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ORIGINAL INVESTIGATIONS

Mitral Surgery After Transcatheter Edge-to-Edge Repair

Society of Thoracic Surgeons Database Analysis

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ABSTRACT

BACKGROUND Transcatheter edge-to-edge (TEER) mitral repair may be complicated by residual or recurrent mitral regurgitation. An increasing need for surgical reintervention has been reported, but operative outcomes are ill defined.

OBJECTIVES This study evaluated national outcomes of mitral surgery after TEER.

METHODS The Society of Thoracic Surgeons (STS) Adult Cardiac Surgery Database was used to identify 524 adults who underwent mitral surgery after TEER between July 2014 and June 2020. Emergencies (5.0%; n = 26), previous mitral surgery (5.3%; n = 28), or open implantation of transcatheter prostheses (1.5%; n = 8) were excluded. The primary outcome was 30-day or in-hospital mortality.

RESULTS In the study cohort of 463 patients, the median age was 76 years (interquartile range [IQR]: 67 to 81 years), median left ventricular ejection fraction was 57% (IQR: 48% to 62%), and 177 (38.2%) patients had degenerative disease. Major concomitant cardiac surgery was performed in 137 (29.4%) patients: in patients undergoing isolated mitral surgery, the median STS-predicted mortality was 6.5% (IQR: 3.9% to 10.5%), the observed mortality was 10.2% (n = 23 of 225), and the ratio of observed to expected mortality was 1.2 (95% confidence interval [CI]: 0.8 to 1.9). Predictors of mortality included urgent surgery (odds ratio [OR]: 2.4; 95% CI: 1.3 to 4.6), nondegenerative/unknown etiology (OR: 2.2; 95% CI: 1.1 to 4.5), creatinine of >2.0 mg/dl (OR: 3.8; 95% CI: 1.9 to 7.9) and age of >80 years (OR: 2.1; 95% CI: 1.1 to 4.4). In a volume outcomes analysis in an expanded cohort of 591 patients at 227 hospitals, operative mortality was 2.6% (n = 2 of 76) in 4 centers that performed >10 cases versus 12.4% (n = 64 of 515) in centers performing fewer (p = 0.01). The surgical repair rate after failed TEER was 4.8% (n = 22) and was 6.8% (n = 12) in degenerative disease.

CONCLUSIONS This study indicates that mitral repair is infrequently achieved after failed TEER, which may have implications for treatment choice in lower-risk and younger patients with degenerative disease. These findings should inform patient consent for TEER, clinical trial design, and clinical performance measures.
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ABBREVIATIONS AND ACRONYMS

ACSD = Adult Cardiac Surgery Database

CI = confidence interval

IQR = interquartile range

OR = odds ratio

STS = Society of Thoracic Surgeons

TEER = transcatheter edge-to-edge repair

Current consensus guidelines recommend transcatheter edge-to-edge repair (TEER) for prohibitive and high-risk patients with severe symptomatic primary mitral regurgitation and for a select subset of patients with chronic severe secondary mitral regurgitation, systolic dysfunction, and persistent severe symptoms while on optimal goal-directed medical therapy (1). Approximately 15,000 TEERs have been performed in the United States since the introduction into clinical practice in 2014 (2,3). In recent multicenter analyses, moderate or severe residual or recurrent mitral regurgitation has been reported in 20% to 30% of patients within 1 year of TEER, and one-quarter of patients are left with a residual a mean transmitral gradient of >5 mm Hg (2,4). Residual mitral regurgitation and stenosis after TEER have each been associated with significantly worse survival and freedom from heart failure and with repeat intervention (3,5). Such patients are increasingly treated with mitral surgery; however, descriptions of this strategy have been limited to small case series, and the outcomes in contemporary practice are poorly defined (6,7). Generalizable population-based outcomes data following failed TEER are needed to inform the design and consent for randomized trials comparing TEER and surgical mitral repair as well as clinical decision making for patients eligible for both therapies (8–10). The Society of Thoracic Surgeons (STS) Adult Cardiac Surgery Database (ACSD), with its very high national cardiac surgery penetrance in the United States, provides a unique opportunity to derive such critical data. We accordingly analyzed STS-ACSD data aiming to quantify the U.S. mortality, complications and mitral repair rates after mitral surgery for failed TEER, including a subgroup analysis in patients with degenerative disease.

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METHODS

PATIENTS. Data access for this study was approved via the STS Participant User File research program. Adult patients ages 18 years or older who underwent mitral valve surgery after failed TEER between July 1, 2014, and June 30, 2020, were identified from the STS ACSD, versions 2.81 and 2.9, which captures data from more than 95% of cardiac surgery programs in North America (11). This study was approved by the Program for Protection of Human Subjects at Cedars-Sinai Medical Center, where the analysis was conducted on deidentified patient data. The approval included a waiver of informed consent.

A total of 524 adult patients undergoing first-time mitral valve surgery with documentation of prior TEER were included. Emergencies (5.0%; n = 26), open implantation of transcatheter prostheses (1.5%; n = 8), and patients with any history of previous mitral surgery (5.3%; n = 28) were excluded (**Figure 1**). Baseline comorbidities, operative variables, and post-operative outcomes were identified from the registry.

DEFINITIONS. All patient characteristics and study endpoints were defined according to the STS-ACSD definitions (11). The primary study endpoint was operative mortality as per the STS definition or in-hospital death during index surgery or within 30 days of surgery after discharge from the hospital. Secondary endpoints were major complications, defined by the STS-ACSD including stroke, unplanned reoperation, and multiorgan failure, and mitral repair rates at surgery following failed TEER (11). Primary mitral valve etiology was classified as "failure of previous mitral valve intervention, unknown or not documented" in 311 (67.2%) patients within the study cohort. The subgroup of patients with degenerative disease was therefore identified by any documentation of degenerative mitral valve etiology and/or the presence of leaflet prolapse. In the remaining 286 (61.8%) patients, the etiology was either non-degenerative (n = 34; 11.9%) or not specified (n = 252; 88.1%); details are provided in Supplemental Table 1. The registry provided additional information on valvular disease, allowing the grade of mitral regurgitation and stenosis to be quantified, but it did not contain information on the timing or mode of TEER failure or the interval between TEER and surgical procedure. The STS predicted risk of mortality was calculated for each patient depending on procedure category (11). (It could not be calculated for 137

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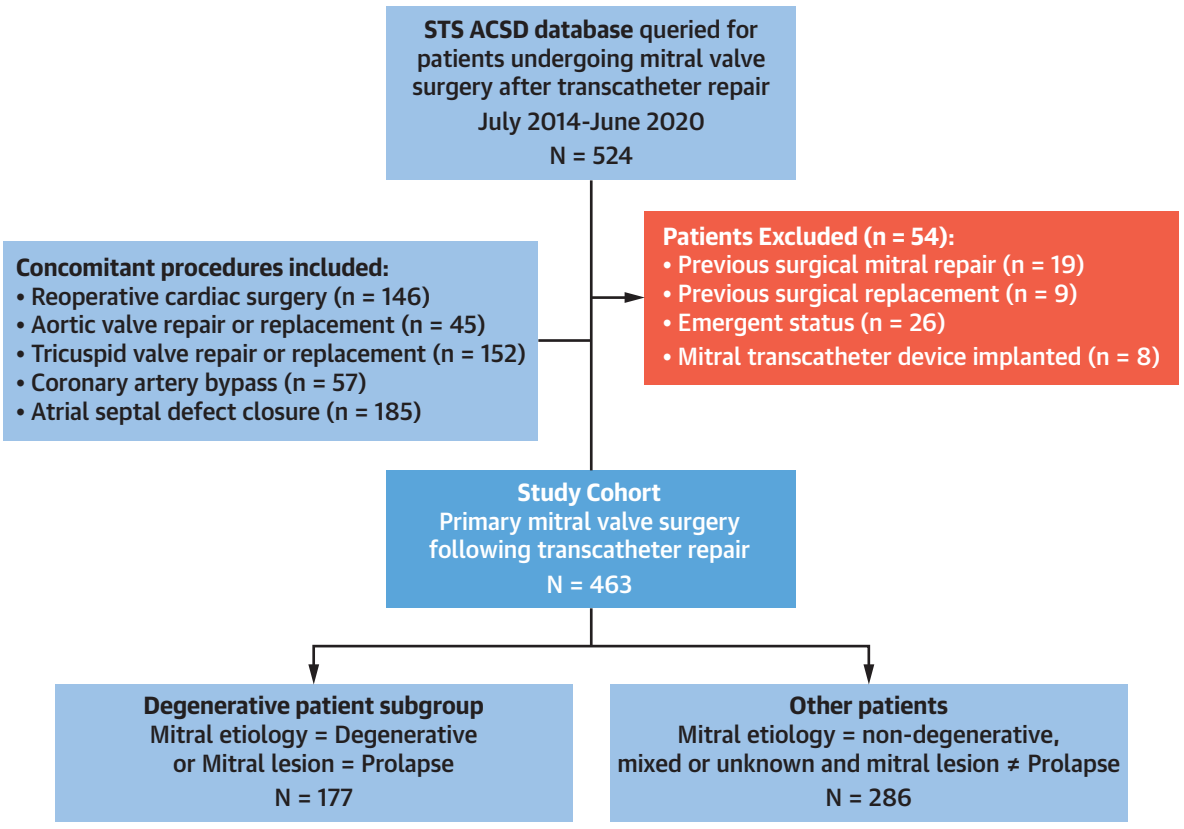
FIGURE 1 Consolidated Standards of Reporting Trials (CONSORT)-Style Diagram Showing Inclusion and Exclusion Criteria



The Society of Thoracic Surgeons (STS) Adult Cardiac Surgery Database (ACSD) was used to identify 524 adults who underwent mitral surgery after transcatheter edge-to-edge mitral repair between July 2014 and June 2020. Emergencies, previous mitral surgery, or open implantation of transcatheter prostheses were excluded.

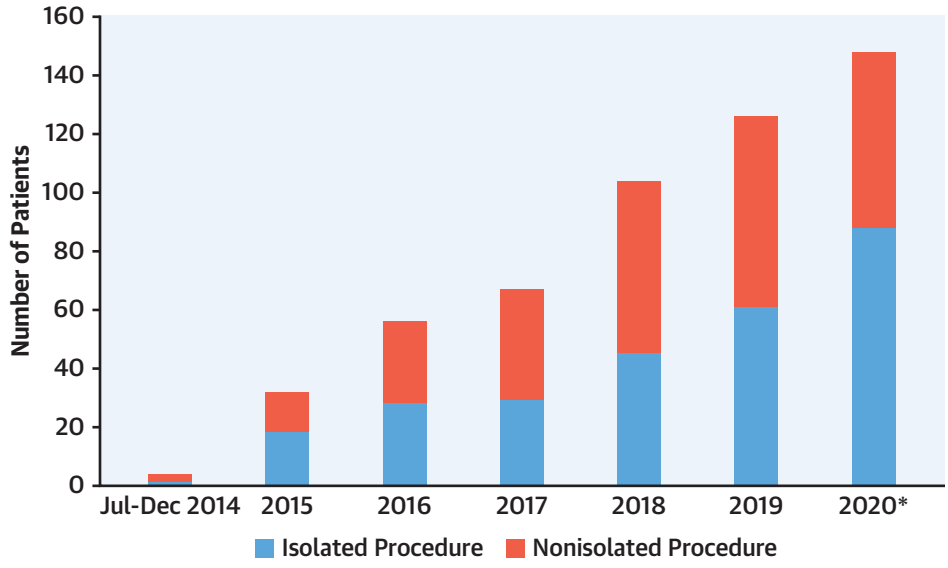
[29.6%] patients who underwent concomitant procedures, such as aortic valve surgery.)

STATISTICAL ANALYSIS. Continuous variables were not normally distributed and are reported as medians and interquartile ranges [IQRs]. Categorical variables are expressed as proportions. Variables with <5% missing were treated with multiple imputation using fully conditional specification for continuous variables, marked as unknown for categorical variables, and eliminated if >5% of values were missing. Two patients (0.4%) had missing survival status at 30 days. Categorical variables with missing data are presented as proportions with the true denominator. Differences in baseline characteristics, comorbidities, operative details, and post-operative outcomes among patients with degenerative mitral regurgitation versus other and unknown etiology were assessed using the Wilcoxon rank sum test for continuous variables and the Pearson chi-square test or Fisher exact test for categorical variables, as appropriate. Predictors of operative mortality were identified by fitting multivariable logistic regression models. The association between mortality and patient baseline and operative characteristics was assessed. Variables with p values of ≤0.25 were included in the model (Supplemental Table 2), and only variables with p values of <0.05 were retained in the final model (urgent status, nondegenerative etiology, pre-operative creatinine of >2 mg/dl, and age of >80 years). All tests were 2-tailed, and an alpha level of 0.05 was considered statistically significant. All statistical analyses were performed using SAS, version 9.4 (SAS Institute, Cary, North Carolina).

RESULTS

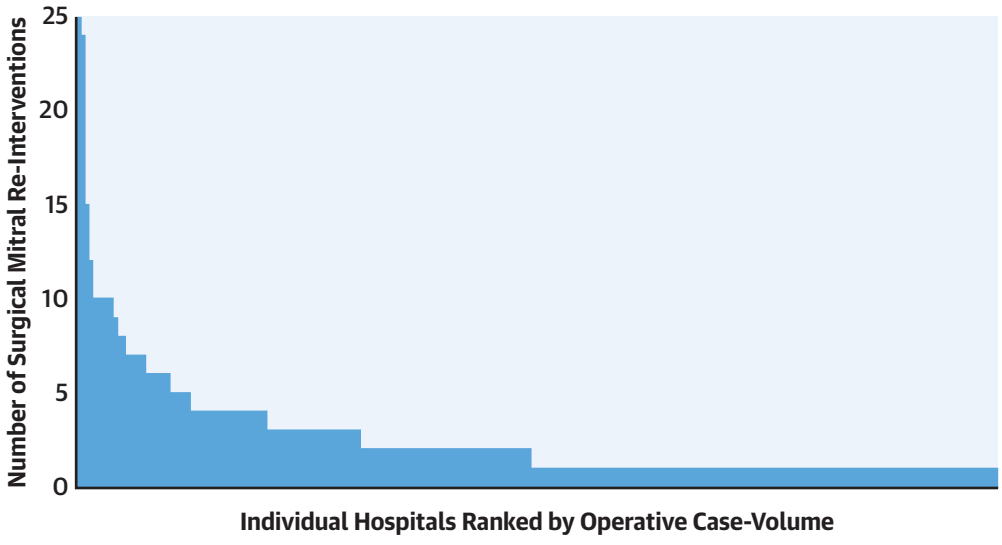
STUDY POPULATION. The annual number of surgical interventions for failed TEER increased from 32 in 2015 to 126 in 2019, with 74 cases recorded between January and June 2020 ($p < 0.001$) (**Figure 2**). Before exclusion criteria, the cases were performed by 357

FIGURE 2 Trends in Mitral Surgery for Failed TEER, 2014–2020



Trend analysis of patients undergoing mitral surgery for failed transcatheter edge-to-edge repair (TEER) in the United States between 2014 and 2020 shows a steady increase, with more than half of patients requiring concomitant cardiac surgery, including tricuspid or aortic valve surgery, or coronary bypass grafting. *Projected figure based on available data for January to June 2020.

FIGURE 3 Surgical Reinterventions for Failed TEER by Individual Hospitals



Surgical mitral reinterventions for failed transcatheter edge-to-edge repair (TEER) performed by individual hospitals in the United States between 2014 and 2020, ranked by operative case volume: the median hospital experience was 1 case, and only 4 hospitals performed more than 10 cases.

different surgeons (median case volume: 1; range 1 to 10) at 227 different hospitals (median case volume: 1; range 1% to 25%) (**Figure 3**).

Baseline characteristics stratified by primary mitral etiology are shown in **Table 1** and for patients with emergency surgery are shown in Supplemental Table 3. In the study cohort, the median age was 76 years (IQR: 67 to 81 years), the median left ventricular ejection fraction was 57% (IQR: 48% to 62%), and 86.1% (400 of 461) had heart failure symptoms. Overall, 24.7% (n = 112 of 454) had severe tricuspid regurgitation, 32.6% (n = 148 of 454) had moderate tricuspid regurgitation, 66.5% (n = 302 of 454) had a history of atrial fibrillation, and 4.5% (n = 21) had active or treated endocarditis. The median STS predicted mortality risk was 7.7% (IQR: 4.5% to 12.1%).

OPERATIVE PROCEDURES. Operative techniques are shown in **Table 2**. The repair rate in the study cohort was 4.8% (n = 22) (repair techniques are listed in Supplemental Table 4). Bioprostheses were implanted in 91.8% (n = 402 of 438) of patients who underwent valve replacement; the remaining patients received mechanical prostheses. Concomitant surgery in addition to mitral valve surgery was performed in 237 (51.2%), while the remaining patients underwent isolated mitral valve procedures (226; 48.8%). Concomitant procedures included closure of atrial septal defects in 39.9% (n = 184 of 461), ablation for atrial fibrillation in 15.8% (n = 73 of 461), closure of left atrial appendage in 35.0% (n = 161 of 460), concomitant tricuspid repair or replacement in 32.8% (n = 152) for moderate or severe tricuspid regurgitation, and concomitant coronary bypass in 12.3% (n = 57) of patients.

MORTALITY AND COMPLICATIONS. Operative outcomes are shown in **Table 3** and for emergency patients are shown in Supplemental Tables 3 and 5. In this cohort of high-risk patients undergoing surgical correction of failed TEER, which included reoperative procedures and concomitant coronary artery bypass and aortic valve replacements, overall, the 30-day or in-hospital mortality was 10.6% (n = 49 of 461). Cause of death, where available, and associated complications are summarized in Supplemental Tables 6 and 7. In patients undergoing isolated mitral surgery, the median STS predicted mortality risk was 6.5% (IQR: 3.9% to 10.5%), the observed mortality was 10.2% (n = 23 of 225), and the ratio of observed to expected mortality was 1.2 (95% confidence interval [CI]: 0.8 to 1.9). The overall incidence of post-operative stroke was 1.3% (n = 6 of 460), of new dialysis was 7.7% (n = 35 of 455), and of any unplanned reoperation was 13.4% (n = 62 of 462) (**Table 3**).

TABLE 1 Baseline Patient Characteristics Stratified by Primary Mitral Etiology

	Overall (N = 463)	Degenerative (n = 177)	Other/Unknown (n = 286)	p Value
Median age, yrs	76 (67–81)	77 (69–82)	75 (66–81)	0.05
Female	227 (49.0)	74 (41.8)	153 (53.5)	0.01
Body mass index, kg/m^2	26.3 (22.7–30.8)	25.5 (23.0–29.6)	26.5 (22.5–31.7)	0.12
Year of surgery				<0.01
July to December 2014	4 (0.9)	2 (1.1)	2 (0.7)	
2015	32 (6.9)	17 (9.6)	15 (5.2)	
2016	56 (12.1)	31 (17.5)	25 (8.7)	
2017	67 (14.5)	33 (18.6)	34 (11.9)	
2018	104 (22.5)	27 (15.3)	77 (26.9)	
2019	126 (27.2)	38 (21.5)	88 (30.8)	
January to June 2020	74 (16.0)	29 (16.4)	45 (15.7)	
Left ventricular ejection fraction,* %	57 (48–62)	57 (47–63)	57 (49–62)	0.93
Heart failure	400/461 (86.08)	150/176 (85.2)	250/285 (87.7)	0.44
Previous myocardial infarction	103/460 (22.4)	34/174 (19.5)	70/291 (24.1)	0.23
Percutaneous coronary intervention	137 (29.6)	54 (30.5)	83 (29.0)	0.73
Cerebrovascular disease	115/457 (25.2)	45/176 (25.6)	70/281 (24.9)	0.87
Peripheral vascular disease	7/462 (15.2)	26/177 (14.7)	44/285 (15.4)	0.83
Pulmonary disease	196/458 (42.8)	68/175 (38.9)	128/283 (45.2)	0.18
Creatinine >2.0 mg/dl	53 (11.5)	16 (9.0)	37 (12.9)	0.20
Dialysis	18 (3.9)	4 (2.3)	14 (4.9)	0.22
Atrial fibrillation	302/454 (66.5)	113/170 (66.5)	189/284 (66.6)	0.99
Endocarditis	21 (4.5)	4 (2.3)	17 (5.9)	0.07
Severe mitral regurgitation	365/460 (79.3)	146 (82.5)	219/283 (77.4)	0.19
Mitral stenosis	124/459 (27.0)	39 (22.0)	85/282 (30.1)	0.06
Severe tricuspid regurgitation	112/454 (24.7)	42/174 (24.1)	70/280 (25.0)	0.84
Surgery status				0.42
Elective	277 (59.8)	110 (62.2)	167 (58.4)	
Urgent	186 (40.2)	67 (37.9)	119 (41.6)	
Previous cardiac surgery	144/458 (31.4)	47 (26.6)	91/281 (34.5)	0.07
STS predicted risk of mortality,† %	7.6 (4.5–12.1)	7.3 (4.4–12.2)	7.6 (4.5–12.1)	0.95

Values are n (%), n/N (%), or median (interquartile range). *7 values were imputed. †STS-predicted risk of mortality could not be calculated for 29.6% (n = 137) of patients because they underwent concomitant procedures not included in the predictive score model.

STS = Society of Thoracic Surgeons.

Multivariable predictors of 30-day or in-hospital mortality (C-statistic: 0.73; Hosmer and Lemeshow goodness-of-fit, p = 0.89) included urgent status (odds ratio [OR]: 2.4; 95% CI: 1.3 to 4.6; p = 0.01), non-degenerative or unknown etiology (OR: 2.2; 95% CI: 1.1 to 4.5; p = 0.03), pre-operative creatinine of >2.0 mg/dl (OR: 3.8; 95% CI: 1.9 to 7.9; p < 0.01), and age of >80 years (OR: 2.1; 95% CI: 1.1 to 4.1; p = 0.02) (Supplemental Table 8). Year of procedure did not significantly affect mortality (Supplemental Table 9). When operative mortality in the overall cohort was analyzed according to hospital case volume, the operative mortality was 2.6% (n = 2 of 76) in the quintile of highest-volume centers that performed >10 cases versus 12.4% (n = 64 of 515) in centers that performed fewer (p = 0.01) (**Table 4, Central Illustration**).

TABLE 2 Concomitant Procedures and Operative Details Stratified by Primary Mitral Etiology

	Overall (N = 463)	Degenerative (n = 177)	Other/Unknown (n = 286)	p Value
Mitral repair	22 (4.8)	12 (6.8)	10 (3.5)	0.11
Closure atrial septal defect	184/461 (39.9)	76/177 (42.9)	108/284 (38.0)	0.3
Atrial ablation	73/461 (15.8)	28/177 (15.8)	45/284 (15.9)	0.99
Left atrial appendage closure	161/460 (35.0)	59/176 (33.5)	102/284 (35.9)	0.6
Tricuspid repair	139 (30.0)	53 (29.9)	86 (30.1)	0.98
Tricuspid replacement	13 (2.8)	6 (3.4)	7 (2.5)	0.55
Aortic replacement	3/461 (0.7)	1/177 (0.6)	2/284 (0.7)	>0.99
Aortic repair	42/461 (9.1)	16/177 (9.0)	26/284 (9.2)	0.97
Coronary bypass	57 (12.3)	20 (11.3)	37 (12.9)	0.6
Cardiopulmonary bypass time, min*	125 (96-165)	129 (96-160)	123 (96-169)	0.71
Cross clamp time	87 (69-116)	87 (66-118)	87 (70-115)	0.79

Values are n (%), n/N (%), or median (interquartile range). *One value was imputed.

DEGENERATIVE MITRAL REGURGITATION. Within the overall study cohort, 38.2% (n = 177) of patients were identified as having underlying degenerative mitral valve disease. These patients had a median STS predicted risk of mortality of 7.3% (IQR: 4.4% to 12.2%): they were older, with a median age of 77 years (IQR: 69 to 82 years), compared to patients with nondegenerative disease or unknown etiology, who had a median age of 75 years (IQR: 66 to 81 years). The prevalence of atrial fibrillation was 66.5% (113 of 170), of severe tricuspid regurgitation was 24.1% (n = 42 of 174), and of previous cardiac surgery was 26.6% (n = 47), which were all similar to values in the cohort of patients with nondegenerative disease. The rate of concomitant procedures was also similar in the subgroup of patients with degenerative disease compared to the rest of the cohort, with concomitant tricuspid repair or replacement in 33.3% (n = 59), predominantly for severe tricuspid regurgitation; concomitant coronary bypass in 11.3% (n = 20); and concomitant aortic valve replacement in 9.0% (n = 16 of 177) of patients. The operative mortality was 6.3% (n = 11 of 175) and 2.8% (n = 3 of 108) in patients with elective surgery. Mitral valve repair was performed in 6.8% (n = 12) of patients with degenerative disease with no mortality.

TABLE 3 Operative Outcomes Stratified by Primary Mitral Etiology

Operative Outcomes	Overall (N = 463)	Degenerative (n = 177)	Other/Unknown (n = 286)	p Value
Mortality	49/461 (10.6)	11/175 (6.3)	38/286 (13.3)	0.02
Mortality in patients having elective surgery	19/275 (6.9)	3/108 (2.8)	16/167 (9.6)	0.03
Stroke	6/460 (1.3)	2/176 (1.1)	4/284 (1.4)	>0.99
Unplanned cardiac reoperation	36/462 (7.8)	13/177 (7.3)	23/285 (8.1)	0.78
Any unplanned reoperation	62/462 (13.4)	22/177 (12.4)	40/285 (14.0)	0.62
New dialysis	35/455 (7.7)	13/175 (7.4)	22/280 (7.9)	0.87
Prolonged ventilation	123/462 (26.6)	43/177 (24.3)	80/285 (28.1)	0.37
Permanent pacemaker or device	54/460 (11.7)	19/175 (10.9)	35/285 (12.3)	0.65
*Post-operative length of stay, days	9 (7-15)	9 (7-15)	10 (7-15)	>0.99

Values are n (%), n/total (%), or median (interquartile range). *Length of stay was missing in 34 (7.3%) patients.

DISCUSSION

This is the first U.S.-wide analysis of mitral surgery for failed TEER, to our knowledge: it is made possible by the high penetrance and completeness of the STS Adult Cardiac Surgery Database. This patient cohort represents patients with primary and secondary mitral regurgitation that, by virtue of their previous selection for TEER, had previously been adjudicated to be at high or prohibitive risk for surgery. The subsequent operative mortality was correspondingly high, at 10.6%; however, it was significantly lower (2.6%) in the quintile of hospitals with the greatest experience in these procedures and, notably, only 2.8% for patients with underlying degenerative disease having elective surgery. The observed repair rate of 6.8% in patients with degenerative valve disease indicates that surgical mitral repair is rarely achieved after failed TEER, which may have implications for treatment choice in lower-risk and younger patients eligible for either TEER or surgical mitral valve repair.

Repair of mitral valves late after TEER is technically challenging because the devices are designed to provoke a proliferative response generating fibrotic tissue that secures the clip; this rapidly causes substantial sclerosis as well as thickening and distortion of the leaflets and subvalvular apparatus (6,7). It is virtually impossible to detach such clips without further damaging the coaptation zone and marginal chorda critical to effective leaflet coaptation. When 1 or more clips are adherent to both A2 and P2 leaflet edges, the destruction of both aspects of the coaptation zone and subvalvular apparatus renders a durable repair unlikely. Surgical repair after failed TEER therefore requires advanced reconstructive techniques in addition to proficiency in degenerative mitral valve repair, and optimal results are most likely to be achieved by experienced mitral surgeons. The presence of functional mitral regurgitation or even a moderate degree of mitral stenosis in this setting is most effectively treated with replacement. These patients are typically at higher risk of adverse operative outcomes and are less likely to tolerate a second clamp time to correct residual mitral regurgitation or stenosis: primary replacement is frequently the most appropriate strategy.

In comparison, surgical repair of acute perforations and procedural failures of TEER including clip detachment is more straightforward (6,7). Immediately after attempted TEER, the clip can easily be detached from the mitral leaflet tissue without causing further damage, and perforations may be repaired with primary closure or pericardial patches, although traumatized surrounding tissue may be too friable to hold sutures. Residual native valve pathology is treated using conventional repair techniques. However, the main barrier to surgical repair in the acute setting may be very high-risk patient characteristics or concomitant pathology, shifting preference to replacement for a more reliable and efficient surgical strategy.

We observed a high prevalence of disease requiring concomitant surgical procedures, with multivessel coronary revascularization, tricuspid and aortic valve reconstruction, and atrial fibrillation procedures performed in more than one-third of patients. Operative mortality in the small subgroup of patients with degenerative disease having elective surgery was 2.8%, highlighting the outcomes that may be achieved in a group of patients who, by virtue of their prior treatment with TEER, had been deemed to be at high or prohibitive risk of isolated mitral surgery. This study was not designed to evaluate whether such patients could have derived greater long-term benefit from primary surgical repair and management of concomitant disease; however, these data may indicate that predicted surgical risk in these patients was overestimated before TEER.

The observation that surgical repair is not achieved after failed TEER in the vast majority of patients should inform the initial decision between transcatheter and surgical repair in patients with degenerative regurgitation who are suitable for both therapeutic approaches. In more than 80% of TEER patients adjudicated to be at prohibitive risk for surgery, the rationale is attributed to frailty, "hostile mediastinum," or "unusual circumstances" (12). In this analysis, the observed mortality was 2.6% for patients with underlying degenerative disease having elective surgery, with 2.6% overall mortality in the highest-volume centers: this suggests that mitral surgery may be carried out in a high-risk population with significantly lower-than-predicted mortality at experienced centers, confirming reports for primary mitral surgery (13–15). This finding could inform referral practice. More importantly, these data may have implications for patients in the lower-risk and younger-age categories, who may access TEER through clinical trials or expanded indications (8,9,12). Recent national registry data report that the prevalence of moderate or severe mitral regurgitation in contemporary practice is 20% to 30% after TEER (2–4). The present study demonstrates that correction of failed TEER is effectively limited to mitral valve replacement, which has been associated with significantly worse survival and freedom from valve-related adverse outcomes compared to degenerative mitral repair (15,16). This information should form part of patient consent for TEER in both clinical practice and clinical trials.

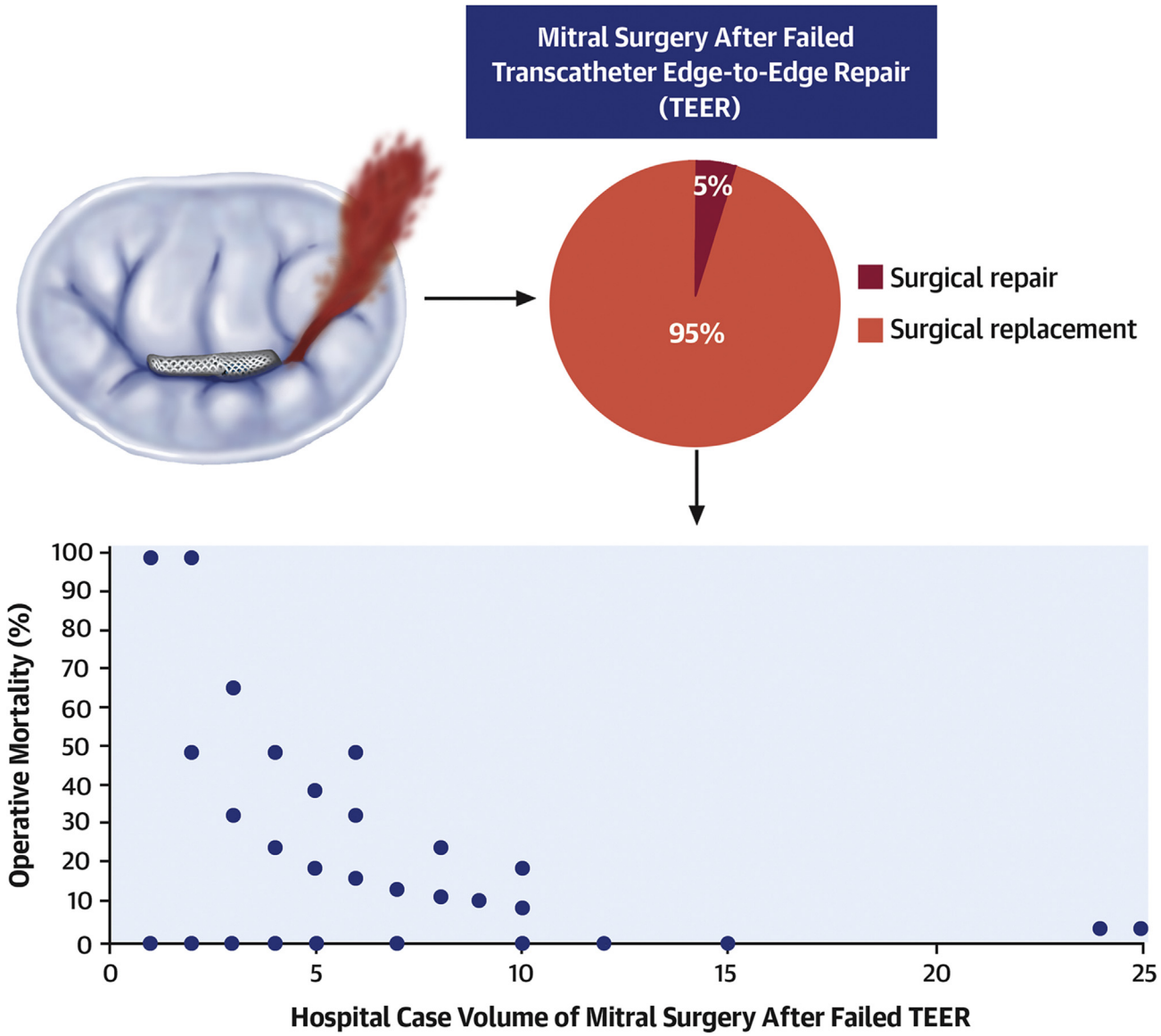
TABLE 4 Operative Mortality Stratified by Hospital Case Volume Quintiles

Hospital Case Volume	Hospitals	Total Cases	Mortality	p Value
1	115	115	12 (10.4)	0.04
2–3	65	153	16 (10.5)	
4–6	30	137	23 (16.8)	
7–10	13	110	13 (11.8)	
>10	4	76	2 (2.6)	

Values are n or n (%).

STUDY STRENGTHS AND LIMITATIONS. The main strength of this study is the ability to evaluate the outcomes of mitral surgery for failed TEER in a comprehensive, national, contemporary patient cohort using a prospective clinical registry (STS-ACSD). This approach is subject to several limitations. Data may be entered by nonclinicians and may be subject to inaccurate coding of data, such as patient diagnoses including primary valve etiology. The classification of mitral valve etiology within the STS-ACSD also changed after July 2017, which may affect the ability to interpret trends in underlying valve etiology. This may partly explain why the overall prevalence of degenerative disease in our cohort, at 37%, was markedly lower than the 70% to 80% reported by the Transcatheter Valve Registry (2,3). Our study was not designed to determine whether failure rates are higher after TEER for functional versus degenerative mitral regurgitation. This dataset provides incomplete data on the interval between TEER and surgery and contains no information on the overall numbers and outcomes of patients with failed TEER who did not undergo surgery or the outcomes of patients after the index admission or 30 days. Additionally, key anatomic and procedural data (including the number of clips used in each valve and the mechanism of failure) are not available within the STS ACSD. Importantly, the median STS predicted mortality risk could not be calculated for a third of patients because they also underwent concomitant procedures such as multivalve and coronary bypass operations not included in the predictive score model; consequently, the median STS-predicted risk

CENTRAL ILLUSTRATION **Surgical Repair Rates and Mortality After Failed Transcatheter Repair**



Chikwe, J. et al. J Am Coll Cardiol. 2021;78(1):1-9.

In a national cohort of all patients undergoing surgical reintervention after failed transcatheter edge-to-edge repair, 95% of patients underwent mitral valve replacement, and 5% underwent mitral valve repair. The lowest operative mortality (2.6%) was achieved by hospitals in the highest case volume quintiles.

reported here may not represent the true operative risk of the cohort. Finally, the numbers of patients in the subgroup analysis are low.

CONCLUSIONS

In this national multicenter analysis of patients undergoing mitral surgery for failed TEER, the operative mortality was 10.6%, versus 2.8% in a subgroup analysis of patients with underlying degenerative disease having elective surgery. Operative mortality was significantly lower (2.6%) in the quintile of centers most experienced in surgery for failed TEER. Surgical mitral repair was performed in fewer than 5% of patients undergoing surgery for failed TEER. The extremely low feasibility of subsequent mitral repair

has major implications for patients with degenerative disease in lower-risk and younger-age categories considered eligible for both TEER and surgical mitral valve repair. The outcomes observed in patients with degenerative disease should inform the design of randomized trials of TEER versus surgical repair for degenerative mitral regurgitation, and the extremely low feasibility of subsequent surgical repair after failure of transcatheter therapy should be included in patient consent for TEER.

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FUNDING SUPPORT AND AUTHOR DISCLOSURES

Dr. O'Gara has served on the executive committees of the APOLLO Transcatheter Mitral Valve Replacement Trial for Medtronic and the EARLY TAVR trial for Edwards Lifesciences, outside the submitted work. Dr. Gammie is a consultant for Edwards Lifesciences; the founder of Protaryx Medical, and the founder of HARPOON medical. Dr. Badhwar discloses institutional research support for clinical trials and has served as a consultant (nonremunerative) for Abbott. Dr. Gillinov is a consultant to AtriCure, Medtronic, Abbott, CryoLife, Edwards Lifesicences, and ClearFlow; the Cleveland Clinic has rights to royalties from AtriCure. Dr. Trento has received research support from Edwards Lifesciences. Dr. Mack discloses nonfinancial support from Edwards Lifesciences, Medtronic, and Abbott. Dr. Adams discloses royalties/research support from Edwards Lifesciences and Medtronic. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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PERSPECTIVES

COMPETENCY IN PATIENT CARE AND PROCEDURAL SKILLS: After failed transcatheter edge-to-edge mitral valve repair, surgical repair is rarely successful.

TRANSLATIONAL OUTLOOK: This observation should inform the design of future clinical trials of surgical versus transcatheter mitral repair.

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KEY WORDS mitral regurgitation, mitral repair, mitral valve replacement, transcatheter edge-to-edge mitral repair

APPENDIX For supplemental tables, please see the online version of this paper.