Koşuyolu Heart Journal

Koşuyolu Heart J 2024;27(3):108–113
DOI: 10.51645/khj.2024.460

Original Article

Surgical Approach to Moderate to Severe Ischemic Mitral Regurgitation Following the First Myocardial Infarction

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Abstract

Objectives: Ischemic mitral valve regurgitation (IMR) is a subgroup of secondary mitral valve insufficiency that develops due to ischemic heart disease. The aim of the study is to evaluate the patients who were operated after acute myocardial infarction (AMI) for the type of interventions to be performed for the mitral valve in terms of mortality and morbidity.

Methods: Patients who were admitted to the hospital with the diagnosis of acute myocardial infarction and operated emergently or urgently between January 2017 and December 2020 were evaluated. Echocardiographic quantitative and qualitative data were measured. Accordingly, patients were evaluated as mild, moderate or severe mitral insufficiency. Patients who were found to have significant IMR (≥ moderate mitral regurgitation) in the early period and who could achieve complete revascularization were included in the study. Patients were divided into two groups whether the mitral valve was intervened or not.

Results: The demographical data of the patients that were included in the study is as follows, 73.4% were male and 33% were female. The average age of the patients was 63.2±8.9. Patients were compared in terms of significant postoperative residual mitral regurgitation. 62.2% (n=23) of the patients undergone isolated CABG had mild mitral regurgitation. 5 patients with mitral valve annuloplasty (17.9%) had significant residual regurgitation ($p<0.001$).

Conclusion: Mitral valve intervention should not be considered in non-severe mitral valve insufficiencies (without papillary rupture or chorda rupture) after AMI. The higher incidence of insufficiency after the use of isolated mitral annular ring due to left ventricular remodeling makes mitral annular ring less of a treatment option in the acute process.

Keywords: Mitral regurgitation; mitral valve; mitral valve annuloplasty; mortality; myocardial ischemia.

Cite This Article: Timur B, Babur Güler G, Aktemur T, Duman ZM, Aksu T, Apaydın Z, İyigün T. Surgical Approach to Moderate to Severe Ischemic Mitral Regurgitation Following the First Myocardial Infarction. Koşuyolu Heart J 2024;27(3):108–113

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Submitted: June 25, 2024
Revised: August 22, 2024
Accepted: August 23, 2024
Available Online: December 06, 2024

İlk Akut Miyokard İnfarktüsü Sonrası İskemik Mitral Yetersizliğine Cerrahi Yaklaşım

Özet

Amaç: İskemik mitral kapak yetmezliği, iskemik kalp hastalığına bağlı olarak gelişen sekonder mitral kapak yetmezliğinin bir alt grubudur. Çalışmanın amacı, akut miyokard enfarktüsü sonrası opere edilen hastaların mitral kapağa yapılacak müdahalelerin türü açısından mortalite ve morbidite açısından değerlendirilmesidir.

Gereç ve Yöntem: Tek merkezli, retrospektif bir çalışmadır. Ocak 2017 ile Aralık 2020 tarihleri arasında akut miyokard enfarktüsü tanısıyla hastaneye başvuran ve acil veya acil ameliyata alınan hastalar değerlendirildi. Ekokardiyografik veriler incelendi. Buna göre hastalar hafif, orta veya şiddetli mitral yetmezliğe sahip olarak değer-

lendirildi. Erken dönemde anlamlı IMR (≥ orta derecede mitral yetersizliği) saptanan ve tam revaskülarizasyon sağlanabilen hastalar çalışmaya dahil edildi. Hastalar mitral kapağa müdahale edilip edilmediğine göre iki gruba ayrıldı.

Bulgular: Araştırmaya dahil edilen hastaların demografik verileri şu şekilde olup %73,4'ü erkek, %33'ü kadındır. Hastaların ortalama yaşı 63,2±8,9 idi. Hastalar anlamlı (orta veya yüksek) postoperatif rezidüel mitral yetersizliği açısından karşılaştırıldı. İzole KABG uygulanan hastaların %62,2'sinde (n=23) hafif mitral yetersizliği mevcuttu. Mitral kapak anüloplastisi yapılan 5 hastada (%17,9) belirgin rezidüel yetersizlik mevcuttu (p<0,001).

Sonuç: Akut MI sonrası ciddi olmayan mitral kapak yetmezliklerinde (papiller rüptürü veya korda rüptürü olmayan) mitral kapak müdahalesi düşünülmemelidir. İzole mitral ring kullanımı sonrası sol ventrikül remodelingine bağlı yetersizlik sıklığının daha yüksek olması, akut süreçte mitral ringin tedavi seçeneği olma ihtimalini azaltmaktadır.

Anahtar sözcükler: Mitral yetmezlik; mitral kapak; mitral anüloplasti, mortalite; miyokardiyal iskemi.

Introduction

Ischemic mitral regurgitation (IMR) is a subgroup of secondary mitral valve insufficiency that develops due to ischemic heart disease.[1] It is caused due to secondary changes in the left ventricular geometry.[2,3] Approximately 12% of patients with coronary artery disease have accompanying moderate or severe mitral valve insufficiency.[4] Current guidelines are still far from clearly formulating a treatment algorithm. Recent studies proved that IMR is not a chronical disorder, but it occurs within the first acute myocardial infarction (AMI).[5,6]

The aim of the study is to evaluate the patients who were operated after AMI for the type of interventions to be performed for the mitral valve in terms of mortality and morbidity and to evaluate the residual regurgitation in the mitral valve.

Materials and Methods

It is a single-centered, retrospective study. Patients who were admitted to the hospital with the diagnosis of AMI and operated for emergency revascularization between January 2017 and December 2020 were evaluated. Patients who were found to have significant IMR (≥ moderate mitral regurgitation) in the early period and who could achieve complete revascularization were included in the study. We included patients with echocardiographic IMR findings, not the patients with mitral regurgitation due to chordae/papillary muscle rupture. A total of 124 patients were included in the study.

Patients with primary mitral valve disorders, patients with chordae or papillary muscle rupture, patients with aortic valve intervention, echocardiographic chronic ischemic mitral insufficiency findings, history of previous myocardial infarction were not included in the study.

Patients were divided into two groups as patients who underwent isolated coronary artery bypass grafting (CABG) (Group 1) and those who underwent mitral valve intervention mitral valve replacement (MVR) or mitral ring annuloplasty (MRA)) in addition to CABG (Group 2). Echocardiographically, patients' ejection fraction (EF%), vena contracta (VC), Proximal Isovelocity Surface Area (PISA), Effective regurgitation orifice (ERO), tenting area, sphericity index, coaptation depth, and regurgitant fraction were measured. Accordingly, patients were evaluated as having mild, moderate or severe mitral insufficiency. Patients with moderate and above insufficiency were included in the study. Ring annuloplasty was performed in patients with isolated annulus dilatation. Rigid annuloplasty ring was preferred in these patients. Mitral valve replacement was preferred in patients at risk of recurrence. Subannular/subvalvular repair methods were not used to any patient. All cases were patients who underwent emergency or urgent surgery due to coronary artery lesions. The study was approved by the local ethics committee (26/02/2021-2021/04).

Patients were accepted as acute myocardial infarction according to fourth universal definition of myocardial infarction.[7] Patients with fasting blood glucose >126 mg/dL or HbA1C ≥6.5% were considered diabetes mellitus (DM). Patients with systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg in the preoperative period were accepted as hypertension (HT) patients. Patients with Glomerular Filtration Rate (GFR) below 60 ml/min/1.73 m^2 were considered as chronic renal failure. Patients who had routine dialysis with an arteriovenous fistula or catheter in the preoperative period were accepted as dialysis patients. Patients with a smoking history of more than 10-pack-years were accepted as smokers. Echocardiographic examinations were used based on the patient files or the preoperative and postoperative echocardiographic examinations in the hospital system. Postoperative echocardiography was performed on the patients in the third postoperative month.

In the perioperative period, cardiopulmonary bypass time and aortic cross clamp times were examined. In the postoperative period, the duration of intensive care hospitalization, wound infection, and cerebrovascular accidents (CVA) were determined by notes of the patients.

Early mortality was determined as the mortality within the first 30 days of operation. In the postoperative period, if serum creatinine levels increased 1.5 times compared to the basal value or GFR decreased by ≥25%, the patient was accepted as acute kidney injury (AKI).

Statistical Analysis

Statistical results were obtained using IBM Statistical Package for the Social Sciences v27.0 (SPSS Inc., Chicago, IL, USA). Mean, standard deviation, median, lowest/highest, frequency and ratio values were used in the descriptive statistics of the data. The distribution of variables is measured with the Kolmogorov-Smirnov test. Independent sample t-test and Mann-Whitney U test were used in the analysis of quantitative independent data. Chi-square test was used in the analysis of qualitative independent data and Fischer's exact test was used when the necessary conditions for the chi-square test were not met. Univariate analysis was performed to determine statistically significant results related to early mortality risk fac-

tors. Binary logistic regression and multivariate analyzes were performed for significant results in univariate analyzes.

Results

The demographical data of the patients that were included in the study is as follows (Table 1), 73.4% (n=91) were male and 33% were female (n=33). The average age of the patients was 63.2±8.9.

The tenting area in Group 2 was significantly higher than in Group 1. The sphericity index did not differ significantly between the two groups. Coaptation depth did not differ significantly between the two groups. Regurgitant fraction in Group 2 was significantly higher than Group 1. Other echocardiographic data did not differ significantly (Table 2).

The operation time, cardiopulmonary bypass duration and cross clamp time were significantly higher in Group 2. Also, the length of hospital and intensive care unit (ICU) stay in Group 2 were significantly higher than Group 1. In comparison of postoperative complications and mortality, no significant difference was found between two groups (Table 3).

Patients were compared in terms of significant postoperative residual mitral regurgitation. 62.2% of the patients undergone isolated CABG had mild mitral regurgitation. None of them had any significant residual regurgitation. Patients with CABG+MVR had no residual regurgitation. 5 patients with mitral valve annuloplasty had significant residual regurgitation (p<0.001).

Comparison of the Mitral Valve Intervention Group

The group with mitral valve intervention was examined in two subgroups (mitral valve replacement and mitral ring annuloplasty). The demographical data and laboratory tests between two subgroups didn't differ significantly. Tenting area was significantly higher in MVR group than MRA group. The VC value in the MVR group was significantly higher than in the MRA group (Table 4).

Regression Analysis

Regression analysis was performed to determine the early mortality factors. First, univariant analyzes were performed. For the preoperative data, it was found statistically significant that increased age and being a female increased the risk of postoperative early mortality. Regression analysis of the intraoperative data showed cross clamping time was a statistically significant factor affecting mortality. On the other hand, whether the mitral valve was intervened or not was not significant.

Binary logistic regression analysis was performed for variables that were found to be significant in univariate analyzes. In these analyzes, female gender, duration of mechanical ventilator, need for IABP and need for postoperative dialysis were found to be significant (Table 5).

Discussion

Mitral valve diseases can also be successfully treated with the pioneering initiatives of the French surgeon Alain Carpentier. Among these, the place of ischemic mitral insufficiency remains a controversial area of cardiac surgery.

Table 1. Demographical data of the patients

	n	Mean±SD	%
Age		63.2±8.9	
Gender			
Male	91		73.4
Female	33		26.6
Height (cm)		167.5±8.2	
Weight (kg)		78.5±12.3	
BSA		1.9±0.2	
DM			
(-)	38		30.6
(+)	86		69.4
HT			
(-)	38		30.6
(+)	86		69.4
HL			
(-)	60		48.4
(+)	64		51.6
Smoking			
(-)	49		39.5
(+)	75		60.5

SD: Standard deviation; BSA: Body surface area; DM: Diabetes mellitus; HT: Hypertension; HL: Hyperlipidemia.

Table 2. Preoperative echocardiographic evaluation for ischemic mitral regurgitation of the patients

	Isolated CABG group Mean±SD	Mitral intervention group Mean±SD	p
Tenting area (0.6–0.8 cm^2)	1.75±0.26	2.44±0.61	**0.000**
Sphericity index	0.60±0.11	0.64±0.08	0.079
Coaptation depth	9.34±1.81	9.39±2.87	0.942
Regurgitating fraction (<20%)	37.7±10.5	51.5±12.4	**0.001**

CABG: Coronary artery bypass grafting; SD: Standard deviation.

Recent studies have shown that IMR develops during the first AMI.[6,8,9] All these studies include primary percutaneous coronary interventions or long-term echocardiographic follow-up. These studies show that these patients should be diagnosed and treated in the acute phase. To best of our knowledge, our study is the first surgical study on this matter.

Ischemic mitral valve insufficiency is a disease with high mortality rates. Despite effective treatment, long-term mortality rates can vary between 19.8–54%.[10,11] According to some studies, the presence of IMR can increase mortality up to 3 times.[12] The development of moderate to higher ischemic mitral insufficiency causes an increase both in mortality and morbidity.[13] Early surgical mortality rates are also high. In a series, the operative mortality after surgery for patients with moderate ischemic mitral insufficiency was found to be 14%,[14] while in another study, the rate was 8% in patients with mitral valve repair and 16% in patients who underwent replacement.[15] Like other studies, our results revealed that early mortality was 16.1% of all patients. In the analysis of the groups, this rate was found to be 17.2% in the group with mitral valve intervention, and 13.5%

Table 3. Perioperative and postoperative data comparisons between two groups

	Isolated CABG group				Mitral intervention group				p
	Mean±SD	n	%	Median	Mean±SD	n	%	Median	
Operation time (min)	202.7±40.8				270.7±45.7			261.0	**0.000**
CPB (min)	87.8±38.3				152.3±45.4			149.0	**0.000**
Cross clamp time (min)	44.3±17.3				92.8±28.5			88.0	**0.001**
CABG graft number (n)	2.87±0.92				2.59±0.95			3.00	0.096
Length of hospital stay (days)				6.0				9.0	**0.004**
ICU stay (days)				2.0				3.0	**0.022**
Mechanical ventilation time (h)				12.0				18.0	0.138
IABP (n)									
(-)		35	94.6			82	94.3		0.940
(+)		2	5.4			5	5.7		
Postoperative pneumonia (n)									
(-)		30	81.1			68	78.2		0.715
(+)		7	18.9			19	21.8		
Surgical site infection (n)									
(-)		33	89.2			82	94.3		0.320
(+)		4	10.8			5	5.7		
Mortality (n)									
(-)		32	86.5			72	82.8		0.606
(+)		5	13.5			15	17.2		

CABG: Coronary artery bypass grafting; SD: Standard deviation; CPB: Cardiopulmonary bypass; ICU: Intensive care unit; IABP: Intra-aortic baloon pump.

in patients who underwent isolated CABG. Again, in subgroup analyzes, among patients who had mitral valve intervention, this rate was 20.3% in patients who underwent MVR, while it was 10.7% in patients who underwent MRA. In our study the result was not found to be statistically significant.

AKI that develops in the postoperative period is a complication that significantly increases both operative mortality and morbidity. In a study conducted by Yamauchi et al., the rate of AKI after valvular surgery was found to be 6.1%, while Chang et al.[16,17] showed that this rate can increase up to 38.7%. These studies showed that mortality increased significantly in patients with AKI. In our study there was no statistically significant difference in terms of postoperative AKI development, however increasing the numbers can lead to significant results.

Another important finding in our study is that being a female increases mortality. Being a female increases mortality, and it is seen that female gender increases the risk ratio in EuroSCORE II.[18] Another study by McNeely et al.[19] showed that women had a 2.5-fold higher mortality risk in isolated mitral surgery compared to men. It was determined in our study that female gender is an independent risk factor for mortality.

Clear mortality factors have not been revealed by the studies conducted. Early mortality markers according to Dufendach et al.[15] performing mitral valve replacement is DM and preoperative use of IABP. In the long term, different factors such as age, low EF, and chronic obstructive pulmonary disease have been found. In our study, multivariant analyzes showed dialysis need, female gender, IABP and prolonged mechanical ventilator need as independent factors in determining mortality.

Keeping the threshold values too low for selecting the type of intervention to be performed will cause unnecessary surgical procedure. On the contrary, keeping the threshold values too high may cause the process to be insufficient. There are differences between guidelines.[3,20] In terms of echocardiographic examinations, a study on early stage IMR findings after AMI was highlighted by Kimura.[6] Accordingly, in the results of our study, it was seen that the postoperative regurgitation was the highest in the MRA group. Preservation of mitral annular dynamism in the early period causes the MRA group to have the highest residual regurgitation rate by disrupting the annular morphology starting from the early period. On the other hand, no moderate or higher insufficiency was observed in the postoperative period in any of the patients who underwent isolated CABG. Therefore, MRA for mitral insufficiency in patients operated in the early period after AMI should not considered an appropriate treatment method.

Sandoval et al.[21] showed us that there is no difference in long-term mortality in patients with moderate IMR compared to patients who underwent isolated CABG with CABG and ring

Table 4. Preoperative echocardiographic comparison of the mitral intervention subgroups

	MVR Mean±SD	MRA Mean±SD	p
Tenting area	2.64±0.68	2.16±0.35	**0.026**
Sphericity index	0.66±0.09	0.61±0.07	0.092
Coaptation depth	9.69±2.85	8.76±2.91	0.280
Regurgitating fraction	51.7±12.7	50.9±11.7	0.684
VC	0.52±0.13	0.45±0.11	**0.034**
PISA	0.88±0.21	0.81±0.19	0.224
ERO	0.31±0.10	0.27±0.08	0.089
RV	45.4±15.2	40.8±10.9	0.207
Pulmonary HTN (mmHg)	42.1±12.5	37.5±8.9	0.106

MVR: Mitral valve replacement; MRA: Mitral ring annuloplasty; SD: Standard deviation; VC: Vena contracta; PISA: Proximal isovelocity surface area; ERO: Effective regurgitating orifice; RV: Regurgitating volume; HTN: Hypertension.

Table 5. Univariant and multivariant analyses for mortality predictors

	Univariate analysis			Multivariate analysis		
	OR	95% CI	p	OR	95% CI	p
Age	1.071	1.008–1.137	**0.025**			
Female gender	2.72	1.011–7.352	**0.047**			
DM	2.874	0.44–3.98	0.109	13.50	1.58–111.111	**0.017**
Smoking	0.497	0.185–1.332	0.165			
Hypertension	0.574	0.177–1.863	0.355			
BSA	0.123	0.006–2.379	0.166			
CRF	2.75	0.959–7.937	0.06			
Mitral valve intervention	1.33	0.44–3.98	0.606			
Operation time	1.017	1.006–1.027	**0.001**			
CPB time	1.017	1.007–1.028	**<0.001**			
Cross clamp time	1.02	1.007–1.038	**0.004**	2.51	0.985–1.038	1.011
MV time	1.03	1.016–1.041	**<0.001**	1.02	1.003–1.037	**0.018**
Postoperative dialysis	42.86	10.927–168.091	**<0.001**	37.04	4.608–333.333	**<0.001**
IABP need	47.54	5.298–426.552	**<0.001**	71.43	3.24–1000	**0.007**
Surgical revision	3.53	1.133–11.054	**0.03**	6.25	0.608–20.408	0.160
Postoperative CVA	0.86	0.098–7.554	0.892			

OR: Odds ratio; CI: Confidence interval; DM: Diabetes mellitus; BSA: Body surface area; CRF: Chronic renal failure; CPB: Cardiopulmonary bypass; MV: Mechanical ventilator; CVA: Cerebrovascular accident, IABP: Intra-aortic baloon pump.

annuloplasty. Isolated CABG has lower operative mortality risks. Hospital and intensive care stay periods have also been found to be shorter. In parallel with these studies, the operation time, cardiopulmonary bypass times and cross clamping times were significantly shorter in patients who underwent isolated CABG. Hospital stay and ICU stay are also significantly shorter in CABG patients. On the other hand, in the comparison of the patients who underwent MVR and MRA, no significant difference was found between the operation time, cardiopulmonary bypass time and cross clamp times. Again, there was no difference between hospitalizations and ICU admissions. Also, another study showed that the dynamism of the mitral annulus structure is preserved.[6] On the contrary there are also studies showing that MRA can be used safely in patients with chronic moderate IMR, and the left ventricular remodeling is better in the postoperative period.[22] Due to the results obtained from the comparison of MVR and MRA groups, the studies conducted, and the demonstration that mitral annulus dynamics are preserved, we think that MRA is not a good treatment option in this patient group. Recent study of Haberman et al.[23] showed that mitral regurgitation following acute myocardial infarction has high mortality rates and early intervention to this patient group has promising results. They claimed that mitral intervention had better results compared to conservative treatment options. Altaş et al.'s[24] study also reveals that rigid rings have a low effect on IMR. Our study is also compatible with the literature.

For valve repair to be an option in IMY, some values must be taken into consideration. Tenting height should not be more than 11mm, tenting area should not be greater than 2.5cm^2. Interpapillary muscle distance should also be less than 20 mm.[25] Otherwise, although the repair may be successful in the short term, it will be ineffective in the long term. When the results between subgroups are compared, the MRA group has a lower tenting area in accordance with the literature.

There are some limitations to this study. The main limitation is the retrospective nature of our study. The fact that there are more than one surgical team in our hospital and that there is no clear preference regarding the types of operation in the guidelines does not allow an operation in accordance with a fixed protocol. We tried to recruit patients who had a myocardial infarction for the first time in this study. We made the patient selection based on the history and applications of the patients, so this is an important limitation of the study. It is a single center study. Mitral valve insufficiency developing after AMI is not included in the guidelines since it is a recent phenomenon. Therefore, a prospective study and patient selection is not yet possible. Conducting multi-center prospective studies in which the number of patients is increased may provide more significant results.

Conclusion

Our study is one of the few studies conducted on interventions for ischemic mitral valve insufficiency after AMI and their results. Although the mechanisms and details of chronic IMR are known, the uncertainty of treatment methods keeps this subject open as a research area. Recent studies reveal that the pathophysiology of IMR begins to develop in the first hours after AMI and early intervention may be beneficial in terms of reversibility. Mitral valve intervention should not be considered in non-severe ischemic mitral valve insufficiencies (without papillary rupture or chorda rupture) after AMI. In conclusion, we believe that isolated coronary artery bypass grafting surgery is a more appropriate option for patients with moderate insufficiencies. Valve replacement should be considered as the first choice in the early period if it is considered to intervene with the mitral valve. The higher incidence of insufficiency after the use of isolated mitral annular ring due to left ventricular remodeling makes mitral annular ring less of a treatment option in the acute process.

Disclosures

Ethics Committee Approval: The study was approved by the İstanbul Mehmet Akif Ersoy Thoracic and Cardiovascular Surgery Training and Research Hospital Ethics Committee (no: 2021/04, date: 26/02/2021).

Authorship Contributions: Concept – G.B.G., B.T., T.İ.; Design – B.T., T.A.; Supervision – T.İ., G.B.G.; Materials – G.B.G., T.A.; Data collection and/or processing – Z.M.D., Z.A., B.T.; Data analysis and/or interpretation – G.B.G., Z.M.D.; Literature search – B.T., G.B.G.; Writing – B.T., G.B.G.; Critical review – G.B.G., T.İ.

Conflict of Interest: All authors declared no conflict of interest.

Use of AI for Writing Assistance: No AI technologies utilized.

Financial Disclosure: The authors declared that this study received no financial support.

Peer-review: Externally peer-reviewed.

References

1. Baez-Ferrer N, Izquierdo-Gomez MM, Mari-Lopez B, Montoto-Lopez J, Duque-Gomez A, Garcia-Niebla J. Clinical manifestations, diagnosis, and treatment of ischemic mitral regurgitation: a review. J Thorac Dis. 2018 Dec; 10(12):6969-686. doi: 10.21037/jtd.2018.10.64
2. Lancelotti P, Tribouilloy C, Hagendorff A, Popescu BA, Edvardsen T, Pierard LA, et al. Recommendations for the echocardiographic assessment of native valvular regurgitation: an executive summary from the European Association of Cardiovascular Imaging. Eur Heart J Cardiovasc Imaging. 2013;14(7):611-44. doi: 10.1093/ehjci/jet105
3. Vahanian A, Beyersdorf F, Praz F, Milojevic M, Baldus S, Bauersachs J, et al. 2021 ESC/EACTS Guidelines for the management of valvular heart disease. Eur Heart J. 2022;12;43(7):561-632 . doi: 10.1093/eurheartj/ehab395.
4. Pastorius CA, Henry TD, Harris KM. Long-term outcomes of patients with mitral regurgitation undergoing percutaneous coronary intervention. Am J Cardiol. 2007;15;100(8):1218-23. doi: 10.1016/j.amjcard.2007.05.050.
5. Harris KM, Pastorius CA, Duval S, Harwood E, Henry TD, Carabello BA, et al. Practice variation among cardiovascular physicians in management of patients with mitral regurgitation. Am J Cardiol. 2009;15;103(2):255-61. doi: 10.1016/j.amjcard.2008.09.065.
6. Kimura T, Roger VL, Watanabe N, Barros-Gomes S, Topilsky Y, Nishino S, et al. The unique mechanism of functional mitral regurgitation in acute myocardial infarction: a prospective dynamic 4D quantitative echocardiographic study. Eur Heart J Cardiovasc Imaging. 2019;1;20(4):396-406. doi: 10.1093/ehjci/jey177
7. Thygesen K, Alpert JS, Jaffe AS, Chaitman BR, Bax JJ, Morrow DA, et al. Fourth universal definition of myocardial infarction. J Am Coll Cardiol. 2018;30;72(18):2231-2264. doi: 10.1016/j.jacc.2018.08.1038
8. Nishino S, Watanabe N, Kimura T, Kuriyama N, Shibata Y. Acute Versus Chronic Ischemic Mitral Regurgitation: An Echocardiographic Study of Anatomy and Physiology. Circ Cardiovasc Imaging. 2018;11(4):e007028. doi: 10.1161/CIRCIMAGING.117.007028.
9. Nishino S, Watanabe N, Kimura T, Enriquez-Sarano M, Nakama T, Furugen M et al. The Course of Ischemic Mitral Regurgitation in Acute Myocardial Infarction After Primary Percutaneous Coronary Intervention: From Emergency Room to Long-Term Follow-Up. Circ Cardiovasc Imaging. 2016;9(8):e004841. doi: 10.1161/CIRCIMAGING.116.004841.
10. Malhatora AK, Evans AS, Weiner MM, Ramakrishna H. Ischemic Mitral Regurgitation: A Paradigm Shift in Surgical Management? Journal of Cardiothoracic and Vascular Anesthesia. 2018;32(1):580-585. doi: 10.1053/j.jvca.2017.05.045
11. Nonaka DF, Fox AA. Ischemic Mitral Regurgitation: Repair, Replacement or Nothing. Semin Cardiothorac Vasc Anesth. 2019;23(1):11-19. doi: 10.1177/1089253218792921
12. Bursi F, Enriquez-Sarano M, Nkomo VT, Jacobsen SJ, Weston SA, Meverden RA, et al. Heart Failure and Death After Myocardial Infarction in the Community. Circulation. 2005;111:295–301. doi: 10.1161/01.CIR.0000151097.30779.04.
13. Núñez Gil IJ, Pérez de Isla L, García-Rubira JC, Fernández-Ortiz A, González Ferrer JJ, Vivas D, et al. Ischemic mitral regurgitation and non-ST-segment elevation acute myocardial infarction: long-term prognosis. Rev Esp Cardiol. 2009;62(11):1267-75. doi: 10.1016/s1885-5857(09)73354-7
14. Kang DH, Kim MJ, Kang SJ, Song JM, Song H, Hong MK, et al. Mitral valve repair versus revascularization alone in the treatment of ischemic mitral regurgitation. Circulation.2006;4;114(1Suppl):I499-503. doi:10.1161/CIRCULATIONAHA.105.000398
15. Dufendach K, Aranda-Michel E, Sultan I, Gleason TG, Navid F, Thoma F, et al. Outcomes of mitral valve surgery for severe ischemic mitral regurgitation. J Card Surg. 2020;35(2):390-396. doi: 10.1111/jocs.14395
16. Yamauchi T, Miyagawa S, Yoshikawa Y, Toda K, Sawa Y. Risk Index for Postoperative Acute Kidney Injury After Valvular Surgery Using Cardiopulmonary Bypass. Ann Thorac Surg 2017;104:868–76. doi: 10.1016/j.athoracsur.2017.02.012
17. Chang CH, Lee CC, Chen SW, Fan PC, Chen YC, Chang SW, et al. Predicting Acute Kidney Injury Following Mitral Valve Repair. Int J Med Sci. 2016;1;13(1):19-24. doi: 10.7150/ijms.13253
18. Nashef SA, Roques F, Sharples LD, Nilsson J, Smith C, Goldstone AR, Lockowandt U. EuroSCORE II. Eur J Cardiothorac Surg. 2012;41(4):734-44. doi: 10.1093/ejcts/ezs043
19. McNeely C, Vassileva C. Mitral Valve Surgery in Women: Another Target for Eradicating Sex Inequality. Circ Cardiovasc Qual Outcomes. 2016;9(2 Suppl 1):S94-6. doi: 10.1161/CIRCOUTCOMES.115.002603
20. Otto CM, Nishimura RA, Bonow RO, Carabello BA, Erwin III JP, Gentile F, et al. 2020 ACC/AHA Guideline for the Management of Patients with Valvular Heart Disease: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. Circulation. 2021;143:e72–e227. doi: 10.1161/CIR.0000000000000923
21. Sandoval Y, Sorajja P, Harris KM. Contemporary Management of Ischemic Mitral Regurgitation: A Review. Am J Med. 2018;131(8):887-895. doi: 10.1016/j.amjmed.2018.01.048
22. El-Hag-Aly MA, El Swaf YF, Elkassas MH, Hagag MG, Allam HK. Moderate ischemic mitral incompetence: does it worth more ischemic time? Gen Thorac Cardiovasc Surg. 2020;68(5):492-498. doi: 10.1007/s11748-019-01212-5.
23. Haberman D, Estevez-Loureireo R, Benito-Gonzalez T, Denti P, Arzamendi D, Adamo M, et al. Conservative, surgical, and percutaneous treatment for mitral regurgitation shortly after acute myocardial infarction. Eur Heart J. 2022;12;43(7):641-650. doi: 10.1093/eurheartj/ehab496
24. Altaş Ö, Sarıkaya S, Kırali K. Comparison of flexible and rigid annuloplasty rings in isolated mitral regurgitation. Cardiovasc Surg Int 2023;10(1):15-22. Doi: 10.5606/e-cvsi.2023.1159
25. Mihos CG, Santana O. Mitral valve repair for ischemic mitral regurgitation: lessons from the Cardiothoracic Surgical Trials Network randomized study. J Thorac Dis. 2016 Jan;8(1):E94-9. doi: 10.3978/j.issn.2072-1439.2016.01.27.