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Clinical, Angiographic, Functional, and Imaging Outcomes 12 Months After Implantation of Drug-Eluting Bioresorbable Vascular Scaffolds in Acute Coronary Syndromes

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ABSTRACT

OBJECTIVES The purpose of this study was to describe the multimodal outcome 12 months after implantation of coronary bioresorbable scaffolds (BVS) for the treatment of patients with acute coronary syndromes (ACS).

BACKGROUND Functional and imaging data on the use of BVS are limited to simple, stable lesions; in the setting of ACS, only short-term clinical follow-up data are available, and no information from intracoronary imaging and vasomotion tests has been reported.

METHODS A total of 133 patients (age 62 ± 12 years, 74% males, 15% diabetic) underwent BVS (n = 166) implantation for the treatment of thrombotic lesions in the setting of ACS (43% non–ST-segment elevation myocardial infarction, 38% ST-segment elevation myocardial infarction, 20% unstable angina). Clinical, angiographic, intracoronary imaging, and vasomotor endpoints were evaluated at 12 months.

RESULTS During the 374 days (interquartile range: 359 to 411 days) of follow-up, there were 4 deaths; 3 definite and 1 probable in-BVS thromboses (all in the first 6 months). At 12-month angiography (75 patients, 83 BVS), in-segment late lumen loss was 0.19 ± 0.45 mm, and 3 (4%) patients showed binary restenosis. Optical coherence tomography (80 BVS, n = 70) showed a mean lumen area of 6.3 ± 2.3 mm^2. Malapposition was evidenced in 21 (26%) BVS. Endothelium-dependent and -independent vasodilation were observed in 48% and 49% of the BVS.

CONCLUSIONS Twelve months after BVS implantation, clinical, intracoronary imaging, and vasomotion data appear to provide a rationale for the use of BVS in the setting of ACS and the basis for a randomized study. (J Am Coll Cardiol Intv 2015;8:770–7) © 2015 by the American College of Cardiology Foundation.

Everolimus-eluting bioresorbable vascular scaffolds (BVS) have been recently introduced in more than 60 countries worldwide for the treatment of de novo coronary lesions, independently of patient and lesion characteristics. Analogue to metal stents, BVS initially provide mechanical scaffolding, preventing acute occlusion and early recoil, and release everolimus for the inhibition of neointima proliferation. Thereafter, the resorption of the scaffold struts has been hypothesized to protect vascular geometry/biomechanics and, in the long-term, allow positive remodeling (1). The latter concepts extend beyond the traditional treatment with metal stents, and phenomena such as the restoration

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of vasomotion, late luminal gain (in contrast to late luminal loss), and expansive remodeling have been advocated as potential advantages of BVS over traditional metal stents (1). These phenomena strongly rely on modifications in plaque/vessel biology, but to date they have been tested only in stable, type A lesions (2,3). Unstable plaques differ regarding many basic aspects (e.g., inflammation, endothelial dysfunction/damage, histopathological characteristics) from stable ones, and the previously-mentioned processes require confirmation in this setting. To date, only short-term clinical outcomes after BVS implantation are available for patients with acute coronary syndrome (ACS). Although these data appear to be comparable to second-generation drug-eluting stents (4–9), important information is still missing, including longer-term outcome data, as well as angiographic, functional, and imaging outcomes.

ABBREVIATIONS AND ACRONYMS

ACS = acute coronary syndrome(s)

BVS = bioresorbable scaffolds

MLD = minimum lumen diameter

OCT = optical coherence tomography

QCA = quantitative coronary angiography

STEMI = ST-segment elevation myocardial infarction

METHODS

Absorb everolimus-eluting BVS (Abbott Vascular, Abbott Park, Illinois) are balloon-expandable scaffolds consisting of a polymer backbone of poly-L-lactic acid coated with an amorphous matrix of poly-D and -L-lactic acid polymer.

ETHICAL CONSIDERATIONS. Since May 2012, BVS have been commercially available in the European Union for the treatment of de novo coronary lesions independently of the patient's clinical presentation. The present report includes all consecutive patients who received a BVS for the treatment of culprit plaques in the setting of unstable angina with high thrombotic burden, non-ST-segment elevation myocardial infarction (STEMI) or STEMI between May 2012 and May 2013. Clinical data were collected in an anonymized way with the approval of the local ethics committee. Patients who underwent an invasive follow-up gave written informed consent for the collection of data within the framework of the prospective MICAT Registry (Ethical committee reference number 837.123.13 8808-F, NCT02180178).

BVS IMPLANTATION. Implantation was performed without specific inclusion/exclusion criteria but respecting the CE certification and manufacturer's indications. BVS were not used to treat lesions in the left main coronary, in-stent restenoses, lesions in bypass, and bifurcation lesions in which a 2-stent strategy was chosen. No patients were on chronic therapy with anticoagulant agents. Pre-dilation was performed in all cases; thrombus aspiration and post-dilation were left to the operator's discretion. Aspirin (loading dose 250 to 500 mg) was administered periprocedurally to patients not on chronic antiplatelet treatment and was protracted indefinitely. Dual antiplatelet therapy with prasugrel, ticagrelor, or clopidogrel was started periprocedurally with an oral loading dose and prescribed for 12 months after the event.

FOLLOW-UP. The 12-month clinical follow-up data were collected from all patients during clinical visits or per telephone using standardized questionnaires. A composite of cardiovascular death, any myocardial infarction, and target lesion revascularization (TLR) was taken as the definition of a major adverse event (10). For data quality purposes, all outcome data were acquired by 1 investigator and adjudicated by another investigator.

INVASIVE FOLLOW-UP. An invasive 12-month follow-up was recommended to the first 100 patients given the novelty and complexity of the procedure. These patients also underwent the following measurements:

Quantitative coronary angiography analysis. Quantitative coronary angiography (QCA) analysis was performed using Xcelera (Philips, Eindhoven, the Netherlands). Definitions are described in Online Table 1.

Assessment of endothelium-dependent and -independent function. QCA analysis was performed in the scaffolded segment in random order by staff not aware of the temporal sequence of the images. Endothelium-dependent and -independent vasomotion were studied as described in the Online Appendix and as previously published (11).

Optical coherence tomography. Methods and definitions are described in the Online Appendix.

STATISTICAL ANALYSIS. Continuous variables are presented as mean ± SD; categorical variables as counts and percentages. Responses to vasomotor stimuli are described as group average and as cumulative frequencies of individual changes in response to each dose. The changes in minimum lumen diameter (MLD) among time periods (before implantation, after implantation, and at follow-up) were compared with 1-way repeated measures analysis of variance. All analyses were exploratory. All statistical tests were performed with SPSS version 22 (IBM, Armonk, New York).

RESULTS

Between May 2012 and May 2013, 260 BVS were implanted in 210 patients for all indications. In the

same period, 133 patients received 164 scaffolds for the treatment of culprit plaques in the setting of ACS.

CLINICAL CHARACTERISTICS AND OUTCOME. Follow-up was available in 100% of the patients at median 374 days (interquartile range: 359 to 411 days) (Tables 1 and 2). Events have been partially reported in our previous publication (9). During follow-up, a total of 18 composite events (13.5%), including 4 deaths (1 sudden death, probable in-BVS thrombosis), 4 STEMIs (all within the first 6 months, 3 caused by in-BVS thromboses treated with DES implantation), and 5 non-STEMIs (1 due to in-BVS restenosis, also treated with DES implantation) were observed. There were another 2 TLRs within the first 6 months. In 1 case, the patient presented with unstable angina 3 weeks after the index PCI due to a de novo lesion >5 mm distal to the BVS. Optical coherence tomography (OCT) showed incomplete expansion of the BVS, which was post-dilated with a good result. Balloon-only post-dilation of a BVS was performed in another patient in the setting of a staged procedure 2 weeks after BVS implantation for OCT evidence of malapposition. The result was controlled with OCT to exclude recoil in both cases. OCT and post-dilation had not been performed at the time of BVS implantation in either case. A third patient showed ~50% BVS restenosis, which was left untreated in the absence of symptoms and evidence of ischemia 6 months after implantation. Three other patients showed binary restenoses in the absence of signs of ischemia at the scheduled 12-month follow-up; all were treated with PTCA and implantation of a DES. Representative images of the events are presented in Figure 1.

TABLE 1 Patient and Lesion Characteristics

Patient characteristics (n = 133)	
Male	98 (74%)
Age, yrs	62 ± 12
Hypertension	91 (68%)
Hyperlipidemia	40 (30%)
Diabetes	20 (15%)
Smoking	76 (57%)
Previous MI	14 (11%)
Previous revascularization	23 (18%)
Clinical presentation (UA, NSTEMI, STEMI)	26 (19.6%), 57 (42.9%), 50 (37.6%)
Peak troponin, ng/ml	27.8 ± 51.0
GP IIb/IIIa inhibitors	45 (34%)
DAPT duration, months	12
DAPT type (ticagrelor, prasugrel, clopidogrel)	44 (33%), 60 (45%), 29 (22%)
Procedural characteristics (n = 166)	
Vessel treated (LAD, RCX, RCA)	72 (43%), 35 (21%), 59 (36%)
Pre-dilation	100%
BVS diameter, mm	3.0 ± 0.4
BVS length, mm	19.2 ± 4.6
Implantation pressure, atm	13.9 ± 2.2
Post-dilation	19 (11%)

Values are n (%) or mean ± SD.

BVS = bioresorbable scaffold; DAPT = dual antiplatelet therapy; GP = glycoprotein; LAD = left anterior descending; MI = myocardial infarction; NSTEMI = non-ST-segment elevation myocardial infarction; RCA = right coronary artery; RCX = circumflex; STEMI = ST-segment elevation myocardial infarction; UA = unstable angina.

TABLE 2 Clinical Outcome of 133 Patients

	1–6 Months	6–12 Months
Composite	12 (9.0%)	6 (4.5%)
Cardiac death	4 (3%)*	0 (0%)
STEMI	4 (3%)†	0 (0%)
NSTEMI	2 (1.5%)‡	3 (2.3%)§
TLR	6 (4.5%)‖	3 (2.3%)¶
TVR	7 (5.3%)	7 (5.3%)
Definite BVS thrombosis	3 (2.3%)	0 (0%)
Probable BVS thrombosis	1 (0.8%)	0 (0%)

Values are n (%). *One death due to lung embolism; 1 sudden death at 18 days of follow-up (probable in-BVS thrombosis); and the remaining 2 as a consequence of the index infarction. There was no noncardiac death. †One in nontarget vessel. ‡1 percutaneous coronary intervention in a nontarget vessel, and 1 TLR. §Target vessel (nontarget lesion) NSTEMI in all 3 cases. ‖Three in the setting of STEMI for BVS thrombosis. See Results section. ¶All due to incidental findings of in-BVS restenosis at scheduled 12-month angiography, treated with DES. There was no ARC possible in-BVS thrombosis up to 12 months.

TLR = target lesion revascularization; TVR = clinically-driven target vessel revascularization (includes TLR); other abbreviations as in Table 1.

QUANTITATIVE CORONARY ANGIOGRAPHY. Control angiography was performed in 75 patients (83 BVS) at 372 days (interquartile range: 359 to 398 days). Follow-up was not carried out in 25 of the initially planned 100 patients who preferred, due to the absence of symptoms, to undergo exercise tests only (negative in all cases). Baseline and follow-up angiographic parameters are shown in Table 3 and Online Table 2. The changes in MLD between index procedure and follow-up and the distribution of late lumen loss are also shown in Figure 2. In-segment late lumen loss was 0.19 ± 0.45 mm (range −0.72 to 1.74 mm). The 3 binary restenoses (3.6% of the BVS, 4% of the patients) were all observed in-scaffold.

OPTICAL COHERENCE TOMOGRAPHY. OCT was performed in 70 patients (80 scaffolds); data are shown in Table 4. A total of 14,498 struts were identified. The mean length of the scaffold was 19.6 ± 4.8 mm. A maximum scaffold eccentricity >1.5 was present in 17 (21%) BVS; the maximum value observed was 1.9. At least 1 malapposed strut was present in 21 (26%) scaffolds; the mean malapposition area in these

patients was 4.1 ± 3.7 mm^2. At least 1 uncovered strut was present in 24 (30%) scaffolds. At follow-up, the remnant of the culprit plaque could be identified in 70 cases. The minimum thickness of its cap was 260 ± 137 μm (range 0 to 620 μm) (Figure 2C).

ENDOTHELIUM-DEPENDENT AND -INDEPENDENT RESPONSES. Acetylcholine and nitroglycerin responses were studied in 52 (65%) and 63 (79%) scaffolds, corresponding to 49 (70%) and 60 (86%) patients. All 3 doses of acetylcholine were administered in 38 (73%) cases (only the highest dose was not applied in the right coronary artery and, in case of vasospasm, at 1 of the lower doses). When analyzed as the average of all subjects, no significant change in the mean lumen diameter were observed in response to the infusions (baseline: 2.6 ± 0.51 mm; during saline infusion: 2.5 ± 0.45 mm; acetylcholine dose 1: 2.5 ± 0.45 mm; acetylcholine 2: 2.5 ± 0.43 mm; acetylcholine 3: 2.3 ± 0.63 mm; nitroglycerin: 2.6 ± 0.44 mm, p = 0.32). The individual responses to each dose of acetylcholine and nitroglycerin were, however, heterogeneous and are presented in Figure 3. A total of 31%, 33%, and 33% of the in-BVS segments responded with a dilation to the low-, mid-, and high-acetylcholine dose, respectively; 21%, 22%, and 37% responded with a constriction to the low-, mid-, and high-acetylcholine dose, respectively. Forty-eight percent of the segments responded with a vasodilation during administration of at least 1 dose of acetylcholine. Forty-nine percent responded with vasodilation after nitroglycerin. The mean response to nitroglycerin was 4 ± 7% (p < 0.001). There were no complications during follow-up examinations.

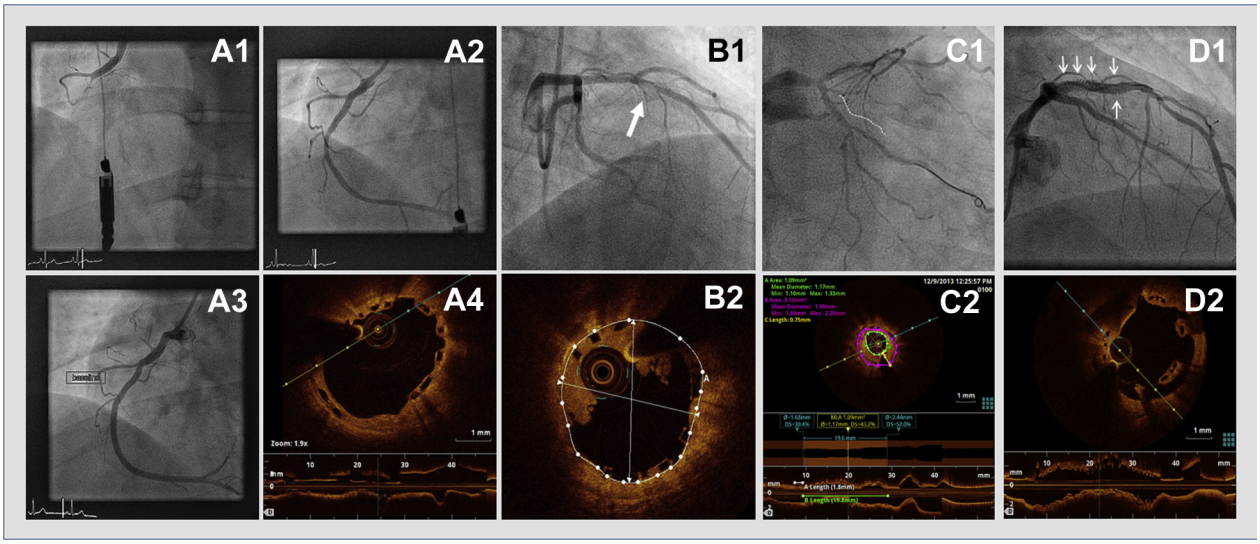
TABLE 3 Quantitative Coronary Analysis Data (In-Segment Analysis, Paired Data)

	Pre-Procedure	After BVS Implantation	Follow-Up	p Value
Stenosis length, mm	11 ± 7			
MLD, mm	0.6 ± 0.6	2.7 ± 0.6	2.6 ± 0.7	<0.0001*
RVD, mm	3.0 ± 0.8	3.1 ± 0.6	3.1 ± 0.7	>0.5
Acute gain, mm	–	2.1 ± 0.8	–	
Relative gain	–	0.7 ± 0.2	–	
Late lumen loss, mm	–	–	0.19 ± 0.45	
Relative loss	–	–	0.06 ± 0.17	
Net gain, mm	–	–	2.0 ± 0.8	
Net gain index	–	–	0.62 ± 0.24	
Loss index	–	–	0.09 ± 0.26	
Binary restenosis (n, % of patients, % of BVS)	–	–		
In-scaffold			3 (4%, 3.6%)	
Edge			3 (4%, 3.6%)	

The p value is for the analysis of variance among the 3 periods. *p > 0.5 for the comparison between immediate result and follow-up.

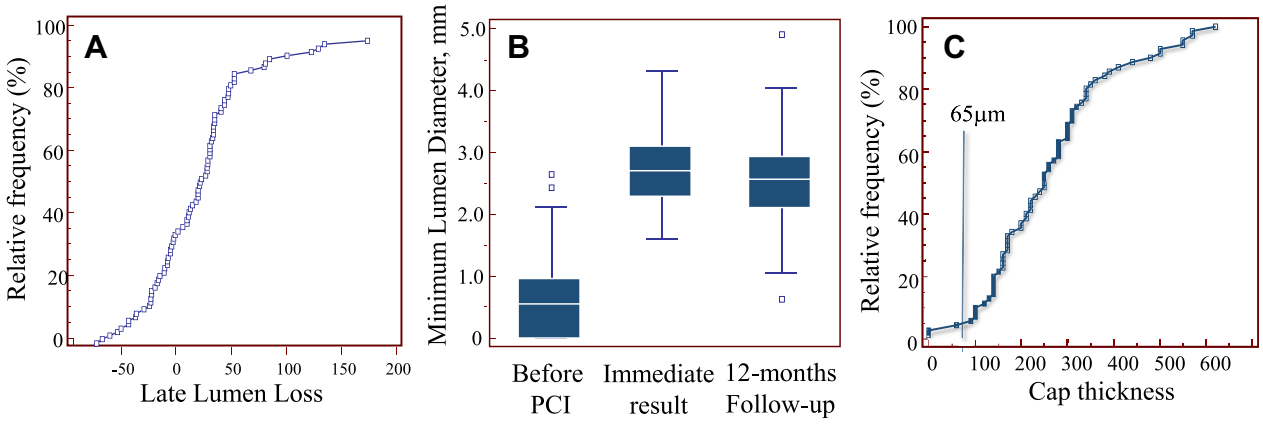
BVS = bioresorbable scaffold; MLD = minimal lumen diameter; RVD = reference vessel diameter.

FIGURE 1 Representative Angiography and OCT Images



ST-segment elevation myocardial infarction before percutaneous coronary intervention **(A1)**, after percutaneous coronary intervention **(A2)**, and at 12 months **(A3)**; 12-month optical coherence tomography (OCT) outcome **(A4)**, showing a 250 μm-thick layer of high-intensity, low-attenuation tissue. **(B1 and B2)** In-bioresorbable scaffold (BVS) thrombosis, likely caused by incomplete BVS expansion (MLA 4 mm^2) (the scaffold is marked by the **white arrow in B1**); **(C1 and C2)** in-BVS restenosis; and **(D1 and D2)** malapposition with evidence of peristent staining.

FIGURE 2 Late Lumen Loss, MLD, and Cap Thickness

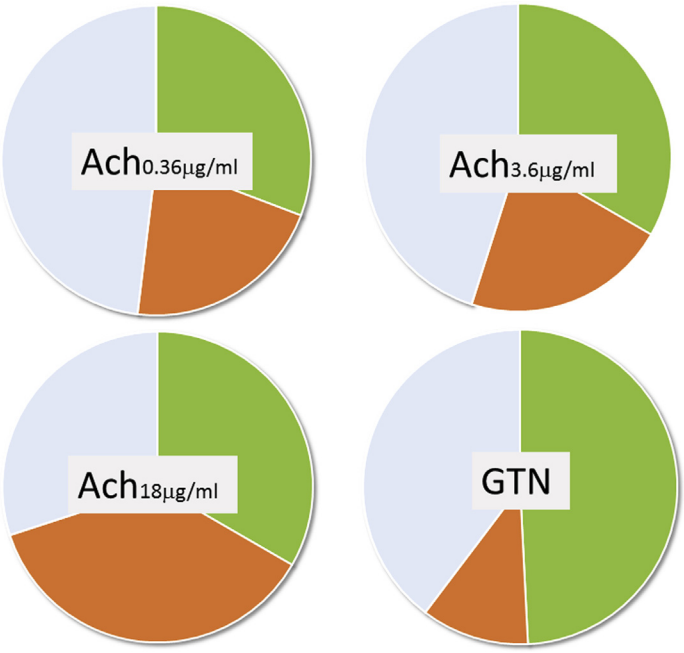


(A) Distribution of angiographic late lumen loss. The variable was normally distributed (Kolmogorov-Smirnov) with a coefficient of skewness of 0.76 ($p = 0.007$) and a coefficient of Kurtosis of 1.59 ($p = 0.03$). The median was 0.20 µm. **(B)** Minimum lumen diameter (MLD) before percutaneous coronary intervention (PCI), after PCI, and at 12 months. **(C)** Distribution of the minimum thickness of the cap covering the remnants of the culprit lesion.

DISCUSSION

BVS are currently approved for use independently of the lesion and clinical presentation. Data in patients with ACS remain, however, limited to clinical outcomes and to the periprocedural period or short-term (1-month) follow-up (4,5,8,9). We report on the 12-month clinical, angiographic, intracoronary imaging, and functional outcomes of a single-center cohort of unselected, consecutive patients treated with BVS in the setting of ACS.

FIGURE 3 Individual Responses to Acetylcholine and Nitroglycerin



The % of scaffolded segments that responded with vasodilation **(green)**, responded with vasoconstriction **(orange)**, or responses <2 SD of the mean error **(blue)**. Ach = acetylcholine; GTN = nitroglycerin.

SUMMARY OF THE DATA. Clinical outcome. The composite endpoint rate of 13.5% was expectedly higher than those previously observed in stable patients (10), but comparable with those of previous randomized controlled studies or all-comer registries enrolling ACS patients treated with DES (12–16) (incidence variable between 4.9% and 26.3% on the basis of definitions used, clinical presentation, and extent of disease). The large majority of events occurred in the first 6 months. The incidence of restenosis was quite low and was comparable to that of DES (12–16). The incidence of definite in-BVS thrombosis, in line with our recently reported figures from a larger dataset of patients (17), was relatively high and will require further attention.

Angiographic outcome. Late lumen loss was very modest and comparable to previous BVS papers in stable settings (3,10). For comparison, the value observed in the SPIRIT trial with second-generation drug-eluting stents was 0.23 ± 0.29 mm at 12 months, that is, slightly larger than that observed here (18). A total of 3 (4%) BVS showed binary restenosis at the 12-month follow-up, and were asymptomatic in all cases. Taken together, these data support the use of BVS with respect to the prevention

TABLE 4 Optical Coherence Tomography Data

General (80 BVS)	
Scaffold length, mm	19.6 ± 4.8
Analyzed struts, n per scaffold	186 ± 55
Lumen (80 BVS)	
Mean area, mm^2	6.3 ± 2.3 (1.9–15)
Minimum area, mm^2	4.2 ± 1.8 (0.4–8.7)
Maximum area, mm^2	8.9 ± 4.5 (2.9–31.9)
Maximum eccentricity	1.5 ± 0.2 (1.2–1.9)
Scaffold (80 BVS)	
Minimum area, mm^2	5.6 ± 1.9 (1.2–10.3)
Maximum area, mm^2	8.2 ± 1.9 (2.5–17.1)
Maximum eccentricity	1.4 ± 0.2 (1.1–1.9)
Neointima (80 BVS)	
Maximum thickness, μm	358 ± 170 (110–1,070)
Maximum % area stenosis	28 ± 14 (8–74)
Maximum burden, mm^2	1.95 ± 0.78 (0.59–5.05)
Malapposed struts	
Malapposition detected, n (% of scaffolds with at least 1 malapposed struts), n of struts (% of struts)	21 (26%), 156 (1.1%)
Malapposed struts, n per scaffold	12.4 ± 15 (1–58)*
Malapposed struts per patient, %	7.1 ± 8.1 (0.5–26.3)*
Incomplete strut apposition area, mm^2	4.1 ± 3.7 (0.5–11.1)*
Malapposition length, mm	1.9 ± 1.6 (1–8)*
BVS with at least 1% malapposed struts	18 (22.5%)
>5% malapposed struts	9 (11.25%)
Uncovered struts	
Uncovered struts detected, n	
Patients	24 (32%)
Struts	121 (0.8%)
Uncovered struts per patient	5.0 ± 5.0 (1–20)
Uncovered struts per patient, %	3.1 ± 3.2 (0.7–14)*
BVS with at least 1% uncovered	18 (22.5%)
At least 5% uncovered	4 (5%)

Values are mean ± SD, mean ± SD (range), or n (%). Data are presented per scaffold unless otherwise noted. *Only patients with malapposition (n = 21 patients, n = 21 scaffolds) or uncovered struts (n = 24) were entered for this analysis.

BVS = bioresorbable scaffold.

of acute occlusion and recoil at implantation and the inhibition of neointima proliferation in the subsequent period.

Intracoronary imaging. Neointima thickness, area, and % restenosis in our cohort were comparable to that observed in metal stents in similar settings (19). The incidence of malapposition was also very similar to that observed after DES implantation in the setting of STEMI (20). The malapposition area was, however, larger as compared with that reported immediately after BVS implantation (21). The rate of uncovered struts was low and was comparable to previous data in metal stent and BVS (19).

Finally, the remnants of the culprit plaque were covered in the majority of cases (95.7%) by a homogeneous, signal-rich tissue that was thicker than 65 μm (the threshold commonly used for discriminating thin- from thick-cap fibroatheroma in de novo lesions [22]). Findings of a layer presenting OCT characteristics possibly compatible with those of a fibrous cap have been previously hypothesized to witness the transformation of vulnerable lesions to stable plaques (1). This hypothesis (and the existence of a threshold for a "stable" cap) remains speculative and will need prospective validation.

Endothelial function. Acetylcholine responses are an accepted diagnostic and risk stratification tool (23), but data on the functional restoration of lesions responsible for an acute event have not been reported before. In our population, endothelium-dependent and -independent vasodilation were observed in about one-half of the lesions, a figure that might improve after further withdrawal of the scaffolding function of the BVS (and the effects of everolimus). Evidence of vasoconstriction in 37% of the lesions at the highest acetylcholine dose, however, points to the long-term persistence of vascular spasm phenomena in a subgroup of patients.

STUDY LIMITATIONS AND STRENGTHS. The fact that this was not a randomized, controlled trial does not allow us to exclude the existence of an inclusion bias even though patients were consecutively enrolled without inclusion/exclusion criteria. To guarantee data quality, all data were entered by 1 researcher and were monitored against original clinical documents by another one. Control coronary angiography was not performed in some of the patients in the absence of symptoms or other evidence of ischemia. This obviously represents a negative bias against the device; since the outcomes reported are in line with those of other studies in stable settings, however, we do not believe that this bias played a significant role. No control group was included in this report; however, we previously showed that the clinical characteristics and short-term outcome of these patients, consecutively included in the present report, do not differ from those of patients who received metal stents during the same period in our institution (9), and the vast majority of the clinical events occurred early after implantation. As well, the vasomotion properties of BVS are obviously unique, and a control group would have added no information with regard to this endpoint. Because OCT was not systematically performed at implantation, we cannot conclude whether this was present directly after implantation of whether it was acquired at later timepoints (e.g., as the effect of the dissolution of thrombi jailed between scaffold struts and vessel wall).

Whatever the mechanism, the implications of the resulting flow disturbances will have to be further investigated. Despite the high resolution of OCT, the identification of uncovered struts is challenging and to a certain extent arbitrary, and the incidence of uncovered struts, in this like in other reports, should be interpreted cautiously. The maximum percent restenosis measured by OCT was larger than theoretically expected on the basis of late lumen loss measures. Differences in the resolution of the methods, the nonuniform distribution of neointima, and the fact that scaffold struts are invisible at x-ray might concur to explain this discrepancy.

CONCLUSIONS

Long-term outcome data after BVS implantation are limited to chronic stable settings, type A lesions, and patients selected using stringent inclusion/exclusion criteria (24). In the current report, we provide the first clinical, functional, and imaging outcome data at 12 months in an unselected cohort of high-risk patients who received 1 or more BVS for the treatment of a thrombotic culprit lesion. Collectively, the incidence of events was high but comparable to that of previous series with metal stents; the implications of malapposed struts and the episodes of in-BVS thrombosis will require further assessments. Finally, the evidence that the majority of the lesions was covered by a high-intensity, low-attenuation layer suggestive of fibrotic neointima as well as the normalization of endothelial responses in about 50% of the lesions provide a biological background for the use of BVS in the treatment of culprit lesions and provide the rationale for a large-scale, long-term follow-up trial.

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PERSPECTIVES

WHAT IS KNOWN? Outcome data on the use of BVS are to date limited to simple, stable lesions; these studies report a normalization of vascular function as early as 1 year after scaffold implantation. The physiology and pathology of thrombotic lesions is however radically different, and these data cannot be directly extrapolated to the setting of acute coronary syndromes. In this setting, only short-term clinical follow-up data are available, and no information from intracoronary imaging and vasomotion tests has been reported.

WHAT IS NEW? We report clinical, intracoronary imaging and vasomotion data 12 months after BVS implantation in patients with thrombotic lesions: our data support the concept of vascular and lesion regeneration after scaffold implantation.

WHAT IS NEXT? Further data, with a longer follow-up, are now necessary.

REFERENCES

1. Iqbal J, Onuma Y, Ormiston J, Abizaid A, Waksman R, Serruys P. Bioresorbable scaffolds: rationale, current status, challenges, and future. Eur Heart J 2014;35:765–76.

2. Brugaletta S, Heo JH, Garcia-Garcia HM, et al. Endothelial-dependent vasomotion in a coronary segment treated by ABSORB everolimus-eluting bioresorbable vascular scaffold system is related to plaque composition at the time of bioresorption of the polymer: indirect finding of vascular reparative therapy? Eur Heart J 2012;33:1325–33.

3. Diletti R, Farooq V, Girasis C, et al. Clinical and intravascular imaging outcomes at 1 and 2 years after implantation of absorb everolimus eluting bioresorbable vascular scaffolds in small vessels. Late lumen enlargement: does bioresorption matter with small vessel size? Insight from the ABSORB cohort B trial. Heart 2013;99:98–105.

4. Kocka V, Maly M, Tousek P, et al. Bioresorbable vascular scaffolds in acute ST-segment elevation myocardial infarction: a prospective multicentre study 'Prague 19.' Eur Heart J 2014;35:787–94.

5. Diletti R, Karanasos A, Muramatsu T, et al. Everolimus-eluting bioresorbable vascular scaffolds for treatment of patients presenting with ST-segment elevation myocardial infarction: BVS STEMI first study. Eur Heart J 2014;35:777–86.

6. Zasada W, Rzeszutko L, Dziewierz A, Dudek D. Patient with non-ST-segment elevation myocardial infarction treated by Absorb bioresorbable scaffold implantation. Kardiol Pol 2013;71:1091–2.

7. Wiebe J, Mollmann H, Most A, et al. Short-term outcome of patients with ST-segment elevation myocardial infarction (STEMI) treated with an everolimus-eluting bioresorbable vascular scaffold. Clin Res Cardiol 2014;103:141–8.

8. Kajiya T, Liang M, Sharma RK, et al. Everolimus-eluting bioresorbable vascular scaffold (BVS) implantation in patients with ST-segment elevation myocardial infarction (STEMI). EuroIntervention 2013;9:501–4.

9. Gori T, Schulz E, Hink U, et al. Early outcome after implantation of Absorb bioresorbable drug-eluting scaffolds in patients with acute coronary syndromes. EuroIntervention 2014;9:1036–41.

10. Serruys PW, Onuma Y, Dudek D, et al. Evaluation of the second generation of a bioresorbable everolimus-eluting vascular scaffold for the treatment of de novo coronary artery stenosis: 12-month clinical and imaging outcomes. J Am Coll Cardiol 2011;58:1578–88.

11. Luscher TF, Pieper M, Tendera M, et al. A randomized placebo-controlled study on the effect of nifedipine on coronary endothelial function and plaque formation in patients with coronary artery disease: the ENCORE II study. Eur Heart J 2009;30:1590–7.

12. Raber L, Kelbaek H, Ostojic M, et al. Effect of biolimus-eluting stents with biodegradable polymer vs bare-metal stents on cardiovascular events among patients with acute myocardial infarction: the COMFORTABLE AMI randomized trial. JAMA 2012;308:777–87.

13. Kang WC, Ahn T, Lee K, et al. Comparison of zotarolimus-eluting stents versus sirolimus-eluting stents versus paclitaxel-eluting stents for primary percutaneous coronary intervention in patients with ST-elevation myocardial infarction: results from the Korean Multicentre Endeavor (KOMER) acute myocardial infarction (AMI) trial. EuroIntervention 2011;7:936–43.

14. Palmerini T, Genereux P, Caixeta A, et al. Prognostic value of the SYNTAX score in patients with acute coronary syndromes undergoing percutaneous coronary intervention: analysis from the ACUITY (Acute Catheterization and Urgent Intervention Triage StrategY) trial. J Am Coll Cardiol 2011;57:2389–97.

15. Dvir D, Barbash IM, Torguson R, et al. Clinical outcomes after treating acute coronary syndrome patients with a drug-eluting stent: results from REWARDS-EMI (Endeavor for Myocardial Infarction Registry). Cardiovasc Revasc Med 2013;14:128–33.

16. Sabate M, Cequier A, Iniguez A, et al. Everolimus-eluting stent versus bare-metal stent in ST-segment elevation myocardial infarction (EXAMINATION): 1 year results of a randomised controlled trial. Lancet 2012;380:1482–90.

17. Capodanno D, Gori T, Nef H, et al. Percutaneous coronary intervention with everolimus-eluting bioresorbable vascular scaffolds in routine clinical practice: early and midterm outcomes from the European multicentre GHOST-EU registry. EuroIntervention 2015;10:1144–53.

18. Zhang YJ, Bourantas CV, Muramatsu T, et al. Comparison of acute gain and late lumen loss after PCI with bioresorbable vascular scaffolds versus everolimus-eluting stents: an exploratory observational study prior to a randomised trial. EuroIntervention 2014;10:672–80.

19. Raber L, Zanchin T, Baumgartner S, et al. Differential healing response attributed to culprit lesions of patients with acute coronary syndromes and stable coronary artery after implantation of drug-eluting stents: an optical coherence tomography study. Int J Cardiol 2014;173:259–67.

20. van Geuns RJ, Tamburino C, Fajadet J, et al. Self-expanding versus balloon-expandable stents in acute myocardial infarction: results from the APPOSITION II study: self-expanding stents in ST-segment elevation myocardial infarction. J Am Coll Cardiol Intv 2012;5:1209–19.

21. Guagliumi G, Costa MA, Sirbu V, et al. Strut coverage and late malapposition with paclitaxel-eluting stents compared with bare metal stents in acute myocardial infarction: optical coherence tomography substudy of the Harmonizing Outcomes with Revascularization and Stents in Acute Myocardial Infarction (HORIZONS-AMI) Trial. Circulation 2011;123:274–81.

22. Bezerra HG, Costa MA, Guagliumi G, Rollins AM, Simon DI. Intracoronary optical coherence tomography: a comprehensive review clinical and research applications. J Am Coll Cardiol Intv 2009;2:1035–46.

23. Montalescot G, Sechtem U, Achenbach S, et al. 2013 ESC guidelines on the management of stable coronary artery disease: the Task Force on the Management of Stable Coronary Artery Disease of the European Society of Cardiology. Eur Heart J 2013;34:2949–3003.

24. Dudek D, Onuma Y, Ormiston JA, Thuesen L, Miquel-Hebert K, Serruys PW. Four-year clinical follow-up of the ABSORB everolimus-eluting bioresorbable vascular scaffold in patients with de novo coronary artery disease: the ABSORB trial. EuroIntervention 2012;7:1060–1.

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APPENDIX For supplemental methods and tables, please see the online version of this article.