 2+ at 3 and 7 years were 89.1 ± 2.6% and 87.9 ± 2.8%, respectively, with no significant difference between groups ($p = 0.056$).

Conclusions: Developing a robotic mitral repair program can be done without compromising the safety and efficacy of repair. After a well-conducted training, robotic approach allows to perform simple and complex mitral repair using similar techniques as in conventional approach and without additional risk for the patient.

KEYWORDS

minimally invasive surgical procedures, mitral valve, mitral valve insufficiency, mitral valve prolapse, robotics

Abbreviations: ACC, aortic cross clamp; AF, atrial fibrillation; CPB, cardiopulmonary bypass; FU, follow-up; ICU, intensive care unit; LV, left ventricule; MR, mitral regurgitation; MV, mitral valve; NYHA, New York Heart Association; rMVr, robotic mitral valve repair; SAM, systolic anterior motion; TTE, transthoracic echocardiogram.

1 | INTRODUCTION

Since the introduction by Dr. Carpentier[1] of the "French correction" in 1980s, valve repair for degenerative mitral regurgitation (MR) is regarded as the gold standard. Minimally invasive surgery has been gradually developed to perform these repair techniques without the morbidity associated to the sternotomy.[2] In 1996, the first video-assisted mitral valve (MV) repair via a right minithoracotomy was performed and the first robotic MV repair (rMVr) was described 2 years later.[3,4] Since then, robotic mitral surgery has been progressively developed with similar results than conventional approaches or other mini-invasive techniques even in complex disease.[5,6] Despite these excellent results, longer operative times, learning curves, and higher costs have conspired against the widespread adoption of rMVr. However, rMVr is regarded as a promising tool especially in asymptomatic patients with severe MR and preserved left ventricular (LV) function (Class IIa recommendation AHA/ACC guidelines).[7] In our center, we sustained rMVr program since 2012. In this paper, we report the clinical and echocardiographic results of our 7 years experience in rMVr. The outcomes of the earliest and the latest patients will be compared to evaluate the evolution of this technique in our institution and its potential impact on morbidity (MV reoperation and MR recurrence) and mortality.

2 | MATERIALS AND METHODS

2.1 | Study design

Between March 2012 and October 2019, 226 patients underwent rMVr with the Da Vinci Si System® (Intuitive Surgical Inc.) for severe MR at the Cliniques Universitaires Saint-Luc, Brussels. The first 113 patients were operated between March 2012 and September 2015 (Group 1) and the last 113 patients were operated between October 2015 and October 2019 (Group 2). The patient's inclusion criteria evolved over time. At the beginning, we only included patients with single scallop prolapse for whom a simple repair was anticipated. We progressively included patients with more complex mitral diseases (anterior/bileaflet/multiscallops prolapses or extensive Barlow's disease). This definition of mitral surgery complexity into simple and complex repair is in line with international guidelines.[7] Finally, patients with concomitant procedures were also included. Our current algorithm which is based on Gillinov's one and exclusions criteria to a robotic approach are presented in Figure 1.[8] All patients had a preoperative thoraco-abdominal CT-scan to rule out presence of anatomical contraindications. All patients signed an informed consent form. The local ethics committee approved this study. Patients characteristics are presented in Table 1.

2.2 | Operative technique

Our surgical technique has been descrided in details in a previous paper.[9] The Da Vinci surgical Si System® (Intuitive Surgical Inc.) was used. A right minithoracotomy (4 cm) was made at the fourth intercostal space (ICS) for working port and optic system, ascending aortic root cardioplegia, and vent. This first incision was made at the mammary fold in women. Four other centimetric incisions were made, one at the third ICS (anterior axillary line) for left instrument arm port and CO_2 insufflation, one at the fifth ICS (midaxillary line) for left suction drainage catheter, one at the sixth ICS (midaxillary line) for right instrument arm port, and a last one at the fourth or fifth ICS (midclavicular line) for left atrial retractor. Cardiopulmonary bypass (CPB) was established via femoral canulation with seldinger technique. In the early experience, a bicaval venous drainage was systematically used through internal jugular vein cannulation. We currently use a multiple stage venous drainage and bicaval venous drainage is only performed in case of surgery for right cavities. Direct external aortic clamping was used through the third ICS on midaxillary line with a Chitwood transthoracic aortic cross clamp (ACC), and cardiac arrest and myocardial protection were obtained with intermittent cold antegrade crystalloid cardioplegia every 30 min. The operations were conducted under moderate hypothermia at 32°C. In case of atrial fibrillation (AF), a cryomaze procedure with left appendage ligation were performed first. Left appendage ligation was performed alone in case of permanent AF or frailty condition of patients.

Conventional techniques normally employed in mitral surgery via full sternotomy and annuloplasty with prosthetic ring were used alone or in association (Table 2). Partial annuloplasty, using a posterior band (ATS band®; Medtronic Inc.), was used for 14 patients during our initial experience, as reported from most authors, and then abandoned to introduce the use of a complete annuloplasty ring, as we routinely do in conventional MVr. Initially secured to the mitral annulus with interrupted U stiches of polyester sutures and tying the knots extracorporally, we introduced the Cor-knot device® (LSI solution; Victor) in October 2015.

2.3 | Follow-up (FU)

MV function was assessed on intraoperative transoesophageal echocardiogram and transthoracic echocardiogram (TTE) before hospital discharge. MV regurgitation was evaluated by Doppler mapping. It was defined as none, mild (Grade 1+), moderate (Grade 2+), moderate to severe (Grade 3+), and severe (Grade 4+). The 2008 Society of Thoracic Surgeons/American Association for Thoracic Surgery/European Association for Cardio-Thoracic Surgery guidelines were used to report morbidity and mortality.[10] Early MV reoperations were defined as these occurring in the first 30 postoperative days while operations beyond the first postoperative month were considered as late reoperations. A routine clinical and echocardiographic FU was obtained at 2 months postoperatively. Further clinical FU and echocardiographic data were obtained yearly from our echocardiographic database, by patient's referring physicians contacts or by patient's phone interviews. The mean clinical FU was 39.3 ± 26.0 months and the mean echocardiographic FU was 38.1 ± 26.5 months. Clinical FU and echographic FU were 96.0% and 94.2% complete, respectively.

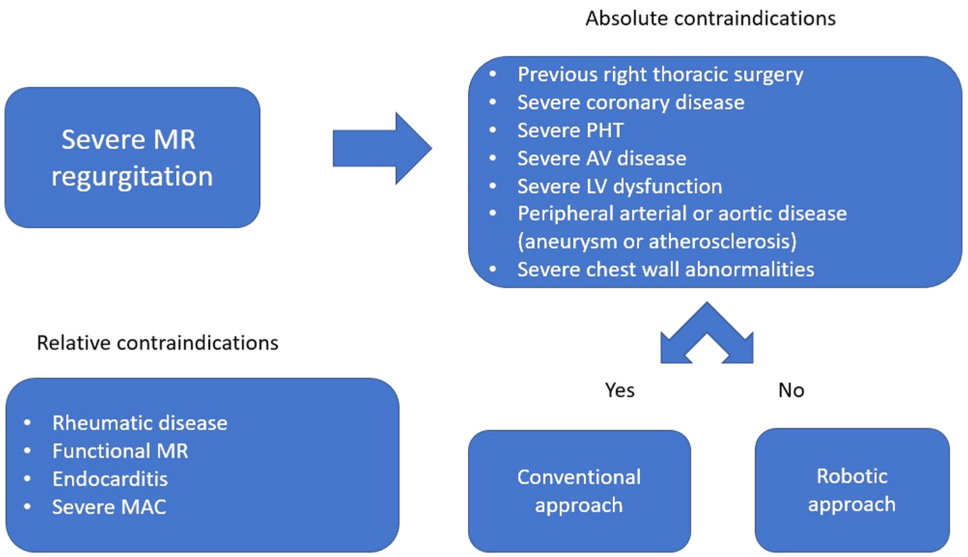

FIGURE 1 Patient's selection algorithm. AV, aortic valve; LV, left ventricule; MAC, mitral annulus calcifications; MR, mitral regurgitation; PHT, pulmonary hypertension.

2.4 | Statistical analysis

IBM SPSS statistics software version 27 was used for statistical analysis. Numeric variables are presented as means ± standard deviation or medians. Categorical variables are presented as frequencies (percentages). χ^2 test was used to compare categorical variables and *T*-test was used to compare continuous variables. Kaplan–Meier curves and log-rank test were used to assess for significance of survival differences. Box plots were used to display the distribution in continuous variables over time and one-way analysis of variance was used to assess for differences between the means of these. For all these tests, a *p*-value of less than 0.05 was the chosen significance level.

3 | RESULTS

3.1 | Patients

Mean age was 57.3 years (±12.1) and 78.8% were male. Most of the patients were referred early to surgery and therefore were no or poorly symptomatic (93.8% of patients had dyspnea New York Heart Association I or II and 11.1% presented with AF). Most presented with a Grade 4+ MR. The principal etiology was a degenerative MV disease (225 patients—99.6%) of which 64 patients had an extensive Barlow's disease (28.3%). One patient had a congenital MV disease with an anterior MV cleft. Among preoperative characteristics, 119 patients (52.7%) had a complex mitral disease defined as anterior, bileaflet (including Barlow's disease), or multiscallops prolapse.[7] The remaining 106 patients (46.9%) had a simple mitral disease (posterior single scallop prolapse). The surgical complexity of cases growing over time is presented in Figure 2. The preoperative patients characteristics are listed on Table 1.

3.2 | Operative and perioperative outcomes (in-hospital)

Among the 226 patients, 201 (88.9%) underwent an isolate MV surgery and 25 (11.1%) had one or more concomitant procedures. In all patients, successful MVr was achieved with no need for mitral replacement. Five patients (2.2%) were converted to open surgery. The reasons were pleural adhesions (one patient), significant blood backflow through left cavities impeding adequate surgical exposure (one patient), technical equipment failure (one patient), tear in the aorta during insertion of the cardioplegia canula (one patient), and a residual MR with systolic anterior motion (SAM) (one patient). Thirteen patients had a second run of CPB (5.8%) for residual MR or SAM. The mean CPB and ACC times were 155.5 ± 34.7 and 108.4 ± 26.6 min, respectively. Both CPB and ACC times improved significatively over the time as shown in Figure 3. The operative outcomes are listed in Table 2.

There was no hospital mortality. Three patients needed a definitive pacemaker implantation for permanent atrioventricular block (1.3%). No femoral artery or vein complications were observed. Two patients (0.9%) suffered from an immediate postoperative acute coronary syndrome requiring a diagnostic left catheterization. One patient had a severe vasospasm of the right coronary artery which was successfully treated by nitrates infusion. The second patient was diagnosed with a total occlusion of circumflex artery probably due to a stitch of the ring annuloplasty and required urgent revascularisation. One patient needed an early MV reoperation at postoperative Day 12 for a recurrent MR due to a ring dehiscence. This patient was reoperated through sternotomy and

TABLE 1 Patients characteristics.

	Overall (*n* = 226)*n* (%) or mean ± SD	Group 1 (*n* = 113)*n* (%) or mean ± SD	Group 2 (*n* = 113)*n* (%) or mean ± SD	*p* value
Demography				
Male	178 (78.8)	94 (83.2)	84 (74.3)	0.104
Age (years), mean ± SD	57.3 ± 12.1	56.5 ± 12.2	58.2 ± 12.1	0.279
BMI	24.8 ± 3.4	24.8 ± 3.6	25.2 ± 3.3	0.439
Clinical data				
NYHA I	118 (52.2)	60 (53.1)	58 (51.3)	0.790
NYHA II	94 (41.6)	45 (39.8)	49 (43.4)	0.589
NYHA III	14 (6.2)	8 (7.1)	6 (5.3)	0.581
AF	25 (11.1)	14 (12.4)	11 (9.7)	0.525
Hypertension	69 (30.5)	32 (28.3)	37 (32.7)	0.470
Diabetes mellitus	5 (2.2)	4 (3.5)	1 (0.9)	0.175
Coronary disease	14 (6.2)	5 (4.4)	9 (8.0)	0.277
Extracardiac arteriopathy	4 (1.8)	4 (3.5)	0 (0.0)	0.044
History of cerebro vascular disease	6 (2.7)	2 (1.8)	4 (3.5)	0.408
Smoking history	49 (21.7)	26 (23.0)	23 (29.4)	0.628
COPD	4 (1.8)	2 (1.8)	2 (1.8)	1.000
Euroscore II	0.67 ± 0.01	0.67 ± 0.01	0.67 ± 0.01	1.000
Echographic data				
LV ejection fraction (%)	64.4 ± 7.4	62.8 ± 6.8	65.9 ± 7.7	0.003
Dilated LV (LVESD > 40 mm)	134 (59.3)	67 (59.3)	67 (59.3)	1.000
RV (ml)	77.9 ± 30.9	81.7 ± 27.0	73.7 ± 34.3	0.073
MR etiology				
Degenerative	225 (99.6)	113 (100)	112 (99.1)	0.316
Simple mitral disease (posterior single scallop prolapse)	106 (46.9)	69 (61.2)	37 (32.7)	<0.001
Complex mitral disease (anterior, blieaflet, or multiscallops disease)	120 (53.1)	44 (38.9)	76 (67.3)	<0.001
Barlow's disease	64 (28.3)	19 (16.8)	45 39.8)	<0.001
Congenital	1 (0.4)	0 (0.0)	1 (0.9)	0.316

Abbreviations: AF, atrial fibrillation; BMI, body mass index; COPD, chronic obstructive pulmonary disease; LV, left ventricule; LVESD, left ventricular end-systolic diameter; MR, mitral regurgitation; NYHA, New York Heart Association; RV, right ventricule.

TABLE 2 Operative details.

	Overall population (n = 226)n (%) or mean ± SD	Group 1 (n = 113)N (%) or mean ± SD	Group 2 (n = 113)N (%) or mean ± SD	p value
MV repair	226 (100)	113 (100)	113 (100)	>0.99
MV repair procedure				
Ring annuloplasty	219 (96.9)	110 (97.3)	109 (96.5)	0.70
Complete ring	205 (90.7)	96 (85.0)	109 (96.5)	0.003
Posterior band	14 (6.2)	14 (12.4)	0 (0.0)	<0.001
Annulus decalcification	2 (0.9)	0 (0.0)	2 (1.8)	0.16
Leaflet resection	117 (51.8)	39 (34.5)	78 (69.0)	<0.001
Quadrangular resection	4 (1.8)	3 (2.7)	1 (0.9)	0.31
Triangular resection	112 (49.6)	36 (31.9)	76 (67.3)	<0.001
Butterfly resection	1 (0.4)	0 (0.0)	1 (0.9)	0.32
Sliding plasty PML	2 (0.9)	0 (0.0)	2 (1.8)	0.16
AML neochords	38 (16.8)	21 (18.6)	17 (15.0)	0.48
PML neochords	148 (65.5)	78 (69.0)	70 (61.9)	0.26
Chordae transfer	2 (0.9)	2 (1.8)	0 (0.0)	0.16
AL commissuroplasty	4 (1.8)	2 (1.8)	2 (1.8)	0.99
PM commissuropalsty	17 (7.5)	14 (12.4)	3 (2.7)	0.006
Cleft repair	52 (23.0)	27 (23.9)	25 (22.1)	0.75
Concomitant procedures	25 (11.1)	8 (7.1)	17 (15.0)	0.06
Tricuspid annuloplasty	4 (1.8)	0 (0.0)	4 (3.5)	0.04
AF ablation surgery	6 (2.7)	2 (1.8)	4 (3.5)	0.51
LA closure	20 (8.8)	9 (8.0)	11 (9.7)	0.64
ASD closure	2 (0.9)	0 (0.0)	2 (1.8)	0.16
Myxoma	2 (0.9)	1 (0.9)	1 (0.9)	0.99
CPB time (min)	155.5 ± 34.7	162.1 ± 35.6	148.9 ± 32.7	0.004
ACC time (min)	108.4 ± 26.6	116.7 ± 25.9	100.2 ± 24.8	<0.001
Operative time (min)	269.8 ± 127.6	309.2 ± 142.3	230.9 ± 97.2	<0.001
Conversion	5 (2.2)	4 (3.5)	1 (0.9)	0.18
Second run	13 (5.8)	6 (5.3)	7 (6.2)	0.76

Abbreviations: ACC, aortic cross clamp; AF, atrial fibrillation; AL, antero-lateral; AML, anterior mitral leaflet; ASD, atrial septal defect; CPB, cardiopulmonary bypass; LA, left appendage; MV, mitral valve; PM, postero-medial; PML, posterior mitral leaflet.

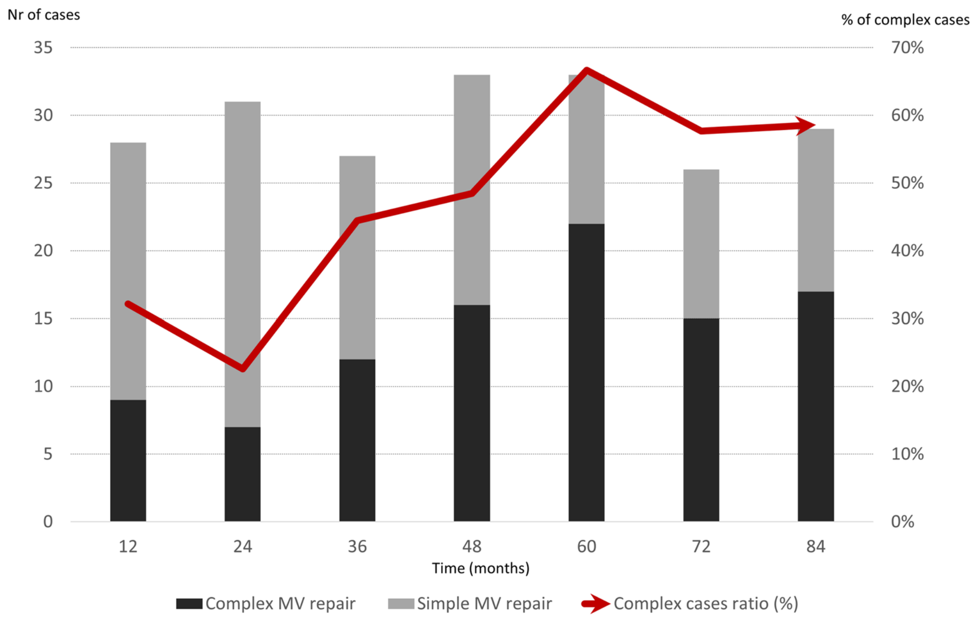

FIGURE 2 Complex cases growth over time. Proportion of complex operative cases is constantly increasing as indicated by the solid line. Number of complex cases by year is shown as a bar graph.

underwent MV rerepair. No surgical site infection was recorded. At discharge TTE, 115 patients (50.9%) had no MR, 109 patients (48.2%) had MR Grade 1+, and 2 patients (0.9%) had MR Grade 2+. Both patients were asymptomatic with stable moderate MR at latest FU (86.2 and 4.6 months, respectively). Mean intensive care unit stay and hospital stay in days were 2.4 ± 1.7 and 7.9 ± 3.2, respectively. The other relevant immediate postoperative outcomes and complications are listed in Table 3.

3.3 | Mid- and long-term outcomes

Five patients (2.2%) died during FU. Causes of death were stroke, cancer, car crash, and unexplained in two patients. Overall survival was 92.7 ± 2.8% and 91.0 ± 3.2% at 3 and 7 years, respectively, with no in between groups difference ($p = 0.513$) (Figure 4). Four patients (1.8%) underwent a late MV reoperation and the MV was rerepaired in all cases. Causes of mitral reoperations were recurrent severe MR for three of them and mitral endocarditis for one patient. The overall freedom from MV reoperation was 97.4 ± 1.2% at 3 and 7 years which was similar in both groups ($p = 0.276$) (Figure 5). Overall freedom from MR (Grade 2+) was 89.5 ± 2.5% and 88.4 ± 2.7% at 3 and 7 years, respectively ($p = 0.056$) (Figure 6). Four patients experienced late recurrence of MR (Grade 3+) in the early experience, and three of them underwent a successful new MV reoperation. The fourth patient presented a recurrent severe MR 10 months after surgery without any symptoms or left ventricular dilatation. Because of the stability of her MR and the absence of symptoms under medical treatment, a watchful waiting approach was adopted. The complexity of MV disease had no impact in the development of MR recurrence or the need of a second MV reoperation ($p = 0.072$ and $p = 0.244$, respectively).

4 | DISCUSSION

This study reports a single center experience on robotic MV repair over a 7-year period. The results of our series are comparable with those reported in other large series.[11–15] In particular, we reported 100% rate of valve repair even in the few cases that needed to be reoperated. Furthermore, there was no in-hospital mortality and very low rate of postoperative complications and conversion.[16] Most of the conversions were reported in our early experience. In our initial series of patients, operative times were significantly longer compared to conventional mitral repair, as reported by other authors.[17]

Differently from other series, in our institution, we had an extensive experience with conventional MVr with Carpentier's techniques and the full sternotomy was the preferred approach. We started our experience with minimally invasive approach using port access in 2000, but we preferred to move to robotic surgery in 2012. We reproduced in robotic setting all the conventional surgical techniques we were familiar with in open surgery including the use of complete annuloplasty. This allows us to assess to robotic program also complex mitral diseases differently from other groups who preferred only to address simple repairs only.[18] The percentage of robotic approach in our mitral practice has gradually increased over time. At the beginning, only patients with simple mitral disease for which a simple repair was expected were referred to a robotic surgery which represented about 30% of all MV repair. As illustrated in Figure 2, we started to include more and more complex cases 2 years later, after 60 operated cases. Today, patients are no more selected according to the complexity of their mitral pathology and about 70% of isolated mitral disease (that do not require any aortic procedure or myocardial revascularization) are performed robotically. A certain percentage of mitral repairs are still performed by

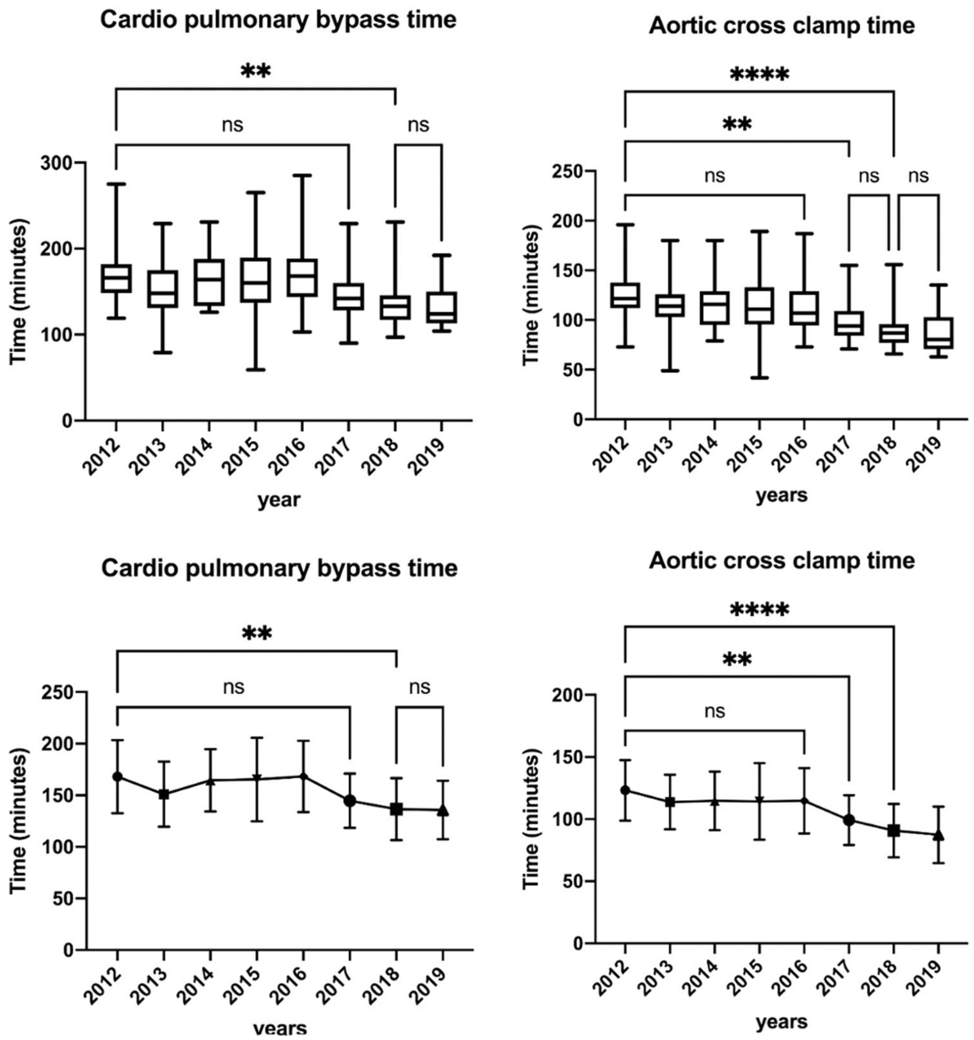

FIGURE 3 CPB and ACC times over the time. Both CPB and ACC times improved significatively over the time. For CPB time, there was a significant difference between 2012 and 2018 ($p = 0.009$) while the difference began to be significative already in 2017 for ACC time ($p = 0.008$). **CPB < 0.0009,**ACC < 0.008,****ACC < 0.001. ACC, aortic cross clamp; CPB, cardiopulmonary bypass.

sternotomy in case of exclusion criteria contraindicating a robotic approach (Figure 1). Moreover, the MV repair teaching and learning are still performed by sternotomy in our center.

Reasons of this positive experience could be found in the surgical easiness provided by the intuitive robotic set up and in the intensive training (wet and dry labs) sustained in our institution. Second, a careful selection of the patient and a dynamic inclusion algorithm was the key in ensuring positive outcomes with progressively more surgical complexity. Third, the introduction of technique advancements as Cor-Knot® DEVICE LSI Solutions Technology improved surgical ease and contributed to reduce CPB and ACC times. The steady appearances of ACC and CPB times during the four first years could be explained by the superposition of different learning curves due to several changes in the surgical team. Two surgeons (A and B) composed the team at the beginning. When the surgeon B left in 2013, another one (surgeon C) joined temporarily for 2 years. Finally, a new surgeon (D) joined the team in 2015 and the current team is composed of surgeons A and D. These changes can explain that ACC and CPB times seems to plateaued between 2015 and 2016 before continuing to decline from 2017 (Figure 3). However, this must be balanced with the fact that we continued to operate more and more complex cases, which may also explain these plateaus. Despite these changes, no impact on survival, recurrence rate of MR, or MV reoperation were seen. This underlines the greater importance of a dedicated team experience and expertise rather than the individual one to ensure safety and efficiency in robotic MV surgery. In that way, we believe that the surgical team's learning curve is more important than the individual one. However, overall operative times are still comparable with other series [16].

Another important point regards conversion rate which was 2.2%, largely within the reported incidence as described in a recent review of the evidence.[19] Interestingly, reasons for conversion in our series also included preoperatively detectable conditions as pleural adhesions or aortic dilation. This underlines the importance of a preoperative work-up protocol including thoraco-abdominal CT to rule out chest or vascular conditions at risk and contraindicating a

TABLE 3 Early postoperative morbidity and outcomes.

	Overall (n = 226) N (%) or mean ± SD	Group 1 (n = 113) N (%) or mean ± SD	Group 2 (n = 113) N (%) or mean ± SD	p value
Clinical data				
New onset-AF	55 (24.3)	21 (18.6)	44 (38.9)	0.04
Flutter	7 (3.1)	3 (2.7)	4 (3.5)	0.70
Pacemaker	3 (1.3)	2 (1.8)	1 (0.9)	0.56
STEMI	2 (0.9)	1 (0.9)	1 (0.9)	>0.99
Diaphragmatic paralysis	1 (0.4)	0 (0.0)	1 (0.9)	0.32
Early MV reoperation	1 (0.4)	0 (0.0)	1 (0.9)	0.32
30-Day stroke/cerebral bleeding	4 (1.8)	3 (2.7)	1 (0.9)	0.31
Hospital mortality	0 (0.0)	0 (0.0)	0 (0.0)	/
ICU length of stay	2.4 ± 1.7	2.3 ± 2.1	2.4 ± 1.2	0.44
Hospital length of stay	7.9 ± 3.2	7.9 ± 3.5	7.9 ± 2.8	0.10
Discharge echography				
MR Grade 0	115 (50.9)	47 (41.6)	68 (60.2)	0.005
MR Grade 1+	109 (48.2)	65 (57.5)	44 (38.9)	0.005
MR Grade 2+	2 (0.9)	1 (0.9)	1 (0.9)	>0.99
Mitral mean gradient (mmHg)	3.0 ± 1.4	3.2 ± 1.4	2.7 ± 1.3	0.01

Abbreviations: AF, atrial fibrillation; ICU, intensive care unit; MR, mitral regurgitation; MV, mitral valve; SD, standard deviation.

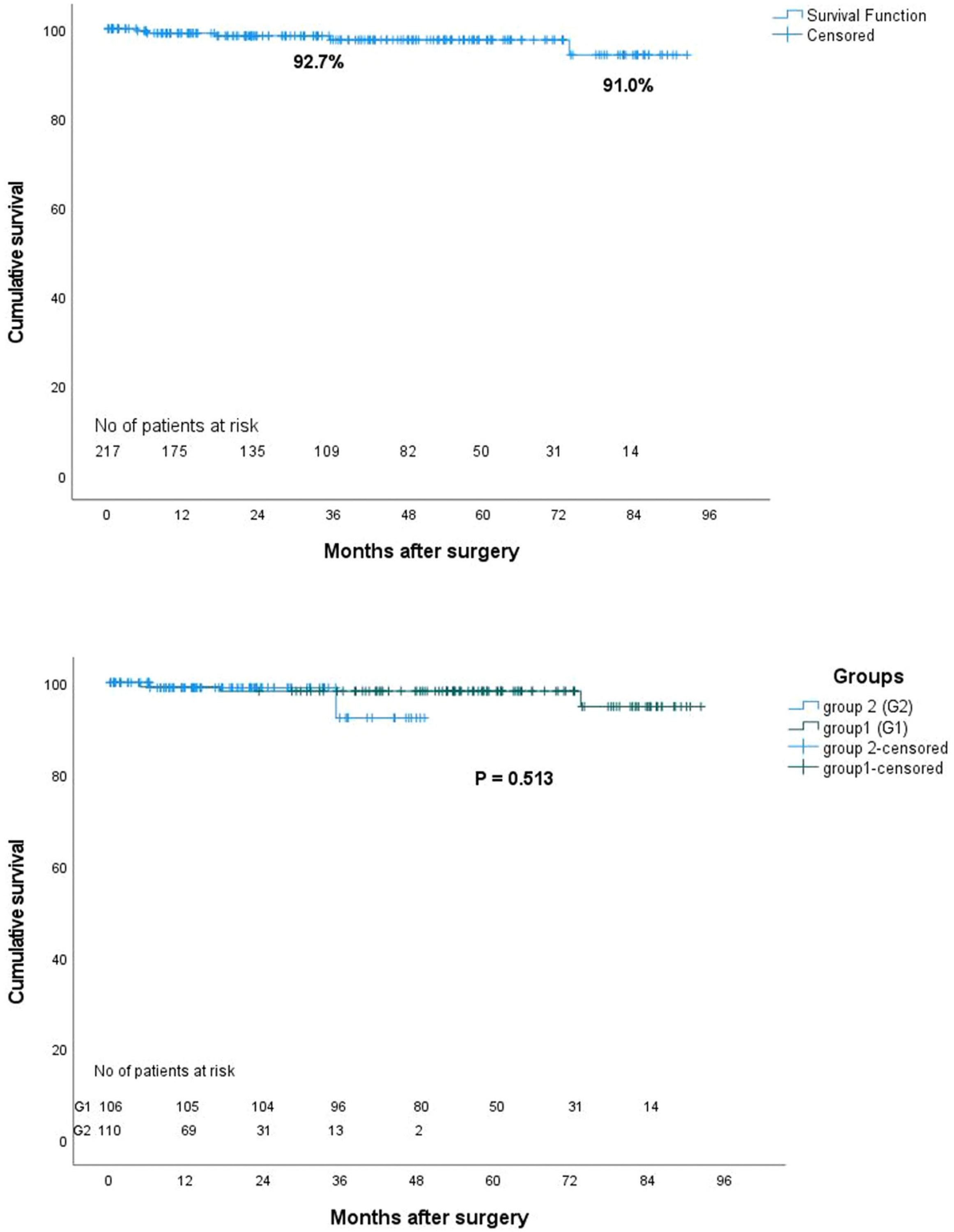

FIGURE 4 Overall survival for the complete cohort and by groups. No significant difference was seen between groups ($p = 0.513$).

robotic approach. A preoperative angiogram to identify left circumflex dominance or any other coronary abnormalities is also paramount to prevent coronary injury or issue in myocardial protection. The actual rate of postoperative permanent pacemaker implantation was 1.3% while other series reported even doubled incidence.[14] In our experience, the implantation of a definitive pacemaker took place on average postoperative Day 10. The lack of a fast-track program in our institution could also explain these longer hospital stays. There was no operative and hospital mortality and the rates of major cardiac or neurological events and

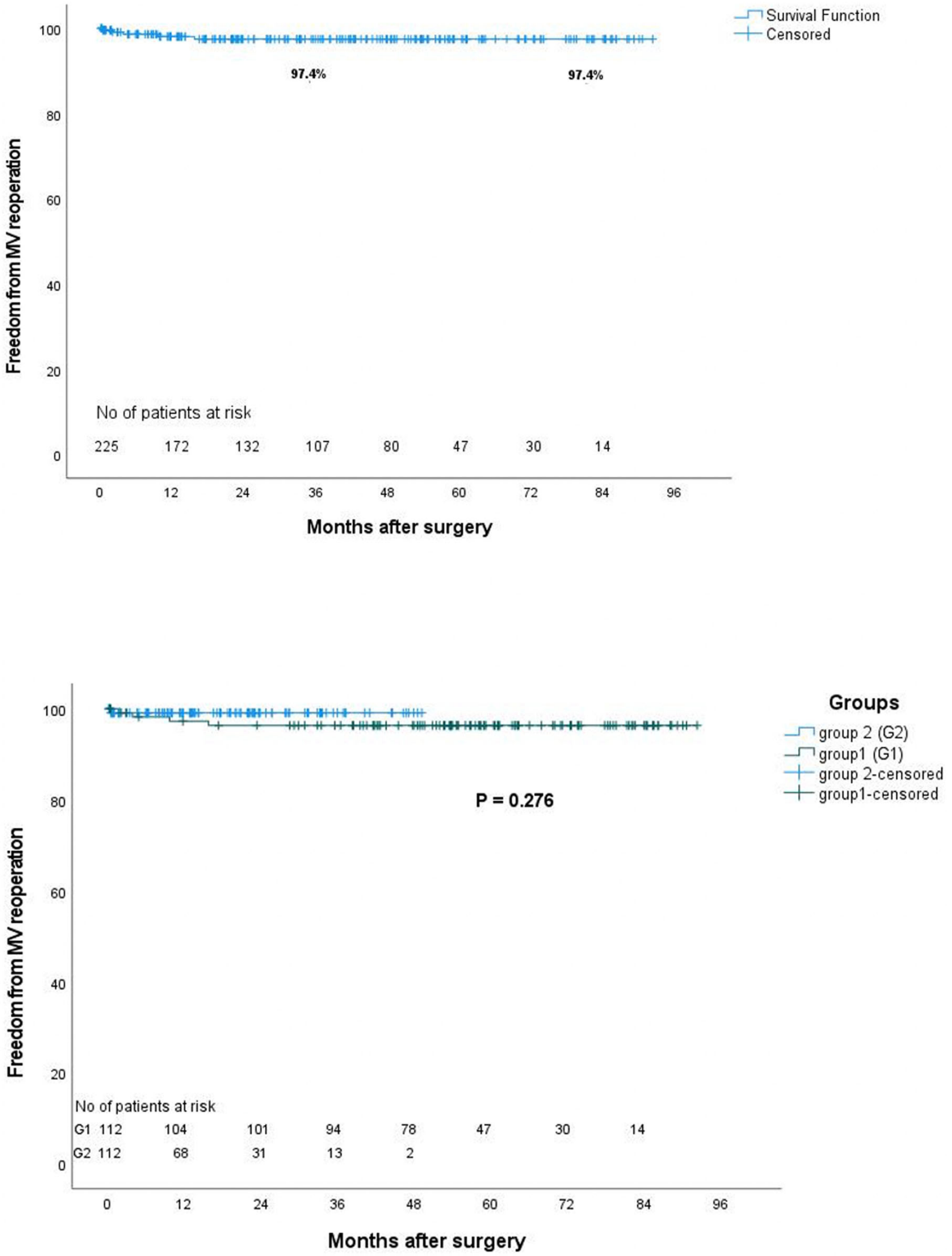

FIGURE 5 Freedom from MV reoperation for the overall cohort and by groups. Freedom from MV reoperation is excellent with no difference between groups ($p = 0.276$). MV, mitral valve.

reoperation were very low and similar to previously reported series.[15,16] Success rate in MV repair at discharge was 98% which positively compares with other series.[11,16] Freedom from MR Grade 2+ and from reoperation at 7 years remains excellent and in agreement with the literature on both minimally invasive and classical sternotomical approach.[12,15] Importantly, all patients

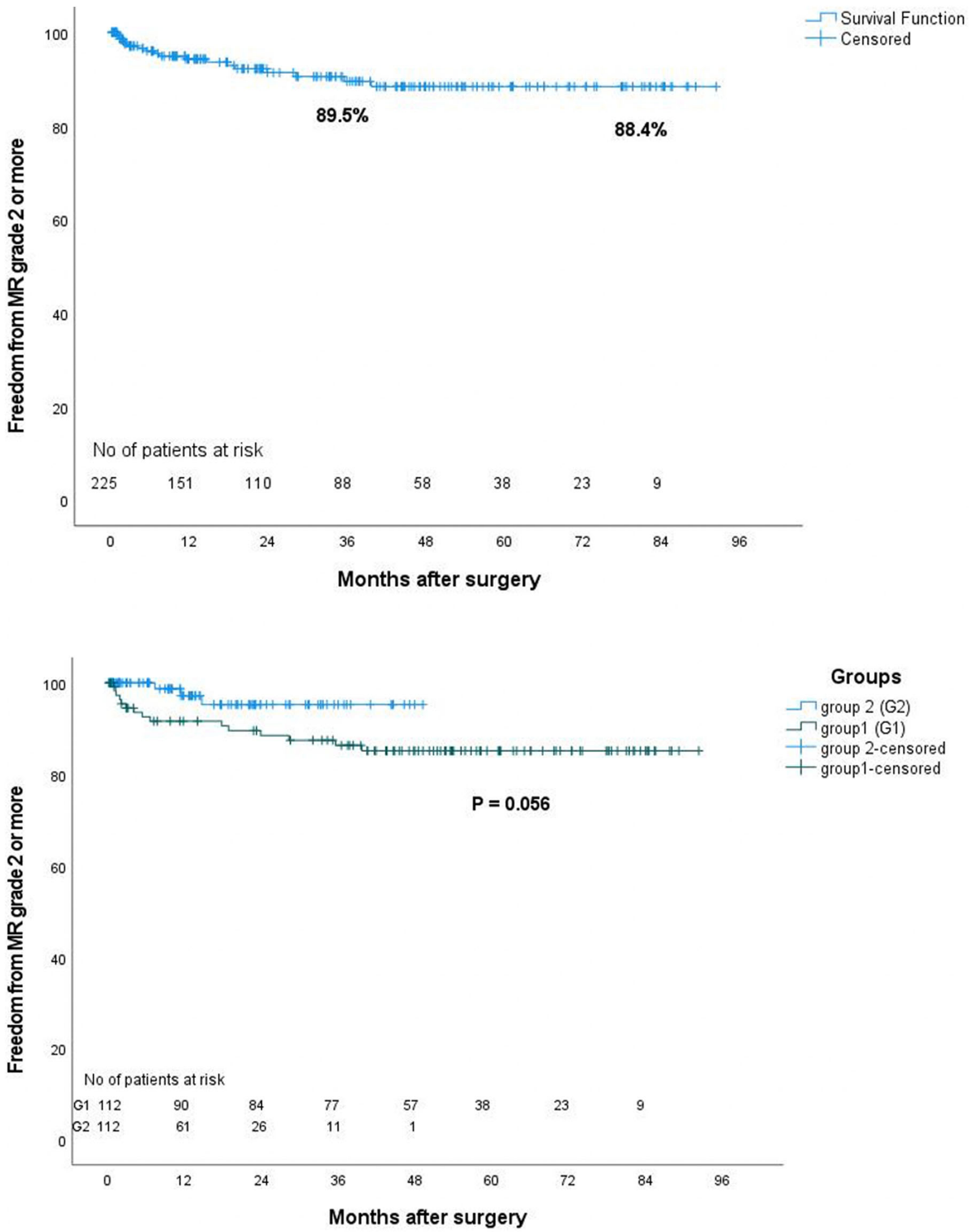

FIGURE 6 Freedom from MR Grade 2 or more for the overall cohort and by groups. Freedom from MR Grade 2 or more for the entire cohort and by groups. No significant difference was seen between groups ($p = 0.056$). MR, mitral regurgitation.

needing a late mitral reintervention belonged to the first group and the majority of reoperation occurred in the first postoperative year due to early repair failure. This observation again underlines the importance of an adequate learning curve and the need for a dedicated team as previously described.[20]

4.1 | Limitations

The retrospective nature of this study impedes to draw definitive conclusions from the results reported. The fact that the clinical and echocardiographic FU were not performed in the same center and by the same practitioners could have introduced a bias in the analysis and affect the results.

5 | CONCLUSIONS

In our series of 226 consecutive patients undergone robotic mitral repair, we report no operative and early mortality, infrequent complications, and satisfactory mid- and long-term outcomes in terms of freedom from significative MR recurrence and MV reoperation. Our team learning curve only highlighted the technical improvements as shown by ACC and CPB times reduction but never compromised the safety and quality of repair even for complex MV disease. In that way, we can say that developing a robotic mitral repair program after a well-conducted training and accurate dynamic patient's selection with progressive complexity of disease is a safe, feasible, reproductible, and durable approach.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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