JACC: CARDIOVASCULAR IMAGING
VOL. 7, NO. 2, 2014

ISSN 1936-878X/$36.00
PUBLISHED BY ELSEVIER INC.

iMAIL

LETTERS TO THE EDITOR

3D OCT Versus FFR for Jailed Side-Branch Ostial Stenoses

The relationship between 3-dimensional (3D) optical coherence tomography (OCT) and fractional flow reserve (FFR) evaluation of a jailed side-branch ostium has not been investigated. Therefore, after a single-stent cross-over technique was used to treat bifurcation stenoses, we used OCT to image the stented main vessel, performed 3D OCT reconstruction of the orifice of jailed side-branch ostia, and compared the 3D OCT analysis with FFR measurements of the side-branch.

We enrolled 90 patients with bifurcation lesions who underwent both OCT of the main vessel and FFR of jailed side branches after a single-stent crossover technique. The inclusion criteria were the following: a side-branch ostium with a reference vessel diameter ≥2 mm; lesion length <10 mm by visual estimation; and TIMI (Thrombolysis In Myocardial Infarction) flow grade 3.

OCT imaging of the target lesion was performed using a frequency-domain OCT system (C7-XR OCT imaging system, St. Jude Medical, St. Paul, Minnesota). The OCT cross-sectional images acquired by the C7-XR system were processed offline using ImageJ software (National Institutes of Health, Bethesda, Maryland) and then imported into a 3D volume-rendering program (OsiriX 3.9.4, The OsiriX Foundation, Geneva, Switzerland). Side-branch minimal lumen area (MLA) was calculated with the following steps. First, the most normal-looking cross section of the side branch (Figs. 1A and 1B) perpendicular to the expected blood flow direction was selected. Next, the MLA of side branch was calculated using the multiplanar reconstruction (MPR) viewer supported in the OsiriX volume-rendering program. The 3D MPR viewer generates an MPR slice in any position and orientation through the 3D volume (Fig. 1C). As the blue line in Figure 1C represents the location of the orthogonal plane in Figure 1D, the position and orientation of the blue line was moved so that the blue line was perpendicular to the expected blood flow direction within the side branch. Finally, the MLA of the side branch was measured in the MPR slice (Fig. 1D). MLA measurement by OCT was highly reproducible (r = 0.996, intraclass correlation coefficient: 0.994 for intraobserver; r = 0.994, intraclass correlation coefficient: 0.995 for interobserver agreement).

After successful stent implantation into the main vessel across the side branch, the 0.014-inch pressure guidewire

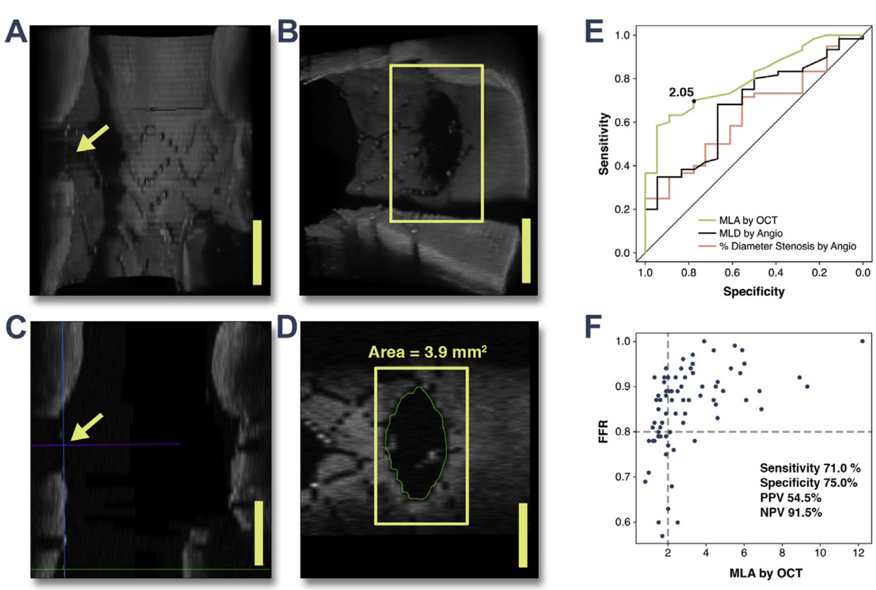

Figure 1. 3D OCT and FFR Measurement at Jailed Side Branch

Representative 3-dimensional optical coherence tomographic images of a jailed side-branch ostium **(A to D)** and the receiver-operating characteristic curve analysis of minimal lumen area (MLA) by optical coherence tomography (OCT) measurement versus fractional flow reserve (FFR) **(E,F)**. Scale bar = 2 mm. **(E)** The best cutoff value of the MLA by the closest to the top-left method was 2.05 mm^2 (area under the curve [AUC]: 0.81, 95% confidence interval [CI]: 0.71 to 0.91; $p < 0.001$). In contrast, any angiographic parameters failed to predict a functional significance of the jailed side-branch stenosis. (AUC of minimal lumen diameter [MLD]: 0.64, 95% CI: 0.50 to 0.77; p = 0.06; AUC of percentage of diameter stenosis: 0.61, 95% CI: 0.48 to 0.74; p = 0.09). **(F)** The relationship of OCT-measured MLA with a cutoff value of 2.05 mm^2 versus fractional flow reserve of 0.8 (sensitivity: 71.0%; specificity: 75.0%; positive predictive value [PPV]: 54.5%; negative predictive value [NPV]: 91.5%).

(St. Jude Medical) was applied with an intracoronary bolus administration of adenosine (80 μg in the left coronary artery and 40 μg in the right coronary artery) to induce maximal hyperemia. The jailed side branch was considered functionally significant when the FFR was ≤0.8.

Initially, 90 patients with 90 lesions were studied. However, 8 lesions were excluded due to poor quality of the reconstructed 3D OCT images. Therefore, 82 lesions in 82 patients were finally included in this study. A functionally significant stenosis was observed in 20 (24.4%) jailed side branches. Using receiver-operating characteristic curve analysis, the best cutoff value of the 3D OCT reconstructed side-branch MLA was 2.05 mm^2 for predicting a functionally significant stenosis (area under the curve: 0.81, 95% confidence interval: 0.71 to 0.91; $p < 0.001$; sensitivity: 71.0%; specificity 75.0%; positive predictive value: 54.5%; negative predictive value: 91.5%) (Figs. 1E and 1F).

In conclusion, 3D OCT had a modest ability to predict the functional significance for borderline lesions caused by a jailed side-branch ostium.

Jinyong Ha, PhD, Jung-Sun Kim, MD, Gary S. Mintz, MD, Byeong-Keuk Kim, MD, Dong-Ho Shin, MD, MPH, Young-Guk Ko, MD, Donghoon Choi, MD, Yangsoo Jang, MD, Myeong-Ki Hong, MD*

*Division of Cardiology, Severance Cardiovascular Hospital, Yonsei University College of Medicine, 250 Seongsanno, Seodaemun-gu, Seoul 120-752, Korea. *E-mail:* *mkhong61@yuhs.ac*

http://dx.doi.org/10.1016/j.jcmg.2013.06.011

Please note: This study was supported by a faculty research grant of Yonsei University College of Medicine (#6-2010-0018); a grant from the Korea Healthcare Technology Research and Development Project, Ministry for Health, Welfare and Family Affairs, Republic of Korea (#A085012 and #A102064); a grant from the Korea Health 21 Research and Development Project, Ministry of Health and Welfare, Republic of Korea (#A085136); and the Cardiovascular Research Center, Seoul, Korea. The authors have reported that they have no relationships relevant to the contents of this paper to disclose. Drs. Ha and J. S. Kim contributed equally to this paper. Morton Kern, MD, served as Guest Editor for this paper.

ICE-Classification of Interatrial Septum Anatomy in Patients With R→L Shunt

Right-to-left (R-to-L) shunt caused by patent foramen ovale (PFO) is a dark field for interventionalists, particularly after the conflicting results from the most recent trials regarding PFO transcatheter closure. It seems that the confusing results (negative in the Closure I [Closure or Medical Therapy for Cryptogenic Stroke With Patent Foramen Ovale] trial [1] and slightly positive in the RESPECT [Randomized Evaluation of Recurrent Stroke Comparing PFO Closure to Established Current Standard of Care Treatment] and PC [Percutaneous Closure of Patent Foramen Ovale in Cryptogenic Embolism] [2,3] trials) might be related to patient selection, in particular anatomical inclusion/exclusion criteria and device choice. We tried to clarify the relationships of different anatomical subtypes and the association of anatomical characteristics of the interatrial septum with risk of recurrent paradoxical embolism and shunt grade.

We retrospectively reviewed the medical and instrumental data of 520 consecutive patients (mean age 44.0 ± 15. 5 years; 355 females) who had been referred to our center over a 10-year period (February 2003 to February 2013) for R-to-L shunt catheter-based closure. Inclusion criteria for percutaneous closure of PFO included the following: 1) a concurrent permanent or shower or curtain shunt pattern on transcranial Doppler with Valsalva maneuver; 2) positive (single or multiple ischemic foci) cerebral magnetic resonance imaging; 3) previous neurologically confirmed stroke or transient ischemic attack; and 4) moderate or large PFO on transesophageal echocardiography. The hospital ethical board approved the study, and written informed consent was obtained from all patients enrolled in the study.

In all patients, the attempt at transcatheter closure was preceded by a mechanical 9-F, 9-MHz, 360° scan probe (UltraICE, EP Technologies, Boston Scientific Corporation, San Jose, California) intracardiac echocardiography. This study was conducted in 2 projections, measuring diameters of the oval fossa, the entire atrial

Table 1. Distribution of Demographic, Clinical, and Functional Parameters Among the 4 Anatomical Subtypes

	Type 1 (n = 71 [13.7%])	Type 2 (n = 232 [44.6%])	Type 3 (n = 175 [33.6%])	Type 4 (n = 42 [8.1%])	p Value	Total (N = 520)
Age <45 yrs	54 (76.0)	135 (58.2)	102 (58.3)	21 (50.0)	<0.0001	312 (61.7)
Female	46 (64.8)	168 (72.4)	119 (68.0)	22 (55.5)	0.0752	355 (68.3)
Hypertension	24 (33.8)	90 (38.8)	36 (20.5)	6 (14.3)	<0.0001	156 (30.0)
CoA	23 (32.3)	58 (25.0)	66 (37.7)	14 (33.3)	0.0955	162 (31.1)
Curtain shunt	28 (39.4)	123 (53.0)	108 (61.7)	30 (71.4)	0.0068	289 (55.6)
Permanent shunt	25 (35.2)	117 (50.4)	138 (78.8)	21 (50.0)	<0.0001	301 (57.8)
Recurrent CIE	34 (47.8)	138 (59.4)	128 (73.1)	21 (50.0)	<0.0001	321 (61.7)
Multiple CIF RMi	30 (42.2)	121 (52.1)	118 (67.4)	28 (66.6)	<0.0001	297 (57.1)

Values are n (%).
CIE = cerebral ischemic event; CIF = cerebral ischemic foci; CoA = coagulation abnormalities (deficiency of anti-thrombin III, C, S, or factor V Leiden or homozygotic mutation methylenetetrahydrofolate reductase or antiphospholipid or anticardiolipin antibodies); RMi = resonance magnetic imaging.