



CASE REPORT

Case Report: Post transcatheter aortic valve replacement shock: Value of multimodal imaging [version 1; referees: 1 approved, 1 approved with reservations]

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Abstract

Complications resulting from the delayed clinical presentation of a left main coronary artery obstruction can be catastrophic. This case report presents a 73-year-old woman with severe aortic stenosis who underwent transcatheter aortic valve replacement with a core valve who, approximately 20 minutes after heparin reversal with protamine, became hypotensive and was unresponsive to vasopressor and inotropic therapy. Transesophageal echocardiography demonstrated global hypokinesis, which was highly consistent with the occlusion of the left main coronary artery. Angiography confirmed this diagnosis and demonstrated that valve positioning had not changed compared to post-placement examination. Here we report the partial covering of the ostium of the left main coronary artery by a core valve skirt that converted into a total occlusion following the initiation of heparin reversal with protamine and the value of multimodal imaging in the management of this case.

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1 Wilbert Aronow , New York Medical College USA		
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Introduction

Transcatheter aortic valve replacement (TAVR) is an increasingly popular approach for high-risk patients with severe aortic stenosis. Coronary ostium occlusion after valve implantation is a life-threatening complication that occurs in up to 0.4% of TAVR procedures despite the growing experience in performing this procedure and the constant improvements in TAVR devices^{1,2}. We report the partial occlusion of the ostium of the left coronary artery (LCA) by the skirt of the core valve that was converted into a total occlusion following the initiation of heparin reversal with protamine and the value of multimodal imaging in the management of this case.

Case report

A 73-year-old woman with severe aortic stenosis (aortic valve area 0.7 cm² and a mean gradient of 60 mmHg), preserved left ventricular (LV) systolic function, left ventricular hypertrophy, no significant coronary artery disease, and an Society of Thoracic Surgeons (STS) score of 3 presented to our institution for an aortic valve replacement (<http://tools.acc.org/TAVRRisk/>). The patient had compromised pulmonary function (FEV1 46% and DLCO 46%), and a catheter-based valve replacement was performed. Preoperative computer tomographic derived measurements demonstrated: aortic valve annulus diameter of 25 mm (major) and

20 mm (minor); coronary artery ostium distance of 18 mm (right) and 11.6 mm (left); coronary sinus diameter/height of 26/18 mm (right coronary), 28/19 mm (left coronary), 28/19 mm (non-coronary); and a moderate severe calcific valve with moderate-severe impaired leaflet excursion (Figure 1). A 26 mm Medtronic CoreValve (Medtronic, Minneapolis, MN, USA) was implanted via a right ileo-femoral approach. The patient had an uneventful valve deployment. A preoperative transesophageal echocardiography (TEE) verified a calcific, severely stenotic aortic valve with a normal left ventricular systolic function (ejection fraction 60% (Video 1 & Video 2). Deployment was facilitated using brief, temporary rapid pacing at 120 beats per minute; the patient was hemodynamically stable after valve deployment. A subsequent TEE examination revealed mild aortic paravalvular regurgitation (Video 3). A post-deployment angiography demonstrated a cephalad migration of the valve (from position 2 to -2), but coronary artery perfusion was maintained, as shown in a right anterior oblique (RAO) image (Figure 2B & Figure 3). Based on the images provided and the hemodynamic stability of the patient, the operative team was satisfied with the position of the valve and focused on repairing the femoral access site. The access site was repaired with normal flow twenty minutes after deployment as demonstrated by angiography. The decision was then made to reverse the

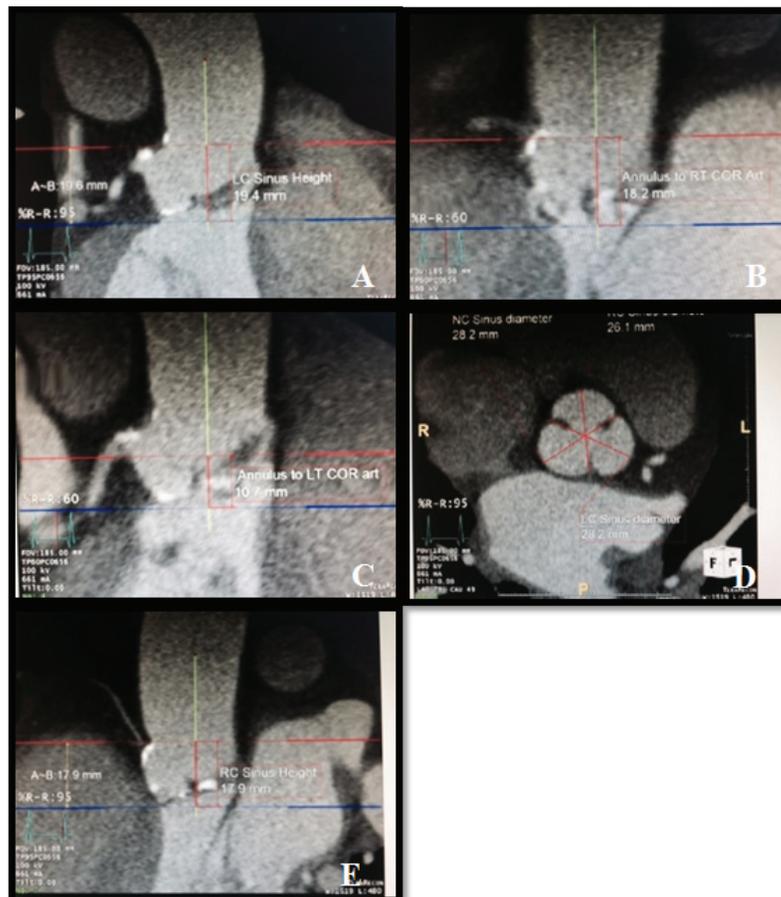


Figure 1. CT images aortic valve measurements. Preoperative measurements of the aortic valve.

anticoagulation with protamine. Shortly after the slow administration of protamine, the patient became hypotensive and unresponsive to vasopressor or inotropic therapy.

A TEE probe was emergently placed for examination and revealed normal right ventricular size and function, with global hypokinesis of the left ventricle (Video 4). These findings were consistent

with a left main coronary artery occlusion in a left dominant system patient. Cardiopulmonary bypass (CPB) was instituted as a result of hemodynamic instability, and the diagnosis of coronary occlusion was confirmed with angiography (Figure 4). Due to the position of the valve, the decision was made to refrain from coronary stent placement and to convert to an open surgical replacement of the aortic valve. After the Medtronic CoreValve was removed, the left coronary ostium was examined and determined to be patent. After the placement of a 21 mm Perimount Magna valve (Edwards Lifesciences, Irvine, CA, USA), the patient was weaned from CPB without any problems. Further TEE was performed which revealed a normal left ventricular function. The patient was extubated on postoperative day one and remained hemodynamically stable without further concerns regarding her aortic valve or coronary ischemia. On the 7th postoperative day, the patient developed

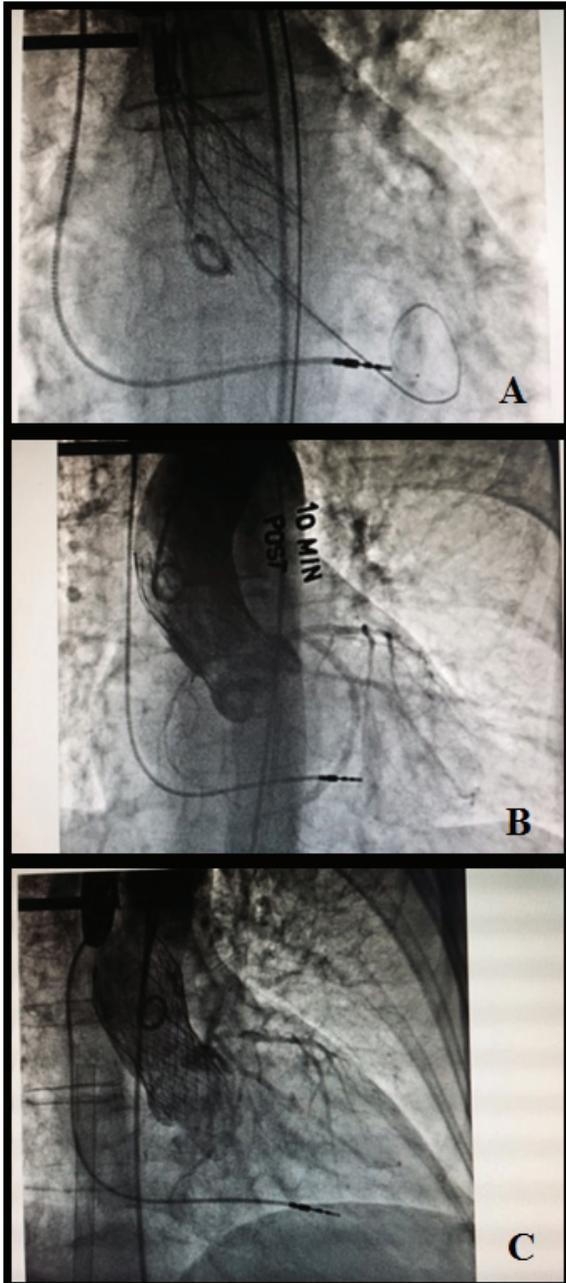


Figure 2. Images before and after deployment of the valve. **A.** Details post-deployment of core valve. **B.** RAO view of the deployed valve, detailing flow. **C.** LAO view depicting lack of flow.

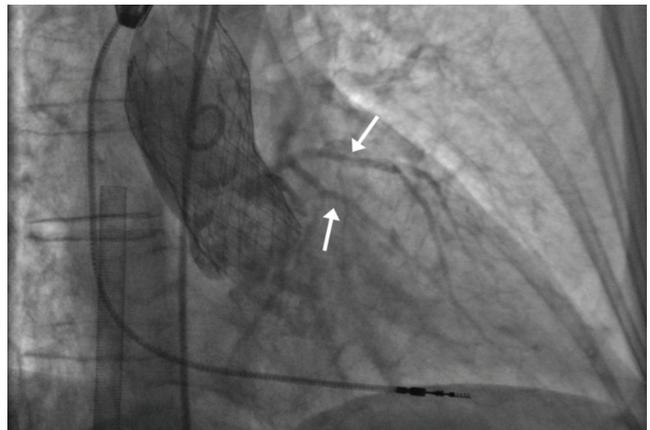


Figure 3. RAO coronary angiography. RAO coronary angiography showing flow through the left main coronary artery and branches.

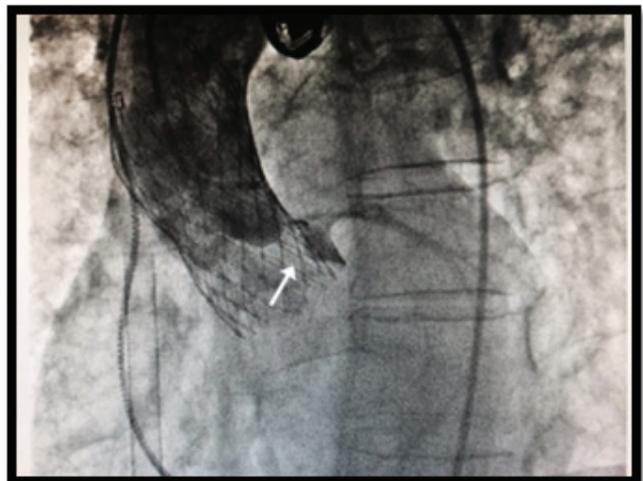


Figure 4. LAO coronary angiography. LAO coronary angiography showing lack of perfusion and stasis of blood within the left sinus of Valsalva.

complete heart block that necessitated the placement of a dual chamber permanent pacemaker. She was discharged on postoperative day eight.

TEE short axis transgastric video

1 Data File

<http://dx.doi.org/10.6084/m9.figshare.3507419.v1>

TEE aortic valve long axis color video

1 Data File

<http://dx.doi.org/10.6084/m9.figshare.3507428.v1>

TEE Post Deployment Aortic valve long axis color

1 Data File

<http://dx.doi.org/10.6084/m9.figshare.3571206.v1>

TEE four chamber video

1 Data File

<http://dx.doi.org/10.6084/m9.figshare.3507431.v1>

Discussion

TAVR is a novel approach for the treatment of high-risk patients with severe aortic stenosis, especially those deemed inoperable. Complications associated with TAVR include: (1) access related problems, including bleeding and occlusion (dissection or vascular); and (2) procedure-related problems such as cardiac tamponade, root rupture (annular or aortic), apical tears, right ventricular perforation, aortic regurgitation, coronary artery occlusion, renal failure, stroke, and conduction system disturbances requiring permanent pacemaker implantation.

Left main coronary artery occlusion after TAVR is a rare but potentially fatal complication. A complete occlusion of the left main coronary artery will manifest itself immediately; however, a partial compromise can be initially silent, such as the occlusion in our case. A partial LCA occlusion can result if calcific particles from the native aortic leaflet become displaced over the ostium while the aortic valve device is being expanded^{3,4}. Other proposed mechanisms include incorrect positioning of the valve frame (obstructive portion) directly over the coronary ostium, hematoma formation or leaflet distortion, and apposition on the LCA ostium^{5,6}. Valve design is an additional factor related to coronary obstruction⁷. Higher probabilities of occlusions occur with the balloon-expandable SAPIEN XT valve (Edwards Lifesciences, Irvine, CA, USA) than the Medtronic CoreValve⁴. This can be attributed to the hourglass-like design of the Medtronic CoreValve, which is less prone to native cusps displacement over the ostia⁴. However, a previous case has been reported using the Medtronic CoreValve that resulted in a left main coronary artery occlusion from calcium nodules³.

In our case, hemodynamic instability developed shortly after the administration of protamine. The initial working diagnosis

suggested this instability resulted from an adverse reaction to the drug. Cardiovascular reactions to protamine vary from vasodilation-related hypotension to pulmonary hypertension, with subsequent right heart failure and cardiovascular collapse⁸. While treating our patient's hypotension, which was unresponsive to vasopressors and inotropes, a TEE probe was placed and demonstrated global LV dysfunction. This observation was consistent with a LCA occlusion. Since neither right ventricular (RV) dysfunction nor indirect evidence of pulmonary hypertension were present, causality related to a severe protamine reaction was not likely.

In our case, a post-deployment coronary angiogram was done in the RAO projection and showed adequate coronary blood flow (Figure 3). Following the emergent implementation of CPB, another coronary angiography was performed in the left anterior oblique (LAO) projection and demonstrated complete cessation of flow through the left coronary ostium (Figure 4). Due to the high position (-2) of the Medtronic CoreValve, it was deemed impossible to place a stent across the occluded ostium and restore coronary blood flow in a timely fashion without lasting sequelae. Thus, the decision was made to surgically replace the calcific native valve after removing the prosthesis in place. After visualization of the valve *in situ*, it was noted that the skirt of the valve partially covered the left main coronary ostium. Due to the slightly high position of the prosthetic valve and reduced flow in the native "sinotubular reservoir", protamine administration may have facilitated the formation of small micro thrombi aggregates adherent to the prosthetic material and led to a complete coronary occlusion (Figure 5). Even though a post-deployment cephalad migration of the valve



Figure 5. Image detailing core valve. This is the image of the core valve depicting point of obstruction.

(from 2 to -2) was immediately noted and raised concern regarding a coronary occlusion, an angiogram in the ROA view demonstrated good coronary flow. The assumption was made that the valve was situated in a fashion where adequate blood flow was maintained through the cage portion of the valve and was unobstructed by the overlying curtain (Figure 3).

In retrospect, an LAO view during the coronary angiography would have been helpful to visualize the ostium of the LCA. At the time that the RAO view was performed, filling of the coronary arteries was satisfactory and the ostium itself was not clearly visualized. This angiography most likely demonstrated adequate flow through a partial obstruction. After hemodynamic deterioration, a subsequent angiography in the LAO view did visualize the ostium of the LCA (Figure 2C and Figure 4). The Medtronic CoreValve was then removed and the left coronary ostium was noted to be completely patent, leading to no further LCA intervention. As a result of this case, the routine use of LAO coronary angiography has been instituted in our facility.

Several anatomic risk factors for coronary occlusion have been described in patients undergoing TAVR procedures. These include short distances to either coronary ostium (<10mm), shallow coronary sinuses, and narrow roots^{4,6}. Our patient's anatomy was appropriate for the placement of a Medtronic CoreValve; however, the distance to the LCA was just above 10 mm. This made the possibility of an occlusion after Medtronic CoreValve migration more likely.

Conclusion

Here we report a case of a coronary artery ostial occlusion from the skirt of the core valve that converted into a total occlusion possibly from micro thrombi after protamine administration. This case highlights the vital role of echocardiography in differentiating between a protamine reaction and a coronary occlusion. It also emphasizes use of proper views during coronary angiography to diagnose coronary ostium occlusion, in the context of TAVR. We recommend vigilance and detailed reexamination of any hemodynamic instability after TAVR in order to expeditiously search for and identify impaired coronary blood flow, as well as any additional causes.

Consent

Written informed consent was obtained from the patient for publication of this case report and any accompanying images

and/or other details that could potentially reveal the patient's identity.

Data availability

Figshare: TEE short axis transgastric video. doi: [10.6084/m9.figshare.3507419.v1](https://doi.org/10.6084/m9.figshare.3507419.v1)⁹

Figshare: TEE aortic valve long axis color video. doi: [10.6084/m9.figshare.3507428.v1](https://doi.org/10.6084/m9.figshare.3507428.v1)¹⁰

Figshare: TEE four chamber video. doi: [10.6084/m9.figshare.3507431.v1](https://doi.org/10.6084/m9.figshare.3507431.v1)¹¹

Figshare: TEE Post Deployment Aortic valve long axis color. doi: [10.6084/m9.figshare.3571206](https://doi.org/10.6084/m9.figshare.3571206)¹²

Author contributions

SB, TP, and KT conducted a literature search and prepared the manuscript. AO and KT prepared the multimedia files for the manuscript. JC and BG offered technical guidance for the manuscript. All authors were involved in the revision and drafting of the manuscript, and have agreed to the final format.

Competing interests

The following authors deny any potential conflicts of interest, including commercial relationships such as consultation and equity interests with any of the equipment mentioned in the article: Sujatha P. Bhandary, M.D., Andrew J. Otey, B.S., Thomas J Papadimos M.D.,MPH, Juan A. Crestanello, M.D., Katja R. Turner, M.D.

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Compensation and Benefits

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The author verifies that these relationships did not affect or influence the preparation of this case report.

Grant information

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Current Referee Status:



Version 1

Referee Report 19 December 2016

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The authors present a case of Left Coronary Artery shutdown post Core Valve Deployment that was attended with a cephalad migration of the prosthesis post deployment. While immediate post deployment angiogram did not reveal any limitation to coronary perfusion, the patient developed cardiogenic shock and global hypokinesis consistent with left coronary shutdown necessitating surgical bail out.

I commend the authors for sharing their experience with this interesting case. I do have some critiques to offer regarding the report. I would suggest addressing these prior to indexing of this report.

1. Core valve sizing is perimeter based. The authors should provide the amount of oversizing for 26mm Core valve based on manufacturer guidelines in the initial part of their report. The Left Coronary artery height was borderline although sinus of valsalva width was adequate.
2. Cephalad migration of Core Valve is not always a benign event. The device has three portions. An inflow portion that has the highest radial force, a constrained middle portion designed to allow unhindered coronary perfusion and an outflow portion for maintaining orientation with respect to the ascending aorta. Since Core valve is a nitinol based device it keeps expanding for 10-20 minutes post deployment. I would refer the authors to the findings of the core valve pivotal trial wherein the amount of paravalvar regurgitation was progressively reduced compared with immediate post deployment assessment. This is a function of continuous outward expansion of Core Valve and helps us avoid routine post dilation with BAV balloons. The timing of Coronary occlusion is consistent with a functional occlusion due to continuous expansion of the inflow portion. The presence of a skirt in the inflow portion is also a factor but the lack of thrombus at the time of surgical exploration argues more in favor of a compression of native aortic valvar tissue as the primary mechanism.
3. As the authors point out it is important to perform LAO (Caudal preferably) angiogram post deployment to assess left coronary ostium post deployment. It is not uncommon to have some mobilisation of aortic leaflet tissue in the region of the Left main ostium, however in most cases flow is preserved and "functional" left main stenosis is inconsequential.
4. Protamine reaction is not a likely cause given the imaging and angiographic findings.
5. This report again underscores the need for meticulous preparation and anticipation prior to deployment and an understanding of device behavior to expeditiously solve post deployment issues.

I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Competing Interests: No competing interests were disclosed.

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Wilbert Aronow

Cardiology Division, New York Medical College, Valhalla, NY, 10595, USA

This is an interesting single case report that merits publication.
I concur with the authors' approach to this patient.

I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Competing Interests: No competing interests were disclosed.
