Long-Term Postoperative Complication of the Cabrol Procedure Presenting as Recurrent Anterior ST-Segment Elevation Myocardial Infarction

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INTRODUCTION

The Cabrol procedure is a classic method for the treatment of proximal aortic dissections and thoracic aneurysms involving the aortic root and valve. Pioneered in 1981, this procedure makes use of a composite graft replacement of the aorta, or a valve-sparing aortic replacement, with attachment of an interpositional graft for restoration of blood flow to the coronary arteries. Although initial short-term outcomes had good results, this procedure has now become obsolete because of longer term outcomes leading to occlusion and stenosis of the interposition graft. Despite modifications to the original Cabrol procedure, current management of surgical aortic root and valve replacement typically involves the modified Bentall procedure. Here, we discuss a case involving the classic Cabrol procedure performed in 1985 in which unique postoperative complications were seen. Late presentation of myocardial ischemia related to dysfunction of a Cabrol graft is exceedingly rare. Currently, the Cabrol procedure has been modified from its original version and is used for complex aortic root replacement procedures refractory to the modified Bentall reimplantation technique.[1]

CASE PRESENTATION

The patient was a 72-year-old man who had undergone thoracic aortic aneurysm repair with aortic root graft and mechanical aortic valve replacement (St. Jude Medical, St. Paul, MN) using the Cabrol technique >30 years previously. He was placed on long-term anticoagulation with warfarin. He was lost to follow-up but stated that he did maintain appropriate long-term anticoagulation. He presented to a regional hospital with acute substernal chest pain radiating to the left arm; subsequent electrocardiography revealed an acute anterior ST-segment elevation myocardial infarction (STEMI). The international normalized ratio on presentation was 3.1.

Emergent cardiac catheterization demonstrated 100% thrombotic occlusion of the proximal to mid left anterior descending coronary artery with restoration of flow after balloon angioplasty and aspiration thrombectomy (Figure 1, Video 1). At catheterization, the aortic prosthesis appeared to move normally by fluoroscopy; interestingly, aortography was suggestive of a false lumen with communication to the anterior coronary circulation (Figure 2). Subsequent computed tomographic angiography of the chest showed a contained rupture of the aortic root that appeared to originate from a dehisced suture line of the previous aortic root reconstruction. There was marked dilatation of the ascending aorta measuring up to 7.6 cm in diameter, with communication and flow of contrast between the graft and surrounding aneurysm (Figures 3–5, Video 2).

Further evaluation with transesophageal echocardiography (TEE) revealed severe left ventricular systolic dysfunction (ejection fraction 15%–20%) and an akinetic anteroseptum. Most significantly, there was severe dilation of the ascending aorta, with appearance of a false lumen starting in the aortic root and extending into the ascending aorta (Video 3). Gradient across the aortic valve was normal. There was no echocardiographic evidence of endocarditis, and blood cultures were negative. Given the findings on computed tomography, TEE, and catheterization, there was concern for embolization into the left coronary system via the communication between the false lumen and graft. The finding of thrombotic deposition in the graft near the takeoff of the left main artery was further supportive of this hypothesis (Figures 6–8, Videos 4 and 5), as well as extensive thrombotic findings in the more proximal graft.

Two days after the initial STEMI (while awaiting consideration for redo surgery) the patient had recurrent chest pain and ST-segment elevations on electrocardiography. Subsequent selective angiography revealed recurrent thrombus in the left main coronary artery, left anterior descending coronary artery, and left circumflex coronary artery. Thrombectomy and balloon angioplasty led to restored flow; however, there was residual thrombus appreciable in the left circumflex coronary artery and the second obtuse marginal artery (Figure 9).

The patient surprisingly tolerated the repeat anterior STEMI and remained hemodynamically stable. He underwent high-risk redo aortic valve, root replacement, and right atrial free wall reconstruction. Intraoperatively he was noted to have blood outside the graft, which originated from the left coronary button suture line dehiscence. His composite mechanical graft was covered by significant amount of old and fresh blood clots, revealing the likely cause of the thromboembolic myocardial infarction. Extracorporeal

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VIDEO HIGHLIGHTS

Video 1: Initial cardiac catheterization, balloon angioplasty, and aspiration thrombectomy with restoration of flow.
Video 2: Suggestion of flow between graft and surrounding aneurysm (indicated by *arrow*).
Video 3: TEE showing severe dilation of ascending aorta with appearance of a "false lumen."
Video 4: Flow gradients suggesting a degree of communication between true and false lumens of pseudoaneurysm.
Video 5: Suggestion of left main coronary artery originating from false lumen (indicated by *circle*).

View the video content online at www.cvcasejournal.com.

membrane oxygenation support was required in the postoperative period, and the patient ultimately made a full recovery and was discharged from the hospital on day 30. The patient was discharged to a skilled nursing facility and has been doing well with steady symptomatic improvement.

DISCUSSION

Repair of thoracic aortic aneurysms and dissections has typically involved an aortic conduit with anastomosis of the coronary ostia. The Cabrol procedure was developed as a method for this approach and was originally thought to be the superior method because of less difficulty with coronary anastomosis and lower mortality rates postoperatively.[1] However, this procedure subsequently became a last-resort indication because of modifications and enhancements to other procedures. Monitoring of potential long-term complications of the Cabrol procedure is still ongoing. This case demonstrated the importance of imaging, notably TEE, in the diagnosis of potential complications. It was crucial in detecting an ascending dissection with communication between the false lumen and embolization of thrombus leading to repeated myocardial infarctions, all of which occurred >30 years after the procedure.

Originally, the Cabrol procedure used a synthetic polyester graft (i.e., Dacron graft) with a prosthetic mechanical valve (Björk-Shiley Medical, Portland, OR) sewn into it[2,3] (Figure 10). This complex was sutured into the aortic annulus and enclosed within the aortic aneurysmal sac. A separate shorter Dacron graft was then attached to the coronary arteries and anastomosed to the larger composite graft in a side-to-side fashion.[4] Anatomic difficulties and coronary ostia occlusion led to modifications of the Cabrol procedure, such as the development of the "legs technique," which involved two shorter and separate interpositional grafts from each coronary ostium to be anastomosed to the composite. The goal of this was to minimize blood loss and hematoma formation during the procedure, with anticipation that the fistula would spontaneously close on its own.

Although many studies demonstrate low mortality rates and beneficial long-term results,[5] there have been complications associated with the Cabrol procedure. Studies have shown that patients with complications from the Cabrol procedure tolerate TEE well.[6] Interestingly, the majority of ischemia-related complications that have been reported in the literature appear to have occurred within 5 years of the initial procedure, with the most delayed presentation occurring 12 years postoperatively, as noted by Coram *et al.*[7] (Table 1[8-14]).

CONCLUSION

In our case, dissection with false lumen formation was detected from the aortic root spreading distally to ascending aortic arch. Additionally, there an area of fibrin deposition within the

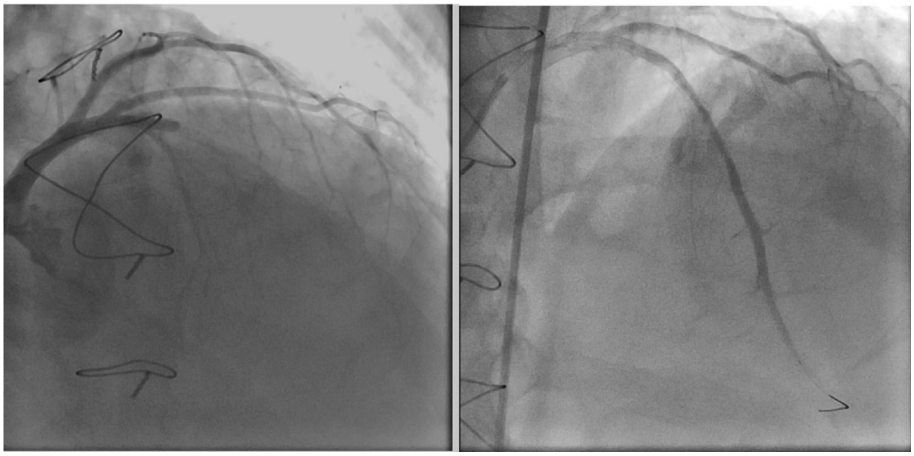

Figure 1 Initial selective angiography; pre- and postintervention images are shown. Aspiration thrombectomy and balloon angioplasty of left anterior descending coronary artery.

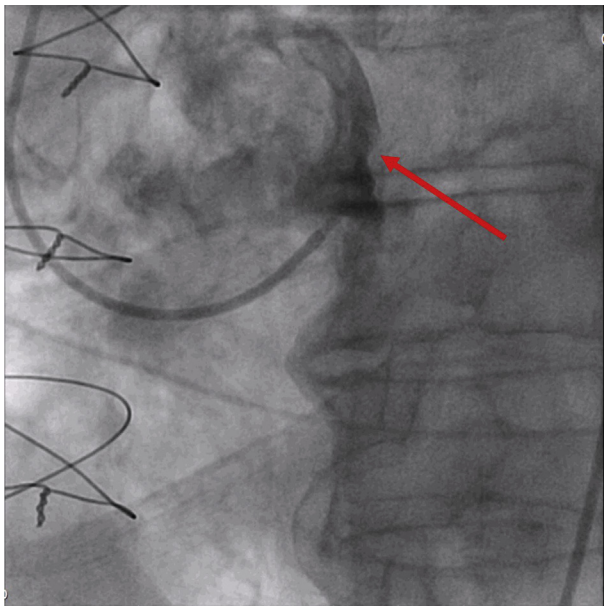

Figure 2 Aortogram revealing possible communication or false lumen (indicated by *arrow*).

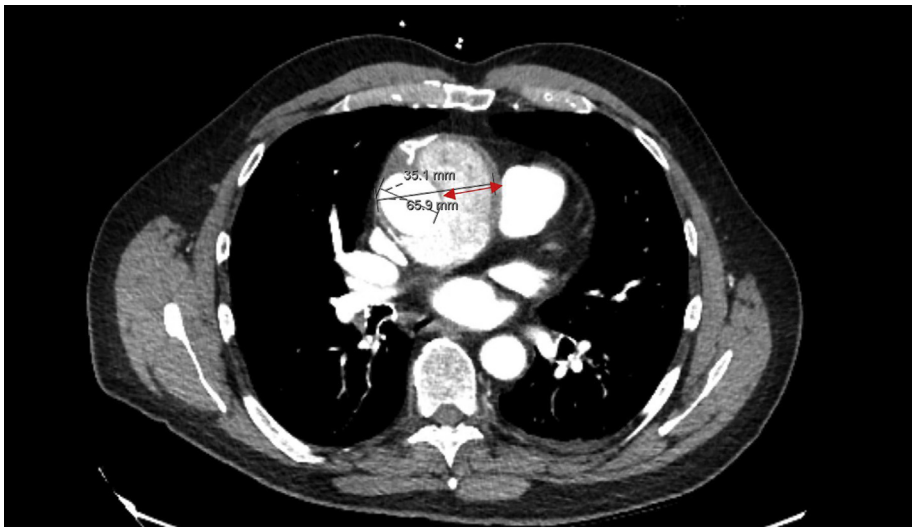

Figure 3 Chest computed tomographic angiography showing 7.6-cm ascending aorta dilatation with false lumen (*red arrow*).

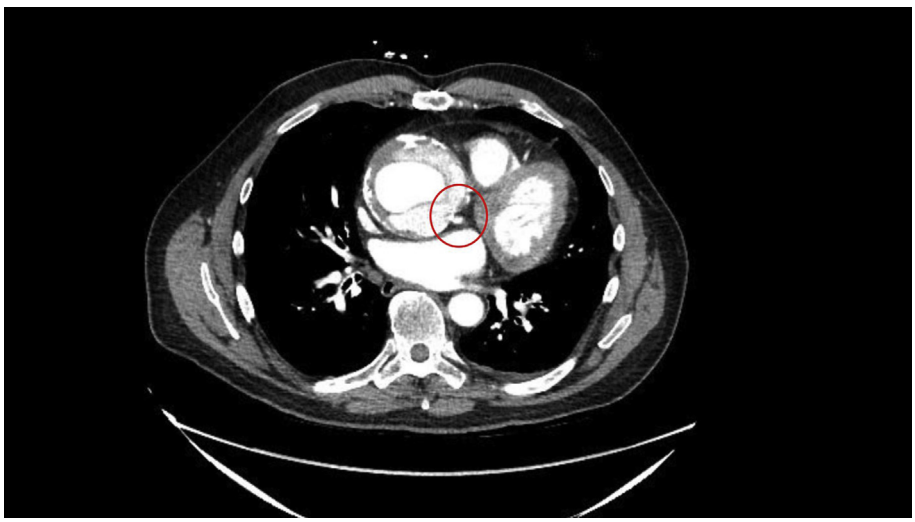

Figure 4 Chest computed tomographic angiography showing left anterior descending coronary artery likely originating from false lumen of aneurysm (*circled*).

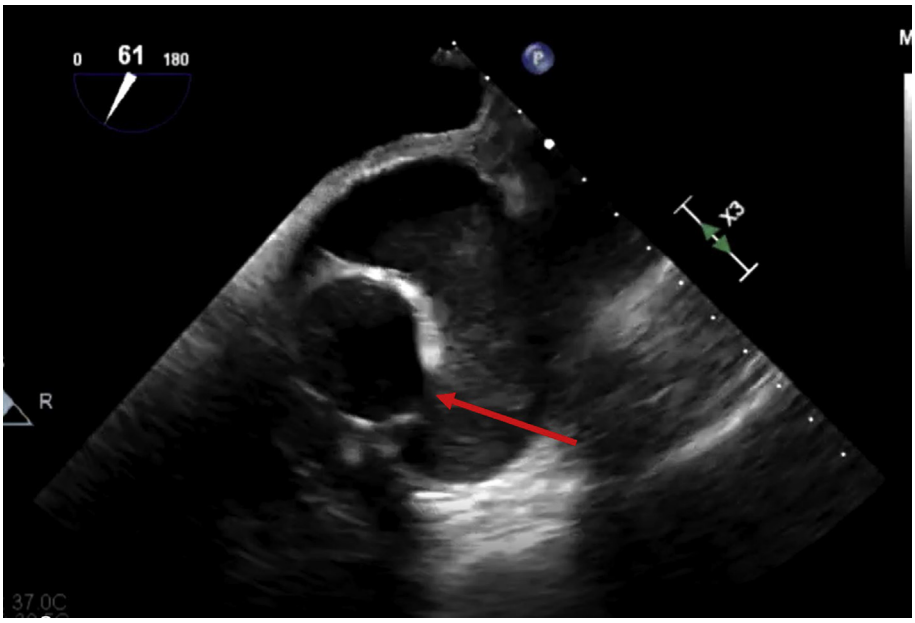

Figure 5 Suggestion of flow between graft and surrounding aneurysm (indicated by *arrow*). This is a still from Video 2.

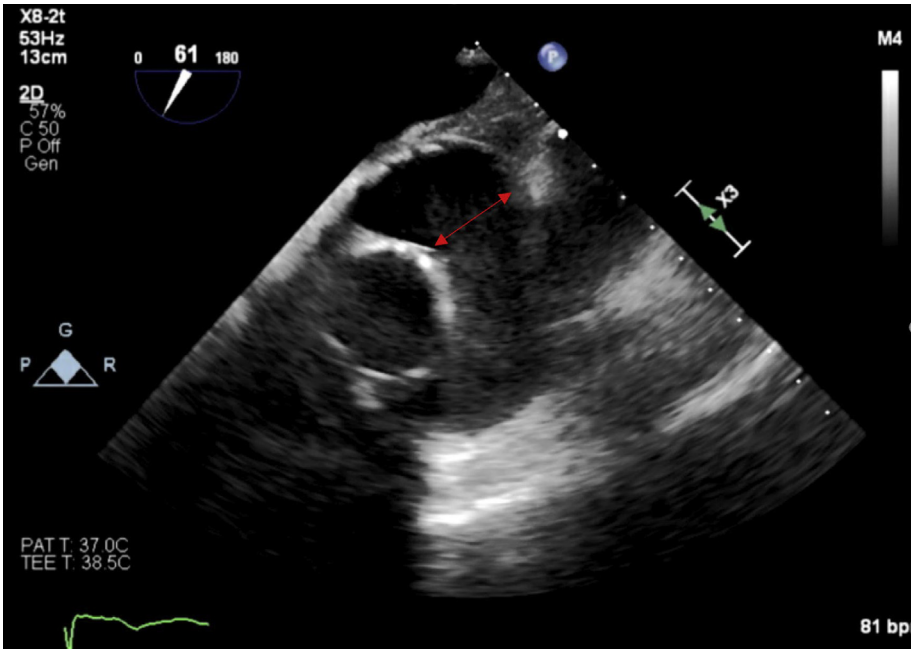

Figure 6 Short-axis view: TEE demonstrating aneurysmal dilatation of ascending aorta and false lumen (indicated by *red arrow*).

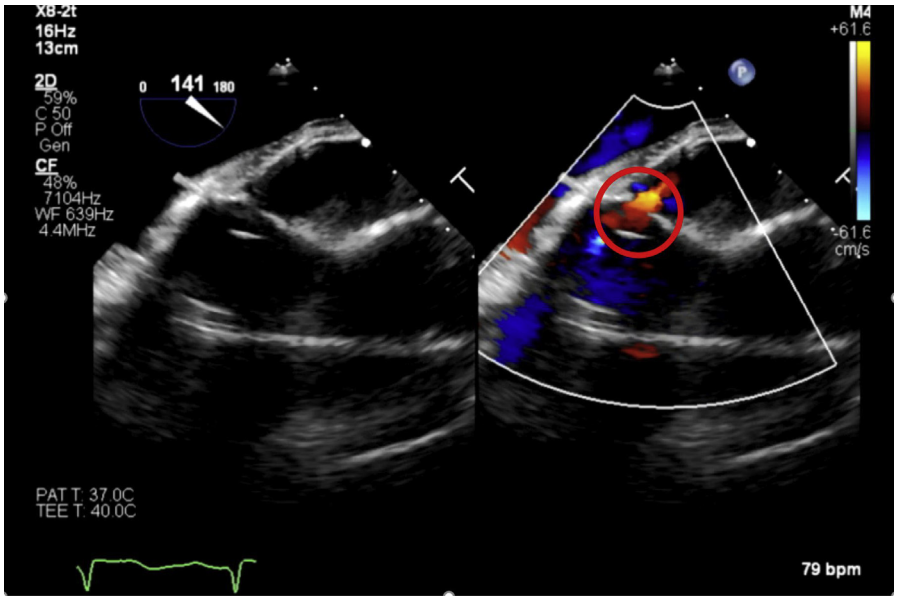

Figure 7 Long-axis view: TEE demonstrating aneurysmal dilatation of ascending aorta and false lumen. Doppler flows indicating degree of communication between true and false lumens (indicated by *circle*). See Video 4.

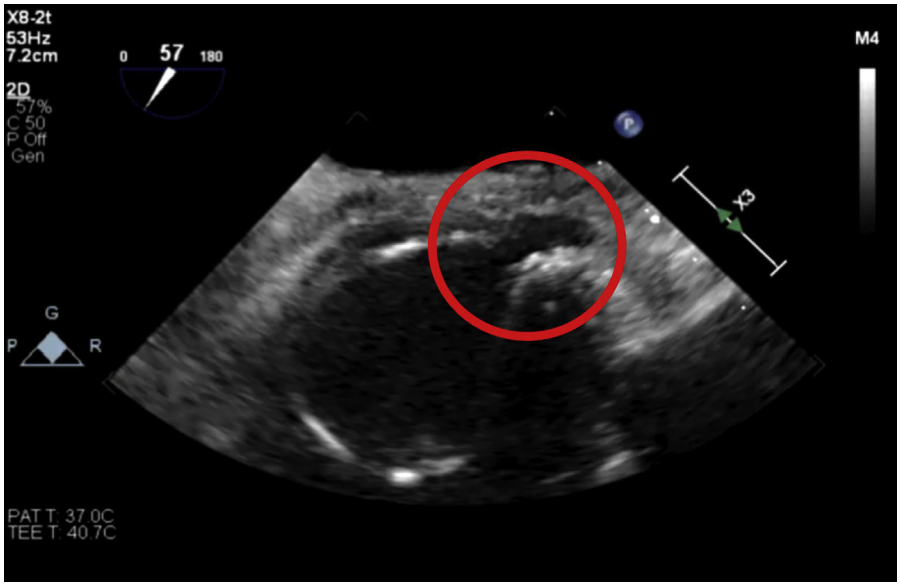

Figure 8 TEE demonstrating origin of left main coronary artery (indicated by *circle*). See Video 5.

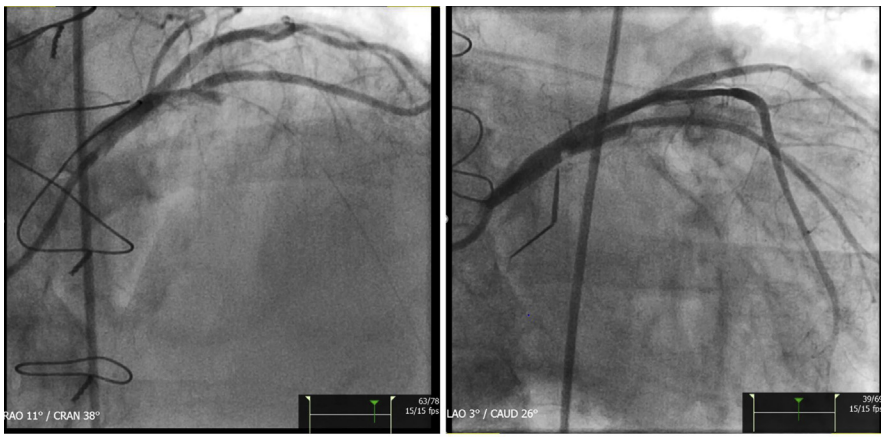

Figure 9 Repeat cardiac catheterization showing repeat occlusion of left anterior descending coronary artery. Pre- and postintervention images showing restoration of flow.

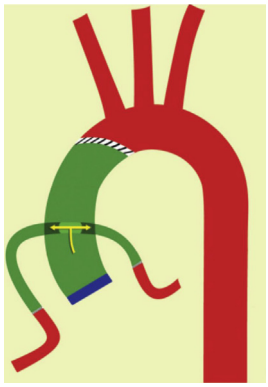

Figure 10 The Cabrol procedure. This diagram shows how a composite aortic graft and prosthetic conduit are used to connect the coronary ostia. These are then anastomosed to the aortic graft. Blood flows (*arrows*) from the aorta into the right and left coronary limbs. (Reproduced with permission from Prescott-Focht *et al.*[3])

Dacron graft proximal to the branching of the left main coronary artery. Repeated embolization from the communication between the false lumens to the coronary circulation, as well as thrombotic material in the graft itself, was likely responsible for the repeated anterior STEMIs. It is quite likely that late development of communications or fistulae between the aneurysm sac and aortic graft conduit could be a source of emboli in patients treated with the Cabrol procedure. The intraoperative findings further confirmed the echocardiographic findings, which illustrate how TEE enables an accurate and safe way to diagnose an uncommon and serious late postoperative complication. Careful follow-up of patients using echocardiography can detect early and late complications in patients who have undergone complex aortic root surgery.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at https://doi.org/10.1016/j.case.2019.07.003.

Table 1 Literature review documenting long-term postoperative complications

Authors	Complications	Onset of complications after Cabrol procedure	Interventional treatments
Patel *et al.*[4]	Ischemia in left anterior descending coronary artery and left circumflex coronary artery	12 y	CABG; showed substantial improvement in exercise tolerance and reduction of angina
Coram *et al.*[7]	Unstable angina due to stenosis of the left coronary artery ostia and occlusion of the RCA ostia at the site of anastomosis of the Cabrol interposition graft in a patient with myelodysplastic syndrome	12 y	Emergent primary PCI with bare-metal stenting of left coronary artery, without complications
Ohki *et al.*[8]	Pseudoaneurysm of the descending aorta with enlargement of the RCA at anastomotic site and stenosis of the left coronary artery in a patient with Marfan syndrome	21 y	Aortic valve replacement with resection and reconstruction of the RCA, CABG for left coronary artery, palliative repair of pseudoaneurysm due to residual dilated aortic wall around coronary ostium
Davis *et al.*[9]	Pseudoaneurysm of aortic root with periprosthetic regurgitation and an abscess formation communication with the mediastinum	2 mo	Abscess drainage and subsequent antibiotic treatment, reoperation of the aortic root for repair of pseudoaneurysm
Hoskins *et al.*[10]	STEMI (leads V_1, aVR, and aVL) in the left anterior descending coronary artery with subsequent cardiogenic shock	6 mo	Emergent primary PCI with bare-metal stenting of left anterior descending coronary artery; death occurred several hours later because of refractory ventricular arrhythmias
Jang *et al.*[11]	STEMI (leads I, aVL, V_3–V_6) of the RCA with complete thrombotic occlusion due to twisting of the Cabrol graft–RCA interposition graft anastomosis in a patient with Marfan syndrome	12 d	Emergent primary PCI with bare-metal stenting of the RCA, without complications
Hussain *et al.*[12]	Non-STEMI due to stenosis of the left coronary artery at the site of anastomosis of Cabrol interposition graft in a patient with Marfan syndrome	4 y	Primary PCI with drug-eluting stenting of left coronary artery, without complications
Uribe Gonzalez *et al.*[13]	Hemodynamic instability due to stenosis of left coronary artery with decreased flow to its distal branches from the Gore-Tex graft at the coronary-aorta anastomosis	48 h	Emergent primary PCI with bare-metal stenting of the left coronary artery through radial approach, without complications
Wells *et al.*[14]	Anterior STEMI due to thrombotic stenosis of the left coronary artery at the site of anastomosis of the Cabrol interposition graft	6 mo	Emergent primary PCI with bare-metal stenting of left coronary artery; death occurred the following morning because of refractory ventricular arrhythmias

As noted, before the present case, the latest documented ischemic complication of surgical root replacement with valve replacement was at 12 years, as noted by Coram *et al.*[7]
CABG, Coronary artery bypass graft; *PCI*, percutaneous coronary intervention; *RCA*, right coronary artery.

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