CASE REPORT

Consecutive transcatheter valve-in-valve implantations: the first in the aortic position, the second in the mitral position, in a patient with failing aortic and mitral bioprostheses

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SUMMARY

A 69-year-old man with a failing aortic valve homograft and failing mitral valve xenograft was admitted with an inability to complete full sentences and pulmonary oedema with right ventricular overload. Severe aortic and mitral regurgitation, severe biventricular impairment and pulmonary hypertension were confirmed on transthoracic and transoesophageal echocardiography. An urgent transfemoral valve-in-valve transcatheter valve implantation (TAVI) was performed within the aortic valve homograft with full resolution of aortic regurgitation. Three months later, a semielective transapical valve-in-valve procedure was performed in the mitral position, under cardiopulmonary bypass, with full resolution of mitral regurgitation. His exercise tolerance increased from 5 yards to half a mile. This case report summarises a staged double valve-in-valve procedure in a patient who had three previous sternotomies and who had severe heart failure due to failing aortic and mitral bioprostheses. We report two different delivery approaches, using two different transcatheter devices, and describe valve-in-valve techniques, including cardiopulmonary bypass, in the catheter laboratory.

BACKGROUND

The long-term durability of bioprosthetic valves is limited,¹ and after 20 years, the majority of valves will have failed. The current standard of care for patients with a degenerating bioprosthetic valve replacement is reoperation. However, repeat sternotomy is a high-risk procedure, not least because many of these patients are elderly, with multiple comorbidities. Off-label use of transcatheter valve implantation (TAVI) via a valve-in-valve procedure may offer an alternative means of valve implantation with significantly lower mortality and morbidity.² Valve-in-valve intervention for failing aortic valve replacement (AVR) is increasingly practiced, although experience in performing TAVI in stentless bioprosthetic aortic valves remains relatively limited except in specialist centres. Mitral valve-in-valve implantation is an emerging clinically effective technique in some patients with a failing mitral valve replacement (MVR).^{3–7}

In this case, we report the first worldwide case of a valve-in-valve TAVI in a stentless aortic bioprosthesis followed by a mitral valve-in-valve procedure in a failing mitral bioprosthesis, using two different access routes and two different valve types, with

elective circulatory support, in the same patient with intractable heart failure.

CASE PRESENTATION

A 69-year-old man was admitted to The Royal Brompton Hospital with acute shortness of breath, such that he was struggling to complete sentences. This was on a background of a 3-month history of increasing breathlessness and orthopnoea (he was sleeping with four pillows) and ankle swelling.

In his medical history, he had an AVR in 1980 for rheumatic aortic stenosis with a bioprosthetic pericardial xenograft, and a re-do AVR in 1991 with a homograft. In 1995, he underwent mitral balloon valvuloplasty for mitral stenosis, which was complicated by progressive mitral regurgitation, and subsequently underwent an MVR in 1997 with a bioprosthetic 29 mm Carpentier-Edwards xenograft. Postoperatively he required implantation of a VVI permanent pacing device for complete heart block. His other medical history included long-standing atrial fibrillation, moderate chronic obstructive airways disease and mild coronary artery disease.

On clinical examination at presentation, he was cachectic (weight 51 kg, body surface area 1.47 m², body mass index 22 kg/m²) and had a malar flush. He was in controlled atrial fibrillation (rate 76 bpm), his blood pressure was 108/39 mm Hg, he had mitral and aortic regurgitant murmurs on auscultation of his precordium, and he had signs of right ventricular volume overload (his jugular venous pressure (JVP) was raised 5 cm above the clavicle), and he had bilateral pitting oedema to his knees.

His medications on admission were ramipril 10 mg at night, bisoprolol 2.5 mg once daily, digoxin 250 µg once daily, furosemide 40 mg mane at lunchtime, pravastatin 10 mg and warfarin as required.

INVESTIGATIONS

Routine blood tests showed haemoglobin (Hb) 15.6 g/L, Na 140 mmol/L, impaired renal function (Ur 8.3 mmol/L, Cr 89 µmol/L, expected glomerular filtration rate (eGFR) 50 mL/min) and normal albumin level (33 g/L). His brain natriuretic peptide (BNP) was significantly elevated at 772 ng/L (normal <20 ng/L). An ECG showed atrial fibrillation and a paced ventricular rhythm (rate 93 bpm). His chest X-ray showed signs consistent with pulmonary venous congestion. Pulmonary function tests showed reduced lung volumes (total lung

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Video 1 Pre-procedural transoesophageal echo imaging showing severe mitral and aortic regurgitation.

diffusing capacity for carbon monoxide 45% predicted), with a normal transfer factor (90% predicted), and reduced forced expiratory volume in one second (46% predicted), forced vital capacity (FVC) (58% predicted) and peak expiratory flow rate (66% predicted).

Transthoracic echocardiography demonstrated a dilated and hyperdynamic left ventricle (LV) with an LV ejection fraction of 60%, biatrial dilatation, and a dilated and impaired RV (longitudinal amplitude 7 mm, normal >15 mm). There were two jets of severe aortic regurgitation, and moderate-severe mitral regurgitation was

present. Transoesophageal echocardiography confirmed severe aortic regurgitation (due to significant leaflet prolapse, aortic annular dimension 2 cm), and severe mitral regurgitation due to a degenerated MVR (again due to significant leaflet prolapse) (video 1).

Coronary angiography confirmed 50% proximal right coronary artery stenosis, severe aortic regurgitation (video 2), and qualitatively well-preserved LV ejection fraction.

In anticipation of a transcatheter-based intervention, a CT scan was performed to size both the AVR and MVR bioprostheses and to assess potential TAVI access routes. The aortic annulus measured 20

Video 2 Pre-aortic TAVI fluoroscopy showing severe aortic regurgitation. Note the lack of fluoroscopic markers defining the aortic annulus (the landing zone for TAVI device deployment).

Video 3 Valve-in-valve deployment of a self-expanding CoreValve within a failing homograft using a transfemoral approach.

Video 4 2-dimensional transoesophageal imaging compared with colour Doppler. Note the severely degenerated mitral valve leaflets, and severe concomitant mitral regurgitation.

mm×24 mm, with a perimeter of 78 mm. The internal mitral valve diameter measured 26 mm×27 mm. The pelvic sidewall vessels were tortuous but were >7 mm on both sides, that is, they were adequate calibre for transfemoral TAVI. A cardiac MRI was not performed as the patient had a permanent pacemaker in situ.

The patient was discussed in a Structural Heart Disease Multi-Disciplinary Team (SHD MDT) meeting. His calculated Society of Thoracic Surgeons Predicted Risk of Mortality score was 46.1% and his Logistic EUROSCORE was 28.7%. He was therefore deemed a high surgical risk, and was accepted for transcatheter aortic valve intervention, potentially followed by transcatheter mitral valve intervention depending on symptom resolution.

TREATMENT

Initially, the patient was treated medically by discontinuing bisoprolol and commencing frusemide (80 mg). This resulted in a

2 kg weight loss over 2 days. Five days later, the patient underwent a transfemoral aortic valve-in-valve TAVI under general anaesthesia. A 26 mm self-expanding CoreValve was deployed within the degenerative aortic bioprosthesis during a short period of rapid LV pacing. The result was a fully deployed, well-seated valve-in-valve TAVI, with an excellent angiographic result and complete resolution of aortic regurgitation ([video 3](#)).

The patient made an excellent recovery from this procedure and was discharged 5 days later. On clinical review after 6 weeks, he reported some improvement in symptoms in that he

Video 5 3-dimensional transoesophageal imaging of the failing MVR. Note the prolapse of all three mitral valve leaflets.

Video 6 Fluoroscopic view of valve-in-valve deployment of a balloon-expandable SAPIEN XT device within a failing mitral bioprosthesis using a trans-apical approach.

Video 7 Echocardiographic view of valve-in-valve deployment of a balloon-expandable SAPIEN XT device within a failing mitral bioprosthesis using a transapical approach.

was notably less breathlessness on exertion, but was still short of breath on climbing hills or stairs. He had no orthopnoea. On examination, he remained cachectic, his JVP was raised to the angle of his jaw, he had a pulsatile liver, a pan-systolic murmur at the apex, but no clinical features of aortic regurgitation. His medications at that time were ramipril 10 mg at night, bisoprolol 2.5 mg once daily, digoxin 250 µg once daily, frusemide 60 mg mane and 40 mg lunchtime, pravastatin and aspirin (75 mg).

He was re-presented at a SHD MDT, where consensus agreement was that he should be offered catheter-based intervention on his failed MVR. Four weeks later, the patient was admitted semielectively for valve-in-valve procedure. Two-dimensional (video 4) and three-dimensional echocardiography (video 5) confirmed severe mitral regurgitation due to a degenerated MVR. In the absence of

Video 9 3-dimensional transoesophageal imaging of the mitral valve-in-valve device with well-functioning SAPIEN Device leaflets.

aortic regurgitation, the left ventricular ejection fraction had fallen to 34% (but still in the presence of mitral regurgitation). For these reasons, the mitral valve-in-valve procedure was performed under general anaesthesia with a short period of elective circulatory support. The patient was primed for femoral-femoral cardiopulmonary bypass through a transverse left groin incision with exposure of the femoral artery and vein. According to manufacturer's specifications with regard to the inner diameter of a 29 mm Carpentier Edwards Xenograft, a 29 mm balloon-expandable SAPIEN XT device was implanted via an apical approach under a period (<10 min) of cardiopulmonary bypass and a short burst of rapid LV pacing (videos 6 and 7). The result was a fully deployed, well-seated mitral valve-in-valve device, with excellent angiographic and echocardiographic results (videos 8–10). The patient again made an excellent recovery, had an uneventful postprocedural period, and was discharged 9 days later.

Video 8 2-dimensional transoesophageal imaging compared with colour Doppler. Note well-functioning, competent mitral valve leaflets, and the absence of mitral regurgitation.

Video 10 The end-result was a well-seated CoreValve device in the failed aortic homograft with no aortic regurgitation, a SAPIEN device in the failed mitral valve bioprosthesis with no mitral regurgitation, the venous cannula of the circulatory support, a VVI pacemaker and a temporary transvenous pacemaker, and a transoesophageal probe for guidance of valve placement and to assess ventricular and valvular function.

OUTCOME AND FOLLOW-UP

The patient was reviewed in outpatients 1 month later. He reported a significant improvement in his exercise capacity in that he was able to walk half a mile at slow pace, and climbing stairs was no longer problematic. He described no orthopnoea, no palpitations or chest pain. Indeed, in his own words, he felt that he had made a 'fantastic recovery'. On examination, he was euvolaemic, his heart rate was 70 bpm, blood pressure (BP) 110/60 mm Hg, JVP was not raised and there were no murmurs on auscultation of his chest. His left anterior thoracotomy wound was well healed. His postprocedural transthoracic echo reported an LV ejection fraction of 50%, mildly impaired right ventricular function (long axis amplitude 13 mm), no mitral regurgitation, mild mitral stenosis (peak pressure drop 9 mm Hg), peak aortic gradient 13 mm Hg and only mild anterior paravalvular aortic regurgitation. His Hb was 13 g/dL, his renal function remained stable (Ur 7.2 mmol/L, Cr 75 μ mol/L, eGFR 90 mL/min), and BNP had decreased significantly to 282 ng/L. He is currently being followed-up by both the Transcatheter team and a Heart Failure Consultant, has been started on nutritional supplementation, and has a local dietician referral.

DISCUSSION

This is the first report of a valve-in-valve transcatheter aortic valve implantation in a failing stentless aortic bioprosthesis, followed by a second valve-in-valve transcatheter procedure, this time within a failing stented mitral bioprosthesis, using two different valve types and two different access routes. The procedure was performed in a high-surgical risk patient who had undergone three previous sternotomies. Although aortic valve-in-valve TAVI is increasingly performed,^{1 2} the majority of these cases have been in stented aortic valves. Stented AVRs have radio-opaque struts to add TAVI device positioning, and the aortic leaflets are usually calcified. TAVI in a stentless bioprosthesis is more technically challenging, as the stentless valve has no radio-opaque landmarks and the aortic valve leaflets are frequently not calcified.² Positioning of the TAVI within the failing

bioprosthetic AVR is complex, and requires operator experience and expert perioperative transoesophageal imaging guidance in defining the 'annular' level and the intended depth of device implantation below this level. A self-expanding CoreValve device is the valve of choice for failing aortic homograft position to minimise the potential risks of annular rupture and coronary occlusion.

Transcatheter valve-in-valve procedures for failing mitral bioprosthesis are much less commonly performed than failing aortic prosthesis, and to the best of our knowledge, sequential procedures in the same patient using two different valve types and two separate access routes have not previously been undertaken. We report both these transcatheter techniques, using two different (but most commonly used) transcatheter devices, using two separate access routes (transfemoral and transapical) during two separate procedures in the same patient. Furthermore, we report the safety of performing a mitral valve-in-valve transcatheter implantation using a transapical approach under a short period of cardiopulmonary bypass to provide peri-procedural haemodynamic stability and to ensure correct positioning of the transcatheter device, again under expert transoesophageal imaging guidance. A balloon-expandable Sapien XT device was implanted into the failing mitral bioprosthesis owing to the transapical access route used to access this failing valve. The result was full clinical and echocardiographic resolution of severe aortic and mitral regurgitation with reported excellent symptomatic benefit from the patient.

Patient's perspective

At outpatient follow-up, the patient reported he had a fantastic recovery from his procedures, which have transformed his symptoms.

Learning points

- ▶ Off-label transcatheter valve in valve procedures can be safely performed in the aortic and mitral positions for failing stentless aortic bioprosthesis and failing stented mitral bioprosthesis with excellent clinical and echocardiographic resolution of aortic and mitral regurgitation.
- ▶ A self-expanding CoreValve device was implanted in the failing aortic homograft position, as it minimises the potential risk of annular rupture and coronary occlusion associated with aortic valve-in-valve TAVI. It is also the most commonly used device for a failing stentless bioprosthesis in the Global Valve-In-Valve Registry.² The transapical approach to the failing mitral bioprosthesis necessitated the use of a balloon-expandable Sapien XT device in the mitral position.
- ▶ Sizing is a major issue in transcatheter valve-in-valve implantation. It is essential not only to know the surgical valve and implant method in detail, but to use the manufacturer's guidance and multi-modality imaging to assist in sizing.
- ▶ A trans-apical approach during a short elective period of cardiopulmonary bypass facilitates haemodynamic stability during a mitral valve-in-valve transcatheter implantation.
- ▶ A transcatheter approach significantly shortens in-hospital length of stay, and the avoidance of repeat sternotomy significantly reduces patient morbidity and accelerates patient rehabilitation following corrective valvular heart disease intervention.

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Competing interests None.

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