Transaortic edge-to-edge mitral valve repair for moderate secondary/functional mitral regurgitation in patients undergoing aortic root/valve intervention

Shiv Kumar Choudhary, MCh,^a Atul Abraham, MS,^a Amol Bhoje, MCh,^a Parag Gharde, DM,^b Manoj Sahu, MD,^a Sachin Talwar, MCh,^a and Balram Airan, MCh^a

ABSTRACT

Objective: The present study evaluates the feasibility, safety, and efficacy of edge-to-edge repair for moderate secondary/functional mitral regurgitation in patients undergoing aortic valve/root interventions.

Methods: Sixteen patients underwent transaortic edge-to-edge mitral valve repair. Mitral regurgitation was 2+ in 8 patients and 3+ in 6 patients. Two patients in whom cardiac arrest developed preoperatively had severe (4+) mitral regurgitation. Patients underwent operation for severe aortic regurgitation ± aortic root lesions. The mean left ventricular systolic and diastolic diameters were 51.5 ± 12.8 mm and 70.7 ± 10.7 mm, respectively. Left ventricular ejection fraction ranged from 20% to 60%. Primary surgical procedure included Bentall's ± hemiarch replacement in 10 patients, aortic valve replacement in 5 patients, and noncoronary sinus replacement with aortic valve repair in 1 patient.

Results: Severity of mitral regurgitation decreased to trivial or zero in 13 patients, 1+ in 2 patients, and 2+ in 1 patient. There were no gradients across the mitral valve in 9 patients, less than 5 mm Hg in 6 patients, and 9 mm Hg in 1 patient. There was no operative mortality. Follow-up ranged from 2 weeks to 54 months. Echocardiography showed trivial or no mitral regurgitation in 12 patients, 1+ in 2 patients, and 2+ in 2 patients. None of the patients had significant mitral stenosis. The mean left ventricular systolic and diastolic diameters decreased to 40.5 ± 10.3 mm and 58.7 ± 11.6 mm, respectively. Ejection fraction also improved slightly (22%-65%).

Conclusions: Transaortic edge-to-edge mitral valve repair is a safe and effective technique to abolish secondary/functional mitral regurgitation. However, its impact on overall survival needs to be studied. (*J Thorac Cardiovasc Surg* 2017;154:1624-9)

Transaortic edge-to-edge mitral repair.

Central Message

Transaortic edge-to-edge mitral valve repair is a safe and effective technique to abolish secondary/functional MR in patients undergoing aortic root/valve intervention.

Perspective

Management of moderate functional MR in patients undergoing aortic root/valve intervention remains elusive. Because of lack of conclusive evidence of survival benefit, increased morbidity, and technical difficulties, transatrial mitral repair has not become popular. In this setting, transaortic edge-to-edge mitral repair is a technically feasible, effective, and safe option.

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Secondary or functional mitral regurgitation (MR) is a frequent accompaniment in patients undergoing aortic valve interventions.^{1,2} Although there are clear-cut guidelines for management of severe secondary/functional regurgitation, recommendations are vague for moderate

secondary/functional regurgitation,³⁻⁵ perhaps because the MR decreases with correction of the aortic pathology alone in a significant number of patients.^{6,7} Second, adding a conventional transatrial mitral intervention to aortic valve surgery is often associated with increased ischemia time, perioperative mortality, and morbidity.^{4,8} Moreover, exposure of the mitral valve through the left atrium is frequently difficult in patients with aortic pathology because of the leftward displacement of the

From the Departments of ^aCardiothoracic and Vascular Surgery and ^bCardiac Anesthesia, Cardiothoracic Centre, All India Institute of Medical Sciences, New Delhi, India.

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Address for reprints: Shiv Kumar Choudhary, MCh, Department of Cardiothoracic and Vascular Surgery, All India Institute of Medical Sciences, Room No 11, 7th Floor, CN Centre, New Delhi 110029, India (E-mail: shivchoudhary@hotmail.com).

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Scanning this QR code will take you to a supplemental video for the article.

Abbreviations and Acronyms

AR = aortic regurgitation

MR = mitral regurgitation

TEE = transesophageal echocardiography

mitral annulus. However, reduction in concomitant MR after correction of aortic valve pathology does not occur in all patients, and it is difficult to predict which patients will show improvement. Early persistence of MR has been found to affect survival adversely.^{1,2,4,9} Thus, a policy of not intervening on the mitral valve leaves some of the patients with increased risk associated with persistent MR. Therefore, at present, the surgeon has to consider a tradeoff between the increased operative risks and technical difficulties of a formal mitral valve repair and the potential risk associated with possible persistent MR postoperatively.

It is in this setting that transaortic edge-to-edge repair (Alfieri repair) of mitral valve emerges as a quick and technically simple procedure compared with conventional transatrial mitral valve repair. It does not add to the crossclamp times or the technical complexity. Transatrial edge-to-edge repair of the mitral valve has a proven history of safety and efficacy.^{10,11} Although described by Kavarana and colleagues¹² in the year 2000, there are few reports¹³⁻¹⁵ of transaortic edge-to-edge repair in the literature.

The present study has been performed to assess the feasibility and early outcomes after transaortic edge-to-edge repair of the mitral valve in patients undergoing aortic valve/root intervention having concomitant moderate (2+ or 3+) secondary/functional MR.

PATIENTS AND METHODS

After obtaining approval from the Institutional Review Board, we retrospectively reviewed the records of patients who underwent transaortic edge-to-edge mitral valve repair at the time of aortic root/valve intervention. Between January 2012 and November 2016, 16 patients (age 24-76 years, 47.7 ± 16.9 years) underwent transaortic edge-to-edge mitral valve repair. MR was 2+ in 8 patients and 3+ in 6 patients. Two patients in whom cardiac arrest developed preoperatively had severe (4+) functional MR and were operated as salvage procedures. Edge-to-edge repair was not performed if MR was organic or eccentric. However, patients with rheumatic cause who had ventricular enlargement and annular dilatation without any evidence of cuspal or subvalvular pathology were included. Fifteen patients were primarily operated for severe aortic regurgitation (AR) $\pm$ aortic root lesions. One patient had combined stenosis and regurgitation. The underlying aortic pathology was annuloaortic ectasia in 6 patients, annuloaortic ectasia with type A dissection in 1 patient, localized aneurysm of noncoronary sinus of Valsalva in 1 patient, bicuspid aortic valve with dilated sinuses in 3 patients, bicuspid valve with severe AR in 1 patient, rheumatic aortic valve disease in 3 patients, and degenerative aortic valve disease in 1 patient. A profile of the patients is shown in Table 1.

Assessment of severity of MR and evaluation of other echocardiographic parameters were performed by intraoperative transesophageal echocardiography (TEE). The mean left ventricular internal diameter in

end-systole and end-diastole were 51.5 ± 12.8 mm (range, 35-69) and 70.7 ± 10.7 mm (range, 54-85 mm), respectively. Left ventricular ejection fraction ranged from 20% to 60%. Six patients had severe dysfunction (left ventricular ejection fraction $\leq 30\%$). The echocardiographic parameters of individual patients are shown in Table 2.

Surgical Technique

Intraoperative TEE was performed in all patients after anesthetic induction. After excision of the aortic valve in cases of aortic valve replacement (but before repair is started in cases of aortic valve repair), the mitral valve was visualized through the aortic annulus. The mid portion of the A2 segment of the anterior mitral leaflet was approximated with the mid portion of the P2 segment of the posterior mitral leaflet in an area free of chordal attachments. This was achieved with a pledgeted horizontal mattress stitch with 4-0 polypropylene suture taken 3 to 4 mm from the edge of the leaflet (Figure 1). The stitch was reinforced with 2 to 3 throws of the same suture. The technique of repair is shown in the accompanying Video 1.

Results of repair were assessed immediately by intraoperative TEE. The same echocardiographer performed all preoperative and postrepair TEE examinations. A predischarge transthoracic echocardiographic assessment was performed in all patients. Subsequently, patients were followed in the outpatient department by the single surgical team. Follow-up transthoracic echocardiographic assessment was performed by multiple echocardiographers at 3 months and annually thereafter.

RESULTS

Primary surgical procedure included Bentall's $\pm$ hemi-arch replacement in 10 patients, aortic valve replacement in 5 patients, and noncoronary sinus replacement with aortic valve repair in 1 patient.

There was no operative mortality. The mean cardiopulmonary bypass time was 104 ± 30.5 minutes, and the mean aortic crossclamp time was 80.3 ± 21.5 minutes. Intraoperative TEE showed diminished severity of MR in all patients (Figure 2). There was trivial or no MR in 13 patients, mild (1+) MR in 2 patients, and moderate (2+) MR in 1 patient. There were no gradients across the mitral valve in 9 patients, less than 5 mm Hg in 6 patients, and 9 mm Hg in 1 patient (Table 2).

The median intensive care unit stay was 2 days, and the median duration of hospital stay was 7 days. Follow-up ranged from 2 weeks to 54 months (median, 20 months) and was 100% complete. There was no late death. One patient was in New York Heart Association class II at 1 year. All other patients were asymptomatic. Follow-up echocardiography showed trivial or no MR in 12 patients, mild MR in 2 patients, and moderate MR in 2 patients. One patient who had no MR intraoperatively developed mild MR after 3 months. In 1 patient, MR progressed from mild to moderate at 1 year. In 1 patient with moderate MR intraoperatively, it remained stable at 16 months (Table 2). None of the patients had significant mitral stenosis (mean gradient >5 mm Hg). Left ventricular internal diameter in end-systole and end-diastole decreased to 40.5 ± 10.3 (range, 28-64 mm) and 58.7 ± 11.6 (range, 42-74 mm), respectively. Ejection fraction also improved mildly (22%-65%).

TABLE 1. Demographic profile of patients

SN	Age/sex	Etiopathology	Aortic lesion	Degree of MR	Aortic procedure
1	25/M	Type A aortic dissection	Severe AR	2+	Bentall's + hemiarch replacement
2	58/M	Annuloaortic ectasia	Severe AR	2+	Bentall's procedure
3	76/M	Aneurysm of noncoronary sinus	Severe AR	2+	Aortic valve repair + reconstruction of noncoronary sinus
4	36/M	Marfan's syndrome, annuloaortic ectasia	Severe AR	3+	Bentall's procedure
5	62/M	BAV with dilated sinuses and ascending aorta	Severe AR	2+	Bentall's + hemiarch replacement
6	62/M	Annuloaortic ectasia	Severe AR	2+	Bentall's procedure
7	40/M	BAV with dilated sinuses and ascending aorta	Severe AR	3+	Bentall's + hemiarch replacement
8	68/M	Annuloaortic ectasia	Severe AR	3+	Bentall's procedure
9	56/M	Rheumatic heart disease	Severe AR	2+	Aortic valve replacement
10	60/M	Annuloaortic ectasia	Severe AR	2+	Bentall's + hemiarch replacement
11	61/M	Degenerative aortic stenosis	Severe AS, moderate AR	2+	Aortic valve replacement
12	24/M	Annuloaortic ectasia	Severe AR	3+	Bentall's procedure
13*	27/M	Rheumatic heart disease	Severe AR	4+	Emergency aortic valve replacement after cardiac arrest
14	36/M	BAV	Severe AR	3+	Aortic valve replacement
15*	30/M	Rheumatic heart disease	Severe AR	4+	Emergency aortic valve replacement after cardiac arrest
16	42/M	BAV with dilated sinuses and ascending aorta	Severe AR	3+	Bentall's + hemiarch replacement

SN, Serial number; MR, mitral regurgitation; AR, aortic regurgitation; BAV, bicuspid aortic valve. *Cardiac arrest in patient before surgery.

DISCUSSION

Functional or secondary MR evolves from a primarily ventricular pathology of any cause that causes ventricular

dilatation. Ventricular dilatation, in the setting of a structurally normal valve, increases the distance between the papillary muscles, leading to an area of failed coaptation

TABLE 2. Perioperative and follow-up echocardiographic findings

SN	Degree of MR	Prerepair TEE			Postrepair TEE		Follow-up (transthoracic echocardiography)				
		EF (%)	LVIDes (mm)	LVIDed (mm)	Degree of MR	MDG	Follow-up duration (mo)	Latest echocardiography (mo)	Degree of MR	LVIDes (mm)	LVIDed (mm)
1	2+	60	40	63	0	0	54	48	0	32	45
2	2+	55	45	80	0	0	42	36	0	35	66
3	2+	60	35	54	0	0	40	36	0	28	42
4	3+	45	65	84	0	0	40	24	0	47	70
5	2+	30	68	78	0	3	37	36	0	45	64
6	2+	60	42	67	0	0	25	20	0	34	52
7	3+	55	40	60	1+	3	22	18	1+	32	48
8	3+	30	67	83	2+	0	20	16	2+	48	72
9	2+	60	43	75	0	0	20	12	0	32	51
10	2+	60	58	74	0	2	16	12	0	44	67
11	2+	60	40	62	0	3	16	15	0	34	48
12	3+	30	69	85	0	0	15	12	0	52	74
13	4+	25	68	79	1+	0	14	12	2+	64	73
14	3+	25	41	54	0	9	12	12	0	33	44
15	4+	20	60	73	0	4	6	3	1+	54	69
16	3+	55	43	60	0	3	2 wk	1 wk	0	34	55

SN, Serial number; TEE, transesophageal echocardiography; EF, ejection fraction; LVIDes, left ventricular internal diameter end-systole; LVIDed, left ventricular internal diameter end-diastole; MDG, mean diastolic gradient.

FIGURE 1. Schematic drawing showing the surgeon's view through the excised aortic valve (the coronary buttons also have been harvested for aortic root replacement) with the edge-to-edge stitch approximating the anterior and posterior mitral leaflets. *L*, Left coronary sinus; *AML*, anterior mitral leaflet; *R*, right coronary sinus; *N*, noncoronary sinus.

and subsequent MR.¹⁶ Moderate secondary/functional MR in patients undergoing aortic root/valve replacement is a tricky situation that is encountered frequently.^{1,2,4} There are conflicting reports about the impact of moderate/severe secondary/functional MR on survival. Some investigators found that presence of moderate to severe MR preoperatively adversely affected 30-day mortality, heart failure outcomes, and long-term survival.⁹ However, others failed to find any difference.^{6,7} Thus, the actual prognostic implications of concomitant moderate MR are unclear. Thus, there is lack of consensus about indication to intervene in cases of concomitant moderate secondary/functional MR.

Surgical correction of the aortic valve pathology has been proposed to improve MR by reducing the left ventricular pressure overload in aortic stenosis and volume overload in AR. In a meta-analysis involving 3053 patients

FIGURE 2. A line diagram showing the severity of MR in preoperative TEE and postrepair TEE. *MR*, Mitral regurgitation.

undergoing isolated aortic valve replacement for aortic stenosis with concomitant MR, Harling and colleagues¹¹ showed that 55% of patients had improvement in MR after aortic surgery. There was a significant reduction in left ventricular end-diastolic diameter and left ventricular mass after surgery. Despite evidence suggesting reverse remodeling, 44.5% of patients had no change or worsening of MR. At least theoretically in these cases, if the MR persists, the vicious cycle of ventricular dilatation and increasing MR will progress. Coutinho and colleagues¹⁷ compared patients who underwent mitral valve repair with those who did not for concomitant moderate functional MR during aortic valve replacement. Early persistence of MR was found to be a significant risk factor for survival. Patients not undergoing repair, obviously, had more chance of persistence of MR. But whether the risk of the later outweighs the additional surgical risk of adding a mitral valve intervention is a matter of contention.

When MR accompanies a patient undergoing aortic root/valve surgery, problems are manifold. Adding a formal transatrial mitral valve repair/replacement to an already complex procedure will further prolong the crossclamp time and increase the technical difficulty. In the experience of McCarthy and colleagues,⁴ the crossclamp time increased by more than 1 hour on average in patients undergoing additional mitral valve repair. There was an increased incidence of postoperative renal failure in these

VIDEO 1. Technique of transaortic edge-to-edge mitral repair. Video available at: [http://www.jtcvsonline.org/article/S0022-5223\(17\)31185-6/addons](http://www.jtcvsonline.org/article/S0022-5223(17)31185-6/addons).

patients. Moreover, the need to make an extra left atrial incision, the leftward displacement of the mitral annulus due to aortic root dilatation, and the frequently small left atrium in these cases make the left atrial route disadvantageous.

In such situations, a transaortic edge-to-edge repair of the mitral valve emerges as a technically simple and time-saving alternative.¹²⁻¹⁵ It neither prolongs the crossclamp times significantly nor adds to the technical complexity of the procedure. The frequently dilated aortic root in patients undergoing aortic root replacement makes the transaortic route easier. The edge-to-edge repair of the mitral valve has a proven track record of safety and efficacy.^{10,11} Furthermore, the percutaneous MitraClip procedure (Abbott, Abbott Park, Ill), which is conceptually the same as the edge-to-edge repair, has shown good results in the setting of secondary/functional MR. However, in the presence of primary valvular pathology, edge-to-edge repair without annuloplasty yields inferior results.¹¹

The results of our study show that transaortic edge-to-edge repair of the mitral valve is a technically feasible, effective, and safe option for concomitant secondary/functional MR in patients undergoing aortic valve interventions. The procedure does not take more than 2 minutes and thus does not increase the ischemia time of the heart. It was able to reduce the degree of MR in all but 1 patient. Even in 2 patients who had severe MR with severe ventricular dysfunction and developed cardiac arrest preoperatively, it was possible to salvage the patients with an expeditious edge-to-edge repair. The MR correction remained stable in the postoperative period up to 48 months. MR increased by 1 grade in only 2 patients after an interval of 3 and 12 months.

Primarily, we use transaortic edge-to-edge repair in patients with moderate secondary/functional MR only. However, in 2 extremely sick patients who developed ventricular fibrillation preoperatively and underwent salvage operation, this technique was used even for severe MR. To assess the effectiveness and durability of this technique, these 2 patients were also included in the study. Likewise, patients with rheumatic cause of disease are not suitable for this technique. However, we used this technique if there was isolated mild to moderate annular dilatation accompanying ventricular dilatation without cuspal or subvalvular pathology.

Interpretation of follow-up echocardiography data is a complex affair, because it involves interval-censored observations. Moreover, because of the dynamic nature of MR, loading conditions and systemic resistance at the time of evaluation may affect results. Therefore, absence of MR at 1 time point may not necessarily mean that it was constant over the entire time interval since the previous

measurement. Thus, each patient needs careful follow-up and intelligent interpretation of data.

Finally, we are not defining the indications for intervention in concomitant secondary/functional MR. Our only contention is that if one plans to intervene in moderate secondary/functional MR, transaortic edge-to-edge repair is an effective and handy tool. However, patient selection is crucial for this procedure. The presence of organic or eccentric MR precludes this technique. A good intraoperative transesophageal echocardiogram also is mandatory.

Study Limitations

The study is limited by its retrospective nature, small numbers, and unequal follow-up of patients.

CONCLUSIONS

Transaortic edge-to-edge mitral valve repair is a safe and effective technique to abolish functional MR. However, its impact on overall survival cannot be predicted.

Conflict of Interest Statement

Authors have nothing to disclose with regard to commercial support.

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