

# Minimally Invasive Transaortic Repair of the Mitral Valve

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## ABSTRACT

**Objective:** We retrospectively evaluated the results of an edge-to-edge repair (Alfieri stitch) of the mitral valve performed via a transaortic approach in patients who were undergoing minimally invasive aortic valve replacement.

**Methods:** From January 2010 to September 2010, 6 patients underwent minimally invasive edge-to-edge repair of the mitral valve via a transaortic approach with concomitant aortic valve replacement. The patients were considered to be candidates for this procedure if they were deemed by the surgeon to be high-risk for a double valve procedure and if on preoperative transesophageal echocardiogram the mitral regurgitation jet originated from the middle portion (A2/P2 segments) of the mitral valve.

**Results:** There was no operative mortality. Mean cardiopulmonary bypass time was 137 minutes, and mean cross-clamp time was 111 minutes. There was a significant improvement in the mean mitral regurgitation grade, with a mean of 3.8 preoperatively and 0.8 postoperatively. The ejection fraction remained stable, with mean preoperative and postoperative ejection fractions of 43.3% and 47.5%, respectively. Follow-up transthoracic echocardiograms obtained at a mean of 33 days postoperatively (range, 8-108 days) showed no significant worsening of mitral regurgitation.

**Conclusion:** Transaortic repair of the mitral valve is feasible in patients undergoing minimally invasive aortic valve replacement.

## INTRODUCTION

Minimally invasive valve surgery was introduced in 1996 [Cosgrove 1996]. When compared to a standard median sternotomy approach, the reported benefits of minimally invasive surgery include reduced surgical trauma; need for reoperation for bleeding, blood loss; and pain; shorter ventilation time; shorter intensive care unit and hospital stay; reduced cost; less use of rehabilitation resources; and a more rapid return to functional activity [Modi 2008; Brown 2009; Raja 2009; Scarci 2009]. These benefits may be more significant in high-risk patients.

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Clinically significant mitral regurgitation is often found in conjunction with severe aortic valve stenosis. Performing double valve surgery in these patients is associated with increased morbidity and mortality [Leavitt 2009]. In patients for whom performing a double valve procedure carries a high surgical risk, an option is to perform the aortic valve replacement and do a transaortic edge-to-edge repair of the mitral valve. The aim of our study was to analyze the benefits, safety, and feasibility of performing a transaortic repair of the mitral valve via a minimally invasive approach in patients undergoing aortic valve replacement.

## PATIENTS AND METHODS

After obtaining approval from the Independent Review Board, we retrospectively evaluated the charts of 6 patients (5 men and 1 woman) who underwent minimally invasive aortic valve replacement with concomitant transaortic edge-to-edge repair of the mitral valve at our institution. The patients underwent surgery between January 1, 2010, and September 1, 2010. Five patients had severe aortic stenosis, and 1 had severe prosthetic aortic valve insufficiency. Four had 4+ mitral regurgitation, 1 had 3+, and 1 had 2+. They all had dyspnea at rest (New York Heart Association [NYHA] heart failure class IV), and 2 also had angina. The mean age was 83.1 years. The cause of the mitral regurgitation was rheumatic heart disease in 1 patient and functional in the other 5. Three patients were re-operations, 2 having previous coronary artery bypass graft surgery and 1 having a previous aortic valve replacement. Two of the patients undergoing a re-operation had significant obstructive coronary artery disease on cardiac catheterization: 1 had a 90% ostial lesion in a large diagonal artery, and the other a 70% right coronary artery lesion. In order to avoid a median sternotomy for a single-vessel bypass along with valve surgery, a "hybrid" approach was undertaken in which patients had angioplasty with stent placement of a coronary artery lesion and subsequently underwent minimally invasive valve surgery while on aspirin and clopidogrel (Table 1).

## TECHNIQUE FOR THE SURGICAL PROCEDURE

The patients were placed in the supine position and underwent anesthetic induction and intubation with a single lumen endotracheal tube and a bronchial blocker. Intraoperative transesophageal echocardiography was performed to evaluate the mitral valve. The mitral regurgitation was graded as

Table 1. Patient Characteristics\*

Case Number	Sex	Age, y	Aortic Valve Lesion	Mitral Valve Lesion	History	Surgery
1	M	87	AS	Functional (ischemic)	CABG 10 years prior; 90% diagonal lesion	Re-operation with PCI/stent of diagonal 1 week prior to surgery (hybrid)
2	F	74	AS	Rheumatic		
3	M	77	AS	Functional	Dilated cardiomyopathy	
4	M	92	AS	Functional (ischemic)	PCI/stent of LAD; 100% RCA lesion	
5	M	91	AS	Functional (ischemic)	CABG 9 years prior	Re-operation
6	M	78	PVI	Functional	Bioprosthetic AVR 5 years prior; 70% RCA	Re-operation with PCI/stent of RCA 3 weeks prior to surgery (hybrid)

\*AS indicates aortic stenosis; CABG, coronary artery bypass graft surgery; PCI, percutaneous coronary intervention; LAD, left anterior descending coronary artery; RCA, right coronary artery; PVI, prosthetic valve insufficiency.

severe (4+), moderate to severe (3+), moderate (2+), or mild (1+). The mitral regurgitation jet was evaluated at different angles (0, 60, 90, 120), as well as in the transgastric short-axis view and looking at the mitral valve to determine the origin of the jet. If the mitral regurgitation jet originated from the A2-P2 portions of the mitral valve, the patient was considered a candidate for the edge-to-edge repair.

A femoral platform was utilized to establish cardiopulmonary bypass. A 2 to 3 cm incision was made in the left inguinal crease. A 5-0 prolene (Ethicon, Somerville, NJ, USA) purse string suture was placed on the femoral artery and vein. The left femoral artery was cannulated with a 16-18 French arterial cannula, and the left femoral vein was cannulated with a 25 French venous cannula (BioMedicus, Medtronic, Minneapolis, MN, USA) and was placed in the superior vena cava with the aid of transesophageal echocardiography. A 4 to 5 cm transverse parasternal incision was then made over the third intercostal space, and the 4th costochondral cartilage was transected in order to allow adequate exposure of the aorta (Figure 1). This interspace was chosen in the event that the left atrium required entry and exposure. The pericardium was opened above the phrenic nerve and over the aorta to facilitate exposure. A retrograde coronary sinus catheter was directly inserted through the incision, and a purse string suture was placed in the right atrium. A left ventricular vent was inserted into the left ventricle via a purse string suture in the right superior pulmonary vein.

A transverse aortotomy was performed for exposure of the aortic valve. The aortic valve was removed under direct vision. After removal of the aortic valve, the A2 and P2 segments of mitral valve were identified, and an edge-to-edge repair was carried out with a 5-0 Prolene mattress suture reinforced with pericardial pledgets on the ventricular side of the mitral valve. Thereafter, the aortic valve prosthesis was implanted utilizing standard techniques. The aortotomy was closed in a 2-layer fashion, and the patient was weaned from cardiopulmonary bypass. The transected rib was then reattached to the sternum with a 1 cm metal plate (Synthes, West Chester, PA, USA), and a fiberwire was placed in a figure of 8 fashion. A single chest tube was left in the pleural space. The thoracotomy incision was closed in the routine fashion.

In patients with a history of previous coronary artery bypass graft surgery and a patent left internal mammary graft (LIMA), we used moderate hypothermia (28°C) with 1 induction dose of antegrade cardioplegia. Thereafter, retrograde cardioplegia is delivered at 20-minute intervals. We do not dissect the LIMA pedicle. In the setting of a patent LIMA, we prefer the native left anterior descending artery to be totally occluded. This diminishes a constant stream of blood return from the left main obscuring the operative field. If the left anterior descending artery is patent, we place a #10 Fr red rubber catheter, connected to a pump suction, into the left main to aspirate the blood.

After weaning from cardiopulmonary bypass, a postoperative transesophageal echocardiogram was performed to evaluate the adequacy of the repair, and the possible remaining mitral regurgitation was again graded. The mitral regurgitation was again evaluated on subsequent transthoracic or transesophageal echocardiograms.

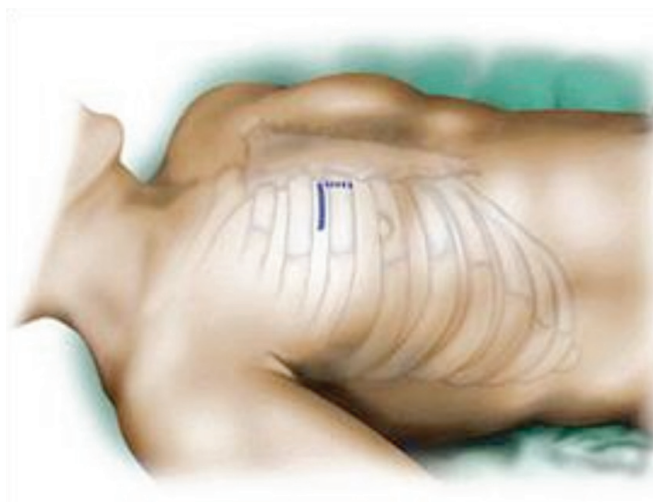


Figure 1. For the procedure, a 4 to 5 cm transverse parasternal incision is made over the right third intercostal space, and the fourth costochondral cartilage is transected.

Table 2. Operative Data\*

Case Number	Aortic Prosthesis		Cross-Clamp Time, min	Preoperative EF, %	Postoperative EF, %	Preoperative MR Grade†	Postoperative MR Grade‡	Length of Hospital Stay, d
	Size, mm	CPB Time, min						
1	25	153	105	50	50	4	2	11
2	21	207	174	55	65	4	1	20
3	27	116	99	20	20	3	0	8
4	25	89	66	25	35	4	0	13
5	27	121	111	45	50	4	2	4
6	25	157	126	65	65	2	0	4

\*CPB indicates cardiopulmonary bypass; EJ, ejection fraction; MR, mitral regurgitation.

†Preoperative MR grade by transesophageal echocardiography.

‡Postoperative MR grade by transesophageal echocardiography.

## RESULTS

There were no operative mortalities. The mean cardiopulmonary artery bypass time was 140.5 minutes, and the mean cross-clamp time was 113.5 minutes. Five of the patients underwent aortic valve replacement with a Hancock II porcine tissue valve (Medtronic, Minneapolis, MN, USA), and 1 had a stentless pericardial valve (ATS Medical, Minneapolis, MN, USA) implanted.

The median mitral regurgitation grade preoperatively was 4+. Postoperatively, 2 patients had moderate mitral regurgitation (2+), 1 had mild mitral regurgitation, and the other 3 had no discernible mitral regurgitation. The mean preoperative ejection fraction was 43.3%, which was similar to the postoperative ejection fraction of 47.5%. The mean hospital length of stay was 10 days (Table 2). A follow-up transthoracic echocardiogram performed at a mean of 33 days showed the grade of the mitral regurgitation to be the same when compared to the immediate postoperative transesophageal echocardiogram (Table 3).

## DISCUSSION

The edge-to-edge mitral valve repair involves placing a suture at the center (A2-P2 portion) of the margins of both mitral leaflets, creating a double orifice mitral valve (Figure 2). By performing this technique via a transaortic approach when replacing the aortic valve, one may reduce the operative risk for high-risk patients when compared to a standard double valve procedure. The advantages of this technique over double valve surgery are that it reduces the cardiopulmonary bypass time, the cross-clamp time, and the total operative time. It also eliminates the need for performing an atriotomy and avoids extensive dissection, which minimizes trauma and reduces perioperative bleeding.

Data about the edge-to-edge repair of the mitral valve via a transaortic approach are limited to single case reports and case series [Kavarana 2000; Kallner 2001; Shanker 2005; Kim 2007; Lozonshi 2007; Santana 2009]. The largest of the case series involved 20 patients: 13 had aortic valve replacement, and 7 had a Bentall operation along with edge-to-edge repair of the mitral valve [Kim 2007]. Preoperative mitral

regurgitation did not exceed a moderate (grade 2) degree, and there was no significant organic mitral valve disease. The authors reported an improvement in mitral regurgitation for all patients ( $P = .002$ ), with an improvement in the ejection fraction in 14 patients (70%) ( $P = .005$ ). The second largest of the case series involved 13 patients [Santana 2009]. In this case series, the preoperative mitral regurgitation was significantly reduced from a median of 3+ to 1+ postoperatively,  $P < .0001$ . On follow-up echocardiography, at a mean of 12.5 months after surgery, no worsening of mitral regurgitation was noted.

Aside from the edge-to-edge mitral valve repair, there have been other techniques performed via a transaortic approach. Lozonshi et al [2007] reported a case of a patient with severe aortic stenosis, moderate mitral regurgitation, and atrial fibrillation. Besides the transaortic edge-to-edge mitral repair, they also carried out a cryomaze procedure. With a flexible cryosurgical probe, they performed an endocardial ablation, along with epicardial ablation encircling the pulmonary veins. Other authors have repaired the anterior leaflet of the mitral valve with artificial chordae implantation [Koizumi 2004], and some

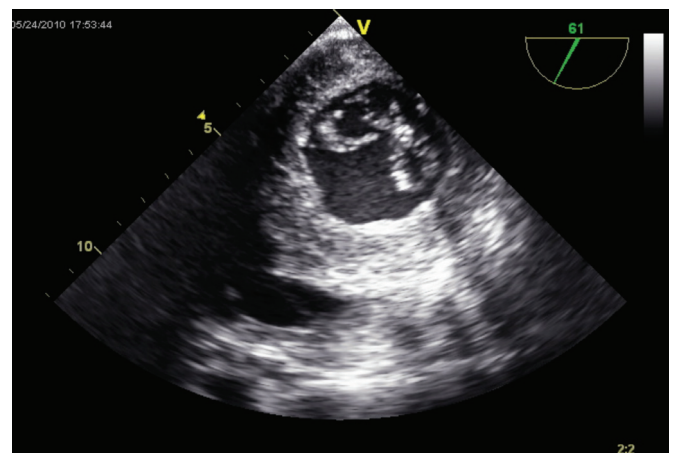


Figure 2. Transgastric short-axis view of the mitral valve demonstrating a double orifice due to the edge-to-edge repair.

Table 3. Follow-up Data

Case Number	Time for Follow-up Echocardiogram, d	Follow-up Mitral Regurgitation Grade
1	25	2
2	108	1
3	8	0
4	11	0
5	28	2
6	18	Trace

have performed posterior mitral annuloplasty [Matsumoto 2005]. Replacement of the mitral valve through an aortotomy has also been performed. This was first described in 1983 by Carmichael et al [1983]. Since then, there have been a few cases reported of mitral valve replacement using this approach [Crawford 1988; Najafi 1994; Sirbu 1999; Abraham 2002]. Crawford et al [1988] reported 6 patients with Marfan's syndrome who underwent composite valve graft replacement of the aortic root along with transaortic mitral valve replacement. When replacing the mitral valve, they removed the entire anterior mitral leaflet and its chordae and preserved the posterior mitral leaflet chordal apparatus. Subsequently, Abraham et al [2002] reported 4 cases of transaortic mitral valve replacement with total chordal preservation. They excised the anterior mitral leaflet, separating the chordal apparatus on either side, and affixed the chordae to the trigones (Miki's technique of chordal preservation [Miki 1995]). A radial incision was made in the mid-posterior mitral leaflet, and then the mitral prosthesis was placed. They obtained good results in all 4 patients.

The concern of the edge-to-edge repair without annuloplasty is its durability. It has been demonstrated that this type of repair offers better results when associated with a ring annuloplasty. In an analysis of 260 patients who underwent the edge-to-edge repair, those who received an annuloplasty had a 92%  $\pm$  3.4% freedom from reoperation at 5 years, compared with a 70%  $\pm$  15.0% freedom from reoperation in those who had a ringless repair ( $P = .02$ ) [Alfieri 2001]. The patients with worse outcomes associated with this procedure are those with mitral annular calcification, rheumatic mitral valve, functional mitral regurgitation, and edge-to-edge repair done as a rescue procedure [Maisano 2003; Bhudia 2004]. In our experience, we consider calcification of the mitral annulus to be a contraindication to edge-to-edge repair and avoid doing it in those settings.

All of the previous reports detailing this technique have involved performing it via a median sternotomy. This is the first case series of transaortic mitral valve repair utilizing the edge-to-edge repair via a minimally invasive approach in patients undergoing aortic valve replacement. Although this technique can be a bit more difficult to perform in patients with a small, non-elastic aortic annulus, we were able to obtain adequate exposure in all patients and were able to obtain adequate results.

## LIMITATIONS

The main limitation of our study is its small size. It encompassed a fairly heterogeneous group that had a short-term follow-up. This was a single surgeon, single center study.

## CONCLUSIONS

In patients undergoing minimally invasive aortic valve replacement who have significant mitral regurgitation that originates in the A2-P2 portion and are at a prohibitively high risk for double valve surgery, the edge-to-edge mitral repair via a transaortic approach is an option that may be utilized.

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