Letter to the Editor

Detecting coronary artery obstruction by intravascular ultrasound during transcatheter aortic valve replacement

Yang Li, Bin Wang, Weiwei Zhou, Kai Xu, Yaling Han

Laboratory of Frigid Zone Cardiovascular Disease, Cardiovascular Research Institute and Department of Cardiology, General Hospital of Northern Theater Command, Shenyang, China

Correspondence to: Kai Xu, MD. Laboratory of Frigid Zone Cardiovascular Disease, Cardiovascular Research Institute and Department of Cardiology, General Hospital of Northern Theater Command, No. 83 Wenhua Rd., Shenyang 110016, China. Email: xukai2001@sina.com.

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Introduction

Despite high mortality rates and the availability of new preventive treatments (1,2), the prediction of coronary artery occlusion (CAO) associated with transcatheter aortic valve replacement (TAVR) is still unsatisfactory. During the process of transcatheter heart valve implantation, CAO occurs directly when the surgical or natural aortic valve leaflets shift outward and block the coronary artery ostia, or indirectly when the sinus of Valsalva is sequestered at the sinotubular junction (3). The detection and prevention of CAO complicating TAVR represent significant challenges in clinical practice. Computed tomography angiography (CTA) is a sensitive but non-specific predictor of CAO (4). However, it is extremely challenging to identify partial CAO without acute hemodynamic compromise and without angiographic findings of coronary flow impairment after valve implantation, especially in cases in which the self-expandable bioprosthetic valve is used. In this article, we report a case in which intravascular ultrasound (IVUS) imaging was used after TAVR to help clarify the risk of partial delayed CAO caused by the native leaflet shifting toward the sinus of Valsalva.

Case presentation

All the procedures in this study were performed in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patient for the publication of this article and any accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

A 64-year-old male patient, diagnosed with severe symptomatic aortic stenosis and coronary artery disease, was admitted to our hospital to undergo TAVR. The patient had been suffering from paroxysmal chest tightness and shortness of breath (New York Heart Association Class III) for one year. He had been experiencing increasingly severe post-exertion breathing difficulties in the past three months.

During the physical examination, the patient's pulse rate was 81 beats/minute, and his blood pressure was 90/45 mmHg. A 3/6 systolic ejection murmur was auscultated in the aortic area. Transthoracic echocardiography revealed severe calcified aortic stenosis (peak velocity =4.7 m/s; peak gradient =88 mmHg; mean transvalvular gradient =57 mmHg; estimated valve area =0.68 cm^2). Mild-to-moderate aortic, mitral and tricuspid regurgitation was observed with a left ventricular ejection fraction (LVEF) of 30% and a diastolic left ventricular diameter of 65 mm. Preoperative systolic phase reconstruction of the CTA revealed bicuspid aortic valve type 1 with right-left coronary cusp fusion and a bulky calcification in the non-coronary leaflet. Further anatomical measurements on CTA included an annular perimeter of 88.1 mm, an annular area of 582.6 mm^2, a left main (LM) coronary artery ostium height of 8.8 mm and a right coronary artery height of 14.8 mm. The sinus of Valsalva diameter was 26.8–33.6 mm. The average dimension and height of the sinotubular junction were 28.8 mm and 15.6 mm, respectively. Measured on the plane of the LM ostium, the distance of the edge of the thickened valve leaflet

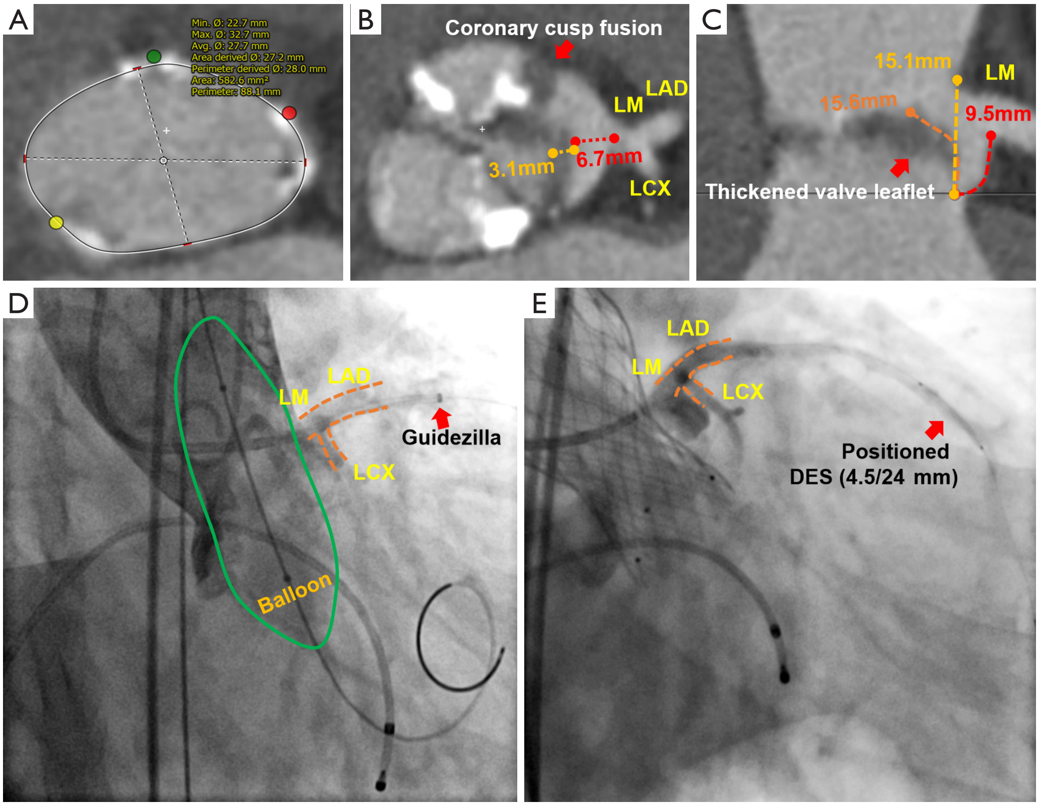

Figure 1 Risk of CAO assessed by CTA before TAVR and aortography and coronary angiography during TAVR. CTA image of the aortic annulus (A) and the plane of the LM ostium (B,C). Aortography of the aortic root during the balloon dilatation (D) and coronary angiography after TAVR (E). LAD, left anterior descending; LM, left main; LCX, left circumflex; DES, drug eluting stent; CAO, coronary artery obstruction; CTA, computed tomography angiography; TAVR, transcatheter aortic valve replacement.

(maximum thickness: 3.1 mm) to the LM ostium was 6.7 mm, which suggested a high risk of CAO (*Figure 1A-1C*). Based on the risk assessment, the patient had a Society of Thoracic Surgeons score of 2%; however, he refused surgery due to his severe frailty and poor rehabilitation potential and was thus treated with minimally invasive TAVR.

The patient received monitored anesthesia care with local anesthesia. Diagnostic coronary angiography revealed mild-to-moderate stenosis in the left anterior descending (LAD), normal LM, and left circumflex coronary artery; no stenosis was observed in the right coronary artery. Balloon pre-dilatation prior to the TAVR was performed to assess the risk of coronary occlusion using a 22 mm × 40 mm semicompliant balloon based on the annulus perimeter derived diameter. No reduced blood flow in the LM artery was observed during the balloon dilatation (*Figure 1D*); however, we still decided to implement coronary artery protection based on the CTA analysis. A 6F JL-3.5 guide catheter inserted through a transfemoral access was used to engage the LM artery, and a guiding wire of 0.014 inches was advanced to the LAD artery. A GUIDEZILLA II Guide Extension Catheter was used to disengage the guiding catheter during the valve deployment and to prevent catheter-induced LM artery ostial injury. Next, a 4.5 mm by 24 mm drug eluting stent (DES) was positioned within the proximal LAD artery. Subsequently, during rapid ventricular pacing at 180 beats/minute, a 26 mm retrievable VenusA-Plus self-expanding transcatheter valve was implanted in a satisfactory position. No CAO was observed on the contrast aortography (*Figure 1E*), nor were any signs of myocardial ischemia observed on the electrocardiogram. Traces of mild perivalvular aortic regurgitation were observed on the aortography and transthoracic echocardiography. The patient's post-TAVR blood pressure was 100/50 mmHg, and his hemodynamics were stable. The peak transvalvular gradient was 10 mmHg. However, the IVUS evaluation

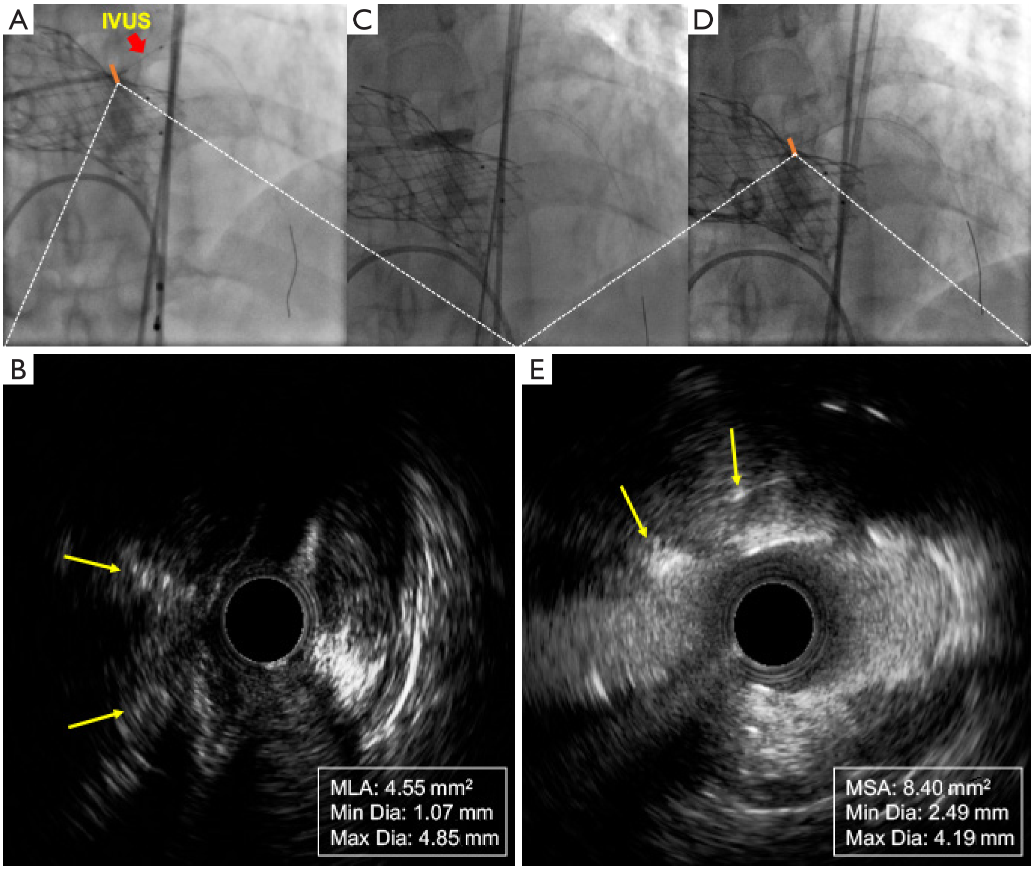

Figure 2 IVUS-guided CAO detection and stent deployment. (A,B) IVUS in the LM ostium after TAVR. (C) Stent deployment. (D,E) The final IVUS image revealed a well-expanded stent. The red arrow indicates IVUS catheter. The yellow arrows indicate the folded native leaflet. IVUS, intravascular ultrasound; MLA, minimal lumen area; Min Dia, minimal diameter; Max Dia, maximal diameter; MSA, minimal stent area; CAO, coronary artery obstruction; LM, left main; TAVR, transcatheter aortic valve replacement.

showed that the native leaflet folded toward the sinus of Valsalva causing partial CAO with a minimum lumen area of 4.55 mm^2 (*Figure 2A,2B*), which indicated a risk of delayed CAO after TAVR using a self-expanding transcatheter valve. A 4.5 mm × 24 mm DES was then implanted from the ostium of the LM artery to the sinotubular junction to improve radial force to prevent the total occlusion of the LM artery caused by the thickened valve leaflet (*Figure 2C*). The IVUS results showed good stent expansion, with a minimal luminal area and diameter of 8.40 mm^2 and 4.19 by 2.49 mm, respectively (*Figure 2D,2E*). During the six-month follow-up period, the patient showed no symptoms of paroxysmal chest tightness, shortness of breath and chest pain. The follow-up transthoracic echocardiography revealed mild perivalvular aortic regurgitation, mitral and tricuspid regurgitation with a LVEF of 65%, and a diastolic left ventricular diameter of 54 mm. The patient's cardiac function improved significantly following the TAVR.

Discussion

CAO is a rare but fatal complication after TAVR with a mortality rate of over 50% (1). The main causes of CAO include sealing the sinus of Valsalva at the sinotubular junction by long or redundant leaflets, low lying coronary ostia, and an inadequate sinus width. Acute CAO usually occurs during TAVR and is accompanied by hemodynamic instability or electrocardiogram changes (5). However, approximately 0.22% of TAVR patients may also experience subacute and late CAO, which have similar presentations to that of non-ST elevation myocardial infarction (6). The risk factors for CAO have not yet been clearly defined, seem to be multifactorial, and may include aortic root anatomy, the type of the aortic valve, and the type of the transcatheter heart valve. Often, detailed CTA assessments before TAVR, and balloon predilation and aortography during TAVR can be used to predict the risk of CAO (7). Anatomic predictors of CAO include long or redundant leaflets, severe calcification, a coronary ostia height <10 mm, a sinus of Valsalva diameter <30 mm, a leaflet length-to-sinotubular junction height ratio >1, a transcatheter valve-to-coronary ostia distance <3.0 mm, and a transcatheter valve-to-sinotubular junction distance <1.0 mm with a sinotubular junction height-leaflet length <0 mm (8,9). However, without acute hemodynamic compromise and angiographic findings of coronary flow impairment after valve implantation, it is challenging to identify partial CAO.

In this article, we report a unique case in which IVUS imaging was used to help clarify the risk of CAO and evaluate stent expansion between the valve strut and aortic leaflet. The pre-operative CTA assessment of the patient revealed a high risk of CAO. No angiographic appearance of CAO and no ischemic changes were observed on the electrocardiogram during TAVR; however, partial CAO caused by the native leaflet shifting toward the sinus of Valsalva was observed on IVUS imaging, indicating a risk of delayed CAO after TAVR using a self-expanding transcatheter valve.

In this case, the chimney stent technique was used to protect the left coronary artery. Chimney stenting and the bioprosthetic or native aortic scallop intentional laceration to prevent iatrogenic coronary artery obstruction (BASILICA) procedure are two techniques that can be used to prevent CAO after TAVR. A study titled "Chimney stenting vs BASILICA for prevention of acute coronary obstruction during transcatheter aortic valve replacement" presented at the EuroPCR 2023 showed that chimney stenting and the BASILICA procedure were equally successful at preventing CAO after TAVR (10). This case study showed that IVUS could serve as an important adjunctive tool in the prevention of partial CAO after TAVR and could improve percutaneous results and clinical outcomes. Future refinements are required to establish accurate assessments and the risk stratification of CAO using IVUS and to identify the optimal post-procedural antithrombotic strategy after TAVR with a chimney stent.

Conclusions

IVUS could serve as an important adjunctive tool to detect and prevent CAO during TAVR, especially when patients are at risk of CAO (as revealed by CTA) but there is no acute hemodynamic compromise and there are no angiographic findings of coronary flow impairment after valve implantation.

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Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://qims.amegroups.com/article/view/10.21037/qims-23-1385/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All the procedures in this study were performed in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patient for the publication of this article and any accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

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