Title	Re-do mitral valve replacement for a bioprosthetic valve with central transvalvular leakage in a patient with ischemic cardiomyopathy : a case report
Author(s)	Seki, Tatsuya; Shingu, Yasushige; Wakasa, Satoru; Katoh, Hiroki; Ooka, Tomonori; Tachibana, Tsuyoshi; Kubota, Suguru; Matsui, Yoshiro
Citation	Journal of artificial organs, 22(2), 177-180 https://doi.org/10.1007/s10047-018-1086-6
Issue Date	2019-06
Doc URL	http://hdl.handle.net/2115/78254
Rights	The final publication is available at link.springer.com.
Type	article (author version)
File Information	J Artif Organs_22_177.pdf

Re-do mitral valve replacement for a bioprosthetic valve with central transvalvular leakage in a patient with ischemic cardiomyopathy: A case report

Tatsuya Seki,[1] Yasushige Shingu,[1] Satoru Wakasa,[1] Hiroki Katoh,[2]
Tomonori Ooka,[1] Tsuyoshi Tachibana[1], Suguru Kubota,[1] Yoshiro Matsui[1]

[1] Department of Cardiovascular and Thoracic Surgery, Faculty of Medicine and Graduate School of Medicine, Hokkaido University

[2] Emergency and Critical Care Center, Hokkaido University Hospital

Manuscript type: Case Report

Running title: Re-do MVR for TVL in an ICM patient

Corresponding author: Dr. Yasushige Shingu

Department of Cardiovascular and Thoracic Surgery

Faculty of Medicine and Graduate School of Medicine, Hokkaido University

Kita 15, Nishi 7, Kita-ku, Sapporo 060-8638, Japan

Tel: +81-11-716-1161 (6041); Fax: +81-11-706-7612

Email: shingu@huhp.hokudai.ac.jp

Key words: bioprosthetic valve, mechanical valve, transvalvular leakage

Field of research: Artificial valve

Total number of words: 2933

Total number of pages: 4

Abstract

Transvalvular leakage (TVL) of a prosthetic heart valve is not negligible regurgitant flow in patients with critically low contractile function. Although the opening function of prosthetic valves has been reported, its closing function is not well understood. A man in his 70s had a history of mitral valve replacement (MVR) with a Magna Mitral® valve for ischemic mitral valve regurgitation. He presented with dyspnea two years postoperatively. Echocardiography showed moderate TVL. The pulmonary capillary wedge pressure and cardiac index were 37 mmHg and 1.65 L/min/m^2, respectively. Because we considered his TVL relevant, we performed re-do MVR with a mechanical valve and papillary muscle approximation and suspension (“papillary muscle tugging approximation”). His cardiac function improved postoperatively; he was discharged with New York Heart Association class I. For MVR in patients with critically low contractile function, prosthetic valves, such as mechanical valves, with small TVL are recommended.

Introduction

The selection of prosthetic valves in mitral valve replacement (MVR) has been mainly based on the risk of anticoagulation-related bleeding and thromboembolism with a mechanical valve versus the risk of structural valve deterioration with a bioprosthetic valve or on the patient's lifestyle and preferences [1, 2]. The opening functional parameters of prosthetic valves such as effective orifice area and pressure gradient have been reported [3-5]. However, their closing function is not well understood. Although transvalvular leakage (TVL) of prosthetic valves is usually considered negligible regurgitant flow in patients with preserved contractile function, it may become significant in those with critically low contractile function. Re-do MVR for TVL of the bioprosthetic valve for patients with severely deteriorated ischemic cardiomyopathy (ICM) has not been reported. Herein, we report a case of re-do MVR with a mechanical valve for significant TVL after MVR with Magna Mitral® valve (Edwards Lifesciences LLC, Irvine, CA).

Case Report

A man in his 70s with ICM and mitral valve regurgitation was admitted to our hospital due to dyspnea. He underwent MVR with Magna Mitral® valve (29 mm) (Edwards Lifesciences LLC) with total chordal preservation (anterior leaflet was cut in the A2 part and divided at both commissure), papillary muscle approximation, and tricuspid valve annuloplasty with Contour 3D annuloplasty ring® (Medtronic, Minneapolis, MN). He was discharged with improved New York Heart Association (NYHA) class and mild TVL. Two years postoperatively, he presented with dyspnea after walking only 10 meters. His brain natriuretic peptide (BNP) level was 3500–5000 pg/mL. His electrocardiogram showed normal sinus rhythm. Echocardiography **(Figure 1a)**, right-heart catheter examination, and single photon emission computed tomography were performed preoperatively **(Table 1)**. Preoperative echocardiography showed moderate TVL through the bioprosthetic valve at the mitral position. TVL grade was mild, mild, mild-moderate, and moderate in just after MVR, 6 months after MVR, 1 year after MVR, and just before second MVR. The pressure gradient between the left ventricle and left atrium, which was considered the closing force of the bioprosthetic valve, was decreased from 81 to 58 mmHg, just after the first MVR and before the second MVR, respectively. The mean pressure gradient of the bioprosthetic valve was 3.6 and 3.8 mmHg just after first MVR and the second MVR, respectively. Therefore, we denied mitral bioprosthetic valve stenosis. Preoperative coronary angiography showed no significant stenosis. We considered the TVL to be relevant in this patient with low forward stroke volume (SV).

To eliminate moderate TVL, we performed re-do MVR with a mechanical valve. We also concomitantly performed our original procedure "papillary muscle tugging approximation" to improve the efficiency of forward stroke by directing the contraction of the papillary muscles toward the left ventricular outflow tract**. A mechanical valve was selected to minimize TVL and not to disturb the approximated papillary muscles and chordae tendineae. Detailed surgical procedures were as follows: The previous mitral bioprosthetic valve appeared to be grossly normal and there was not fibrin, clot, and the findings of interference of preserved chordae. The previous ligatures between the papillary muscles were loosened. The papillary muscles were approximated again with 4-0 Prolene and suspended toward the annulus of C1, A2, and C2 with three expanded polytetrafluoroethylene sutures (CV-4). Finally, re-do MVR was performed at the intra-annular position with a mechanical valve (27 mm; St Jude Medical, Minnesota, USA). According to the detailed examination by the manufacturer, there was no structural valvular deterioration in the explanted bioprosthetic valve. **Table 1** shows the preoperative and postoperative cardiac function data. LVEF, forward SV, and cardiac output and index increased postoperatively. TVL was mild (**Figure 1b**). Pulmonary arterial pressure (PAP) and pulmonary capillary wedge pressure decreased postoperatively. The patient was discharged on postoperative day 39 with NYHA class I. He continued to be with NYHA class I, and his BNP level was decreased to 1500 pg/mL at 6 months postoperatively.

Informed consent was obtained from the patient for the publication of this case report and accompanying images.

Discussion

We reported a case of re-do MVR with a mechanical valve to treat moderate TVL of a Magna Mitral valve® (Edwards Lifesciences LLC). We attributed the patient’s congestive heart failure to moderate TVL. In recent European guidelines, moderate regurgitation in ICM is considered severe in secondary mitral regurgitation given its poor prognosis [1]. Furthermore, his worsened TVL would have been caused by the decreased closing force of the prosthetic valve. This decreased left ventricular closing force would be due to the natural course of ICM or loosened sutures for papillary muscle approximation. Another mechanism would be change of flow direction. The large left atrium and ventricle would make the difference between the axis of the tissue valve and the direction of the intraventricular systolic flow. The difference might result in uneven pressure to each leaflet of the bioprosthesis, which may also potentially worsen TVL. For MVR in patients with critically low contractile function, we should not only consider the opening function but also the closing function of artificial valves.

Closing function of prosthetic valves

Although long-term durability and hemodynamic performance of bioprosthetic valves have been widely reported [4, 5], information about regurgitant flow (TVL) is limited. Regurgitant flow of bioprosthetic valves was reported in an in vitro study. Gerosa et al. reported that Carpentier-Edwards Magna® valve (Edwards Lifesciences LLC) had the largest total regurgitant volume in the five commercially available bioprosthetic valves (Sorin Soprano®, Carpentier-Edwards Magna®, SJM-Biocor-Epic-Supra®, Medtronic Mosaic®, and Mitroflow®). The regurgitant volume of the Magna® valve (Edwards Lifesciences LLC) in an aortic valve position did not change even in various cardiac outputs (12.64 mL/beat in cardiac output 2.0 L/min, diastolic pressure 80 mmHg) [7]. Dzemali et al. reported that the Magna® valve (Edwards Lifesciences LLC) at the aortic valve position demonstrated an increased diastolic energy loss compared with Medtronic Mosaic® valve (5.4±1.1% versus 2.2±0.6%) in a low-output situation due to the closing delay, which was associated with regurgitant flow [8]. They recommended porcine prosthesis than bovine valves in heart failure patients from the point of closing function. We agree with that the porcine valve is better than the bovine pericardial valve in patients with severely deteriorated cardiac function. We can also choose a porcine valve with low profile. Regurgitant flow of mechanical valves has been reported to be 4-9 mL including physiological flow for five commercially available valves in an in vitro study [9]. Therefore, Magna Mitral® (Edwards Lifesciences LLC) may have the risk of TVL in patients with critically low contractile function. Notably, mechanical valves have lower regurgitant flow than Magna® valves (Edwards Lifesciences LLC).

Opening function of prosthetic valves

Regarding the opening function of prosthetic valves, effective orifice area and pressure gradient have been reported [3-5]. Recently, preferable results have been reported for MVR with mechanical valves in patients with ICM [10], showing that MVR with mechanical valves was superior to MVR with bioprosthetic valves in terms of the 6-minute walk test and exercise stress echocardiographic parameters. They also reported 30% reduction in PAP during exercise and 50% reduction in cardiac-related hospitalization after MVR with mechanical valves compared with MVR with bioprosthetic valves. These results were attributed to larger effective orifice area in mechanical valves, which would prevent patient prosthesis mismatch [7, 9, 10]. In the present case, the larger effective orifice area with the mechanical valve may have influenced the increased forward SV.

Implications for additional subvalvular procedure to MVR

The strategy of mitral valve repair or MVR in patients with ischemic mitral valve regurgitation is not well established [11]. Chordal-sparing MVR has been reported to improve left ventricular function during exercise [12]. Yun et al. reported that complete retention of the subvalvular apparatus during MVR resulted in improved ejection performance and smaller chamber volumes due to reduced systolic wall stress compared with posterior chordal preservation alone [13]. Therefore, the chordal preservation could influence closing function after MVR. Goldstein et al. reported no significant difference in LV reverse remodeling or survival at 2 years between patients who underwent mitral valve repair and those who underwent MVR for severe ischemic mitral valve regurgitation [6]. Nonetheless, the rate of death at 2 years was still high (23.2%) even after complete chordal-sparing MVR. As an additional procedure to chordal-sparing MVR, we have recently developed "papillary muscle tugging approximation" concomitant with MVR for 14 patients with functional mitral regurgitation and severely dilated heart**. For this subvalvular procedure, mechanical valves with low profile would be more preferable to bioprosthetic valves. We are following the patients to examine the long-term clinical benefits of this new approach.

Conclusion

For patients with critically low contractile function, MVR with a mechanical valve would be recommended because of the advantages in opening and closing functions and possible additional subvalvular procedures.

Acknowledgements

We would like to thank Editage (*www.editage.jp*) for English language editing.

Disclosure statement

The authors have no conflicts of interest to declare.

References

****** Matsui Y, Shingu Y, Wakasa S, Ooka T, Kubota S. Papillary muscle tugging approximation for functional mitral regurgitation. Ann Thorac Surg. 2018 submitted.

1. Baumgartner H, Falk V, Bax JJ, et al. 2017 ESC/EACTS Guidelines for the management of valvular heart disease. Eur Heart J. 2017; 38: 2739-86.

2. Nishimura RA, Otto CM, Bonow RO, et al. 2017 AHA/ACC focused update of the AHA / ACC guideline for the management of patients with valvular heart disease. Circulation. 2017; 135: 1159-95

3. Banbury MK, Cosgrove DM, White JA, et al. Age and valve size effect on the long-term durability of the Carpentier-Edwards aortic pericardial bioprosthesis. Ann Thorac Surg. 2001; 72: 753–7.

4. Kuehnel R, Puchner R, Pohl A, et al. Characteristic resistance curves of aortic valve substitutes facilitate individualized decision for a particular type. Eur J Cardiothorac Surg. 2005; 27: 450–5.

5. M J Dalmau, J M Gonzalez-Santos, Lopez-Rodrguez MB, et al. The Carpentier-Edwards Perimount Magna aortic xenograft : a new design with an improved hemodynamic

performance. Interact Cardiocasc Thorac Surg. 2006; 5: 263–7.

6. Goldstein D, Moskowitz AJ, Gelijns AC, et al. Two-year outcomes of surgical treatment of severe ischemic mitral regurgitation. N Engl J Med. 2016; 374: 344–53.

7. Gerosa G, Tarzia V, Rizzoli G, et al. Small aortic annulus: the hydrodynamic performances of 5 commercially available tissue valves. J Thorac Cardiovasc Surg. 2006; 131: 1058-64.

8. Dzemali O, Bakhtiary F, Steinseiffer U, et al. Hemodynamic performance of fresh and calcified aortic valve prostheses in critical low stroke volume. J Heart Valv Dis. 2008; 17: 317-24

9. Bottio T, Caprili L, Casarotto D, et al. Small aortic annulus: The hydrodynamic performances of 5 commercially available bileaflet mechanical valves. J Thorac Cardiovasc Surg. 2004;128:457–62.

10. Fino C, Iacovoni A, Pibarot P, et al. Exercise hemodynamic and functional capacity after mitral valve replacement in patients with ischemic mitral regurgitation. Circ Hear Fail. 2018; 11: e004056. doi: 10.1161/CIRCHEARTFAILURE.117.004056

11. Acker MA, Adams DH, Ailawadi G, et al. 2016 update to The American Association for

Thoracic Surgery consensus guidelines : Ischemic mitral valve regurgitation. J Thorac Cardiovasc Surg. 2017; 153: 1076–9.

12. T E David, R J Burns, C M Bacchus. Mirel valve replacement for mitral regurgitation with and without preservation of chordae tendineae. J Thorac Cardiovasc Surg. 1984; 88: 718–25.

13. Yun KL, Sintek CF, Miller DC, et al. Randomized trial of partial versus complete chordal preservation methods of mitral valve replacement. A preliminary report.Circulation. 1999; 100: 90–4.

Figure legends

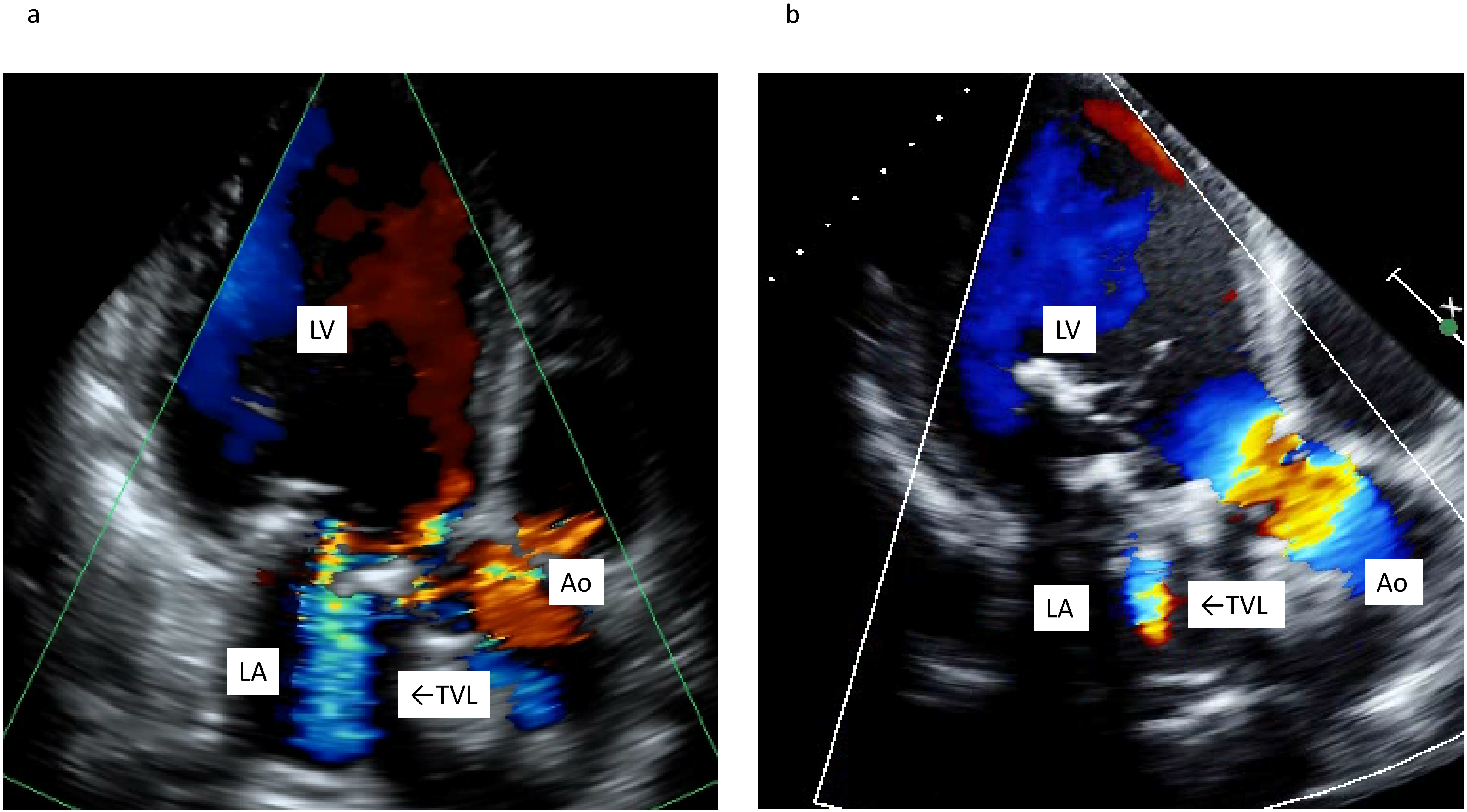
Figure 1. a) Preoperative apical long axis view showing moderate transvalvular leakage (TVL) through the bioprosthetic valve. Bioprosthetic valve was slightly tilted to the ventricular septum. b) Postoperative apical long axis view showing mild TVL through the mechanical valve.

Table 1. Pre- and postoperative parameters of cardiac function in first and second MVR

	Preoperative data of first MVR	Postoperative data of first MVR	Preoperative data of second MVR	Postoperative data of second MVR
Echocardiogram				
LVDd, mm	76	71	86	85
LVds, mm	69	67	83	82
LVEF, %	28	19	12	15
Forward SV, mL	59	59	32	42
Mitral regurgitation grade	Severe	mild	Moderate	Mild
Right heart catheter	None	None		
RAP, mmHg			18	11
PAP, mmHg, s/d/m			50/35/40	37/22/27
PCWP, mmHg			36	17
PVR, wood			1.5	2.5
CO, L/min			2.65	3.98
CI, L/min/m^2			1.65	2.47
SPECT	None	None		
EDV, mL			641	476

ESV, mL	602	411
LVEF, %	6	14

CI: cardiac index; CO: cardiac output; LVDd/s: end-diastolic/end-systolic left ventricular dimension; LVEF: left ventricular ejection fraction; PAP: pulmonary artery pressure; PCWP: pulmonary capillary wedge pressure; PVR: pulmonary vascular resistance, RAP: right atrium pressure; SPECT: single photon emission computed tomography; SV: stroke volume; ESV: end-systolic volume; EDV: end-diastolic volume


a
LV
Ao
LA
←TVL
b
LV
Ao
LA
←TVL