

EDITORIAL COMMENT

Snowshoe Versus Ice Skate for Scaffolding of Disrupted Vessel Wall*



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The advance of coronary stent technology and scaffolding devices in coronary intervention procedures aims at reducing both short-term and long-term adverse cardiac events. However, periprocedural myocardial infarction (PMI) still occurs during the coronary procedure. In the report by Kawamoto et al. (1) in this issue of *JACC: Cardiovascular Interventions*, the investigators present the clinical impact of “average” abluminal strut surface area (ASSA) on PMI (based on extended historical MI definition) and long-term clinical outcome. The results from this group showed that compared with the Cypher stent (Cordis, Johnson and Johnson, Warren, New Jersey) with an ASSA of 67 mm², the Absorb device (Abbott Vascular, Santa Clara, California) has a larger ASSA of 133 mm² and is associated with PMI rates twice as high as those in Cypher group. There was no significant difference in long-term clinical outcomes between the 2 devices.

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The results of the present study may warrant a word of caution in interpretation. First, the propensity analysis can lead to misleading statements. Previously, it has been suggested in a propensity matched nonrandomized comparison conducted by our group that Absorb bioresorbable vascular scaffold was associated with a higher incidence of post-procedural side branch occlusion (SBO) compared

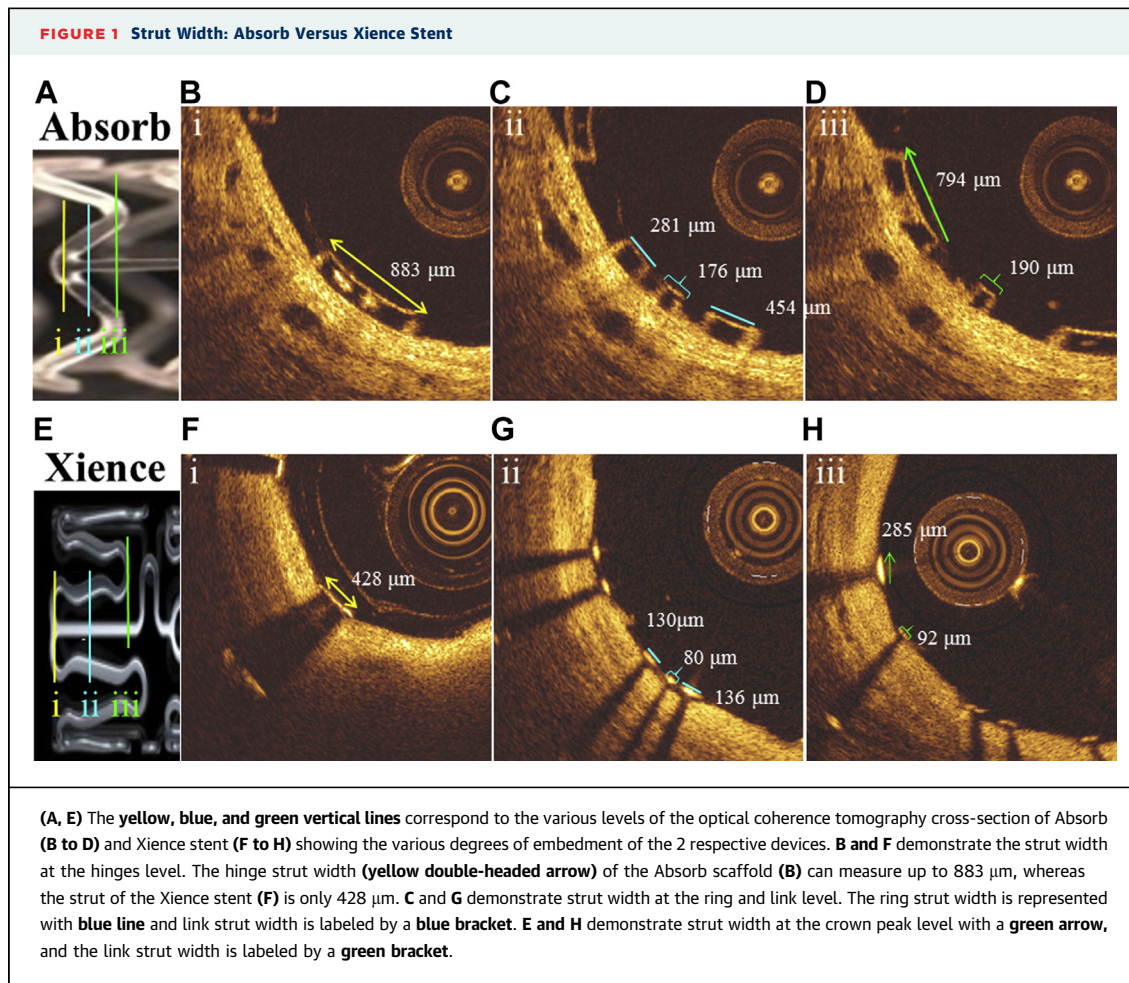
with the metallic everolimus-eluting stent. The difference was more pronounced with small side branches with a reference vessel diameter ≤ 0.5 mm (2). However, there was no significant difference in the incidence of post-procedure creatine kinase-myocardial band elevation. The hypothesis has been tested again in the ABSORB II (ABSORB II Randomized Controlled Trial: A Clinical Evaluation to Compare the Safety, Efficacy, and Performance of Absorb Everolimus Eluting Bioresorbable Vascular Scaffold System Against Xience Everolimus Eluting Coronary Stent System in the Treatment of Subjects With Ischemic Heart Disease Caused by De Novo Native Coronary Artery Lesion) randomized control trial (3) in which all 3 cardiac biomarkers were explored and analyzed in a core lab. There was no significant difference in the normalized value for each enzyme. To our surprise, the randomized data showed that the SBO (core lab analysis) occurred more often in the metallic stent group (39 of 503 side branches [8%]) than in the bioresorbable scaffold group (52 of 998 side branches [5%]), but this difference did not reach a statistical significance, $p = 0.07$.

Second, despite their hypothesis that greater ASSA is associated with PMI rate, mechanical complications such as SBO were not reported. SBO should be assessed rigorously by an independent core lab using quantitative coronary angiography whenever possible (e.g., side branch diameter ≥ 0.5 mm, the lower limit of automated edge detection).

Finally, it is unclear whether the cardiac biomarkers were systematically obtained. Generally, the incidence of PMI depends on the availability, type of post-procedural cardiac biomarkers, and enzymatic criteria used, as well as the frequency of cardiac biomarkers sampling. PMI remains a debatable issue with a heterogeneous incidence due to a diversity of definitions. The incidence of PMI could vary from 1%

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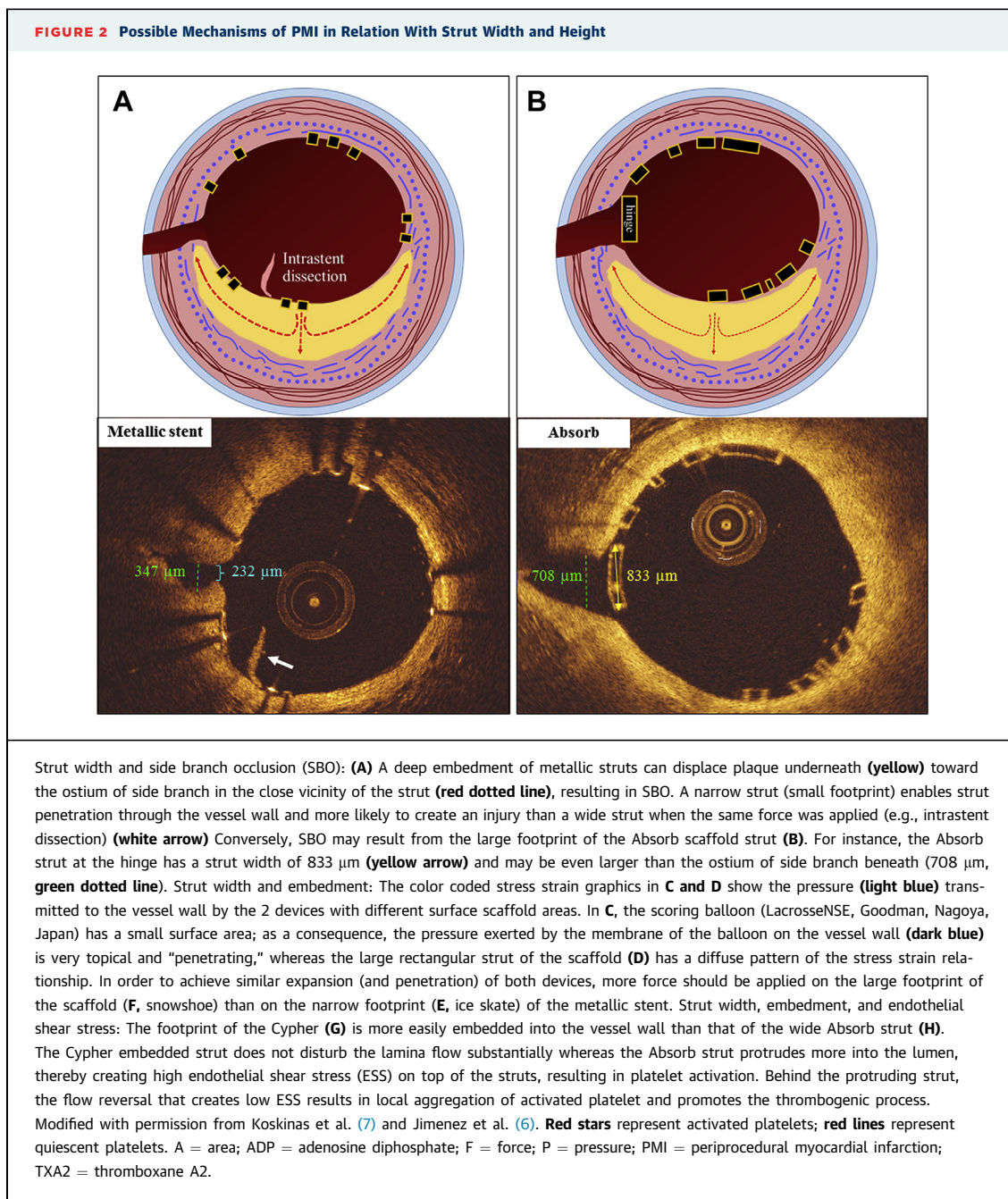


to 32% (3). For example, cardiac troponin T for the third universal definition can lead to overestimation of PMI. Ideally, an assessment of 3 cardiac biomarkers is recommended.

Nevertheless, the study results could put forward some new mechanical and rheological hypotheses. The implantation of a device with a large “footprint” could potentially cause small SBO and subsequent cardiac biomarkers to rise. One can speculate that the large footprint of the ABSORB (scaffold area covers 26% to 32% of the vessel wall area) could accidentally cover the ostium of small side branches, resulting in SBO. When measured using optical coherence tomography, the width of the Absorb struts at the hinge point can be as large as 800 μm (Figure 1). Therefore, a side branch with a diameter of <0.8 mm could be occluded by the device (Figure 2B). The width of the strut could also influence the embedment of the strut. When the same force is applied, a device with a smaller contact area would generate a higher pressure to the vessel wall according to the

simple principle: Pressure = Force/Area (Figures 2C and 2D). Taking into account the fact that a more aggressive post-dilation was applied in the Cypher group, the Cypher stent may have been more embedded (Figure 2E) into the vessel wall than the Absorb device was (Figure 2F). Embedded struts imply penetration of the cutting edge of the metals through fibrous, calcific, and necrotic plaques. The deep penetration of the strut into the vessel wall could also disrupt and displace the edge of the ostium of a side branch, with possible reduction or occlusion of its ostium (Figure 2A); additionally injury of the necrotic core can squeeze microparticles, which results in distal embolization and rise in cardiac biomarkers (4).

On the other hand, the thick protruding strut of the Absorb disrupts the laminar flow and induces flow disturbances. In a flow simulation of a microenvironment computed by optical coherence tomography/angiography fusion in a human coronary artery (5), the relatively high shear stress on top of the

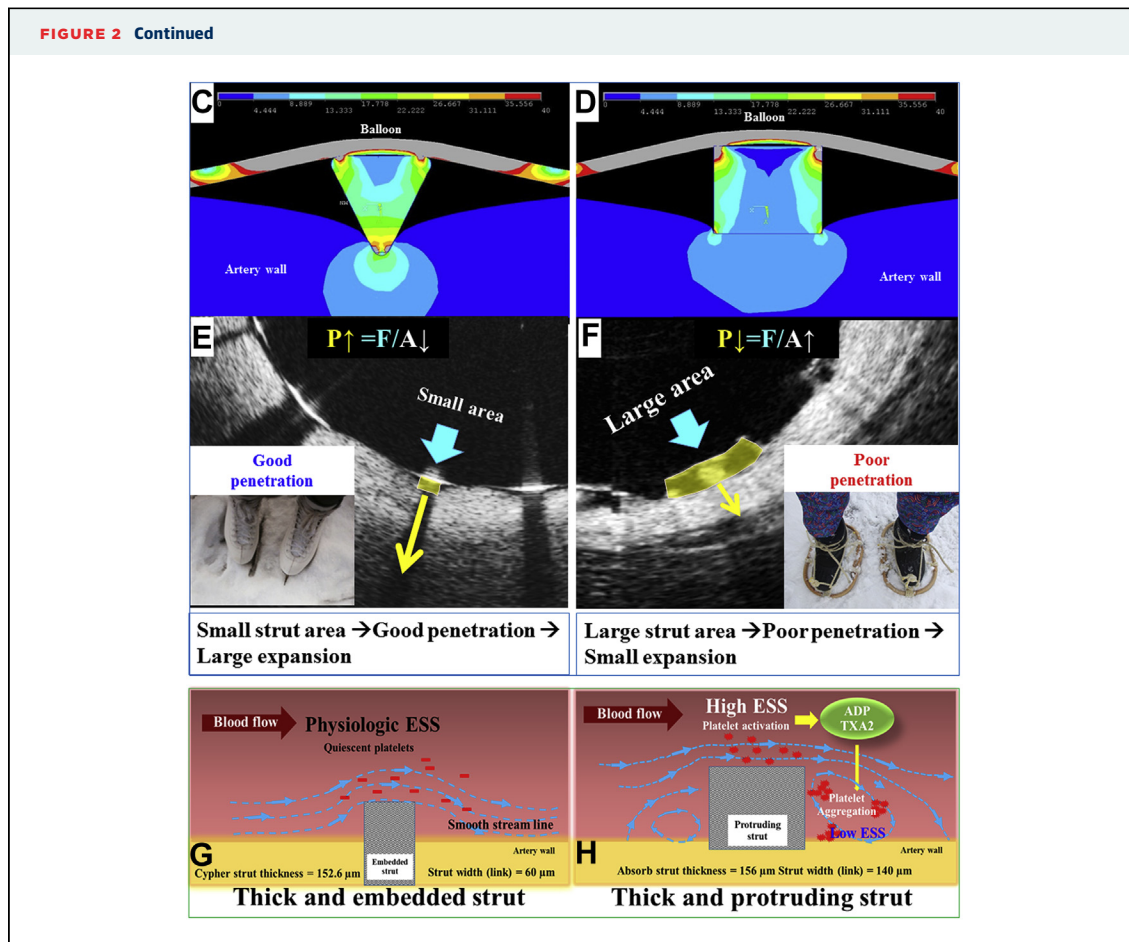


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strut activates a platelet-signaling pro-coagulation pathway (**Figure 2H**), whereas the low shear stress measured behind and between the strut induces reversal of the flow in a de-endothelialized area (5-7) (**Figure 2H**). The magnitude of flow disturbance depends on the degree of protrusion of the strut into the lumen. A low shear rate is known to induce platelet aggregation, formation of microthrombi

with potential embolization, and micromyocardial necrosis.

Although the clinical results and generating hypothesis from the current study are intriguing, the result should be cautiously interpreted and be confirmed in a randomized study, which is practically unexecutable due to the unavailability of Cypher stent. In the future, the new generation of bioresorbable scaffolds with a



thinner strut (100 μm) should be compared with metallic stents having a similar thickness.

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REFERENCES

- Kawamoto H, Panoulas VF, Sato K, et al. Impact of strut width in periprocedural myocardial infarction: a propensity-matched comparison between bioresorbable scaffolds and the first-generation sirolimus-eluting stent. *J Am Coll Cardiol Intv* 2015;8:900-9.
- Muramatsu T, Onuma Y, Garcia-Garcia HM, et al., for the ABSORB-EXTEND Investigators. Incidence and short-term clinical outcomes of small side branch occlusion after implantation of an everolimus-eluting bioresorbable vascular scaffold: an interim report of 435 patients in the ABSORB-EXTEND single-arm trial in comparison with an everolimus-eluting metallic stent in the SPIRIT first and II trials. *J Am Coll Cardiol Intv* 2013;6:247-57.
- Serruys PW, Chevalier B, Dudek D, et al. A bioresorbable everolimus-eluting scaffold versus a metallic everolimus-eluting stent for ischaemic heart disease caused by de-novo native coronary artery lesions (ABSORB II): an interim 1-year analysis of clinical and procedural secondary outcomes from a randomised controlled trial. *Lancet* 2015;385:43-54.
- Kawamoto T, Okura H, Koyama Y, et al. The relationship between coronary plaque characteristics and small embolic particles during coronary stent implantation. *J Am Coll Cardiol* 2007;50:1635-40.
- Papafakis MI, Bourantas CV, Farooq V, et al. In vivo assessment of the three-dimensional haemodynamic micro-environment following drug-eluting bioresorbable vascular scaffold implantation in a human coronary artery: fusion of frequency domain optical coherence tomography and angiography. *EuroIntervention* 2013;9:890.
- Jimenez JM, Davies PF. Hemodynamically driven stent strut design. *Ann Biomed Eng* 2009; 37:1483-94.
- Koskinas KC, Chatzizisis YS, Antoniadis AP, Giannoglou GD. Role of endothelial shear stress in stent restenosis and thrombosis: pathophysiologic mechanisms and implications for clinical translation. *J Am Coll Cardiol* 2012;59:1337-49.

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