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Original Research

Echocardiographic Predictors of Suboptimal Transcatheter Mitral Valve Repair in Patients With Secondary Mitral Regurgitation

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ABSTRACT

Background: Residual mitral regurgitation (MR) following mitral valve transcatheter edge-to-edge repair (TEER) is associated with worse outcomes. This study sought to identify echocardiographic predictors of suboptimal residual MR after TEER in patients with secondary MR.

Methods: In this retrospective single-center study, we identified all patients with secondary MR who underwent TEER between 2016 and 2021. Pre- and intraprocedural transesophageal echocardiographic images were reviewed. The primary outcome was suboptimal residual MR, defined as ≥2+ residual MR on postprocedural transesophageal echocardiography. The association of preprocedural echocardiographic parameters with the primary outcome was tested via logistic regression.

Results: Sixty-five patients (69 ± 15 years; 49% women) with secondary MR underwent TEER with MitraClip. All patients had moderate-severe or severe (3-4+) MR preoperatively, with an average left ventricular ejection fraction of 35% and New York Heart Association class III symptoms. Procedural success, defined as ≤2+ MR post-TEER, was achieved in 94%. A suboptimal residual MR was observed in 38%. Independent predictors of suboptimal residual MR included bicommissural MR (odds ratio [OR], 7.95; 95% CI, 1.50-42.3; P = .02), 2-dimensional anteroposterior diameter (OR, 6.46; 95% CI, 1.85-22.51 per cm; P < .01), and mitral valve area to left ventricular end-diastolic volume ratio (OR, 0.69; 95% CI, 0.50-0.93 per mm^2/mL; P = .02).

Conclusions: Certain echocardiographic features, including bicommissural MR, a larger annular diameter, and a smaller ratio of mitral valve area to left ventricular end-diastolic volume, are associated with suboptimal residual MR following TEER. These preprocedural measurements may optimize patient selection in those with secondary MR being considered for TEER.

Introduction

Secondary mitral regurgitation (SMR) is associated with increased morbidity and mortality in patients with heart failure.[1] In patients with severe, symptomatic SMR at high surgical risk, transcatheter edge-to-edge repair (TEER) has emerged as a standard minimally invasive treatment. However, because of conflicting results from 2 large randomized controlled trials, COAPT (Cardiovascular Outcomes Assessment of the MitraClip Percutaneous Therapy for Heart Failure Patients with Functional Mitral Regurgitation) and MITRA-FR (Percutaneous Repair with the MitraClip Device for Severe Secondary Mitral Regurgitation), there remains considerable debate regarding which patients respond best to TEER.[2,3] Recent data suggest that the clinical benefit of TEER is largely driven by a greater and more durable reduction of MR compared with guideline-directed medical therapy alone.[4]

There is a growing body of evidence supporting a graded relationship between residual MR severity following TEER and recurrent severe MR over time.[5-12] Indeed, patients with moderate (2+) residual MR appear to be more likely to suffer from recurrent severe MR, increased hospitalizations, worse symptoms, and increased mortality compared with patients in whom mild or trivial residual MR (≤1+) is achieved.[7,8,11] Considering the prognostic importance

Abbreviations: 2D, 2-dimensional; ALC, anterolateral commissure; AML, anterior mitral leaflet; APd, anteroposterior diameter; EROA, effective regurgitant orifice area; ICd, intercommissural diameter; PMC, posteromedial commissure; PML, posterior mitral leaflet; TEE, transesophageal echocardiography; TEER, transcatheter edge-to-edge repair.

Keywords: echocardiography; secondary mitral regurgitation; percutaneous mitral valve repair; MitraClip.

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Table 1. Baseline clinical and echocardiographic characteristics.

	Overall (N = 65)	Optimal residual MR (n = 40)	Suboptimal residual MR (n = 25)	*P* value
Demographic characteristics				
Age, y	69 ± 15	70 ± 16	68 ± 14	.67
Female	32 (49)	19 (47.5)	13 (52)	.72
NYHA class	3.1 ± 0.6	3.0 ± 0.7	3.2 ± 0.5	.28
Left ventricular dimensions and function				
LVEDD, cm	5.92 ± 0.99	5.79 ± 0.92	6.14 ± 1.07	.08
LVESD, cm	4.75 ± 1.11	4.59 ± 1.05	5.15 ± 1.14	.02
LVEDV, mL	162.5 ± 80.2	148.1 ± 78.3	185.7 ± 79.5	.03
LVESV, mL	109.4 ± 67.6	98.8 ± 66.4	126.2 ± 67.4	.06
LVEF, %	34.5 ± 15.2	35.4 ± 15.0	33.0 ± 15.6	.54
Echocardiographic characteristics				
Mean TMPG, mm Hg	2.1 ± 0.9	2.0 ± 0.8	2.3 ± 1.1	.13
MR EROA, cm^2	0.42 ± 0.17	0.41 ± 0.17	0.43 ± 0.17	.3
LA volume, mL	114.3 ± 51.0	110.7 ± 49.9	120 ± 53.2	.24
PLL ≤9 mm, %	25 (38)	11 (27.5)	14 (56)	.02
Angle of posterior leaflet tethering, °	37.8 ± 19.8	34.1 ± 19.5	43.7 ± 19.1	.03
Bicommissural MR	43 (66.2)	20 (50)	23 (92)	.0005
2D-APd, cm	3.48 ± 0.59	3.29 ± 0.44	3.78 ± 0.69	.0004
2D-ICd, cm	3.70 ± 0.59	3.51 ± 0.47	4.00 ± 0.65	.0005
MVA, cm^2	5.9 ± 1.8	5.8 ± 1.6	5.9 ± 2.2	.43
Vena contracta, mm	0.67 ± 0.16	0.61 ± 0.16	0.73 ± 0.13	.001
Calcification	39 (60)	24 (60)	15 (60)	>.99
MVA:LVEDV, mm^2/mL	4.48 ± 2.51	5.04 ± 2.69	3.60 ± 1.93	.01
MR severity				.04
Severe	51 (78.5)	28 (70)	23 (92)	
Moderate-severe	14 (21.5)	12 (30)	2 (8)	
Preprocedural tricuspid regurgitation				.84
None/trace	9 (13.8)	3 (7.5)	6 (24)	
Mild	31 (47.7)	22 (55)	9 (36)	
Moderate	18 (27.7)	11 (27.5)	7 (28)	
Severe	7 (10)	4 (10)	3 (12)	
sPAP, mm Hg	46.2 ± 14.6	47.0 ± 15.7	44.6 ± 12.7	.28
TAPSE, cm	1.79 ± 0.45	1.73 ± 0.44	1.91 ± 0.45	.08

Values are mean ± SD or n (%).

2D-APd, 2-dimensional anterolateral-posteromedial diameter; 2D-ICd, 2-dimensional intercommissural diameter; EROA, effective regurgitant orifice area; LA, left atrium; LVEDD, left ventricular end-diastolic diameter; LVEDV, left ventricular end-diastolic volume; LVEF, left ventricular ejection fraction; LVESD, left ventricular end-systolic diameter; LVESV, left ventricular end-systolic volume; MR, mitral regurgitation; MVA, mitral valve area; NYHA, New York Heart Association; PLL, posterior leaflet length; sPAP, pulmonary artery systolic pressure; TAPSE, tricuspid annular plane systolic excursion; TMPG, transmitral pressure gradient.

of recurrent MR in this difficult patient population, it is critical to identify the predictors of procedural outcomes. However, there remains a relative paucity of data regarding how certain morphologic features affect procedural outcomes. The purpose of this study was to determine whether baseline echocardiographic characteristics are associated with suboptimal residual MR in patients with SMR undergoing TEER.

Methods

Patients

Between December 2016 and October 2021, 160 consecutive patients underwent TEER with MitraClip at our institution. Patients were screened for inclusion with the University of California – Los Angeles REDCap database that prospectively records the data of all patients (and their associated demographic characteristics and perioperative events) who underwent TEER at Ronald Reagan University of California – Los Angeles Medical Center. All patients with primary MR or underlying congenital heart disease were excluded from this study. Only patients with predominantly SMR were included. Of the 160 patients initially screened for inclusion, 65 patients met the parameters for the study. This overall cohort was further subdivided into 2 subgroups based on the degree of residual MR following TEER, suboptimal residual MR (≥2+ MR on postprocedural TEE) and optimal residual MR (<2+ residual MR).

This study was approved by the University of California Los Angeles Institutional Review Board. Informed consent and permission for the release of information were obtained from each participant.

Echocardiographic analysis

Echocardiographic analysis was based on current American Society of Echocardiography guidelines and recommendations.[13] The severity of MR was determined on preoperative TEE and graded as follows: 0, none to trace; 1+, mild; 2+, moderate; 3+, moderate to severe; and 4+, severe. Intraprocedural transesophageal echocardiographic images were retrospectively reviewed to both confirm the etiology of MR and to assess the predetermined echocardiographic characteristics outlined below (Table 1). The measurement of mitral annular dimensions by 2-dimensional (2D) TEE was conducted in biplane image loops, including the intercommissural 2-chamber view and a perpendicular long-axis view (Figure 1). The perpendicular long-axis view was used to measure the 2D anteroposterior diameter (APd) of the mitral annulus, and the intercommissural 2-chamber view was used to measure the 2D intercommissural annular diameter (ICd). All annular dimensions and angle of tethering were recorded at end-systole. Posterior leaflet (PL) length was measured in diastole (Figure 2). Of note, secondary outcomes, including fluoroscopy time and complication rate, were collected and reviewed as well.

Outcomes

The primary outcome of this study was suboptimal residual MR, which was defined as ≥2+ MR on postprocedural TEE. Optimal residual MR (n = 40) included patients in whom <2+ residual MR was achieved immediately following TEER. The secondary outcome was fluoroscopy time. Complications and intraoperative mortality were evaluated as

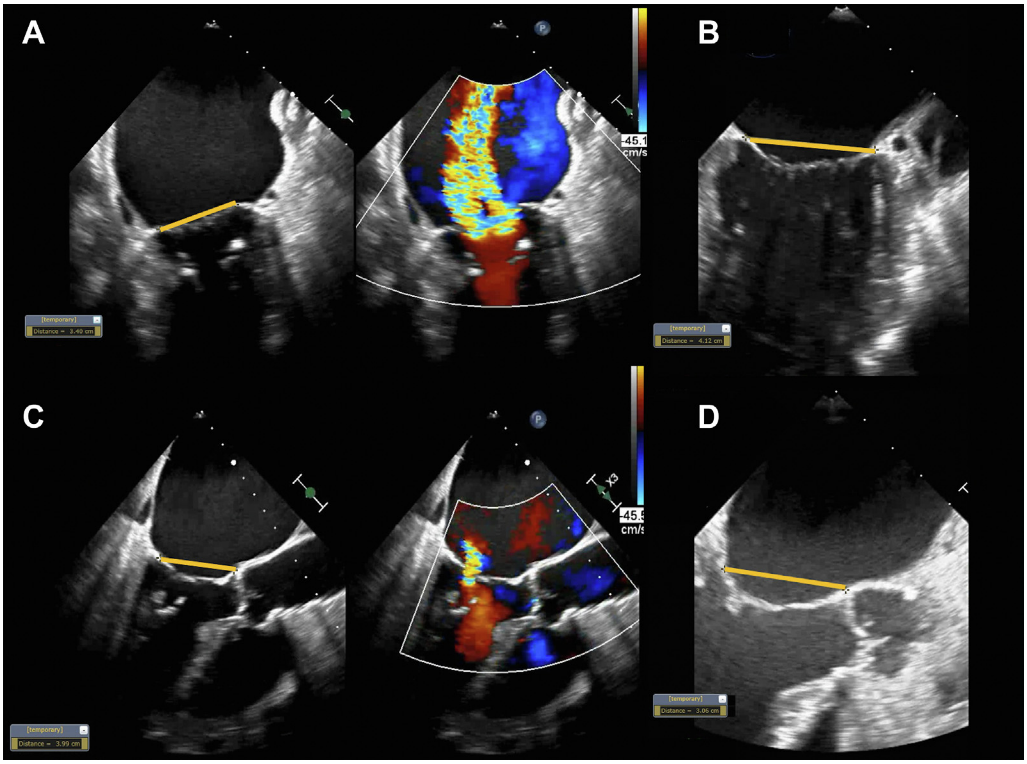


Figure 1. Echocardiographic assessment of mitral annular dimensions. (**A**) and (**B**), 2-dimensional measurement of intercommissural annular diameter in secondary mitral regurgitation. (**C**) and (**D**), 2-dimensional measurement of anteroposterior annular diameter of mitral valve.

well. Data were entered prospectively into a longitudinal database maintained at our institution.

Statistical analysis

Demographic, intraprocedural, and echocardiographic characteristics were compared between the optimal and suboptimal residual MR groups. Continuous variables are expressed as mean ± standard deviation or as median (interquartile range), as appropriate. Categorical variables are expressed as frequencies (percentages). Continuous outcomes between the 2 groups were compared with the 2-sample *t* test on normally distributed continuous variables or the Mann-Whitney *U* nonparametric test was used for skewed distributions. Similarly, categorical outcomes were compared with the χ^2 or Fisher exact tests.

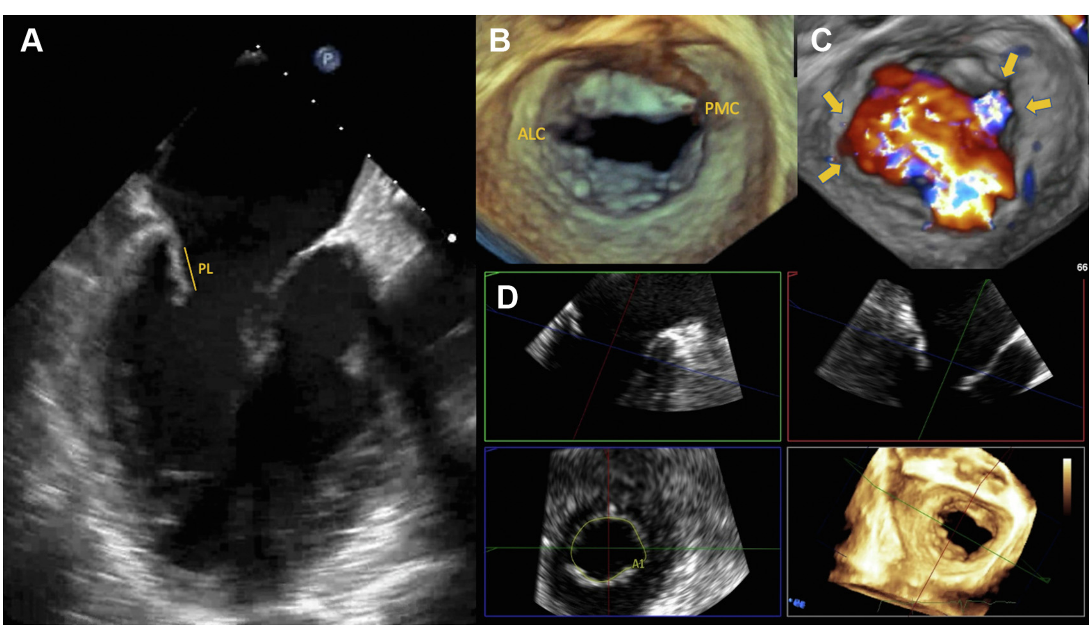


Figure 2. Echocardiographic features of suboptimal residual mitral regurgitation. (**A**) Posterior leaflet (PL) length in mid-diastole. (**B**) 3-dimensional reconstruction of the mitral valve. (**C**) Arrows indicating the presence of bicommissural mitral regurgitation. (**D**) Multiplanar reconstruction planes with measurement of mitral valve area. ALC, anterolateral commissure; PMC, posteromedial commissure.

Table 2. Procedural characteristics and outcomes.

	Overall (N = 65)	Optimal residual MR (n = 40)	Suboptimal residual MR (n = 25)	*P* value
No. of clips	1.8 ± 0.7	1.7 ± 0.7	1.9 ± 0.7	.2
1	25 (38)	17 (42.5)	8 (32)	
2	29 (45)	17 (42.5)	12 (48)	
3	11 (17)	6 (15)	5 (20)	
Clip type				
NT	40 (61.5)	26 (65)	14 (56)	.46
NTW	9 (13.8)	6 (15)	3 (12)	.64
XT	16 (24.6)	8 (20)	8 (32)	.27
XTW	0	0 (0)	0 (0)	
Procedural outcomes				
Technical success	61 (94)	40 (100)	21 (84)	.009
Mean TMPG, mm Hg	3.9 ± 1.5	3.7 ± 1.4	4.2 ± 1.5	.06
Fluoroscopy time, min	40.9 ± 17.0	37.5 ± 15.9	46.2 ± 17.5	.02
Complications				.07
SLDA	0 (0)	0 (0)	0 (0)	
Device embolization	0 (0)	0 (0)	0 (0)	
Chordae entrapment	0 (0)	0 (0)	0 (0)	
Urgent cardiac surgery	0 (0)	0 (0)	0 (0)	
Acute HF	2 (3)	0 (0)	2 (8)	
IABP	2 (3)	0 (0)	2 (8)	
Inotropic drugs	4 (6)	2 (5)	2 (8)	
Vascular complications	0 (0)	0 (0)	0 (0)	
Major MVARC bleed	1 (2)	0 (0)	1 (4)	
Cardiac tamponade	1 (2)	0 (0)	1 (4)	
Intraprocedural death	0 (0)	0 (0)	0 (0)	

Values are mean ± standard deviation or n (%).
HF, heart failure; IABP, intra-aortic balloon pump; MR, mitral regurgitation; MVARC, Mitral Valve Academic Research Consortium; SLDA, single-leaflet device attachment; TMPG, transmitral pressure gradient.

Twenty-six pre- and perioperative variables were evaluated by univariate logistic regression to identify the predictors of suboptimal residual MR following TEER. Significant covariates on univariate analysis ($P < .10$) were entered into a backward selection multivariate logistic regression model to determine the independent predictors of suboptimal MR reduction. These variables are reported as odds ratios (ORs) with 95% CIs. A *P* value of <.05 was considered statistically significant. Receiver operating characteristic analysis was used to evaluate the most accurate echocardiographic thresholds for predicting suboptimal residual MR. Similarly, separate analyses were performed for the secondary outcome using linear regression analysis. All data analyses were performed using SPSS for Macintosh Version 28.0.

Results

Patient characteristics

Of the 65 patients with SMR who underwent TEER, the mean age was 69 years, 32 (49%) patients were women, and the mean New York Heart Association class was 3.1. All patients had either 3+ (22%) or 4+ (88%) MR preprocedurally. The baseline clinical and echocardiographic characteristics are listed in Tables 1 and 2, respectively.

Procedural characteristics

The implantation of at least 1 MitraClip was achieved in all 65 patients. Of these, 25 (38%) patients received 1 clip, 29 (45%) patients received 2 clips, and 11 (17%) patients had 3 clips deployed. The clip types included NT, NTW, and XT (Table 2). The average fluoroscopy time was 40.9 ± 17.0 minutes. Major complications, as listed in Table 2, were defined according to the Mitral Valve Academic Research Consortium criteria.[14] Technical success, defined as ≤2+ MR on postprocedural TEE, was achieved in 61 (94%) patients undergoing TEER.

Optimal versus suboptimal reduction. Suboptimal residual MR was observed in 25 (38%) patients, of which 21 (84%) had 2+ and 4 (16%) had 3+ residual MR. There were no significant differences in age, sex, or New York Heart Association class between patients who achieved suboptimal versus optimal residual MR following TEER. However, there was a greater proportion of patients with preprocedural severe MR in the suboptimal residual MR cohort compared with patients in whom an optimal result was achieved. Although there were no differences in left ventricular function, right ventricular function, or systolic pulmonary artery pressure between groups, patients with suboptimal residual MR had significantly larger left ventricular end-diastolic volumes (LVEDVs; $P = .03$), end-systolic diameters ($P = .02$), angles of PL tethering ($P = .03$), 2D-APd ($P < .01$), 2D-ICd ($P < .01$), and vena contracta width ($P < .01$). Patients with suboptimal residual MR were also noted to have smaller PL lengths ($P = .02$), more bicommissural MR ($P < .01$), and a smaller ratio of mitral valve area (MVA) to LVEDV ($P = .01$; Table 1).

Most of the procedural characteristics were similar between both groups. There were no differences between the groups in terms of the type or number of clips placed. Additionally, there was no significant difference in operative mortality or complications between each cohort (Table 2). The average fluoroscopy time, however, was significantly longer in patients with suboptimal residual MR following TEER ($P = .02$).

Predictors of suboptimal residual MR

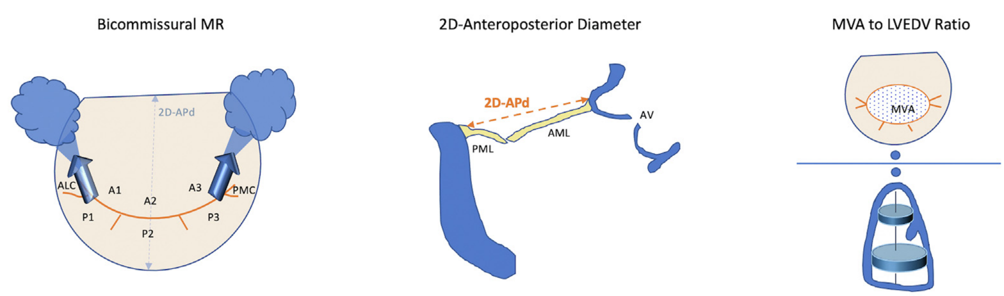
As aforementioned, 2D-APd, 2D-ICd, left ventricular end-diastolic diameter, LVEDV, PL length, angle of PL tethering, bicommissural MR, vena contracta, and MVA to LVEDV ratio were associated with suboptimal residual MR in univariate analysis. Following adjustment, the predictors of suboptimal residual MR after TEER included the presence of bicommissural MR (OR, 7.95; 95% CI, 1.50-42.3; $P = .02$), a larger 2D-APd (OR, 6.46; 95% CI, 1.85-22.51 per cm; $P < .01$), and a smaller MVA to LVEDV ratio (OR, 0.69; 95% CI, 0.50-0.93 per mm^2/mL; $P = .02$) (Central Illustration). On receiver operating characteristic analysis of individual annular measurements, the end-systolic 2D-APd of >3.5 cm and end-systolic 2D-ICd of >3.75 were the most predictive thresholds associated with suboptimal residual MR, with area under the curves of 0.75 and 0.73, respectively.

A similar logistic regression model was created to evaluate the fluoroscopy time. The echocardiogram parameters of left atrial volume, MVA, 2D-APd, 2D-ICd, and vena contracta were positively associated with increased fluoroscopy time. In multivariate analysis, echocardiogram parameters associated with prolonged fluoroscopy time included 2D-ICd (*B*, 8.0 minutes; 95% CI, 0.95-15.14 per cm; $P = .027$) and left atrial volume (*B*, 0.11 minutes; 95% CI, 0.02-0.19 per mL; $P = .013$). *B* is the beta coefficient which represents the degree of change in the outcome for every 1 unit change in the predictor.

Durability of MR reduction over time

Figure 3 depicts serial changes in MR reduction over time following TEER. As noted above, on postprocedural TEE, suboptimal residual MR was observed in 25 (38%) patients. The same proportion, 23 of 61 patients, was noted on transthoracic echocardiography at discharge. Of

CENTRAL ILLUSTRATION Echocardiographic Predictors of Suboptimal Residual MR post-TEER



Echocardiographic Predictors of Suboptimal Residual MR						
				Multivariate Analysis		
				OR	95% CI	*P*-value
	Overall (n=65)	Optimal Residual MR (n=40)	Suboptimal Residual MR (n=25)			
Bicommissural MR	43 (66)	20 (50)	23 (92)	7.95	1.50 – 42.3	0.02
2D-APd, cm	3.48	3.29	3.78	6.46	1.85 – 22.5	<0.01
MVA:LVEDV, mm^2/mL	4.48	5.04	3.60	0.69	0.50 – 0.93	0.02

Central Illustration. Echocardiographic predictors of suboptimal residual MR after transcatheter edge-to-edge repair (TEER). Graphical depictions of echocardiographic features independently associated with suboptimal residual mitral regurgitation (MR) after TEER (top). Arrows in the top left image demonstrate regurgitation at each commissure. The top middle image shows the measurement of 2-dimensional anteroposterior diameter (2D-APd) from the hinge point of the posterior mitral leaflet (PML) to the base of the noncoronary aortic cusp. The top right image shows mitral valve area (MVA): left ventricular end-diastolic volume (LVEDV) with the depiction of Simpson's method to capture LVEDV. The bottom image shows the final multivariate model created via backward selection. ALC, anterolateral commissure; AML, anterior mitral valve; AV, aortic valve; OR, odds ratio; PMC, posteromedial commissure.

patients in whom optimal residual MR was achieved immediately post-TEER, 95% (36/38) remained with optimal residual MR at discharge. Similarly, in the suboptimal residual MR cohort, 91% (21/23) had ≥2+ MR at discharge. The 30-day and 1-year follow-up echocardiography identified that the proportion of patients with ≥2+ MR was 43% (24/56) and 46% (16/35), respectively. Most patients in whom optimal residual MR was achieved post-TEER had a sustained reduction of MR at the 1-year follow-up.

Discussion

This study evaluated whether specific echocardiographic characteristics are associated with suboptimal residual MR following TEER. Although previous series have investigated the impact of demographic characteristics, comorbid conditions, and hemodynamics on the efficacy of TEER, few studies have directly assessed the extent to which specific morphologic features on echocardiography impact the optimal reduction

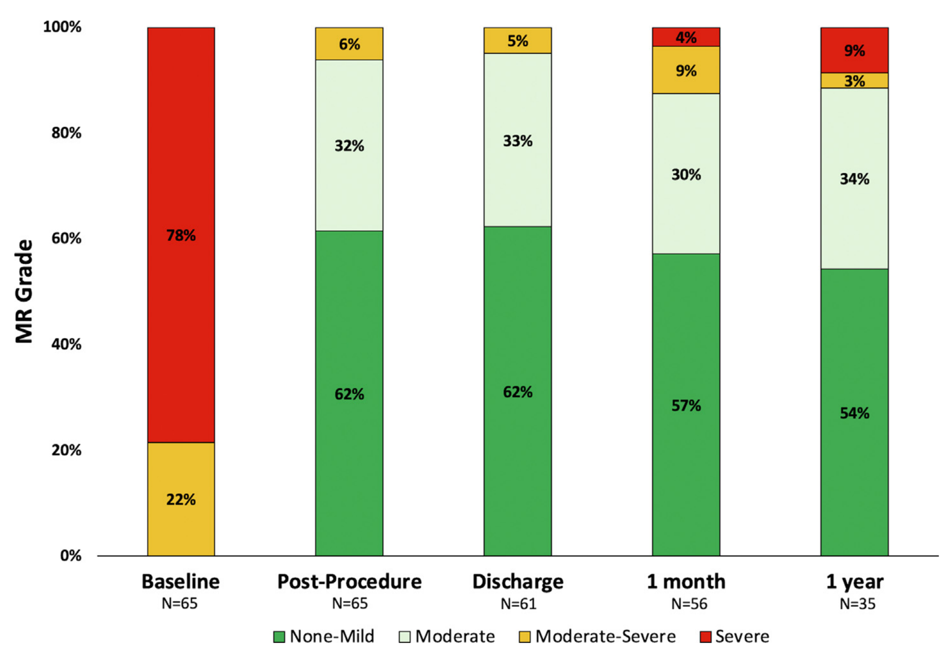


Figure 3. Serial changes in mitral regurgitation (MR) after transcatheter edge-to-edge repair. MR grades depicted before and after the procedure at various time points.

of SMR.[6,12,15-18] To the best of our knowledge, this report includes several echocardiographic features not yet assessed within this particular patient population. Accordingly, this study offers a unique opportunity to identify the baseline morphological characteristics on echocardiography that may predict optimal technical success. Delineating the pathoanatomic features that are associated with suboptimal residual MR following TEER will help refine patient selection in this vulnerable population and ultimately improve outcomes.

In this single-center study, independent predictors of suboptimal residual MR included the presence of bicommissural MR, a larger annular diameter, and a smaller MVA to LVEDV ratio. Importantly, procedural success (≤2+ MR on postprocedural TEE) and optimal residual MR (≤1+) were achieved in 94% and 62% of cases, respectively. These proportions are consistent with multiple prior studies with regard to both acceptable and optimal procedural success after TEER.[5,7,10,15]

The presence of bicommissural MR was an independent predictor of suboptimal residual MR in patients with SMR undergoing TEER. Bicommissural MR specifically refers to the presence of a regurgitant jet at both the posteromedial and anterolateral commissures of the mitral valve. This is the first known report of bicommissural MR as an independent predictor of suboptimal MR reduction following TEER. Of note, 1 previous study identified multiple jets as a risk factor for worse outcomes following MitraClip therapy.[18] However, this analysis was conducted in a heterogeneous cohort of patients with predominantly mixed or primary MR. Especially among patients with SMR, the presence of bicommissural MR underlies the severity and width of the regurgitant jet and often necessitates additional clips. Indeed, these results are consistent with the findings of few reports demonstrating an association with large regurgitant jets and suboptimal MR reduction.[15,19,20] Although other mechanisms of suboptimal residual MR are likely at play here, concern for iatrogenic mitral stenosis via progressive reduction of the mitral valve orifice area likely precluded additional clip placement. Indeed, within this cohort, there was a trend ($P = .06$) toward higher postprocedural mean transmitral pressure gradient in patients with suboptimal residual MR compared with those in whom optimal residual MR was achieved. When residual commissural MR is observed following clip deployment, additional clip implantation is often not feasible or ill-advised given limited space or elevated transmitral pressure gradient.[21] Accordingly, the presence of bicommissural MR on preoperative echocardiography may inform the risk of suboptimal outcomes if TEER is pursued.

Severe mitral annular dilation was independently associated with suboptimal residual MR. Specifically, a larger 2D-APd diameter, measured in end-systole, was predictive of ≥2+ MR immediately following TEER. This finding is corroborated by prior studies which identified annular dilation to be predictive of the degree of MR reduction with MitraClip.[8,22,23] In fact, recent data from Kreidel et al[8] further detail how morphological alterations in the mitral valve apparatus challenge the success of TEER. Indeed, based on their findings, 2D TEE measurements of the mitral valve annulus were performed in end-systole, with special attention paid to identifying the true hinge point of both the posterior and anterior mitral leaflets. The present study identified both 2D-ICd and 2D-APd to be strongly associated with suboptimal residual MR. Furthermore, our proposed cutoff values for annular dilation associated with suboptimal residual MR are comparable with those reported in other studies.[8,22,23] This validates the study by Kreidel et al[8] in an independent cohort thereby further supporting the consideration of mitral annular thresholds to guide clinical decision making with regard to TEER.

Annular size is one of many morphologic criteria currently being evaluated to further elucidate the pathophysiologic mechanism underlying SMR. SMR appears to be a heterogeneous disease with a variety of phenotypes.[24] Indeed, these phenotypic variations have been proposed as the reason for the discordant results between the 2 largest randomized trials with MitraClip—COAPT and MITRA-FR.[24] Specifically, the concept of proportionate and disproportionate SMR has evolved to delineate some of the key morphological differences between these 2 distinct cohorts. Unlike patients with proportionate MR, those with disproportionate MR appear to benefit from TEER.[24] The exact mechanism underlying this observation remains ill-defined but has been attributed to the more asymmetric geometric distortions of the mitral valve apparatus because of focal left ventricular wall motion abnormality with a resultant regurgitant jet that may be more amenable to TEER.[25] Barko et al[26] further described the phenotypic variability of SMR, supporting the proposed concept of a force-balance relationship among the left atrium, mitral apparatus, and left ventricle. In short, the complexity of the pathomorphology of SMR remains a significant hurdle in the identification and assessment of morphologic features that predict success or failure.

Based on these data heretofore described, we identified a novel measure that accounts for both the size of the mitral valve apparatus and the dilation of the left ventricle—the MVA:LVEDV index. This measure incorporates 2 variables previously associated with worse outcomes following repair with MitraClip.[7,16,23,24,27] In the present study, a smaller ratio of MVA to LVEDV was identified as an independent predictor of suboptimal residual MR following TEER. This is a simple and inexpensive indicator of annular-to-ventricular mismatch with values readily obtained from preprocedural TEE. Importantly, other metrics, including a leaflet-to-annulus index, have been found to be predictive of residual MR with TEER.[28] However, unlike the leaflet length, a composite of posterior mitral leaflet and anterior mitral leaflet, MVA is routinely assessed according to specific guidelines. Other indices created to capture the phenotypic variation in SMR include effective regurgitant orifice area (EROA):LVEDV, as aforementioned. EROA is derived from the use of proximal isovelocity surface area, a measurement predicated on the assumptions of a hemispherical regurgitant jet through a flat annular plane.[13] However, particularly in patients with SMR, the convergence zone is asymmetric, jets are often eccentric, and regurgitant orifice can be crescent-shaped, resulting in significant underestimation of MR severity.[13] Accordingly, EROA calculation and accompanying ratios, EROA:LVEDV, are fraught with difficulties and may not be a reliable measure to predict immediate postprocedural suboptimal residual MR. Instead, our results suggest that the MVA:LVEDV index could aid clinicians in identifying patients who may have a suboptimal outcome with TEER, independent of the baseline MR severity.

Study limitations

This was a single-center retrospective study with a limited sample size. However, by defining suboptimal residual MR as ≥2+ MR on postprocedural TEE, multiple morphologic variables were identified that may be clinically relevant. Furthermore, it should be noted that many demographic, echocardiographic, and intraoperative variables were collected prospectively, and this was a series of consecutive patients. A larger cohort of patients would improve the statistical power and possibly reveal additional morphologic predictors of residual MR. The study is underpowered to comment on the correlation between procedural and clinical outcomes including mortality. Additional demographic and clinical data, including the use of guideline-directed medical therapy, the presence of comorbid conditions, and short- and long-term follow-ups, would provide further insight into each cohort and delineate the prognostic value of the associated predictors of residual MR. Although echocardiographic measurements were not validated by an independent core laboratory, MR, both pre- and postprocedurally, was evaluated prospectively by imaging specialists according to current guidelines. Our results are hypothesis-generating, and further investigations with independent large cohorts are needed to validate our preliminary findings.

Conclusions

Mitral valve echocardiographic characteristics, including the presence of bicommissural MR, annular dilation, and a small MVA:LVEDV index, are predictive of suboptimal residual MR following TEER.

Preprocedural evaluation of these pathoanatomic features on echocardiography may optimize patient selection for MitraClip therapy.

Declaration of competing interest

Dr Aksoy is a proctor for Edwards. Dr Parikh receives research support from the American Heart Association, Janssen, Infraredx, Abbott Vascular, and Bayer, and consulting fees from Abbott Vascular, all unrelated to the contents of this manuscript. Dr Calfon Press was a proctor from 2019-2021 for MitraClip (Abbott). Drs Labin, Tehrani, Yang, Lluri, Nsair, Rafique, and Ms Lai reported no financial interests.

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Ethics statement

This study was approved by the University of California Los Angeles Institutional Review Board. Informed consent and permission for release of information was obtained from each participant.

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