How to Select the Most Appropriate Patient and Lesion to be Treated with a Coronary Bioresorbable Vascular Scaffold

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Abstract

Bioresorbable vascular scaffolds (BVS) are an exciting novel treatment for coronary artery disease (CAD) as their eventual resorption renders the artery free from a permanent metallic cage. Clinical trials regarding these novel devices have demonstrated promising results, although their use in this context has largely been restricted to simple lesions. More recently, BVS use has expanded to patients with more complex lesions including those with long diffuse disease, and results from several registries are awaited with regard to their efficacy in 'real-world' patients. Although any patient who requires percutaneous treatment for CAD could benefit from BVS implantation, there are certain cohorts of patients and lesions in whom BVS could be of particular benefit. In this review, we attempt to identify which patient and lesion cohort is most suitable for treatment with these novel devices.

Keywords

Bioresorbable vascular scaffold, target lesion revascularisation, major adverse cardiac events

Disclosure: The authors have no conflicts of interest to declare.

Received: 5 August 2013 **Accepted:** 18 August 2013 **Citation:** *Interventional Cardiology Review*, 2013;8(2):90–2

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Although the introduction of metallic stents has revolutionised the percutaneous treatment of coronary artery disease (CAD) and has been demonstrated to improve clinical outcomes as compared with plain old balloon angioplasty (POBA), the permanent presence of a metallic cage that stays on the vessel wall beyond its intended purpose of preventing acute recoil, is associated with a number of drawbacks. The recent introduction of bioresorbable vascular scaffolds (BVS) offers the potential of dealing with these drawbacks as these devices allow positive remodelling and restoration of normal vasomotor vessel function.^{1,2} They also offer the potential of reducing restenosis and stent thrombosis rates because they tend to be more biocompatible as compared with conventional metallic drug-eluting stents (DES), whilst also maintaining access for coronary bypass grafting in the future if required. Until recently, the use of BVS has largely been in the context of clinical trials, but an increasing number of 'real-world' patients are being treated with these scaffolds. Despite the fact that most, if not all, patients can be treated with these devices, it is clear that certain patient cohorts have more to gain than others from BVS use, especially if these innovative devices fulfil their expected potential. In view of their higher cost and challenges in implantation technique as compared with conventional DES, the selective use of BVS is appropriate especially in the current climate.

Bioresorbable Vascular Scaffolds Available for Clinical Use

Recent years have seen a huge expansion in the development of BVS many of which are undergoing preclinical or clinical assessment. One of these, the ABSORB™ BVS (Abbott Vascular, Santa Clara, California, US) is currently available with the DESolve™ BVS (Elixir Medical,

Sunnyvale, California, US) being available for clinical use later in the year. The ABSORB BVS is made from semicrystalline poly-L-lactic acid (PLLA) coated with an amorphous poly-D, L-lactide (PDLLA) polymer eluting everolimus. Degradation of the scaffold is mainly through hydrolysis, a process that takes approximately two years to complete. The efficacy of the currently used ABSORB BVS (revision 1.1) has been assessed in the multicentre, single-arm ABSORB Cohort B trial, which recruited 101 patients with single- or two-vessel *de novo* disease, all of which received a 3 x 18 millimetre (mm) BVS. Patients were divided into two groups for follow-up purposes with group 1 being assessed at six months and two years and group 2 at one and three years, respectively. Scaffold area was shown to progressively increase during follow-up with no differences in late lumen loss (LLL) (0.29 ± 0.16 mm versus 0.25 ± 0.22 mm, $p=0.439$) being noted between small vessels (<2.5 mm) and large vessels (≥ 2.5 mm) at two-year angiographic follow-up.³ At 18 months follow-up in the entire cohort, there were three non-ST elevation myocardial infarctions (MIs) and four ischaemia-driven target lesion revascularisations (TLR).⁴ In the ABSORB EXTEND study, aiming to recruit 1,000 patients, in which the recruitment of patients with disease in smaller vessels (>2.0 mm) as well as those with long lesions is allowed, the ischaemia-driven TLR and major adverse cardiac events (MACE) rates at one-year has been reported as 1.8 and 4.2 %, respectively. Definite/probable stent thrombosis (ST) rate was 0.9 %.⁵ Data from the treatment of real-world patients is also emerging. In the prospective, single-centre, BVS Expand registry in which the liberal use of BVS is permitted with the exception of patients with ST-elevation MI (STEMI) and restenotic lesions, the use of BVS was associated with one MI and one non-target vessel revascularisation (TVR) at 30-day follow-up in a cohort of

131 patients.⁶ BVS has also been evaluated in the context of acute coronary syndromes although meaningful clinical follow-up data is not yet available.^{7,8} Other studies currently underway include the ABSORB III and ABSORB IV studies that aim to compare ABSORB to XIENCE PRIME™ Everolimus Eluting Stent (Abbott Vascular, Santa Clara, California, US).

The DESolve bioresorbable scaffold is made from a PLLA-based polymer eluting novolimus and has been designed to be fully resorbed within two years. In the multicentre CE Mark DESolve Nx trial, which enrolled 126 patients worldwide, quantitative coronary angiography at six months demonstrated a LLL of 0.21 ± 0.34 mm with an increase in scaffold area over the same interval ($5.86 > 6.78$ mm², $p \leq 0.001$). The incidence of MACE was 3.25 % with one cardiac death, one target-vessel MI and two clinically indicated TLR. There were no reported cases of ST.⁹ Following these results, DESolve has received CE Mark approval and the scaffold is expected to be available for commercial use in a variety of lengths and sizes later this year.

Use of Bioresorbable Vascular Scaffold in Routine Clinical Practice

Although most studies to date have evaluated BVS implantation for short, non-calcified lesions in moderately-sized vessels, it is likely that these novel devices, assuming that they fulfil their full potential, will offer most of their benefit in patients with more complex lesions (see Table 1). Thus BVS use should not be restricted to patients with simple (American Heart Association/ American College of Cardiology [AHA/ACC] Type A or B) lesions as such patients would probably have experienced similar benefits with the implantation of conventional metallic DES. This of course does not mean that these patients should not be treated with BVS since the absence of a permanent implant and restoration of vasomotion can still be advantageous as this may reduce the risk of very late ST whilst normal coronary physiology is also returned. Patients with long segments of diffuse disease, long occlusions requiring vessel reconstruction and those requiring multivessel revascularisation can particularly benefit from BVS implantation since stent length returns to zero after resorption (see Figure 1). This is important not only because it permits subsequent percutaneous treatment without the addition of more stent layers whilst also keeping the option of coronary bypass graft surgery open, but also because it can reduce late adverse events such as ST and clinically significant restenosis, the risk of which rises with increasing total stent length. Furthermore, in these patients any 'jailed' side branches following BVS implantation are liberated as the scaffold is resorbed. Thus BVS should also be considered for lesions that involve side branches, which are too small for dilatation following stent implantation. It is important to mention that when treating patients with long disease to try and limit BVS overlap since currently available devices have much thicker struts (≈ 150 micrometres (μ m)) as compared with conventional DES. Thus in areas of overlap, 300 μ m of BVS surround the vessel, which can impact significantly on lumen area especially in smaller vessels. This can be achieved by first deciding whether to implant proximal to distal or vice versa, something that largely depends on whether greater accuracy is needed for the proximal or distal landing zone. In cases where the proximal landing zone is short it is best to implant first proximally whereas the opposite should be performed with a short distal landing zone. Large overlap can also be avoided by placing the balloon marker of the BVS about to be implanted side-by-side with the platinum marker of the already implanted BVS, since the platinum markers are within the BVS edges.

Table 1: Bioresorbable Vascular Scaffold Use on the Basis of Patient and Lesion Characteristics

Favour Bioresorbable Vascular Scaffold	Use Bioresorbable Vascular Scaffold with Caution	Avoid Bioresorbable Vascular Scaffold
Young patient	STEMI	Lesions in vessel with diameter <2.5 mm and >4.0 mm
Any lesion in vessels with diameter >2.5 mm and $\leq$ 4.0 mm	Patient where DAPT <6 months is preferred	
Long diffuse disease especially in LAD		
Long occlusion requiring vessel reconstruction		
Multivessel disease		

DAPT = dual-antiplatelet therapy; LAD = left anterior descending; mm = millimetres; STEMI = ST elevation myocardial infarction.

Figure 1: A Case of a Long Left Anterior Descending Disease Treated with Bioresorbable Vascular Scaffolds

(A) Initial angiographic image, (B) Angiographic image following rotational atherectomy and (C) Angiographic and intravascular images following BVS implantation. BVS = bioresorbable vascular scaffold; mm² = square millimetres; SA = scaffold area.

Figure 2: A Case of a Long Left Anterior Descending and Diagonal Bifurcation Treated with Systematic Two-stenting Using Bioresorbable Vascular Scaffolds

(A) Initial angiographic image and (B) Angiographic and optical coherence tomography images following BVS implantation. BVS = bioresorbable vascular scaffold; LAD = left anterior descending; mm² = square millimetres; SA = scaffold area.

Young patients are also attractive candidates for BVS for exactly the same reasons as mentioned above. Patients that require a dedicated two-stent technique for the treatment of a coronary bifurcation may also fare better with a BVS especially when a mini-crush or T-stenting technique is undertaken (see *Figure 2*). It is important when considering BVS for this indication to ensure that the side branch diameter is ≥ 2.5 mm as this is the smallest BVS available, and that the main branch can accommodate ≈ 450 μ m of struts on the other side of the carina, which will result after a mini-crush technique. Although BVS use in this setting can be slightly challenging, it can be achieved by ensuring adequate predilatation with a balloon of the same diameter as the BVS intended to be implanted. This applies for any lesion to be treated with BVS as it helps to ensure complete BVS expansion. The advantage of using BVS for a dedicated two-stent strategy is that the 'congestion' of struts after a mini-crush technique is undertaken stops being an issue as the scaffold undergoes hydrolysis. It is important to note here that we do not advocate the use of a 'culotte' technique with BVS as these result in relatively long segments of BVS overlap.

Although BVS can be used for most lesions, there are certain occasions that these should be avoided or at least used with caution. However, this does not include patients with heavily calcified lesions, as currently available tools such as rotational atherectomy, scoring, cutting and ultra-high pressure balloons can ensure that a calcified lesion is well-prepared for BVS implantation. This is a principle that applies also to conventional DES. In our experience, excellent results can be obtained with BVS in such lesions when meticulous lesion preparation as well as post-dilatation have been performed. Occasions where BVS use may not be appropriate includes the treatment of lesions where vessel diameter is < 2.5 mm not only because a 2.25 mm BVS is not available but also

because the thicker struts of currently available devices may lead to significant lumen reductions. They should also not be used when vessel diameter is > 4.0 mm as the largest available BVS is 3.5 mm and the maximum recommended balloon diameter that can be used for this is 4.0 mm (0.5 mm tolerance). In our opinion, they should also be used with caution in STEMI until evidence with regards to BVS use in this context becomes available. Finally, although the use of BVS can theoretically allow shorter periods of dual-antiplatelet therapy (DAPT) due to the inherent biocompatibility of the device, it is not yet known whether this is possible or not. Thus, for patients in whom a DES is required and DAPT cannot be given for more than six months it is perhaps judicious to use a second generation metallic DES for which a shorter DAPT period is possible such as the XIENCE PRIME or XIENCE V® (Abbott Vascular, Santa Clara, California, US) or the Endeavor Resolute (Medtronic, Santa Rosa, California, US).

Conclusion

BVS have the potential of revolutionising the percutaneous treatment of CAD as their greater biocompatibility and eventual resorption offer the possibility of further improving clinical outcomes whilst maintaining the future option of further revascularisation if necessary. In our experience, BVS can be used in a wide-range of lesions with good procedural and early outcome results. Patients that may especially benefit from this technology include those with multivessel disease, diffusely diseased vessels, bifurcation lesions and those of younger age. They should, however, be avoided in patients with too large (> 4.0 mm) or too small (< 2.5 mm) vessels for currently available devices. They should also be used with caution in patients with STEMI and in those that may require shorter DAPT durations until further evidence becomes available. ■

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