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CASE REPORT
Heart failure

Successful transcatheter aortic valve implantation in a patient after an apico-aortic conduit for severe aortic stenosis complicated by haemolytic anaemia: a case report

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Background Apico-aortic conduit (AAC) which connects the left ventricular (LV) apex directly to the descending aorta through a valved conduit, is an alternative to surgical aortic valve replacement (AVR) for patients with aortic stenosis (AS) who are inoperable or high risk for surgical AVR and are not suitable candidates for transcatheter aortic valve implantation (TAVI).

Case summary An 84-year-old man with severe AS underwent an AAC combined with coronary artery bypass grafting 8 years earlier. A saphenous vein graft was anastomosed from the conduit to the left anterior descending artery. He had developed haemolytic anaemia requiring frequent blood transfusions. The stenosis at the anastomosis of the left ventricle and the conduit might be the cause of a turbulent flow and a shear stress which led to mechanical haemolysis. We expected that dilatation of native aortic valve would reduce the blood flow at the anastomosis site and thereby improve haemolytic anaemia. Since balloon aortic valvuloplasty improved haemolytic anaemia without exacerbation of myocardial ischaemia, transsubclavian TAVI was performed. After the TAVI, significant reductions in the pressure gradient between the left ventricle and the ascending aorta and that between the left ventricle and the conduit were achieved, and the patient remained clinically stable without the recurrence of haemolytic anaemia.

Discussion This is the first report regarding mechanical haemolytic anaemia after AAC which might result from a turbulence and a shear stress by the stenosis of the anastomosis of the LV apex and the conduit. A careful monitoring for conduit dysfunction should be made after AAC.

Keywords Transcatheter aortic valve implantation • Apico-aortic conduit • Aortic stenosis • Haemolytic anaemia • Case report

Learning points

- An apico-aortic conduit (AAC), also known as an aortic bypass surgery is an alternative for patients with severe aortic stenosis who are not suitable candidates for either surgical aortic valve replacement or transcatheter aortic valve implantation (TAVI).
- We experienced a patient who developed mechanical haemolytic anaemia due to the stenosis at the anastomosis of the left ventricular apex and the conduit, and successfully treated by TAVI for native aortic valve stenosis.
- A careful monitoring for conduit dysfunction should be made after AAC.

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Introduction

An apico-aortic conduit (AAC), also known as an aortic bypass surgery, connects the left ventricular (LV) apex directly to the descending thoracic aorta through a valved conduit and shunts blood from the LV apex to the descending aorta. An AAC is an alternative for patients with severe aortic stenosis (AS) who are not suitable candidates for either surgical aortic valve replacement (AVR) or transcatheter aortic valve implantation (TAVI). An AAC can be performed without median sternotomy or cardiopulmonary bypass with low rate of postoperative stroke, conduction system injury, and late complications including conduit stenosis or insufficiency are rare.[1–3] Here, we report a case of successful TAVI for a patient with mechanical haemolytic anaemia due to the stenosis at the anastomosis of the LV apex and the conduit after AAC.

Timeline

Time	Event
2008	Underwent an apico-aortic conduit (AAC).
	Saphenous vein graft (SVG) was anastomosed from AAC to left anterior descending artery.
2010	Developed acute decompensated heart failure (required mechanical ventilation).
	An echocardiograhy, a cardiac magnetic resonance imaging demonstrated the presence of severe stenosis at the anastomosis of left ventricle and the conduit.
August 2014	Developed severe haemolytic anaemia requiring frequent blood transfusions.
	Suffered from shortness of breath and fatigue on exertion (New York Heart Association Class III).
December 2014	A left heart and AAC catheterization also demonstrated the presence of severe stenosis at the anastomosis of left ventricle and the conduit.
September 2015	Balloon aortic valvuloplasty (BAV).
	To confirm whether BAV would reduce the blood flow at the anastomosis site and thereby improve haemolytic anaemia without exacerbation of myocardial ischaemia due to the decrease in SVG flow via the conduit.
January 2016	Transsubclavian transcatheter aortic valve implantation using a 29-mm self-expandable valve.
	The serum levels of haemoglobin and lactic dehydrogenase were normalized.
2019	Follow-up echocardiography demonstrated that there was still flow in the conduit and there were no signs of transcatheter aortic valve failure.
	Remained clinically stable without the recurrence of haemolytic anaemia.

Case presentation

An 84-year-old male with severe AS and severely calcified ascending aorta underwent AAC using a valved conduit with a 21-mm Freestyle valve (Medtronic, Minneapolis, MN, USA) and a 20-mm vascular graft combined with coronary artery bypass grafting 8 years earlier. The conduit was directly anastomosed to the LV apex without an apical connector. Since he had a severe stenosis in the proximal portion of left anterior descending artery, a saphenous vein graft (SVG) was anastomosed from the AAC to a left anterior descending artery. His past medical history included hypertension, diabetes mellitus, dyslipidaemia, Y-graft replacement for abdominal aortic aneurysm, and femoral–femoral bypass surgery. Two years after an AAC (in 2010), he had developed acute decompensated heart failure classified as New York Heart Association (NYHA) Class IV which required intubation and mechanical ventilation. After the medical therapy including vasodilators and diuretics, he recovered to NYHA Class II symptoms. A physical examination revealed a prominent systolic ejection murmur at the apex which radiated to the axilla and the left back, and decreased breath sounds on the left side. Abdominal examination was unremarkable. Mild pitting oedema of the legs was present. A transthoracic echocardiography revealed increased peak velocities at the anastomosis of the LV apex and the AAC (4.6 m/s), and at the heavily calcified native aortic valve (4.3 m/s). A cardiac cine magnetic resonance imaging revealed the flow void directed from the LV apex to the AAC, which suggested the presence of severe stenosis at the anastomosis site (*Video 1*). His functional capacity was NYHA Class II and remained stable after the hospital discharge, we decided to manage him conservatively. However, he began to experience severe anaemia that required frequent blood transfusions from 2014 and suffered from shortness of breath and fatigue after walking about 100 m on level ground (NYHA Class III). An esophagogastroduodenoscopy and a colonoscopy showed no signs of gastrointestinal bleeding. Laboratory findings demonstrated elevated levels of serum lactic dehydrogenase and reticulocyte counts, reduced levels of serum haptoglobin, negative Coombs test and presence of urine haemosiderin, which confirmed the diagnosis of haemolytic anaemia with intravascular haemolysis. He did not receive any drugs that can cause immune haemolytic anaemia or thrombotic microangiopathy including cephalosporins, penicillins, platinum compounds, quinidine, nonsteroidal anti-inflammatory drugs, cyclosporine, or thienopyridine antiplatelet agents. The serum level of B-type natriuretic peptide increased to 1078.3 pg/mL, suggesting that his symptoms were consistent with heart failure. Medications included loop diuretics, angiotensin receptor blocker, and calcium channel blocker for heart failure and hypertension. A left heart and AAC catheterization were performed to evaluate haemodynamics more accurately (*Figures 1* and *2*). A slow pullback of the end-hole catheter from the distal limb of the AAC to the ascending aorta showed increased peak-to-peak pressure gradient of 83 mmHg at the anastomosis of the LV apex and the conduit, and that of 72 mmHg across the native aortic valve. Coronary angiography and computed tomography revealed a stenosis in the proximal left anterior descending artery and a patent SVG. There was no significant stenosis in the left circumflex artery and the right coronary artery (*Figure 3*).

We speculated that his haemolytic anaemia might result from a turbulence and a shear stress at the stenosis of the anastomosis of

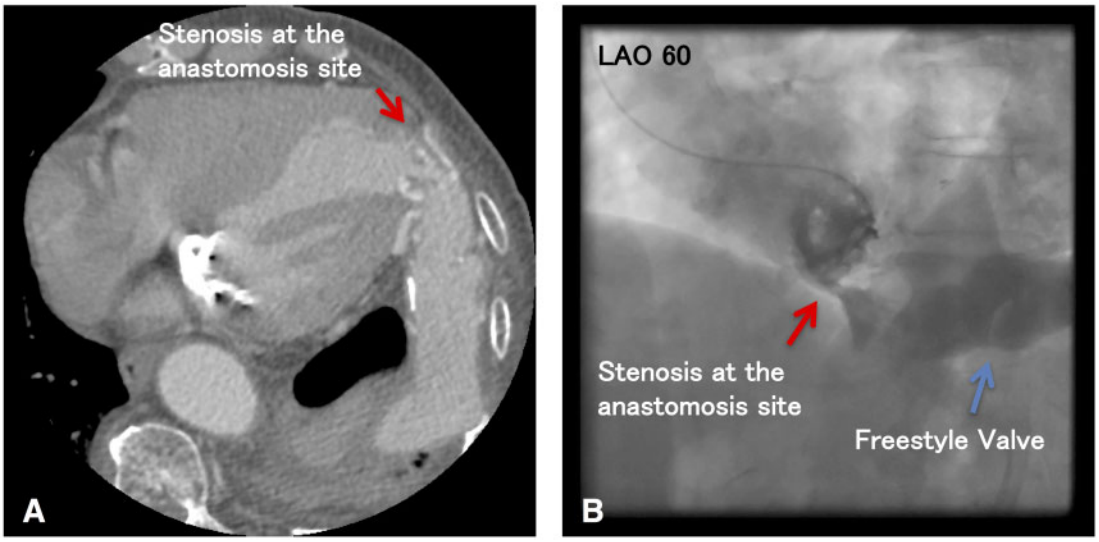


Figure 1 A severe stenosis at the anasotomosis site of the left ventricle and the apico-aortic conduit. (*A*) An electrocardiogram-gated contrast-enhanced computed tomography. (*B*) Left ventriculography in systole in the left anterior oblique view.

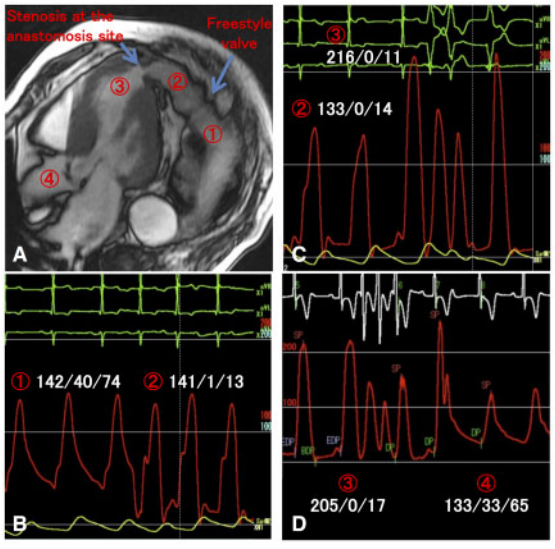


Figure 2 Pressure waveforms obtained during a cardiac catheterization. (*A*) Magnetic resonance imaging indicating the position of the end-hole catheter. (*B–D*) The pressures of the distal limb of the apico-aortic conduit (①), the proximal limb of the apico-aortic conduit (②), the left ventricular apex(③), and the ascending aorta (④).

the LV apex and the conduit, and might be a major cause of dyspnoea. In this case, treatment for the native aortic valve stenosis would reduce the blood flow at the anastomosis site and thereby improve haemolytic anaemia and dyspnoea. However, there was a concern that reducing the conduit flow might reduce myocardial perfusion through the SVG and exacerbate ischaemia. Therefore, a balloon aortic valvuloplasty (BAV) was planned at first. Because he had histories of a Y-graft replacement for an abdominal aortic aneurysm and a femoral–femoral bypass surgery for a right common iliac artery occlusion (*Figure 4A*), an antegrade transseptal BAV using a 22-mm Inoue balloon (Toray Medical, Japan) via a right femoral vein was chosen. After transseptal puncture, multiple inflations of the Inoue balloon with stepwise increases from 16 to 20.5 mm were successfully performed (*Figure 4B* and *C*). Since BAV was effective in improving his haemolytic anaemia and there were no signs of marked exacerbation of myocardial ischaemia such as worsening angina or new ST-T changes on electrocardiogram, TAVI was performed 4 months after BAV. Because of the porcelain ascending aorta and histories of a Y-graft replacement, a femoral–femoral bypass and an AAC, we chose a transsubclavian approach (Supplementary material online, *Figure S1*). Computed tomography findings revealed his basal ring area was 423 mm^2 and perimeter was 74 mm, suggesting a 29-mm self-expandable valve (CoreValve, Medtronic, Minneapolis, MN, USA) would be suitable. After predilatation using a 20-mm balloon, a 29-mm CoreValve was successfully implanted and additional postdilatation using a 22-mm balloon was performed. A postoperative echocardiography showed a favourable transcatheter aortic valve performance. The peak velocity was 1.9 m/s and the mean gradient was 6 mmHg, in addition, paravalvular aortic regurgitation was mild. The peak flow velocity at the anastomosis of the LV apex and the conduit was remarkably reduced to 1.4 m/s. After the TAVI procedure, the patient reported no angina and his electrocardiogram showed second-degree Mobitz type I atrioventricular block with no new ST-T changes. The serum levels of haemoglobin and lactic dehydrogenase were normalized (*Figure 5*). The follow-up transthoracic echocardiography performed in 2019 demonstrated that there was still flow in the conduit with a peak velocity of 2.0 m/s and there were

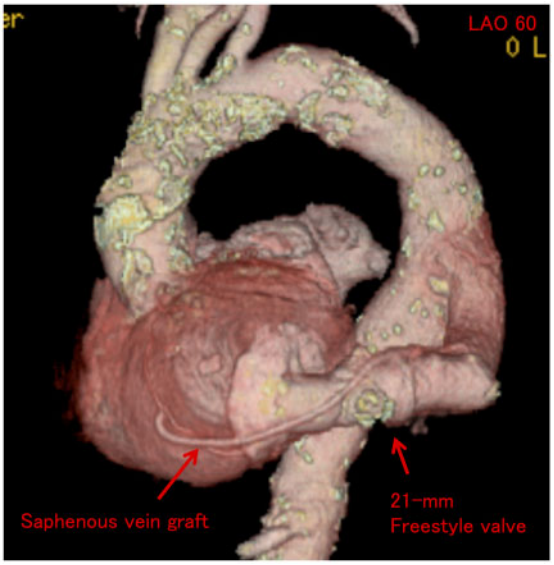


Figure 3 A computed tomography angiography (left anterior oblique 60° projection) showing the apico-aortic conduit that connects the left ventricular apex directly to the descending aorta and patent saphenous vein graft from the conduit to the left anterior descending artery.

no signs of transcatheter aortic valve failure. The patient remained clinically stable with NYHA functional class II without the recurrence of haemolytic anaemia.

Discussion

Since TAVI has been approved for patients with severe AS and high surgical risk, an AAC seems to be less performed. However, an AAC still remains a therapeutic option for patients who are not suitable for either AVR or TAVI, such as those who have very small annulus or require complex reoperations after previous valve surgery. The late complications of AAC include LV anastomotic aneurysm, tissue valve dysfunction, and conduit stenosis. Although a few cases of successful treatments with TAVI for the native aortic valve have been reported in patients with AAC dysfunctions,[4,5] to our knowledge, this report is the first to show that mechanical haemolytic anaemia after AAC was successfully treated with TAVI for the native aortic valve.

It has been shown in animal studies that apical left ventriculotomy would become narrow over time and cause obstruction unless a rigid stent was implanted to maintain this orifice.[6,7] A possible reason for the anastomosis stenosis between the LV apex and the conduit in the present case might be disuse of a rigid apical connector with an

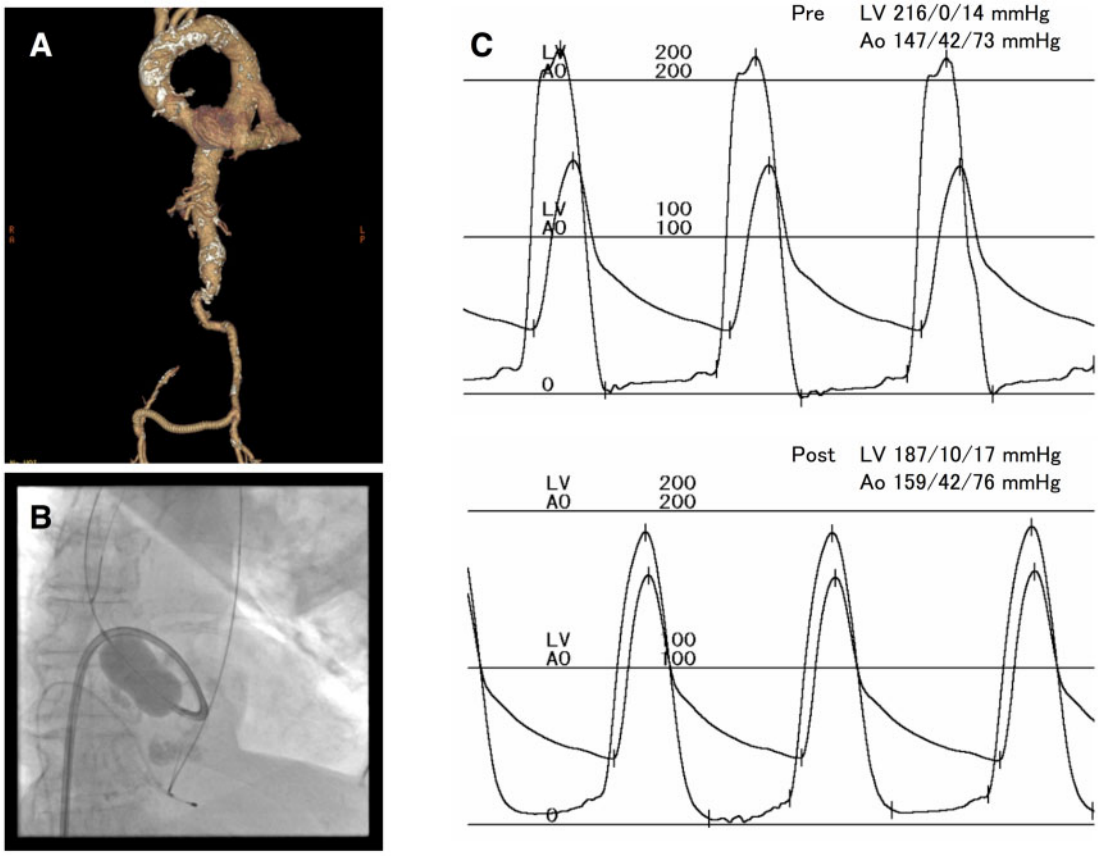


Figure 4 (*A*) A computed tomography angiography of aorta and iliac arteries. A total occlusion of the right limb of Y-graft, and a patent femoro-femoral bypass can be seen. An apico-aortic conduit which connects a left ventricular apex and a thoracic descending aorta is also visualized. (*B*) A fluoroscopy image during an antegrade transseptal balloon aortic valvuloplasty using a 22-mm Inoue balloon via a right femoral vein approach. (*C*) The haemodynamics before and after balloon aortic valvuloplasty.

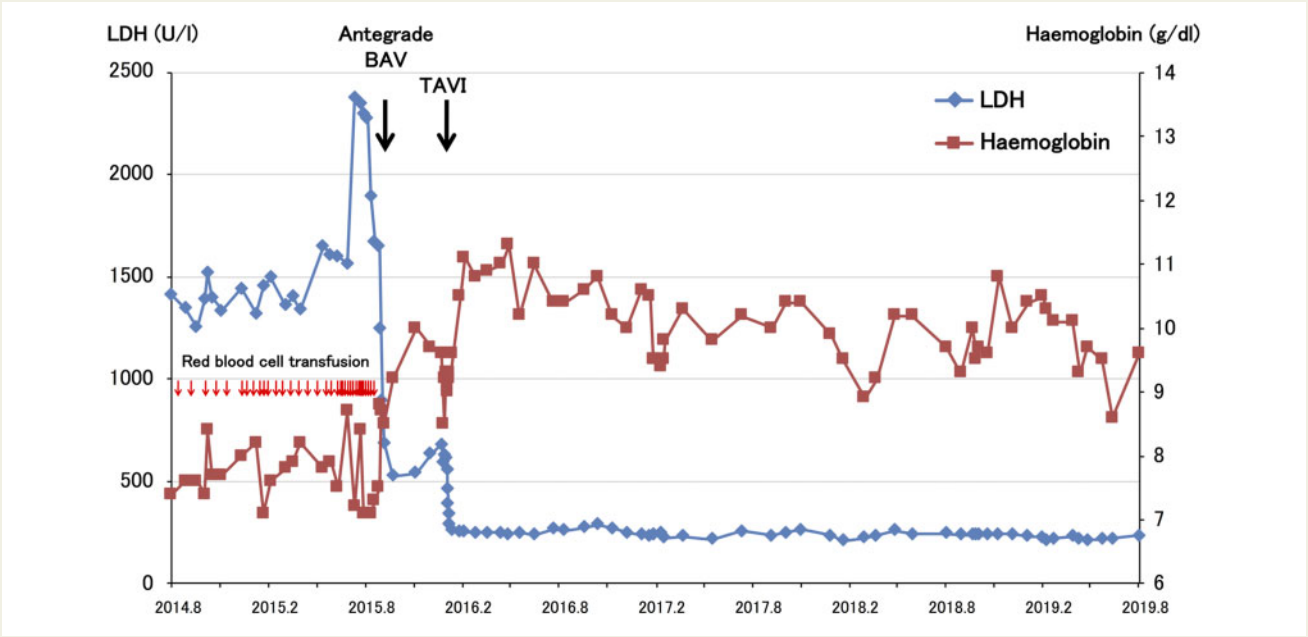
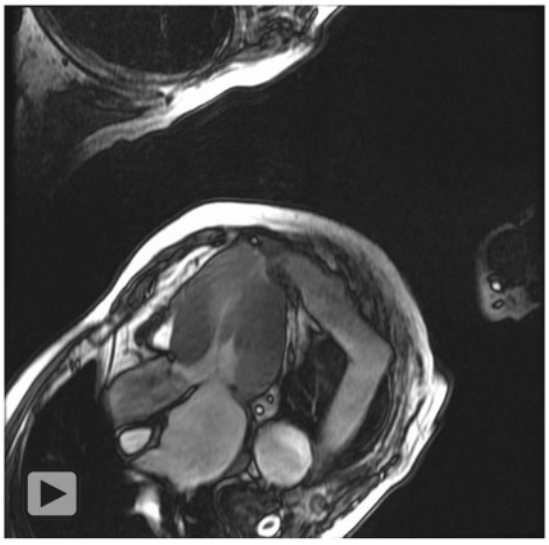


Figure 5 Serial changes in haemoglobin and lactic dehydrogenase levels. BAV, balloon aortic valvuloplasty; LDH, lactic dehydrogenase; TAVI, transcatheter aortic valve implantation.



Video 1 A cardiac cine magnetic resonance imaging. The flow void directed from the left ventricular apex to the apico-aortic conduit suggested the presence of severe stenosis at the anastomosis site.

attached sewing ring. The use of the apical connector might have prevented the anastomosis stenosis in the present case.

Chronic mechanical haemolysis in patients following aortic or mitral valve replacement is well recognized, which is commonly associated with structural deterioration or paravalvular leak of mechanical or biological prosthesis.[8] We speculate that a turbulence and a shear stress at the stenosis of the anastomosis was the major cause of his mechanical haemolysis in the present case, because haemolysis is rarely caused by native AS. Thus, TAVI for the native aortic valve was planned to attenuate the turbulence and the shear stress and improve haemolytic anaemia by decreasing conduit flow.

Balloon aortic valvuloplasty is a therapeutic option for haemodynamically unstable AS patients who are at high risk for surgical AVR or TAVI, or for palliation in AS patients in whom AVR or TAVI cannot be performed because of serious comorbidities. The American College of Cardiology/American Heart Association (ACC/AHA) guidelines recommend BAV as a possibly-reasonable bridge therapy to surgical AVR or TAVI.[9] In our case, a BAV was performed in advance of TAVI to confirm that dilatation of the native aortic valve would not exacerbate ischaemia by decreasing blood flow of the SVG. In patients for whom a transarterial approach is not suitable, an antegrade BAV using an Inoue balloon via a femoral vein is a reasonable choice. Severely calcified degenerative aortic valves tend to respond poorly to a limited number of inflations with a conventional balloon via retrograde transarterial approach. Multiple inflations of the Inoue balloon with stepwise increases of the balloon size showed an improved efficacy and safety in patients with severely calcified aortic valve compared with the conventional retrograde BAV.[10]

We considered that the self-expandable valve was more suitable than the balloon expandable valve for TAVI in the present case because of extensive calcification of aortic valve. Patients with bulky calcifications may have an increased risk of annulus rupture which is one of the lethal complications of TAVI, and self-expandable valves may be safer than balloon expandable valves in such patients.[11,12]

Conclusion

This is the first report regarding mechanical haemolytic anaemia after AAC which might result from a turbulence and a shear stress by the

stenosis of the anastomosis of the LV apex and the conduit. BAV and subsequent TAVI for the native aortic valve could improve mechanical haemolytic anaemia and heart failure. A careful monitoring for conduit dysfunction should be made after AAC.

Lead author biography

Dr Kitae Kim received the MD degree from Kobe University School of Medicine, Kobe, Japan in 2005. Currently, he works as an interventional cardiologist at Kobe City Medical Center General Hospital, Kobe, Japan, and performs coronary intervention, transcatheter aortic valve implantation. He is also involved in cardiac implantable electronic device implantation including cardiac resynchronization therapy device. His research interest is mainly focused on valvular heart disease, especially mitral valve disease.

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.

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