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EDITORIAL COMMENT

# Does Asymmetric Expansion of Bioresorbable Vascular Scaffolds Cause Stent Failure?*

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Bioresorbable vascular scaffolds (BVSs) have been introduced in clinical practice to overcome the limitations of metallic stents. First-generation metallic drug-eluting stents (DES) were developed to decrease in-stent restenosis of bare-metal stents (1). However, incomplete endothelial coverage and excess inflammation might be associated with late DES thrombosis (2). Next-generation (second- and third-generation) DES were modified with adequate amounts of drugs, better biocompatible or biodegradable polymers, and thinner stent designs, which decrease DES thrombosis (3). Although recent stent technology has led to advances in DES performance, the metallic stent platform remains permanently in the vessel wall, which can be an obstacle to repeated dilation of the lesion in cases of in-stent restenosis. Neoatheroscleosis is another issue that is observed in approximately 25% of DES in-stent restenotic lesions during long-term follow-up (4). Therefore, complete vascular healing of treated lesions and the disappearance of stent material may be ideal for patients with coronary artery disease in terms of long-term clinical follow-up. Currently available BVS are composed of a poly-L-lactic acid-based polymer 154 μm in thickness, which has a less tolerant mechanical profile than metallic DES. During BVS implantation it may be cautious to obtain an optimal scaffold area as well as symmetric scaffold expansion. Furthermore, their subsequent clinical implications should be clarified.

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In this issue of *JACC: Cardiovascular Interventions*, Suwannasom et al. (5) discussed the relationship of stent/scaffold expansion and symmetricity between metallic everolimus-eluting stents (EES) versus BVS, and subsequent clinical outcomes at 1-year follow-up in the ABSORB II (A bioresorbable everolimus-eluting scaffold versus a metallic everolimus-eluting stent for ischaemic heart disease caused by de-novo native coronary artery lesions) trial. The authors applied the MUSIC (Multicenter ultrasound stenting in coronaries) criteria for optimal scaffold/stent expansion, the asymmetry index (AI) (derived from different several cross sections) and the eccentricity index (derived from the same single cross section) in this study (6). As expected, metallic EES expanded more symmetrically and concentrically than BVS immediately after stenting procedures. Optimal stent expansion was achieved at higher rates in metallic EES (20%) than BVS (8%). An AI $>0.3$ predicted device-oriented composite endpoints in univariate analysis for BVS ($p = 0.03$), but not metallic EES ($p = 0.66$) (see Table 4 in Suwannasom et al. [5]). Asymmetric expansions of stents including both BVS and EES were associated with greater numbers of clinical events at 1 year (6.9% vs. 1.8% in symmetric expansion; $p = 0.007$), mostly driven by a higher incidence of periprocedural myocardial infarction (4.5% vs. 1.8% in symmetric expansion; $p = 0.09$). However, according to the type of device, the impact of asymmetric expansion on clinical outcomes was significant in BVS (hazard ratio: 9.19; 95% confidence interval: 1.19 to 70.60; $p = 0.03$), but not in metallic EES (hazard ratio: 1.51; 95% confidence interval: 0.25 to

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9.35; $p = 0.65$) (see Figure 3 in Suwannasom et al. [5]). This suggests that this parameter of AI could be useful for BVS implantation, but not for metallic EES implantation. The clinical implications of asymmetric expansion remain unclear in metallic DES. Although a previous study reported an association between the asymmetric expansion of metallic DES and thrombus formation inside the stent, other reports did not show any differences in neointimal hyperplasia or in clinical outcomes between concentric and eccentric stent expansion conditions (7–9). Although the current study hints that there might be unfavorable effects of asymmetric EES expansion, the number of EES-treated patients enrolled in this study was too small to draw clear conclusions.

Next, how can we achieve optimal and symmetric stent expansion? The adequate and symmetric expansion of BVS is usually affected by underlying plaque characteristics and burden. A previous optical coherence tomography study of BVS demonstrated the relationship between stent eccentricity and extent of calcified or fibrous plaque (10). Pre-stent lesion preparation with appropriately sized balloon catheters was a crucial step. Imaging guidance such as intravascular ultrasound or optical coherence tomography can provide more accurate information regarding vessel size and plaque characteristics for obtaining adequate modifications of plaque for optimal stent expansion. In this study, post-stent balloon dilation was more frequently performed in asymmetric expansion groups, which might be associated with a higher incidence of periprocedural myocardial infarction. Theoretically, proper lesion preparation should result in a greater likelihood of optimal symmetric stent expansion, which may reduce the frequency of post-stent balloon dilation. This concept is more relevant to BVS implantation because BVS implantation is more resistant to expansion and is easier for scaffolding fractures compared to metallic stents when post-stent dilation with bigger balloons or higher pressure is applied. Therefore, pre-intervention surveillance with intravascular imaging may be emphasized to prepare lesions before stent implantation and to promote selection of adequate BVS size. The impact of intravascular imaging on favorable long-term clinical outcomes was reported in EES-treated diffuse long lesions in a previous intravascular ultrasound study (11). Although intravascular imaging modalities are useful for guiding BVS implantation, the new angiography-guided BVS implantation strategy showed a 70% decrease in scaffold thrombosis compared to previous BVS registries (12). At this time, the utility of imaging-guided BVS implantation should be tested in comparison with recently proposed angiography-guided strategies.

The current study has statistical limitations in terms of patient assessment and procedural factors affecting clinical outcomes because of its low 1-year event rate. In addition, most events were derived from peri-procedural myocardial infarctions, which are not considered long-term clinical outcomes, but procedure-related events. Furthermore, post-intervention indices including symmetricity should be investigated with follow-up angiographic or intravascular imaging for their influence on the degree of neointimal proliferation and scaffold healing patterns, which can provide more useful information to explain the underlying mechanism for future clinical events. Lastly, although AI $>0.3$ may be a more meaningful parameter than the eccentricity index, easily applicable criteria are necessary to assess optimal scaffold expansion in daily catheterization procedures for large numbers of patients scheduled for BVS implantation. The use of AI is more complicated than that of the eccentricity index because the calculation of AI is derived from several different cross sections in the whole scaffold segment, not a single cross section.

In conclusion, this paper suggests that symmetric BVS, not EES, expansion is necessary to reduce the frequency of device-related clinical events. Clinicians should endeavor to correct stent symmetricity.

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**KEY WORDS** asymmetric stent expansion, bioresorbable vascular scaffold, optical coherence tomography