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Identification of Coronary Artery Side Branch Supplying Myocardial Mass That May Benefit From Revascularization

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ABSTRACT

OBJECTIVES The authors sought to identify whether a coronary side branch (SB) is supplying a myocardial mass that may benefit from revascularization.

BACKGROUND The amount of subtending myocardium and physiological stenosis is frequently different between the main vessel (MV) and SB.

METHODS In this multicenter registry, 482 patients who underwent coronary computed tomography angiography and fractional flow reserve (FFR) measurement were enrolled. The % fractional myocardial mass (FMM), the ratio of vessel-specific myocardial mass to whole myocardium, was assessed in 5,860 MV or SB consisting of 2,930 bifurcations. Physiological stenosis was defined by fractional flow reserve (FFR) <0.80. Myocardial mass that may benefit from revascularization was defined by %FMM $\geq$10%.

RESULTS In per-bifurcation analysis, MV supplied a 1.5- to 9-fold larger myocardial mass compared with SB. Unlike left main bifurcation ($n = 482$), only 1 of every 5 non-left main SB ($n = 2,448$) supplied %FMM $\geq$10% (97% vs. 21%; $p < 0.001$). SB length $\geq$73 mm could estimate %FMM $\geq$10% (c-statistic = 0.85; $p < 0.001$). In 604 vessels interrogated by FFR, diameter stenosis was similar (p = NS), but %FMM $\geq$10%, FMM/minimal luminal diameter, and frequency of FFR <0.80 was higher in MV compared with SB ($p < 0.001$, all). Generalized estimating equations modeling demonstrate that vessel diameter, left myocardial mass, and FFR were not (p = NS), but SB length $\geq$73 mm and left main bifurcation were significant predictors for %FMM $\geq$10% ($p < 0.001$).

CONCLUSIONS Compared with MV, SB supplies a smaller myocardial mass and showed less physiological severity despite similar stenosis severity. SB supplying a myocardial mass of %FMM$\geq$10%, which may benefit revascularization could be identified by vessel length $\geq$73 mm. Pre-procedural recognition of these findings may guide optimal revascularization strategy for bifurcation. (J Am Coll Cardiol Intv 2017;■:■–■) © 2017 by the American College of Cardiology Foundation.

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ABBREVIATIONS AND ACRONYMS

CAG = coronary angiography

CCTA = computed tomography angiography

FFR = fractional flow reserve

FMM = fractional myocardial mass

LAD = left anterior descending coronary artery

LCX = left circumflex coronary artery

LV = left ventricular

MV = main vessel(s)

OM = obtuse marginal artery

PCI = percutaneous coronary intervention

PDA = posterior descending artery

PL = posterolateral artery

RCA = right coronary artery

SB = side branch(s)

The major role of percutaneous coronary intervention (PCI) is restoration of sufficient blood flow required to the supplying myocardium through the target vessel. Bifurcations are frequent in daily practice and account for 1 of 5 in PCI (1,2). Unlike nonbifurcations, coronary bifurcations supply 2 different territories of myocardium subtended by the main vessel (MV) and the side branch (SB), respectively (3). It often necessitates simultaneous 2-balloon dilation or stent implantation in both vessels. Despite advances in technology and devices, PCI of a bifurcation lesion is still limited by higher periprocedural myocardial infarction and long-term adverse events such as stent thrombosis, compared with a non-bifurcation lesion (4).

The burden of myocardial ischemia is highly relevant to the clinical benefit of revascularization and long-term prognosis (5). Therefore, identification of a SB supplying a myocardial mass that benefits more from revascularization than optimal medical therapy may clarify the need of additional procedures for the SB, and may guide optimal revascularization strategy for bifurcation (6).

Recently, we established the concept of fractional myocardial mass (FMM), a vessel-specific amount of myocardium derived from coronary computed tomography angiography (CCTA) (7). We assessed the myocardial mass subtended by the MV and SB of each bifurcation and investigated how to identify SB supplying clinically meaningful myocardial mass as defined by ≥10% of the total myocardium (8) (**Figure 1**).

METHODS

STUDY DESIGN. Data were derived from a prospective multicenter registry of 5 university teaching hospitals in Korea. From January 2010 to May 2015, 482 patients were enrolled who underwent clinically indicated CCTA and following elective invasive coronary angiography (CAG) with invasive fractional flow reserve (FFR) assessment without an intervening coronary event. Patients with ST-segment elevation myocardial infarction, uncompensated heart failure, bypass surgery with patent graft, contraindication to adenosine, complex structural or congenital heart disease, prosthetic valves, or any clinical instability or life-threatening disease were not included. The institutional review board at each institute approved the study protocol. Data were anonymized and analyzed independently by the core lab in the Samsung Medical Center.

FFR AND ANGIOGRAPHIC ANALYSIS. CAG and FFR measurement was performed according to the standard protocol of each institute (7). In brief, FFR was measured using a pressure wire (PressureWire Certus, St. Jude Medical Systems, St. Paul, Minnesota; ComboWire, Philips Healthcare, Amsterdam, the Netherlands) under maximal hyperemia induced by adenosine infusion. FFR has done on vessels that were visually estimated to have diameter stenosis ≥40% and to have clinical significance based on the interventionist's expertise. Quantitative CAG was done in vessels interrogated by FFR. A computer-assisted automatic arterial contour detection system (Centricity CA-1000, GE Healthcare, Little Chalfont, United Kingdom) was used to measure minimal luminal diameter, reference diameter, and diameter stenosis in the end-diastolic angiographic image with optimal projection showing minimal foreshortening of the lesion. Decision of revascularization strategy was made by agreement of attending physician and interventional cardiologist.

ACQUISITION AND ANALYSIS OF CCTA. CCTA data were obtained as described previously (7). In brief, multivendor computed tomography scanners equipped with 64 or higher detectors (Aquilion One or Aquilion 64, Toshiba Medical Systems, Otawara, Japan; SOMATOM Definition, Siemens Medical Solution, Erlangen, Germany; Lightspeed VCT, GE Healthcare) were used. Image dataset with 0.5- or 0.6-mm slices were processed by a dedicated workstation (iNtuition, TeraRecon, Foster City, California). The 3-dimensional coronary arterial tree model was segmented according to the modified American Heart Association classification of coronary artery anatomy. All major epicardial coronary arteries and 1st order branches ≥1.5 mm in diameter were tracked from ostium to distal end. The vessel central axis was determined and confirmed by reviewing all cross-sectional images from the proximal ostium to distal end. A total of 8,259 vessel segments were evaluated in length.

%FRACTIONAL MYOCARDIAL MASS. Transport of vital materials such as oxygen or glucose in hierarchical fractal-like branching network plays a key role in the metabolism of life. Therefore, the anatomy of the coronary artery tree would meet the principle of efficiency or minimum energy loss in transportation. Allometric scaling law is a universally observed logarithmic relationship among anatomic dimension, physiological function, and energy expenditure in