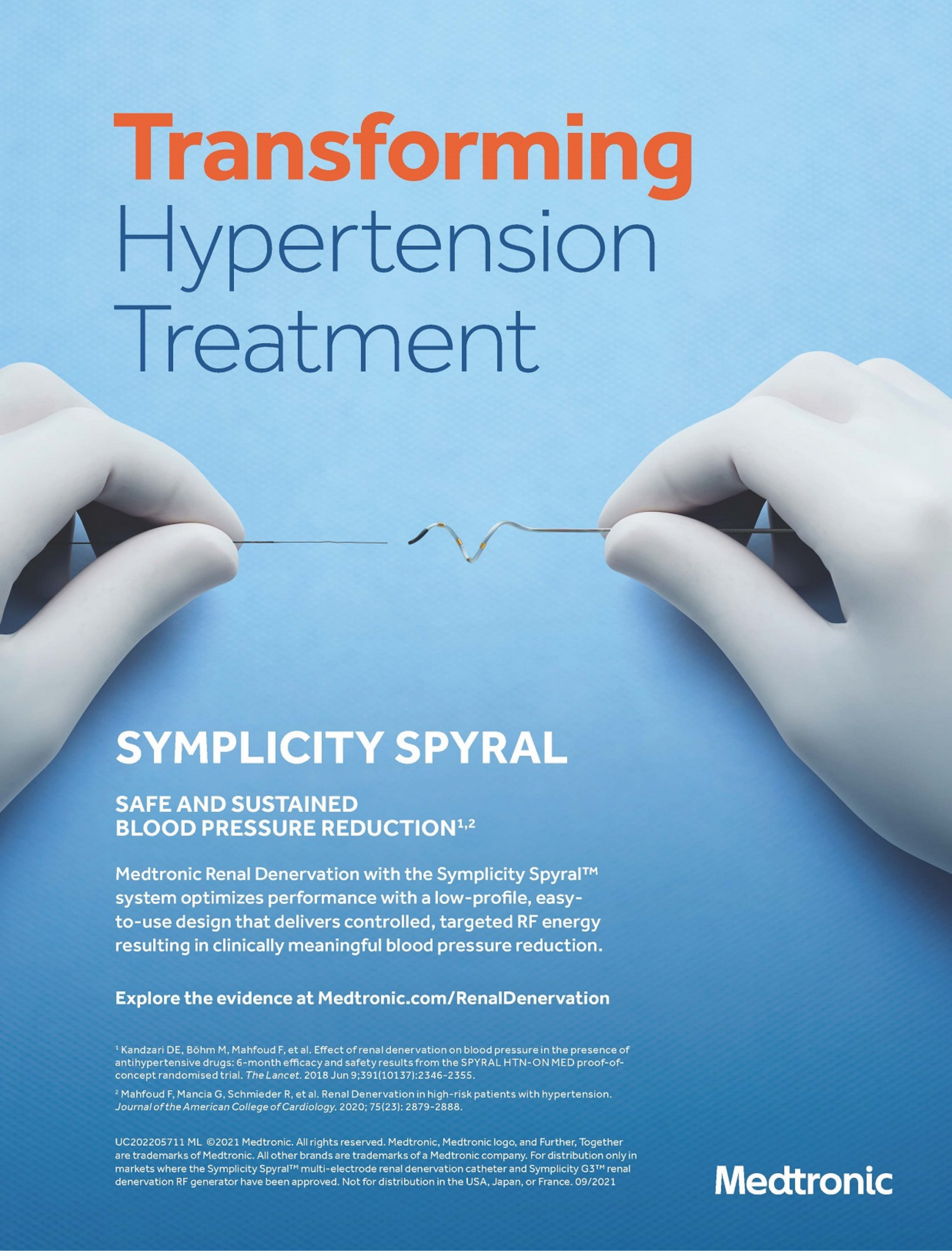
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CASE REPORT

Staged revascularization in patients with acute coronary syndromes due to saphenous vein graft failure and chronic total occlusion of the native vessel: A novel concept

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Abstract

Percutaneous coronary intervention of saphenous vein graft (SVG) lesions can be challenging due to high risk for acute and long-term complications. Treating the corresponding native coronary artery lesion(s) is preferable, but may not be feasible in the acute setting, due to high technical difficulty, especially when the native coronary lesion is a chronic total occlusion (CTO). We describe a novel concept of "staged revascularization" in patients presenting with an acute coronary syndrome due to SVG failure, whose native coronary artery supplied by the SVG has a CTO. In the first stage, the culprit SVG lesion is treated restoring flow to the supplied myocardium and minimizing the extent of myocardial injury. During the second stage (typically few weeks later), revascularization of the corresponding native coronary artery lesion(s) is performed, often using the initially treated SVG for retrograde crossing of the native coronary artery CTO. We describe two cases of non-ST segment elevation acute myocardial infarction due to SVG failure that were treated with "staged revascularization": the culprit SVG was initially treated followed by staged revascularization of the corresponding native coronary artery CTO. Staged revascularization of SVG lesions causing acute coronary syndromes may allow optimization of both acute and long-term outcomes.

KEYWORDS

ACS/NSTEMI, percutaneous coronary intervention, saphenous vein graft interventions

1 | INTRODUCTION

Coronary artery bypass graft surgery (CABG) is commonly used for coronary revascularization. Saphenous vein grafts (SVGs) are used in the majority of CABG in addition to the left internal mammary artery, but have high rates of early and late failure, with approximately 68% patency 10 years after surgery. As a result, prior CABG patients often require percutaneous coronary intervention (PCI): in NCDR 18.5% of all patients undergoing PCI had prior CABG and 6% of all PCIs were performed in SVGs.[1–3] SVG PCI is associated with high risk of acute complications and poor long-term outcomes.[4–7] Treating the corresponding native coronary artery provides better outcomes but may be challenging to perform, as such lesions are often chronic total occlusions (CTOs) and have heavy calcification.[8] Therefore, treatment of the native coronary artery may not be feasible in the acute setting, especially when patients present with SVG occlusion that requires early restoration of flow to minimize the extent of myocardial injury.

We describe two cases illustrating the novel concept of "staged revascularization" for patients presenting with an acute coronary syndrome due to SVG failure, in whom the corresponding native coronary syndrome has a CTO: the culprit SVG lesion is treated in the acute setting, followed by staged revascularization of the corresponding native coronary artery CTO a few weeks later.

1.1 | Case 1

An 81-year-old-woman who had undergone CABG surgery 8 years prior and multiple PCIs, presented with a non-ST segment elevation myocardial infarction (NSTEMI) due to thrombosis of a previously implanted stent in the anastomosis of the SVG to the right coronary artery (RCA). The SVG was recanalized but the stent could not be fully expanded despite multiple high-pressure balloon inflations (Figure 1A). Computed tomography coronary angiography demonstrated a CTO of the distal RCA, proximal to its anastomosis with the SVG (Figure 2).

Three weeks later the patient returned for staged revascularization of the native RCA CTO. Antegrade wire escalation allowed crossing to the distal cap at the stent location; however, despite using multiple high-penetration force guidewires (Hornet 14 [Boston Scientific, Natick, Massachusetts], Gaia 2nd and 3rd [Asahi Intecc, Nagoya, Japan], and Pilot 200 [Abbott Vascular, Santa Clara, California]) entry into the distal true lumen failed. A Pilot 200 guidewire was advanced within the sub-stent space, followed by re-entry into the distal true lumen using the Stingray balloon and the "stick and swap" technique with a Pilot 200 guidewire (Figure 1B,C). The RCA was predilated and a 6-French GuideLiner V3 catheter (Teleflex, Wayne, Pennsylvania) was used to deliver two 2.25 × 32 mm and one 3.0 × 32 mm drug-eluting stents from the proximal to the distal RCA, crushing the previously placed SVG stents and obliterating flow through the SVG to the RCA (Figure 1D). A distal edge dissection was successfully treated with implantation of a fourth 2.25 × 12 mm drug-eluting stent in the distal RCA with an excellent final result and TIMI flow 3 (Figure 1E). The patient had an uneventful recovery without recurrent symptoms at 1 month follow-up.

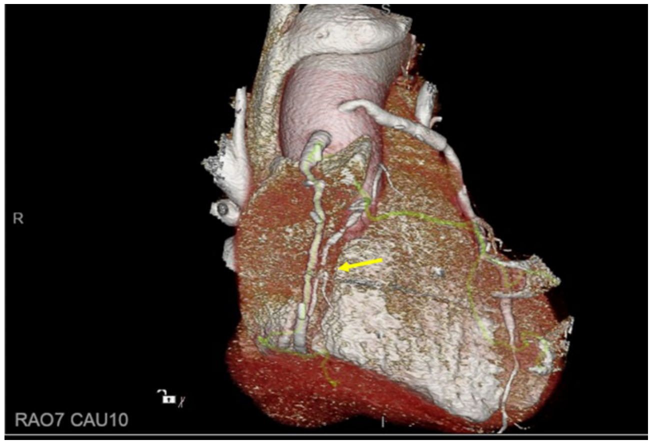

FIGURE 2 CT-angiography. The arrow points to a chronic total occlusion in the right coronary artery, proximal to its anastomosis with the saphenous vein graft (arrow) [Color figure can be viewed at wileyonlinelibrary.com]

1.2 | Case 2

A 68-year-old man who had undergone CABG 11 years ago and had an NSTEMI 2 years prior, was admitted with another NSTEMI due to a subtotal occlusion in a SVG to the RCA, that was successfully recanalized despite transient hemodynamic instability. Two months later, the patient was referred for staged PCI of a complex RCA CTO with a blunt ostial occlusion and long lesion length. Using co-registration of

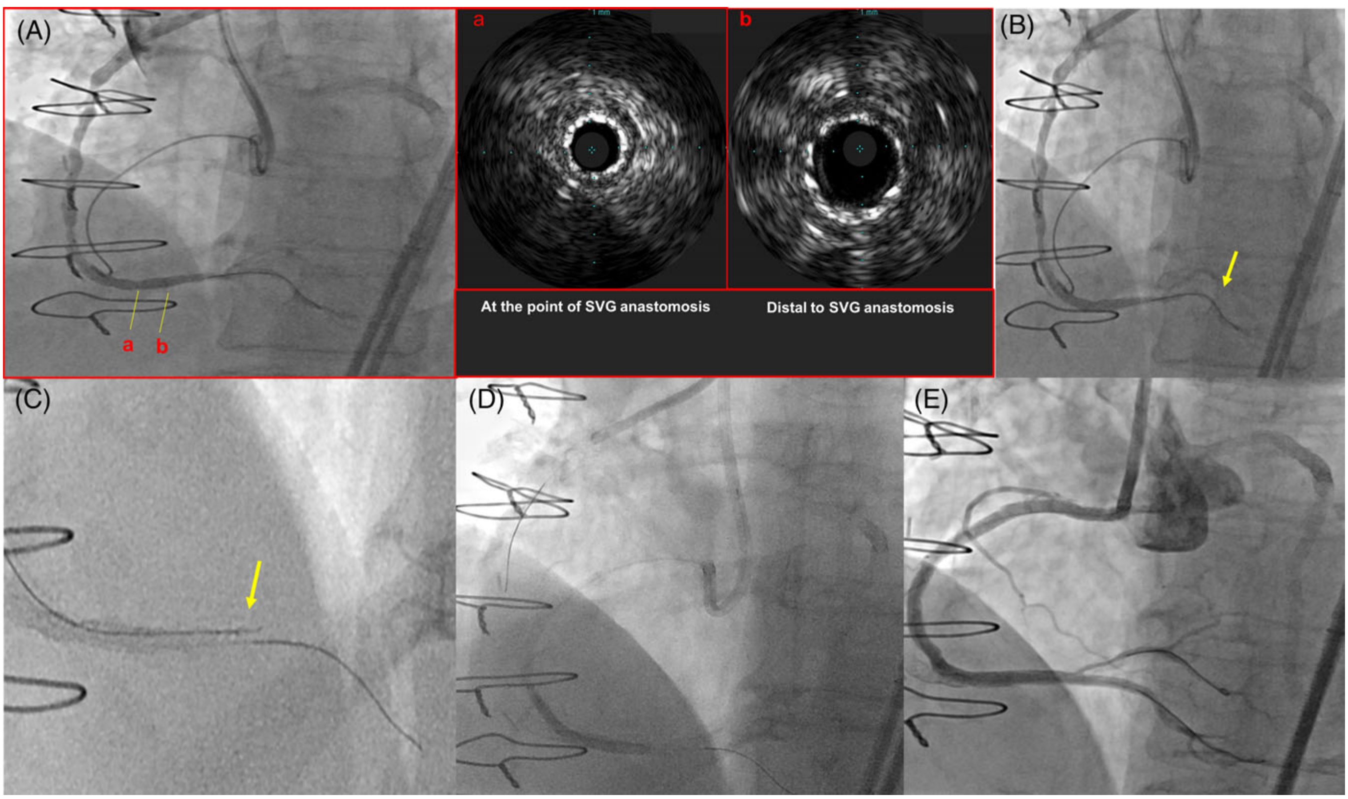

FIGURE 1 Panel A: under-expanded, previously implanted drug-eluting stents over the distal SVG anastomosis in to the right coronary artery. In panel a, IVUS demonstrates the underexpanded stent at the anastomosis while distally the stent is well expanded (panel b). Panel B: a Pilot 200 guidewire entered the subintimal space (arrow). Panel C: a Stingray balloon (arrow) was used for re-entering into the distal true lumen distal to the previously placed stents. Panel D: stent deployment in the native right coronary artery, crushing the previously implanted SVG stents. Panel E: final result with antegrade TIMI flow 3 and occlusion of the SVG [Color figure can be viewed at wileyonlinelibrary.com]

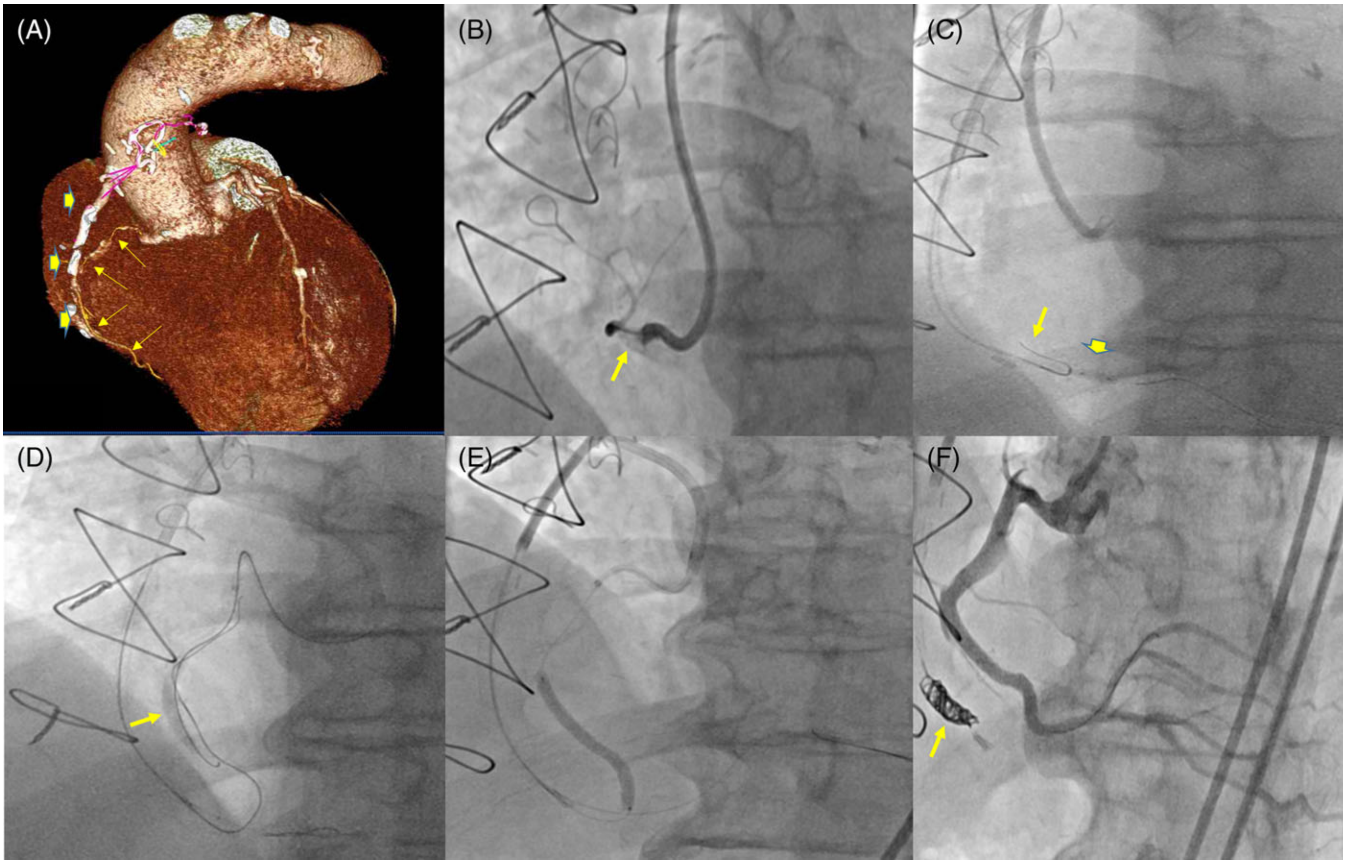

FIGURE 3 Panel A: CT-angiography demonstrating the course of the native right coronary artery (arrows) and the saphenous vein graft (arrowheads). Panel B: ostial, blunt stump right coronary artery occlusion. The wire kept entering a side branch instead of the main vessel (arrow). Panel C: A 3.0 × 8 mm balloon (arrowhead) was inflated immediately distal to the SVG anastomosis helping guide a Pilot 200 wire and the Caravel microcatheter to the mid-RCA (arrow). Panel D: reverse controlled antegrade and retrograde tracking and dissection (reverse CART): A 3.0 mm balloon was inflated over a miracle 6 guidewire expanding the subintimal space and allowing the retrograde pilot 200 wire enter the antegrade guide catheter extension (arrow). Panel E: after externalization of an R350 wire, the RCA was predilated from the ostium to the anastomosis of the saphenous vein graft with a 3.5 mm non-compliant balloon and three drug-eluting stents were deployed. Panel F: final result: TIMI flow 3 was restored. Three Axium coils (Medtronic) (two 5 × 15 mm and one 7 × 15 mm) were deployed to occlude the SVG (arrow) [Color figure can be viewed at wileyonlinelibrary.com]

CT-angiography and fluoroscopy to determine the course of the vessel, antegrade crossing attempts were performed (Figure 3A), but were unsuccessful because the antegrade wire kept entering a side branch (Figure 3B). Side branch anchoring and balloon assisted subintimal entry (BASE) were performed without success, hence retrograde crossing was attempted.

Contrast injection through the SVG to RCA revealed flow in the distal RCA with acute angulation of the SVG distal anastomosis. Using a Turnpike 90 microcatheter (Teleflex) and a Fielder FC wire (Asahi Intecc), attempts were made for retrograde wiring, but were unsuccessful. A 3.0 × 8 mm balloon was inflated immediately distal to the SVG anastomosis in the native RCA, "blocking" the guidewire and microcatheter prolapse into the distal RCA and enabling advancement of a Caravel microcatheter (Asahi Intecc) to the mid-RCA (Figure 3C). Due to the extreme tortuosity and calcification at the mid-RCA, we were unable to further advance the microcatheter.

Repeat attempts were made for antegrade crossing. The "scratch and go" technique was performed using a Hornet 14 guidewire (Boston Scientific) to create a dissection at the proximal vessel, followed by advancement of a Turnpike LP microcatheter (Teleflex) into the dissection plane. A Pilot 200 guidewire (Abbott Vascular) was advanced subintimally using fluoroscopy co-registration with CT-angiography to the mid RCA. The Trapliner (Teleflex)-reverse controlled antegrade and retrograde tracking (reverse CART) technique was performed in the mid RCA with successful retrograde guidewire crossing into the Trapliner and the guide catheter (Figure 3D). An R350 guidewire (Teleflex) was externalized, the RCA was predilated with several balloons followed by implantation of three drug-eluting stents from the proximal to the distal RCA past the SVG distal anastomosis (Figure 3E). After restoring TIMI 3 antegrade flow in the native RCA, 3 coils were deployed in the SVG-RCA to minimize competitive flow (Figure 3F). The patient had an uneventful recovery.

2 | DISCUSSION

Our cases demonstrate the feasibility of "staged revascularization" in patients presenting with acute coronary syndrome due to a SVG lesion, in whom the corresponding native coronary artery has a CTO. The culprit SVG lesion is initially recanalized in the acute setting, followed by staged PCI of the native coronary artery CTO few weeks later. Acute treatment of the SVG lesion was easier in the first case and quite challenging in the second case, resulting in transient hemodynamic instability. In both cases, however, SVG antegrade flow was successfully restored.

SVG interventions carry high risk for both acute (distal embolization and periprocedural myocardial infarction [MI]) and long-term (high restenosis and re-occlusion rates) complications. This is especially true for highly degenerated SVGs with diffuse disease. A SVG degeneration score has been developed by Coolong et al. as an ordinal metric of the extent of lumen irregularities and ectasia (>20% of the reference normal segment) within the SVG that makes up 25% (SVG degeneration score, 0), 26–50% (SVG degeneration score, 1), 51–75% (SVG degeneration score, 2), or >75% (SVG degeneration score, 3) of the total SVG length.[7] Higher SVG degeneration score and SVG plaque volume were associated with higher risk for periprocedural complications.[7] Several other clinical (older age, preprocedural high diastolic blood pressure, diabetes, acute MI) and angiographic (proximal lesion, culprit multiple plaque ruptures, tissue prolapse, presence of ulcer, preintervention less than TIMI 3 grade flow) factors have been associated with no reflow[9–14] and worse long-term outcomes.[2,10,11]

Given the poor outcomes with PCI of complex SVG lesions, PCI of the corresponding native coronary artery appears appealing. A report from the National Cardiovascular Data Registry, demonstrated that native coronary artery PCI was associated with lower in-hospital mortality (0.9% vs. 1.5%, $P < 0.001$) than SVG PCI,[5] suggesting that native coronary artery PCI may be preferred with diffusely degenerated SVGs, whereas SVG PCI may be preferred in the presence of long, tortuous, and calcified native coronary artery lesions or in the presence of CTOs.[5] Similar results were observed in the Veterans Affairs health care system: as compared with native coronary PCI, SVG PCI was associated with higher in-hospital mortality (0.83 vs. 1.79%, $P < 0.001$), periprocedural MI (0.43% vs. 1.00%, $P = 0.001$) and cardiogenic shock (0.13% vs. 0.36%, $P = 0.013$). During five-year follow-up, mortality (17.5% vs. 24.39%, $P < 0.001$), MI (8.3% vs. 14.11%, $P < 0.001$) and repeat revascularization (23.25% vs. 33.71%, $P < 0.001$) were all higher in the SVG PCI group.[2]

Native coronary artery PCI, however, can be challenging and often involves treatment of CTOs, which requires technical expertise, equipment availability, and carries a risk for complications, such as perforation, which can cause loculated effusions and death in the prior CABG patients.[15] Moreover, native coronary arteries in prior CABG patients are often heavily calcified and tortuous.[8,16–18] CTO PCI in the prior CABG patients often requires use of the retrograde approach and has been associated with lower technical success but similar major adverse cardiac events rates as compared with patients without previous CABG.[19] Therefore, a decision to treat a native coronary artery vs. a diseased SVG should take into account both the short- and long-term benefits and risks of each approach.[20]

Several technical challenges had to be overcome to achieve native CTO recanalization. In the first case, antegrade-dissection re-entry was required to cross around the previously placed stents from the SVG to the native artery and re-enter immediately distally, crushing the prior stents. The positive consequence of this technique was to obviate the need for expanding the previously unexpanded stents and also to stop flow through the SVG, which has been linked to thrombosis of the native coronary stents. The long-term patency of the new stents remains to be determined. There are several case reports of subintimal stent crushing with promising results.[21–25] Azzalini et al. reported the outcomes of 32 such cases: the occluded stent was crushed partially in 37%, and completely in 63% of cases. Follow-up with angiography was performed in 10 patients, showing patent stents in six, mild neointimal hyperplasia in one, and severe restenosis at the subadvential stenting site in three patients. The 24-month incidence of target vessel failure was 13.8%.[26]

Several challenges had to be overcome in the second case, that is, ostial occlusion, proximal cap ambiguity, severe tortuosity and calcification, and severe tortuosity for retrograde crossing. Antegrade subintimal crossing was achieved using the "scratch and go technique", in which a stiff guidewire is advanced into the vessel wall to create a dissection, followed by insertion of a microcatheter and knuckling of a polymer-jacketed guidewire (Pilot 200). Fluoroscopy and CT co-registration allowed advancement of the guidewire in a superior angulated course reassuring concerns about perforation. Use of the Supercross 90° microcatheter (Teleflex) and the "blocking balloon" allowed wire and microcatheter advancement proximal to the SVG anastomosis. Use of the Trapliner catheter facilitated reverse CART and also stent delivery.

Advantages of "staged revascularization" in patients with culprit SVG lesions and native vessel CTO or other complex lesions include prompt restoration of flow to the culprit SVG, potentially minimizing myocardial injury. Staging also allows for careful planning of the native coronary artery CTO, including performing CT-angiography and referral to an experienced center that successfully completed the procedure. Disadvantages include the need for performing a second procedure and the need to obtain arterial access again. If the SVG cannot be recanalized in the acute setting (e.g., due to heavy thrombus burden), ad hoc recanalization of the native coronary artery can restore flow to the affected myocardium.[27]

3 | CONCLUSIONS

Staged revascularization in patients with an acute coronary syndrome due to culprit SVG lesion and a CTO in the corresponding native coronary artery represents a new paradigm in the treatment of acute SVG failure. Recanalization of the SVG in the acute setting minimizes myocardial injury and subsequent recanalization of the native coronary artery may improve the long-term clinical outcomes.

CONFLICT OF INTEREST

Dr. Xenogiannis: nothing to disclose.

Dr. Tajti: nothing to disclose.

Dr. Burke: consulting and speaker honoraria from Abbott Vascular and Boston Scientific.

Dr. Brilakis: consulting/speaker honoraria from Abbott Vascular, ACIST, American Heart Association (associate editor Circulation), Amgen, Asahi, Cardiovascular Innovations Foundation (Board of

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SUPPORTING INFORMATION

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