

# Valve-in-valve transcatheter aortic valve implantation with fracturing of a failed small surgical aortic bioprosthesis: a case report

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## Background

Failure of a small surgical aortic bioprosthesis represents a challenging clinical scenario with valve-in-valve (ViV) transcatheter aortic valve implantation (TAVI) often resulting in patient-prosthesis mismatch. Bioprosthetic valve fracture (BVF) performed as a part of the ViV TAVI has recently emerged as an alternative approach with certain types of surgical bioprostheses.

## Case summary

An 81-year-old woman with a history of three surgical aortic valve procedures presented with heart failure. Aortic bioprosthesis degeneration with severe stenosis and moderate regurgitation was found. The patient was deemed a high-risk surgical candidate and the heart team decided that ViV TAVI was the preferred treatment option. Due to the very small 19 mm stented surgical aortic bioprosthesis Mitroflow 19 mm (Sorin Group, Italy) we decided to perform BVF as a part of ViV TAVI to prevent patient-prosthesis mismatch. Since this was the first BVF procedure in our centre, an *ex vivo* BVF of the same kind of bioprosthetic valve was performed first. Subsequently, successful BVF with implantation of Evolut R 23 mm (Medtronic, USA) self-expandable transcatheter valve was performed. Excellent haemodynamic result was achieved and no periprocedural complications were present. The patient had an immediate major improvement in clinical status and remains asymptomatic after 6 months.

## Discussion

Bioprosthetic valve fracture together with ViV TAVI is a safe and effective emerging technique for treatment of small surgical aortic bioprosthesis failure. Bioprosthetic valve fracture allows marked oversizing of implanted self-expandable transcatheter aortic valves, leading to excellent haemodynamic and clinical results. An *ex vivo* BVF can serve as an important preparatory step when introducing the new method.

## Keywords

Bioprosthetic valve fracture • Case report • Transcatheter aortic valve implantation • Valve-in-valve • Aortic bioprosthesis failure

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## Learning points

- Bioprosthetic valve fracture (BVF) together with valve-in-valve transcatheter aortic valve implantation is a safe and effective emerging technique for treatment of failure of certain types of surgical aortic bioprostheses.
- Bioprosthetic valve fracture allows marked oversizing of implanted self-expandable transcatheter aortic valves, leading to excellent haemodynamic and clinical results.
- An *ex vivo* BVF can serve as an important preparatory step when introducing the new method.

## Introduction

Valve-in-valve (ViV) transcatheter aortic valve implantation (TAVI) is an established treatment method for failed surgical aortic bioprostheses.<sup>1</sup> However, small surgical aortic bioprostheses represent a challenging and increasingly common clinical scenario with ViV TAVI often resulting in high residual gradients and patient-prosthesis mismatch.<sup>2</sup> This results in increased late mortality.<sup>3,4</sup> High implantation of TAVI prostheses and use of valves with supra-annular design have been associated with decreased post-procedural gradients.<sup>5</sup> Furthermore, bioprosthetic valve fracture (BVF) performed as a part of the ViV TAVI has recently emerged as an alternative approach with certain types of surgical bioprostheses.<sup>6</sup> With BVF the operator 'cracks' the ring of the surgical bioprosthesis by means of non-compliant transcatheter balloons, either before or after implanting the transcatheter valve. This allows implantation of larger TAVI prostheses with better haemodynamic performance.<sup>7</sup>

In the present article, we present a case of a successful ViV TAVI with BVF of a degenerated 19 mm stented surgical aortic bioprosthesis and implantation of a markedly oversized 23 mm self-expandable transcatheter valve. We also demonstrate an *ex vivo* BVF, which served as a preparatory step for the procedure, since it was the first TAVI with BVF in our centre.

## Timeline

2007	First surgical aortic valve replacement due to severe stenosis
2007	First reoperation due to dehiscence of aortic bioprosthesis
2012	Second reoperation due to degeneration of aortic bioprosthesis
April 2019	Percutaneous coronary intervention of the right coronary artery
2 August 2019	Hospitalization in our institution due to heart failure
21 August 2019	Transcatheter aortic valve implantation with fracturing of aortic bioprosthesis
March 2020	Feeling well, excellent functional status (New York Heart Association I)

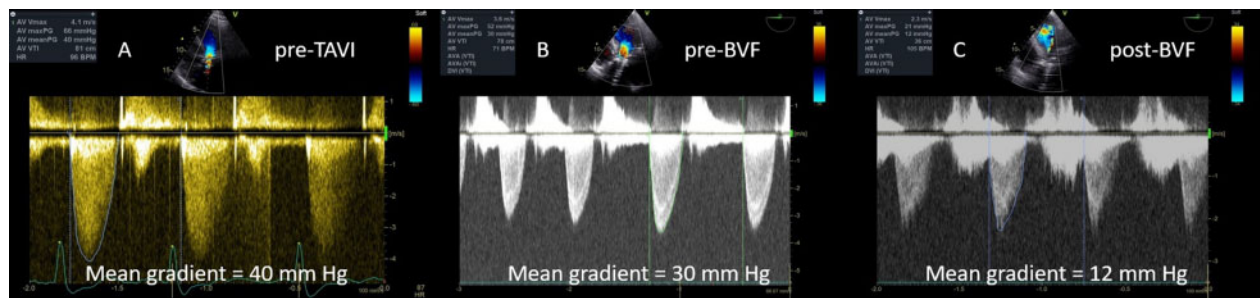
## Case presentation

In August 2019, an 81-year-old female was admitted due to progressive worsening of heart failure symptoms. She had dyspnoea at rest, orthopnoea, and had gained weight. Physical examination revealed loud systolic ejection murmur radiating to the neck, diminished breath sounds in lower pulmonary fields on both sides suggesting pleural effusion and bilateral leg oedema.

The patient had a surgical aortic valve replacement due to severe aortic stenosis in 2007 and a reoperation due to valve dehiscence in the same year (Sorin Freedom SOLO 23 mm, Sorin Group, Italy). In 2012, a second reoperation was performed due to severe stenosis of the degenerated aortic bioprosthesis. At that time, a stented aortic bioprosthesis Mitroflow 19 mm (Sorin Group, Italy) was implanted. At discharge, left ventricle size and ejection fraction (EF) were normal (end-diastolic volume index 56 mL/m<sup>2</sup>, EF 53%), mean transaortic gradient was 17 mmHg, and there was no aortic regurgitation. The patient also had a history of coronary artery disease with percutaneous coronary intervention of the right coronary artery in April 2019, arterial hypertension, hyperlipidaemia, persistent atrial fibrillation, and hypothyroidism following Hashimoto thyroiditis. She was treated with bisoprolol, ramipril, spironolactone, furosemide, rosuvastatin, warfarin, digoxin, and levothyroxine.

After admission, echocardiography was performed. Aortic bioprosthesis degeneration with severe stenosis (maximum velocity 4.1 m/s, mean gradient 40 mm Hg, *Figure 1A*) and moderate regurgitation was diagnosed. Additionally, moderate primary mitral regurgitation (effective regurgitant orifice area 20 mm<sup>2</sup>), moderate secondary tricuspid regurgitation, and moderate post-capillary pulmonary hypertension (estimated systolic pulmonary artery pressure 57 mm Hg) were present. Left ventricle was dilated (end-diastolic volume index 71 mL/m<sup>2</sup>) with preserved EF 66% and the right ventricle was dilated (basal diameter of 4.4 cm) with reduced systolic function (fractional area change 29%). Coronary angiography showed non-obstructive coronary atherosclerosis with no restenosis of the stent in the right coronary artery. Laboratory tests showed greatly elevated pro brain natriuretic peptide (BNP) levels (30 986 ng/L, normal values for patients age < 738 ng/L), stable chronic kidney disease with a glomerular filtration rate of 35 mL/min, normocytic anaemia due to intravascular haemolysis (haemoglobin 84 g/L, mean corpuscular volume 101 fL), and pathologic hepatic enzymes attributed to liver congestion.

With EuroSCORE 2 of 21.98% and STS risk score of 16.77%, the patient was deemed a high-risk surgical candidate and the combined team of cardiovascular surgeons and cardiologists decided that ViV



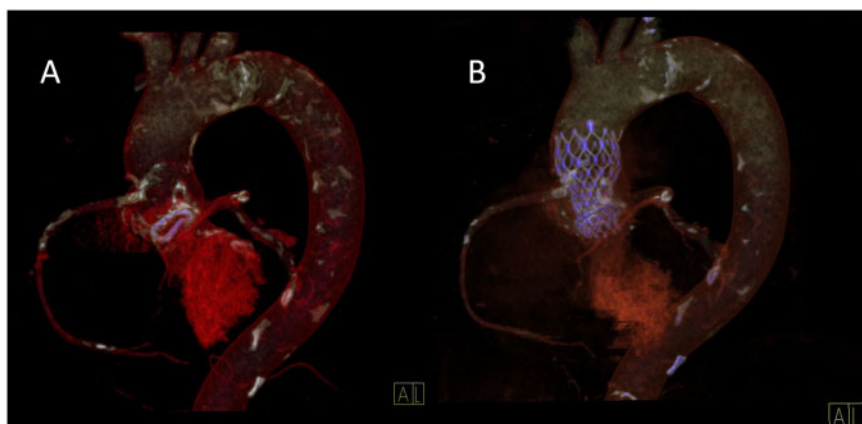
**Figure 1** Evaluation of bioprosthesis function with continuous-wave Doppler echocardiography before transcatheter aortic valve implantation (A), before bioprosthetic valve fracture (B), and after bioprosthetic valve fracture (C).

TAVI was the preferred treatment option. In order to prevent patient-prosthesis mismatch due to a very small aortic bioprosthesis (true inner diameter of the Mitroflow 19 mm valve reported by industry is 15.4 mm<sup>8</sup>) we decided to perform BVF as a part of TAVI procedure.

Since this was the first BVF procedure in our centre, to get hands-on experience we first performed an *ex vivo* simulation of the BVF. We used a Mitroflow 23 mm bioprosthesis (the smallest available size in our centre at that time) and a 22 mm non-compliant Atlas Gold balloon (Bard, USA). Bioprosthetic valve fracture was achieved at a pressure of 14 atm (Supplementary material online, Video S1) and could be felt by the operator as a sudden drop in the balloon pressure. The inspection of the prosthesis revealed a single fracture of the silicone ring. We also determined the burst pressure for the Atlas Gold balloon, which was achieved at a pressure of 32 atm (Supplementary material online, Video S2). Rupturing caused a formation of a tiny hole in the distal part of the balloon.

We proceeded with TAVI using right femoral approach. Without pre-dilation, an Evolut R 23 mm (Medtronic, USA) transcatheter valve was implanted in the degenerated 19 mm Mitroflow

bioprosthesis. We targeted high implantation to enhance supra-annular position of the leaflets. Mean transvalvular pressure gradient with transoesophageal echocardiography immediately after transcatheter valve deployment was 30 mmHg due to suboptimal valve leaflet opening (Figure 1B). To fracture the Mitroflow silicone ring and achieve optimal prosthesis deployment we performed a post-dilation using Atlas Gold 22 mm balloon. At a 12 atm of pressure, a sudden drop of pressure was felt by the operator and an increase of annular size was observed on fluoroscopy (Supplementary material online, Videos S3 and S4). Mean transvalvular gradient dropped to 12 mmHg (Figure 1C). Minimal paravalvular regurgitation was observed (Supplementary material online, Video S5). We confirmed good position of the TAVI prosthesis with computed tomography 4 days after the procedure (Figure 2). The post-procedural stay was uneventful and the patient left the hospital 7 days later with major improvement in clinical status. Six months after procedure the patient was feeling good and reported no symptoms of heart failure (Class I functional capacity according to New York Heart Association). Serum proBNP concentration dropped to 8847 ng/L.



**Figure 2** Computed tomography reconstructions of aortic bioprostheses. (A) A Mitroflow 19 mm annulus is painted in violet. (B) An Evolut R 23 mm frame inside of a Mitroflow 19 mm annulus (both painted in violet).

## Discussion

In the presented case, we have demonstrated a successful ViV TAVI in a failed small surgical aortic bioprosthesis. By combining BVF with implantation of an oversized supra-annularly positioned self-expandable transcatheter valve, we have achieved excellent haemodynamic and clinical result.

Recently, BVF has been increasingly used to overcome patient-prosthesis mismatch after ViV TAVI in small surgical aortic bioprostheses.<sup>9</sup> According to the bench testing, all bioprostheses without metal frame and some with metal frame are feasible for BVF.<sup>6</sup> Successful BVF and ViV TAVI in a degenerated Mitroflow bioprosthesis has shown to be feasible with balloon- and self-expandable transcatheter valves.<sup>6,7,10–14</sup> However, most authors have reported to implant a moderately oversized transcatheter valve (1–2 mm larger than the outer diameter of the surgical bioprosthesis).<sup>6,9–12</sup> In contrast, we have chosen a prosthesis with a 4 mm larger outer diameter and 7.6 mm larger (49% device annular sizing ratio) than the true inner diameter of the surgical bioprosthesis. We had extensive discussion in the heart team prior to the procedure about the optimal transcatheter bioprosthesis size. Despite the possibility of potential annular damage, the arguments for the Evolut R 23 mm bioprosthesis prevailed. First, we tried to avoid the potential patient-prosthesis mismatch with a smaller valve. Furthermore, the first implanted surgical aortic bioprosthesis in 2007 was a 23 mm size, which reassured us that the patient could tolerate greater transcatheter valve. Finally, by being a high-volume TAVI centre we have substantial experience with ViV procedures. The supra-annular design of the self-expandable valve as well as high implantation was crucial to allow successful implantation with adequate leaflet opening and closure. Importantly, our case is one of the first in the literature to show that BVF of a Mitroflow 19 mm surgical aortic bioprosthesis and ViV TAVI with markedly oversized self-expandable transcatheter valve is feasible.<sup>13</sup>

While the optimal timing of BVF is unknown recently published bench testing showed that BVF performed after vs. before TAVI is associated with superior prosthesis expansion and lower residual transvalvular gradients with certain balloon- and self-expandable transcatheter valves.<sup>10</sup> However, in the same study the Evolut R transcatheter valve showed similar hydrodynamic performance irrespective of the BVF timing.<sup>10</sup> We decided to first implant the transcatheter valve and subsequently performed BVF mainly to reduce the chance of intermittent severe aortic regurgitation.

Finally, we have demonstrated how BVF can be safely and successfully introduced as a new method in a centre. The *ex vivo* BVF simulation was a very important step for gaining operator hands-on experience with the technique and we recommend it as an essential step when introducing the new method.

## Conclusions

The presented case demonstrates that BVF together with ViV TAVI is a safe and effective emerging technique for treatment of failure of certain types of small surgical aortic bioprostheses. Bioprosthetic valve fracture allows marked oversizing of implanted self-expandable transcatheter aortic valves, leading to excellent haemodynamic and

clinical results. An *ex vivo* BVF can serve as an important preparatory step when introducing the new method.

## Lead author biography



Matjaz Bunc is an internationally renowned expert in the field of cardiology, research, and education. He is a head of interventional cardiology UKC Ljubljana, president of the working group for interventional cardiology of Slovenian Society of Cardiology. He is an expert in the structural heart disease (TAVI, Mclip, PV leaks, CFR) and coronary interventions (CTO). He is a faculty,

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## Supplementary material

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

## Acknowledgements

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**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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