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Does Percutaneous Coronary Interventions of Coronary Chronic Total Occlusions to Patients with Prior Coronary Artery Bypass Graft Surgery Have Poorer Pocedural Outcome?

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Abstract

Objectives: This study aimed to investigate procedural outcomes of Percutaneous Coronary Intervention (PCI) for Chronic Total Occlusion (CTO) in patients with prior Coronary Artery Bypass Graft (CABG).

Background: Patients with prior CABG often have more comorbidities, complex coronary anatomy, and poorer outcomes than those without prior CABG. Success of PCI for CTO may be more challenging in patients with prior CABG.

Methods: We evaluated clinical characteristics and procedural outcomes in 317 consecutive patients undergoing CTO-PCI, and compared the results between patients with ($n = 70$) and without prior CABG ($n = 247$).

Results: Patients with prior CABG were older and had more coronary artery disease risk factors than those without prior CABG. CTO-PCI was more often performed in the right coronary artery. Patients with prior CABG had significantly higher mean J-CTO score (2.3 ± 1.2 *vs*. 1.7 ± 1.3, $P = 0.0019$). Detailed investigation of the characteristics of J-CTO score indicated the greatest impact of the presence of calcifications. Patients with prior CABG were treated more frequently with the retrograde approach (41.4% *vs.* 17.8%, $P = 0.0004$) and had longer fluoroscopic times, higher radiation dose, and more contrast administration. Technical and procedural success were achieved in 80.0% *vs*. 85.0% ($P = 0.35$) and 78.6% *vs.* 83.6% ($P = 0.38$), respectively; these differences were not significant.

Conclusions: CTO-PCIs of patients with prior CABG did not indicate poorer procedural outcome. However, patients with prior CABG had more complex CTO lesions, and CTO-PCIs of them were required higher use of the retrograde approach.

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Keywords: Percutaneous coronary intervention; Chronic total occlusion; Prior coronary artery bypass graft surgery

Abbreviations and Acronyms: CTO: Chronic Total Occlusion; PCI: Percutaneous Coronary Intervention; CABG: Coronary Artery Bypass Grafting Surgery; TIMI: Thrombolysis In Myocardial Infarction; RCA: Right Coronary Artery; LCX: Left Circumflex Artery; LAD: Left Ascending Artery; SVG: Saphenous Vein Grafts; CART: Controlled Antegrade and Retrograde Tracking

Introduction

Regardless of operator expertise and the development of novel interventional devices, Percutaneous Coronary Intervention (PCI) for Chronic Total Occlusion (CTO) is still challenging, but has contributed to higher procedural success rates in the current era of rapid change[1,2].

Previous studies indicated that a history of Coronary Artery Bypass Graft Surgery (CABG) impacts the procedure success rate of PCI for CTO[3-6]. However, clinical outcomes associated with CTO-PCI in a native artery in patients with prior CABG have not been elucidated.

This study was performed to research patients, lesion characteristics, and both procedural and clinical outcomes of PCI for CTO lesions in patients with prior CABG compared to those without prior CABG.

Methods

We evaluated patient demographics, lesion characteristics, procedural characteristics, and clinical outcomes of 317 consecutive CTO patients undergoing coronary intervention between April 2005 and Aug 2014 in our cardiac catheterization laboratory. The results were compared between patients with and without prior CABG.

The indication for CTO-PCI or CABG treatment during this study period was decided by discussion among the heart team of our institution with observation the ACCF/AHA/SCAI Guideline for Percutaneous Coronary Intervention[7] or the ESC/EACTS Guidelines on myocardial revascularization[8] to drive the best management choice in their clinical condition. Emergent cases, such as patients with ST-segment elevation myocardial infarction, were excluded from this study. However, most of the patients with prior CABG had been undertaken surgery before this study period or at other hospitals. Therefore, the reasons for initial CABG referral were unclear due to each cardiologist's discretion of those days. When enrolled patients had CTO lesions in several vessels, only the one vessel that was treated first was included in the study.

The patients had either symptomatic angina or a positive functional stress test, such as a treadmill test or a myocardial perfusion imaging study. Before CTO-PCIs, a computer tomography coronary angiography was availed as a pre-procedural evaluation in 139 patients (43.8%) between 30 patients (42.9%) with and 109 patients (44.0%) without prior CABG, respectively. All patients received dual anti-platelet therapy with aspirin at a dose of 75 mg to 200 mg/day and ticlopidine at a dose of 200 mg/day or clopidogrel at a 75 mg/day from the peri-procedural period. All patients were taking 1 or more antianginal medications, including a long-acting beta-blocker, calcium-channel blocker, alone or in combination, along with either an angiotensin-converting enzyme inhibitor or angiotensin receptor blockers as standard secondary prevention. All patients received a moderate to high-intensity statin therapy in order to reduce the low-density lipoprotein cholesterol target level. On the other hand, study population did not take as antioxidant therapy such as α-lipoic acid therapy on sympathetic heart innervation[9]. Peri-procedural tight glycemic control during CTO-PCI periods had been pursued, since it may protect from myocardial damage extension[10].

All procedures were performed by two experienced operators in a standard manner. The use of specialized devices or techniques and the choice of stent deployment or kinds of stents were left to the operator's discretion. All CTO-PCI procedures in the patients with prior CABG were performed in native coronary arteries that had previously been bypassed. Intravascular ultrasounds were used in most of all CTO-PCI procedures between the study period regardless procedural success or failure.

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1964 and later revision. Informed consent or substitute for it was obtained from patients in this study.

Coronary CTO is defined as a true total occlusion with complete interruption of antegrade blood flow as assessed by coronary arteriography (Thrombolysis In Myocardial Infarction [TIMI] flow grade 0) and with as estimated duration of occlusion of ≥ 3 months. Fluoroscopic time and radiation dose were recorded automatically with a cine device. Contrast volume was extracted from each CTO-PCI report. Overall technical success was achieved when both the guidewire and balloon crossed the occluded lesion completely, successfully dilating the occluded artery and achieving restoration of antegrade flow (TIMI Grade Flow score of 3) with less than 30% residual stenosis on final angiography. Procedural success was defined as achievement of technical success with no in-hospital Major Adverse Cardiac and Cerebrovascular Events (MACCE), including any of the following adverse events before hospital discharge: death from any cause, Q-wave myocardial infarction, recurrent symptoms requiring urgent repeat target vessel revascularization with PCI or coronary bypass graft surgery, tamponade requiring either pericardiocentesis or surgery, and stroke. The J-CTO score was calculated using five angiographic characteristics as described by Morino et al.[11]: "blunt stump" of the proximal CTO cap, the presence of calcifications, a long lesion length (≥ 20 mm), a tortuous anatomy (bending > 45° within the CTO route), and/or previous failed attempt.

Statistical Analysis

Continuous data are summarized as means ± SD (normally distributed data) or medians and interquartile range (non-normally distributed data), and were compared using the t test or Wilcoxon's rank sum test, as appropriate. Categorical variables are expressed as percentages and were compared using the $\chi 2$ or Fisher's exact test, as appropriate. In all analyses, $P < 0.05$ was taken to indicate statistical significance.

Results

Of the 317 consecutive patients that underwent CTO-PCI during the study period, 70 had a history of prior CABG (22.1%), while 247 had no such history (77.9%). The clinical demographics of patients included in this study are listed in Table 1. Compared to patients without prior CABG, patients with prior CABG were older, less likely to be current smokers, and had more comorbidities (diabetes mellitus, hemodialysis, peripheral artery disease, three vessel disease, and left main disease).

Table 1: Clinical characteristics of the study patients, classified based upon history of prior CABG.

Varible	with prior CABG(*n* = 70)	without prior CABG(*n* = 247)	*p* value
Age (years)	71.4 ± 8.5	69.1 ± 10.0	0.048
Male(%)	87.1	85.0	0.66
Diabetes Mellitus (%)	65.7	50.6	0.043
Insulin required(%)	18.6	19.4	0.72
Hypertention (%)	75.7	82.1	0.14
Dyslipidemia (%)	65.7	72.5	0.19
Current Smoker (%)	28.6	42.1	0.02
Chronic kidney disease (%)	47.1	34	0.07
Hemodialysis (%)	20.0	8.1	0.022
Perpheral vascular disease (%)	37.1	14.2	0.00006
Cerebrovascular disease (%)	21.4	17.4	0.22
Heart failure (%)	37.1	28.7	0.26
Single vessel disease (%)	10.0	17.8	0.12
Multivessel disease (%)	90.0	82.2	0.2
Two vessel disease (%)	31.4	42.5	0.06
Three vessel disease (%)	58.6	39.7	0.009
Left main disease (%)	52.9	16.2	< 0.001
Prior CABG	70 (100.0)	0 (0.0)	
Previous myocardial infarction (%)	50.0	44.5	0.55
Left ventricle ejection fraction (%)	51.7 ± 12.8	54.4 ± 15.8	0.13

Continuous values are means ± SD or medians (interquartile range).
CABG: Coronary Artery Bypass Grafting
Diabetes Mellitis was defined as glycemic control of A1C targets of ≥ 6.5%.
Chronic kidney disease was defined as not being on maintenance hemodialysis and estimated glomerular filtration rate (eGFR) < 60 ml/min/1.73 m2, calculated by the modification of diet in renal disease formula.
Single vessel disease was defined as no having min. 50% stenosis in other two epicardial coronary arteries (regarding patients with prior CABG, these were evaluated in the form of vessels which were patent by graft were excluded from the epicardial coronary arteries having diseased).
Multivessel disease was defined as the presence of min. 50% stenosis in at least two of the epicardial coronary arteries (regarding patients with prior CABG, these were evaluated in the form of vessels which were patent by graft were excluded from the epicardial coronary arteries having diseased).
Two vessel disease was defined as the presence of min. 50% stenosis in two of the epicardial coronary arteries (regarding patients with prior CABG, these were evaluated in the form of vessels which were patent by graft were excluded from the epicardial coronary arteries having diseased).
Three vessel disease was defined as the presence of min. 50% stenosis in all of the epicardial coronary arteries (regarding patients with prior CABG, these were evaluated in the form of vessels which were patent by graft were excluded from the epicardial coronary arteries having diseased).
Left main disease was defined as the presence of min. 50% stenosis at the left main trunk.
Prior CABG was defined as patients who had a history of coronary artery bypass grafting.
Previous myocardial infarction was defined as patients who had a history of myocardial infarction.

In the target vessels (Table 2), CTO-PCIs were performed in the Right Coronary Artery (RCA) more often (37.1% *vs*. 38.9%, respectively, $P = 0.96$) followed by the left circumflex artery (LCX) (27.1% *vs*. 32.8%, respectively, $P = 0.66$) and the left anterior descending artery (LAD) (28.6% *vs*. 23.1%, respectively, $P = 0.37$), and these were not significantly different between patients with and without prior CABG.

Table 2: Angiographic and Lesion Characteristics of the Study Patients, Classified Based upon History of Prior CABG

Variable	with prior CABG (*n* = 70)	without prior CABG (*n* = 247)	*p* value
CTO target vessel			
Right coronary artery (%)	35.7	38.9	0.96
Left anterior descending artery (%)	28.6	23.1	0.37
Left circumflex artery (%)	27.1	32.8	0.66
Left mail (%)	2.9	0.9	0.16
Branch (%)	4.3	5.3	0.73
Bypass (%)	1.4	0.0	0.32
Denovo (%)	82.9	72.1	0.16
Prior percutaneous intervention (%)	17.1	27.9	
In-sent occlusion (%)	12.9	14.6	0.80
Syntax seores (point)	28.9 ± 12.3	31.8 ± 12.3	n.s
J-CTO scores (overall)	2.3 ± 1.2	1.7 ± 1.3	0.0019
Blunt stump of the proximal cap (%)	57.1	48.2	0.19
The presence of calcifications (%)	50.0	25.5	0.004
A tortuous morphology (%)	38.6	25.1	0.027
A long lesion length (≥ 20 mm) (%)	48.5	37.2	0.09
Previously failed CTO PCI attempt (%)	24.3	18.2	0.26

Continuous values are means ± SD or medians (interquartile range).
CABG: Coronary Artery Bypass Grafting, CTO: Chronic Total Occlusion
PCI: Percutaneous Coronary Intervention
Branch was defined as target CTO vessels which were equivalent branching vessels from three main epicardial coronary arteries.
Denovo was defined as target vessels which had no history of percutaneous coronary intervention.
Prior percutaneous intervention was defined as target vessels which had a history of percutaneous coronary intervention.
In-stent occlusion was defined as target vessels which had occluded inside of stents having a history of deployments at prior percutaneous coronary intervention.
Syntax scores were extracted from the SYNTAX Calculator 2.11. (regarding the calculation of prior CABG lesions, these were evaluated in the form of vessels which were patent by graft were excluded from the original SYNTAX score algorithm).
Overall J-CTO scores were calculated and extracted using the J-CTO score sheet by Morino et al. from five characteristics which were standardized way in lesion complexity as will be described as follows.
Blunt stump of the proximal cap was defined that the morphology of a CTO entry had no tapered tip or dimple indicating of the true lumen.
The presence of calcifications was defined as positive assigned if any evident calcifications were detected within the CTO segment in fluoroscopy or angiography, regardless of severity.
A tortuous morphology was defined as bending > 45° within the CTO route.
A long lesion length (≥ 20 mm) was defined as that total occlusion length was longer than 20mm to measure true distance of occlusion using good collateral images.
Previously failed CTO PCI attempt was defined as positive assigned if this is re-try procedure which means previously attempted but failed.

Patients with prior CABG had significantly higher mean J-CTO score (2.3 ± 1.2 *vs*. 1.7 ± 1.3, respectively, $P = 0.0019$). In detailed evaluation of each characteristic of J-CTO score, the presence of calcifications had the greatest impact (50.0% *vs*. 25.5%, respectively, $P = 0.004$), followed by tortuous morphology (38.6% *vs*. 25.1%, respectively, $P = 0.027$), and long lesion length (≥ 20 mm) (48.5% *vs*. 37.2%, respectively, $P = 0.09$) in patients with compared to those without prior CABG (Table 2).

The CTO-PCI procedural and clinical outcomes are listed in Table 3. Technical success was achieved in 56 of 70 (80.0%) patients with prior CABG and 210 of 247 (85.0%) patients without prior CABG ($P = 0.35$). The corresponding rates for procedural success were 55 of 70 (78.6%) and 207 of 247 (83.6%), respectively ($P = 0.38$). The procedural approaches were different between patients with and without prior CABG, with the retrograde/bilateral approach being more common in patients with prior CABG (42.9% *vs*. 17.8%, $P = 0.0004$). In patients undergoing retrograde wiring, transseptal collaterals were utilized less frequently among those with prior CABG. On the other hand, Saphenous Vein Grafts (SVGs) were utilized as conduit for retrograde approach about one-third of patients with prior CABG. With regard to the approach site, a femoral approach and larger-sized guiding catheter utilized were more frequently in patients with prior CABG. These differences may have contributed to the closing of differences in success rates of CTO-PCI between patients with and without CABG. The CTO-PCIs among patients with prior CABG were more complex requiring more contrast administration (210.5 ± 78.5 *vs*. 190.3 ± 69.4 ml, $P = 0.032$), longer fluoroscopic times (79.1 ± 48.8 *vs*. 53.0 ± 40.2 minutes, $P < 0.05$), higher dose area product radiation dose (504.6 ± 288.3 *vs*. 348.2 ± 242.8 Gray-cm^2, $P < 0.05$), and greater numbers of wires per CTO-PCI (4.7 *vs*. 3.3, $P < 0.05$) compared with patients without prior CABG.

Table 3: Procedural Outcomes among the Study Patients, Classified Based upon History of Prior CABG.

Variable	with prior CABG (*n* = 70)	without prior CABG (*n* = 247)	*p* value
Procedural outcome			
Technical success (%)	80.0	85.0	0.35
Procedural success (%)	78.6	83.8	0.38
Procedural approach			
Conventional antegrade approach (%)	57.1	82.2	0.0004
Retrograde/ bilatereal approach (%)	42.9	17.8	
Collateral used in retrograde wining			
(via) Septal (%)	32.3	71.7	0.0013
(via) Epicardial (%)	32.3	28.3	0.58
(via) Saphenous vein graft (%)	32.3	0.0	< 0.001
(via) Internal mamary artery (%)	3.2	0.0	0.23
Approach site			
Femoral (%)	87.1	70.3	< 0.0001
Brachila (%)	1.4	0.5	0.49
Radial (%)	11.5	29.2	0.027
Size of Guiding catheter			
8Fr (%)	5.7	10.0	0.35
7Fr (%)	79.9	57.1	0.05
6Fr (%)	14.3	32.8	0.027
Fluoroscopic time (min)	79.1 ± 48.8	53.0 ± 40.2	< 0.05
Contrast Volume (ml)	210.5 ± 78.5	190.3 ± 69.4	0.032
Dose area product radiation dose (Gray-cm^2)	504.6 ± 288.3	348.2 ± 242.8	< 0.05
Number of wires per one CTO-PCI	4.7 ± 3.1	3.3 ± 2.2	< 0.05
MACCE (%)	5.7	2.4	0.17

Continuous values are means ± SD or medians (interquartile range).
CABG: Coronary Artery Bypass Grafting, CTO: Chronic Total Occlusion
PCI: Percutaneous Coronary Intervention
MACCE: Major Adverse Cardiac and Cerebrovascular Events
Technical success was defined as positive achievement when both the guide wire and balloon crossed the occluded lesion completely, successfully dilating the occluded artery and achieving restoration of antegrade flow (TIMI Grade Flow score of 3) with less than 30% residual stenosis on final angiography.
Procedural success was defined as achievement of technical success without MACCE.
Conventional antegrade approach was defined as conclusion CTO PCI procedures with antegrade approach only.
Retrograde / bilateral approach was defined as utilization CTO PCI procedures with retrograde/ bilateral approach via collaterals.
Numbers of wires per one CTO-PCI was calculated average numbers which was used guide wires in one CTO-PCI procedure.

Overall, major procedural complications occurred in 6 of 317 patients (2.4%). In the prior CABG group, major complications were reported in 4 of 70 patients (5.7%): one patient died due to congestive heart failure despite successful interventional revascularization, two patients died due to multiple organ failure triggered by bacterial infection, and one patient experienced a stroke. In the non-prior CABG group, complications occurred in 6 of 317 patients (2.4%, $P = 0.17$ compared with prior CABG group). Non-cardiac deaths were reported in three patients: two due to multiple organ failure and one patient due to cancer. Two patients experienced strokes and one patient required pericardiocentesis for tamponade.

Discussion

The major findings of our study were that: (1) patients with prior CABG were older and had more comorbidities, and therefore, CTO lesions of these subjects were especially affected by calcification within the CTO segment; (2) CTO-PCIs in patients with prior CABG were more likely to involve the retrograde/bilateral approach for interventional revascularization; and (3) the technical and procedural success rates of CTO-PCI were not significantly different but slightly lower among patients with prior CABG, whereas complication rates were similar between the two groups.

Patients with prior CABG are known to have more comorbidities and poorer outcomes than those without prior CABG. This may be due to the acceleration of the atherosclerotic process in bypassed vessels, and these patients often have diffusely diseased vessels with heavy calcification, leading to target CTO lesions of higher complexity[12-14]. Sakakura, et al.[15] showed that CTO lesions in patients with a history of CABG had increased areas of calcification by histological evaluation. These findings were consistent with the results of the present study indicating that patients with prior CABG had a much higher prevalence of calcification compared to those without prior CABG, which had the greatest impact among characteristics of the J-CTO score.

While the patency of the left internal mammary artery is over 90% at 10 years post-CABG, the per-patient incidence of 1-year SVGs failure has been reported to as high as 45%[16]. At 10 years post-CABG, 50% – 60% of SVGs are either occluded or have hemodynamically significant stenosis[17]. There is evidence suggesting that the patency of SVGs is poorer when anastomosed to a CTO vessel.

Treatment of patients presenting post-CABG with degenerated or occluded SVGs remains a significant clinical challenge. Repeat CABG has often been associated with a greater risk of adverse outcomes compared with the initial CABG[18]. When comparing CTO-PCI for native vessels with repeat CABG from the perspective of risks and benefits, lower success rates have been observed after CTO-PCI in patients with prior CABG. However, as repeat CABG is itself associated with higher postoperative mortality rates, it is reasonable to perform CTO-PCI in native vessels before repeat CABG[18].

PCI of degenerated or occluded SVGs is limited by the higher incidence rates of the no-reflow phenomenon, periprocedural myocardial infarction, in-hospital mortality, restenosis, and reocclusion compared with PCI of native coronary arteries. Despite the use of embolic protection devices, SVG-PCI is still inferior to native vessel PCI, and therefore PCI of the native vessels should be considered whenever possible[17]. For the above reasons, interventional revascularization to native CTO vessels may be particularly attractive in patients with prior CABG[19].

In the target vessels of CTO-PCIs, there were no statistical differences between patients with and without prior CABG. But, it may be interesting in our study that CTO-PCIs for LCX vessels represented a higher overall proportion than what is typically reported in previous studies. I.e., typically, trends in previous reports are that CTO-PCIs are performed on RCA > LAD > LCX.

Previous autopsy studies have shown that atherosclerosis is usually less pronounced in LCX as compared to the other two arteries[20]. Furthermore, lesions in LCX tend to produce false negative results on noninvasive assessments, implying that the disease may not be evident until later stages[21]. As a result, when patients with LCX-CTO lesions are referred for PCI, they tend to be part of multivessel disease[22]. Although our study is undoubtedly small population, CTO-PCIs for LCX vessels are performed more frequently both in patients with and without prior CABG. It might be considered complete interventional revascularization as procedural steps against progressive multivessel disease in our study population. Otherwise, it might be affected that revascularization to the LCX-CTOs in without prior CABG patients might be given preference PCI than CABG surgery having procedural difficulty in “grafting” to the LCX vessel with restricted operating field. As a result, it might not had been undertaken complete bypass “grafting” to the LCX-CTOs in some patients with prior CABG.

CTO-PCI success rates were lower among patients with prior CABG in some previous studies[3,5,6,23,24]. This may have been due to higher lesion complexity, as reflected in the significantly higher mean J-CTO score of the target CTO lesions among patients with prior CABG, as shown in the present study. Although Galassi, et al.[25] reported no significant association between prior CABG and procedural success of CTO-PCI, the proportion of prior CABG was higher in the failed PCI group in several CTO registries. Teramoto, et al.[5] analyzed CTO-PCI procedures at the Toyohashi Heart Center in Japan and reported significant statistical differences regarding technical success rates in 71% of patients with prior CABG versus 83% in patients without prior CABG. Christopoulos, et al.[6] analyzed 496 CTO-PCIs from a contemporary multicenter US registry using the “hybrid” crossing algorithm among patients with a history of prior CABG and reported lower procedural success rates with prior CABG in combination with a higher rate of application of the retrograde approach. The present study did not use the hybrid algorithm, because it was published in 2012, in the latter part of the study period, moreover, re-entry devices were not commercially available in Japan.

In contrast, the present study demonstrated that the gap in success rates is closing, with no significant differences between the two groups (technical success: 80.0% *vs*. 85.0%, $P = 0.35$; procedural success 78.3% *vs*. 83.8%, $P = 0.38$), although retrograde attempts were made much more frequently in patients with prior CABG (43% *vs*. 18%, $P = 0.0004$). Importantly, these outcomes were achieved while maintaining a low risk for major complications, which occurred at similar rates between patients with and without prior CABG, as reported in several previous studies[2,3,5,6,26].

As mentioned above, CTO-PCI with prior CABG is technically challenging; on the other hand, bypass grafts can be used as conduits (even when occluded) that can facilitate CTO recanalization via the retrograde approach. The greater use of the retrograde approach among patients with prior CABG could be related to the complexity of CTO lesions in patients requiring more aggressive crossing techniques after wire escalation crossing attempts fail and the increasing availability of bypass grafts that can act as retrograde conduits in patients with prior CABG[27,28].

Study limitations

Our study had several limitations. It was performed at a single center, in a retrospective manner, and with a very small sample population. Our study may be somewhat mixed in procedural limitation of antegrade manner, as it started in 2005 prior to CART (Controlled Antegrade and Retrograde Tracking) and reverse CART being widely spread as well as learning retrograde techniques and may be considered learning curve effects by two operator’s expertise using contemporary devices and techniques for a decade. Also the center volume is less than 40 per year and this might be affected overall outcomes compared to other registries and operators. In addition, this was an observational study without independent review of the coronary angiographic laboratory. In the procedural approach, re-entry devices, such as the Bridge Point system, were not used in any cases, as these devices were not commercially available in Japan during the study period. Also it might not be unclear to affect overall outcomes that study population did not perform measurement s of apoptotic proteins expression[29].

Study Future Perspectives

Additional studies or registries in multiple facilities are required. Further studies are also required to improve the acute and long-term outcomes in CTO-PCI, particularly in patients with prior CABG.

Conclusions

In summary, CTO-PCIs of patients with prior CABG did not indicated poorer procedural outcome, but had slightly lower success rate, while patients with prior CABG were older and had more comorbidities and complex CTO lesions, and CTO-PCIs of them were required more complex procedures including higher rates of use of the retrograde approach.

Conflict of Interest: M.Tanabe declares that they have no conflict of interest.

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