JACC: CARDIOVASCULAR INTERVENTIONS
VOL. 8, NO. 7, 2015

ISSN 1936-8798/$36.00
PUBLISHED BY ELSEVIER INC.
http://dx.doi.org/10.1016/j.jcin.2015.04.002

EDITORIAL COMMENT

Can Multimodal Invasive Imaging Be Used to Predict Periprocedural Myocardial Infarctions?*

Marc D. Feldman, MD,†‡ Jennifer E. Phipps, PhD†

More than 1 million percutaneous coronary interventions (PCIs) are performed per year in the United States. Although technological advances have significantly improved outcomes following PCI, 5% to 44% of PCI patients still experience periprocedural myocardial infarction (PMI). PMI can be either macro-sized (coronary dissection or occlusion of a side branch) or microvascular such as distal embolization and/or microvascular plugging. PMIs have recently been defined as Type 4a: cardiac troponin (cTn) levels >5× elevation above the 99th percentile upper reference limit (URL), but only if the baseline cTn levels were normal (≤99th percentile URL) (1). In addition to the elevated cTn levels, at least 1 of the following must be present: 1) symptoms suggestive of myocardial ischemia; 2) new ischemic electrocardiographic (ECG) changes; 3) angiographic loss of patency of a coronary artery or side branch; or 4) imaging demonstration of new loss of viable myocardium or new regional wall motion abnormality (1). Despite the extensive literature on this topic, most studies only utilize the enzyme definition of type 4a infarction—rarely are angina, ECG changes, and new wall motion abnormalities taken into account. Although the universal definition of type 4a myocardial infarction (MI) requires elevation of cTn, the elevation of the biomarker creatine phosphokinase myocardial band fraction (CPK-MB) is felt by many clinicians to be a more specific marker of PMI. Reflecting this view, a Society for Cardiac Angiography and Interventions consensus document recently proposed a more stringent definition, based only on cardiac enzymes, of CPK-MB >10× upper limit of normal (ULN) and cTn >70× ULN (2).

PMIs are associated with increased future mortality. Whether PMI is simply a marker for more extensive coronary artery disease or the actual myocardial necrosis is accounting for the increased mortality is unknown. In either case, it would be of benefit to identify these patients before PCI and incorporate approaches during the intervention to limit or prevent elevation of cTn and CPK-MB. Approaches of proven benefit include pre-treatment with high-dose statin therapy and oral dual antiplatelet therapy, and treatments during PCI including distal protection devices, glycoprotein IIb/IIIa inhibition, and pre-conditioning.

Because it is the lipid-filled plaque that is responsible for distal embolization with secondary platelet activation and aggregation, one approach to preidentify these individuals is through the use of invasive imaging techniques at the time of intervention (3). These include attenuated plaques by gray-scale intravascular ultrasound (IVUS), the necrotic core by radiofrequency IVUS, the thin-capped fibroatheroma (TCFA) by optical coherence tomography (OCT), and the large lipid core plaque by near-infrared spectroscopy (NIRS). The search for which of these approaches will best predict PMI, including the use of combinations of these approaches, is the goal of the 2 articles in this issue of *JACC: Cardiovascular Interventions* (4,5).

*Editorials published in *JACC: Cardiovascular Interventions* reflect the views of the authors and do not necessarily represent the views of *JACC: Cardiovascular Interventions* or the American College of Cardiology.

From the †University of Texas Health Science Center San Antonio, San Antonio, Texas; and the ‡Department of Veterans Affairs, South Texas Veterans Health Care System, San Antonio, Texas. Dr. Feldman is supported in part by National Institutes of Health grant RO1 HL 118176; and is on the speakers bureau of St. Jude Medical. Dr. Phipps has reported that she has no relationships relevant to the contents of this paper to disclose.

Stone et al. (4) and Kini et al. (5) both used invasive imaging endpoints that correlated with rates of PMI following PCI. Both studies validated the previous literature and found that the presence of large lipid cores as identified by NIRS was associated with higher levels of PMI. This finding, along with single-center data demonstrating the association of NIRS-identified lipid with material captured in filter devices (6), was the basis for the CANARY (Coronary Assessment by Near-infrared of Atherosclerotic Rupture-prone Yellow) trial. The hope was that despite the negative previous literature related to the use of distal protection devices in native coronary arteries, invasive imaging would provide a rebirth of distal protection in this patient subset. Despite these high hopes, the CANARY trial was negative. The impact of more than one-half of PMIs arising from lesions with a maximum lipid-core burden index in 4 mm ($maxLCBI_{4mm}$) ≤600, and 57% of target lesions having side branches that could not be protected by the filter wire both mitigated against a positive finding for this study.

SEE PAGES 927 AND 937

The limitation of NIRS is that it does not provide axial resolution, that is, the depth of lipid cannot be determined. Thus, a small superficial lipid pool may have a similar appearance to a large, deep lipid pool. However, a large, deep lipid pool is less likely to embolize during intervention. That may explain the inability of NIRS to consistently predict PMI. For instance, a $maxLCBI_{4mm}$ ≥500 only predicted 50% of PMI (7 of 14 patients) in a previous study (7), and $maxLCBI_{4mm}$ ≥600 only predicted 29% (9 of 31 patients) in Stone et al. (4). The Kini et al. (5) study found that $maxLCBI_{4mm}$ ≥500 predicted 80% of PMI (8 of 10 patients), but by multivariant analysis, OCT-determined fibrous cap thickness was the only independent predictor for cTn elevations >3× ULN.

Although Kini et al. (5) are the first to demonstrate the superiority of OCT-defined TCFA compared with other imaging modalities, other investigators have previously demonstrated the strong association between OCT TCFA and PMI. Lee et al. (8) demonstrated TCFA to be the strongest independent predictor of PMI. The magnitude and consistency of association of OCT TCFA and adverse outcomes post-intervention were also supported by 2 subsequent studies (9,10). We have reviewed the more than 1,600 studies that have been published regarding coronary OCT, particularly the 40 that examined OCT-defined TCFA. Eight of these studies tabulated the frequency per coronary artery length of the presence of TCFA. An average of 0.99 ± 1.14 OCT TCFA per 10 cm of coronary artery was tabulated (11–18). With this high frequency, the next step in invasive imaging to predict and prevent PMI would be a trial comparing patients with the presence of OCT TCFA in the vessel undergoing intervention randomized to either distal protection or antiplatelet medications versus control. Finally, it would be ideal for future studies to use the universal definition of type 4a MI (1) that includes angina and/or ECG changes—both studies reviewed here identified patients with PMI by cTn elevation >3× the URL. Likely, the more stringent inclusion criteria would limit the number of patients enrolled in these studies but could improve the accuracy of the results.

REPRINT REQUESTS AND CORRESPONDENCE: Dr. Marc D. Feldman, University of Texas Health Science at San Antonio, Cardiology, 7703 Floyd Curl Drive, MSC 7872, San Antonio, Texas 78229. E-mail: feldmanm@uthscsa.edu.

REFERENCES

1. Thygesen K, Alpert JS, Jaffe AS, et al. Third universal definition of myocardial infarction. Circulation 2012;126:2020–35.

2. Moussa ID, Klein LW, Shah B, et al. Consideration of a new definition of clinically relevant myocardial infarction after coronary revascularization. J Am Coll Cardiol 2013;62:1563–70.

3. Patel VG, Brayton KM, Mintz GS, et al. Intracoronary and noninvasive imaging for prediction of distal embolization and periprocedural myocardial infarction during native coronary artery percutaneous intervention. Circ Cardiovasc Imaging 2013;6:1102–14.

4. Stone GW, Maehara A, Muller JE, et al. Plaque characterization to inform the prediction and prevention periprocedural myocardial infarction during percutaneous coronary intervention: the CANARY trial (Coronary Assessmnet by Near-infrared of Atherosclerotic Rupture-prone Yellow). J Am Coll Cardiol Intv 2015;8:927–36.

5. Kini AS, Motoyama S, Vengrenyuk Y, et al. Multimodality intravascular imaging to predict periprocedural myocardial infarction during percutaneous coronary intervention. J Am Coll Cardiol Intv 2015;8:937–45.

6. Brilakis ES, Abdel-Karim AR, Papayannis AC, et al. Embolic protection device utilization during stenting of native coronary artery lesions with large lipid core plaques as detected by near-infrared spectroscopy. Catheter Cardiovasc Interv 2012;80:1157–62.

7. Goldstein JA, Maini B, Dixon SR, et al. Detection of lipid-core plaques by intracoronary near-infrared spectroscopy identifies high risk periprocedural myocardial infarction. Circ Cardiovasc Interv 2011;4:429–37.

8. Lee T, Yonetsu T, Koura K, et al. Impact of coronary plaque morphology assessed by OCT on cardiac troponin elevation in patients with elective stent placement. Circ Cardiovasc Interv 2011;4:378–88.

9. Ozaki Y, Tanaka A, Tanimoto T, et al. Thin-cap fibroatheroma as high risk plaque for microvascular obstruction in patients with acute coronary syndrome. Circ Cardiovasc Interv 2011;4:620–7.

10. Porto I, Di Vito L, Burzotta F, et al. Predictors of periprocedural (type IVa) myocardial infarction, as assessed by frequency domain OCT. Circ Cardiovasc Interv 2012;5:89–96.

11. Kume T, Okura H, Yamada R, et al. Frequency and spatial distribution of thin-cap fibroatheroma

assessed by 3-vessel intravascular ultrasound and optical coherence tomography: an ex vivo validation and an initial in vivo feasibility study. Circ J 2009;73:1086–91.

12. Fujii K, Kawasaki D, Masutani M, et al. OCT assessment of thin-cap fibroatheroma distribution in native coronary arteries. J Am Coll Cardiol Img 2010;3:168–75.

13. Rathore S, Terashima M, Matsuo H, et al. In-vivo detection of the frequency and distribution of thin-cap fibroatheroma and ruptured plaques in patients with coronary artery disease: an optical coherence tomographic study. Coron Artery Dis 2011;22:64–72.

14. Sawada T, Shite J, Garcia-Garcia HM, et al. Feasibility of combined use of intravascular ultrasound radiofrequency data analysis and optical coherence tomography for detecting thin-cap fibroatheroma. Eur Heart J 2008;29:1136–46.

15. Sawada T, Shite J, Shinke T, et al. Low plasma adiponectin levels are associated with presence of thin-cap fibroatheroma in men with stable coronary artery disease. Int J Cardiol 2010;142:250–6.

16. Tanaka A, Imanishi T, Kitabata H, et al. Distribution and frequency of thin-capped fibroatheromas and ruptured plaques in the entire culprit coronary artery in patients with acute coronary syndrome as determined by optical coherence tomography. Am J Cardiol 2008;102:975–9.

17. Tian J, Dauerman H, Toma C, et al. Prevalence and characteristics of TCFA and degree of coronary artery stenosis: an OCT, IVUS, and angiographic study. J Am Coll Cardiol 2014;64:672–80.

18. Tian J, Ren X, Vergallo R, et al. Distinct morphological features of ruptured culprit plaque or acute coronary events compared to those with silent rupture and thin-cap fibroatheroma: a combined optical coherence tomography and intravascular ultrasound study. J Am Coll Cardiol 2014;63:2209–16.

KEY WORDS atherosclerosis, coronary artery disease, distal protection, embolization, fibrous cap thickness, intravascular imaging, myocardial infarction, near-infrared spectroscopy, percutaneous coronary intervention