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CASE REPORT
Coronary heart disease

Aortic root rupture during balloon-expandable transcatheter aortic valve replacement in a patient without recognized risk factors for aortic root rupture: a case report

Masaki Tsuda , Isamu Mizote*, Takashi Mukai, and Yasushi Sakata

Department of Cardiovascular Medicine, Osaka University Graduate School of Medicine, 2-2 Yamada-oka, Suita 565-0871, Japan

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Background Aortic root rupture is a severe complication of balloon-expandable transcatheter aortic valve replacement (TAVR). Although previous studies have revealed several risk factors for this complication, predicting this complication is occasionally difficult.

Case summary A 78-year-old male patient underwent TAVR via a transfemoral approach using a 29-mm balloon-expandable valve. No recognized risk factors for aortic root rupture existed in pre-procedural multi-detector computed tomography (MDCT) analysis. However, after the valve deployment, sudden haemodynamic collapse occurred. Transoesophageal echocardiography revealed pericardial effusion, which led to an immediate diagnosis of cardiac tamponade following aortic root rupture. Following pericardial drainage via a subxiphoid approach, the haemodynamics were immediately stabilized. After 10 days of close observation, the patient was discharged on Day 39 without additional problems. He was still alive at the 6-month follow-up without sequelae.

Discussion Established risk factors for aortic root rupture include >20% area oversizing, bicuspid aortic valve, small annulus (<20 mm), shallow sinus of Valsalva (SOV) compared with the aortic annulus, and massive annular or subannular calcification. Our patient did not have any of the recognized risk factors for aortic root rupture, suggesting the existence of other factors. Pre-procedural MDCT showed a flat calcification orthogonal to the aortic root wall, and post-procedural MDCT revealed that this calcification penetrated the SOV with extravasation. Thus, we suggest that a flat calcification orthogonal to the aortic root wall might be an additional risk factor for aortic root rupture.

Keywords Case report • Aortic stenosis • TAVR • Calcification • Complication • Computed tomography

Learning points

- Aortic root rupture can occur without recognized risk factors for this complication, especially in balloon-expandable transcatheter aortic valve replacement.
- A flat calcification orthogonal to the aortic root wall might be an additional risk factor for aortic root rupture.
- A mismatch between the annular diameter and the minimum diameter at the level where a flat calcification exists might be helpful for detecting aortic root rupture.

* Corresponding author. Tel: +81-6-6879-3640, Fax: +81-6-6879-3639, Email: i-mizote@cardiology.med.osaka-u.ac.jp

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Introduction

Aortic root rupture is a life-threatening complication of balloon-expandable transcatheter aortic valve replacement (TAVR).[1] Currently, multi-detector computed tomography (MDCT) is usually performed before TAVR, and it provides a clearer understanding of the aortic root. Previous studies have revealed several risk factors for aortic root rupture, such as >20% area oversizing, a bicuspid aortic valve, a small annulus (<20 mm), a shallow sinus of Valsalva (SOV) compared with the aortic annulus, and massive annular or subannular calcification.[2–4] However, aortic root rupture still occurs in ~1% of all TAVR procedures,[3] suggesting the existence of unknown risk factors for aortic root rupture.

Timeline

Day	Events
0	The patient underwent transcatheter aortic valve replacement with a balloon-expandable valve, and aortic root rupture occurred just after valve deployment. Conservative therapy was performed and the patient's haemodynamics were stabilized
0–7	The patient was sedated and placed under close observation. A respirator was applied
7	Computed tomography (CT) showed no re-rupture and pseudoaneurysm in the patient's aortic root
8	Extubation was performed
14	Repeat CT showed no re-rupture and pseudoaneurysm in the patient's aortic root, and anticoagulant therapy using warfarin was started
39	The patient was discharged in a stable condition
180	The patient was alive without sequelae, and valve performance was maintained. Repeat CT showed no re-rupture and pseudoaneurysm in the patient's aortic root.

Case presentation

A 78-year-old male patient with a history of hypertension, paroxysmal atrial fibrillation, and symptomatic severe aortic stenosis was scheduled to undergo surgical aortic valve replacement (SAVR) at another hospital. However, he was diagnosed with cold agglutinin disease during the preoperative examination, which led to a change in the plan to perform SAVR. He was referred to our hospital for TAVR. His cardiac symptom was shortness of breath, classified as New York Heart Association Class III. On physical examination, he had normal respiratory sounds, a systolic ejection murmur, and slight leg oedema. Electrocardiography revealed a normal sinus rhythm, normal axis deviation, and left ventricular hypertrophy. Chest radiography showed mild cardiomegaly and mild pulmonary congestion without pleural effusion. Transthoracic echocardiography showed a mildly reduced left ventricular ejection fraction (44%) with severe aortic stenosis, a peak velocity of 4.0 m/s, a mean pressure gradient of 40 mmHg, and an aortic valve area of 0.75 cm^2. Aortic regurgitation was mild, and mitral regurgitation was moderate. All laboratory values were within the normal range except for cold agglutinin, which had a high titre value. Although his EuroSCORE II was 3.47%, our heart team considered TAVR appropriate for this patient because SAVR was considered too risky due to cold agglutinin disease with possible thrombolysis caused by hypothermia.

Pre-procedural MDCT measurements showed that the mean diameter (area derived) and area of the native annulus were 27.2 mm and 580 mm^2, respectively. No extensive calcification was detected in the aortic valve. The sizes of the left ventricular outflow tract, SOV, and sino-tubular junction were sufficiently large (*Table 1*, Supplementary material online, *Video S1*). We selected a 29-mm SAPIEN 3 valve (Edwards Lifesciences, Irvine, CA, USA) with -3 mL underfilling (12% area oversizing when the valve was deployed with a nominal volume). Transcatheter aortic valve replacement was performed under general anaesthesia. After balloon valvuloplasty with a 25-mm balloon (nominal volume), a 29-mm SAPIEN 3 valve was deployed with -3 mL underfilling (Supplementary material online, *Video S2*). After the deployment, sudden haemodynamic collapse occurred. Transoesophageal echocardiography revealed pericardial effusion, which led to an immediate diagnosis of cardiac tamponade following aortic root rupture (*Figure 1*, Supplementary material online, *Video S3*). Fluoroscopy revealed aortic leakage just above the calcification of the left SOV (Supplementary material online, *Video S4*). After pericardial drainage via a subxiphoid approach, heparin neutralization, and blood transfusion, the haemodynamics were stabilized within 15 min. No further surgical treatment was performed because of his haemodynamic stability and risk of thrombolysis caused by hypothermia due to the cold agglutinin disease. After 10 days of close observation, the patient was discharged on Day 39 without additional problems, although he required physical therapy because of muscle weakness. The patient remained alive at the 6-month follow-up without sequelae. Valve performance was maintained throughout the 6-month follow-up period despite a 2-week interruption of antithrombotic therapy due to aortic root rupture. He had received apixaban as antithrombotic therapy for paroxysmal atrial fibrillation before TAVR, but we treated him with warfarin after TAVR because the effects of apixaban are not easily adjustable and neutralizing drugs remain unavailable.

The pre-procedural MDCT showed that a flat calcification existed 4.0 mm above the aortic annulus at the 5 o'clock position (*Figure 2*). Post-procedural MDCT revealed that this calcification penetrated the left SOV with extravasation.

Discussion

We could not predict aortic root rupture in this case because we did not identify any of the risk factors described above.[2–4] In this case, a flat calcification orthogonal to the aortic root wall was detected with

Table 1 Pre-procedural computed tomography measurements of the aortic root

Annulus area (mm^2)	LVOT area (mm^2)	Sinus of Valsalva dimensions								STJ area (mm^2)
		Diameter (mm)			CV (mm^3)				CV index (mm^3/m^2)	
580	759	NCC	RCC	LCC	NCC	RCC	LCC	Total	Total	638
		32.9	30.1	32.9	398	216	245	859	479	

CV, calcium volume; LCC, left coronary cusp; LVOT, left ventricular outflow tract; NCC, non-coronary cusp; RCC right coronary cusp; STJ, sino-tubular junction.

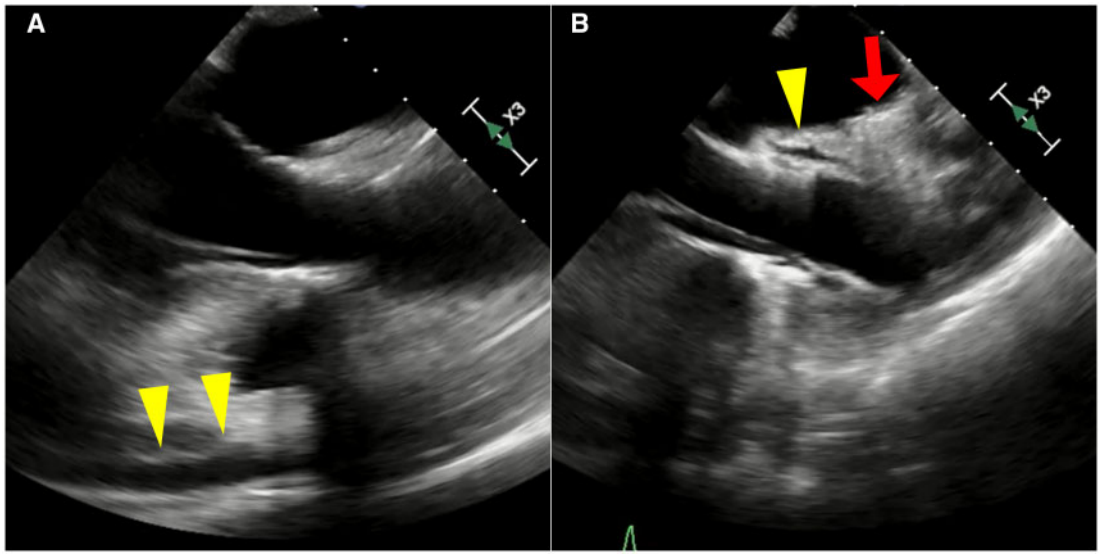


Figure 1 Transoesophageal echocardiography images immediately after valve deployment. (*A*) Pericardial effusion (yellow arrowheads). (*B*) Pericardial effusion (yellow arrowhead) and haematoma (red arrow) surrounding the aortic root.

pre-procedural MDCT. This calcification was not massive but was sharp, which could have allowed a stronger penetration force to the aortic root during balloon dilatation or valve deployment. Post-procedural MDCT showed that this calcification penetrated the SOV like an iron nail, and aortic root rupture occurred at a site other than 'the vulnerable area' where aortic rupture is known to often occur because of the absence of surrounding cardiac structures.[5] These findings suggested that this calcification was displaced out of the SOV by the valve without being folded into the SOV. Thus, a flat calcification orthogonal to the aortic root wall was considered the main cause of aortic root rupture in this case.

Predicting an aortic root rupture due to a flat calcification seems difficult because of the unpredictable movement of a calcification. Therefore, using self-expandable valves may be safer in the presence of such calcifications to avoid aortic root rupture,[4] although balloon-expandable valves were the only options available for patients with large aortic annuli (>26 mm) in Japan at that time. Indeed, no case of aortic root rupture has been recorded with self-expandable valves in over 200 cases at our institution. However, the minimum diameter between a flat calcification and the aortic root wall at the level where this calcification exists might be helpful for predicting this complication. In this case, the minimum diameter between the calcification and the aortic root wall was 22.0 mm, which was much smaller than the balloon or valve size. A mismatch between the annular diameter and minimum diameter at the level where a flat calcification exists may represent a new predictor for aortic rupture during balloon-expandable TAVR, although further research is necessary to test our hypothesis.

Moreover, our patient survived beyond 6 months without a re-rupture or pseudoaneurysm detected with MDCT, which was performed 7 days, 14 days, and 6 months after TAVR (Supplementary material online, *Figure S1*). The patient's long-term outcomes are unknown, but we will continue to follow him closely.

Conclusion

Aortic root rupture is a rare but severe complication with high mortality in balloon-expandable TAVR. Predicting aortic root rupture is occasionally difficult; however, the incidence of a flat calcification orthogonal to the aortic root wall might be an additional risk factor for

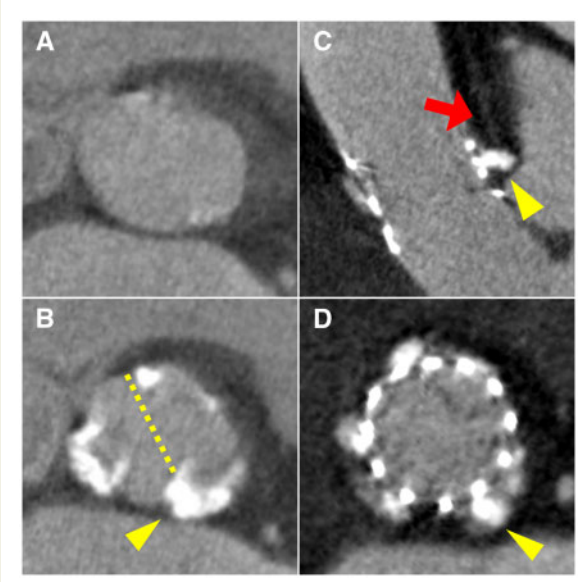
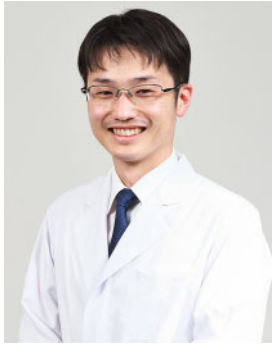


Figure 2 Computed tomography images before and after valve deployment. (*A*) Few calcifications are noted at the level of the aortic annulus. (*B*) A flat calcification is located 4.0 mm above the aortic annulus (yellow arrowhead). The yellow dotted line shows the minimum diameter between the calcification and the aortic root wall. (*C*) The flat calcification has penetrated the left sinus of Valsalva (yellow arrowhead), causing extravasation (red arrow). (*D*) Cross-sectional image at the level of the penetration. The flat calcification was displaced from the left sinus of Valsalva with a prosthesis.

aortic root rupture in balloon-expandable TAVR. Further research is required to confirm this hypothesis.

Lead author biography



Masaki Tsuda is an interventional cardiologist. He graduated from Mie University and received the M.D. degree in 2010. He worked as a staff at Department of Cardiovascular Medicine, Osaka University, Japan from 2016 to 2019. From 2019, He serves as a staff cardiologist at Osaka Rosai Hospital, Japan.

Supplementary material

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

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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 guidelines.

Conflict of interest: none declared.

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