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EDITORIAL COMMENT

How Quickly We Forget*

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Those who cannot remember the past are condemned to repeat it.

—George Santayana (1)

In this issue of *iJACC*, Otake et al. (2) present an imaging substudy from the larger OPINION (OPtical frequency domain imaging versus INtravascular ultrasound in percutaneous coronary interventiON) trial, a multicenter, prospective, randomized, noninferiority trial comparing optical frequency domain imaging (OFDI)-guided percutaneous coronary intervention (PCI) with intravascular ultrasound (IVUS)-guided PCI.

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In the main OPINION trial, 800 patients were randomized and followed for 1 year. Recently presented data demonstrated that OCT-guided PCI resulted in equivalent clinical and angiographic outcomes at 12 months to IVUS-guided PCI (3). In the current substudy, patients (n = 103) were randomized to either OFDI- or IVUS-guidance of stent implantation. Importantly, all patients had both IVUS and OFDI performed at the conclusion of the initial treatment. Also of note is that the stent implantation protocol for the 2 groups was different. In the OFDI-guided group, stent size was based on the lumen diameter in the reference segment. In the IVUS-guided group, stent size was based on the reference external elastic membrane diameter. Thus, by protocol, the stent size chosen for the IVUS group was larger than in the OFDI group. After a satisfactory angiographic result was obtained, the protocol-assigned imaging modality was repeated and stent optimization performed at the operator's discretion. Once stent implantation was optimized, final imaging was completed using both imaging modalities. All patients had follow-up angiography and OFDI imaging at 8 months. An important strength of the study was the ability to directly compare OFDI and IVUS after stent implantation in all patients.

The most important take away message from this study is that using either OFDI or IVUS imaging for second generation drug-eluting stent implantation yields similar acute and 8-month imaging results (and in the main trial, similar clinical outcomes). Direct comparison of measurements by the 2 imaging modalities showed reassuring similarity (Figure 4 in Otake et al. [2]) with correlations in excess of 0.9. Thus, either modality allows accurate determination of the post-implantation stent area.

The very detailed analysis of surface features possible with OFDI is also well-demonstrated. Based (in my opinion) on the larger stent sizes chosen by the IVUS protocol, features of plaque disruption including plaque protrusion and reference segment hematoma were more frequent in the IVUS-guided group. These findings did not seem to have any negative clinical implications. Although detailed surface imaging may not be needed to optimize stent expansion, this feature of OFDI has been very important in assessing stent apposition, strut coverage and intimal hyperplasia (4).

The notable differences between OFDI and IVUS imaging are, however, negligible compared with the alternative of angiographic-based stent implantation. The excellent result seen in the patients in this study rests on a multiyear foundation of imaging studies.

Let me remind our readers of the "past" and the insights we have gleaned from intravascular imaging about stent implantation. In 1994, Nakamura et al. (5) reported a 34% improvement in minimal stent area after IVUS-guided optimization at mean balloon inflation pressures of 12 atm. Based on the work of Colombo et al. in 1995 (6), we learned that to avoid stent thrombosis, appropriately sized balloons (ratio to reference 1.05) at high pressure (15.7 atm) were needed to ensure appropriate stent expansion. In that study, the minimal stent area increased

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on average by >2 mm^2 after IVUS guidance. Similarly, Fitzgerald et al. (7) continued to show an increased minimal stent area in the IVUS-guided group in the CRUISE (Can Routine Ultrasound Influence Stent Expansion) study, even when dilation pressures were increased to near 18 atm. A relatively modest (0.7 mm^2) improvement in minimal stent area, however, resulted in a 44% reduction in death or infarction over 9 months!

Many further studies have established the importance of intravascular imaging for improving clinical outcomes after stenting. Ahn et al. (8) reported a meta-analysis of 26,503 patients in randomized and registry trials comparing IVUS with angiographic stent implantation (8). Using all comers, or a subset of propensity matched subjects, they showed a roughly 40% relative risk reduction in death, myocardial infarction, and stent thrombosis when IVUS guidance was used. In a subsequent meta-analysis of only randomized trials using contemporary stent designs, Elgendy et al. (9) showed similar results. In 3,192 randomized patients, including multiple complex lesion subsets, they showed a 40% to 50% relative risk reduction in death and stent thrombosis. A consistent finding in these comparative studies is a larger minimal stent area in the IVUS-guided cohort (8).

In addition to assisting in optimizing the final stent area, intravascular imaging yields important information on calcium, a major determinant of stent expansion (10,11). Failure to recognize lesion calcification can lead to acute and late procedure failure. Many intraprocedural adjustments occur when imaging is used as part of the intervention. These include changes in balloon size (usually larger), changes in inflation pressure (usually higher), changes in stent length, changes in lesion preparation, changes in landing zones and accurate recognition of angiographically complex anatomy. In the contemporary ADAPT-DES study with experienced operators, imaging still led to changes in strategy in 74% of cases (12)!

Despite nearly 30 years of imaging data detailing the mechanisms of intervention, the predictors of success and failure, and the benefit for clinical outcome, use of intravascular imaging during stent implantation in the United States remains around 20% (13). The study by Otake et al. (2) demonstrates that either OFDI or IVUS can be used to guide stent implantation. The question should therefore not be which intravascular imaging modality is "best," but rather, why are we not using any modality?

Failure to remember the imaging lessons of the past will condemn us to failure in the future. This is already evident in the new era of bioresorbable scaffolds. It is well recognized that failure to optimize scaffold implantation leads to poor clinical outcome (14). Once again, Colombo's group (15) is showing that scaffold implantation (even in calcified lesions) can be successfully accomplished with IVUS guidance. They clearly have not forgotten. How is it that most of us have forgotten; or have we just chosen to ignore?

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REFERENCES

1. Wikiquotes. Available at: https://en.wikiquote.org/wiki/George_Santayana. Accessed June 26, 2017.

2. Otake H, Kubo T, Takahashi H, et al. Optical frequency domain imaging versus intravascular ultrasound in percutaneous coronary intervention (OPINION trial): results from the OPINION imaging study. J Am Coll Cardiol Img 2018;11:111–23.

3. OPINION study shows good clinical outcomes with optical frequency domain imaging in PCI. Available at: http://citoday.com/2016/05/31/opinion-study-shows-good-clinical-outcomes-with-optical-frequency-domain-imaging-in-pci?center=23. Accessed June 26, 2017.

4. Matthews SD, Frishman WH. A review of the clinical utility of intravascular ultrasound and optical coherence tomography in the assessment and treatment of coronary artery disease. Cardiol Rev 2017;25:68–76.

5. Nakamura S, Colombo A, Gaglione A, et al. Intracoronary ultrasound observations during stent implantation. Circulation 1994;89:2026–34.

6. Colombo A, Hall P, Nakamura S, et al. Intracoronary stenting without anticoagulation accomplished with intravascular ultrasound guidance. Circulation 1995;91:1676–88.

7. Fitzgerald PJ, Oshima A, Hayase M, et al. Final results of the can routine ultrasound influence stent expansion (CRUISE) study. Circulation 2000;102:523–30.

8. Ahn JM, Kang SJ, Yoon SH, et al. Meta-analysis of outcomes after intravascular ultrasound-guided versus angiography-guided drug-eluting stent implantation in 26,503 patients enrolled in three randomized trials and 14 observational studies. Am J Cardiol 2014;113:1338–47.

9. Elgendy IY, Mahmoud AN, Elgendy AY, Bavry AA. Outcomes with intravascular ultrasound-guided stent implantation: a meta-analysis of randomized trials in the era of drug-eluting stents. Circ Cardiovasc Interv 2016;9:e003700.

10. Mintz GS. Intravascular imaging of coronary calcification and its clinical implications. J Am Coll Cardiol Img 2015;8:461–71.

11. Albrecht D, Kaspers S, Fussl R, Hopp HW, Sechtem U. Coronary plaque morphology affects stent deployment: assessment by intracoronary ultrasound. Cathet Cardiovasc Diagn 1996;38:229–35.

12. Witzenbichler B, Maehara A, Weisz G, et al. Relationship between intravascular ultrasound guidance and clinical outcomes after drug-eluting

stents: the assessment of dual antiplatelet therapy with drug-eluting stents (ADAPT-DES) study. Circulation 2014;129:463–70.

13. Dattilo PB, Prasad A, Honeycutt E, Wang TY, Messenger JC. Contemporary patterns of fractional flow reserve and intravascular ultrasound use among patients undergoing percutaneous coronary intervention in the United States: insights from the National Cardiovascular Data Registry. J Am Coll Cardiol 2012;60:2337–9.

14. Chamie D, Garcia-Garcia H, Costa RA, Onuma Y, Abizaid A, Serruys PW. Role of invasive imaging in acute and long-term assessment of bioresorbable scaffold technology. Catheter Cardiovasc Interv 2016;88 Suppl 1:38–53.

15. Kawamoto H, Ruparelia N, Latib A, et al. Expansion in calcific lesions and overall clinical outcomes following bioresorbable scaffold implantation optimized with intravascular ultrasound. Catheter Cardiovasc Interv 2017;89:789–97.

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