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Clinical restenosis and its predictors after implantation of everolimus-eluting bioresorbable vascular scaffolds: results from GABI-R

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KEYWORDS

- bioresorbable scaffolds
- in-stent restenosis
- stent thrombosis

Abstract

Aims: The aim of this study was to assess clinical restenosis and its predictors after implantation of bioresorbable vascular scaffolds (BVS) in everyday practice in the large-scale German-Austrian ABSORB Registry (GABI-R).

Methods and results: Between November 2013 and January 2016, 3,264 patients underwent BVS implantation in the 93 centres of GABI-R (ClinicalTrials.gov NCT02066623). At six-month follow-up, 24 patients experienced clinically indicated target lesion revascularisation (cTLR) unrelated to BVS thrombosis (cumulative incidence 0.76%; angiographically, 58.3% of in-BVS restenosis of focal pattern). Compared to patients without cTLR, patients with cTLR had more lesions per patient (1.83±1.0 vs. 1.36±0.7), complex (52.3% vs. 36.2%) and mild-to-moderately calcified lesions (65.9% vs. 60.5%) treated, and more frequently had overlapping BVS (22.2% vs. 10.8%), all $p<0.05$. Implanted BVS length was 40.0 mm (28.0, 46.9) vs. 23.0 mm (18.0, 30.0), $p<0.001$, remaining in the multivariable analysis the only independent predictor of cTLR (hazard ratio 1.02, 95% CI: 1.01-1.04, $p<0.001$). The myocardial infarction rate was also significantly higher among patients with cTLR, 29.2% vs. 1.7%, $p<0.0001$.

Conclusions: cTLR related to BVS restenosis at six months after BVS implantation is a rare event depending on implanted BVS length. Whether cTLR increases the myocardial infarction risk needs to be evaluated at longer-term follow-up and within the setting of adequately powered randomised trials.

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Abbreviations

BVS	bioresorbable vascular scaffold
CI	confidence interval
cTLR	clinically indicated target lesion revascularisation
DES	drug-eluting stents
HR	hazard ratio
MI	myocardial infarction
PCI	percutaneous coronary intervention
SD	standard deviation

Introduction

Restenosis with the need for repeat revascularisation, although infrequent, continues to represent a clinical risk during long-term follow-up after implantation of drug-eluting stents (DES)[1]. Therefore, stent technologies, which allow temporary scaffolding of the vessel while providing a device-free coronary tree at longer term, are an attractive concept. Of the currently available fully bioresorbable drug-eluting platforms, the Absorb™ (Abbott Vascular, Santa Clara, CA, USA) scaffold – a polylactic acid-based bioresorbable vascular scaffold (BVS) is the most frequently used and the most extensively clinically tested device. After the first studies reported very promising data at short- and long-term follow-up, a series of randomised studies was started[2-7]. Available results indicate a risk of scaffold thrombosis which is higher than for DES, and which seems to be strongly dependent on lesion selection and implantation technique[8-10]. On the other hand, the reported incidences of clinically indicated target lesion revascularisation (cTLR) were comparabale between BVS and modern everolimus-eluting stents[3,6]. Several anatomical and procedural factors such as calcified and ostial lesions, small vessel size, lack of adequate lesion preparation or BVS overlapping have been identified as increasing this risk[8,11]. These findings have led to a more rigorous selection of lesions considered for BVS implantation and to the use of a strictly standardised implantation procedure. To monitor the clinical usage and performance of BVS in everyday practice, the German-Austrian ABSORB Registry (GABI-R) was designed – a prospective registry enrolling consecutive patients undergoing BVS implantation at 93 centres in two countries[12]. The large number of prospectively included patients and detailed characterisation of the population in this registry allow the assessment of adverse events and their predictive factors. In the current analysis we aimed to assess the incidence of clinical restenosis and its predictors within six months after BVS implantation.

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Methods

Between November 2013 and January 2016, 3,264 patients underwent implantation of the latest version of the BVS (Absorb BVS) in the 93 GABI-R centres. As published previously[12], GABI-R is an observational study and patient participation in this registry has no impact on further management. BVS use was left to the operators' discretion. The recommended BVS implantation procedure followed most recent standards and has been been published previously[13]. The extent of lesion preparation and use of intracoronary imaging (for BVS sizing reasons) was left to the individual operator's discretion. Antiplatelet therapy consisted of aspirin and a $P2Y_{12}$ receptor inhibitor for at least 12 months.

The study was conducted in accordance with the provisions of the Declaration of Helsinki. The ethics committees of the participating institutions approved the registry protocol. All patients provided written, informed consent.

DATA MANAGEMENT, DEFINITIONS AND OUTCOME OF INTEREST

Data within GABI-R are collected electronically via an internet-based application and centralised at the Institut für Herzinfarktforschung (IHF GmbH, Ludwigshafen, Germany). All events were adjudicated and classified by an independent events adjudication committee.

The incidence of clinical restenosis and identification of its predictors are the outcomes of interest of the current analysis. Clinical restenosis was defined as clinically indicated percutaneous or surgical TLR not related to BVS thrombosis. Scaffold thrombosis was defined as definite or probable according to Academic Research Consortium (ARC) criteria. Cardiac death was defined as death from immediate cardiac cause or complications related to the procedure as well as any death in which a cardiac cause could not be excluded. Myocardial infarction (MI) was defined according to the World Health Organization extended definition[3]. Target lesion failure (TLF) was defined as a composite of cardiac death, target vessel MI, and cTLR. Target vessel failure (TVF) was defined as a composite of cardiac death, target vessel MI, and clinically indicated target vessel revascularisation (TVR).

STATISTICAL ANALYSIS

Distributions of metric variables within the two groups, with and without cTLR, are described by means±standard deviations or median (quartiles). Binary variables are described by absolute frequencies and percentages. Frequencies of outcomes are complemented by odds ratios and their 95% confidence limits, where possible. All descriptive statistics are based purely on known (non-missing) values. To explain the incidence of in-BVS restenosis by baseline and procedural variables, a multiple proportional hazards (Cox) regression model was built. Missing values were imputed either by random drawing from the standardised empirical distribution (in case of missing times-to-event), by modal values (binary) or by median values (metrical variables). Predictor variables in the model were pre-specified initially and reduced after assessing the results of a preliminary model. A two-tailed p-value <0.05 was considered to indicate statistical significance. Statistical analysis was performed using SAS software, version 9.3 (SAS Institute Inc., Cary, NC, USA).

Results

PATIENT AND PROCEDURAL CHARACTERISTICS

At six-month follow-up, of the 3,264 BVS-treated patients enrolled, 86 patients (2.6%) had unknown vital status (mean follow-up 49±2 days) and 32 patients (1.0%) had unknown clinical

status. Of the total cohort of 3,146 patients eligible for the current analysis, 24 patients (cumulative incidence 0.76%) **(Figure 1)** experienced cTLR. Both patient groups - with or without cTLR - were comparable regarding their baseline profile **(Table 1)**.

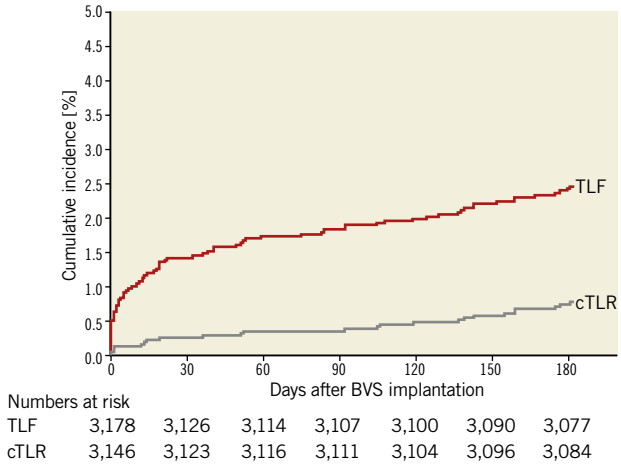

Figure 1. *Clinically indicated target lesion revascularisation and target lesion failure at six-month follow-up after BVS implantation. BVS: bioresorbable vascular scaffold; cTLR: clinically indicated target lesion revascularisation; TLF: target lesion failure*

Table 1. Baseline clinical characteristics.

	With cTLR	Without cTLR	*p*-value
Age, yrs	63.4±9.9	60.9±11.0	0.29
Women	25.0 (6/24)	23.1 (720/3,122)	0.82
Diabetes	27.3 (6/22)	21.1 (652/3,097)	0.48
Current smoker	18.2 (4/22)	35.1 (1,039/2,959)	0.10
Hypertension	66.7 (16/24)	73.2 (2,254/3,079)	0.47
Hypercholesterolaemia	66.7 (16/24)	56.3 (1,681/2,985)	0.31
Chronic kidney disease	4.2 (1/24)	8.0 (247/3,098)	0.49
History of myocardial infarction	29.2 (7/24)	22.2 (683/3,073)	0.42
History of PCI	25.0 (6/24)	27.8 (852/3,069)	0.76
History of aorto-coronary bypass surgery	0.0 (0/24)	2.4 (76/3,109)	0.44
History of stroke	4.2 (1/24)	2.7 (84/3,121)	0.66
Acute coronary syndrome at presentation	33.3 (8/24)	51.8 (1,616/3,121)	0.07
Stable angina pectoris	37.5 (9/24)	33.2 (1,037/3,121)	0.66
Left ventricular ejection fraction	53.6±9.5	56.1±10.5	0.30
Severity of CAD			
Single-vessel CAD	33.3 (8/24)	42.0 (1,312/3,122)	0.39
Two-vessel CAD	37.5 (9/24)	30.9 (964/3,122)	0.48
Three-vessel CAD	29.2 (7/24)	27.1 (845/3,122)	0.82

Values are mean±SD or % (absolute number/number of available records). CAD: coronary artery disease; cTLR: clinically indicated target lesion revascularisation; PCI: percutaneous coronary intervention

Compared to patients without cTLR, patients with cTLR underwent more complex procedures requiring significantly longer radiation times, had a higher number of treated lesions/patient, and more complex and severely calcified lesions. In addition, they more frequently had overlapping and longer implanted BVS **(Table 2)**. No differences in chronic antiplatelet therapy at admission and at discharge were observed, while a significantly higher proportion of patients with cTLR was on angiotensin receptor blocker and nitrate therapy at six-month follow-up **(Table 3)**.

CLINICAL OUTCOMES

The mean follow-up period was 212±21 days among cTLR patients, and 219±36 days in patients without cTLR, p=0.98. A total of 38 patients died, all in the substantially larger group of patients without cTLR. Definite scaffold thrombosis occurred in 30 of the 3,122 patients without cTLR (1.0%) and one patient (0.4%) in the cTLR group after re-PCI for BVS restenosis **(Table 4)**. The overall incidence of MI during follow-up was significantly higher among patients with cTLR (29.0% vs. 1.7%, p<0.001). Angiographically, the majority of in-BVS restenosis had a focal pattern, while malapposition was observed among cases with early in-BVS restenosis undergoing optical coherence tomography **(Table 5)**.

For multivariable analysis, next to the factors that significantly differed between the two groups, traditional predictors of restenosis were forced into the model. Except total implanted BVS length (per each mm increase, hazard ratio [HR] 1.02, 95% CI: 1.01-1.04, p<0.001), none of the other factors (calcified lesion, HR 0.41 [0.12-1.41], p=0.16; complex lesion, HR 0.90 [0.38-2.12], p=0.81; implanted BVS size, HR 0.79 [0.23-2.73], p=0.71; diabetes, HR 1.48 [0.58-3.78], p=0.41) independently predicted the risk of cTLR after BVS implantation.

Discussion

GABI-R is the largest investigator-initiated international registry monitoring routine use and outcomes after BVS implantation. In the current analysis of more than 3,000 patients, we found that: i) the incidence of cTLR related to in-BVS restenosis was extremely low at six months after BVS implantation; ii) none of the traditional factors except implanted BVS length independently predicted the risk of clinical in-BVS restenosis; and iii) the majority of angiographic in-BVS restenoses have a focal pattern and in-BVS restenoses occurring early after implantation are frequently caused by BVS malapposition.

The ongoing process of restenosis in the very long term after DES implantation and the need for treatment of recalcitrant restenosis created the scientific basis for development of BVS platforms[1,14]. The polylactic acid-based Absorb BVS, the first commercially available BVS being used on a routine basis, has been evaluated in an extensive programme of registries and randomised trials. While the overall performance of the scaffold was found to be good, several trials and meta-analyses have revealed a slightly, but significantly increased risk of scaffold thrombosis

Table 2. Angiographic and procedural characteristics.

	With cTLR	Without cTLR	*p*-value
Procedure duration, minutes	70.2±44.0	58.7±28.8	0.33
Radiation time, minutes	15.0±8.7	11.8±8.2	<0.05
Amount of contrast medium, ml	194.6±88.5	174.7±74.4	0.40
Treated lesion/ patient	1.83±1.0	1.36±0.7	<0.01
Treated vessel			
Left anterior descending artery	40.9 (18/44)	45.8 (1,942/4,239)	0.52
Left circumflex artery	22.7 (10/44)	21.5 (912/4,239)	0.85
Right coronary artery	36.4 (16/44)	32.1 (1,360/4,239)	0.55
Venous graft	0.0 (0/44)	0.1 (3/4,239)	0.86
Complex lesions (B2/C)	52.3 (23/44)	36.2 (1,532/4,231)	<0.05
De novo lesion	97.7 (43/44)	94.2 (3,989/4,233)	0.32
Ostial lesion	0.0 (0/44)	0.9 (36/4,233)	0.54
Bifurcation lesion	0.0 (0/44)	3.0 (126/4,233)	0.25
Calcified lesion			
None	31.8 (14/44)	36.0 (1,524/4,231)	0.56
Mild	59.1 (26/44)	41.9 (1,771/4,231)	<0.05
Moderate	6.8 (3/44)	18.7 (790/4,231)	<0.05
Severe	2.3 (1/44)	3.5 (146/4,231)	0.67
Coronary artery flow prior to PCI			
TIMI 0	9.1 (4/44)	13.4 (566/4,227)	0.40
TIMI 1	0.0 (0/44)	8.0 (337/4,227)	0.05
TIMI 2	15.9 (7/44)	15.4 (652/4,227)	0.93
TIMI 3	75.0 (33/44)	63.2 (2,672/4,227)	0.11
Predilatation performed	100.0 (43/43)	99.9 (3,875/3,877)	0.88
Debulking device use	9.3 (4/43)	8.7 (338/3,877)	0.89
BVS overlapping	22.2 (8/36)	10.8 (407/3,760)	<0.05
Implanted BVS size, mm	3.0±0.4	3.1±0.6	0.53
Total implanted BVS length, mm	40.0 (28.0, 46.9)	23.0 (18.0, 30.0)	<0.001
BVS implantation pressure, atm	12.7±2.8	13.5±2.7	0.12
Additional DES implantation	4.5 (2/44)	2.9 (122/4,233)	0.51
Post-dilatation performed	75.0 (33/44)	72.2 (3,055/4,232)	0.68
Post-dilation balloon size, mm	3.2±0.5	3.3±0.5	0.69
Post-dilation balloon pressure, atm	16.2±3.8	16.7±4.1	0.51
Final TIMI 3 flow	100.0 (44/44)	98.1 (4,146/4,228)	0.35

Values are mean±SD, median (quartiles) or % (absolute number/number of available records). BVS: bioresorbable vascular scaffold; cTLR: clinically indicated target lesion revascularisation; DES: drug-eluting stent; PCI: percutaneous coronary intervention

Table 3. Patients' medical treatment.

	With cTLR	Without cTLR	*p*-value
At admission			
Aspirin	62.5 (15/24)	47.9 (1,494/3,121)	0.15
$P2Y_{12}$ receptor inhibitors	20.8 (5/24)	19.8 (617/3,121)	0.90
Clopidogrel	40.0 (2/5)	46.2 (285/617)	0.78
Prasugrel	40.0 (2/5)	27.6 (170/617)	0.54
Ticagrelor	20.0 (1/5)	26.3 (162/617)	0.75
Oral anticoagulants	8.3 (2/24)	4.9 (154/3,121)	0.44
Peri-interventionally			
Aspirin	33.3 (8/24)	33.0 (1,029/3,121)	0.97
Heparin	95.8 (23/24)	93.9 (2,931/3,121)	0.69
Bivalirudin	0.0 (0/24)	1.0 (30/3,121)	0.63
Glycoprotein IIb/IIIa inhibitor	8.3 (2/24)	8.1 (253/3,121)	0.97
Loading with $P2Y_{12}$ receptor inhibitor	83.3 (20/24)	65.1 (2,028/3,117)	0.06
Clopidogrel	50.0 (10/20)	47.3 (960/2,028)	0.81
Prasugrel	40.0 (8/20)	33.8 (686/2,028)	0.56
Ticagrelor	10.0 (2/20)	18.5 (375/2,028)	0.33
At discharge			
$P2Y_{12}$ receptor inhibitors	95.8 (23/24)	97.7 (3,047/3,119)	0.55
Clopidogrel	43.5 (10/23)	43.9 (1,338/3,047)	0.97
Prasugrel	47.8 (11/23)	34.0 (1,037/3,047)	0.16
Ticagrelor	8.7 (2/23)	22.1 (672/3,047)	0.12
At 6-month follow-up			
Aspirin	95.7 (22/23)	93.2 (2,532/2,718)	0.64
$P2Y_{12}$ receptor inhibitors	91.3 (21/23)	93.2 (2,516/2,699)	0.72
Clopidogrel	42.9 (9/21)	43.9 (1,099/2,506)	0.93
Prasugrel	42.9 (9/21)	33.3 (835/2,506)	0.36
Ticagrelor	14.3 (3/21)	22.8 (572/2,506)	0.35
Oral anticoagulants	20.0 (4/20)	8.3 (219/2,623)	0.06
Beta-blocker	66.7 (16/24)	64.3 (1,992/3,100)	0.81
ACE inhibitors	37.5 (9/24)	46.4 (1,439/3,100)	0.38
Angiotensin receptor blocker	45.8 (11/24)	25.5 (790/3,100)	<0.05
Nitrates	8.3 (2/24)	1.5 (47/3,100)	<0.01
Statins	79.2 (19/24)	75.1 (2,327/3,100)	0.64

Values are mean±SD or % (absolute number/number of available records). cTLR: clinically indicated target lesion revascularisation

as compared to thrombosis of metal-based DES[3-7,9,10]. On the other hand, the necessity for revascularisation due to restenosis seemed to be comparable among BVS and DES[3,6]. In the Comparison of Everolimus- and Biolimus-Eluting Stent with Everolimus-Eluting Bioresorbable Scaffold Stents (EVERBIO) II trial, the BVS platform was randomly compared with two DES platforms regarding the amount of angiographic late lumen loss at nine-month angiographic follow-up. The incidence of TLR was 10% after

Table 4. Clinical outcomes at 6-month follow-up.

	With cTLR N=24	Without cTLR N=3,122	Hazard ratio (95% CI)	*p*-value
All-cause death	0.0 (0)	1.2 (38)	0.59	
Cardiac	0.0	0.4 (12)	0.76	
Cardiovascular	0.0	0.4 (12)	0.90	
Non-cardiac	0.0	0.2 (7)	0.82	
Unknown origin	0.0	0.2 (7)	0.82	
Definite/probable BVS thrombosis	4.2 (1)	1.4 (44)	3.04 (0.40-23.02)	0.26
Definite	4.2 (1)	1.0 (30)	4.48 (0.59-34.26)	0.11
Probable	0.0 (0)	0.4 (14)		0.73
Any myocardial infarction	29.2 (7)	1.7 (53)	23.84 (9.49-59.90)	<0.0001
Target vessel-related MI	25.0 (6)	1.3 (41)	25.05 (9.48-66.34)	<0.0001
Target lesion revascularisation	100.0 (24)	1.0 (30)		<0.0001
Repeat PCI	91.7 (22)	1.0 (30)	273.00 (36.8-2,035)	<0.0001
CABG surgery	8.3 (2)	0.3 (10)	28.30 (5.86-136.7)	<0.0001
Any revascularisation	100.0 (24)	8.0 (250)		
PCI	91.7 (22)	7.8 (242)	273.72 (36.81-2,035)	<0.0001
CABG graft surgery	8.3 (2)	0.3 (10)	28.29 (5.86-136.67)	<0.0001
Target lesion failure	100.0 (24)	1.5 (48)		<0.0001
Target vessel failure	100.0 (24)	2.6 (80)		<0.0001

Values are mean±SD or % (number). BVS: bioresorbable vascular scaffold; CI: confidence interval; cTLR: clinically indicated target lesion revascularisation; PCI: percutaneous coronary intervention

BVS implantation and 8% after DES implantation, p=0.59. These findings are supported by the recently published Amsterdam Investigator-initiateD Absorb strategy all-comers (AIDA) randomised trial which was powered for clinical endpoints (n=1,845). The trial required no routine angiographic follow-up and the incidence of cTLR due to restenosis was 2.4% with Absorb and 2.5% with DES at one-year follow-up[6]. Compared to randomised trials, much lower rates of TLR unrelated to thrombosis have been reported for real-world cohorts. In the GHOST-EU registry, of the 1,189 enrolled patients, 25 patients required in-BVS revascularisation (cumulative incidence, 2.5%) due to thrombosis (n=20) or restenosis (n=5) at six-month follow-up[4]. In the current analysis of GABI-R, we also observed a very low rate of cTLR (0.76%). Lack of routine angiographic follow-up, patient selection and particularly lesion selection play an important role in explaining the very low rate of this complication. In our registry, 23% of lesions were of complex morphology. The use of BVS in bifurcation lesions and ostial lesions was discouraged and occurred in only 3% of cases. This is a relevant difference in comparison to the AIDA trial, where 55% of BVS-treated lesions were of complex and 10% of ostial or bifurcational morphology[6]. On the other hand, widespread use of appropriate lesion preparation and BVS implantation techniques as encouraged in GABI-R (predilatation in all cases and post-dilatation in approximately ¾ of all patients) might have contributed to the low cTLR[15].

Diabetes mellitus, vessel size (device size), stented length, residual stenosis or stent overlap have frequently been identified as predictors of restenosis after percutaneous coronary intervention[16]. In the current study, only the total length of the implanted BVS was identified as a predictor of cTLR at follow-up. The very selected nature of the population and lesions in the GABI-R, technically more demanding procedures among patients with cTLR leading to additional BVS implantation and BVS size-lesion mismatch might have played a role in these findings. Another explanation might be the type of in-BVS restenosis. Nearly 25% of cTLR occurred within the first 30 days and were therefore most likely not related to neointimal hyperplasia (intracoronary imaging of some of these cases supports this). The lower radial strength with polylactic acid-based BVS as compared to DES might lead to early restenosis within BVS due to elastic recoil[17].

Generally, restenosis is considered a benign event being either asymptomatic or with stable clinical presentation. However, in the GABI-R, about one quarter of patients with cTLR presented with target vessel MI compared to only 1.3% of patients without cTLR (1% due to BVS thrombosis). Long-term follow-up of large registries and randomised trials will be required to corroborate our observations and to investigate further the mechanisms and consequences of in-BVS restenosis.

Limitations

GABI-R is a prospective clinical registry, which inherently harbours patient selection bias, heterogeneity regarding lesion preparation and PCI technique, as well as a certain degree of incompleteness of data collection. On the other hand, determination of restenosis or thrombosis at the time of revascularisation was based on centrally reviewed angiograms. However, lack of systematic intracoronary

Table 5. Key clinical and angiographic characteristics of patients with cTLR.

Case	Treated vessel	Clinical presentation at cTLR	BVS size/ length mm	Angiographic in-BVS restenosis pattern	% DS	Additional findings	Type of cTLR	Days to cTLR
1	Proximal LCx	SAP	3.0/28	Diffuse intra-BVS	90		DES	105
2	Distal LAD	SAP	2.5/18	Focal body	70		DEB	159
3	Mid LCx	UAP	3.0/18	No restenosis	30	70% stenosis of left main artery	CABG surgery	13
4	Distal RCA	SAP	3.0/18 2.5/12	Diffuse intra-BVS	60		DES	175
5	Mid RCA	SAP	3.0/12	Focal body	90		DES	159
6	Mid LAD	UAP	3.0/28	Focal body	70	OCT: BVS malapposition	POBA	6
7	Mid RCA	NSTEMI	3.0/18	Focal margin proximal	90	OCT: BVS malapposition and residual dissection	DES	2
8	Mid RCA	Exercise-induced ischaemia (echocardiography)	3.5/28	Diffuse intra-BVS	60		DES	51
9	Distal LAD	SAP	2.5/28	Focal margin distal	99		DES	181
10	Mid LAD	UAP	3.5/18 3.0/28	Multifocal	70	Restenosis also at BVS overlap	DES	106
11	Mid RCA	UAP	3.0/28 3.0/28	Diffuse intra-BVS	70		DES	92
12	Mid LAD	UAP	2.5/12 2.5/18	Focal gap	90	Restenosis within the gap between 2 BVS	DES	119
13	Distal LAD	Exercise-induced ischaemia (myocardial scintigraphy)	3.5/18	Focal margin distal	60		DES	52
14	Diagonal branch	STEMI	2.5/18	Focal margin proximal	99	Ostial lesion at index PCI	DES	137
15	Mid LAD	UAP	3.5/12	Diffuse intra-BVS	50	Angiographically no tissue growth	POBA	14
16	Mid LAD	UAP	2.5/28	Focal margin distal	70		DES	80
17	Mid RCA	UAP	3.5/18	Diffuse intra-BVS	40	Angiographically no tissue growth	DES	36
18	Mid LCx	SAP	2.5/18 2.5/12	Complete occlusion	100		CABG surgery	177
19	Proximal RCA	exercise-induced ischaemia (cycle ergometer)	3.5/18	Focal body	75		DES	143
20	Proximal RCA	UAP	3.5/23	Focal margin proximal	50	Angiographically tissue prolapse	DES	5
21	Mid LAD	NSTEMI	2.5/18	Focal margin distal	90		DES	152
22	Mid LCx	NSTEMI	2.5/28	Diffuse intra-BVS	40	OCT: BVS malapposition	DES	1
23	Distal LAD	UAP	2.5/18	Focal margin proximal	70		DES	139
24	Marginal branch	NSTEMI	3.0/28	Focal margin proximal	50	OCT: BVS malapposition at the vessel ostium	DES	19

BVS: bioresorbable vascular scaffold; CABG: coronary artery bypass grafting; cTLR: clinically indicated target lesion revascularisation; DEB: drug-eluting balloon; DES: drug-eluting stent; LAD: left anterior descending artery; LCx: left circumflex artery; (N)STEMI: (non) ST-segment elevation myocardial infarction; OCT: optical coherence tomography; POBA: plain old balloon angioplasty; prox: proximal; RCA: right coronary artery; (U)SAP: (un)stable angina pectoris

imaging at the time of cTLR might have hampered the evaluation of the true incidence and aetiology of in-BVS restenosis. Finally, a follow-up duration of six months is probably not sufficient to evaluate the clinical performance of BVS. GABI-R will follow all patients for up to five years after BVS implantation, which will allow a detailed time-dependent characterisation of restenosis after BVS implantation.

Conclusions

Clinical restenosis at six months after BVS implantation, a rare event, is associated with a greater length of implanted BVS. Whether this is related to a higher risk of myocardial infarction or other hard endpoints needs to be evaluated at longer-term follow-up and within the setting of adequately powered randomised trials.

Impact on daily practice

The rate of thrombosis after bioresorbable vascular scaffold implantation is higher than expected, but this may be addressed by meticulous lesion selection and implantation technique. Clinical restenosis is a parameter that characterises treatment success independently from scaffold thrombosis but has been infrequently reported. We demonstrate that clinical restenosis within six months after BVS implantation is an infrequent event and depends on the implanted BVS length. This is encouraging, since it highlights that implantation strategies which achieve low rates of thrombosis will not be offset by high rates of other clinical events. Furthermore, in-BVS restenosis occurring earlier after BVS implantation suggests elastic recoil as one of its possible mechanisms and emphasises that BVS implantation within vessel segments at high mechanical stress should be avoided.

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Conflict of interest statement

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