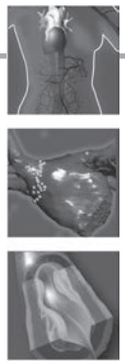
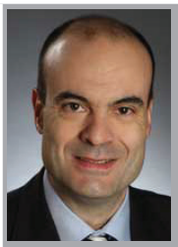


Does prior coronary artery bypass grafting affect percutaneous chronic total occlusion revascularization?

"...achieving high procedural success rates of chronic total occlusion percutaneous coronary intervention in patients with prior coronary artery bypass graft is even more challenging than chronic total occlusion percutaneous coronary intervention in noncoronary artery bypass graft patients."

KEYWORDS: chronic total occlusion ■ outcomes ■ percutaneous coronary intervention ■ prior coronary artery bypass graft



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Chronic totally occluded coronary arteries are commonly encountered and often referred to as the "final frontier of interventional cardiology" [1]. Despite recent advances in wires, catheters, devices and techniques, this lesion subset remains the most technically challenging in the current era of interventional cardiology. Prior coronary artery bypass graft (CABG) surgery further increases the complexity of chronic total occlusion (CTO) percutaneous coronary intervention (PCI) and many of these special considerations are highlighted in this article.

CTOs are commonly discovered among patients referred for coronary angiography. In a large Canadian catheterization registry 18% of patients were found to have at least one CTO [2]. While CTOs are common among all patients referred for angiography, those with prior CABG represent a population with very high CTO prevalence. Approximately half of post-CABG patients undergoing coronary angiography have an unrevascularized CTO [2].

Among CTOs identified during coronary angiography, PCI is attempted in only 10–13%, and the CTOs successfully revascularized by PCI are a mere 7% [2,3]. In the SYNTAX trial, successful revascularization was achieved in only 49.4% of CTOs in the PCI cohort and 68.1% of CTOs in the surgical cohort on a per-lesion basis [4]. This observation suggests that CTO revascularization remains a challenge not only for interventionalists, but also for surgeons. However, the presence of a CTO, particularly in the setting of multivessel disease remains one of the strongest predictors of referral for CABG [3].

While the patency of the left internal mammary artery is over 90% at 10 years post-CABG, the per-patient incidence of 1-year saphenous vein graft (SVG) failure (defined as stenosis >75%) has been reported to be as high as 45% [5]. At 10 years post-CABG, 50–60% of SVGs are either occluded or have hemodynamically significant stenoses [6]. There is evidence to suggest that the patency of SVGs is worse when they are anastomosed to a CTO vessel. In the Prague-4 trial, only 23% of SVGs placed for CTOs in locations other than the left anterior descending artery were patent 1 year post-CABG [7]. These patients develop signs and symptoms of ischemia (angina, or angina equivalents such as dyspnea on exertion or arrhythmias) frequently, or present with abnormal functional studies similar to the patients without prior CABG.

Patients who present post-CABG with degenerated or occluded SVGs remain a significant clinical challenge as to the best way they should be treated. Redo CABG is often a suboptimal choice since most studies have reported increased morbidity and mortality compared with the first CABG [8].

PCI of chronically occluded SVGs is associated with poor short- and long-term outcomes and is, thus, considered to be a class III indication for PCI [9].

PCI of degenerated, but not occluded, SVGs is limited by higher incidence of the no-reflow phenomenon, periprocedural myocardial infarction (MI), in-hospital mortality, restenosis and reocclusion compared with PCI of the native coronary arteries. Despite the use of embolic protection devices, pharmacological therapies and drug-eluting stents, SVG PCI is still inferior to native vessel PCI and as such, PCI of the native vessels should be considered whenever possible [6].

Patients who present with recurrent signs and symptoms of ischemia post-CABG with occluded, diffusely degenerated or previously

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stented SVGs and a CTO are a particularly problematic subset.

Historically, CTO PCI attempts in the USA have been disappointingly low and hindered by low success rates in the 60–70% range [3]. Recently, with the development of CTO wires and catheters, dissection re-entry devices and the adoption of the retrograde techniques, CTO PCI has achieved success rates of approximately 85–90% with acceptable complication rates in selected high-volume centers [10–14].

However, achieving high procedural success rates of CTO PCI in patients with prior CABG is even more challenging than CTO PCI in non-CABG patients [15].

> *"Approximately half of postcoronary artery bypass graft patients undergoing coronary angiography have an unrevascularized chronic total occlusion."*

We recently published a report on the impact of prior CABG on CTO PCI revascularization, analyzing data from a large registry of 1363 consecutive patients that underwent CTO PCI by experienced operators at three US institutions (St Joseph Medical Center, WA, USA; Piedmont Heart Institute, GA, USA; and Veteran Affairs North Texas Healthcare System, TX, USA) [16]. In total, 508 patients (37%) had prior CABG and 86.2% were men. Compared with patients without prior CABG, those post-CABG were older (mean age 67.7 ± 9.0 vs 63.3 ± 10.4 years; $p < 0.001$), and had statistically significant higher prevalence of coronary artery disease risk factors (diabetes 44.3 vs 36.8%, $p < 0.011$; hypertension 92.6 vs 87.2%, $p < 0.005$; hyperlipidemia 96 vs 92.6%, $p < 0.016$) and prior stroke (8.0 vs 4.5%; $p < 0.015$). The technical success rate was lower among prior CABG patients (79.7 vs 88.3%; $p = 0.015$). The reasons for failure were inability to cross the CTO lesion (92.7%) and failure to dilate the lesion after successful wire crossing (7.3%). Use of the retrograde approach was more frequent in prior CABG patients (47.6 vs 27.1%; $p < 0.001$) and the retrograde channels used were septals (68%), epicardials (24%) and bypass grafts (8%). This may be a reflection of the higher technical complexity of the CTOs treated in post-CABG patients. The right coronary artery was the most common target vessel for revascularization (56.2%), followed by the left circumflex (23%) and the left anterior descending artery (21%). The mean fluoroscopy time (49 ± 30 vs 38 ± 27 min; $p < 0.001$), as well as the air kerma (5.5 ± 5.0 vs 4.3 ± 3.0 Gy; $p = 0.003$) were also higher in the post-CABG group. In multivariate analysis, prior CABG remained a predictor of technical failure (odds ratio: 0.49; 95% CI: 0.35–0.70; $p<0.001$). Years from initiation of a formal CTO PCI program (i.e., the experience of the center) at participating centers were predictors of CTO PCI success.

The incidence of major complications was similar in those with and without prior CABG (2.1 vs 1.5%, respectively; $p = 0.392$). In the post-CABG group, there were two deaths (one owing to coronary perforation, and one owing to intracranial bleeding), one donor vessel dissection, two perforations requiring emergency surgery or pericardiocentesis, one equipment entrapment, one transient ischemic attack and four acute myocardial infarctions. It should be emphasized that although the risk of tamponade after perforation of epicardial collaterals may be reduced in post-CABG patients, tamponade can still occur and it may be particularly difficult to diagnose and treat as it may occur in unexpected locations around the heart, such as localized tamponade compressing the left atrium [17,18].

An interesting observation from reviewing the literature of large CTO CPI registries is that the proportion of CTO PCI performed in our series (37%) is higher than in series published from Europe and Japan (5.0–15.9%) [11–13,19,20]. This may be a result of overall different revascularization methods used in different parts of the world, with more frequent use of surgical revascularization in the US. Nevertheless, CTO PCI is performed on a significant number of patients with prior CABG around the world despite its technical complexity, and this is important, given the limited therapeutic options available to these patients.

> *"Patients who present with recurrent signs and symptoms of ischemia postcoronary artery bypass graft with occluded, diffusely degenerated or previously stented saphenous vein grafts and a chronic total occlusion are a particularly problematic subset."*

Our findings, that CTO PCI success rates are lower in post-CABG patients, are consistent with previously published literature [12,15,19–21]. Several potential factors could explain this observation. Patients with prior CABG tend to be older, have more comorbidities and longer duration of the CTOs. In addition, prior CABG can accelerate the progression of atherosclerosis and these patients often have diffusely diseased vessels with heavy calcification, leading to target CTO

lesions of higher complexity. Furthermore, prior CABG may complicate the native anatomy due to tenting of the vessels making CTO PCI extremely challenging. Patients with prior CABG frequently have more than one CTO and more than one failed bypass graft, making visualization of the target vessel and understanding of the anatomic connections between the different vascular territories extremely difficult. This may also limit the available technical approaches (antegrade or retrograde) that can be used. The 'standard' dual injections for CTO PCI are frequently inadequate and using three catheters or alternating the two catheters in different vessels is required.

Conclusion

Does prior CABG affect CTO revascularization? The answer is 'yes'. It is more technically challenging and is associated with lower success rates compared with CTO PCI in non-CABG patients. The complication rate is comparable to CTO PCI in other patients. On the other hand, CTO PCI may be particularly attractive in patients with prior CABG, because treatment of failing saphenous vein bypass grafts can be challenging with high rates of periprocedural myocardial infarction and subsequent failure and occlusion, even when using embolic protection devices, optimal pharmacotherapy and drug-eluting stents. It is encouraging that CTO PCI is attempted worldwide with good, albeit lower, success rates and low complication rates in this very challenging patient population. It should, thus, be considered a viable therapeutic option for this most challenging patient population, at least in selected centers with expertise in CTO PCI. More work is certainly required in the future to improve the acute and long-term outcomes in CTO PCI in general, and in CTO PCI in patients with prior CABG in particular.

Financial & competing interests disclosure

D Karmpaliotis has received honoraria from Boston Scientific, Abbott Vascular, Medtronic, Asahi and Bridgepoint Medical. The author's institution, Piedmont Heart Institute, has received a research grant from Medtronic. The author has no other relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript apart from those disclosed.

No writing assistance was utilized in the production of this manuscript.

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