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Impact of previous coronary artery bypass surgery on clinical outcome after percutaneous interventions with second generation drug-eluting stents in TWENTE trial and Non-Enrolled TWENTE registry

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ABSTRACT

Background: Patients with previous coronary artery bypass grafting (CABG) who underwent percutaneous coronary intervention (PCI) have an increased repeat revascularization rate, but data on contemporary second-generation drug-eluting stents (DES) are scarce.
Methods: We evaluated 1-year clinical outcome following secondary revascularization by PCI in patients of the TWENTE trial and non-enrolled TWENTE registry, and compared patients with previous CABG versus patients without previous CABG.
Results: Of all 1709 consecutive patients, 202 (11.8%) had previously undergone CABG (on average 11.2 ± 8.5 years ago). CABG patients were older (68.5 ± 9.4 years vs. 64.1 ± 10.7 years, $P < 0.001$) and more often had diabetes (28.7% vs. 20.9%, $P = 0.01$) and previous PCI (40.1% vs. 19.8%, $P < 0.001$) compared to patients without previous CABG. Nevertheless, a higher target vessel revascularization (TVR) rate following PCI in the CABG patients (9.4% vs. 2.3%, $P < 0.001$) was the only significant difference in clinical outcome at 1-year follow-up (available for 99.6%). Among CABG patients, the TVR rate was significantly higher in patients treated for graft lesions ($n = 65$; 95.4% in vein grafts) than in patients treated for native coronary lesions only ($n = 137$) (18.5% vs. 5.1%, $P = 0.002$). Among 1638 patients with PCI of native coronary lesions only, there was only a non-significant difference in TVR between patients with previous CABG versus patients without previous CABG (5.1% vs. 2.3%, $P = 0.08$).
Conclusions: Patients with previous CABG showed a favorable safety profile after PCI with second-generation DES. Nevertheless, their TVR rate was still much higher, driven by more repeat revascularizations after PCI of degenerated vein grafts. In native coronary lesions, there was no such difference.

1. Introduction

In patients with previous coronary artery bypass graft surgery (CABG), progression of atherosclerosis and degeneration of bypass grafts may lead to secondary revascularizations — in the majority of patients by means of percutaneous coronary intervention (PCI) [1,2]. So far, most PCI studies with comprehensive assessment of patients with a history of CABG were performed in the era of bare metal and early generation drug-eluting stents (DES) [3–5], while only limited data are available from second-generation DES.

Second-generation DES with more bio-compatible coatings have been shown to be safe and efficacious in several randomized clinical trials with limited exclusion criteria. An example of such a trial is the randomized TWENTE trial, which studied a broad population of patients undergoing PCI with second-generation DES [6]. In parallel with the randomized TWENTE trial, we performed a registry which assessed patients who also underwent PCI with second-generation DES and were eligible for enrollment in the randomized trial but were not enrolled for various reasons [7]. The pooled population of the randomized trial and the non-enrolled registry represent a consecutive series of patients with stable angina or non-ST-elevation myocardial infarction

Abbreviations: DES, drug-eluting stent; PCI, percutaneous coronary intervention; STEMI, ST-elevation myocardial infarction; TVR, target vessel revascularization; Non-ST-ACS, non-ST-elevation acute coronary syndromes; CABG, coronary artery bypass grafting.

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(MI) who underwent a PCI at Thoraxcentrum Twente during a period of 26 months. A total of 11% of patients of the TWENTE trial and 17% of the non-enrolled TWENTE registry had a history of CABG.

In the present study, we analyzed the pooled population of the TWENTE trial and non-enrolled TWENTE registry to assess the impact of previous CABG on individual clinical endpoints following PCI with second-generation DES. In addition, we investigated the potential impact of lesion location (i.e. in bypass graft versus native coronary artery) on clinical outcome.

2. Methods

2.1. Study design and patient population

We performed a pooled analysis of the prospective TWENTE trial and TWENTE non-enrolled registry. We analyzed 1709 consecutive patients, undergoing PCI with second-generation DES for stable angina or non-ST-elevation acute coronary syndromes (Non-ST-ACS) at Thoraxcentrum Twente in Enschede, The Netherlands. Patients were treated between June 2008 and August 2010. To compare baseline characteristics and clinical outcome between patients with previous CABG versus patients without previous CABG, the patient population was sub-divided, based on history of CABG. Details of the randomized TWENTE trial have previously been reported [6]. In brief, TWENTE (ClinicalTrials.gov NCT01066650) is a randomized, prospective, controlled, patient-blinded DES trial, comparing Resolute ZES and Xience V EES stents after 1:1 randomization in 1391 patients. Patients with stable angina or non-ST-ACS were eligible, and few exclusion criteria were applied [6]. The non-enrolled TWENTE registry has also been reported in detail; it included 318 eligible patients who were not enrolled during the course of the randomized TWENTE trial [7].

2.2. Intervention, medication, electrocardiography, and laboratory testing

Five experienced interventional cardiologists, of whom each had individual experience of at least 4000 PCI procedures as a first operator, performed all PCI procedures by the use of standard techniques. Pharmacological therapy before, during, and after PCI as well as systematic laboratory testing and ECG assessment have previously been described and did not differ between the TWENTE trial and TWENTE non-enrolled registry [6]. Angiographic analyses were performed offline at Thoraxcentrum Twente.

2.3. Definitions of clinical endpoints

Definitions of clinical endpoints have been fully described in the main report on the randomized TWENTE trial [6]. In general, the definitions of the Academic Research Consortium (ARC) were applied [8,9]. Cardiac death was defined as any death due to proximate cardiac cause, unwitnessed death and death of unknown cause, and all procedure-related deaths, including those related to concomitant treatment.

Myocardial infarction (MI) was defined by any creatine kinase concentration of more than twice the upper limit of normal with elevated confirmatory cardiac biomarkers [9]. Further classification and location of MI have been previously described [6]. Target vessel-related MI was related to the target vessel or could not be related to another vessel. Target vessel and target lesion revascularization (TVR and TLR) were defined as any repeat coronary revascularization of the target vessel or target lesion by re-PCI or surgery. Stent thrombosis was defined according to ARC [8].

2.4. Data acquisition and follow-up

In-hospital adverse events were recorded prior to discharge. One-year follow-up data after PCI of all patients were obtained at visits in outpatient clinics or, if not feasible, by telephone follow-up or questionnaire. For any event trigger, all clinical information available from the referring cardiologist, general practitioner, and hospital involved was gathered. The adjudication of adverse clinical events was performed by an independent CRO (Cardialysis, Rotterdam, The Netherlands).

2.5. Statistical analysis

Data analysis was performed with the Statistical Package for Social Sciences (SPSS; version 17, SPSS Inc., Chicago, IL). Data were reported as frequencies and percentages for dichotomous and categorical variables and as mean ± standard deviation for continuous variables. The chi-square test and the Fisher's exact test were used to compare frequencies as appropriate. The Student's *t*-test was used to compare normally distributed continuous variables. The Kaplan–Meier method was used to calculate the time to clinical endpoints and the Log-rank test was used to compare between-group differences. A two-sided P value < 0.05 was considered statistically significant.

3. Results

3.1. Characteristics of patients, lesion, and PCI procedures

Of all 1709 patients, 202 (11.8%) had a history of CABG (Table 1). These patients were older (68.5 ± 9.4 vs. 64.1 ± 10.7 years), more often males (79.7% vs. 71.1%), and suffered more often from diabetes (28.7% vs. 20.9%), chronic renal failure (6.4% vs. 3.1%), and heart failure (6.9% vs. 3.2%) than patients without a history of CABG. In addition, patients with previous CABG had more often a history of MI (40.6% vs. 33.5%) and PCI (40.1% vs. 19.8%). Despite the – on average – higher cardiovascular risk profile, patients with previous CABG were more often treated for stable angina, rather than for acute coronary syndromes (55.0% vs. 47.4%; Table 1). At discharge, patients with previous CABG did not differ from patients without previous CABG in use of statins (90% vs. 86%, P = 0.18), ACE inhibitors (31% vs. 29%, P =0.42), beta blockers (82% vs. 82%, P = 0.85), acetylsalicylic acid (99% vs. 99%, P = 0.76), and thienopyridine (99% vs. 99.5%, P = 0.13) (Table 1).

Patients with previous CABG versus patients without history of previous CABG differed in several lesion characteristics and procedural details (Table 1), including more index PCI for in-stent restenosis (11.4% vs. 5.9%) and type C lesions (62.4% vs. 48.7%) — a difference that was mainly related to bypass graft lesions. Patients with previous CABG less often underwent PCI of lesions in left anterior descending coronary arteries (17.3% vs. 55.4%).

Of the 202 patients with previous CABG, 65 (32.2%) patients were treated for at least one lesion in a bypass graft, of which 62 (95.4%) were located in saphenous vein grafts and 3 (4.6%) in arterial grafts. PCI was performed on average 11.2 ± 8.5 years after CABG. Time between CABG and PCI differed significantly between patients treated for bypass lesions versus native coronary lesions only (9.6 ± 8.6 vs. 14.3 ± 7.5 months, P < 0.001). Fig. 1 shows the distribution of patients in time intervals from CABG to index PCI for 65 patients with PCI in graft lesions versus 132 patients with PCI in native coronary lesions only.

3.2. Clinical outcome

One-year follow-up was available in 1703 (99.6%) patients. Table 2 shows the clinical outcome of patients with previous CABG versus patients without previous CABG. The only difference was a higher TVR rate in patients with previous CABG (9.4% vs. 2.3%, P < 0.001) (Fig. 2A) and explains the significantly higher rate of dual anti-platelet therapy continuation beyond 12 months (12.7% vs. 4.5%, P < 0.001) in these patients.

Table 3 presents the outcome of the 202 patients with previous CABG; it shows that *the TVR rate was much higher in 65 patients who were treated for bypass graft lesions* than in the 137 patients who were treated for native coronary lesions only (18.5% vs. 5.1%, p = 0.002) (Fig. 2B).

As shown in Table 4, among 1638 patients who underwent PCI for the treatment of native coronary lesions only (irrespective of a history of CABG), there was a non-significant difference in TVR between patients with previous CABG versus patients without previous CABG (5.1% vs. 2.3%, P = 0.08).

4. Discussion

4.1. Major findings

In this pooled analysis of 1709 consecutive patients of the prospective TWENTE trial and the TWENTE non-enrolled registry, patients with previous CABG had a 4-fold higher 1-year risk of TVR after PCI than patients without previous CABG. Differences in the incidence of cardiac death, target vessel-related MI, and stent thrombosis showed the same trend, but were non-significant. Within patients who underwent PCI for native coronary lesions only, there also appeared to

Table 1
Baseline characteristics of patients and procedures of patients with versus without previous CABG.

	Patients with CABG in history (N = 202)	Patients without CABG in history (N = 1507)	P value
Age (yrs)	68.5 ± 9.4	64.1 ± 10.7	<0.001
Men	161 (79.7)	1072 (71.1)	0.011
Diabetes mellitus (any)	58 (28.7)	315 (20.9)	0.012
Chronic renal failure*	13 (6.4)	46 (3.1)	0.013
Arterial hypertension	113 (55.9)	845 (56.1)	0.972
Hypercholesterolemia	143/199 (71.9)	853/1476 (57.8)	<0.001
Current smoker	22 (10.9)	388 (25.7)	<0.001
Family history of CAD	108/181 (59.7)	734/1403 (52.3)	0.062
Myocardial infarction (any)	82 (40.6)	505 (33.5)	0.046
Previous PCI	81 (40.1)	299 (19.8)	<0.001
Clinical characteristic			0.023
Stable angina pectoris	111 (55.0)	714 (47.4)	
Acute coronary syndrome	91 (45.0)	793 (52.6)	
Unstable angina	51 (25.2)	358 (23.8)	
Non-ST-elevation MI	40 (19.8)	435 (28.9)	
Left ventricular ejection fraction < 30%†	10/144 (6.9)	35/1106 (3.2)	0.022
Multivessel treatment	52 (25.7)	345 (22.9)	0.368
Total no lesions treated per patient			0.381
One lesion treated	133 (65.8)	927 (61.5)	
Two lesions treated	49 (24.3)	436 (28.9)	
Three of more lesions treated	20 (9.9)	144 (9.6)	
At least one CTO	12 (5.9)	111 (7.4)	0.462
At least one bifurcation	36 (17.8)	409 (27.1)	0.005
At least one in-stent restenosis	23 (11.4)	89 (5.9)	0.003
Postdilatation	177 (87.6)	1323 (87.8)	0.946
Target coronary artery			
Left main‡	35 (17.3)	34 (2.3)	<0.001
Left anterior descending	35 (17.3)	835 (55.4)	<0.001
Left circumflex	60 (29.7)	461 (30.6)	0.797
Right coronary artery	66 (32.7)	550 (36.5)	0.288
Bypass graft	65 (32.2)	–	<0.001
ACC-AHA lesion class			0.003
A	5 (2.5)	70 (4.6)	
B1	22 (10.9)	240 (15.9)	
B2	49 (24.3)	463 (30.7)	
C	126 (62.4)	734 (48.7)	
Medication at discharge			
Statin	180/201 (89.6)	1279/1485 (86.1)	0.182
Ace-inhibitor	63/201 (31.3)	425/1486 (28.6)	0.421
Beta-blocker	164/201 (81.6)	1219/1484 (82.1)	0.848
Acetylsalicylic acid	199 (98.5)	1486 (98.6)	0.757
Thienopyridine	199 (98.5)	1497/1505 (99.5)	0.132
DAPT	196 (97.0)	1479 (98.1)	0.281
Medication at 1-year§	N = 142	N = 1216	
Acetylsalicylic acid	130 (91.5)	1133 (93.2)	0.473
Thienopyridine			<0.001
Stopped after 1 year	118 (83.1)	1130 (92.9)	
Less than 1 year	4 (2.8)	17 (1.4)	
Continued after 1 year	20 (14.1)	69 (5.7)	
Dual anti-platelet therapy			<0.001
Stopped after 1 year	109 (76.8)	1062 (87.3)	
Less than 1 year	15 (10.6)	99 (8.1)	
Continued after 1 year	18 (12.7)	55 (4.5)	

Data are number (%) or mean (SD). CAD = coronary artery disease. PCI = percutaneous coronary intervention. CABG = coronary artery bypass grafting. MI = myocardial infarction. CTO = chronic total occlusion.

* Chronic renal failure was defined by serum creatinine level ≥ 130 μmol/L.

† Left ventricular ejection fraction was assessed with ultrasound, MRI or LV angiography.

‡ 2/35 PCI in left main stems were performed for unprotected left main disease.

§ Based on data from the randomized TWENTE trial. No data are available for patients from the Non-enrolled TWENTE registry.

be a difference in TVR rate between patients with previous CABG versus patients without previous CABG, which was almost significant. Among patients with previous CABG, the TVR rate was 3.5-fold higher in patients treated for target lesions in bypass grafts. Thus, the increased TVR risk of patients with prior CABG is mainly related to PCI performed in vein grafts.

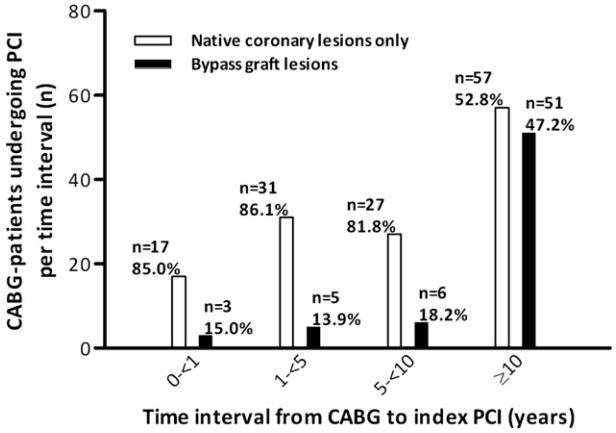

Fig. 1. PCI per time interval from CABG to index PCI in patients with previous CABG. The distribution of patients in time intervals from CABG to index PCI for the two patient groups (65 patients with PCI in graft lesions vs. 132 patients with PCI in native coronary lesions only). Analysis based on 197/202 patients with knowledge of exact time interval. Among the 17 pts. who underwent PCI in native coronary vessels during 0–1 year from previous CABG, 9 were treated in grafted and 8 in ungrafted coronary arteries.

4.2. Comparison with previous studies

In the present study, 11.8% of patients had a previous CABG (on average 11.2 years before PCI), which is similar to or higher than several randomized DES trials where 7% to 11.5% had prior CABG procedures [10–14]. During the last decades, there has been an increase in patients with previous CABG, who ultimately required additional coronary revascularization procedures. Some factors may have contributed to this development. For instance, the aging of populations with a western lifestyle has increased the likelihood of developing very

Table 2
Clinical endpoints at 1-year follow-up of patients with versus without previous CABG.

	Patients with CABG in history (N = 202)	Patients without CABG in history (N = 1.501)	P value
Death			
Any cause	7 (3.5)	29 (1.9)	0.185
Cardiac cause	5 (2.5)	17 (1.1)	0.171
Target vessel-related MI			
Any	13 (6.4)	66 (4.4)	0.196
Clinically indicated TVR			
Any	19 (9.4)	35 (2.3)	<0.001
Percutaneous	18 (8.9)	27 (1.8)	<0.001
Surgical	1 (0.5)	8 (0.5)	1.0
Clinically indicated TLR			
Any	13 (6.4)	25 (1.7)	<0.001
Percutaneous	13 (6.4)	18 (1.2)	<0.001
Surgical	0	7 (0.5)	1.0
Definite ST (0–360 days)	0	4 (0.3)	1.0
Probable ST (0–360 days)	3 (1.5)	8 (0.5)	0.133
ST (0–360 days)			
Possible	3 (1.5)	6 (0.4)	0.080
Definite or probable	3 (1.5)	12 (0.8)	0.408
Definite, probable or possible	6 (3.0)	18 (1.2)	0.056

Data are number of patients (%). MI = myocardial infarction. TVR = target vessel revascularization. TLR = target lesion revascularization. ST = stent thrombosis.

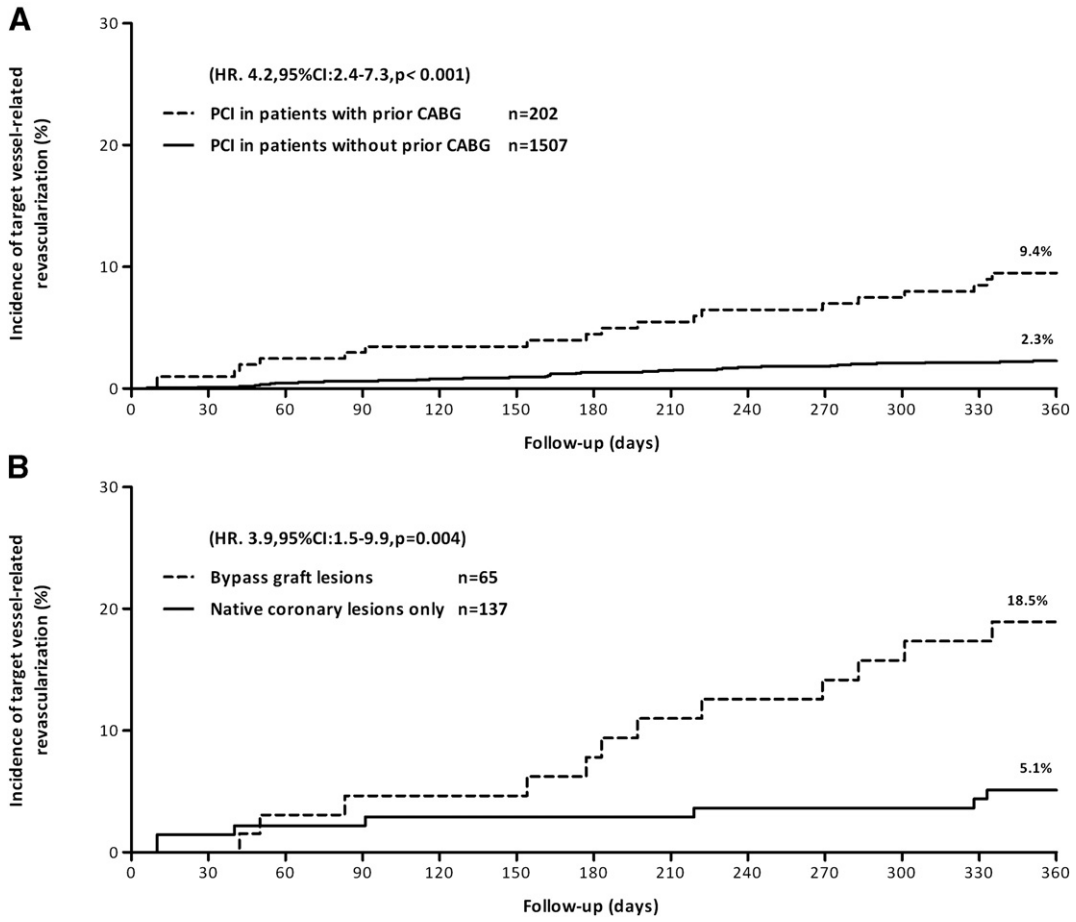

Fig. 2. Target vessel revascularization during follow-up of 1 year. A: Kaplan–Meier cumulative incidence curves at 1-year for target vessel revascularization for patients with versus without prior CABG. B: Kaplan–Meier cumulative incidence curves at 1-year for target vessel revascularization for patients with prior CABG treated for graft lesions versus lesions in native coronary vessels only.

advanced stages of coronary disease and graft failure [1]. In addition, coronary revascularization techniques have been spread over time, leading to a substantial increase in the accessibility of coronary revascularization procedures [15].

Angiographic studies have shown that 10 years from CABG approximately 75% of vein grafts are occluded or severely diseased [16,17]. The attrition of vein grafts with the formation of intimal hyperplasia is promoted by the exposure of the thin-walled conduit to the higher

Table 3
Clinical outcome at 1-year of CABG patients treated for graft lesions versus native coronary lesions only.

	Graft lesions (N = 65)	Native vessels only (N = 137)	P value
Death			
Any cause	3 (4.6)	4 (2.9)	0.538
Cardiac cause	1 (1.5)	4 (2.9)	0.555
Target vessel-related MI			
Any	6 (9.2)	7 (5.1)	0.265
Clinically indicated TVR			
Any	12 (18.5)	7 (5.1)	0.002
Percutaneous	12 (18.5)	6 (4.4)	0.001
Surgical	0	1 (0.7)	0.490
Clinically indicated TLR			
Any	10 (15.4)	3 (2.2)	<0.001
Percutaneous	10 (15.4)	3 (2.2)	<0.001
Surgical	–	–	–
Probable ST (0–360 days)	1 (1.5)	2 (1.5)	0.966
ST (0–360 days)			
Possible	–	3 (2.2)	0.229
Definite, probable or possible	1 (1.5)	5 (3.6)	0.409

Data are number of patients (%). MI = myocardial infarction. TVR = target vessel revascularization. TLR = target lesion revascularization. ST = stent thrombosis.

Table 4
Clinical outcome after 1 year of patients treated for lesions in native coronary vessels only, comparing patients with versus without previous CABG.

	Native vessels CABG (N = 137)	Native vessels non-CABG (N = 1501)	P value
Death			
Any cause	4 (2.9)	29 (1.9)	0.350
Cardiac cause	4 (2.9)	17 (1.1)	0.092
Target vessel-related MI			
Any	7 (5.1)	66 (4.4)	0.665
Clinically indicated TVR			
Any	7 (5.1)	35 (2.3)	0.080
Percutaneous	6 (4.4)	27 (1.8)	0.052
Surgical	1 (0.7)	8 (0.5)	0.545
Clinically indicated TLR			
Any	3 (2.2)	25 (1.7)	0.504
Percutaneous	3 (2.2)	18 (1.2)	0.412
Surgical	–	7 (0.5)	1.000
Probable ST (0–360 days)	2 (2.2)	8 (0.5)	0.201
ST (0–360 days)			
Possible	3 (2.2)	6 (0.4)	0.033
Definite, probable or possible	5 (3.6)	18 (1.2)	0.037

Data are number of patients (%). MI = myocardial infarction. TVR = target vessel revascularization. TLR = target lesion revascularization. ST = stent thrombosis.

and pulsatile pressure in the systemic circulation [18], the compliance mismatch between vein graft and native coronary arteries, and early endothelial damage along suture lines or due to intraoperative handling of vein graft material. Migration of vascular smooth muscle cells, sustained collagen proliferation, and lipid deposition result in the accelerated formation of more friable atherosclerotic plaques [19]. While there are several similarities in the predisposing factors and the general process of atheroma formation between vein graft and native coronary atheromas, vein graft atheromas are more diffuse and concentric, less calcified, and often have poorly developed or absent fibrous caps [19,20]. As a consequence of the higher friability of the lesions, PCI in vein grafts are associated with a higher risk of plaque embolization, no-reflow during PCI, and TVR, as compared to PCI in native coronary arteries [21,22].

PCIs of arterial grafts are more rare and are generally required after a shorter time interval from CABG, as arterial graft lesions are often the result of neo-intimal hyperplasia secondary to a vascular trauma during the preparation of a graft or anastomosis [15]. In addition, the proximal segments of grafted native coronary arteries (i.e. proximal to the anastomosis) often show an increased disease progression as a result of the reduced flow through these segments [23,24]. On the other hand, as a result of a general progression of atherosclerosis in the native coronary vasculature, native vessels may develop significant lesions distal to the anastomosis of a graft [15].

In our present study, patients with STEMI were not assessed, as this subset of PCI patients was not considered for enrollment in the TWENTE trial [6]. However, the rate of STEMI patients with previous CABG is relatively low [25]. In a large US registry, for instance, only 6% of STEMI patients had a previous CABG; and in the randomized APEX-AMI trial 2.2% of all 5,745 STEMI patients had a history of CABG. STEMI patients with previous CABG were older and had more comorbidities (e.g. more diabetes), which may have contributed to a higher mortality (12% vs. 5%, $P < 0.001$; in APEX-AMI trial) [26]. The mortality of STEMI patients with CABG was particularly high if the culprit vessel was a bypass graft rather than a native coronary artery (19% vs. 6%, $P = 0.03$) [26].

The majority of our patients with previous CABG underwent PCI for target lesions in native coronary arteries (68%) rather than bypass grafts (32%). This relation is quite similar to that of other studies, in which patients with previous CABG underwent PCI in 56% to 63% for treatment of lesions in native coronary arteries [3,4,27,28]. In a study among 91 consecutive patients with previous CABG who were treated by PCI with BMS or first-generation DES, a repeat revascularization rate of 10.9% was found [3]. Despite the use of second-generation DES in our present study, we still found a TVR rate of 9.4%.

In another study, 161 patients with previous CABG who were treated between September 2005 and April 2008 with PCI using BMS or DES were analyzed. In that study, a higher incidence of TVR was the only difference in individual clinical endpoints between patients treated for graft versus native coronary lesions (15.0% vs. 4.9%, after mean follow-up of 13 months) [4]. In addition, previous studies have demonstrated a clinical benefit of PCI with DES versus BMS in vein grafts [21]. Our data show that, despite the use of contemporary second-generation DES with biocompatible durable coatings, the discrepancy in TVR between patients treated for graft lesions versus native coronary lesions remained similar (19% vs. 5%, at 1-year follow-up). Data from the large National Cardiovascular Data Registry CathPCI Registry have shown that the in-hospital mortality was higher in patients with previous CABG if they were treated for graft lesions (OR: 1.22, 95% CI: 1.12–1.32, $P < 0.001$) [27]. However, CABG with arterial grafting was associated with lower rates of major adverse cardiac events [29].

4.3. Clinical implications

If a secondary revascularization is required in patients with previous CABG, many patients prefer to undergo a PCI rather than a redo-CABG [30], as the redo-CABG is associated with a higher mortality than the initial CABG [31]. Our data confirm that PCI with contemporary DES is feasible and safe in patients with previous CABG. But despite the use of modern DES, PCI of bypass graft lesions is still associated with a much higher TVR rate. Therefore, if PCI of both native coronary and corresponding graft lesions is feasible with a similar resource utilization and chance of lesion success, a thorough heart team discussion on clinical risk may help to choose the most appropriate therapeutic strategy.

5. Study limitations

Because of its post hoc nature, the results of the present study should be considered hypothesis generating. The TWENTE trial as well as the non-enrolled TWENTE registry assessed patients with limited exclusion criteria but no acute STEMI; therefore, our results may not be extrapolated to the setting of STEMI [6,7]. In addition, follow-up of this pooled patient population is limited to 1 year [32]. A longer-term follow-up may be of interest to assess potential differences in long-term mortality and morbidity between patients with previous CABG versus patients without previous CABG.

6. Conclusions

Patients with previous CABG were older and had a higher prevalence of diabetes, but the safety profile of PCI with contemporary second-generation DES was favorable in this group of patients. Nevertheless, their overall TVR rate was still higher than that of patients without a history of CABG, and it was driven by a higher TVR rate in degenerated vein grafts. Following PCI of native coronary arteries, there was no significant difference between patients with previous CABG versus patients without previous CABG.

Conflicts of interest

CvB is consultant to and has received lecture fees or travel expenses from Abbott Vascular, Boston Scientific, and Medtronic; he received travel expenses from Biotronik and a lecture fee from MSD. All other authors declare that they have no conflict of interest. The institution has received research grants, provided by Abbott Vascular, Biotronik, Boston Scientific, and Medtronik. The randomized TWENTE trial has been supported by Abbott Vascular and Medtronic.

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