2772-9931
https://doi.org/10.1016/j.atssr.2023.06.008

Valve: Short Report

Mitral Valve Repair Is Effective When Performed With Valve-Sparing Aortic Root Replacement

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ABSTRACT

BACKGROUND Concurrent aortic and mitral valve repair presents specific technical challenges to surgeons. Here we evaluate the outcomes of patients undergoing combined valve-sparing aortic root reimplantation and mitral valve repair.

METHODS We performed a retrospective review of patients at our center between 2006 and 2021 who underwent concomitant valve-sparing aortic root replacement and mitral valve repair. Patient characteristics, including preoperative and postoperative valve function, and operative outcomes were analyzed.

RESULTS Between 2006 and 2021, 14 patients underwent valve-sparing aortic root replacement with concurrent mitral valve repair. Mean age of the patients at operation was 39 ± 20 years. Almost half of the patients (6/14) had Marfan disease. The primary indication for operation in all patients was aortic root dilation. Preoperatively, all patients (14/14) had moderate to severe mitral regurgitation, and half (7/14) had moderate to severe aortic regurgitation. Patients underwent mitral annuloplasty alone (9/14) or had concurrent leaflet repair (5/14). The median length of intubation was 0 day (interquartile range, 0-1 day), and median length of stay was 7 days (interquartile range, 6-10 days). At average follow-up of 6.8 ± 4.2 years, 13 of 14 patients had none to trace aortic and mitral regurgitation. One patient required reoperation for late recurrence of aortic and mitral regurgitation. There was no early or late cardiovascular mortality.

CONCLUSIONS Mitral valve repair can be performed safely with excellent short-term and long-term results in selected patients undergoing valve-sparing aortic root reimplantation. For durable bivalvular repair to be achieved, specific technical considerations should be adhered to.

(Ann Thorac Surg Short Reports 2023;1:638-641)

Up to 7% of patients who present with aortic root disease have concomitant mitral valve regurgitation.[1] This multivalvular pathologic process is especially common in patients with connective tissue disorders, such as Marfan syndrome.[2,3] In patients with aortic root aneurysms or mitral insufficiency, valve-sparing approaches are preferred to valve replacement when it is technically possible because they obviate the need for long-term anticoagulation, preserve the native valve complex with its superior performance, reduce need for reoperation due to prosthetic valve degeneration, and offer improved survival.[4,5] Despite the high rate of

IN SHORT

- Mitral insufficiency occurs commonly in patients with aortic root aneurysms, especially in patients with connective tissue disorders.
- Mitral valve repair can be performed safely with excellent short-term and long-term results in selected patients undergoing valve-sparing aortic root reimplantation.

Accepted for publication Jun 12, 2023.

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concurrent aortic root and mitral valve disease, little is known about the outcomes of concurrent valve-sparing aortic root replacement and mitral valve repair in patients with both aortic root and mitral valve disease.

PATIENTS AND METHODS

The prospectively maintained aortic database at our institution was queried between 2006 and 2022 to identify patients who underwent concomitant valve-sparing aortic root replacement and mitral valve repair. Permissions for query were granted by the University of Pennsylvania institutional review board. Patient characteristics, echocardiograms before and after repair, and operative outcomes were analyzed.

SELECTION OF PATIENTS. The decision to offer concurrent aortic valve and mitral valve repair was made by the operating surgeon and cardiologist on the basis of current guidelines, patient-specific anatomic factors, and patient-specific risk factors for operation, with only low-risk patients considered for concurrent valve repair techniques. The threshold for aortic root replacement was 5.5 cm without a known genetic aortopathy, 5 cm in patients with a bicuspid aortic valve, and 4.5 cm in the setting of confirmed Marfan syndrome. A valve-sparing approach was considered at time of root replacement if there was favorable leaflet disease and an absence of aortic stenosis or valvular calcification.

Concurrent mitral valve repair was offered in patients with at least moderate mitral regurgitation, leaflet disease believed to be amenable to repair, and absence of mitral stenosis or calcification. The final decision to proceed with a completely valve-sparing approach was based on an intraoperative assessment of leaflet disease by direct visual inspection and transesophageal echocardiography.

ECHOCARDIOGRAPHY. All patients underwent preoperative, intraoperative, and postoperative echocardiography to assess valvular function. All intraoperative transesophageal echocardiograms were performed by board-certified echocardiographers, and standard measurements of left ventricular function were calculated by Simpson biplane method. Valvular regurgitation was quantified on the basis of spectral and color Doppler and width of regurgitant jet.

SURGICAL TECHNIQUE. The valve-sparing root replacement was performed by the reimplantation technique as described.[6] After the aortic root had been replaced, hemiarch replacement was performed under circulatory arrest if ascending diameter was $\geq$4.5 cm. Retrograde cerebral perfusion at 18 °C was used in such cases. The mitral valve was then approached through Sondergaard groove. Valve inspection focused on a comprehensive valve analysis including segmental leaflet analysis, tissue quality, chordal anatomy, annular dilation, and cleft prominence. It is vital to use a partial annuloplasty band, which was placed from the left to right trigone. Leaflet disease was addressed, if necessary, with resection of prolapsed leaflets or neochords. Both the aortic and mitral leaflets were assessed for valvular insufficiency by direct visualization after repair and transesophageal assessment. For all cases, both antegrade and retrograde cardioplegia was used throughout the case.

STATISTICS. GraphPad Prism, version 5.0, was used to perform all statistical analyses and to plot data. All continuous data were expressed as means with SD or median with range when noted. Wilcoxon signed rank tests were used to compare continuous variables on preoperative and discharge echocardiograms, and Fisher exact tests were used to compare categorical variables.

RESULTS

CHARACTERISTICS OF THE PATIENTS. The patients' demographic characteristics are summarized in Table 1. The mean age of patients undergoing concomitant valve-sparing root replacement and mitral valve repair was 39 $\pm$ 20 years. Nearly half of the patients (6/14) had genetically proven Marfan syndrome. Aside from the high rate of connective tissue disease, most patients had no other medical problems.

All patients had aortic root dilation, with the average size of the aortic root being 5.2 $\pm$ 0.4 cm at time of operation. Half of the patients (7/14) had moderate to severe aortic insufficiency, and all patients (14/14) had moderate to severe mitral insufficiency. All patients had

TABLE 1 Demographic Characteristics of the Patients

Variable	No. (%) or Mean $\pm$ SD
Age at surgery, y	39 ± 20
Male sex	7 (50)
Comorbid conditions	
Marfan syndrome	6 (43)
Atrial fibrillation	3 (21)
Hypertension	4 (29)
Coronary artery disease	3 (21)
Aortic root diameter at surgery, cm	5.2 ± 0.4
Preoperative echocardiography	
Moderate to severe AI	7 (50)
Moderate to severe MR	14 (100)
Ejection fraction, %	55 ± 9
Left ventricle end-diastolic diameter, cm	6.0 ± 0.7
Left ventricle end-systolic diameter, cm	4.1 ± 0.7
Tricuspid leaflets	14 (100)

AI, aortic insufficiency; MR, mitral regurgitation.

Ann Thorac Surg Short Reports
2023;1:638-641

dilated mitral annulus by transesophageal echocardiography and direct measurement with mean annular size of 46 ± 2 mm. Other common mitral pathologic processes included prolapsed posterior leaflet (5/14), prolapsed anterior leaflet (1/14), and bileaflet prolapse (2/14). Despite high rates of severe valvular disease, most patients were well compensated, with all patients having New York Heart Association class 1-2 symptoms of heart failure.

OPERATIVE DETAILS. The operative details are summarized in Table 2. Three patients had histories of prior cardiac operation. All patients underwent a valve-sparing aortic root replacement by the reimplantation technique. A variety of techniques were used for mitral valve repair: annuloplasty band alone (9/14), triangular or quadrangular resection with annuloplasty (3/14), Alfieri repair with annuloplasty (1/14), and neochords with annuloplasty (1/14). Annuloplasty bands were incomplete, and mean size was 35 ± 3 mm. Other procedures were commonly performed, including hemiarch replacement (6/14) and maze (3/14). The mean cardiopulmonary bypass time was 320 ± 69 minutes, and mean cross-clamp time was 273 ± 61 minutes. When hemiarch was performed (6/14 patients), retrograde cerebral protection was used for all patients, with mean time of 20 ± 3 minutes. All patients left the operating room with none to trace mitral and aortic insufficiency and normal left and right ventricular function.

POSTOPERATIVE OUTCOMES. There were no early mortalities. Most patients (11/14) had no complications during the index hospital admission. Two patients experienced new atrial fibrillation, and 1 patient had complete heart block requiring a pacemaker. All patients were extubated by postoperative day 1. No patient required a take-back for postoperative bleeding. No patient had acute renal failure, required reintubation, or had a prolonged intensive care unit stay. The average length of stay was 8 ± 2 days. Three patients were readmitted within 3 months of discharge for syncope (1/14) and rapid atrial fibrillation (2/14). There were no perioperative deaths. Two patients died at 2 years and 9 years after operation of unknown causes. Neither patient had residual mitral or aortic regurgitation on the last echocardiograms before their deaths.

TABLE 2 Operative Details

Variable	No. (%) or Mean ± SD
Reoperative sternotomy	3 (21)
Mitral repair type	
Annuloplasty alone	9 (64)
Triangular or quadrangular resection	3 (21)
Alfieri	1 (7)
Chordal transfer and neochords	1 (7)
Other procedures performed	
Transverse aortic arch repair	6 (43)
Maze procedure	3 (21)
Coronary artery bypass graft	1 (7)
Annular graft size, mm	31 ± 2
Mitral valve band size, mm	35 ± 3
CPB time, min	320 ± 69
Cross-clamp time, min	273 ± 61
Circulatory arrest time, min (n = 6)	20 ± 3

CPB, cardiopulmonary bypass.

ECHOCARDIOGRAPHIC FOLLOW-UP. All patients were observed with yearly echocardiograms. The median time of echocardiographic follow-up is 4.4 years (interquartile range, 1.9-8.2 years). On follow-up echocardiography, recurrent severe mitral and aortic insufficiency developed at 6 years in 1 patient with Marfan syndrome, and a reoperation was required for mitral and aortic valve replacement. Of the remaining living cohort, no patients (11/11) have had recurrent aortic or mitral insufficiency.

COMMENT

Mitral regurgitation is common in patients with aortic root disease, particularly in patients with connective tissue disorders.[1] Addressing both mitral insufficiency and aortic root disease is a challenging clinical and technical problem for the cardiac surgeon. Valve-sparing aortic root replacement has excellent demonstrated long-term durability and obviates the need for anticoagulation.[5] The addition of mitral repair adds technical complexity to an already challenging operation, but mitral replacement, especially in the young patient, has limited durability or necessitates lifelong anticoagulation. Living aortic and mitral valves exhibit several properties not replicated by prostheses that are particularly important for patients with extended anticipated life expectancy. These include superior hemodynamics, production of natural anticoagulants, capacity for regeneration, and resistance to infection.[7,8] Concomitant mitral repair and valve-sparing aortic root replacement offers the advantages of avoiding prostheses that have limited durability and suboptimal performance, but long-term results of this combined operation are unknown. Here we examined our results of combined mitral repair and aortic valve-sparing root replacement with reimplantation and found that the operation can be performed safely with excellent long-term valve durability.

Selection of patients was an important factor in technical success. All selected patients had aortic valves and mitral valves that were amenable to repair. Patients

with aortic valve asymmetry, significant leaflet calcification, large fenestrations, or restricted mitral leaflets were not considered for valve-sparing approaches. In addition, all considered patients had preserved ventricular function and performance status. The cardiopulmonary bypass and aortic cross-clamp times were long for these technically challenging operations, and thus patients with impaired ventricular function or performance status were not considered for bivalvular repair. Half of the patients in this series had Marfan disease, so importantly, connective tissue disease was not a contraindication to selection of patients.

There were also important technical considerations that contributed to the long-term durability of valve repair. Partial flexible annuloplasty bands for the mitral repair were preferred to complete rings because they led to less distortion and asymmetry of the aortic annulus. As Yacoub and coworkers[9] have demonstrated, the aortic annulus and mitral annulus share a dynamic anatomy based on the cardiac cycle, which is essential to the competence and function of both. Respecting this point is critical to not restrict the function of either valve. Mitral bands were also somewhat undersized to the true annulus size, again to prevent distortion of the aortic annulus, which could lead to aortic insufficiency. There was 1 patient with recurrent mitral and aortic insufficiency who required reoperation. This was the first patient who underwent concomitant repair, so we hypothesize that technical factors may have contributed.

There are several limitations to this study. Foremost, this is a small sample size with variable follow-up, so larger, multicenter long-term studies are needed to ultimately determine the safety and durability of this technique. Next, these surgeries were performed by a team of experienced surgeons and echocardiographers, so these results may not be generalizable. This study does demonstrate that technical success can be achieved with mitral valve repair and aortic root replacement with reimplantation and identifies important criteria for selection of patients.

FUNDING SOURCES

The authors have no funding sources to disclose.

DISCLOSURES

Wilson Y. Szeto reports a relationship with Edwards, Medtronic, Terumo, Artivion, and Abbott that includes: consulting or advisory and speaking and lecture fees. Joseph E. Bavaria reports a relationship with Edwards, Gore, Abbott, Medtronic, Terumo, and CardiaAQ that includes: consulting or advisory, equity or stocks, and paid expert testimony; is on the STS-ACC Transcatheter Valve Therapy Registry steering committee and co-chair of the TAVR writing committee; and is a site investigator or consultant in transcatheter/surgical valve trials.

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