

Long-term Durability of Mitral Valve Repair Surgery for Degenerative Regurgitation

Durabilidad a largo plazo de la cirugía reparadora de la válvula mitral con insuficiencia de tipo degenerativo

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ABSTRACT

Background: The aim of this study was to evaluate long-term results of degenerative mitral valve regurgitation (MR) repair.

Methods: Between January 2008 and December 2019, 457 patients (mean age 64.9 ± 12.2 years; 61.1% men) with severe MR underwent MV repair surgery. Median follow-up was 3.0 years (IQR 4.1 years) and was completed in 98.7% of patients. Periodic echocardiographic studies were performed, and long-term survival, the recurrence rate of moderate-severe MR and the need for reintervention were analyzed.

Results: At 10-year follow-up, long-term survival was high without significant differences according to the affected leaflet: posterior leaflet $95 \pm 2.1\%$, and anterior leaflet $94 \pm 2.2\%$ ($p=0.54$). Patients with preoperative functional class III/IV ($n=142$) presented higher mortality at follow-up: $13.9 \pm 4.1\%$ vs. $2.7\% \pm 1.2\%$ ($p=0.001$). The risk of recurrence for moderate-severe MR at the end of follow-up for the total group of patients was $14.6 \pm 4.3\%$ and freedom from recurrence according to the affected leaflet was high without significant difference: posterior leaflet $90 \pm 3.4\%$ and anterior leaflet $80 \pm 8.5\%$ ($p=0.97$). Finally, the need for reoperation in post-repair follow-up was $4.7 \pm 3.3\%$

Conclusions: Long-term survival after MV repair is high and the need for reoperation is infrequent. There is a progressive increase in MR recurrence at the long-term follow-up.

Key words: Heart Valve Prosthesis Implantation - Mitral Valve Insufficiency - Mitral Valve/Surgery - Treatment Outcome

RESUMEN

Introducción: El objetivo del estudio es evaluar los resultados alejados de la reparación de la válvula mitral (VM) con insuficiencia de tipo degenerativo.

Material y Métodos: Entre enero 2008 y diciembre 2019 se efectuó cirugía reparadora de la VM en 457 pacientes con insuficiencia mitral grave (IM). La edad promedio fue $64,9 \pm 12,2$ años, y 61,1% eran de sexo masculino. El seguimiento clínico mediana 3,0 (RIC 4,1 años) se completó en el 98,7% de los pacientes. Se efectuaron estudios ecocardiográficos de seguimiento en forma periódica, se analizó la sobrevida, la recurrencia de IM moderada-grave en forma global y según el tipo de valva afectada, y la necesidad de re intervención en el seguimiento alejado.

Resultados: A 10 años de seguimiento la sobrevida alejada fue elevada sin diferencias significativas según la valva afectada: valva posterior $95 \pm 2,1\%$, y valva anterior $94 \pm 2,2\%$ ($p=0,54$). El grupo de pacientes con clase funcional preoperatoria III/IV ($n=142$) presentó mayor mortalidad al seguimiento: $13,9 \pm 4,1\%$ vs. $2,7\% \pm 1,2\%$ ($p=0,001$). El porcentaje de recurrencia de IM moderada-grave al finalizar el seguimiento para el grupo total de pacientes fue del $14,6 \pm 4,3\%$ y el periodo de libertad de recurrencia según valva afectada fue elevado sin diferencia significativas: valva posterior $90 \pm 3,4\%$ y valva anterior $80 \pm 8,5\%$ ($p=0,97$). Por último, la necesidad de reintervención en el seguimiento post reparación fue del $4,7 \pm 3,3\%$

Conclusiones: la sobrevida alejada post reparación de IM es elevada y la necesidad de reintervención poco frecuente. Existe un aumento progresivo en la recurrencia de IM en el seguimiento alejado.

Palabras clave: Implantación de Prótesis de Válvulas Cardíacas - Insuficiencia de la Válvula Mitral - Válvula Mitral/cirugía - Resultado del tratamiento

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INTRODUCTION

Although no randomized clinical trials have been carried out comparing mitral valve (MV) repair surgery vs. valve replacement in patients with degenerative mitral valve regurgitation (MR), the benefits of valve preservation have been demonstrated by a large number of retrospective clinical studies. (1, 2) In most hospitals of our setting, there has been a slow but constant increase of MV repair procedures, although there is still a great disparity in the adoption of this technique, especially in complex cases. The durability of MV repair in degenerative MR has been a topic of intense debate in the last decade. It is now possible to recognize the factors associated with early and late recurrence of severe post repair regurgitation. (3) This has allowed the development of surgical groups with more experience in the management of complex cases, with the need to use new valve repair techniques. (4) In order to maximize long-term repair durability, it is necessary to a) consider the indication for surgery in earlier stages, b) perform a complete correction of pathological lesions, c) use mitral annuloplasty systematically, d) employ the new repair techniques and e) not tolerate post-surgical residual regurgitation. (5)

The global aim of the study was to evaluate long-term results of MV repair in degenerative MR in a single specialty center.

The specific points to evaluate were: 1- Long term survival according to the type of affected leaflet and its association with preoperative symptoms. 2- Recurrence of moderate-severe MR at follow-up. 3- period free from MR according to the leaflet repaired. 4- The need for reintervention at follow-up.

METHODS

Study design: This report is a retrospective analysis of a prospective cohort, consecutively including all patients with degenerative MR operated on between January 2008 and December 2019.

Population: Inclusion criteria: Patients older than 18 years, with severe degenerative MR, with or without coronary artery disease, and Maze surgery in atrial fibrillation.

Exclusion criteria: Patients with aortic valve disease, post endocarditis, and functional, ischemic or rheumatic MR.

Procedures: For this report, the population was divided into two periods, according to the feasibility of MV repair over the years: period I (PI) from 2008 to 2013, and period II (PII) from 2014 to 2019. Complete patient information was prospectively and consecutively collected in a specially designed database of the cardiac surgery service, including pre-established definitions of all the variables of interest and endpoints.

Early and long-term postoperative clinical follow-up was carried out to analyze survival and the incidence of events, through direct communication with the patient, his family, the general practitioner and the review of medical records in our institution. Early postoperative events were defined according to surgical society guidelines. In-hospital mortality, deep sternal infection (mediastinitis), postoperative acute myocardial infarction (AMI), stroke, reoperation due to bleeding and kidney failure requiring dialysis

were evaluated. In-hospital mortality was defined as that occurring during the hospitalization period or within 30 days of surgery. All patients underwent an intraoperative-transesophageal echocardiogram, in order to confirm the mechanism of MR and to evaluate the immediate result of the repair in the operating room. Additionally, an annual echocardiographic follow-up study was performed using a Phillips Epiq 7 ultrasound machine (Philips Medical Systems, Andover, MA) with Matrix 5-1 transducer. Ventricular function and ventricular diameters as well as left atrial area and volume were evaluated and MR was quantified using qualitative and quantitative methods according to ASE guidelines. (6) Carpentier's classification was used to determine the mechanism of MR: Type I (normal leaflet motion, annular dilation, leaflet perforation), Type II (excessive leaflet motion, leaflet prolapse-flail) and Type III (restricted leaflet motion). (7)

All data and echocardiographic changes found in the last study performed during the long-term follow-up were collected.

Ethical considerations

The study was approved by the Ethics Committee of our institution.

Statistical analysis

Preoperative patient characteristics are expressed as mean \pm standard deviation, median and interquartile range (IQR) or prevalence (in percentage), as appropriate.

Long-term survival at 10 years was analyzed according to the type of leaflet repaired and its relationship with preoperative symptoms, the incidence of moderate-severe MR recurrence, the period free from this complication according to the type of leaflet affected and the need for reintervention at follow-up were examined. Event-free survival curves were built using the Kaplan-Meier method. The differences in the time-to-event curves between both groups were analyzed using the log-rank test. Statistical significance was considered for $p < 0.05$.

RESULTS

The study included 457 patients with mean age 64.9 ± 12.2 years and 61.1% men. Baseline population characteristics are described in Table 1. A total of 305 patients were asymptomatic or had mild symptoms before surgery; 83% had sinus rhythm and ventricular function was normal (left ventricular ejection fraction, LVEF, $> 60\%$) in 70% of operated patients. Mitral valve repair surgery was performed as an elective procedure in 86.9% of patients. Associated procedures were coronary surgery in 24.9% and Maze surgery in 14.4% of cases.

Table 2 shows the aspects of the surgical technique used and early hospital results. Posterior leaflet repair: 96.4% ($n=275$) was significantly higher than anterior/bileaflet repair: 84.1% ($n=182$), $p < 0.001$.

In PI, a triangular or quadrangular posterior leaflet resection was performed in 47% of cases ($n=222$). In PII, the use of artificial chordae tendineae (Gore-Tex sutures WL Gore & Associates Inc, Elkton Maryland) increased to 40% ($n=183$) of patients, with less resection and greater respect for the leaflet tissue as a prolapse reduction strategy. Most patients under-

Table 1. Baseline population characteristics

		n	%
Age, years (n=457)	< 45	30	6.6
	45 - 60	119	26.0
	61 - 75	242	53.0
	> 75	66	14.4
Surgery date	PI: 2008-2013	179	41.6
	PII: 2014-2019	278	58.4
CABG		114	24.9
Tricuspid repair		26	5.7
Aortic replacement		5	1.1
VSD closure		3	0.7
MAZE surgery		66	14.4
Other surgeries		8	1.8
Elective surgery		397	86.9
Preop. Functional Class.	Asymptomatic	74	16.2
	I/II	241	52.7
	III/IV	142	31.1
Diabetes		37	8.1
Hypertension		251	54.9
Dyslipidemia		184	40.3
Cardiac rhythm	Sinus Rhythm	380	83.2
	Atrial fibrillation	71	15.5
	Permanent pacemaker	6	1.3
LVEF	≥ 60 %	321	70.2
	40-59%	121	26.5
	20-39%	13	2.8
	<20%	2	0.4
Tricuspid regurgitation	None or Mild	446	97.6
	Moderate or severe	11	2.4
Affected leaflet	Posterior	275	60.6
	Anterior	84	18.5
	Annular dilation	49	10.8
Myxomatous change	Bileaflet	46	10.1
	None or Mild	21	4.6
	Moderate	354	78.0
	Severe	79	17.4
Annular calcification		21	4.60

CABG: Cardiovascular bypass grafting. VSD: Ventricular septal defect. LVEF: Left ventricular ejection fraction

went a conventional sternotomy, while 12% (n=55) were subjected to a minimally invasive surgical technique. Annuloplasty was performed in most patients of this series, using a complete prosthetic annulus in 82% of cases, and more recently, an incomplete prosthetic annulus.

When comparing the percentage of repairability according to the two surgery periods, there were no significant differences in the probability of posterior leaflet repair: PI: 98.3% (n=121) vs. PII: 95.1% (n=157), p=0.53. Conversely, the feasibility of performing anterior or bileaflet repair throughout time was different: PI: 62.1% (n=58) vs. PII: 87.5% (n=121), p=0.04 (Fig. 1. A and B). It is worth mentioning the increase in the use of artificial chordae tendineae as the technique of choice to reduce leaflet prolapse during PII and the

consequent decrease in triangular or quadrangular resection techniques, more used in the initial stage of the study.

Post-repair intraoperative transesophageal echocardiography reported 72.3% (330/457) of patients without residual MR, 23.5% (107/457) with mild MR, 2.4% (12/457) with moderate residual MR and 1.8% (8/457) with severe MR

Conversion to valve replacement in the operating room was 8.5% (39/457); it should be noted that, in some cases, it was the intervening surgeon's decision to proceed with valve replacement directly without intraoperative echocardiographic evaluation. Clinical follow-up was complete in 98.7% of patients, with a median time of 3.0 years (IQR 4.1 years). Long-term survival at 10 years was over 90% for the total group

of patients. There was no significant difference in long-term survival according to the type of leaflet repaired: anterior leaflet 94±2.2% vs. posterior leaflet 95±2.1%, p=0.54 (Fig. 2A). Patients with NYHA functional class III-IV dyspnea (n=142, 31%), most of them with LVEF <60%, had a higher risk of mortality during follow-up: 13.9±4.1% vs. 2.7±1.2%, log-rank test p=0.001 (Fig. 2B).

Echocardiographic follow-up was completed in 84.3% of the patients. It should be noted that in more than 95% of the operated patients an initial echocardiographic study was obtained within thirty days after surgery. In the long-term follow-up, there was an inci-

dence of moderate-severe MR of 4.7% (18/376); 15 out of 18 patients developed moderate MR and 3 severe MR. The risk of recurrence of moderate-severe MR at 10 years was 14.6±4.3%, and freedom from recurrence was 90±3.4% in patients with posterior leaflet involvement and 80±8.5% for the group with anterior leaflet involvement, p=0.97. (Fig. 3 A and B)

Myxomatous changes in repaired mitral valves were considered moderate in 78% (n=354) and severe (Barlow's disease) in 17.4% (n=79) of cases; in the rest of the patients these changes were considered mild (fibroelastic deficiency). Finally, long-term risk of post-repair reoperation was 4.7%±3.3%.

Surgical techniques used	n	N	%
Type of annulus used	Complete	364	82.5
	Incomplete	77	17.5
Artificial chordae (PII)		183	40.0
Posterior triangular resection. (PI)		121	25.1
Posterior cuadrangular resection (PI)		101	21.6
Sliding technique		11	2.3
CPB time (minutes)		123	IQR: 119 - 129
Clamping time (minutes)		101	IQR: 97 - 104

Hospital results	Elective (n= 397)	Non-elective (n=60)	Total (n=457)	p*
Death 30 days	5 (1.3%)	6 (10%)	11 (2.4%)	< 0.001
MRA	10 (2.5%)	4 (6.6%)	14 (3.1%)	0.08
Stroke	4 (1%)	0 (0%)	4 (0.9%)	0.44
Dialysis	4 (1%)	6 (10%)	10 (2.2%)	< 0.001

Table 2. A. Surgical techniques used. B Hospital results

A- CPB: cardiopulmonary bypass

B- *elective vs non elective

PI: Period I, PII: Period II. CPB: Cardiopulmonary bypass. MRA: Mechanical respiratory assistance: >48hrs.

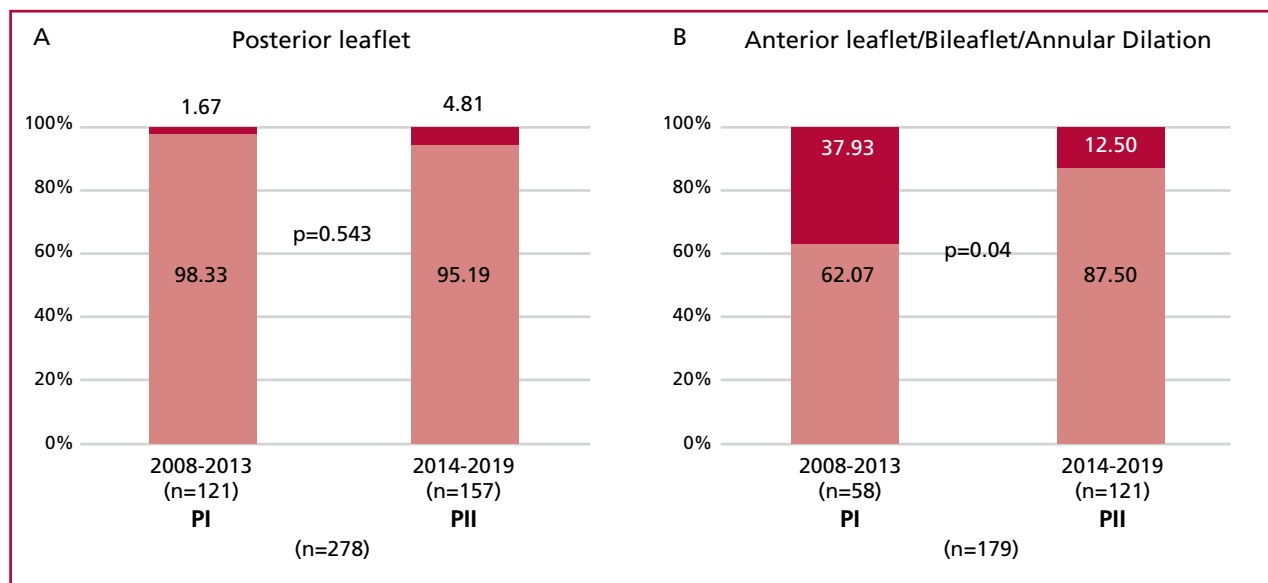


Fig. 1. A: Feasibility of posterior leaflet repair. **B:** Anterior leaflet and bileaflet repair in two study periods. PI: First period. PII: Second period. Percentage of patients with successful mitral repair (light red). Percentage of patients without repair (dark red).

DISCUSSION

Mitral valve repair surgery has been shown to substantially improve outcomes and reduce mortality of patients with severe degenerative MR. (8) Furthermore, this type of preservation surgery has been associated with reduction in the risk of thromboembolism and improvement in long-term survival, even in elderly patients. (9, 10)

This is a retrospective study on a consecutive group of 457 patients with severe degenerative MR who underwent MV repair surgery. Clinical follow-up was carried out in the vast majority of patients, and a 10-year survival rate of 95% was verified, with no significant difference depending on the type of leaflet repaired. Watt et al. suggest, in a multicenter long-term follow-up study, that MV repair surgery restores life expectancy for the general population, regardless of age. (11) Early repair surgery in the asymptomatic patient without complications, that is, without the presence of ventricular dilation and/or dysfunction, and without atrial fibrillation or pulmonary hypertension, is associated with longer survival free of cardiovascular events at 10-year follow-up. (12) In a recent meta-analysis, Hannan et al. demonstrated that this group of patients with severe MR, asymptomatic, and without ventricular function involvement, have a better long-term survival than the group of patients undergoing valve replacement. (13) Recent ACC/AHA guidelines recommend early surgery in this group of patients as long as valve repair can be performed with 95% success and with in-hospital mortality $\leq 1\%$. (14) In our series, more than 65% of the operated patients were considered asymptomatic or with mild symptoms and with LVEF $>60\%$, which demonstrates the tendency of our group to indicate surgery in the initial stages of degenerative MV disease. The analysis of results of the most recent period (PII) shows that in this group of patients the probability of recurrence was 92.5% with an in-hospital mortality of 1.3%. In their now classic publication, Enriquez-Sarano et al. identi-

fied quantitative predictors with prognostic value for long-term survival, very related to surgical time and the presence of preoperative signs of left ventricular dysfunction, which negatively affect long-term post-repair survival. (15)

In a previous report of patients with severe MR, our group identified the degree of preoperative dyspnea as an independent predictor of shorter long-term survival in multivariate analysis. (16) In this series, patients with functional class III-IV (31%), most of them with left ventricular dysfunction, had a higher risk of remote mortality, data that coincide with the majority of publications on MV repair and ventricular dysfunction. (17)

The pathophysiology of MR and the type of leaflet involved are factors that affect the durability of repair in degenerative MV disease. (18) Several surgical groups report better results in posterior leaflet prolapse treatment than in anterior leaflet or bileaflet prolapse repair. (19) This allows us to assume a successful repair and has been the reason for the indication of early surgical treatment when the involvement was located in the posterior leaflet. (20) Similar results were obtained in the initial stage of our experience, in which patients with MV repair surgery secondary to posterior leaflet degenerative disease had longer survival and a lower incidence of reoperation in the long-term follow-up. (21)

In recent years, this has changed due to the development of new surgical techniques, as the use of artificial chordae tendineae and of new technical concepts, such as respecting rather than resecting leaflet tissue. This new approach has increased the probability of successfully repairing complex cases with diffuse involvement of both mitral leaflets. (22) Cetinkaya et al. demonstrated that, in patients with MR due to posterior leaflet prolapse, the use of artificial chordae tendineae without leaflet resection was superior to traditional resection techniques. (23) Similar results were published by various surgical groups. (24-26)

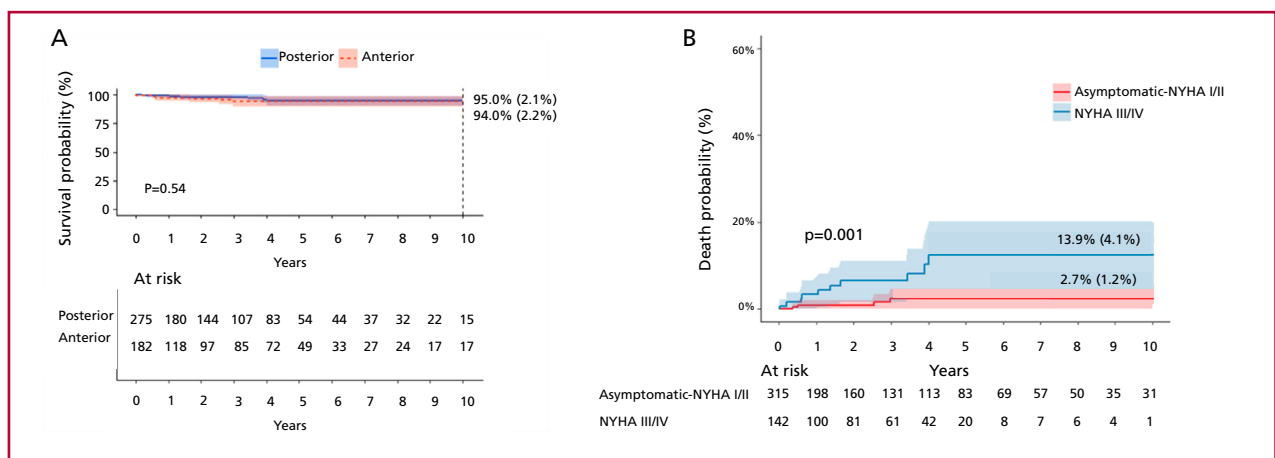


Fig. 2. A: Long-term survival according to the type of leaflet repaired and **B:** Mortality risk at follow-up according to the presence of preoperative clinical symptoms

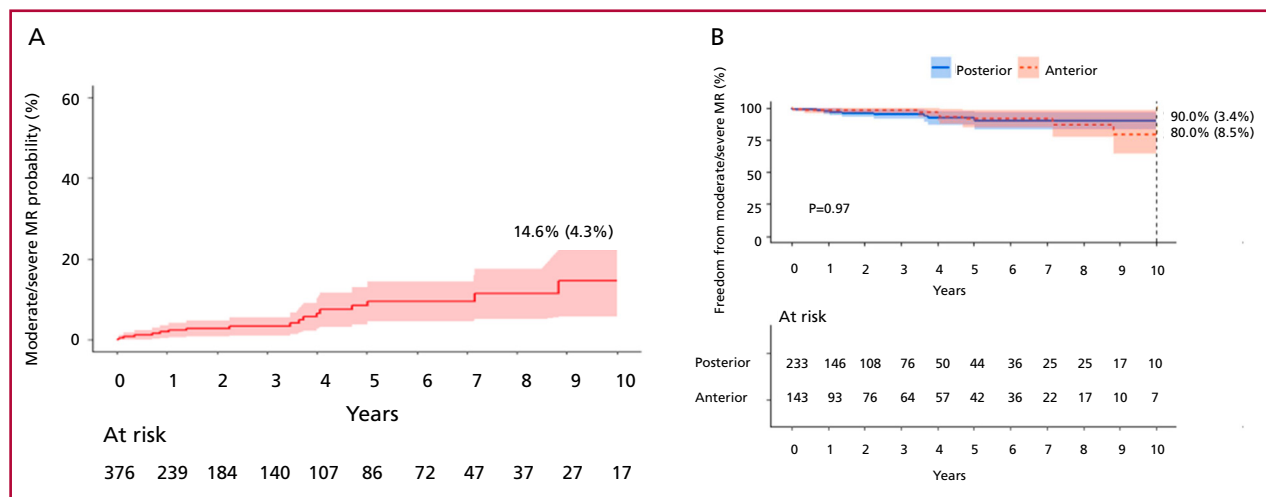


Fig. 3. A: Risk of recurrence of moderate-severe mitral valve regurgitation at long-term follow-up according to the type of leaflet repaired. **B:** Period free of moderate-severe mitral regurgitation at long-term follow-up according to the type of leaflet repaired.

Our series shows the change in surgical technique over time; we performed leaflet resection in the initial stage and in recent years we have used artificial chordae tendineae in most of our repair surgeries, which has been accompanied by a significant increase in the probability of successfully repairing anterior leaflet or bileaflet prolapse. (PI: 62% vs PII: 87%, $p=0.04$). Although the feasibility of performing a correct MV repair would support the indication of early surgery, it is very important to consider the incidence of MR recurrence in the long-term follow-up. While some series have shown that the need for post-repair reoperation has an incidence of 0.5% to 1% per year, this does not seem to be a complete way of analyzing this complication. (27, 28)

Echocardiographic follow-up and the detection of moderate-severe MR is the only way to evaluate its incidence, analyze the mechanism of recurrence, identify predictors and evaluate the impact on ventricular remodeling and long-term survival. (29) Suri et al. showed that the recurrence of post repair moderate or major MR had an incidence of 13.3% at 15-year follow-up with need for reoperation of 6.9%, which was a negative predictor of ventricular remodeling and lower long-term survival (HR: 1.72). The authors highlight that the incidence of recurrence in their series has been markedly lower in recent years, as a result of new surgical techniques. (30) In our series, 18 (4.7%) patients with moderate-severe MR recurrence were identified in the long-term echocardiographic follow-up after the initial study carried out within 30 post-operative days. No significant difference was found in the free from moderate-severe MR period according to the type of leaflet repaired in this series. The risk of moderate-severe MR recurrence at 10 years was 14.6%, a result shared by most publications.

The limitations of this study are its observational, retrospective and single specialty center nature; more-

over, selection biases in the surgical indication cannot be ruled out. It was possible to carry out a clinical face-to-face or telephone follow-up in most patients; however, echocardiographic follow-up was only possible in 84% of patients, which limits the possibility of identifying independent predictors of MR recurrence.

CONCLUSIONS

Successful valve repair surgery was possible in most of the patients with severe degenerative MR. Long-term survival of patients was high and the incidence of recurrence of moderate-severe MR in echocardiographic follow-up was low. The presence of preoperative symptoms of heart failure was an independent predictor of shorter long-term survival. The use of artificial chordae tendineae as a repair technique in the last stage of the study significantly improved the probability of repairing anterior leaflet and bileaflet prolapse.

Conflicts of interest

None declared.

(See authors' conflict of interests forms on the web/Additional material.)

REFERENCES

- Chikwe J, Toyoda N, Anyanwu AC, et al. Relation of mitral valve surgery volume to repair rate, durability, and survival. *J Am Coll Cardiol* 2017;69:2397-406. <https://doi.org/10.1016/j.jacc.2017.02.026>
- Jung JC, Jang MJ, Hwang HY. Meta-analysis comparing mitral valve repair versus replacement for degenerative mitral regurgitation across all ages. *Am J Cardiol* 2019; 123:446-53. <https://doi.org/10.1016/j.amjcard.2018.10.024>
- Tirone E, David, Carolyn M. David, Wendy Tsang, Myriam Lafreniere-Roula, Cedric Manlihot. Long-Term Results of Mitral Valve Repair for Regurgitation Due to Leaflet Prolapse *J Am Coll Cardiol* 2019;74:1044-53. <https://doi.org/10.1016/j.jacc.2019.06.052>
- Gillinov M, Mick S, Suri RM. The specialty of mitral valve repair. *J Am Coll Cardiol* 2017; 69:2407-9. <https://doi.org/10.1016/j.jacc.2017.01.059>
- Lazam S, Vanoverschelde JL, Tribouilloy C, et al., for the MIDA

(Mitral Regurgitation International Database) Investigators. Twenty-year outcome after mitral repair versus replacement for severe degenerative mitral regurgitation: analysis of a large, prospective, multicenter, international registry. *Circulation* 2017;135:410–22. <https://doi.org/10.1161/CIRCULATIONAHA.116.023340>.

6. Zoghbi WA, Adams D, Bonow RO, Enriquez-Sarano M, Foster E, Grayburn PA. Recommendation for noninvasive evaluation of native valvular regurgitation: a report from American Society of Echocardiography developed in collaboration with the Society for Cardiovascular Magnetic Resonance. *J Am Soc Echocardiogr* 2017;30:303–71. <https://doi.org/10.1016/j.echo.2017.01.007>

7. Anyanwu AC., Adams DH., Etiologic Classification of Degenerative Mitral Valve Disease: Barlow’s Disease and Fibroelastic Deficiency. *Semin Thorac Cardiovasc Surg* 19:90–96, 2007

8. Enriquez-Sarano M, Akins CW, Vahanian A. Mitral regurgitation. *Lancet* 2009; 373:1382–94. [https://doi.org/10.1016/S0140-6736\(09\)60692-9](https://doi.org/10.1016/S0140-6736(09)60692-9)

9. Shuhaiber J, Anderson RJ. Meta-analysis of clinical outcomes following surgical mitral valve repair or replacement. *Eur J Cardiothorac Surg* 2007;31:267–75. <https://doi.org/10.1016/j.ejcts.2006.11.014>

10. Gillinov AM, Blackstone EH, Nowicki ER, Slisatkorn W, Al-Dossari G, Johnston DR, et al. Valve repair versus valve replacement for degenerative mitral valve disease. *J Thorac Cardiovasc Surg* 2008;135:885–93, 893.e1–2. <https://doi.org/10.1016/j.jtcvs.2007.11.039>

11. Watt T, Brescia A, Murray S, Burn M, Wisniewski A, Romano M, Bolling S, on behalf of the Michigan Mitral Research Group (MMRG) Degenerative Mitral Valve Repair Restores Life Expectancy. *Ann Thorac Surg* 2020;109:794–801. <https://doi.org/10.1016/j.athoracsur.2019.07.014>

12. Montant P, Chenot F, Robert A, Vancraeynest D, Pasquet A, Gerber N, et al. Long-term survival in asymptomatic patients with severe degenerative mitral regurgitation: A propensity score-based comparison between an early surgical strategy and a conservative treatment approach. *J Thorac Cardiovasc Surg* 2009;138:1339–48. <https://doi.org/10.1016/j.jtcvs.2009.03.046>

13. Hannan E, Samadashvili Z, Smith C, Lahey S, Gold S, Jordan M, et al. Mitral valve repair versus replacement for patients with preserved left ventricular function without heart failure symptoms. *J Thorac Cardiovasc Surg* 2019;157:1432–9. <https://doi.org/10.1016/j.jtcvs.2018.08.091>

14. 2020 ACC/AHA Guideline for the Management of Patients with Valvular Heart Disease: Executive Summary. A Report of the American College of Cardiology /American Heart Association Joint Committee on Clinical Practice Guidelines. Otto C., Nishimura R., *Circulation* 2021;143:e35–e71. <https://doi.org/10.1161/CIR.0000000000000960>

15. Enriquez-Sarano M, Avierinos JF, Messika-Zeitoun D, Detaint D, Capps M, Nkomo V, et al. Quantitative determinants of the outcome of asymptomatic mitral regurgitation. *N Engl J Med* 2005;352:875–83. <https://doi.org/10.1056/NEJMoa041451>

16. Vaccarino G, Piccinini F, Vrancic M, Raich H, Thierer J, Navia D. ¿La gravedad de los síntomas preoperatorios es predictora de riesgo en la cirugía de la insuficiencia mitral? *Rev Argent Cardiol* 2009;77:101–7.

17. Bolling SF, Li S, O’Brien SM, Brennan JM, Prager RL, Gammie

JS. Predictors of mitral valve repair: clinical and surgeon factors. *Ann Thorac Surg* 2010;90:1904–11. <https://doi.org/10.1016/j.athoracsur.2010.07.062>

18. David TE, Ivanov J, Armstrong S, Christie D, Rakowski H. A comparison of outcomes of mitral valve repair for degenerative disease with posterior, anterior, and bileaflet prolapse. *J Thorac Cardiovasc Surg* 2005;130:1242–9. <https://doi.org/10.1016/j.jtcvs.2005.06.046>

19. David TE, Ivanov J, Armstrong S, Rakowski H. Late outcomes of mitral valve repair for floppy valves: implications for asymptomatic patients. *J Thorac Cardiovasc Surg* 2003; 125:1143–52. <https://doi.org/10.1067/mtc.2003.406>

20. Perier P, Hohenberger W, Lakew F, Diegeler A. Prolapse of the posterior leaflet: resect or respect. *Ann Cardiothorac Surg* 2015;4:273–7. <https://doi.org/10.3978/j.issn.2225-319X.2014.11.16>

21. Vrancic M, Piccinini, Camporrotondo M, Espinoza J, Navia D. Resultados a largo plazo de la plástica mitral en enfermedad degenerativa: prolapso posterior versus anterior o bivalvar. *Rev Argent Cardiol* 2014;82:409–15. <https://doi.org/10.7775/rac.es.v82.i5.4662>

22. Mazine A, Verma S, Yanagawa B. Mitral valve repair with resection versus neochordae: a call for high-quality evidence. *J Thorac Cardiovasc Surg* 2018;155:601–8. <https://doi.org/10.1016/j.jtcvs.2017.10.034>

23. Cetinkaya A, Bär S, Hein S, Bramlage K, Bramlage P, Schönburg M, et al. Mitral valve repair for posterior leaflet prolapse: Long term comparison of loop implantation vs resection. *J Card Surg* 2019;1–10. <https://doi.org/10.1111/jocs.14388>

24. David TE, Armstrong S, Ivanov J. Chordal replacement with polytetrafluoroethylene sutures for mitral valve repair: a 25-year experience. *J Thorac Cardiovasc Surg* 2013; 145:1563–9. <https://doi.org/10.1016/j.jtcvs.2012.05.030>

25. Falk V, Seeburger J, Czesla M, Borger MA, Willige J, Kuntze T, et al. How does the use of polytetrafluoroethylene neochordae for posterior mitral valve prolapse (loop technique) compare with leaflet resection? A prospective randomized trial. *J Thorac Cardiovasc Surg* 2008;136:1200–6. <https://doi.org/10.1016/j.jtcvs.2008.07.028>

26. Bourguignon T, Mazine A, Laurin C, Bouchard D, Demers P, Pellerin M. Repair of anterior mitral leaflet prolapse: comparison of mid-term outcomes with chordal transposition and chordal replacement techniques. *J Heart Valve Dis* 2016;25:187–94.

27. Suri RM, Schaff HV, Dearani JA, et al. Survival advantage and improved durability of mitral repair for leaflet prolapse subsets in the current era. *Ann Thorac Surg* 2006; 82:819–26. <https://doi.org/10.1016/j.athoracsur.2006.03.091>

28. Mohty D, Orszulak TA, Schaff HV, Avierinos JF, Tajik JA, Enriquez-Sarano M. Very long-term survival and durability of mitral valve repair for mitral valve prolapse. *Circulation* 2001;104: 11–7. <https://doi.org/10.1161/hc37t1.094903>

29. Stevens LM, Basmadjian AJ, Bouchard D, El-Hamamsy I, Demers P, Carrier M, et al. Late echocardiographic and clinical outcomes after mitral valve repair for degenerative disease. *J Card Surg* 2010;25:9–15. <https://doi.org/10.1111/j.1540-8191.2009.00897.x>

30. Suri RM, Clavel MA, Schaff HV, Michelena HI, Huebner M, Nishimura RA, et al. Effect of Recurrent Mitral Regurgitation Following Degenerative Mitral Valve Repair: Long-Term Analysis of Competing Outcomes. *J Am Coll Cardiol* 2016;67:488–98. <https://doi.org/10.1016/j.jacc.2015.10.098>