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CASE REPORT
Heart failure

Percutaneous mitral valve edge-to-edge repair for late systolic anterior motion after surgical mitral valve repair: a case report

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Background Late post-operative systolic anterior motion (SAM) is a rare but challenging issue. The feasibility of percutaneous mitral valve edge-to-edge repair (PMVR) using the MitraClip to treat late refractory SAM after surgical mitral valve repair has rarely been reported in the literature.

Case summary An 88-year-old woman with a history of mitral valve repair for a P2 prolapse 14 years before, presented with signs of congestive heart failure. Transoesophageal echocardiogram (TOE) demonstrated significant SAM of the anterior mitral leaflet, resulting in the detachment from the posterior mitral leaflet in mid-to-late systole and severe mitral regurgitation (MR). The heart team decided to perform PMVR using the MitraClip to simultaneously address the issues of SAM and MR, considering the patient's high surgical risk. TOE after the clip deployment at the medial edge of the mitral valve, where the most severe SAM was detected, confirmed resolution of SAM with marked reduction of MR. The patient was discharged home with good haemodynamic compensation.

Discussion Post-operative SAM typically occurs immediately after the reparative surgery and resolves with conservative treatment; however, persistent SAM requiring repeat surgery remains a serious concern. As an alternative strategy, the MitraClip has some advantages, including low procedural risk, immediately observable results, and the ability to relocate the clip. Meanwhile, the greater risk of post-procedural mitral stenosis, particularly in patients undergoing mitral repair, should be taken into account. In our case, the clip deployment at the medial edge of the valve could minimize the progression of mitral stenosis with a satisfactory reduction of MR.

Keywords Mitral regurgitation • Post-operative • Echocardiography • Left ventricular outflow tract obstruction • Case report

Learning points

- Post-mitral valve repair systolic anterior motion (SAM) typically occurs immediately after the surgery, whereas it can be discovered postoperatively after years.
- Temporal changes of the angle between the inflow and outflow of the left ventricle might be a cause for late post-mitral valve repair SAM by locating the leaflets coaptation point towards the left ventricular outflow tract.
- In patients with severe mitral regurgitation due to significant SAM after mitral repair, percutaneous mitral valve edge-to-edge repair with the MitraClip can be a possible alternative to redo mitral valve surgery.

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Introduction

Percutaneous mitral valve edge-to-edge repair (PMVR) with the MitraClip (Abbott Vascular, Abbott Park, IL, USA) is an established alternative to surgical mitral valve repair in patients with high and prohibitive surgical risk.[1,2] Recently, the feasibility of PMVR to treat systolic anterior motion (SAM) of the anterior mitral leaflet (AML) and secondary mitral regurgitation (MR) in hypertrophic obstructed cardiomyopathy was reported.[3,4] The authors surgically shifted a redundant AML edge away from the left ventricular outflow tract (LVOT) by combining it with the posterior mitral leaflet (PML). However, there are few reports on the PMVR procedure in patients with significant SAM following mitral valve repair.

Timeline

14 years prior	The patient underwent mitral valve repair for a P2 prolapse (quadrangular resection and annuloplasty witd a 28-mm flexible band)
12 years prior	Transthoracic echocardiogram (TTE) showed normal left ventricular function with mild systolic anterior motion (SAM) and mild mitral regurgitation (MR)
Re-admission	The patient presented with signs of congestive heart failure. TTE revealed normal left ventricular function with significant SAM resulting in left ventricular outflow tract obstruction and severe MR
Day 6	Transoesophageal echocardiogram (TOE) demonstrated significant SAM of the anterior mitral leaflet, resulting in the detachment from the posterior mitral leaflet in mid-to-late systole with severe MR
Days 7–15	Exhaustive medical therapies were tried but intolerant or ineffective; therefore, an invasive treatment was considered necessary
Day 16	Percutaneous mitral valve edge-to-edge repair was successfully performed. TOE confirmed displacement of the leaflets' coaptation point towards the left ventricular inflow with resolution of SAM and marked reduction of MR
Day 24	The patient was discharged home after an uneventful recovery with good haemodynamic compensation
1 year later	The patient had no cardiovascular symptoms. Follow-up TTE showed no SAM and mild MR

Case presentation

An 88-year-old woman with a history of mitral valve repair for a P2 prolapse (quadrangular resection and annuloplasty with a 28-mm flexible band) 14 years before, paroxysmal atrial fibrillation, and pacemaker implantation for atrioventricular block presented to our institution with dyspnoea upon minimal exertion. Her medications included bisoprolol 1.25 mg once daily and Warfarin titrated to an international normalized ratio target of 2–3. Upon arrival, she was afebrile with a blood pressure of 93/60 mmHg, heart rate of 76 beats/min, and oxygen saturation of 90% on room air. Physical examination revealed jugular venous distension, coarse crackling in both lungs, and a Levine IV/VI systolic murmur radiating to the apex. The electrocardiogram demonstrated sinus rhythm with evidence of left atrial enlargement. Laboratory test results were normal except for a B-type natriuretic peptide level of 810.2 pg/mL (<18.4 pg/mL) and creatinine level of 1.65 mg/dL (<1.03 mg/dL). A chest radiograph revealed pulmonary congestion with an increased cardiothoracic ratio of 64%. Post-operative transthoracic echocardiogram (TTE) conducted 2 years following the original mitral surgery had shown normal left ventricular function (ejection fraction 58.9%) with mild SAM and mild MR (*Figure 1A and B*), while resting TTE on the current admission revealed somewhat hyperkinetic left ventricle (ejection fraction 66.2%) with significant SAM resulting in LVOT obstruction and severe MR (*Figure 1C and D*). Although left ventricle was not hypertrophic with the posterior wall thickness of 8.7 mm and the intraventricular septal thickness of 9.0 mm, intraventricular septum bulging (the sigmoid septum) with narrow aorto-mitral angle was observed. The peak velocity of LVOT could not be precisely measured owing to the wide MR jet but was estimated to be ∼5 m/s. A dilated left atrium with a diameter of 50.2 mm was detected. A transoesophageal echocardiogram (TOE) demonstrated significant SAM of the AML, resulting in the detachment from the PML in mid-to-late systole with severe MR (regurgitant volume of 83 mL and effective regurgitant orifice area of 0.47 cm^2) (*Figure 2A and B* and *Videos 1 and 2*). In particular, the medial portion of the AML was severely affected (*Figure 2C and D*), where the peak velocity of LVOT of 5.4 m/s was detected (*Figure 2E*). The mean transmitral pressure gradient (TMPG) was 5.0 mmHg at a heart rate of 60 beats/min (*Figure 2F*), and the three-dimensional mitral valve area (MVA) was 2.36 cm^2. Mild degenerative changes of mitral leaflets were detected with an AML length of 25.1 mm and a PML length of 11.2 mm. Aortic valve also presented mild degenerative changes with no more than mild to moderate regurgitation (vena contracta 4.7 mm) but without valvular or subvalvular stenosis.

The patient experienced heart failure attributable to severe MR due to significant SAM following mitral valve repair, without echocardiographic evidence of left ventricular hypertrophy. Increased dosage of bisoprolol to 2.5 mg per day and initiation of verapamil of 80 mg per day was tried but intolerant because of symptomatic hypotension without changes in SAM and severe MR. Disopyramide was avoided due to the multiple factors including a history of chronic kidney disease and glaucoma. Fluid administration and right ventricular pacing also had only limited effects. Therefore, an invasive treatment was considered necessary. The heart team dismissed the option of a second mitral valve surgery because of advanced age and high surgical risk (Society of Thoracic Surgeons Predicted Risk of Mortality of 12.015%). Instead, we opted to perform PMVR using the MitraClip to simultaneously address the issues of SAM and concomitant MR.

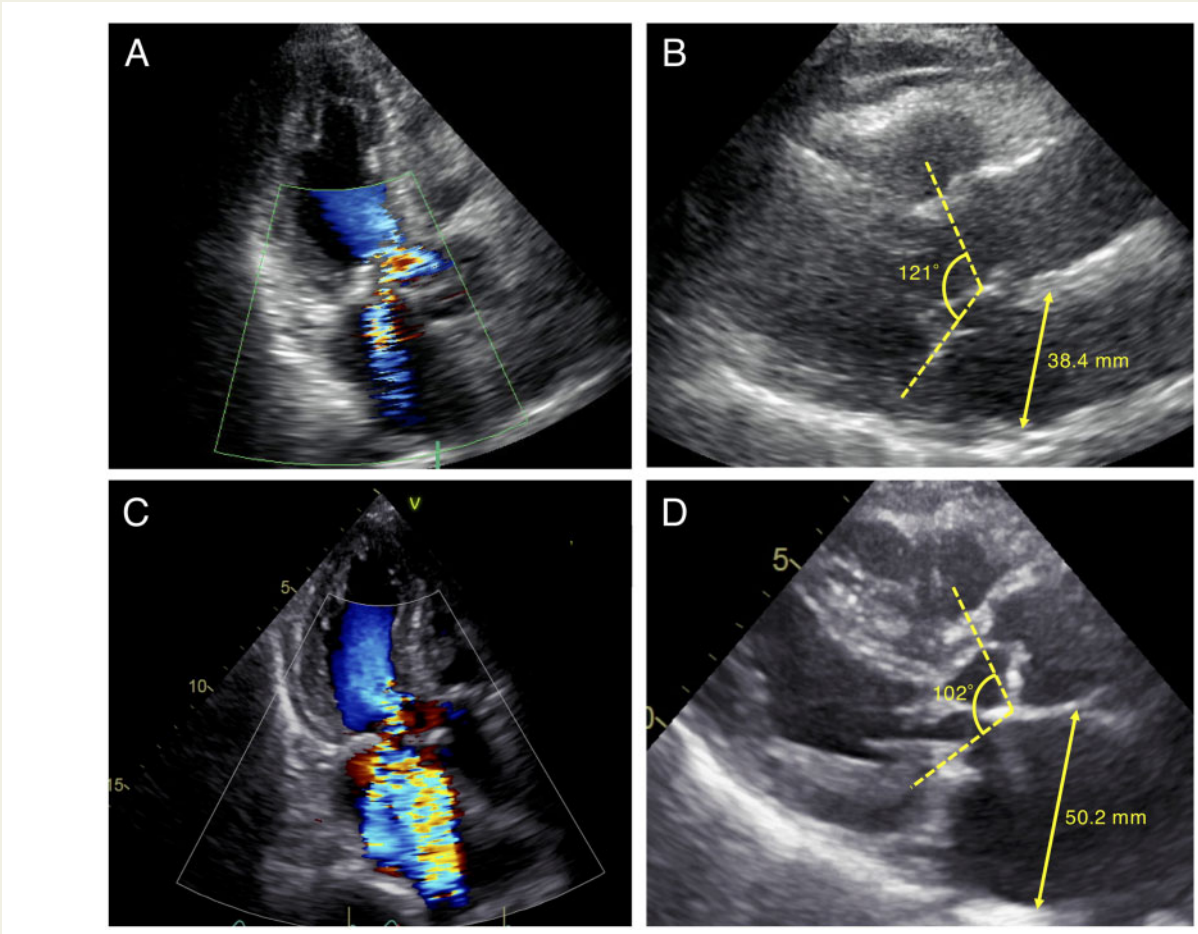


Figure 1 Transthoracic echocardiogram 12 years before the current admission showing mild systolic anterior motion with mild mitral regurgitation (*A*), and an aorto-mitral angle of 121° with left atrial diameter of 38.4 mm and indexed left atrial volume of 41.3 mL/m^2 (*B*). Transthoracic echocardiogram on admission showing the development of intraventricular septum bulging (the sigmoid septum) with narrow aorto-mitral angle, resulting in significant systolic anterior motion and severe mitral regurgitation (*C*), and an aorto-mitral angle of 102° with left atrial diameter of 50.2 mm and indexed left atrial volume of 88.2 mL/m^2 (*D*).

Under general anaesthesia and with TOE guidance, PMVR was performed on Day 16. After ineffective attempts to place the clip near the central portion of the mitral valve with an increased TMPG to 8 or 9 mmHg, we deployed a single NTR clip definitely at the medial edge of the mitral valve where the most severe SAM was detected. TOE confirmed displacement of the leaflets' coaptation point towards the left ventricular inflow with resolution of SAM. As a result, MR decreased from severe to mild (regurgitant volume of 16 mL and effective regurgitant orifice area of 0.09 cm^2) (*Figure 3A–D*, *Video 3*, and Supplementary material online, *Video S1*) and the peak velocity of LVOT also decreased to 1.7 m/s (*Figure 3E*). The post-procedural TMPG of 5.1 mmHg at a heart rate of 60 beats/min and three-dimensional MVA of 1.37 cm^2, which indicated moderate mitral stenosis, was considered acceptable (*Figure 3F*). Haemodynamic parameters improved immediately following the clip deployment. Invasive blood pressure increased from 79/37 to 117/40 mmHg, and mean left atrial pressure decreased from 21 to 14 mmHg (*Figure 4*). Pre- and post-procedural right heart catheterization showed an increase of cardiac index from 1.7 to 2.4 mL/min/m^2 with no significant change of mean right atrial pressure (pre 12 mmHg, post 11 mmHg).

The patient's post-operative course was uneventful, and she was discharged home 8 days after PMVR with good haemodynamic compensation. TTE at discharge showed normal left ventricular ejection fraction of 59.2% with no SAM, mild MR, and moderate mitral stenosis (TMPG 6.0 mmHg, MVA 1.50 cm^2). At the 1-month, 6-month, and 1-year follow-ups, she had no cardiovascular symptoms and showed improvements in walking distance on a 6-min walk test. The 1-year follow-up TTE showed the lasting therapeutic effects with no SAM, mild MR, and moderate mitral stenosis (TMPG 6.1 mmHg, MVA 1.68 cm^2).

Discussion

SAM following surgical mitral valve repair for degenerative MR is a well-known post-operative complication that occurs in 7–11% of

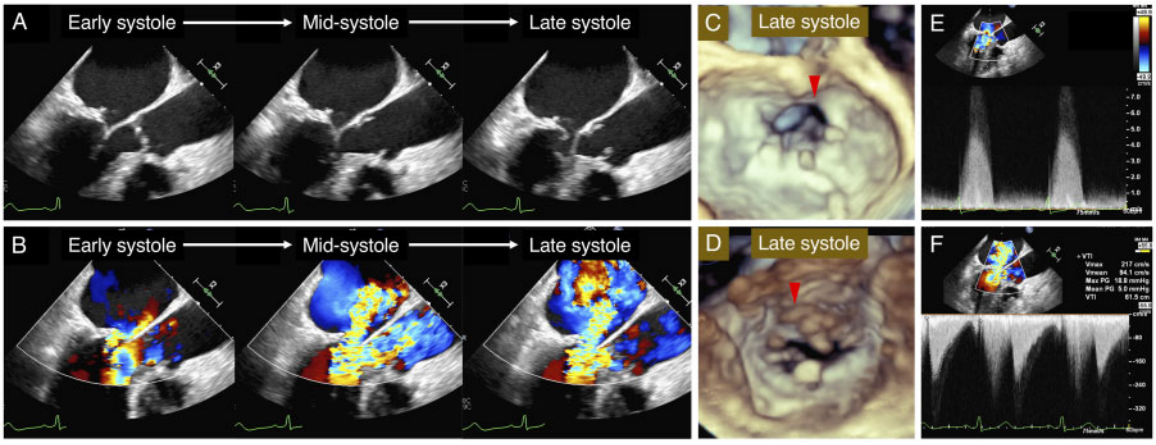
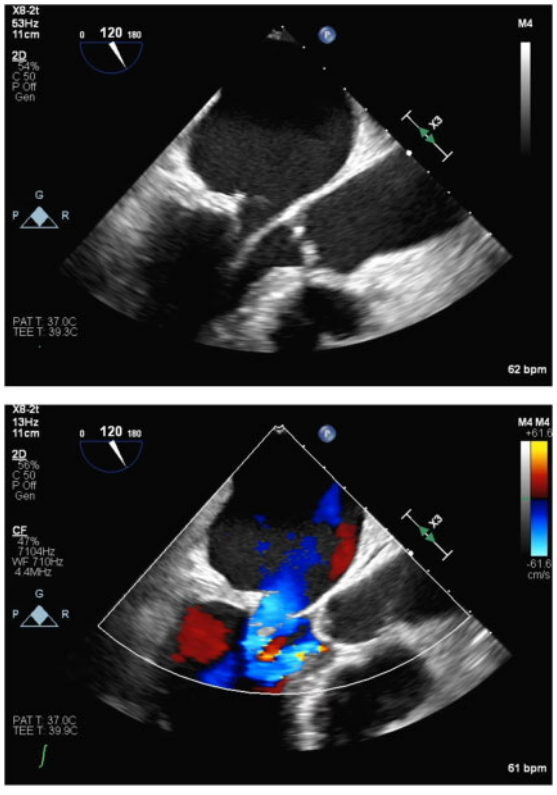


Figure 2 Pre-MitraClip transoesophageal echocardiographic images demonstrated significant systolic anterior motion of the anterior mitral leaflet with the detachment from the posterior mitral leaflet in mid-to-late systole (*A*) and severe mitral regurgitation (*B*). Three-dimensional mitral valve viewed from the left atrium (*C*) and left ventricle (*D*) in late systole showing that the medial portion of the valve was severely affected (arrowheads). A continuous wave Doppler trace through the left ventricular outflow tract showing the peak velocity of left ventricular outflow tract of 5.4 m/s (*E*). A continuous wave Doppler trace through the mitral valve showing the transmitral pressure gradient of 5.0 mmHg (*F*).



Videos 1 and 2. Pre-MitraClip transoesophageal echocardiogram showing significant systolic anterior motion of the anterior mitral leaflet with the detachment from the posterior mitral leaflet inducing severe mitral regurgitation in mid-to-late systole.

patients.[5,6] SAM typically occurs immediately after the reparative surgery and resolves with conservative treatment. The late clinical outcome of patients with transient SAM has been found to be satisfactory with conservative measures;[7,8] however, persistent SAM with LVOT obstruction requiring repeat surgery remains a serious concern. In general, the predictors of early post-operative SAM were reported to be excessive leaflet tissue with a tall posterior leaflet (>15 mm), ratio between the heights of the AML and PML ≤1.3, aorto-mitral angle <120°, short distance between the intraventricular septum and the mitral leaflet coaptation point (<15 mm), small and hyperkinetic left ventricle and anterior displacement of the papillary muscles and procedure-related factors like inadequate reduction of the PML height remaining >15 mm, and insertion of a small prosthetic ring.[9,10] Although late post-operative SAM refractory to medical therapy has rarely been reported in the literature, temporal changes of cardiac structure after the mitral repair, including regrowth of AML and thickening of papillary muscles, have been proposed as possible causes.[11,12] Moreover, hypovolemic or hyperdynamic state can contribute to dynamic LVOT obstruction with late post-operative SAM. However, in the present case of significant SAM with severe MR, which manifested 14 years following mitral valve repair, there was no evidence of those cardiac structural changes, and the patient presented with not hypovolemic but rather hypervolemic state due to heart failure. A review of the patient's serial TTE images elucidated the development of sigmoid septum with narrowing of the aorto-mitral angle to 102° due to the ageing process (*Figure 1B and D*), which might have mainly induced the patient's late post-operative SAM by the Venturi effect. In addition, although there was no evidence of hyperdynamic state including anaemia, fever, and hyperthyroidism, deterioration of MR was likely to enhance left ventricular hyperkinetic motion, leading to a vicious circle that progressively exacerbated SAM, LVOT obstruction, and MR.

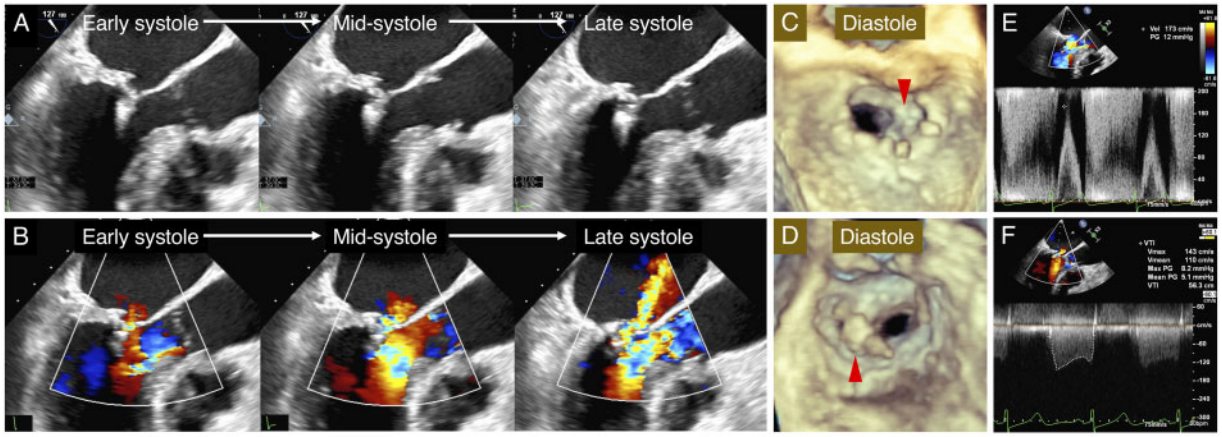
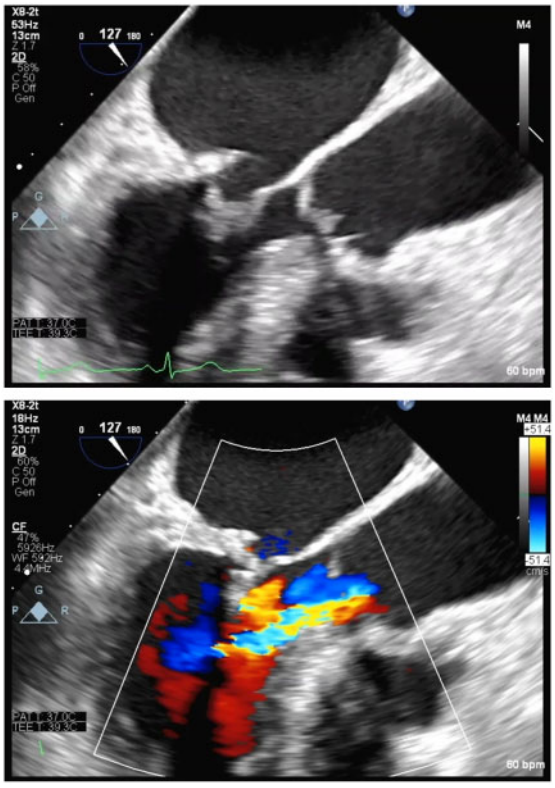


Figure 3 Post-MitraClip transoesophageal echocardiographic images demonstrated displacement of the leaflets' coaptation point towards the left ventricular inflow with resolution of systolic anterior motion (*A*) and decreased mitral regurgitation to mild (*B*). Three-dimensional mitral valve viewed from the left atrium (*C*) and left ventricle (*D*) in diastole showing a single NTR (arrowheads) deployed at the medial portion. A pulse wave Doppler trace through the left ventricular outflow tract showing the decreased peak velocity of left ventricular outflow tract to 1.7 m/s (*E*). A continuous wave Doppler trace through the mitral valve showing the slightly increased transmitral pressure gradient to 5.1 mmHg (*F*).



Videos 3 and S1. Post-MitraClip transoesophageal echocardiogram showing displacement of the leaflets' coaptation point towards the left ventricular inflow with resolution of systolic anterior motion and decreased mitral regurgitation to mild.

The surgical edge-to-edge technique (Alfieri's stitch) has been shown to be feasible for eliminating post-operative SAM,[6,13] while re-operation carries significant risks for mortality and morbidity. As an alternative strategy, PMVR using the MitraClip has some advantages, including low procedural risk, immediately observable results, and the ability to relocate the clip. Meanwhile, the greater risk of post-MitraClip mitral stenosis, particularly in patients undergoing reparative surgery, should be taken into account. In the present case, considering the patient's high surgical risk, we decided to perform PMVR using the MitraClip for SAM refractory to pharmacotherapy, fluid retention, and right ventricular pacing. Although MVA was relatively small prior to the procedure, the clip deployment at the medial edge of the valve could minimize the progression of mitral stenosis. We also believe that the dramatic decrease of MR would reduce a left atrial pressure and transmitral flow, resulting in slightly increased TMPG of 5.1 mmHg despite of moderately decreased MVA of 1.38 cm^2. These data indicated moderate mitral stenosis and were considered to be clinically insignificant in the context of torrential MR and LVOT obstruction at baseline. However, if PMVR with MitraClip system for the patient had not achieved a sufficient reduction of MR or induced significant mitral stenosis, we would have had to perform a redo mitral surgery. The use of a bigger ring or band would have been not possible, which means that a mitral valve replacement would have been selected as a bail-out strategy, albeit with high risk for mortality and morbidity.

Patient perspective

Our patient was satisfied with the relief of symptoms after percutaneous edge-to-edge mitral valve repair.

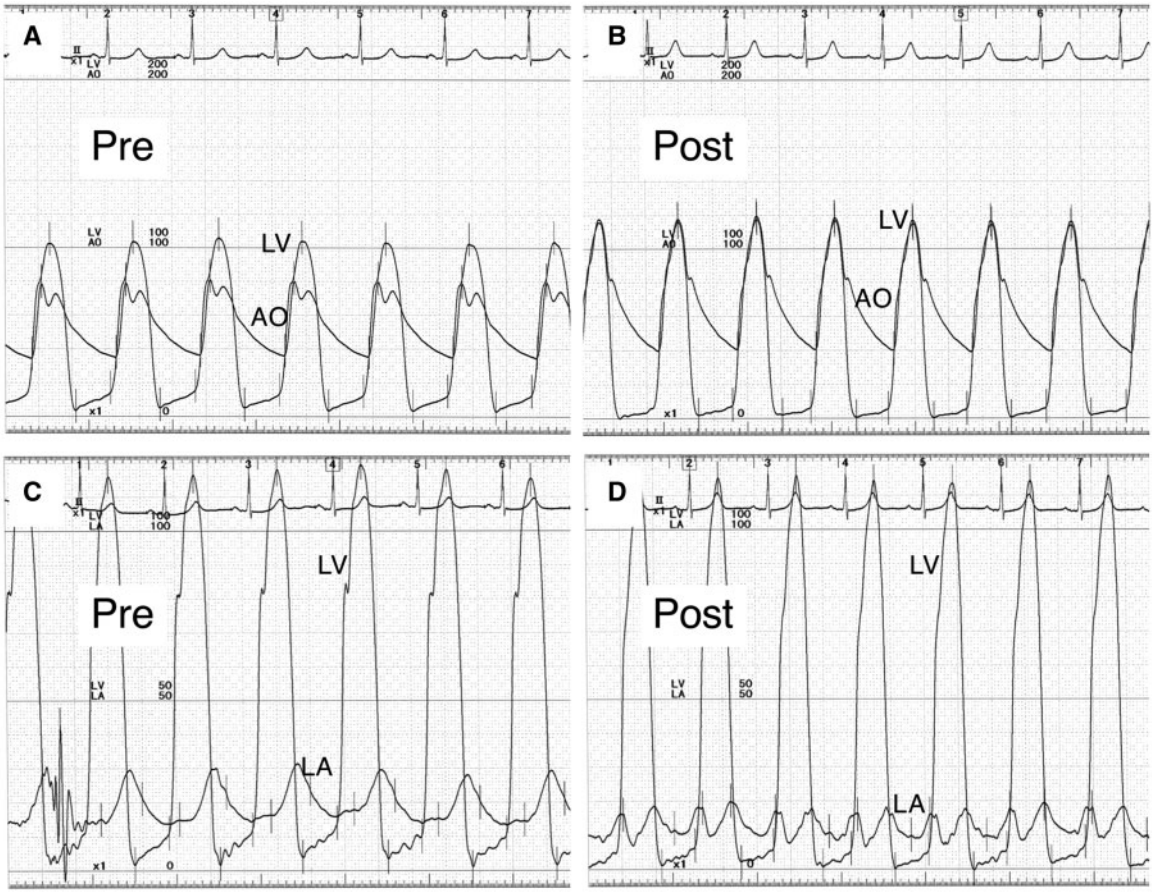


Figure 4 Pre- and post-MitraClip haemodynamic assessment by cardiac catheterization. Left ventricular and aortic pressure tracings showing post-MitraClip disappearance of pressure gradient (*A* and *B*). Left atrial pressure tracings showing decreased mean pressure with smaller v wave after the MitraClip (*C* and *D*). AO, aorta; LA, left atrium; LV, left ventricle.

Lead author biography

Kenichi Ishizu graduated from Kyoto University and started his career in Kobe City Medical Center General Hospital, Kobe, Japan. Currently, he is an interventional cardiologist in the Department of Cardiology, Kokura Memorial Hospital, Kitakyushu, Japan.

Supplementary material

Supplementary material is available at *European Heart Journal - Case Reports* online.

Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: The authors confirm that written consent for submission and publication of this case report including images and associated text has been obtained from the patient in line with COPE guidance.

Conflict of interest: None declared.

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