

# Mitral Valve Repair Rate at a Veterans Affairs Hospital Utilizing a Multidisciplinary Heart Team



Ernesto Jimenez, MD,<sup>\*,†</sup> Darrell Wu, MD,<sup>\*</sup> Shuab Omer, MD,<sup>\*,†</sup> Lorraine Cornwell, MD,<sup>\*,†</sup> Paulino Nunez, MD,<sup>‡</sup> Todd K. Rosengart, MD,<sup>\*,†</sup> and Joseph S. Coselli, MD<sup>\*,†</sup>

Between 2000 and 2008, the mitral valve (MV) repair rate in patients with severe mitral regurgitation at our low-volume Veterans Affairs hospital was 21%. After instituting a multidisciplinary valve team in 2009, we determined whether this rate increased and characterized the outcomes of patients with degenerative disease. We retrospectively reviewed data from 103 MV operations performed at our hospital between 1/2009 and 8/2016. MV pathology was categorized as degenerative, rheumatic, endocarditis, ischemic, hypertrophic cardiomyopathy, or failed prior MV repair. The surgical techniques used for MV repair were reviewed. For the patients with degenerative disease who underwent MV repair, we assessed leaflet involvement and postoperative valve function. For the full cohort, the MV repair rate was 67% and the 30-day mortality rate was 0.97%. Of the 74 patients with degenerative disease, 64 (86.5%) underwent MV repair (none required reoperation). For these patients, the MV repair rate was significantly higher when the surgical approach was sternotomy rather than minimally invasive right minithoracotomy (92.5% vs 71.4%,  $P=0.03$ ). After MV repair, 95.3% of the degenerative disease patients had mild or less mitral regurgitation; median echocardiography follow-up time was 555 days. Anatomic features associated with a reduced MV repair rate in patients with degenerative disease were dystrophic leaflet calcification and severe mitral annular calcification. In an institution with a low volume of MV operations, preoperative surgical planning with a multidisciplinary valve team was associated with improved MV repair rates and excellent repair quality in patients with degenerative valve disease.

**Semin Thoracic Surg** 31:434–441 © 2019 Elsevier Inc. All rights reserved.

**Keywords:** Mitral valve repair, Multidisciplinary team

## INTRODUCTION

A recent study of 4165 mitral valve (MV) procedures performed at 40 US Veterans Affairs (VA) hospitals demonstrated

*Abbreviations:* MR, mitral regurgitation; MV, mitral valve; TEE, transthoracic echocardiography; VA, Veterans Affairs; NYHA, New York Heart Association

<sup>\*</sup>Department of Cardiothoracic Surgery, Baylor College of Medicine/Texas Heart Institute, Houston, Texas

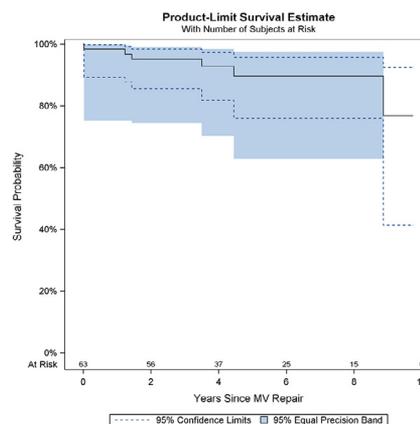
<sup>†</sup>Division of Cardiothoracic Surgery, Michael E. DeBakey Veterans Affairs Hospital, Houston, Texas

<sup>‡</sup>Department of Anesthesia, James A. Haley Veterans Hospital, Tampa, Florida

**Funding:** This work was not funded by a grant or any other source of external funding.

**Conflicts of Interest:** None of the authors has any potential conflict of interest with regard to the work described in this manuscript.

Address reprint requests to Ernesto Jimenez, MD, Michael E. DeBakey VA Medical Center, 2002 Holcombe Boulevard, Houston, TX 77030. E-mail: [Ernesto.jimenez3@va.com](mailto:Ernesto.jimenez3@va.com)



Survival curve for the degenerative pathology patients who underwent mitral valve repair.

## Central Message

In a low-volume VA hospital, preoperative surgical planning with a multidisciplinary heart team and open sternotomy were associated with improvements in the rate and quality of MV repair.

## Perspective Statement

In centers with a high MV procedure volume, the MV repair quality and rates for patients with severe MR are increased. Our study suggests that a preoperative multidisciplinary team approach to degenerative MV disease in hospitals with a low MV procedure volume is associated with surgical outcomes that are similar to those of high-volume centers.

good surgical outcomes despite the low volume of MV operations performed per hospital.<sup>1</sup> However, the repair rate for degenerative MVs (63%) was disappointingly low. The ACC/AHA guidelines<sup>2</sup> have suggested that the MV repair rate for patients with degenerative MV disease should be 90% or greater. In a study by Bolling et al,<sup>3</sup> higher MV procedural volume per surgeon was an independent predictor of MV repair. An inflection point of 40 isolated MV cases per surgeon per year has been suggested as a threshold for a center to qualify as a “MV center of excellence.”<sup>4</sup>

Within the VA health system, the median number of MV operations performed per center per year has been reported to

be 7. The MV repair rates for the VA hospitals varied widely and were not strongly associated with each facility's MV surgical volume.<sup>1</sup>

A multidisciplinary approach to aortic valve disease, as well as to ischemic heart disease, has been demonstrated to result in better patient outcomes.<sup>5</sup> At the James A. Haley VA Hospital (an institution with a low volume of MV operations), the MV repair rate in patients with severe mitral regurgitation (MR) was 21% for the years 2000–2008. Because of this low repair rate, the hospital implemented a multidisciplinary heart team approach to MV disease treatment in 2009. Herein, we sought to determine whether implementing this approach resulted in better MV repair rates and outcomes.

## PATIENTS AND METHODS

This study was initially started as a VA Surgical Quality Improvement Project and was subsequently approved by the institutional review board of the James A. Haley Veterans Hospital. Since January 2009, the James A. Haley VA Hospital has developed both a multidisciplinary valve heart disease conference and a minimally invasive MV surgical program to improve the quality and outcomes of MV operations. We retrospectively reviewed the records of 103 consecutive patients who were referred to this single VA center for an MV operation between January 2009 and August 2016. For each of these patients, the case was discussed by a multidisciplinary weekly conference composed of anesthesia, cardiology, and cardiac surgery faculty before the operation was performed. All patients with severe MR were considered for repair, and the specific cause of regurgitation was identified. The transesophageal echocardiography (TEE) results of the patients with severe MR due to degenerative disease were specifically reviewed to determine the anatomic mechanism for the MR, and a surgical plan was formulated for repair. At least 1, but up to 3, cardiologists board certified in cardiac echocardiography were present during the weekly conference to review the echocardiograms.

Intraoperative TEE performed by an anesthesiologist certified in echocardiography was used to confirm the MV pathology and evaluate the efficacy of the repair. One surgeon (EJ) performed the overwhelming majority of the operations within the study.

For every patient, we obtained a baseline postoperative transthoracic echocardiogram before the patient was discharged. Follow-up echocardiograms were obtained during the initial postoperative visit with either a cardiologist or surgeon at our institution and were adjudicated by 1 of our 3 cardiologists board certified in echocardiography. Additional follow-up echocardiograms were obtained at the discretion of the patient's clinician (cardiologist or primary care physician). All echocardiograms from a referral VA institution were adjudicated by a board-certified cardiologist.

Data were obtained from the operative notes, the most recent postoperative echocardiogram, and the patients' follow-up records. MV disease processes were categorized as degenerative, rheumatic, endocarditis, ischemic, hypertrophic cardiomyopathy, or failed prior repair. The surgical techniques used

for the MV repairs were assessed, including annuloplasty type, leaflet resection, chordae replacement with Gore-Tex sutures, commissuroplasty, Alfieri technique, sliding repair, and use of annular plication. For the patients with degenerative MV disease, in-depth analyses of leaflet involvement (posterior, anterior, or bi-leaflet prolapse) and postoperative valve function were performed. In addition, the effects of the surgical approach (open sternotomy vs minimally invasive right minithoracotomy) on the rate and quality of MV repair were examined in these patients. Postoperative follow-up transthoracic echocardiography exams were performed within routine clinical practice using standard methods.

Minimally invasive right minithoracotomy was performed via a 5-cm anterolateral incision on the right side with peripheral cannulation via the femoral artery and vein. A cross clamp was placed on the aorta, and antegrade and retrograde cardioplegia were administered. The retrograde catheter (Edwards) was inserted into the coronary sinus by a single anesthesiologist via the right internal jugular vein under TEE and fluoroscopic guidance.

## Statistical Analysis

Statistical analyses were performed with SAS, Version 9.4 (SAS Institute Inc., Cary, NC). The cutoff value for statistical significance was  $P < 0.05$ , and all tests were 2-sided. There were no adjustments to the  $P$  values for multiplicity. Group differences in the distribution of preoperative characteristics, repair rates, postoperative outcomes, and repair quality were tested with chi-square analysis or the Fisher exact test for the categorical variables and with the Wilcoxon 2-sample test for the continuous variables. Non-normality of the continuous variables was verified both visually and with the Kolmogorov-Smirnov test.

The time-to-event outcome of survival in the degenerative pathology patients was analyzed by using the Kaplan-Meier method, and the median follow-up time was calculated by using the reverse Kaplan-Meier method. Patients who did not die before the end of the study period (7/1/2018) were considered censored at the time of the last follow-up when confirmed alive. Patients who did die were censored upon death. All patients had at least 1 postoperative echocardiography exam before they died.

## RESULTS

### Full Cohort

Between January 2009 and August 2016, 103 MV procedures were performed at the James A. Haley Hospital. An assessment of preoperative characteristics showed that the patients who underwent MV repair and those who underwent MV replacement were similar in terms of age, gender, ejection fraction, and atrial fibrillation (Table 1). However, the 2 groups differed in the distribution of patients within the New York Heart Association (NYHA) functional classifications ( $P < 0.01$ ); the prevalence of NYHA III–IV heart failure was higher in the

## ADULT — MV REPAIR RATE AT A VA HOSPITAL

**Table 1.** Preoperative Patient Characteristics, Intraoperative Details, and Postoperative Outcomes of Patients Who Underwent Mitral Valve Repair vs Mitral Valve Replacement

| Variable                                     | Mitral Valve Repair<br>(n = 69) | Mitral Valve Replacement<br>(n = 34) | P Value |
|--|---------------------------------|--------------------------------------|---------|
| <b>Preoperative</b>                          |                                 |                                      |         |
| Age, y                                       | 64 [58.5–67]                    | 68 [63–72]                           | 0.06    |
| Male sex                                     | 67 (97.1)                       | 32 (94.1)                            | 0.60    |
| Preoperative EF by echocardiography          | 50 [40–55]                      | 55 [50–58]                           | 0.23    |
| NYHA class                                   |                                 |                                      | <0.01   |
| I  | 10 (14.5)                       | 0 (0.0)                              |         |
| II   | 25 (36.2)                       | 11 (32.4)                            |         |
| III  | 25 (36.2)                       | 9 (26.5)                             |         |
| IV   | 9 (13.0)                        | 14 (41.2)                            |         |
| Preoperative atrial fibrillation             | 20 (29.0)                       | 6 (17.7)                             | 0.21    |
| Mitral valve disease process                 |                                 |                                      | <0.01   |
| Degenerative disease                         | 64 (92.8)                       | 10 (29.4)                            |         |
| Barlows                                      | 1 (1.4)                         | 3 (8.8)                              |         |
| Ischemic disease                             | 5 (7.3)                         | 4 (11.8)                             |         |
| Calcific stenosis/rheumatic disease          | 0 (0.0)                         | 10 (29.4)                            |         |
| Hypertrophic cardiomyopathy                  | 0 (0.0)                         | 2 (5.9)                              |         |
| Endocarditis                                 | 0 (0.0)                         | 4 (11.8)                             |         |
| Redo mitral valve operation                  | 0 (0.0)                         | 4 (11.8)                             |         |
| <b>Intraoperative</b>                        |                                 |                                      |         |
| Cross-clamp time, min                        | 72 [63–88]                      | 88 [80–100]                          | 0.02    |
| Pump time, min                               | 93 [89–108.5]                   | 126 [108.5–135]                      | <0.01   |
| Blood transfusion                            | 13 (26.5)                       | 9 (42.9)                             | 0.18    |
| Surgical approach                            |                                 |                                      | 0.11    |
| Minithoracotomy                              | 16 (23.2)                       | 13 (38.2)                            |         |
| Sternotomy                                   | 53 (76.8)                       | 21 (61.8)                            |         |
| <b>Concomitant surgery</b>                   |                                 |                                      |         |
| CABG   | 13 (18.8)                       | 3 (8.8)                              | 0.19    |
| Aortic valve replacement                     | 3 (4.4)                         | 3 (8.8)                              | 0.39    |
| Tricuspid valve repair                       | 3 (4.4)                         | 2 (5.9)                              | 1.00    |
| Redo surgery                                 | 2 (2.9)                         | 3 (8.8)                              | 0.33    |
| Maze procedure for AF                        | 13 (18.8)                       | 3 (8.8)                              | 0.19    |
| ASD  | 1 (1.5)                         | 0 (0.0)                              | 1.00    |
| VSD  | 1 (1.5)                         | 0 (0.0)                              | 1.00    |
| <b>Postoperative</b>                         |                                 |                                      |         |
| Postoperative EF                             | 55 [45–60]                      | 55 [50–55]                           | 0.40    |
| Duration of follow-up by echocardiography, d | 526 [340.5–1361]                | 380 [92–761]                         | 0.06    |
| 30-day mortality                             | 1 (1.3)                         | 0 (0.0)                              | 1.00    |

AF, atrial fibrillation; ASD, atrial septal defect; CABG, coronary artery bypass grafting; EF, ejection fraction; NYHA, New York Heart Association; VSD, ventricular septal defect.

Data shown as *n* (%) or median (interquartile range).

MV replacement group than in the MV repair group (67.7% vs 49.2%).

Two-thirds of the total cohort underwent MV repair (69/103, 67%), and one-third underwent MV replacement (34/103, 33.0%; Table 1). MV repair was primarily used to treat degenerative MV disease (64/69, 92.8%) but was also used to treat ischemic MV disease (5/69, 7.3%). MV replacement was performed not only for degenerative and ischemic MV disease but also for calcific stenosis/rheumatic MV disease, hypertrophic cardiomyopathy, endocarditis, and redo MV operations. None of the patients with MV endocarditis had anatomy that allowed for limited resection and MV repair. Of the 74 patients

who had degenerative pathology, 64 (86.5%) underwent MV repair and 10 (13.5%) underwent MV replacement. For the patients with ischemic disease, the type of surgery performed was more evenly split; of the 9 patients with ischemic disease, 5 (55.6%) underwent MV repair and 4 (44.4%) underwent MV replacement.

An evaluation of intraoperative details showed that compared to the patients in the MV repair group, those in the MV replacement group required a longer cross-clamp time (72 vs 88 min,  $P = 0.02$ ) and a longer pump time (93 vs 126 min,  $P < 0.01$ ; Table 1). The patients in the 2 groups showed no significant difference in blood transfusion rates, surgical approaches

**Table 2.** Mitral Valve Repair Details

| Variable                                    | Mitral Valve Repair<br>(n = 69) |
|---|---------------------------------|
| Annuloplasty                                | 69 (100.0)                      |
| Full ring (Physio II)                       | 20 (29.4)*                      |
| GeoForm ring                                | 4 (5.9)*                        |
| Posterior partial band                      | 44 (64.7)*                      |
| Ring size                                   | 28 [28–30]                      |
| Commissuroplasty/Alfieri                    | 6 (8.8)                         |
| Chordal replacement with PTFE sutures       | 20 (29.0)                       |
| Leaflet resection                           | 40 (58.0)                       |
| Triangular                                  | 30 (43.5)                       |
| Quadrangular                                | 10 (14.5)                       |
| Cleft leaflet closure                       | 3 (4.3)                         |
| Mitral annulus reduction, annular plication | 4 (5.9)                         |
| Sliding leaflet repair                      | 8 (11.8)                        |

PTFE, polytetrafluoroethylene.

Data shown as *n* (%) or median (interquartile range).

\*Percentage out of 68 patients with known ring type.

(minithoracotomy vs sternotomy), or the concomitant surgeries undergone. Of the 20 patients with atrial fibrillation who underwent MV repair, 13 (65%) also underwent a complete left maze procedure. Exclusion criteria for having a maze procedure were having an enlarged left atrium (>6 cm) and reoperative status. All patients in atrial fibrillation were treated with left atrial appendage ablation, which was most often performed with an AtriCure clip.

The median duration of echocardiography follow-up after MV surgery was not significantly different for the patients who underwent MV repair than for those who underwent MV replacement (526 vs 380 days,  $P = 0.06$ ; Table 1). Because patients within the VA system do not routinely undergo long-term, longitudinal, time-based follow-up with echocardiography, the mean time of echocardiography follow-up after MV repair was relatively short compared to that for other MV repair series. The 30-day mortality rate for the entire cohort was 0.97%. The patients in the 2 groups showed no significant difference in 30-day mortality rate or postoperative ejection fraction. Details regarding the MV repair techniques used are provided in Table 2.

### Patients With Degenerative MV Disease

Table 3 shows the leaflet involvement for the 74 patients with degenerative pathology. The most frequent finding was

posterior leaflet involvement (44/74, 59.5%), followed by bi-leaflet involvement (22/74, 29.7%) and anterior leaflet involvement (8/74, 10.8%). For the 64 patients with degenerative disease who underwent MV repair, these proportions were similar (posterior: 43/64, 67.2%; anterior: 7/64, 10.9%; bi-leaflet: 14/64, 21.9%).

Ten patients with degenerative MV disease underwent MV replacement. In 6 of these patients, the valve was replaced instead of repaired because of intraoperative anatomic features that the surgeon believed were highly predictive of poor MV repair outcomes. Five of the 6 patients had severe dystrophic calcification of at least 1 leaflet and severe mitral annular calcification. One patient had an excessively long anterior leaflet, a short coaptation-to-septum distance, and a very small left ventricle cavity; therefore, the risk of systolic anterior motion was believed to be prohibitive for MV repair. Three of the patients with degenerative disease underwent MV replacement because they had extensive bi-leaflet degenerative pathology that was causing severe bi-leaflet MV prolapse and because they were undergoing concomitant procedures. Finally, 1 patient required intraoperative conversion from repair to replacement because he developed severe MR after the repair due to systolic anterior leaflet motion that was not responsive to standard intraoperative hemodynamic therapy.

The MV repairs for degenerative disease were performed via sternotomy in 76.6% of cases (49/64) and via right minithoracotomy in 23.4% of cases (15/64). For the patients with degenerative pathology, the likelihood of MV repair differed depending on the operative approach; the MV repair rate was higher in the patients who underwent sternotomy than in those who underwent right minithoracotomy (92.5% vs 71.4%,  $P = 0.02$ ).

Of the 64 patients with degenerative pathology who underwent MV repair, 39 (60.9%) did not develop postoperative MR, 61 (95.3%) had no greater than mild postoperative MR, only 3 (4.7%) developed moderate MR, and none developed severe postoperative MR (Table 4). The surgical approach used (sternotomy vs right minithoracotomy) did not affect the repair quality in the patients with degenerative pathology; the rates of greater than mild MR recurrence were similar for the patients who underwent sternotomy and those who underwent right minithoracotomy ( $P = 0.68$ ).

Of the 64 patients with degenerative pathology who underwent MV repair, 62 (96.9%) had no greater than mild postoperative stenosis (ie, a MV area >1.5 cm<sup>2</sup> and a mean gradient <5 mm Hg; Table 4).

**Table 3.** Leaflet Involvement for the Patients With Degenerative Mitral Valve Disease

| Leaflet Involvement | All (Repair or Replacement)<br>(n = 74) | Mitral Valve Repair<br>(n = 64) | Mitral Valve Replacement<br>(n = 10) |
|---------------------|---|---------------------------------|--------------------------------------|
| Posterior leaflet   | 44 (59.5)                               | 43 (67.2)                       | 1 (10.0)                             |
| Anterior leaflet    | 8 (10.8)                                | 7 (10.9)                        | 1 (10.0)                             |
| Both leaflets       | 22 (29.7)                               | 14 (21.9)                       | 8 (80.0)                             |

Data shown as *n* (%).

**Table 4.** Comparison of the Intraoperative TEE and Follow-Up Echocardiography Results of the Patients With Degenerative Mitral Valve Disease Who Underwent Mitral Valve Repair

| Outcome                 | Intraoperative TEE<br>(n = 64) | Follow-Up Echocardiography*<br>(n = 64) |
|-------------------------|--------------------------------|---|
| No mitral regurgitation | 58 (90.6)                      | 39 (60.9)                               |
| Mitral regurgitation    | 6 (9.4)                        | 25 (39.0)                               |
| Trace                   | 4 (6.3)                        | 7 (10.9)                                |
| Mild                    | 2 (3.1)                        | 15 (23.4)                               |
| Moderate                | 0 (0)                          | 3 (4.7)                                 |
| Severe                  | 0 (0.0)                        | 0 (0.0)                                 |
| No mitral stenosis      | 63 (98.4)                      | 51 (79.7)                               |
| Mitral stenosis         | 1 (1.6)                        | 13 (20.3)                               |
| Trace                   | 0 (0.0)                        | 1 (1.6)                                 |
| Mild                    | 1 (1.6)                        | 10 (15.6)                               |
| Moderate                | 0 (0.0)                        | 2 (3.1)                                 |
| Severe                  | 0 (0.0)                        | 0 (0.0)                                 |

TEE, transesophageal echocardiography.

Data shown as n (%).

\*Echocardiography follow-up period: range = 6–3597 days, mean = 887 days, median = 555 days, interquartile range = 338–1365 days.

None of the patients who underwent MV repair for degenerative disease has required reoperation, but 1 died within 30 days of his operation from a pulmonary embolus.

As shown in Figure 1, patients with degenerative pathology who underwent MV repair had an 89.7% survival rate at the median follow-up time of 4.4 years (95% confidence interval, 3.9–6.6 years). At 9 years, the survival rate remained high at 77%.

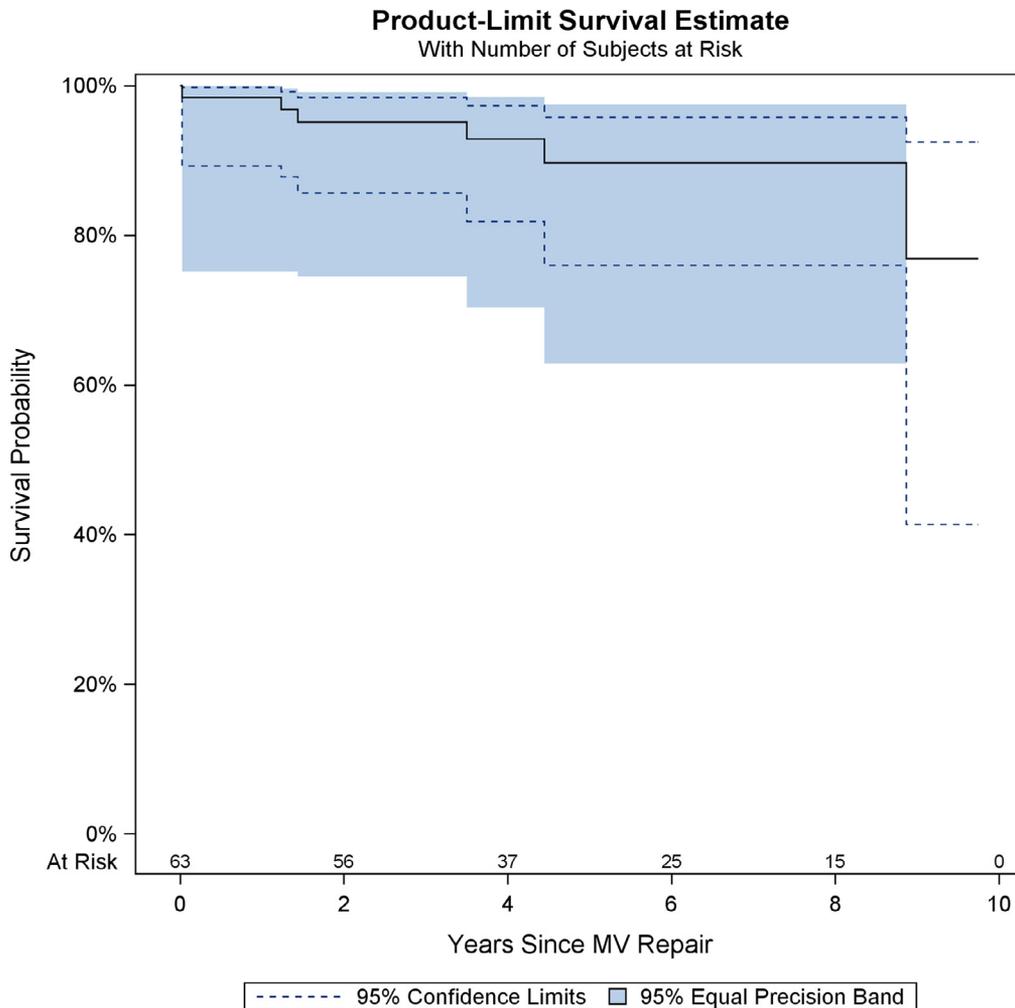
## DISCUSSION

Under the current guidelines, MV repair is recommended over MV replacement for patients with severe MR due to degenerative MV disease.<sup>6</sup> The MV repair rates for degenerative pathology have, therefore, increased over time.<sup>1,3,7–11</sup> A metric presently being advocated to measure quality of MV surgery in all symptomatic patients with severe MR due to degenerative pathology, regardless of the location of prolapse, is having a MV repair rate of at least 90%.<sup>8,11,12</sup> In addition, 2 criteria being advocated as being necessary for offering surgery to asymptomatic patients with severe MR due to degenerative valve disease and preserved LV function (ie, class 2 indications) are having a residual MR rate of less than 5% and an expected mortality rate of less than 1%.<sup>13</sup> Increased MV procedure volume per surgeon has been shown to be independently associated with an increase in MV repair rate and a decrease in operative risk.<sup>3,14</sup> However, an analysis by Chatterjee et al<sup>15</sup> of data from the Society of Thoracic Surgeons database suggested that the decrease in operative mortality was also associated with an increase in the number of MV repairs performed in low-risk patients. Recently, some medical centers with a high volume of MV operations have advocated the development of quality metrics that enable a hospital to be classified as a “MV

center of excellence,” even though such thresholds have not yet been determined using a broadly representative and clinically rich data source. Such MV centers of excellence would be expected to have a greater than 90% MV repair rate for patients with a degenerative valve and to meet minimum MV procedure volume requirements for surgeons and centers (~40 per year per surgeon).<sup>4</sup> Referrals to high-volume centers from low-volume hospitals would be encouraged to improve MV surgical outcomes. Because few, if any, VA centers could meet both the minimum MV procedure thresholds for surgeons and centers and the greater than 90% MV repair rate for degenerative pathology, VA centers probably could not be designated as MV centers of excellence.

Having multidisciplinary teams that are able to discuss and evaluate all the treatment options for the patients has been shown to facilitate better decision-making and adherence to clinical guidelines.<sup>5</sup> The development of a multidisciplinary approach for transcatheter aortic valve surgery is an example of when collaboration between cardiologists and surgeons has led to improved patient outcomes. VA hospitals are also known to use multidisciplinary teams to treat ischemic heart disease. A recent study that compared VA hospitals to private hospitals found that the VA hospitals had equivalent coronary artery bypass grafting outcomes, despite having lower volumes of these procedures.<sup>16</sup> Therefore, we asked the following question: Is surgical volume the determining factor in the quality of MV surgery, particularly in the rate of MV repairs? In this study of a single-surgeon experience at a low-volume hospital, we evaluated whether having a multidisciplinary valve conference increased the MV repair rate in our veteran population with severe MR. For such patients, the MV repair rate at our hospital for the 60 MV procedures performed between 2000 and 2008 (before the multidisciplinary valve conference) was 21%. However, as shown in the current study, the MV repair rate for the 103 MV procedures performed between 2009 and 2016 (after we initiated the multidisciplinary valve conference) was 67%, suggesting that the new approach resulted in a significant increase in MV repairs. The pattern of referrals to our hospital remained the same during the 2 time periods, and the prevalence of degenerative MV disease in our cohort was the same as that noted in the national VA database.<sup>1</sup> These facts suggest that the improvement in the MV repair rate was due to the multidisciplinary approach and not to changes in the referral pattern or prevalence of degenerative MV pathology during the 2 time periods.

In addition, we evaluated whether having a multidisciplinary MV conference provided the surgeon the support required to establish a MV surgery program that emulates the MV repair rates and surgical outcomes of MV centers of excellence for patients with severe MR due to degenerative MV disease. Our subanalysis of the patients with degenerative MV disease showed that our multidisciplinary team approach resulted in an MV repair rate of 87% for these patients. For the patients with degenerative pathology who underwent open sternotomy, the repair rate was 93%.



**Figure 1.** Survival probability curve for the patients with degenerative pathology who underwent mitral valve (MV) repair.

Forty-nine percent of the patients in our MV repair group had NYHA class III or IV symptoms, 28% had at least 1 concomitant procedure, and the mean Left Ventricular Ejection Fraction (LVEF) of these patients was moderately reduced. Nevertheless, the 30-day mortality rate for our MV repair group was 1.3%. This rate compares favorably with the 1.4% 30-day mortality rate reported for the patients in the Society of Thoracic Surgeons database who underwent primary MV repair-only procedures, a high proportion of whom were younger, low-risk patients who lacked other serious comorbidities.<sup>15</sup>

Recurrent MR, defined as MR of moderate or greater severity after MV repair, has been associated with adverse left ventricular remodeling and increased mortality in patients with a degenerative valve.<sup>17,18</sup> MR recurrence has been noted to be higher during the first postoperative year and lower thereafter.<sup>11,18,19</sup> For our patients with degenerative MV disease who underwent MV repair, the incidence of MR recurrence and greater than mild postoperative mitral stenosis was 4.7% (3/64) and 3.1% (2/64), respectively, at a mean postoperative

echocardiography follow-up of 887 days. Both values compare favorably to those previously reported for several MV centers of excellence.<sup>17,18,20–22</sup>

In our veteran population with severe MR, degenerative MV disease caused the posterior leaflet, anterior leaflet, or both leaflets to prolapse in 59.5%, 29.7%, and 10.8% of patients, respectively. These rates of leaflet involvement were similar to those previously reported for the general population.<sup>9</sup> In addition, we noted that 5 (6.8%) of our 74 patients with advanced degenerative MV disease and severe MR had extensive dystrophic calcification of at least 1 leaflet and severe annular calcification, which precluded them from undergoing MV repair. The high rate of leaflet degeneration may be related to the fact that VA patients, such as ours, are generally older and have more comorbidities. Gillinov et al<sup>23</sup> have suggested that some patients who have a valve with advanced myxomatous degeneration and dystrophic calcification of the annulus may not benefit more from MV repair than they would from MV replacement.

## ADULT — MV REPAIR RATE AT A VA HOSPITAL

Finally, for our patients with degenerative disease who underwent a minimally invasive right minithoracotomy, the MV repair rate was 71.4%. This repair rate was low compared to that for a similar group of 1114 patients who underwent surgery at a heart valve center with long-term experience using the right minithoracotomy approach.<sup>24</sup> The significantly lower repair rate at our hospital when the right minithoracotomy approach was used rather than open sternotomy (71.4% vs 92.5%) was likely due to the surgeon still being in the early stages of the learning curve for minimally invasive MV procedures during the study period.

Our study was not without limitations. First, it was observational and retrospective in nature and, therefore, had the associated biases. Second, the data were from a single-center experience and, thus, may not be representative of other VA centers. Third, the selection of an open sternotomy approach vs the right minithoracotomy approach could be associated with selection bias. Finally, we could not use a longitudinal model to analyze serial echocardiography results to better delineate the exact timing of recurrent MR because patients within the VA hospital system do not routinely undergo long-term, longitudinal, time-based postoperative follow-up with echocardiography. Our method of assessing long-term recurrence of MR by relying on 2 time points (intraoperative TEE vs the latest echocardiogram on file with MR) would tend to underestimate the cohort's incidence of long-term MR recurrence. However, we had a postoperative follow-up echocardiogram for 100% of our patients.

It should also be noted that the surgeons and cardiologists at our hospital had an interest in improving our MV program, which was the stimulus for creating the multidisciplinary team. Thus, the improvements seen may have been due not only to the multidisciplinary approach itself but also to the team members' determination to obtain outcomes equivalent to those of high-volume centers.

In conclusion, even though our cohort comprised high-risk patients from a VA center, our MV repair rate, quality of repair, and mortality rate were comparable to the metrics required to establish a high-quality MV surgery program. Our study suggests that the rate of MV repair in patients with degenerative valve disease can be optimized in low-volume institutions by using a multidisciplinary team for preoperative surgical planning and intraoperative TEE analysis, as well as by using an open sternotomy surgical approach. We also found that specific anatomic features, including dystrophic leaflet calcification and severe annular calcification of the MV, were associated with a reduction in MV repair in our veteran population with degenerative valve disease. Therefore, earlier referral of patients with severe MR for repair (before they develop advanced myxomatous degeneration with dystrophic calcification) may improve both the rate and quality of MV repair in veteran populations. In contrast, young patients with degenerative, multisegment, bi-leaflet pathology who require a complex repair may benefit from referral to an expert MV surgeon who is better able to perform a more reliable and durable MV repair.

### Acknowledgment

The authors would like to thank Dr David Whitaker for his help in the preparation of this manuscript.

### SUPPLEMENTARY MATERIAL

The following is the supplementary data to this article:



**Video 1.** Multidisciplinary Heart Team in Mitral Valve Repair.

### REFERENCES

1. Bakaeen F, Shroyer A, Zenati M, et al: Mitral valve surgery in the US Veterans Administration health system: 10-Year outcomes and trends. *J Thorac Cardiovasc Surg* 155:105–117, e5, 2018
2. Nishimura R, Otto C, Bonow R, et al: 2014 AHA/ACC guideline for the management of patients with valvular heart disease: Executive summary: A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol* 63:2438–2488, 2014
3. Bolling S, Li S, O'Brien S, et al: Predictors of mitral valve repair: Clinical and surgeon factors. *Ann Thorac Surg* 90:1904–1911, 2010. discussion 12
4. Bonow R, Adams D: The time has come to define centers of excellence in mitral valve repair. *J Am Coll Cardiol* 67:499–501, 2016
5. Crawford T, Conte J, Sanchez J: Team-based care: The changing face of cardiothoracic surgery. *Surg Clin North Am* 97:801–810, 2017
6. Nishimura R, Otto C, Bonow R, et al: 2014 AHA/ACC Guideline for the management of patients with valvular heart disease: Executive summary: A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation* 129:2440–2492, 2014
7. Badhwar V, Peterson E, Jacobs J, et al: Longitudinal outcome of isolated mitral repair in older patients: Results from 14,604 procedures performed from 1991 to 2007. *Ann Thorac Surg* 94:1870–1877, 2012. discussion 7–9
8. Castillo J, Anyanwu A, Fuster V, et al: A near 100% repair rate for mitral valve prolapse is achievable in a reference center: Implications for future guidelines. *J Thorac Cardiovasc Surg* 144:308–312, 2012
9. David T, Ivanov J, Armstrong S, et al: A comparison of outcomes of mitral valve repair for degenerative disease with posterior, anterior, and bileaflet prolapse. *J Thorac Cardiovasc Surg* 130:1242–1249, 2005
10. Gammie J, Sheng S, Griffith B, et al: Trends in mitral valve surgery in the United States: Results from the Society of Thoracic Surgeons Adult

- Cardiac Surgery Database. *Ann Thorac Surg* 87:1431–1437, 2009. discussion 7–9
11. Goldstone A, Cohen J, Howard J, et al: A “repair-all” strategy for degenerative mitral valve disease safely minimizes unnecessary replacement. *Ann Thorac Surg* 99:1983–1990, 2015. discussion 90–91
  12. Anyanwu A, Adams D: Another case of underprovision of mitral valve repair surgery: Lessons from the Veterans Affairs health system. *J Thorac Cardiovasc Surg* 155:118–119, 2018
  13. Enriquez-Sarano M, Sundt T, 3rd: Early surgery is recommended for mitral regurgitation. *Circulation* 121:804–811, 2010. discussion 12
  14. Chikwe J, Toyoda N, Anyanwu A, et al: Relation of mitral valve surgery volume to repair rate, durability, and survival. *J Am Coll Cardiol* 69:2397–2406, 2017.
  15. Chatterjee S, Rankin J, Gammie J, et al: Isolated mitral valve surgery risk in 77,836 patients from the Society of Thoracic Surgeons database. *Ann Thorac Surg* 96:1587–1594, 2013. discussion 94–95
  16. Barnett P, Hong J, Carey E, et al: Comparison of accessibility, cost, and quality of elective coronary revascularization between veterans affairs and community care hospitals. *JAMA Cardiol* 3:133–141, 2018
  17. Shimokawa T, Kasegawa H, Katayama Y, et al: Mechanisms of recurrent regurgitation after valve repair for prolapsed mitral valve disease. *Ann Thorac Surg* 91:1433–1438, 2011. discussion 8–9
  18. Suri R, Clavel M, Schaff H, et al: Effect of recurrent mitral regurgitation following degenerative mitral valve repair: Long-term analysis of competing outcomes. *J Am Coll Cardiol* 67:488–498, 2016
  19. Gillinov A, Blackstone E, Nowicki E, et al: Valve repair versus valve replacement for degenerative mitral valve disease. *J Thorac Cardiovasc Surg* 135:885–893, 2008. 93 e1–2
  20. Chan K, Chen S, Mesana T, et al: Development of mitral stenosis after mitral valve repair: Importance of mitral valve area. *Can J Cardiol* 33:1701–1707, 2017
  21. Flameng W, Herijgers P, Bogaerts K: Recurrence of mitral valve regurgitation after mitral valve repair in degenerative valve disease. *Circulation* 107:1609–1613, 2003
  22. Stevens L, Basmadjian A, Bouchard D, et al: Late echocardiographic and clinical outcomes after mitral valve repair for degenerative disease. *J Card Surg* 25:9–15, 2010
  23. Gillinov A, Faber C, Houghtaling P, et al: Repair versus replacement for degenerative mitral valve disease with coexisting ischemic heart disease. *J Thorac Cardiovasc Surg* 125:1350–1362, 2003
  24. Glauber M, Miceli A, Canarutto D, et al: Early and long-term outcomes of minimally invasive mitral valve surgery through right mini-thoracotomy: A 10-year experience in 1604 patients. *J Cardiothorac Surg* 10:181, 2015