



# Perforation of a Saphenous Vein Graft Anastomosed at a Y-Configuration to the Left Internal Mammary Artery

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## ABSTRACT

Perforation of a saphenous vein graft (SVG) is a rare, yet dreadful complication during percutaneous coronary intervention (PCI). Perforation of a SVG arising at a Y-construction from the left internal mammary artery (LIMA) can be catastrophic since manipulations and material delivery through the single LIMA inflow can aggravate ischemia and accelerate hemodynamic collapse. Prior CABG and pericardial obliteration should not offer reassurance against tamponade, since coronary perforation in these patients may cause the development of loculated pericardial effusions, a complication associated with high mortality. Treating physicians must be alert for potential periprocedural pitfalls during PCI in post-CABG patients and these should be taken into consideration during interventional planning, procedure and follow-up.

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## 1. Introduction

Perforation of a saphenous vein graft (SVG) is a rare, yet dreadful complication during percutaneous coronary intervention (PCI) [1,2]. Risk factors include stent oversizing, aggressive post-dilatation, SVGs older than 2-years and extensive SVG atherosclerosis, whereas slight stent undersizing may reduce the risk of rupture [1,2]. Perforation of SVG arising at a Y-construction from the left internal mammary artery

(LIMA) can be catastrophic since manipulations and material delivery through the single LIMA inflow can aggravate ischemia and accelerate hemodynamic collapse [3]. In contrast with the common belief that patients with prior coronary artery bypass grafting (CABG) are relatively protected from tamponade, coronary perforation (CP) in these patients may cause the development of loculated pericardial effusions, a complication associated with high mortality [1,2].

## 2. Case presentation

A 49-year old man was referred to our center due to unstable angina. He had a history of CABG and Bentall operation a year ago. Coronary angiography revealed totally occluded native vessels, a patent LIMA to the left anterior descending (LAD) and a severe stenosis of the SVG-Y graft between the ramus intermedia (RI) and obtuse marginal (OM) (Fig. 1A, arrow, Video 1). Recent transthoracic echocardiography (TTE)

*Abbreviations:* CABG, coronary artery by-pass grafting; CS, covered stent; GC, guiding catheter; CP, coronary perforation; ECMO, extracorporeal membrane oxygenation; IABP, intra-aortic balloon pump; LAD, left anterior descending; LIMA, left internal mammary artery; OM, obtuse marginal; PCI, percutaneous coronary intervention; RI, ramus intermedia; SVG, saphenous vein graft; TTE, transthoracic echocardiography.

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revealed normal left ventricular function. We opted for an urgent high-risk PCI of the SVG through the LIMA, from the left radial approach. He was already on acenocoumarol and was loaded with aspirin, clopidogrel and 6000 IU of heparin with an activated clotting time around 300 s.

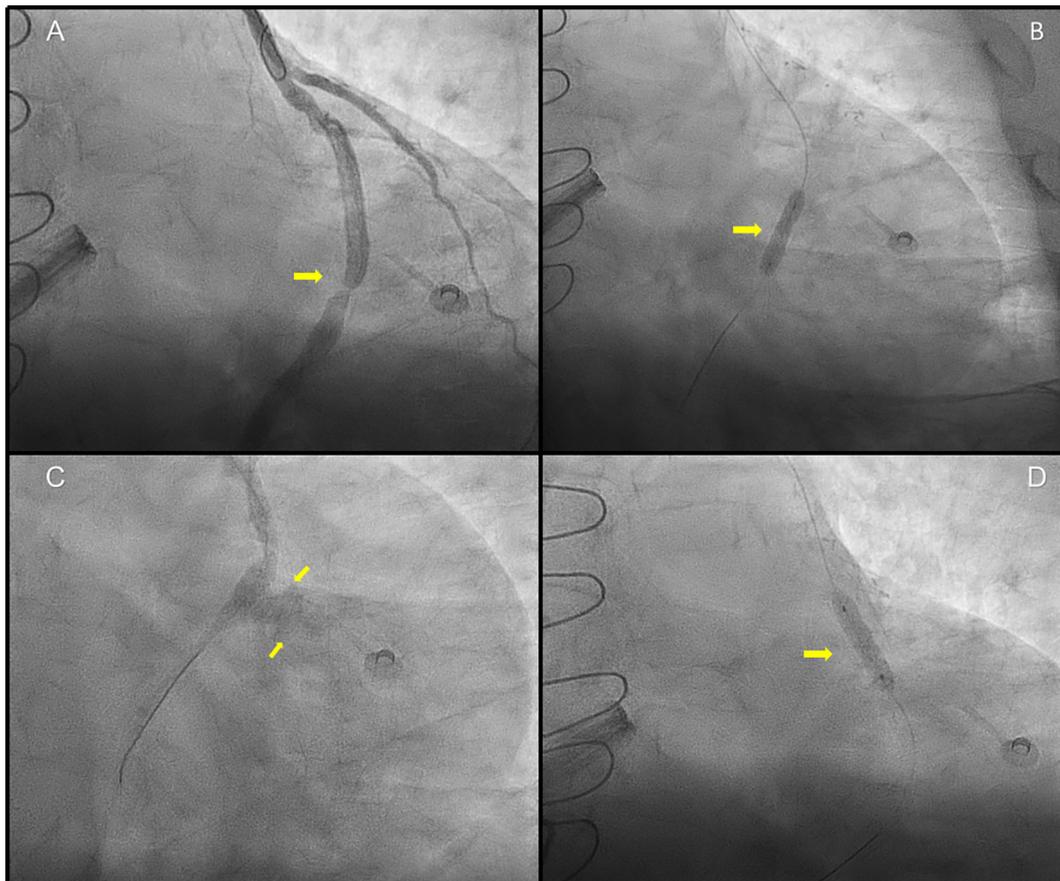
A 90 cm 6-French internal mammary artery guiding catheter (GC) was chosen for more support. In order to minimize the time of material-induced ischemia through the single LIMA inflow, we performed direct stenting with a  $4.00 \times 12$  mm drug-eluting stent to a pressure of 12 atm (Fig. 1B, arrow, Video 2). Stent sizing was done according to the diameter of the SVG in the 1st diagnostic film (Video 1), after intra-arterial administration of nitrates. After stent deployment, the patient developed severe chest pain with ST-segment elevation. Control angiography revealed active contrast extravasation implying perforation of the vein graft (Fig. 1C, arrows, Video 3). We directly inflated the stent-balloon for 5 min proximal to the perforation site to occlude the vein graft and stop active bleeding (Fig. 1D, arrows). During balloon occlusion the patient was hemodynamically stable while the ECG recorded ST-segment elevation. Control injection showed residual extravasation (Video 4), so we decided to seal the perforation with a covered stent (CS). We approached through the existing GC since a ping-pong guiding technique, even though ideal to minimize the duration of bleeding in the pericardium, would necessitate advancement of the second GC in the left subclavian from the contralateral side and hence would end up in having two GCs or even two wires stretching the ostium of the LIMA from opposite directions [4]. We decided not to reverse anticoagulation with protamine due to the increased risk of acute valve thrombosis (mechanical aortic prosthesis of the Bentall procedure) and thrombosis of the intracoronary equipment as well.

The stent-balloon was retrieved and a CS  $4.00 \times 20$  mm was advanced but would not reach further than the proximal segment of the LIMA due to tortuosity and CS high-crossing profile. Advancement of a 6-Fr GC extension deep into the LIMA (Fig. 2A, arrow) allowed delivery of the CS at the perforation site (Fig. 2B, arrow, and arrowheads showing the struts of the drug-eluting stent) and successful sealing of the perforation (Fig. 2C, Videos 5 and 6). Since the patient recovered rapidly after covered stent implantation we decided not to insert any hemodynamic support device. Bedside TTE showed no pericardial effusion.

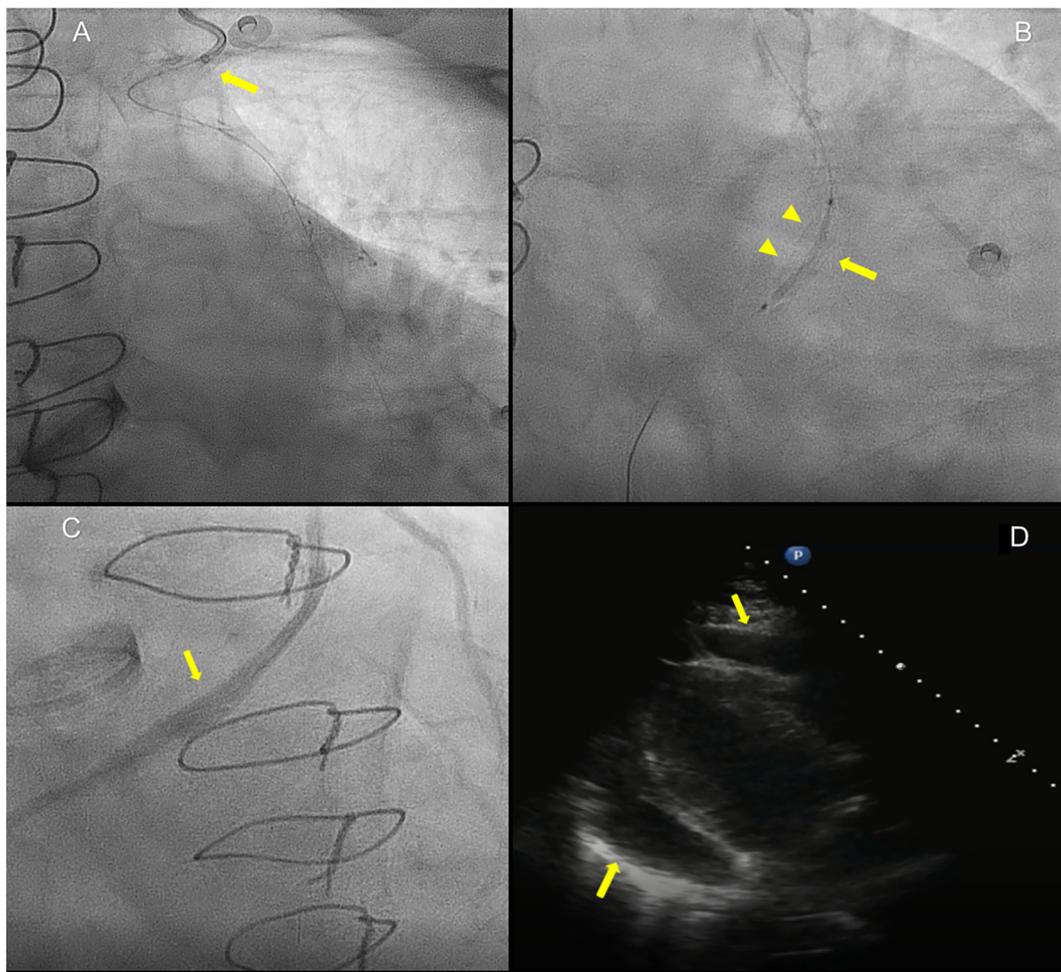
After 2 h, the patient developed dyspnea and hypotension. Repeat TTE showed rapid development of pericardial effusion of 20 mm in front of the apex and the posterior wall without clinical signs of tamponade (Fig. 2D, Video 7). Urgent transapical pericardiocentesis resulted in aspiration of 250 ml of hemorrhagic fluid with subsequent echocardiographic and hemodynamic improvement. With the pericardial drain in situ, we opted for dual therapy with aspirin and low molecular weight heparin. TTE at 48-h showed no residual fluid. The patient was discharged in good condition under triple therapy with acenocoumarol, aspirin and clopidogrel for 3 months and lifelong dual therapy with acenocoumarol and aspirin (mechanical aortic valve and CS).

### 3. Discussion

Y-grafting during CABG, in which the conduit (venous or arterial) is proximally anastomosed to the LIMA, is a surgical approach which allows multiple branches of the circumflex and right coronary artery to be revascularized with the LIMA in a sequential manner [3]. Potential



**Fig. 1.** A. Coronary angiogram showing severe stenosis of the SVG (arrow). B. Drug-eluting stent implantation (arrow). C. Contrast extravasation through the perforation (arrows). D. Stent-balloon inflation at the perforation site (arrow).



**Fig. 2.** A. Coronary angiogram illustrating LIMA tortuosity and guiding catheter extension positioning (arrow). B. Positioning of the covered stent (arrow) inside the struts of the drug-eluting stent (arrowheads). C. Successful sealing of the perforation after covered stent implantation (arrow). D. Transthoracic echocardiography revealing pericardial effusion (arrows).

disadvantages include the dependence of the Y-configuration on a single inflow making it more vulnerable to ischemia, the steal phenomenon from the LIMA by the grafts and the technical difficulties of the anastomoses [5]. Accordingly, manipulations and material delivery during PCI through the single LIMA inflow can aggravate ischemia and accelerate hemodynamic collapse. Additionally, even the most sophisticated techniques for material delivery, such as a ping-pong GC technique or the use of a GC extension, can damage the LIMA with dreaded consequences [4,6].

CP is a rare, yet devastating complication during PCI with an estimated incidence of 0.4%, with prior CABG being an independent risk factor of CP [7,8]. Predictors of perforation during PCI in post-CABG patients include age, chronic total occlusion intervention, use of rotational atherectomy, number of stents, hypertension and female sex [9]. In particular, risk factors for SVG perforation include stent oversizing, aggressive post-dilatation, old SVGs and extensive SVG atherosclerosis [1,2]. Prognosis of graft perforation is overall dismal, with various registries reporting significant impact on early and long term mortality [1,9].

Management of SVG perforation is similar to that of native CP and includes balloon inflation proximal to the perforation site to prevent bleeding into the pericardium or the mediastinum [1]. If blood extravasation continues anticoagulation reversal with protamine and implantation of a CS using the ping-pong technique or a GC extension is essential [1,4]. CP in a patient with a prior Bentall procedure and mechanical aortic prosthesis is even more challenging since anticoagulation reversal with protamine is questionable given the risk of acute valve thrombosis [10]. Moreover, hemodynamic support with an Impella device is

contraindicated in patients with a mechanical aortic prosthesis. Nonetheless, hemodynamic support with an intra-aortic balloon pump (IABP) or extracorporeal membrane oxygenation (ECMO) device, when timely available, is a helpful tool during such major complications.

In addition, a unique manifestation of CP in post CABG patients is the development of loculated pericardial effusions, a complication associated with high mortality. A recently published British registry identified that 10% of post-CABG patients with perforation after PCI developed tamponade, with similar frequency between native and graft vessel perforation, dispelling the myth that tamponade does not occur after perforation post-CABG [9]. Therefore, prior CABG and pericardial obliteration should not offer reassurance against tamponade [1,2,9]. Moreover, draining a pericardial effusion in post-CABG patients may not be always feasible percutaneously and emergency CT-guided or even surgical drainage may be necessary [2]. Finally, unrestrained bleeding into other body cavities such as the right atrium, pleural cavity or mediastinum and pulmonary artery compression can occur with dismal prognosis [11,12].

CS may require higher pressure to reach adequate expansion while caution is needed not to exceed the pressure compliance of the balloon, overexpanding it and causing tears in the membrane (polytetrafluoroethylene, polyurethane and pericardium-covered stents). CS sizing in a 1:1 ratio is required as both overexpansion and underexpansion are undesirable. CS is more resistant to balloon expansion during inflation, resulting in shortening of the membrane, which can impede adequate coverage of the perforation site. Intracoronary imaging techniques may be useful to ensure CS expansion [13]. Over/under expansion or longitudinal shortening of the CS in combination with the continued antithrombotic therapy may

have been the cause of late pericardial effusion in our patient even though angiography after CS implantation showed no obvious extravasation.

It is well known that, when feasible, native vessel PCI is preferred over SVG PCI. In our patient, all native vessels were totally occluded. Performing in the acute setting a CTO PCI without any visible collaterals (except from injections through the LIMA) would have been almost impossible. In an elective setting however, CTO PCI of the native vessels with contralateral injections through the LIMA or with the guidance of a preprocedural coronary computed tomography angiography would be an alternative approach [14].

#### 4. Conclusions

Perforation of a SVG arising at a Y-configuration from the LIMA, carries high mortality and its treatment can be technically very challenging. Physicians must be alert for prompt recognition and management with balloon inflation, anticoagulation reversal after removal of intracoronary equipment, covered stent implantation, use of advanced PCI techniques and timely insertion of Impella, IABP or ECMO while close hemodynamic monitoring for potential tamponade is essential.

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#### Conflicts of interest

None.

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