

Robotic mitral valve repair for rheumatic mitral stenosis and regurgitation: a case report

Shin Yajima , Satsuki Fukushima , Takashi Kakuta, and Tomoyuki Fujita*

Department of Cardiovascular Surgery, National Cerebral and Cardiovascular Center, 5-7-1, Fujishirodai, Suita, Osaka 565-8565, Japan

Received 17 June 2019; first decision 17 July 2019; accepted 19 December 2019; online publish-ahead-of-print 7 February 2020

Background

Rheumatic mitral valve (MV) disease is the major cause of congestive cardiac failure in children and young adults, particularly in developing countries. Mitral valve repair with minimum prosthetic material is the gold standard treatment for this condition. However, MV repair for rheumatic MV disease is known to be technically demanding.

Case summary

A 27-year-old woman without a history of cardiac disease presented with dyspnoea on exertion. Echocardiography revealed rheumatic severe mitral stenosis and regurgitation, with thickening of the bileaflets, doming of the anterior leaflet, shortening of the posterior leaflet, fusions of the lateral and particularly the medial commissure, and enlargement of the mitral annulus. We successfully performed robot-assisted MV repair with bicommissural release, patch augmentation of the two leaflets, and implantation of an originally sized partial band.

Discussion

Robotic MV repair can contribute to precise valve inspection and operative procedures. This approach seems feasible for complex rheumatic MV disease particularly in young patients.

Keywords

Mitral valve repair • Rheumatic heart disease • Rheumatic mitral stenosis • Rheumatic mitral regurgitation • Robotic surgery • Robotic mitral valve repair • Case report

Learning points

- Commissural release should be extended adequately along the annulus to obtain a sufficient mitral orifice. More importantly, anterior autologous pericardial patch should be sutured to the native anterior annulus and the native anterior leaflet apart from the commissure edge to prevent post-operative mitral stenosis.
- A robot-assisted operation provides the precise movements of instruments and high-definition three-dimensional visualization with a line of vision parallel to the mitral valve (MV), closer than that provided by the conventional minimally invasive technique.
- Robotic MV repair can contribute to precise valve inspection and technical accuracy, which is feasible for complex rheumatic mitral disease, especially in cases of young or female patients who strongly desire cosmetically pleasing results.

* Corresponding author. Tel: +81 6 6170 1070, Email: tfujita@ncvc.go.jp

Handling Editor: Alexander Ghanem

Peer-reviewers: Cemil Izgi, Nikolaos Bonaros, Marcelo Haertel Miglioranza, and Laszlo Gobolos

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Supplementary Material Editor: Peysh A. Patel

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Introduction

Rheumatic mitral valve (MV) disease remains common, particularly in developing countries, where its prevalence is underestimated by clinical examination and is estimated at 2–3%.¹ Mitral valve replacement using a prosthetic valve is the standard treatment for this condition because rheumatic valve repair is often associated with high failure and reoperation rates.^{2,3} However, for young female patients with rheumatic MV disease, MV replacement using mechanical prosthesis is not a favourable option, as repeat MV replacement is required after biological valve replacement; above all, being on anticoagulants and planning to become pregnant and being pregnant makes the pregnancy high risk for the foetus and mother. Therefore, MV repair with minimum prosthetic material should be ideal; however, MV repair for rheumatic MV disease is challenging.

This article reports the case of a young woman with severe rheumatic MV disease, who was successfully treated with robot-assisted MV repair that included bicommissural release, bileaflet autologous pericardial patch augmentation, and prosthetic partial band placement, via a mini-right thoracotomy.

Timeline

Time	Events
2016	Heart murmur was first noted during a medical check-up.
6 September 2018	Dyspnoea on exertion was noted. Severe mitral stenosis and regurgitation with rheumatic changes were diagnosed via echocardiography.
8 April 2019	Referral to our hospital for minimally invasive surgery.
10 April 2019	Robotic mitral valve repair was performed.
15 April 2019	Post-operative echocardiography revealed no residual mitral regurgitation and mild mitral stenosis with a mean pressure of 7 mmHg.
17 April 2019	Discharged.

Case presentation

A 27-year-old woman with no significant medical history, presented with progressive exertional dyspnoea related to congestive cardiac failure. On cardiovascular examination, a pansystolic murmur and diastolic cardiac murmur with a point maximal impulse at 5th left intercostal space in midclavicular line were noted. Chest radiography showed cardiomegaly and pulmonary congestion with a cardiothoracic ratio of 53%. An electrocardiogram demonstrated a sinus rhythm. Transthoracic and transoesophageal echocardiography revealed severe mitral stenosis and regurgitation, with typical rheumatic changes, such as doming of the anterior leaflet (Figure 1A), shortening of the posterior leaflet, thickening of the bileaflets (Figure 1B),

fusion of the lateral and particularly the medial commissures, and an enlarged annulus. Mitral regurgitation was mainly caused by bileaflet coaptation error (Figure 1C). The MV area and mean transmitral pressure gradient were 1.18 cm² (normal range > 2 cm²) and 17.1 mmHg (normal range < 5 mmHg), respectively, assessed using the pressure half-time method (Figure 1D). The size of the anterior and posterior leaflets at the lateral, middle, and medial positions were 24.6/17.5 mm, 25.6/15.2 mm, and 25.0/17.1 mm, respectively. The annulus diameter at the middle portion was 40 mm. The left atrium was severely dilated with an index of left atrial volume of 150 mL/m² (normal range < 34 mL/m²), without thrombus. The left ventricular diastolic/systolic dimension and ejection fraction were 37/30 mm and 63%, respectively. The tricuspid regurgitation was trivial, with a pressure gradient of 44 mmHg (normal range < 25 mmHg).

The patient requested a minimally invasive approach without sternotomy for cosmetic reasons, and valve repair without the need for warfarin for fertility reasons. We therefore opted for robot-assisted MV repair using the da Vinci surgical system (Intuitive Surgical Inc., Sunnyvale, CA, USA), as she was eligible to undergo the minimally invasive approach in view of having normal healthy great arteries and adequate anterior mediastinal space, as assessed using systemic enhanced computed tomography.

The MV showed typical chronic rheumatic disease features, such as well-thickened and shortened valve leaflet tissue and commissural fusion (Figure 2), but fibrosis or fusion of the subvalvular apparatus was non-substantial. Moreover, calcium deposits were absent in the leaflets or commissures. Both leaflets were pliable. Fusions of the bilateral commissures were released, extending to the annulus (Figure 3A). The incision was then extended along the annulus to detach the anterior leaflet from the annulus. The posterior leaflet was also detached from the annulus, keeping the commissural connection intact (Figure 3B). An oval-shaped 0.6% of the glutaraldehyde-treated autologous pericardial patch (2 × 4 cm) was sutured to the native anterior annulus, and then to the native anterior leaflet approximately 7–8 mm apart from the commissure edge to obtain a generous mitral orifice. Another oval-shaped glutaraldehyde-treated autologous pericardial patch (1.5 × 3 cm) was sutured to the native posterior leaflet and the posterior annulus sequentially to fill the defect (Figure 3C). Subsequently, a Tailor band (St. Jude Medical, St Paul, MN, USA) sized to 29 mm, which was determined by reference to the inter-trigone distance, was fixed to the posterior annulus by running sutures (Figures 3D and 4). Since the water test showed a competent MV, the left atrial incision was approximated and the cross-clamp was released after a de-airing manoeuvre. All incision and suturing of the autologous patch and atrial closure were completed with the da Vinci system. The console, cardiac arrest, cardiopulmonary bypass, and operation times were 150, 161, 230, and 335 min, respectively. Blood products were not administered perioperatively.

Transoesophageal echocardiography prior to chest closure showed a competent MV with a sufficient mitral orifice, without systolic anterior motion. Transthoracic echocardiography at 5 days post-surgery showed absent regurgitation (Figure 5A), extended mitral both leaflets (Figure 5B), and a mean mitral gradient of 7 mmHg (Figure 5C). The patient was discharged on post-operative day 7. Currently, although moderate mitral stenosis is present, her New York Heart Association class is currently grade I with administration

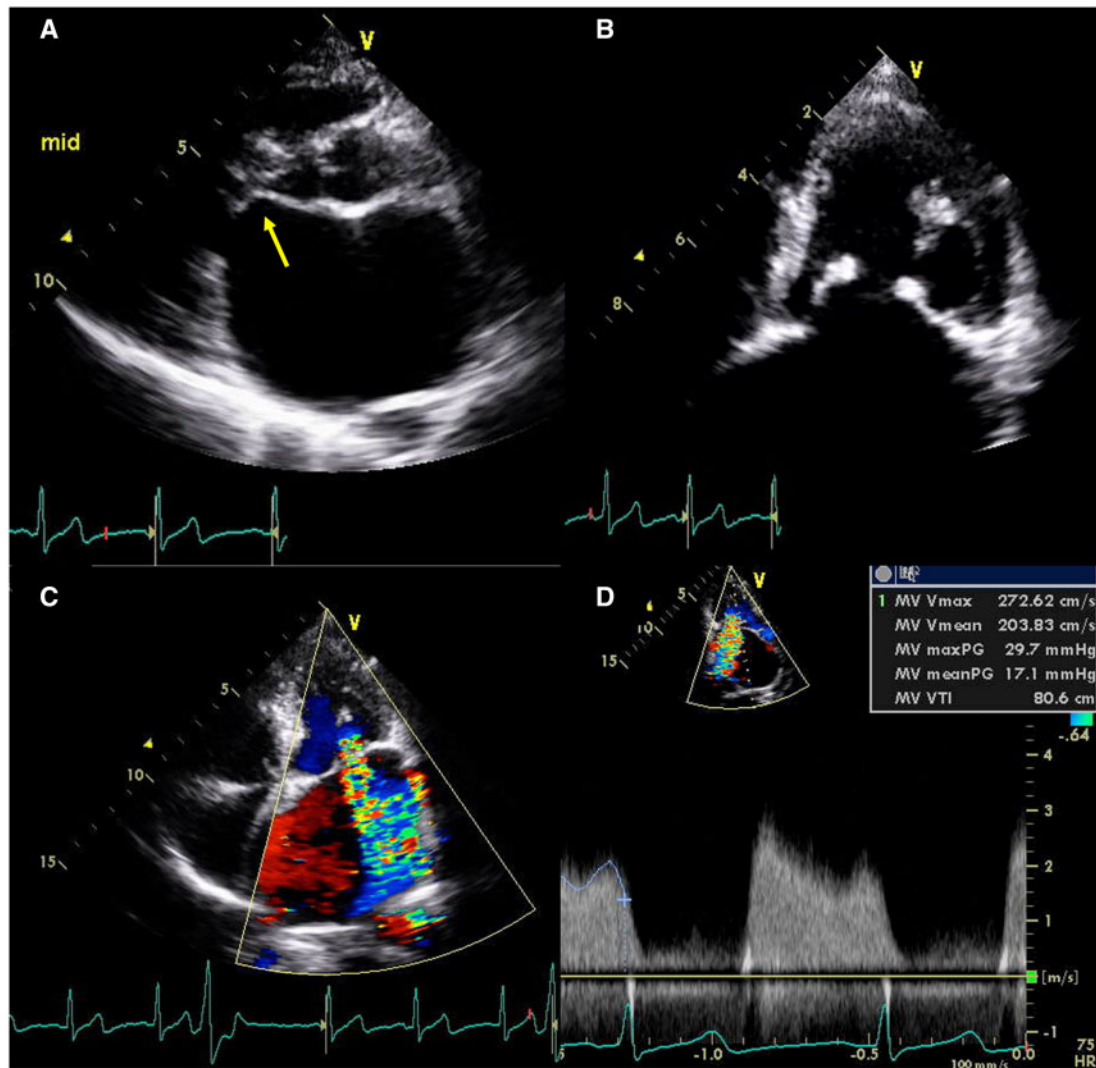


Figure 1 Preoperative transthoracic echocardiography demonstrated (A) doming of the anterior leaflet (yellow arrow), (B) thickening of the bileaflets, (C) severe mitral regurgitation due to coaptation error. (D) Three-dimensional image of the mitral valve assessed by transoesophageal echocardiography.

of neither diuretics nor other medications; complete resolution of cardiac symptoms was seen in the 4th post-operative month.

Discussion

Mitral valve repair for chronic rheumatic disease is challenging depending on the degree of structural change in the leaflets and subvalvular apparatus. Stenosis is caused by commissural fusion and/or restricted leaflet motion. In the present case, the mitral stenosis was primarily caused by bilateral commissural fusion with relatively pliable leaflets without calcium deposits. Bilateral commissural release to the annulus was therefore effective in relieving the mitral stenosis. Mitral regurgitation in rheumatic disease is generally caused by leaflet shortening, producing shallow coaptation, and by leaflet thickening with

calcium deposition, leading to unbalanced coaptation. In the present case, both leaflets were homogeneously thickened and shortened causing a central regurgitation jet. The bilateral leaflet augmentation therefore produced a balanced and deep coaptation to create a competent valve. To prevent post-operative mitral stenosis, commissural cutting was extended sufficiently near the annulus to release the fusions, and the anterior leaflet was attached to the anterior pericardial patch leaving the commissural part free. This technique could prevent immediate and late mitral stenosis following patch augmentation. Slicing the leaflet to enhance pliability is considered effective for rheumatic MV repair; however, in the present case, the leaflets appeared sufficiently pliable, therefore, slicing seemed unnecessary.

Mitral valve replacement using a tissue valve might be a good option. Although tissue valves have good long-term results with

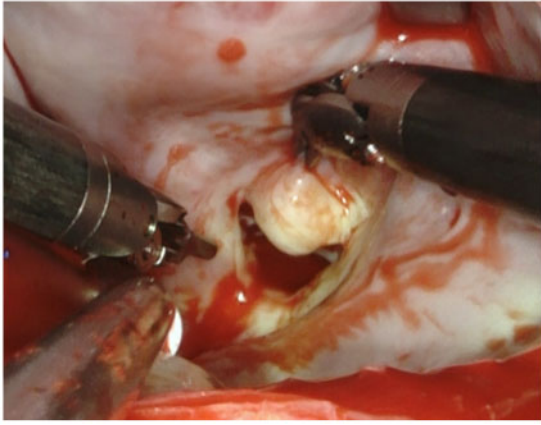


Figure 2 Intraoperative findings demonstrated thickened mitral leaflets, commissural fusions, and shortening of the posterior leaflet.

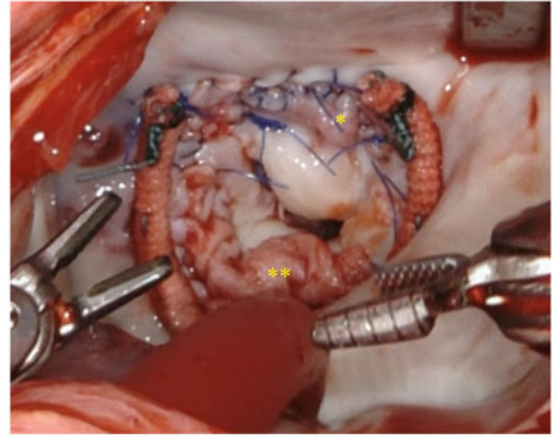


Figure 4 An intraoperative image after the mitral valve repair (*anterior autologous pericardial patch; **posterior autologous pericardial patch).

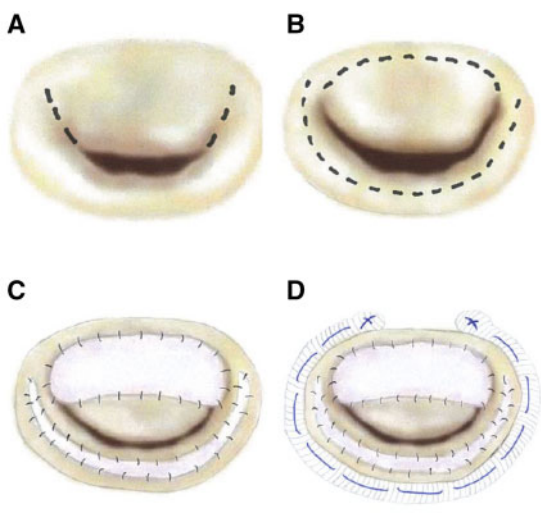


Figure 3 Schema of the operative procedure. (A) Commissural cutting to the annulus (broken line). (B) The anterior leaflet was completely detached from the annulus. The posterior leaflet was also detached from the annulus, keeping the commissural connection intact. (C) Autologous pericardial patch augmentation of double leaflets. One side of the anterior patch was sutured to the native anterior annulus, and the other side was to the native anterior leaflet approximately 7–8 mm apart from the commissure edge. The posterior patch was sutured to the native posterior leaflet and the posterior annulus sequentially to fill the defect. (D) Twenty-nine millimetres of the Tailor band (St. Jude Medical, St Paul, MN, USA) was fixed to the posterior annulus with running sutures.

standardized tissue fixation, considering the patient's young age (27 years), she will definitely require repetitive valve replacement surgery. Valve-in-valve surgery could avoid a large incision redo-surgery at later deterioration, but several valve-in-valve surgery would be needed, and the results remain unknown. Therefore, we think that

MV repair, which can help avoid repetitive surgery, is a feasible strategy for this young lady.

Rheumatic MV repair remains controversial because of its inferior feasibility and durability, while degenerative MV repair was well-established procedure and numerous reports showed excellent long-term results.^{4,5} Gillinov et al.⁶ have published the largest known cohort of single institutional robotic mitral experience: 1000 patients in a timeframe of 8 years. In their experience, only 1% of patients were suitable for robotic procedure for rheumatic lesions. Progression/recurrence of rheumatic disease may lead to early valve failure and reoperation, thus affecting repair durability.^{3,7} However, the results in some recent rheumatic repair reports have shown good long-term results even in young adults.^{8,9} Modifications and maturation of standard repair techniques and recognition of the importance of deep and smooth leaflet coaptation, pliable leaflet motion could have contributed to the improved long-term results. To obtain sufficient coaptation in rheumatic shortened or calcified leaflets, autologous patch augmentation or decalcification of the leaflets or subvalvular apparatus is a feasible manoeuvre.¹⁰ Good early and mid-term outcomes of repair using leaflet extension in rheumatic disease have also been demonstrated.¹¹ In the current era, if technically practical, valve repair should be optimal even in young adults.

Robot-assisted MV repair has become widespread, demonstrating notable early and mid-term results, with low risk of late recurrence of mitral regurgitation and reoperation¹² or a shorter hospitalization and earlier return to work.¹³ Furthermore, robotic MV repair has several potential advantages with regard to enhanced surgical dexterity, thus, facilitating the precise movements of instruments in the closed chest and high-definition three-dimensional visualization with a line of vision parallel to the MV, with good cosmetic results.¹⁴ In performing MV repair, robotic platform provides all instruments required for the repair, and offers more closed and clear vision for evaluating MV pathology. These suggest that in such cases, like the current case, which require detailed inspection and complex manipulations, robot-assisted repair would be more suitable than the

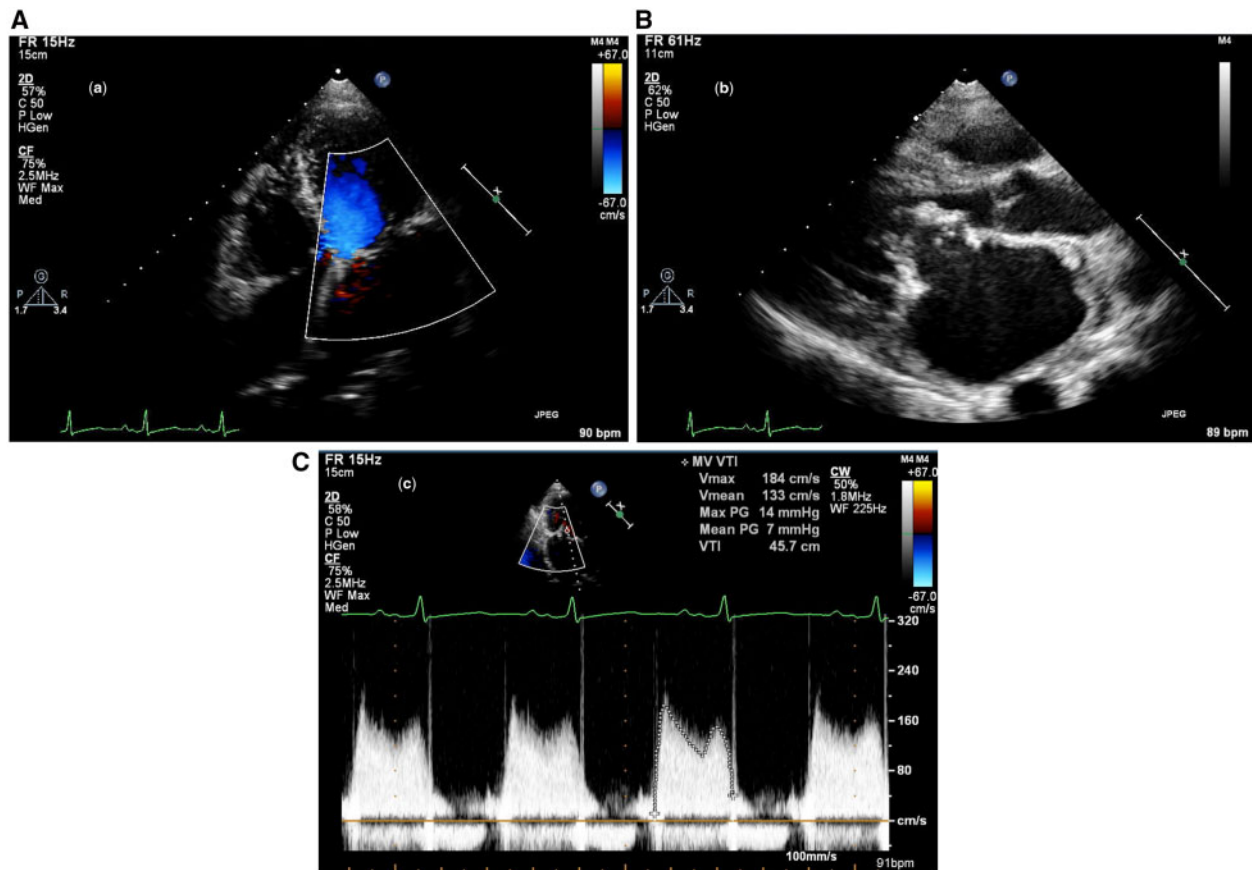


Figure 5 Post-operative transthoracic echocardiography demonstrated (A) absent regurgitation, (B) extended mitral both leaflets, and (C) a mean mitral gradient of 7 mmHg.

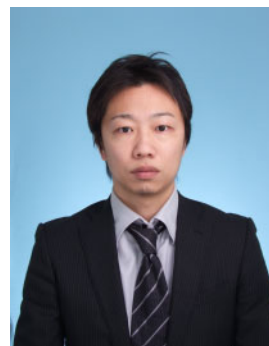
conventional minimally invasive technique. Although conventional median sternotomy approach must be the safest and certain procedure, and should be general, for the cases of young and female patients who strongly desire cosmetically appealing results, the robotic approach would be feasible.

The drawback of robotic approach is lack of haptic feedback, which is crucial in dealing with thickened/calcified tissues in rheumatic mitral lesions. Under these circumstances, risk of possible devastating complications, i.e. atrioventricular rupture or coronary injury, is much higher. In such cases, especially those that need for massive decalcification particularly in the mitral annulus, it would be better to avoid using robotic operation. In the present case, however, we could preoperatively determine the lack of calcification on the mitral annulus, leaflet, or subvalvular apparatus, assessed using the computed tomography. Mitral valve repair for rheumatic aetiology must be challenging, but in selected patients like in the present case, where the patient had minimal calcification on the MV components, can be treated using the robotic approach.

In conclusion, robot-assisted MV repair can contribute to precise valve inspection and technical accuracy, which is feasible for complex rheumatic mitral disease in case of young or female patients who strongly desire cosmetically appealing results. This is the first report to present the complex mitral repair including autologous patch

augmentation of both leaflets for rheumatic mitral disease using the robot-assisted approach.

Lead author biography



Shin Yajima was born on 18 August 1981 at Osaka, Japan. He completed MD in 2007 at Shimane University, Shimane, Japan. In the year 2018, he obtained PhD degree from Osaka University Graduate School of Medicine, Faculty of Medicine, Department of Cardiovascular Surgery, Osaka, Japan. In the year 2019, he was honoured with Excellent Paper Award from The Japanese Association for Thoracic Surgery. In the same year, he obtained

Research Fellowship and grant from Bayer foundation. In 2018, he was the Best at Basic Scientific Research for Cardiovascular Surgery, Japan Circulation Society. He was awarded with the Best of Basic Scientific Poster from American Heart Association in 2016. Also in

the same year, at the 46th congress of the Japanese Society for Cardiovascular Surgery, he was felicitated with Basic Research Award (Hearse-Yamamoto Award).

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 author/s confirm that written consent for submission and publication of this case report including image(s) and associated text has been obtained from the patient in line with COPE guidance.

Conflict of interest: none declared.

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