

Valve: Short Report

Incidence of Underreferral to Multidisciplinary Evaluation in Severe Primary Mitral Regurgitation



Christina Waldron, BS,¹ Markus Krane, MD,^{1,2} Soh Hosoba, MD, PhD,³ Amar Geirsson, MD,¹ and Makoto Mori, MD, PhD^{1,4}

ABSTRACT

BACKGROUND Severe primary mitral regurgitation (MR) warrants multidisciplinary evaluation involving cardiac surgeons and structural interventional cardiologists. The incidence and potential impact on outcomes of missed evaluation remain unknown.

METHODS We conducted a retrospective cohort study of patients with new diagnoses of severe primary MR from an echocardiography database within a large health care network. Of 37,749 unique patients with echocardiograms, 126 had severe primary MR. We compared the 2-year survival of patients who did and did not undergo multidisciplinary evaluation. Propensity score matching was performed on the basis of The Society of Thoracic Surgeons Predicted Risk of Mortality for mitral repair.

RESULTS Of 126 patients with severe primary MR (median age, 79 years [interquartile range, 68-89 years]; 60% women), 37 (29%) underwent multidisciplinary evaluation. Evaluated patients were younger (71 [58-79] years vs 84 [73-90] years), and of those, 26 (70%) underwent operations within 37 days of evaluation. The Society of Thoracic Surgeons Predicted Risk of Mortality median was 1% (1%-5%) and 4% (1%-10%) for evaluated and unevaluated patients, respectively. Of the 74 patients matched, the mortality rate was lower in evaluated patients at 90 days (11% [n = 4] vs 27% [n = 10]; *P* = .08) and 2 years (16% [n = 6] vs 35% [n = 13]; *P* = .06).

CONCLUSIONS The multidisciplinary referral rate for newly identified severe primary MR was low at 29%, with underreferral of low-risk, potentially operative candidates. The observed improved survival with multidisciplinary evaluation calls for efforts to maximize referral of this group of patients.

(Ann Thorac Surg Short Reports 2024;2:241-245)

© 2023 The Author(s). Published by Elsevier Inc. on behalf of The Society of Thoracic Surgeons.
This is an open access article under the CC BY-NC-ND license
(<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Severe primary mitral regurgitation (MR) warrants multidisciplinary evaluation involving structural interventional cardiology and cardiac surgery teams to individualize treatment. However, patients are sometimes lost while navigating a complex health care system from initial identification of mitral disease to arriving at multidisciplinary evaluation.¹ The magnitude of patients newly found to have severe primary MR who are not evaluated by both cardiology

and cardiac surgery teams remains unknown. Understanding the magnitude of this underreferral and the potential impact on patient outcomes is important to mitigate the undertreatment of patients who may qualify for mitral valve intervention.

Using a health care network-wide echocardiography database, we aimed to characterize the incidence of multidisciplinary evaluation of patients newly found to have severe primary MR and to compare the midterm

Accepted for publication Nov 6, 2023.

¹Division of Cardiac Surgery, Yale School of Medicine, New Haven, Connecticut; ²Department of Cardiovascular Surgery, Institute Insure, German Heart Center Munich, Technical University of Munich, Munich, Germany; ³Department of Cardiovascular Surgery, Japanese Red Cross Aichi Medical Center Nagoya Daiichi Hospital, Nagoya, Japan; and ⁴Center for Outcomes Research and Evaluation, Yale New Haven Hospital, New Haven, Connecticut
Address correspondence to Dr Mori, Division of Cardiac Surgery, Yale School of Medicine, BB204, 330 Cedar St, PO Box 208039, New Haven, CT 06510; email: makoto.mori@yale.edu.

outcomes of patients who did and did not undergo multidisciplinary evaluation.

PATIENTS AND METHODS

POPULATION OF PATIENTS. We conducted a retrospective cohort study at Yale New Haven Health, a large health care network encompassing multiple hospitals and outpatient clinics throughout Connecticut and Rhode Island. The systemwide echocardiographic and electronic medical record database was queried to identify all adults who received complete transthoracic echocardiography for any indication between January 1, 2016, and December 31, 2018, during either inpatient or outpatient encounters. We restricted the cohort to severe MR of primary etiology by the following criteria: mitral leaflet described by the words *prolapsed*, *prolapse*, *degenerative*, or *myxomatous*; and including only patients for whom this was the first mention of severe MR during the study period. Exclusion criteria are specified

IN SHORT

- The referral rate to multidisciplinary evaluation was low at 29%.
- A quarter of unevaluated patients had predicted 30-day mortality risk of <1%, suggesting that a substantial portion of potential operative candidates were underreferred for multidisciplinary evaluation.
- Patients who underwent multidisciplinary evaluation had better survival than unevaluated patients, with surgical operations occurring promptly within an average of 37 days after the diagnosis of mitral regurgitation.

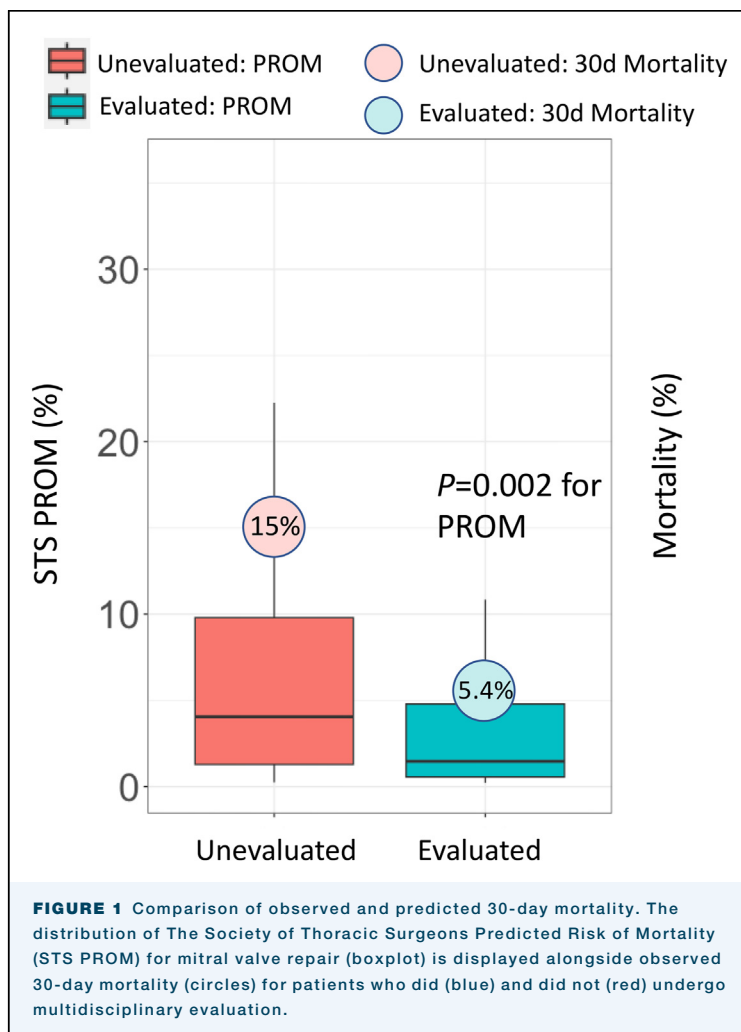
in [Supplemental Figure 1](#). During the study period, 37,749 patients underwent echocardiography, of whom 765 had severe MR and 126 had severe primary MR ([Supplemental Figure 1](#)).

VARIABLE DEFINITIONS. The exposure variable was multidisciplinary evaluation, defined as documentation of evaluation by both cardiology and cardiac surgery teams during the course of workup toward potential intervention. Patients who did and did not undergo multidisciplinary evaluation were categorized as evaluated and unevaluated, respectively. The term *multidisciplinary evaluation* was used instead of heart team as the system did not yet have a formalized heart team consisting of teams specifically dedicated to the evaluation and treatment of mitral structural disease.

Demographics, presenting symptoms, follow-up care, and echocardiographic measurements were extracted from medical records. Admission details included reason for admission and documented heart failure symptoms, and follow-up included incidence of and reason for readmission. Echocardiographic measurements included the severity of mitral annular calcification and left ventricular function and dimensions. The Society of Thoracic Surgeons (STS) Predicted Risk of Mortality (PROM) for mitral valve repair and replacement was calculated for each patient. Patient death was adjudicated by the combination of Connecticut Vital Statistics Database linkage and patient chart review.

OUTCOME MEASURES. Primary end points were 2-year all-cause death and a composite of all-cause death and hospital readmission specific for documented heart failure symptoms. Follow-up was restricted to 2 years to ensure the potential for complete follow-up.

STATISTICAL ANALYSIS. Wilcoxon rank sum tests, χ^2 tests, and Fisher exact test were performed for bivariate analyses when appropriate. Survival was characterized by Kaplan-Meier plot. Propensity score matching was performed by a logistic regression model with STS



PROM as the covariate. Statistical significance was defined as $P < .05$. All data analysis was performed in R version 4.2.2 (R Foundation for Statistical Computing).

RESULTS

CHARACTERISTICS OF THE PATIENTS. In the 126 patients with severe primary MR, the median age was 79 years (interquartile range [IQR], 68-89 years), and 76 (60%) were female. Echocardiograms were obtained predominantly in an inpatient setting ($n = 105$ [83%]). Event-free patients had a median of 729 (IQR, 729-730) follow-up days. The rate of referral to multidisciplinary evaluation was low at 29% ($n = 37$). Evaluated patients were younger (median age, 71 [IQR, 58-79] years vs 84 [IQR, 73-90] years) and less frequently had an echocardiogram obtained in an inpatient setting (65% vs 91%). Of the evaluated patients, most (70%) underwent operations within the median of 37 days (IQR, 6-135 days), 4 (11%) underwent transcatheter edge-to-edge repair, and no unevaluated patients (0%) underwent operations or transcatheter edge-to-edge repair; 62% of evaluated patients and 54% of unevaluated patients had heart failure symptoms on admission. The median STS PROM for mitral valve repair was lower at 1% (IQR, 1%-5%) and 4% (IQR, 1%-10%) for evaluated and unevaluated patients, respectively. The left ventricular ejection fraction was comparable between groups (Supplemental Table). Evaluated patients had lower STS PROM and observed 30-day death than unevaluated patients (Figure 1).

OVERALL SURVIVAL AND HEART FAILURE READMISSION.

Evaluated patients had a lower risk of mortality. Overall death at 90 days, 1 year, and 2 years was 11% ($n = 4$), 14% ($n = 5$), and 16% ($n = 6$) for evaluated patients and 27% ($n = 24$), 36% ($n = 32$), and 46% ($n = 41$) for unevaluated patients (Supplemental Figure 2). Evaluated patients had lower mortality and overall hospital readmission rates (Supplemental Figure 3). Evaluated patients had lower risk of composite death and hospital readmission specific for heart failure symptoms (Figure 2).

PROPENSITY SCORE MATCHING. There were 74 patients matched, 37 evaluated and 37 unevaluated (Table). The variance ratio was 0.51 for STS PROM. The distribution of propensity scores showed good overlap after matching (Supplemental Figure 4). Of matched patients, evaluated patients had lower death rates at 30 days (5.4% vs 14%) and 2 years (16% vs 35%; Figure 3) and had lower risk of composite mortality and hospital readmission specific for heart failure symptoms (Supplemental Figure 5).

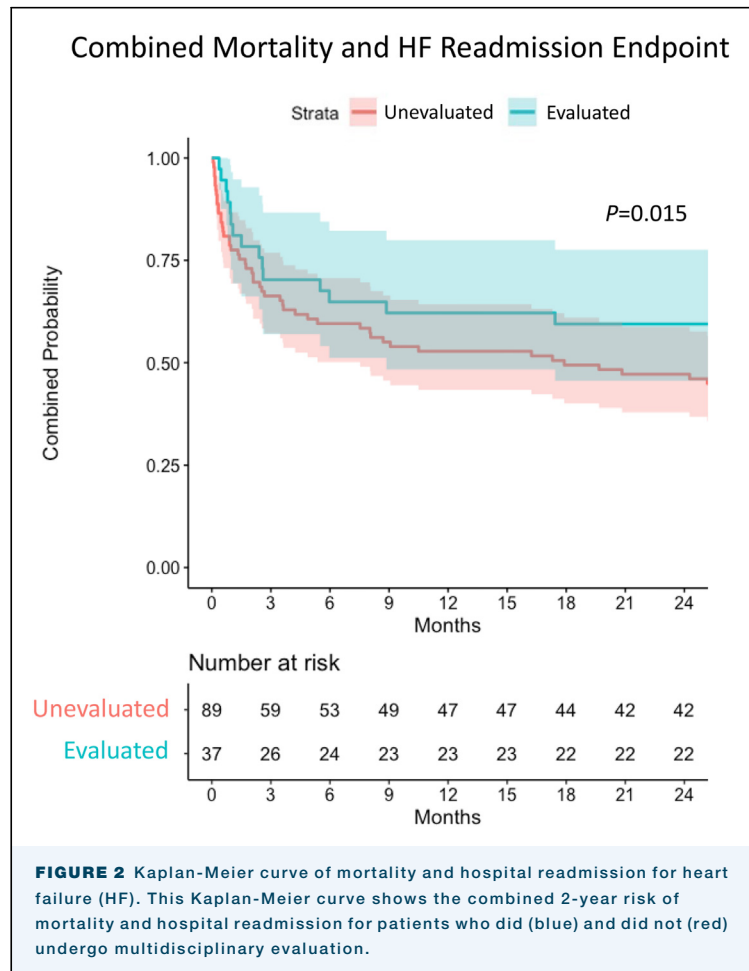


FIGURE 2 Kaplan-Meier curve of mortality and hospital readmission for heart failure (HF). This Kaplan-Meier curve shows the combined 2-year risk of mortality and hospital readmission for patients who did (blue) and did not (red) undergo multidisciplinary evaluation.

COMMENT

Key findings of our study are the following. First, in this group of patients for whom guidelines recommend multidisciplinary evaluation, the referral rate to multidisciplinary evaluation was low at 29%. A quarter of unevaluated patients had predicted 30-day mortality risk of <1%, suggesting that a substantial portion of potential operative candidates were underreferred for multidisciplinary evaluation. Second, patients who underwent multidisciplinary evaluation had better survival than unevaluated patients, with operations occurring promptly within an average of 37 days after the diagnosis of MR. These findings highlight the need for a systematic approach to identification and triage of these patients when the mitral disease is identified as multidisciplinary evaluation may improve patient outcomes by identifying optimal therapy for individual patients.

The study adds to the literature in several ways. First, there are scarce data on referral rates and associated outcomes for patients with severe primary MR. Second, to the best of our knowledge, there are no prior studies directly evaluating the impact of multidisciplinary

TABLE Patient Characteristics, Risk Scores, and Outcomes After Matching

Characteristic	Unevaluated (N = 37)	Evaluated (N = 37)	P Value
Age, y	76 (63-87)	71 (58-79)	.14
Female	20 (54)	18 (49)	.6
Race			.6
White	27 (73)	30 (81)	
Black	7 (19)	6 (16)	
Other	3 (8.1)	1 (2.7)	
Inpatient echocardiography	34 (92)	24 (65)	.005
Hypertension	26 (70)	22 (59)	.3
Diabetes mellitus	4 (11)	4 (11)	>.9
Prior CABG	1 (2.7)	1 (2.7)	>.9
Heart failure	4 (11)	11 (30)	.04
PVD	3 (8.1)	8 (22)	.1
MI	3 (8.1)	5 (14)	.7
Atrial fibrillation/flutter	8 (22)	10 (27)	.6
CVD	1 (2.7)	3 (8.1)	.6
Renal failure	5 (14)	4 (11)	>.9
Liver disease	0 (0)	0 (0)	NA
Heart failure symptoms	16 (43)	23 (62)	.1
MAC			.3
Moderate	9 (24)	3 (8.1)	
Severe	1 (2.7)	2 (5.4)	
LVEDD, mm	49 (44-54)	54 (48-57)	.018
Ejection fraction, %	61 (55-66)	62 (54-67)	>.9
STS PROM: replacement	3.6 (2.2-7.2)	3.4 (1.5-6.8)	.4
STS PROM: repair	1.6 (0.8-4.5)	1.5 (0.6-4.8)	.6
Surgery	0 (0)	26 (74)	<.001
TEER	0 (0)	4 (11)	.11
Mitral valve replacement	0 (0)	9 (24)	.002
Days to surgery		37 (6-135)	

Categorical variables are presented as number (percentage). Continuous variables are presented as median (interquartile range). Boldface P values indicate statistical significance. CABG, coronary artery bypass graft; CVD, cerebrovascular disease; LVEDD, left ventricular end-diastolic diameter; MAC, mitral annular calcification; MI, myocardial infarction; NA, not applicable; PVD, peripheral vascular disease; STS PROM, The Society of Thoracic Surgeons Predicted Risk of Mortality; TEER, transcatheter edge-to-edge repair.

evaluation on the outcomes of patients with severe primary MR,^{2,3} although multidisciplinary evaluation for patients with severe MR is a class I recommendation by guidelines.⁴ This study shows that multidisciplinary evaluation may improve the survival and outcomes of these patients, supporting the implementation of multidisciplinary evaluation for all patients with new diagnoses of severe primary MR.

Unevaluated patients had higher STS PROM and more comorbidities, which may reflect the non-heart team clinician's perception of operative candidacy. However, the lowest quartile of STS PROM for unevaluated patients was low at 1%, suggesting that many unevaluated patients were potential operative candidates. This underreferral may partly be due to clinicians' overestimation of perceived risk.⁵ Establishing a systematic referral pathway for multidisciplinary evaluation is critical to ensure that potential interventional and operative candidates are formally evaluated. Because severe primary MR increases mortality by 6% per year⁶ and

early mechanical correction of severe primary MR may reduce heart failure and mortality risks,⁷ timely referral for potential intervention is critical.⁸ Implementing an automated heart team referral when the transthoracic echocardiogram identifies severe MR may mitigate underreferral and minimize this gap in intervention.

Multidisciplinary evaluation substantially increased the proportion of patients undergoing intervention, which probably functioned as a mediator in the subsequent improvement in survival. Our study demonstrated the potential impact of multidisciplinary evaluation encompassing the varying rate of subsequent intervention or operation.

LIMITATIONS. The single-center nature limits generalizability. However, the health system is large and includes a broad range of case settings throughout Connecticut and Rhode Island, spanning both inpatient and outpatient echocardiograms. Our center's practice may not reflect the pattern of referral at other centers. A relatively small sample size restricted the application of a more robust covariate adjustment, and it is possible that the observed difference in survival between the groups could have been due to residual confounding; however, severe MR consists of a small fraction of all MR, making up 0.46% of the population.¹ The origination of most echocardiograms from an inpatient setting may have contributed to confounding, and there is the possibility of underreferral if the echocardiography report omitted mitral disease. The analysis was limited by the data available in the systemwide database.

CONCLUSION. The referral rate for patients with severe primary MR to multidisciplinary evaluation was low at 29%, with notable underreferral of low-risk, potentially operative candidates. The observed improved survival for patients with multidisciplinary evaluation supplements the current guideline recommendation and calls for improving the surgical multidisciplinary referral rate.

The [Supplemental Material](https://doi.org/10.1016/j.atsr.2023.11.015) can be viewed in the online version of this article [<https://doi.org/10.1016/j.atsr.2023.11.015>] on <http://www.annalsthoracicsurgery.org>.

The institutional review board approved the present study (IRB protocol number: 2000028791, approved on 9/2/21).

FUNDING SOURCES

Supported by surgeon-scientist training program at Yale School of Medicine.

DISCLOSURES

Amar Geirsson reports a relationship with Medtronic that includes: consulting or advisory; and with Edwards Lifesciences Corporation that includes: consulting or advisory. Markus Krane is a physician proctor for Peter Duschek and reports a relationship with JOMDD that includes: consulting or advisory; with Moderna that includes: consulting or advisory; with EVOTEC that includes: consulting or advisory; with Medtronic that includes: speaking and lecture fees; and with Terumo that includes: speaking and lecture fees.

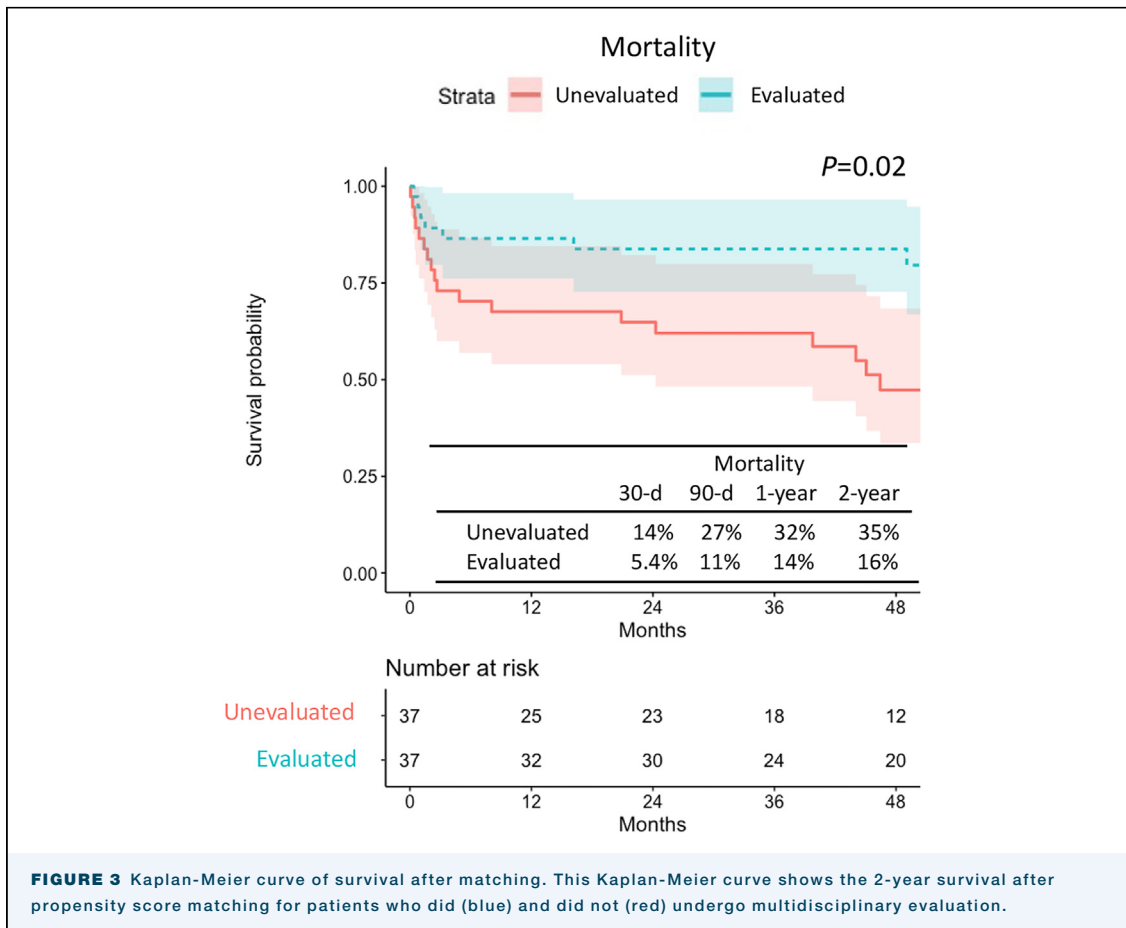


FIGURE 3 Kaplan-Meier curve of survival after matching. This Kaplan-Meier curve shows the 2-year survival after propensity score matching for patients who did (blue) and did not (red) undergo multidisciplinary evaluation.

REFERENCES

1. Dziadzko V, Clavel M, Dziadzko M, et al. Outcome and undertreatment of mitral regurgitation: a community cohort study. *Lancet*. 2018;391:960-969.
2. Heuts S, Olsthooft J, Hermans S, et al. Multidisciplinary decision-making in mitral valve disease: the mitral valve heart team. *Neth Heart J*. 2019;27:176-184.
3. Jonik S, Marchel M, Pedzich-Placha E, et al. Long-term outcomes and quality of life following implementation of dedicated mitral valve heart team decisions for patients with severe mitral valve regurgitation in tertiary cardiovascular care center. *Cardiol J*. 2024;31:62-71. <https://doi.org/10.5603/CJ.a2022.0011>
4. Otto C, Nishimura R, Bonow R, et al. 2020 ACC/AHA Guideline for the Management of Patients with Valvular Heart Disease. *Circulation*. 2021;143:e35-e371.
5. Taniguchi T, Morimoto T, Takeji Y, Kato T, Kimura T. Contemporary issues in severe aortic stenosis: review of current and future strategies from the Contemporary Outcomes after Surgery and Medical Treatment in Patients with Severe Aortic Stenosis registry. *Heart*. 2020;106:802-809.
6. Samad Z, Shaw L, Phelan M, et al. Long-term outcomes of mitral regurgitation by type and severity. *Am Heart J*. 2018;203:39-48.
7. Enriquez-Sarano M, Schaff H, Orszulak T, Tajik A, Bailey K, Frye R. Valve repair improves the outcome for mitral regurgitation. *Circulation*. 1995;91:1022-1028.
8. Nishimura R, Vahanian A, Eleid M, Mack M. Mitral valve disease—current management and future challenges. *Lancet*. 2016;387:1324-1334.