Published Online: 2025 September 20 **Research Article**

A New Scoring System for Predicting the Risk for Mitral Regurgitation and Its Severity in Patients with Mitral Valve Prolapse

Hidayet Demir [1], Mehmet Altuğ Tunccer [1], Mehrdad Sheikhvatan [2,*]

[1] Cardiovascular Surgery Research Center, Okan University, Istanbul, Turkey
[2] Heidelberg University Hospital, Heidelberg, Germany

[*] ***Corresponding Author:*** Cardiovascular Surgery Research Center, Okan University, Istanbul, Turkey. Email: med.msv@gmail.com

Received: 15 February, 2025; **Revised:** 17 June, 2025; **Accepted:** 18 August, 2025

Abstract

Background: Due to the possibility of occurrence and exacerbation of mitral regurgitation (MR) in the context of mitral valve prolapse (MVP) in a significant portion of patients, early and non-invasive prediction of this complication based on clinical and echocardiographic parameters is important and vital. This prediction can essentially be based on the provision of efficient grading systems.

Objectives: We aimed to achieve this goal by identifying factors predicting the exacerbation of MR and classifying them in the form of a new scoring system.

Methods: One hundred and five patients with suspected MVP were included in this cross-sectional study and assessed by echocardiography. The patients underwent echocardiography, and the severity of the MR, as well as structural changes of valves due to prolapse (leaflets and scallops involvements), was determined.

Results: In a multivariable logistic regression model, age > 40 years, posterior mitral valve leaflet (PMVL) involvement, and P2 or A2P2 scallop involvement were identified as the main risk determinants for moderate to severe MR. These factors were structured as a new scoring system (scaled 3 to 10), where a total risk score of less than 6, between 6 to 8, and higher than 8 was considered low, moderate, and high risk for moderate to severe MR, respectively.

Conclusions: The scoring system provided for predicting the exacerbation of mitral insufficiency in patients with a prolapsed valve can potentially guide early intervention.

Keywords: Mitral Regurgitation, Mitral Valve Prolapse, Risk, Scoring

1. Background

About 2 to 3 percent of the general population suffers from mitral valve prolapse (MVP) (1). Due to the causal role of MVP in the development of degenerative mitral regurgitation (MR) requiring surgical repair, the timely management of MVP with the goal of preventing the occurrence of severe MR is vital (2). Several specialists have attempted to introduce clinical and echocardiographic predicting factors for the occurrence of severe MR in the context of MVP progression. Some authors believe that any evidence of symptomatic left ventricular dysfunction may necessitate surgical intervention in patients with MVP (3). In other studies, a collection of structural and functional abnormalities on echocardiogram can predict the severity of MR following MVP (4). Overall, MR severity and its progression is a definitive criterion for the surgical repair of MR (5). It has been demonstrated that about half of the patients with moderate MR progress to severe MR over a 5-year follow-up period (6). In this regard, some echocardiography parameters have been shown to predict such significant changes, including mitral annulus diameter, left ventricular systolic pressure, left atrial to left ventricular filling ratio, and mitral valve thickness (7, 8). Moreover, involved valvular leaflets and scallops may also be powerful predictors for the progression of MR severity and the need for surgical

How to Cite: Demir H, Tunccer M A, Sheikhvatan M. A New Scoring System for Predicting the Risk for Mitral Regurgitation and Its Severity in Patients with Mitral Valve Prolapse. Int Cardiovasc Res J. 2025; 19 (1): e160482. https://doi.org/10.5812/icrj-160482.

intervention (9, 10). It is evident that compiling a set of factors predicting the progression of the severity of valve involvement in the form of a scoring system can provide the possibility of predicting this event more accurately and quickly, facilitating the use of these indicators at the clinical level.

2. Objectives

We aimed to achieve this goal by identifying factors predicting the exacerbation of MR and classifying them in the form of a new scoring system.

3. Methods

3.1. Study Population

One hundred and five patients with suspected MVP were included in this cross-sectional study and assessed by echocardiography at Okan Hospital in Istanbul, Turkey, in 2022. The eligibility parameters included the presence of MVP on echocardiography and the absence of other causes of valvular insufficiency. Thus, those with secondary mitral valve insufficiency due to other causes were excluded from our study. Additionally, all patients with evidence of atrial fibrillation rhythm were also excluded. The Ethics Committee at Okan University thoroughly assessed the study's ethical issues and ultimately confirmed it. According to the study by Singh et al. (11), mitral prolapse was the etiology of the different degrees of MR in 25% of the patients. Considering a confidence interval of 0.05 and a precision limit of 0.1, the minimum sample size required for the study was calculated to be 72. Therefore, in this study, 105 patients available for the study were included in the evaluation. The baseline characteristics, including demographic parameters (gender, age, Body Mass Index), medical history (history of hypertension, hyperlipidemia, diabetes mellitus, smoking), and oral medications, were all extracted from the patients' hospital records.

3.2. The Assessments Protocol

After selecting the patients during their presence in the ward, consent was obtained to record the patient's clinical information, including demographic information, clinical history, and echocardiography findings. The patients then underwent echocardiography by a single experienced echocardiographer using Philips iE 33 xMatrix, Philips HD 11 XE, and GE Vivid 7 machines, and the severity of the mitral valve insufficiency was determined. To assess the severity of valvular involvement (as mild, moderate, and severe), the following criteria were considered: Cases with an effective regurgitant orifice area (EROA) ≥ 0.4 cm^2, regurgitant volume (RgV) ≥ 60 mL, and regurgitant fraction (RgF) $\geq 50\%$ constituted severe MR. In this regard, those with a vena contracta width (VCW) ≤ 0.3 cm, a small central jet < 4 cm^2, a wave dominance, and normal mitral valve morphology were considered as having mild MR. For clinical and echocardiographic evaluation, the principles of blinding were fully observed, such that the clinical evaluation was performed by a cardiologist completely unaware of the echocardiographic evaluation process, and the echocardiography was performed by an experienced echocardiographic specialist (professor), who was also completely unaware of the clinical evaluation process.

3.3. Planning Scoring System and Statistical Analysis

The chi-square test was used for comparative analysis of qualitative data, and the independent *t*-test was used for the comparison of quantitative data. To identify determinants associated with the occurrence of severe MR, multivariable logistic regression modeling was designed. In this regard, variables were chosen for the multivariate model according to the results of univariable analysis ($P < 0.05$), and those variables that were statistically significant in the univariate model were included in the multivariable model. For risk stratification and developing a risk scoring system, the final logistic regression model was used as the method previously described by Sullivan et al. (12). In this regard, all significant qualitative variables were considered in the multivariate regression analysis in binary form. The fitness of the model was assessed by determining the Hosmer-Lemeshow Goodness of Fit Index, and the risk prediction model was internally validated with bootstrapping. To extract the significant quantitative variables in the aforementioned model, first, based on the ROC curve analysis, the best cutoff point for the quantitative variable with the most desirable sensitivity and specificity was determined, and based on that, the relevant variable was defined as a two-way qualitative variable. The distance between each binary variable and its reference was considered as the coefficient size. With

the goal of obtaining final scores for each risk factor, the score value for each risk factor was calculated by dividing the distance of each risk factor from the baseline category in regression coefficient units by this constant. The total score was achieved by adding up the points for significant risk profiles. SPSS software version 22.0 (IBM, Armonk, New York) was applied for final analysis, considering a P-value of less than 0.05 as significant.

4. Results

Overall, 105 patients (mean age 43.97 ± 17.18 years, ranging from 14 to 80 years, 54 men) were included in the study. Regarding MR severity, 1.9% of patients were graded as zero, while 29.5% had trivial, 38.1% had mild, 17.1% had mild to moderate, 8.6% had moderate, 1.9% had moderate to severe, and 2.9% had severe MR. Comparing baseline characteristics between the patients with trivial to mild MR and the group with moderate to severe MR (Table 1) showed that the latter group was older; however, no difference was revealed in other baseline parameters, including gender, mean Body Mass Index, baseline cardiovascular risk profiles, oral medications, and left ventricular ejection fraction (LVEF).

According to the echocardiography assessment and with respect to involving valve leaflets, the anterior mitral valve leaflet (AMVL) was involved in 66.7%, while involvement of the posterior mitral valve leaflet (PMVL) and both leaflets was revealed in 17.1% and 16.2%, respectively, indicating more involvement of anterior valvular leaflets. Regarding prolaptic scallops involvement, A1, A2, and A3 scallops were involved in 22.9%, 47.1%, and 25.7%, and P1, P2, and P3 scallops in 11.8%, 58.8%, and 29.4%, respectively. Meanwhile, involvement of both first, second, and third scallops was found in 1.9%, 9.5%, and 4.8%, respectively.

As shown in Table 2, there was no difference between men and women in the severity of MR (P = 0.13). However, our study showed more severe MR with increasing age (P = 0.01). According to the ROC curve analysis, an age greater than 40 years (with a sensitivity of 78.1% and a specificity of 60.9%) could be the best cutoff value to predict MR severity. The severity of MR was significantly higher in the subgroups with PMVL compared to those with AMVL involvement (P < 0.001). Additionally, the involvement of scallops was statistically associated with the severity of MR (P < 0.001), with those having P2 scallop involvement showing significantly more severe MR than other scallop involvement patterns (Table 3).

Overall, the baseline variables included in the multivariable model were age (with lower than 40 years as the reference), involved leaflet (AMVL as the reference), and scallop involvement (P2 and/or A2/P2 as the target). The planned multivariable logistic regression model is shown in Table 3. The prediction model had an optimism-corrected C statistic of 0.73 after internal validation with bootstrapping and was well-calibrated based on visual inspection of calibration plots (goodness-of-fit P = 0.57). Additionally, the fitness of the model was acceptable based on the Hosmer-Lemeshow Goodness of Fit Index (chi-square = 6.450, P = 0.597).

This model revealed that age greater than 40 years (OR = 2.427, 95% CI: 1.633 to 9.311, P = 0.026), the presence of PMVL (OR = 4.000, 95% CI: 1.137 to 7.499, P = 0.001), and P2 or A2P2 scallop involvement (OR = 1.857, 95% CI: 1.233 to 5.931, P = 0.044) could predict moderate/severe MR. Therefore, the risk factors assessed on admission were age > 40 years, PMVL involvement, and P2 or A2P2 scallop involvement. The point scores related to final risk indices achieved by the logistic regression analysis are presented in Table 4. The total risk score was determined to be 10, and each risk parameter gets one point if it is not present in the patient. There were finally six risk parameters. Therefore, the minimum risk score was considered as 3 for patients without the identified risk factors and 10 for patients older than 40 years, with PMVL involvement as well as P2 or A2P2 scallop involvements (Table 5). Finally, a total risk score of less than 6 was considered as low risk, between 6 and 8 as moderate risk, and higher than 8 as high risk for moderate/severe MR, respectively.

5. Discussion

The MVP, despite being asymptomatic in many individuals, may become symptomatic for various reasons, especially with age, and even lead to MR. It is important to predict such an event because it sometimes results in an exacerbation of mitral insufficiency, and in some cases, the occurrence of moderate to severe insufficiency will make the affected person a candidate for invasive interventions such as

Table 1. Baseline Characteristics Between the Patients with Mild Mitral Regurgitation and Patients with Moderate to Severe Mitral Regurgitation [a]

Characteristics	Trivial-Mild MR (N = 71)	Moderate-Severe MR (N = 5)	P-Value
Male gender	52 (73.2)	3 (66.0)	0.729
Mean age (y)	40.1 ± 16.6	47.1 ± 17.8	0.016
Mean Body Mass Index (kg/m ^{2})	27.4 ± 1.9	26.6 ± 2.2	0.456
History of hypertension	36 (50.7)	2 (40.0)	0.126
History of diabetes mellitus	13 (18.3)	1 (20.0)	0.779
History of hyperlipidemia	38 (53.5)	2 (40.0)	0.226
History of smoking	12 (16.9)	1 (20.0)	0.759
Using beta blockers	25 (35.2)	2 (40.0)	0.226
Using calcium blockers	22 (31.0)	2 (40.0)	0.659
Using ACE inhibitors	28 (39.4)	2 (40.0)	0.897
Using diuretics	17 (23.9)	1 (20.0)	0.822
Using statins	42 (59.1)	3 (60.0)	0.979
Mean LVEF	52.4 ± 4.4	54.6 ± 4.8	0.426

Abbreviations: MR, mitral regurgitation; LVEF, left ventricular ejection fraction.

[a] Values are expressed as No. (%) or mean ± SD.

Table 2. The Association of Mitral Valve Regurgitation and Leaflets Involvement [a]

Item	AMVL	PMVL	Both
MR severity, %			
None	2 (2.9)	0 (0.0)	0 (0.0)
Trivial	26 (37.1)	3 (16.7)	2 (11.8)
Mild	34 (48.6)	3 (16.7)	3 (17.6)
Mild to moderate	8 (11.4)	6 (33.3)	4 (23.5)
Moderate	0 (0.0)	6 (33.3)	3 (17.6)
Moderate to severe	0 (0.0)	0 (0.0)	2 (11.8)
Severe	0 (0.0)	0 (0.0)	3 (17.6)

Abbreviation: MR, mitral regurgitation.

[a] Values are expressed as No. (%).

Table 3. The Association of Mitral Valve Regurgitation and Scallops Involvement [a]

Item	A1	A2	A3	P1	P2	P3	A1P1	A2P2	A3P3
MR severity									
None	1 (6.2)	0 (0.0)	1 (5.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Trivial	7 (43.8)	12 (36.4)	7 (38.9)	1 (50.0)	0 (0.0)	2 (66.7)	0 (0.0)	1 (10.0)	1 (20.0)
Mild	8 (50.0)	17 (51.5)	8 (44.4)	1 (50.0)	1 (8.3)	1 (33.3)	0 (0.0)	2 (20.0)	1 (10.0)
Mild to moderate	0 (0.0)	4 (12.1)	2 (11.1)	0 (0.0)	6 (50.0)	0 (0.0)	1 (50.0)	3 (30.0)	0 (0.0)
Moderate	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	5 (41.7)	0 (0.0)	1 (50.0)	2 (20.0)	0 (0.0)
Moderate to severe	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (20.0)
Severe	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (20.0)	1 (10.0)

Abbreviation: MR, mitral regurgitation.

[a] Values are expressed as No. (%).

valve repair or replacement. Such interventions can not only be associated with morbidity and even mortality

Table 4. The Multivariable Logistic Regression Model in Determining the Risk Profiles of Moderate to Severe Mitral Regurgitation [a]

Variables	Beta	SE	P-Value	OR	95%CI for OR	
					Lower	Upper
Age (y)						
≤ 40 (reference)	-	-	-	1	-	-
> 40	2.246	.686	0.026	2.427	1.633	9.311
Prolaptic MV leaflet						
AMVL (reference)	-	-	-	1	-	-
PMVL or both	4.236	.874	0.001	4.000	1.137	7.499
Involved scallop						
Other forms (reference)	-	-	-	1	-	-
P2 or A2P2	1.679	.801	0.044	1.857	1.233	5.931

Abbreviations: AMVL, anterior mitral valve leaflet; PMVL, posterior mitral valve leaflet.

[a] Hosmer-Lemeshow Goodness of Fit Index: Chi-square = 6.450, P = 0.597.

Table 5. Risk Scores for Moderate to Severe Mitral Regurgitation

Variables	Score
> 40 (y)	
Present	3
Absent	1
PMVL or both leaflets involvement	
Present	5
Absent	1
P2 or A2P2 scallops involvement	
Present	2
Absent	1
Total	
Present	10
Absent	3

Abbreviation: PMVL, posterior mitral valve leaflet.

post-operation, but they also impose a heavy financial burden on the patient. Therefore, it is evident that predicting the occurrence of moderate to severe MR, especially when prolapse is asymptomatic, based on a combination of clinical and echocardiographic indicators, can lead to favorable outcomes. This approach is more practical when the number of predictive indicators is not large and they can be evaluated in an outpatient, non-invasive, and cost-effective manner. The use of demographic, clinical, and echocardiographic indices is valuable in this regard, and identifying factors that are strong predictors for the occurrence of MR severity and structuring them in the form of a scoring system will be very valuable and practical.

By comprehensively evaluating all these factors, three parameters were clearly identified: Age over 40 years, PMVL involvement, and P2 or A2P2 scallop involvements. To facilitate the use of these parameters, they were compiled into a system that allows a specialist doctor to successfully predict the occurrence of MR when detecting MVR. In this regard, patients aged over 40 years with evidence of PMVL and P2 scallop involvement are at the highest risk for severe MR and thus may require MR repair or replacement in the future.

Although various studies have been conducted regarding the determination of predictive factors related to the occurrence of severe MR, these studies were primarily conducted on patients with mild cardiac

MR and not specifically among patients with valve prolapse. In a study by Hall et al. (13), color flow mapping of the vena contracta of the MR jet could quantitatively predict severe MR. In a similar study to our survey by Ma et al. (14), only the mitral annulus diameter was found to be of value in identifying asymptomatic MVP patients at risk of developing severe MR. According to available studies, a significant portion of patients with mitral prolapse may require surgical interventions shortly after the appearance of prolapse due to rapid progression to valve failure. According to the study by Kolibash et al. (15), once symptoms developed in patients with MVP, mitral valve surgery was required within one year in 88.2% of patients. Considering the high rate of patients facing exacerbation of mitral involvement and requiring surgical interventions even within months after the discovery of prolapse, especially in the elderly, we can emphasize the importance of the results obtained from the present study and the value of providing a scoring system to predict the occurrence of this event.

5.1. Conclusions

It can be concluded that the presence of certain baseline clinical and echocardiography parameters, including age over 40 years, the presence of PMVL involvement, and P2 or A2P2 scallop involvements, can effectively predict MR exacerbation in patients with MVP. In the present study, based on these three parameters, a reliable and efficient scoring system was proposed for the first time to predict this event. It is evident that to confirm the efficiency of this new system, it is necessary to test it in future clinical studies. Finally, it should be emphasized that in designing risk level prediction models based on initial factors, internal validation of the model based on the variables used and examination of the model's fitness before presenting the final predictive model are absolutely essential.

5.2. Limitations

The study, however, had some limitations. First, due to the limited number of patients with moderate to severe MR, we were forced to include 105 patients in the evaluation, which may have affected the power of the study and ultimately the reliability of the scoring model obtained. Therefore, testing the reliability of the resulting model in future studies with a larger sample size is recommended. Another potential limitation of the study was its design and implementation as a cross-sectional study, which could be tested in future cohort studies to obtain better results and confirm the effectiveness of the proposed system.

5.3. Key Messages

1. The three baseline parameters — age over 40 years, PMVL involvement, and P2 or A2P2 scallop involvement— are identified as the main determinants for the exacerbation of mitral insufficiency in patients with mitral prolapse and can be linked to poorer clinical outcomes.

2. Considering these three parameters as part of a new scoring system can help predict the exacerbation of mitral insufficiency in patients with MVP.

3. Applying this new scoring system can guide clinicians in selecting the best therapeutic approach for patients with mitral prolapse, with the aim of preventing the exacerbation of mitral insufficiency.

Footnotes

Authors' Contribution: Study concept and design: M. S.; Acquisition of data: H. D.; Analysis and interpretation of data: M. S.; Drafting of the manuscript: M. S.; Critical revision of the manuscript for important intellectual content: M. A. T.; Statistical analysis: M. S.; Administrative, technical, and material support: M. A. T. and H. D.; Study supervision: M. A. T. and H. D.

Conflict of Interests Statement: The authors declare no conflict of interest.

Data Availability: The dataset presented in the study is available on request from the corresponding author during submission or after its publication. The data are not publicly available to prevent misuse and unauthorized publication without obtaining permission from the source and publisher.

Ethical Approval: This study is approved under the ethical approval code of TR.OK.REC.2025.124.

Funding/Support: The study was financially supported by Okan University.

Informed Consent: After selecting the patients during their presence in the ward, consent was obtained to

record the patient's clinical information.

References

1. Aluru JS, Barsouk A, Saginala K, Rawla P, Barsouk A. Valvular Heart Disease Epidemiology. *Med Sci (Basel)*. 2022;**10**(2). [PubMed ID: 35736352]. [PubMed Central ID: PMC9228968]. https://doi.org/10.3390/medsci10020032.
2. Grave C, Gabet A, Tribouilloy C, Cohen A, Lailler G, Weill A, et al. Epidemiology of valvular heart disease in France. *Arch Cardiovasc Dis*. 2024;**117**(12):669-81. [PubMed ID: 39632129]. https://doi.org/10.1016/j.acvd.2024.10.324.
3. Alenazy A, Eltayeb A, Alotaibi MK, Anwar MK, Mulafikh N, Aladmawi M, et al. Diagnosis of Mitral Valve Prolapse: Much More than Simple Prolapse. Multimodality Approach to Risk Stratification and Therapeutic Management. *J Clin Med*. 2022;**11**(2). [PubMed ID: 35054149]. [PubMed Central ID: PMC8781541]. https://doi.org/10.3390/jcm11020455.
4. Coutinho GF, Antunes MJ. Current status of the treatment of degenerative mitral valve regurgitation. *Rev Port Cardiol (Engl Ed)*. 2021;**40**(4):293-304. [PubMed ID: 33745777]. https://doi.org/10.1016/j.repc.2020.10.011.
5. Cimino S, Guarracino F, Valenti V, Frati G, Sciarretta S, Miraldi F, et al. Echocardiography and Correction of Mitral Regurgitation: An Unbreakable Link. *Cardiology*. 2020;**145**(2):110-20. [PubMed ID: 31794963]. https://doi.org/10.1159/000504248.
6. Mantovani F, Bursi F, Di Giannuario G, Barbieri A. Echocardiographic prediction of surgical reparability in degenerative mitral regurgitation due to leaflet prolapse: a review. *Expert Rev Cardiovasc Ther*. 2019;**17**(9):653-62. [PubMed ID: 31483165]. https://doi.org/10.1080/14779072.2019.1664289.
7. Kagiyama N, Shrestha S. Echocardiographic assessment of mitral regurgitation. *J Med Ultrason (2001)*. 2020;**47**(1):59-70. [PubMed ID: 31446501]. https://doi.org/10.1007/s10396-019-00971-1.
8. Fishbein GA, Fishbein MC. Mitral Valve Pathology. *Curr Cardiol Rep*. 2019;**21**(7):61. [PubMed ID: 31123911]. https://doi.org/10.1007/s11886-019-1145-5.
9. Nappi F, Nenna A, Spadaccio C, Lusini M, Chello M, Fraldi M, et al. Predictive factors of long-term results following valve repair in ischemic mitral valve prolapse. *Int J Cardiol*. 2016;**204**:218-28. [PubMed ID: 26681541]. https://doi.org/10.1016/j.ijcard.2015.11.137.
10. Aubert S, Barreda T, Acar C, Leprince P, Bonnet N, Ecochard R, et al. Mitral valve repair for commissural prolapse: surgical techniques and long term results. *Eur J Cardiothorac Surg*. 2005;**28**(3):443-7. [PubMed ID: 15979319]. https://doi.org/10.1016/j.ejcts.2005.05.005.
11. Singh RG, Cappucci R, Kramer-Fox R, Roman MJ, Kligfield P, Borer JS, et al. Severe mitral regurgitation due to mitral valve prolapse: risk factors for development, progression, and need for mitral valve surgery. *Am J Cardiol*. 2000;**85**(2):193-8. [PubMed ID: 10955376]. https://doi.org/10.1016/s0002-9149(99)00645-1.
12. Sullivan LM, Massaro JM, D'Agostino RS. Presentation of multivariate data for clinical use: The Framingham Study risk score functions. *Stat Med*. 2004;**23**(10):1631-60. [PubMed ID: 15122742]. https://doi.org/10.1002/sim.1742.
13. Hall SA, Brickner ME, Willett DL, Irani WN, Afridi I, Grayburn PA. Assessment of mitral regurgitation severity by Doppler color flow mapping of the vena contracta. *Circulation*. 1997;**95**(3):636-42. [PubMed ID: 9024151]. https://doi.org/10.1161/01.cir.95.3.636.
14. Ma JI, Igata S, Strachan M, Nishimura M, Wong DJ, Raisinghani A, et al. Predictive Factors for Progression of Mitral Regurgitation in Asymptomatic Patients With Mitral Valve Prolapse. *Am J Cardiol*. 2019;**123**(8):1309-13. [PubMed ID: 30711245]. https://doi.org/10.1016/j.amjcard.2019.01.026.
15. Kolibash AJ, Kilman JW, Bush CA, Ryan JM, Fontana ME, Wooley CF. Evidence for progression from mild to severe mitral regurgitation in mitral valve prolapse. *Am J Cardiol*. 1986;**58**(9):762-7. [PubMed ID: 3766417]. https://doi.org/10.1016/0002-9149(86)90352-8.