The influence of a percutaneous mitral repair program on surgical mitral valve volume

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ABSTRACT

Objectives: Percutaneous mitral repair with the MitraClip system (Abbott Vascular, Santa Clara, Calif) has been available in trials since 2006 and is currently approved for patients with degenerative mitral valve disease at prohibitive risk for surgery. There has been concern that novel transcatheter approaches may detract from mitral valve surgical volumes. We sought to evaluate the influence of our MitraClip program on our surgical mitral valve volumes and outcomes.

Methods: All patients referred for MitraClip underwent evaluation by a multidisciplinary team. Patients were screened for surgical candidacy and suitable valve anatomy for transcatheter repair. The fate of patients referred for MitraClip as well as the overall surgical mitral volumes and outcomes were evaluated.

Results: From July 2007 to December 2014, 468 patients were referred for the MitraClip procedure at our institution. Of these, 156 patients (33.3%) received a MitraClip (including 45 implanted by surgeons), whereas 82 patients (17.5%) underwent surgical interventions. During this timeframe, the volume of isolated mitral valve operations increased from 50 procedures in 2007 to 93 in 2014 (80% increase; $R^2 = 0.89$). Importantly, operative mortality for all patients undergoing isolated mitral surgery from 2008 to 2014 was 2.6%, with an observed to expected ratio of 0.64.

Conclusions: The availability of MitraClip resulted in an increase in our mitral valve referrals. Despite seeing an increase in higher risk referrals, operative mortality for mitral surgery remained excellent. Multidisciplinary evaluation, including input from experienced mitral surgeons, is necessary to have a successful percutaneous and surgical mitral valve program. (J Thorac Cardiovasc Surg 2015;150:1093-7)

MitraClip and mitral surgery volumes, 2007 to 2014.

Central Message

MitraClip availability is associated with increasing surgical volumes and excellent outcomes despite high-risk referrals.

Perspective

Percutaneous mitral valve repair has sustained slow adoption by surgeons amid concerns including influence on surgical volumes. It is our perception that a valve center inclusive of transcatheter therapies is in itself beneficial to surgical volumes and allows a center to offer the full range of percutaneous, minimally invasive, and full sternotomy complex mitral repair and high-risk mitral replacement.

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Traditional therapy for severe mitral regurgitation (MR) has relied on surgical correction of the mitral valve. One repair technique, the Alfieri stitch, provided the foundation for MitraClip (Abbott Vascular, Santa Clara, Calif) transcatheter valve repair.¹ The MitraClip device has been available

through clinical trials since 2006, and our institution began performing this type of transcatheter mitral repair in 2007.

MitraClip provides an appealing alternative to surgery for properly selected patients. One-year results from the Endovascular Valve Edge-to-Edge Repair Study (EVEREST II) high-risk registry and the Real World Expanded Multicenter Study of the MitraClip System (REALISM) continued access high-risk arm demonstrated that 84% of patients had MR $\leq 2+$ at 1 year with few device-related complications and a 4.8% 30-day mortality.² Recent 5-year data from the EVEREST II trial demonstrated that improvement in MR remains durable with associated decreases in left ventricular end diastolic volumes.³ Moreover, patients at high surgical risk with degenerative MR experienced fewer hospitalizations with improved functional status at 1 year, reflecting the improvement in patient quality of life with this percutaneous option.⁴ These encouraging data

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Abbreviations and Acronyms

MR	= mitral regurgitation
PROM	= predicted risk of mortality
STS	= Society of Thoracic Surgeons

resulted in Food and Drug Administration approval of the MitraClip device for symptomatic patients with 3+ to 4+ primary leaflet disease (degenerative MR) at prohibitive risk for surgery. With functional MR, European studies have shown promising results for MitraClip, with 86% of patients demonstrating New York Heart Association functional class I to II symptoms at 1 year.⁵ In the United States, the ongoing Cardiovascular Outcomes Assessment of the MitraClip Percutaneous Therapy for Heart Failure Patients with Functional Mitral Regurgitation (COAPT) trial is evaluating the efficacy of MitraClip in patients with functional MR.

Performance and acceptance of the MitraClip procedure has experienced slow adoption by surgeons. The reduction in MR with MitraClip is inferior to the reduction obtained with surgery, and many surgeons are concerned that performing the MitraClip procedure will detract from surgical volumes. In this context, we sought to analyze patients referred for MitraClip to determine what risk profiles these patients present and to describe which therapies they eventually received, including MitraClip, surgery, or medical management. We also examined our surgical volumes over the timeframe during which MitraClip has been used at our institution. We hypothesized that MitraClip patient referrals encompass a relatively high-risk group of patients, and that surgical volumes were not detrimentally affected by the availability of the MitraClip procedure at our institution.

METHODS

MitraClip Evaluation Process

Patients who were referred for MitraClip were initially screened. Potential candidates went on to a full evaluation process consisting of transthoracic echocardiography to assess MR severity as well as mitral valve area and coexisting valvular abnormalities, followed by transesophageal echocardiography to identify mitral pathology and to determine if the MitraClip would be efficacious. In many cases where high-risk surgery was considered an option, chest computed tomography was obtained to evaluate for mitral annular calcification and ascending aortic calcium burden, and right and left heart catheterization was performed to evaluate pulmonary hemodynamic parameters and coronary artery disease, respectively. Pulmonary function testing was obtained to rule out intrinsic pulmonary disease.

MitraClip placement was considered feasible in patients with an effective orifice area $>4 \text{ cm}^2$, a single dominant jet, and leaflets without edge calcification. A weekly valve conference consisting of surgeons, interventional cardiologists, heart failure specialists, nurse practitioners, imaging specialists, and selected medical specialists (eg, pulmonologists, nephrologists, oncologists, geriatricians, and hepatologists) discussed each case to determine candidacy for MitraClip procedure versus surgery or optimal medical management. During much of the time period analyzed, selection criteria were specific to available MitraClip trials and registries.

Patients

Approval for this retrospective study was obtained through the University of Virginia Institutional Review Board, with a waiver of individual patient consent. All patients referred for consideration of MitraClip repair from July 2007 through December 2014 were included in our analysis. Internal valve clinic databases were used to identify patients referred for MitraClip evaluation. Patient records were then reviewed to identify the results of the evaluation process and eventual therapy received. For patients who underwent MitraClip procedure or any surgical procedure (ie, patients with a completed preprocedural/preoperative evaluation), the preoperative risk status and outcomes were evaluated. Outcomes included 30-day mortality, renal failure, stroke, and postoperative length of stay.

Statistical Analyses

Surgical volumes were assessed with linear regression to determine the strength of growth trends over time. Continuous variables for patient demographic characteristics and outcomes were compared using Student *t* test or Wilcoxon rank-sum tests as appropriate. Categorical variables were compared using Fisher exact test. Means are presented with standard deviations, and medians are presented with interquartile ranges.

RESULTS

Referrals for MitraClip and Therapy Decisions

From July 2007 through December 2014, 468 patients were referred to our facility for consideration of MitraClip therapy (Figure 1). After evaluation by the multidisciplinary team, 156 patients (33.3%) received a MitraClip. A total of 82 patients (17.5%) underwent surgical interventions, including 52 isolated mitral operations, 12 concomitant mitral surgeries with tricuspid repairs, and 7 concomitant mitral surgeries with coronary artery bypass grafting. Seven patients referred for MitraClip underwent left ventricular assist device placement, and 2 underwent epicardial left ventricular lead placement for chronic resynchronization therapy. A total of 132 patients (28.2%) received medical management, and 6.6% died during the evaluation process.

FIGURE 1. Patients referred for MitraClip procedure and eventual therapies received. LVAD, Left ventricular assist device; LV, left ventricular.

See Figure 1 for the full listing of decisions reached and therapies received for patients referred for MitraClip.

Risk Profiles of Patients Referred for MitraClip

We assessed the Society of Thoracic Surgeons (STS) predicted risk of mortality (PROM) for mitral valve replacement for each patient referred for MitraClip who underwent MitraClip placement or surgical mitral valve procedure, as well as presence of risk factors not captured by STS risk. We were not able to assess the risk score for patients whose MR was not treated for several reasons, including that the patient decided not to go forward with necessary testing, patient death before completion of evaluation, or identification of contraindications to surgery and MitraClip noted early in the process.

The median STS PROM for mitral valve replacement for MitraClip patients was 8.2% (range, 1.1%-30.9%), with a median patient age of 79.4 years. Of these patients, 52% had degenerative MR with the remainder exhibiting functional or mixed etiology.

The median STS PROM for mitral valve replacement for patients referred for MitraClip who underwent mitral surgery was 3.7% (range, 0.7%-35%), with a median patient age of 71.3 years. Of these, 53.4% had degenerative MR (Table 1). In addition to being younger, the patients who ultimately underwent surgery had less comorbid disease, including less atrial fibrillation and coronary artery disease, with better functional class compared with MitraClip patients.

The reasons for mitral surgery after MitraClip referral varied widely. Several patients were in fact low or moderate risk and relatively young, rendering them ineligible for MitraClip during the high risk/REALISM trial era and unsuitable for MitraClip under current Food and Drug Administration approval. Other reasons for mitral surgery included leaflet anatomy not suitable for MitraClip; mitral valve area measuring too small; coexisting severe tricuspid regurgitation; severely reduced ejection fraction requiring other advanced therapies, such as implantable left ventricular assist device; prolonged wait times for MitraClip due to trial limitations; or patients referred for COAPT who did not favor the possibility of randomization to medical management alone.

Surgical Volumes After Availability of MitraClip

The volume of mitral operations and procedures (Figure 2) at our institution has increased over the time period since the MitraClip became available. Annual isolated mitral valve operations numbered 50 in 2007 and increased to 90 in 2014, representing an 80% increase in volume over 8 years. Overall mitral valve surgery increased from 93 cases in 2007 to 123 cases in 2014. Meanwhile, MitraClip volume has fluctuated with the availability of trials,

TABLE 1. Patient characteristics and outcomes

Patient variable	MitraClip* (n = 156)	Referred for MitraClip, underwent surgery (n = 73)	P value
Characteristic			
Age (y)	79.4 (72.9-84.8)	71.3 (58-80)	<.001
Female sex	71 (45.5)	34 (46.6)	.88
Body mass index	24.5 (21.9-28.3)	25.7 (23.5-30.1)	.07
Degree of mitral regurgitation			
3+	53 (34)	16 (22)	.07
4+	103 (66)	57 (78)	
New York Heart Association functional class			
I	5 (3.2)	6 (8.2)	
II	34 (21.8)	26 (35.6)	.03
III	93 (59.6)	34 (46.6)	
IV	24 (15.4)	7 (9.6)	
Left ventricle ejection fraction (%)	45 (30-60)	55 (35-60)	.09
Mechanism of mitral regurgitation			
Degenerative	81 (52)	39 (53.4)	
Functional	61 (39)	25 (34.2)	.74
Mixed	5 (3)	3 (4.1)	
Rheumatic	0 (0)	6 (8.2)	
Unknown	9 (6)	0 (0)	
Atrial fibrillation	86 (55.1)	26 (35.6)	.006
Coronary artery disease	100 (64)	30 (41)	.001
Previous myocardial infarction	61 (39)	22 (30)	.19
Previous cardiac surgery	62 (39.7)	17 (23.2)	.02
Peripheral vascular disease	22 (14.1)	5 (6.8)	.11
Cerebrovascular disease	25 (16)	9 (12.3)	.46
Creatinine (mg/dL)	1.2 (0.95-1.5)	1.05 (0.9-1.3)	.08
Diabetes	41 (26.3)	16 (21.9)	.48
Pulmonary disease			
None	95 (60.9)	50 (68.5)	
Mild	39 (25)	15 (20.5)	.67
Moderate	14 (9)	4 (5.5)	
Severe	8 (5)	4 (5.5)	
Society of Thoracic Surgeons predicted risk of mortality (%) for mitral valve replacement†	8.2 (4.6-9.3)	3.7 (1.6-5.6)	<.001
Outcome			
Postoperative mitral regurgitation			
None	0 (0)	36 (49)	
Trace	32 (21)	18 (25)	
1+	101 (65)	19 (26)	
2+	20 (13)	0 (0)	
3+	2 (1)	0 (0)	
Operative mortality	7 (4.5)	6 (8.2)	
Renal failure	2 (1.3)	2 (2.7)	
Stroke	2 (1.3)	2 (2.7)	
Length of stay	2 (2-3)	7 (5-9)	

Continuous variables are expressed as median (interquartile range). Categorical variables are expressed as n (%). *Abbott Vascular, Santa Clara, Calif. †Society of Thoracic Surgeons predicted risk of mortality is calculated for mitral valve replacement regardless of actual procedure performed in surgical group to facilitate comparisons.

FIGURE 2. Mitral volumes from 2007 to 2014.

and in 2014 (the first full year of commercial availability) our center performed 40 MitraClip procedures.

Procedural Outcomes

Patients who received MitraClip had a 4.5% mortality (median STS risk, 8.2%; estimated observed to expected ratio, 0.48). At the conclusion of the procedure, 99% of MitraClip patients experienced reduction in MR to 2+ or less, with 86% having MR 1+ or less. Mitral surgery following MitraClip was required in 5 out of 156 patients (3.2%). In 2 cases, surgery was performed within 6 months of MitraClip with suboptimal procedural results, and 1 of these patients was able to undergo mitral repair. In the remaining 3 cases surgery was performed 2 or more years after MitraClip, for either stenosis ($n = 2$) or recurrent severe MR ($n = 1$).

For patients who were referred for MitraClip but underwent surgery, 30-day mortality was 8.2%. We are unable to calculate an observed to expected ratio because many of the surgical procedures included concomitant procedures; thus, an STS PROM could not be determined. Our institutional 30-day mortality following isolated mitral repair or replacement from 2008 to 2014 was 2.6%, with an observed to expected ratio of 0.64. Refer to Table 1 for additional outcomes.

DISCUSSION

Patients referred for MitraClip experienced a wide range of therapeutic destinations. One-third of patients referred for MitraClip actually received the device, whereas roughly 20% underwent surgery and an additional 30% were managed medically. Of note, 6.6% of patients died during the evaluation process, reflecting the high-risk nature of this population with significant comorbidities.

The profile of patients referred for MitraClip demonstrated that this is a heterogeneous population with a combination of high STS risk score and several risk factors not accounted for in the STS scoring system. We were not able to fully assess the STS risk score for all patients referred for MitraClip, and it is likely that many of these patients were indeed too high risk to be eligible for

MitraClip (or surgery). Despite the increased risk of referred patients, several of whom underwent surgery, operative mortality for this timeframe remained excellent.

The variety of surgical procedure options offered to these patients reflects the underlying and coexisting cardiac morbidities of referred patients. Whereas most of the surgical procedures included mitral repair or replacement, 9 out of 82 patients instead received advanced heart failure therapies, including 7 left ventricular assist device placements and 2 epicardial left ventricle lead placements for biventricular pacing. These patients experienced the benefit of a truly multidisciplinary approach to patient evaluation, with a process that incorporates diverse medical and surgical opinions to provide the most appropriate therapy possible for each patient.

With the commercial approval of MitraClip and novel mitral transcatheter therapies on the horizon, it is important to establish the resources needed to implement a transcatheter mitral program. Recent guidelines for operator and institutional requirements for transcatheter mitral programs have been set forth by professional societies, including Society for Cardiac Angiography and Interventions, American Association for Thoracic Surgery, American College of Cardiology, and STS. These guidelines emphasize the importance of a multidisciplinary team approach to these novel procedures, and most especially the necessity of a strong collaboration between mitral surgeons and interventional cardiologists.⁶ Centers with very low mitral volumes may not have the experience necessary to adequately assess patients preoperatively for potential candidacy for MitraClip placement.

It has been noted in regions with widespread adoption of transcatheter aortic valve replacement (namely, Germany) that open surgical volumes have been reduced. In contrast to transcatheter aortic valve replacement, which could replace many surgical aortic valve replacement procedures, MitraClip is only 1 method of mitral repair with many more repair and replacement options available surgically. Despite concerns that transcatheter therapies threaten surgical volume, our center's surgical mitral volumes increased substantially—progress that has continued with the availability of the MitraClip. Although MitraClip referrals leading to eventual mitral surgery have contributed to growing surgical volumes, these patients do not fully account for the overall increase in mitral operations. Surgeons performed 45 of the MitraClip procedures at our institution, and we have found substantial value in surgeons participating in this procedure. It is our perception that the availability of a dedicated valve center inclusive of surgical and transcatheter therapies enhances surgical volumes by offering patients the entire gamut of percutaneous to minimally invasive to full sternotomy complex mitral repair and high-risk mitral replacement.

CONCLUSIONS

The availability of MitraClip at our institution is associated with an increase in mitral valve surgical volumes. Referrals have resulted in an increase in higher-risk surgical patients; despite this, mitral surgical outcomes have remained excellent. The multidisciplinary evaluation process for MitraClip referrals includes experienced mitral surgeons and interventional cardiology colleagues, as well as numerous medical specialists. This approach is necessary in developing a successful percutaneous and open surgical mitral valve program.

Conflict of Interest Statement

Drs Ailawadi and Lim consult for Abbott Vascular, the company that owns the MitraClip technology, both for modest fees. Dr Ailawadi also consults for Mitralign (Tewksbury, Mass) and Edwards Lifesciences (Irvine, Calif), and receives speaker fees from St Jude Medical (St. Paul, Minn). All other authors have nothing to disclose with regard to commercial support.

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Key Words: mitral valve, cardiac catheterization

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