

1  
2 *Case series report*  
3  
4  
5

6 **Mechanisms of coronary complications in mitral and aortic valve surgery: Insights from a**  
7 **series using OCT intracoronary imaging .**  
8  
9

10 Roberto Scarsini<sup>1</sup> MD, Giovanni Luigi De Maria<sup>1</sup> MD PhD, Jonathan Ciofani<sup>1</sup> MD, Xu Yu Jin<sup>2</sup> MD  
11 MBBS PhD, Rana Sayeed<sup>2</sup> PhD MRCP, Mario Petrou<sup>2</sup> PhD FRCS, Adrian Banning<sup>1</sup> MD FESC  
12  
13

- 14 1. Oxford Heart Centre, Oxford University Hospitals, NHS Trust, Oxford, UK  
15 2. Department of Cardiothoracic Surgery, Oxford University Hospitals, NHS Trust, Oxford  
16 UK  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36

37 **Correspondence to:**  
38

39 Professor Adrian P. Banning  
40 Oxford Heart Centre,  
41 Oxford University Hospitals  
42 Headley Way,  
43 OX3 9DU,  
44 Oxford, UK  
45 Email: [Adrian.Banning@ouh.nhs.uk](mailto:Adrian.Banning@ouh.nhs.uk)  
46  
47

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26

**Abstract**

Coronary occlusion is a rare but well described complication of heart valve surgery.

The left circumflex coronary artery (LCX), especially when it is dominant, is particularly at risk due to the proximity of the mitral valve annulus. We report on three cases of acute coronary complications of different valvular surgical procedures diagnosed and treated in the cardiac catheterization laboratory. Intracoronary optical coherence tomography was used to identify the cause of coronary flow impairment and provided important insights on the mechanism of intra-operative vascular damage.

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26

**Introduction**

Coronary occlusion is a rare but severe complication of heart valve surgery. Specific anatomical characteristics including a left dominant (or co-dominant) coronary circulation are associated with the risk of coronary damage during surgery<sup>1</sup>. The left circumflex coronary artery (LCX) is particularly at risk due to its intimate proximity with the posterior mitral valve annulus.

Intraoperative transesophageal echocardiography (TOE) has demonstrated value in detecting perioperative complications including changes in coronary blood flow and new regional wall motion abnormalities<sup>2,3</sup>. The best management of perioperative coronary complication is still undetermined. Nevertheless, in cases of acute signs of myocardial ischemia after surgery, urgent coronary angiography is commonly recommended<sup>1</sup>. This can detect the presence of acute coronary obstruction, but it provides limited information about the etiology (Supplementary Fig. 1).

Iatrogenic coronary artery injury is related to the placement of the surgical stitch. Mechanisms of coronary occlusion include causing coronary fixation or complete encircling, distortion and twisting of the vessel anatomy (Fig. 1a, 1b), laceration of the artery leading to both hemorrhagic and thrombotic occlusion (Fig. 1c) and vascular spasm and/or subintimal hematoma provoking dynamic occlusion<sup>1</sup>.

The use of novel techniques of intracoronary imaging including intravascular ultrasound (IVUS) or optical coherence tomography (OCT) may provide important insights on the mechanism of the perioperative coronary occlusion, guiding the interventional cardiologist towards the best management in the cath-lab.

We report here on 3 cases of acute coronary complications of different valve surgical procedures diagnosed and treated in the catheterization laboratory. In all the cases the LCX was involved. Intracoronary optical coherence tomography (OCT) was used to establish the cause of coronary flow impairment and provided important insights on the mechanism of intra-operative vascular damage.

# **Left circumflex coronary artery kinking caused by suture fixation of the annulus ring**

The shortening of the mitral annulus causing distortion and kinking of the artery is the most common mechanism of indirect (not directly involving the vessel wall) injury of the LCX in mitral valve repair surgery. The severity of the LCX damage may vary from mild distortion of the vessel anatomy to complete occlusion caused by severe kinking or intussusception of the artery. The following two cases share the same underlying etiology but with different degree of arterial lumen distortion and intracoronary imaging findings.

Case 1: A 78-year-old female underwent cardiac surgery for severe MV regurgitation. Preoperative cardiac catheterization showed a co-dominant coronary circulation, without obstructive coronary disease. MV repair with annuloplasty was successfully performed. However, during cardiopulmonary bypass weaning, the patient developed persistent left bundle branch block with progressive hemodynamic impairment.

TOE was performed, with new evidence of severe lateral wall hypokinesia. and an absence of flow in the proximal LCX at 2D color Doppler imaging.

Emergent coronary angiography was performed and confirmed the LCX occlusion (Fig. 2). Percutaneous balloon dilatation restored coronary flow, but a second stenosis was evident in the distal segment of the vessel, in proximity with the surgical mitral ring. OCT excluded the presence of large intracoronary thrombus or intimal injury and confirmed the mechanical external distortion of the vessel anatomy as the underlying mechanism (Fig. 2a, 2b). A surgical stitch adjacent to the coronary wall appeared to have caused fixation and indirect distortion of the vessel. PCI was successfully completed with drug-eluting stents implantation (Resolute Onyx, 3.0x18 and 3.5x18mm, Medtronic, California USA).

1

2 Case 2: A 69-year-old male, presented with acute ST elevation in the inferolateral leads following  
3 MV surgery. Immediate coronary angiography showed the LCX was acutely occluded (Fig. 2c).  
4 The lesion was crossed using an Hi-Torque Pilot 150 guidewire (Abbott) allowing coronary flow  
5 restoration. At OCT pullback, the vessel lumen appeared folded on itself and crushed in the  
6 occluded segment, while proximally the lumen appeared stretched and distorted. There was no  
7 evidence of intracoronary thrombus (Fig. 2d, 2e).

8 The likely mechanism of the occlusion in this case was a severe kinking of the vessel caused by  
9 marked constriction of the mitral annulus. At intracoronary imaging the vessel appeared crushed in  
10 the mid portion and strained in the proximal portion of the LCX.

11 PCI was performed and a single drug-eluting stent (Medtronic Resolute Onyx, 5.0x18 mm) was  
12 deployed and post-dilated using a non-compliant short balloon (Emerge 5.0x12 mm). Post-PCI  
13 OCT imaging confirmed the adequate stent sizing and apposition.

14

### 15 **Direct coronary artery wall injury during valve surgery**

16 In the third case, a 79-year-old female underwent an elective implantation of a sutureless aortic  
17 valve for aortic stenosis. The operation was complicated by left atrium bleeding which was  
18 promptly treated in the theatre. However, the patient developed an intraoperative significant lateral  
19 ST depression at ECG and TOE demonstrated a new posterior hypokinesia with absence of flow at  
20 color-Doppler imaging in the LCX (Fig. 3a). The patient was urgently transferred to the cath-lab  
21 where coronary angiography showed a new lesion in the proximal segment of LCX with a hazy  
22 angiographic appearance (Fig. 3b).

23 OCT demonstrated the presence of a significant luminal stenosis with large intracoronary thrombus  
24 burden (Fig. 3).

25 The likely mechanism of LCX occlusion in this scenario was the direct coronary wall laceration,  
26 causing endothelium injury and thrombotic occlusion.

1 PCI was successfully performed using a DES (Synergy Boston Scientific 4.0x15 mm) post-dilatated  
2 with a 4.5x12 mm non-compliant balloon. Post-PCI OCT confirmed the optimal angiographic  
3 result.

## 4 **Discussion**

6 Iatrogenic LCx injury is a recognized but rare complication after MV surgery, particularly frequent  
7 in case of left dominant coronary circulation given the close anatomical proximity of the LCX to  
8 the posterior mitral annulus<sup>1,4</sup>. Adequate definition of coronary anatomy is therefore important to  
9 reduce the risk of LCx injury in patients undergoing MV surgery.

10 Although the underlying etiology can be often suggested by coronary angiography, intravascular  
11 imaging with IVUS or OCT can bring further anatomical details and aid in the ascertainment of the  
12 etiology. Interestingly intracoronary imaging could be used in hybrid operating rooms to define the  
13 mechanism of injury when a coronary complication is suspected.

14 In this series we demonstrate how OCT ~~provided important insights in the definition of about the~~  
15 ~~mechanism of the perioperative coronary injury and~~ had an important role in understanding the  
16 mechanism of injury and then guiding the PCI by assessing the presence of intracoronary thrombus  
17 and providing a detailed characterization of the vessel anatomy to define the size of the stents.

18 Even though these complications are often characterized by acute onset in the context of  
19 perioperative hemodynamic deterioration or instability, long-term post-operative sequelae have  
20 been described<sup>1</sup>. Importantly, an increased awareness of this potential complication of heart valve  
21 surgery can aid in early identification and effective treatment.

23 **Disclosures:** Dr Scarsini served as a consultant for Abbott and has received research and training  
24 grant from European association of percutaneous cardiovascular interventions (EAPCI). Prof  
25 Banning received institutional funding for an interventional fellowship from Boston Scientific. Prof

1 Banning is partially funded by the NHS NIHR Biomedical Research Centre, Oxford. Other authors  
2 have no conflict of interest to declare.

3  
4

## 5 **References**

- 6 1. Hiltrop N, Bennett J, Desmet W. Circumflex coronary artery injury after mitral valve  
7 surgery: a report of four cases and comprehensive review of the literature. Catheter  
8 Cardiovasc Interv 2017;89:78-92.
- 9 2. Nakajima H, Ikari Y, Kigawa I et al. Rapid diagnosis and management of intraoperative  
10 myocardial infarction during valvular surgery using transesophageal echocardiography  
11 followed by emergency coronary artery bypass grafting without coronary angiography.  
12 Echocardiography. 2005; 22;834-838.
- 13 3. Ender J, Selbach M, Borger MA et al. Echocardiographic identification of iatrogenic injury  
14 of the circumflex artery during minimally invasive mitral valve repair. Ann Thor Surg 2010;  
15 89:1866-1872
- 16 4. Aybek T, Risteski P, Miskovic A et al. Seven years' experience with suture annuloplasty for  
17 mitral valve repair. J Thorac Cardiovasc Surg 2006;131:99-106.

18  
19  
20  
21  
22  
23  
24  
25

## Figure legends

### Figure 1. Different mechanisms of coronary injury during mitral valve surgery.

Different mechanisms of iatrogenic LCX injury during mitral valve repair: a) suture fixation with distortion of vessel anatomy; b) severe kinking of the vessel caused by aggressive mitral annulus shortening. At OCT the LCX lumen appears crushed and folded on itself. c) laceration of the vessel wall and endothelium injury causing thrombotic occlusion.

### Figure 2. LCX distortion caused by suture fixation and shortening of the mitral annulus

2a. **Case 1.** Coronary angiography showed the separate ostia of left anterior descending artery and the occluded LCX. After flow restoration two sequential severe angiographic stenosis became evident. 2b. OCT demonstrated the absence of atheroma, large intracoronary thrombus or intimal injury. The anatomy of the LCX was distorted and strained by a suture stitch placed between the vessel and the MV annular ring.

2c. **Case 2.** From left to right, the first panel shows the native pre-operative coronary anatomy. At post-operative angiogram the LCX was occluded. PCI restored flow and OCT enlightened about the mechanism of occlusion. 2d. The surgical suture caused a severe kinking of the LCX that folded on itself and crushed the vessel lumen (red). Conversely, the proximal segment of the vessel was distorted by the perivascular tissue retraction caused by the suture fixation.

### Figure 3. Direct vessel injury with intimal laceration and thrombus formation



1 In this case a perioperative management of a bleeding complication following aortic valve  
2 replacement resulted in an acute LCX occlusion. OCT was useful in detecting the presence of  
3 intracoronary thrombus, likely related to an intimal laceration provoked by surgical suture in  
4 proximity of the atrioventricular groove.