


# Transcatheter aortic valve implantation with a balloon-expandable prosthesis in a patient with single coronary artery: a case report

Makoto Furugen <sup>1\*</sup>, Azusa Furugen<sup>1</sup>, Kenji Yamazaki<sup>2</sup>, and Hirosato Doi<sup>2</sup>

<sup>1</sup>Division of Cardiovascular Medicine, Hokkaido Cardiovascular Hospital, 1-30 South27 West13, Chuo-ku, Sapporo City 064-8622, Japan; and <sup>2</sup>Division of Cardiovascular Surgery, Hokkaido Cardiovascular Hospital, 1-30 South27 West13, Chuo-ku, Sapporo City 064-8622, Japan

Received 10 November 2021; first decision 8 December 2021; accepted 29 April 2022; online publish-ahead-of-print 3 May 2022

## Background

Single coronary artery is a rare coronary artery anomaly with an incidence of <0.03%. The coexistence of coronary artery anomalies with severe aortic stenosis is extremely rare. Due to the singularity of the coronary artery orifice, the most concerning risk of transcatheter aortic valve implantation (TAVI) in such patients is coronary occlusion, which may very well be life-threatening.

## Case summary

An 83-year-old female complaining of chest pain was referred to our hospital for severe aortic stenosis. The multi-slice computed tomography showed a congenital single coronary artery originating from the right sinus of Valsalva. The left coronary artery branched off of the right coronary artery, and passed between the aorta and main pulmonary artery. The heart team of the hospital decided to perform TAVI via femoral artery with a balloon-expandable prosthesis, with coronary angioplasty devices on standby in case of coronary occlusion. The TAVI procedure was performed successfully without coronary occlusion.

## Discussion

Although there have been some case reports of TAVI in patients with single coronary artery, little is known about the safety of TAVI in such cases, and which device (such as the balloon-expandable or the self-expandable prosthesis) is preferable. From this particular case, and accumulation of past and various TAVI experience, the balloon-expandable prosthesis can be a safe device choice in carefully selected patients with coronary artery anomalies.

## Keywords

Case report • Coronary anomaly • Aortic stenosis • Transcatheter aortic valve implantation

## ESC curriculum

3.1 Coronary artery disease • 4.2 Aortic stenosis

## Learning points

- Although coronary anomalies in younger patients are detected earlier in life or result in sudden cardiac death, they are often incidentally detected in elder patients in tandem with heart disease other than coronary artery disease.
- Transcatheter aortic valve implantation can be performed safely by careful selection of patients with coronary artery anomalies.
- For safe procedure of transcatheter aortic valve implantation, a detailed analysis of anatomical features of the aortic valve complex is crucial.

\* Corresponding author. Tel: +81 11 563 3911, Email: [m-furugen@hokujun.or.jp](mailto:m-furugen@hokujun.or.jp)

Handling Editor: Farshad Farouzandeh

Peer-reviewers: Omar Abdelfattah, Mohammed Al-Hijjio, and A Shaheer Ahmed

Compliance Editor: Sara Monosilio

Supplementary Material Editor: Ayshe Djahit

© The Author(s) 2022. Published by Oxford University Press on behalf of the European Society of Cardiology.

This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial License (<https://creativecommons.org/licenses/by-nc/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact [journals.permissions@oup.com](mailto:journals.permissions@oup.com)

## Introduction

Around 0.8–1.3% of patients present with coronary artery anomalies, among whom those having a single coronary artery are especially rare, with an incidence rate of 0.015%.<sup>1</sup> Younger patients with these anomalies exhibit exertional syncope, myocardial infarction, exercise-induced arrhythmias and cardiac arrest, whereas older patients are usually asymptomatic.<sup>1</sup> The coexistence of coronary artery anomaly and severe aortic stenosis (AS) is extremely rare. However, with the widespread use of transcatheter aortic valve implantation (TAVI), several publications have been available on coronary artery anomalies in patients with severe AS treated with TAVI.<sup>2–6</sup> We herein report a patient with a single coronary artery originating from the right sinus of Valsalva (SOV) and severe AS who had been successfully treated using a balloon-expandable (BE) prosthesis.

## Timeline

2 weeks before admission	Admitted to a regional hospital due to chest pain and diagnosed with aortic stenosis.
Day 1	Admitted for examination of aortic stenosis. Transthoracic echocardiography showed normal left ventricular systolic function, and aortic stenosis with peak velocity of 3.8 m/s and mean pressure gradient over aortic valve of 36.5 mmHg.
Day 2	Computed tomography (CT) scan of the heart showed a single coronary artery from the right sinus of Valsalva. Left coronary artery (LCA) passed between the aorta and the pulmonary artery. The CT scan also showed calcified aortic valve.
Day 4	Transoesophageal echocardiography showed calcification and limitation of motion in each leaflet and planimetry of anatomical aortic valve area of 0.47 cm <sup>2</sup> /m <sup>2</sup> , which led to diagnose as severe aortic stenosis.
Day 6	Our heart team decided on TAVI with transfemoral approach. The heart team selected a 23 mm SAPIEN 3 while placing a 0.014" angioplasty guidewire with an angioplasty balloon in the LCA for coronary artery protection during TAVI. The heart team discussed bail out strategies for coronary occlusion, prior to this procedure. Conversion to surgical procedure would be necessary immediately following coronary angioplasty to stabilize systemic haemodynamics. In that scenario, the native right cusp leaflet, which would be occluding the coronary artery orifice, would have been removed via a small incision in the ascending aorta, to relieve the coronary obstruction.

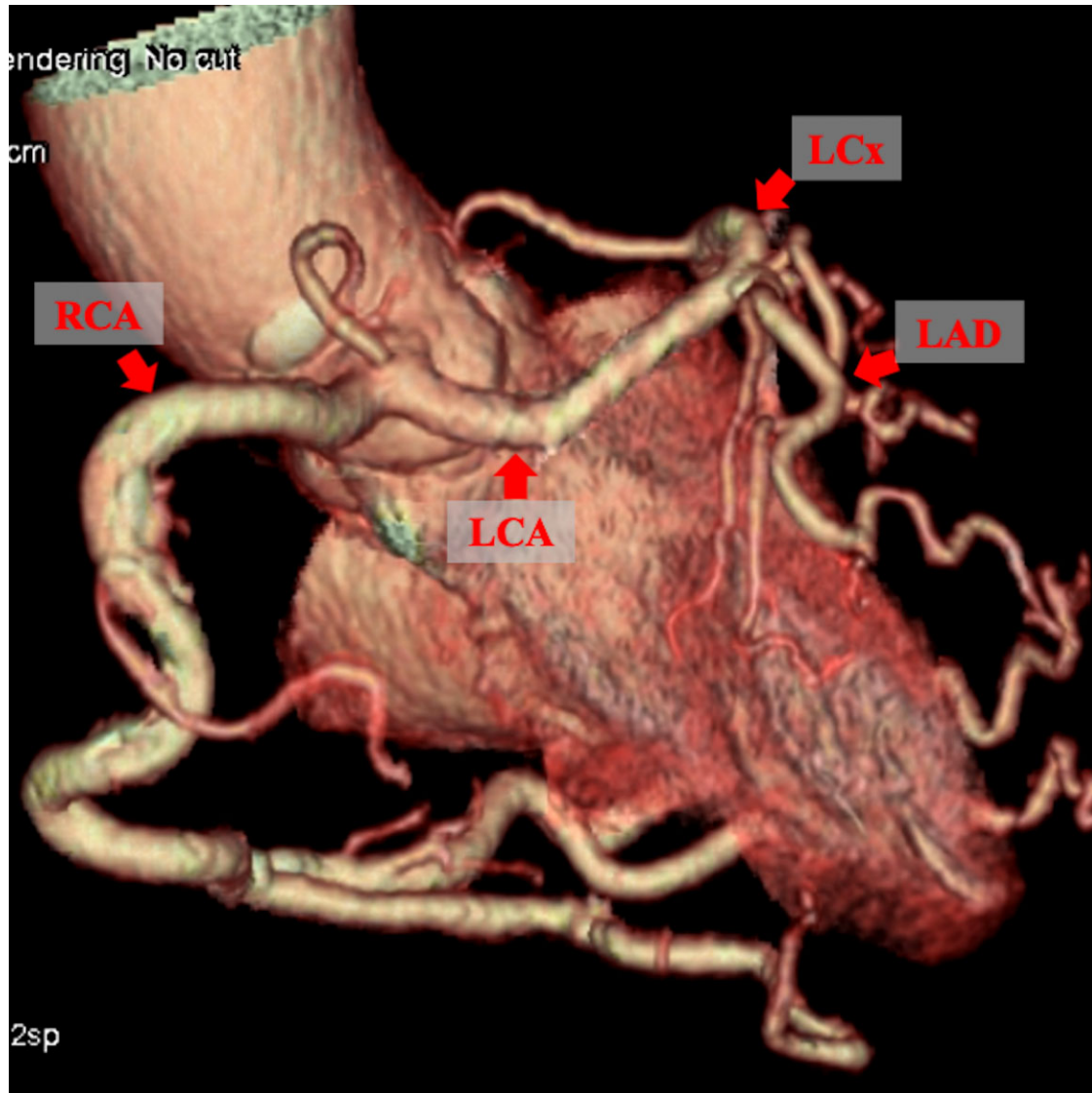
Day 12	The TAVI was performed successfully with SAPIEN 3 underfilled of 2cc with placing a 0.014" angioplasty guidewire and an angioplasty balloon in the LCA to serve as protection for the left main artery.
3 months after discharge	She was able to make her own outpatient visit. The transthoracic echocardiography showed peak velocity of 2.0 m/s, mean pressure gradient over aortic valve of 8.1 mmHg, and effective orifice area of 0.93 cm <sup>2</sup> /m <sup>2</sup> .

## Case presentation

An 83-year-old female presented with recurrent chest pain without any episode of syncope or exertional dyspnoea. Her medical history included hypertension and diabetes. Her physical examination findings were as follows: pulse rate, 78 b.p.m.; blood pressure, 122/70 mmHg; oxygen saturation, 98% in room air; systolic ejection murmur at Levine Grade III/VI; and no rales or crackles in the lung field. Transthoracic echocardiography revealed severe degenerative AS. The peak velocity was 3.8 m/s, the mean pressure gradient over the aortic valve was 36.5 mmHg, the aortic valve area was 0.59 cm<sup>2</sup>/m<sup>2</sup>, with a preserved global ejection fraction of 76.0%, and the indexed stroke volume was 45 mL/m<sup>2</sup>. Transoesophageal echocardiography showed calcification and limitation of motion in each leaflet and planimetry of anatomical aortic valve area of 0.47 cm<sup>2</sup>/m<sup>2</sup> (see [Supplementary material online, Video S1](#)). The patient had a low flow rate of 180 mL/s. Thus, the patient was diagnosed with normal-flow low-gradient severe AS. Cardiac computed tomography showed that the entire left coronary artery (LCA) ectopically originated from the right SOV and that the orifice shared a common ostium with the right coronary artery (RCA; [Figure 1](#)). The LCA passed between the aorta and the main pulmonary artery before its anatomically correct bifurcation into the left anterior descending artery and left circumflex artery. All branches of the single coronary artery were free of significant atherosclerosis. The aortic annulus to coronary ostium distance was 12.9 mm, and the right sinus width was 26.5 mm ([Figure 2](#)). Given that the patient was an octogenarian with a vulnerable status according to the Canadian Study of Health and Ageing Clinical Frailty Scale, our heart team decided on TAVI via the transfemoral approach. The team selected a 23 mm SAPIEN 3 while placing a 0.014 inch angioplasty guidewire and balloon in the LCA for coronary artery protection during TAVI. The surgery was performed successfully without any coronary obstruction or significant perivalvular leakage ([Figure 3](#), see [Supplementary material online, Video S2](#)). Concomitant selective coronary angiogram through SAPIEN 3 showed coronary artery patency ([Figure 3B](#)). The post-procedural course was uneventful, and the patient was discharged on day 7 and has since been asymptomatic without vasodilators or beta-blockers.

## Discussion

Fatal coronary obstruction remains the most catastrophic complication during TAVI in patients with AS with an anomalous single

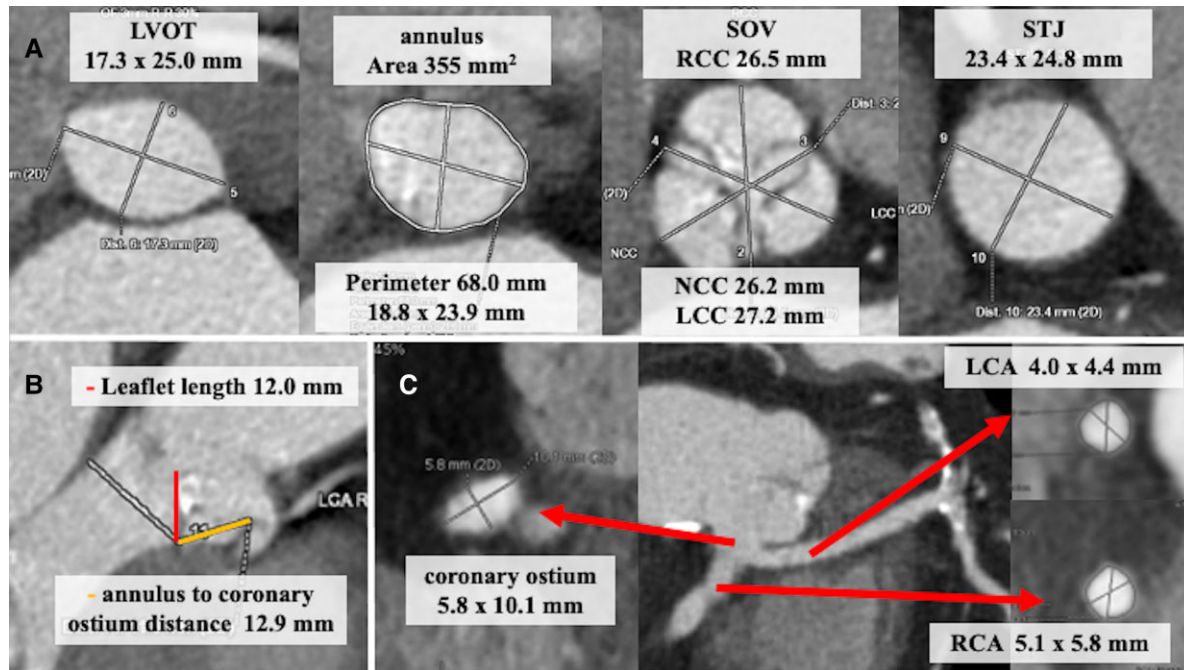


**Figure 1** Cardiac computed tomography of the single coronary artery originating from the right coronary cusp. RCA, right coronary artery; LCA, left coronary artery; LAD, left anterior descending artery; LCx, left circumflex artery.

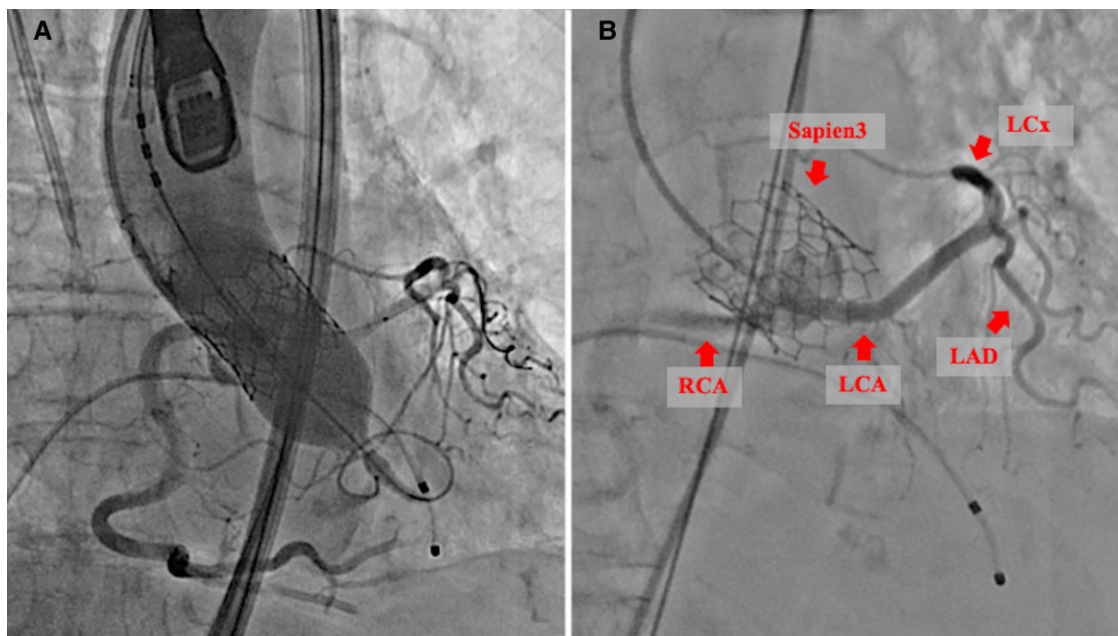
coronary artery. In fact, some case reports have described the use of SAPIEN-XT (Edwards Lifesciences, Irvine, CA, USA) or CoreValve (Medtronic, Minneapolis, MN, USA)<sup>2-7</sup> in similar cases. Accordingly, Dursun *et al.*<sup>4</sup> reported that the self-expandable (SE) valve might be advantageous over the BE valve given its recapturable property to avoid coronary obstruction during the procedure. In our case, however, the SOV (*Figure 2A*) was not large enough for the implantation of a 26 mm Evolut, which could be selected for those with an annulus perimeter of  $\geq 62.8$  mm. In cases using the BE prosthesis, prosthesis oversizing should be minimized to avoid coronary compression considering the report by Sorbets *et al.*<sup>3</sup> showing that a 1:1 ratio seemed reasonable. Given that the annulus area in this case was approximately 355 mm<sup>2</sup> (*Figure 2A*), we decided on a 23 mm SAPIEN 3 with underfilling. Although the necessity of

coronary protection intervention might be controversial, our heart team decided to pre-emptively place coronary angioplasty devices to quickly address any concomitant coronary occlusion should it occur during TAVI. The most important points when using the BE prosthesis, especially in patients with a single coronary orifice, are careful patient selection and accurate imaging analysis.

Recently, head-to-head comparisons of SE and BE valves have been published. France's nationwide registry reported that the BE valve promoted a significantly lower rate of all-cause mortality, cardiovascular mortality, and re-hospitalization for heart failure compared with the SE valve.<sup>8</sup> However, the SOLVE-TAVI and CHOICE trials with follow-up periods of 30 days and 5 years, respectively, reported no statistically significant difference.<sup>9,10</sup> As such, the pertinent question regarding which valve is the best for



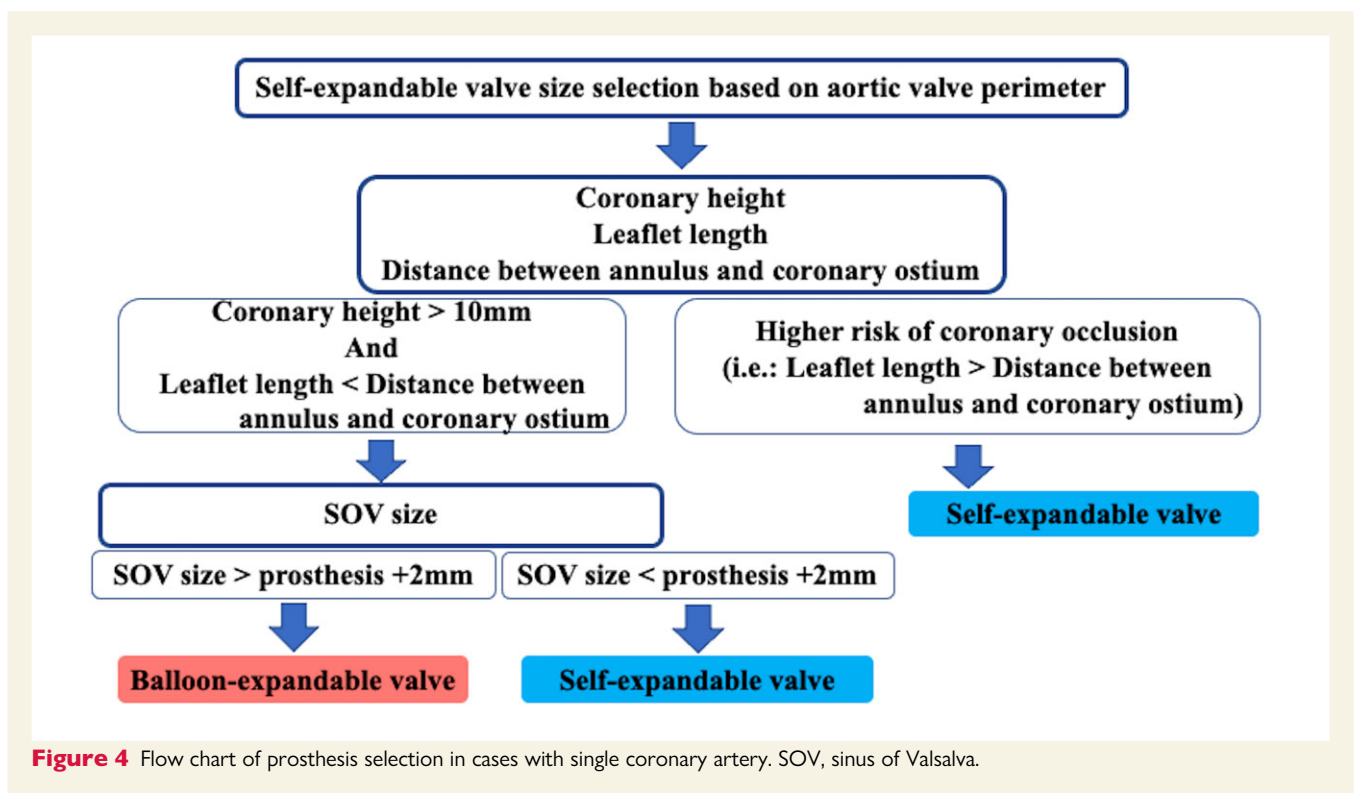
**Figure 2** Computed tomography data of the aortic complex (A) and coronary artery (B and C). The sinus of Valsalva and sinotubular junction were anatomically small for the annulus size. The coronary height was sufficient for transcatheter aortic valve implantation. No heavy calcification was noted on the leaflet tips. In the case of coronary occlusion during transcatheter aortic valve implantation, the coronary orifice was too large to treat solely with coronary intervention. RCC, right coronary cusp; LCA, left coronary artery; LCC, left coronary cusp; LVOT, left ventricular outflow tract; NCC, non-coronary cusp; SOV, sinus of Valsalva; STJ, sinotubular junction.



**Figure 3** (A) Aortic root angiography during SAPIEN 3 deployment. (B) Selective coronary angiogram through SAPIEN 3. RCA, right coronary artery; LCA, left coronary artery; LAD, left anterior descending artery; LCx, left circumflex artery.

**Table 1** Pros and cons of the self-expandable and balloon-expandable valves in single coronary artery cases

	Pros	Cons
Self-expandable valve	<ul style="list-style-type: none"> <li>Recapturable, allowing accurate device positioning</li> <li>Supra-annular leaflet function, associated with better haemodynamics</li> </ul>	<ul style="list-style-type: none"> <li>Valve size limitation due to the anatomical characteristics of the aortic valve complex</li> <li>Higher rate of atrioventricular conduction disturbance</li> <li>Difficult access to the coronary artery post-TAVI</li> </ul>
Balloon-expandable valve	<ul style="list-style-type: none"> <li>Precise valve positioning</li> <li>Lower rate of atrioventricular conduction disturbance</li> </ul>	<ul style="list-style-type: none"> <li>Potential risk of patient–prosthesis mismatch in cases of smaller valve size (e.g. SAPIEN 3 20 mm/23 mm)</li> </ul>



each patient remains unanswered.<sup>11</sup> *Table 1* summarizes the pros and cons of the SE and BE valves. However, *Table 1* only presents the available platforms in Japan: SAPIEN 3 for the BE valve and Evolut family for the SE valve. Although the BE valve can be deployed precisely, the retrievable SE valve may be advantageous to recover during intra-procedural coronary obstruction. After weighing the options for single coronary artery cases, we believe that SE valves should be the primary choice. However, in cases with small SOV or lower risk of coronary obstruction, BE valves can be viable (*Figure 4*).

The heart team discussed bailout strategies for coronary occlusion prior to TAVI. In our case, the RCA and LCA shared a common ostium, which was  $5.8 \times 10.1$  mm (*Figure 2C*). Coronary balloon angioplasty would only partially improve coronary flow, and coronary stents were unsuitable due to the exceedingly high risk for

incomplete apposition. Therefore, to stabilize systemic haemodynamics, conversion to surgical procedure would be necessary immediately following coronary angioplasty. In this scenario, the native right cusp leaflet, which would be occluding the coronary artery orifice, would have been removed via a small incision in the ascending aorta to relieve the coronary obstruction.

## Conclusion

Considering the small number of cases, the safety of TAVI in patients with anomalous coronary arteries remains unclear. Although the SE valve seems advantageous to avoid coronary obstruction, the BE valve could be safely delivered in carefully selected patients with anomalous coronary arteries originating from the right SOV.

## Lead author biography



Makoto Furugen, MD, PhD is a graduate of Sapporo Medical University in Japan. After mastering his specialty in Miyazaki Medical Association Hospital, he is currently chief of the Structural Heart Disease Center at Hokkaido Cardiovascular Hospital.

## Supplementary material

Supplementary material is available at *European Heart Journal – Quality of Care and Clinical Outcomes* online.

**Slide sets:** A fully edited slide set detailing these cases 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 guidelines.

**Conflict of interest:** None declared.

**Funding:** None declared.

## References

1. Yamanaka O, Hobbs RE. Coronary artery anomalies in 126,595 patients undergoing coronary arteriography. *Cathet Cardiovasc Diagn* 1990;**21**:28–40.
2. Giri J, Szeto WY, Bavaria J, Herrmann HC. Transcatheter aortic valve replacement with coronary artery protection performed in a patient with an anomalous left main coronary artery. *J Am Coll Cardiol* 2012;**60**:e9.
3. Sorbets E, Choby M, Tchetché D. Transcatheter aortic valve implantation with either coreValve or SAPIEN XT devices in patients with a single coronary artery. *J Invasive Cardiol* 2012;**24**:342–344.
4. Dursun H, Gönencez JZ, Karabay Ö, Erdal AC, Kaya D. TAVI in a patient with single coronary artery: the choice of self-expandable valve may be reasonable. *Balkan Med J* 2016;**33**:357–359.
5. Weich H, Ackermann C, Viljoen H, Van WJ, Mabin T, Doubell AF. Transcatheter aortic valve replacement in a patient with an anomalous origin of the right coronary artery. *Catheter Cardiovasc Interv* 2011;**78**:1013–1016.
6. Mennuni MG, Pagnotta P, Presbitero P. Percutaneous aortic valve implantation in severe stenosis associated with anomalous origin of the circumflex coronary artery. *Eur. Heart J* 2011;**32**:1687.
7. Marcucci M, Fogante M, Schicchi N, Agliata G, Giovagnoni A. Rare malignant anomalous right coronary artery incidentally detected by dual source computed tomography angiography in an adult referred for transcatheter aortic valve implantation. *Radial Case Reports* 2021;**16**:3481–3484.
8. Deharo P, Bisson A, Herbert J, Lacour T, Saint EC, Grammatico-Guillon L, Porto A, Collart F, Bourguignon T, Cuisset T, Fauchier L. Impact of Sapien 3 balloon-expandable versus Evolut R self-expandable transcatheter aortic valve implantation in patients with aortic stenosis: data from a nationwide analysis. *Circulation* 2020;**260**:260–268.
9. Thiele H, Kurz T, Feistritz HJ, Stachel G, Hartung P, Eitel I, Marquetand C, Nef H, Doerr O, Lauten A, Landmesser U, Abdel-Wahab M, Sandri M, Holzhey D, Borger M, Ince H, Öner A, Meyer-Saraei R, Wienbergen H, Fach A, Frey N, König IR, Vonthein R, Rückert Y, Funkat AK, de Waha-Thiele S, Desch S. Comparison of newer generation self-expandable vs. balloon-expandable valves in transcatheter aortic valve implantation: the randomized SOLVE-TAVI trial. *Eur Heart J* 2020;**41**:1890–1899.
10. Abdel-Wahab M, Landt M, Neumann FJ, Massberg S, Frerker C, Kurz T, Kaur J, Toelg R, Sachse S, Jochheim D, Schäfer U, El-Mawardi M, Robinson DR, Richardt G. 5-Year outcomes after TAVR with balloon-expandable versus self-expanding valves: results from the CHOICE randomized clinical trial. *JACC Cardiovasc Interv* 2020;**13**:1071–1082.
11. Webb J, Wood D, Sathanathan J, Landes U. Balloon-expandable or self-expandable transcatheter heart valves. Which are best? *Eur Heart J* 2020;**41**:1900–1902.