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Original article

The role of integrated backscatter intravascular ultrasound in characterizing bare metal and drug-eluting stent restenotic neointima as compared to optical coherence tomography

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ABSTRACT

Background: To evaluate the role of integrated backscatter intravascular ultrasound (IB-IVUS) in assessing the morphology of neointima in bare-metal stent (BMS) and drug-eluting stent (DES) restenosis as compared to the gold-standard, optical coherence tomography (OCT).
Methods: A total of 120 cross-sections were evaluated by IB-IVUS and OCT at five cross-sections from 24 patients (24 lesions): at the minimal lumen area (MLA) and at 1 and 2 mm proximal and distal to the MLA site in 24 lesions (9 treated with DES and 15 treated with BMS). IB-IVUS and OCT findings were analyzed according to the time at which restenosis was identified (early <12 months and late ≥12 months) and the stent type.
Results: IB-IVUS was found to correctly characterize the neointima of both BMS and DES in-stent restenosis (ISR) as compared to OCT. The overall agreement between the pattern of ISR neointima by IB-IVUS and that by OCT was excellent (kappa = 0.85, 95% CI 0.76–0.94). Late DES ISR was characterized by more non-homogeneous, low backscatter and lipid-laden neointima, as compared to the BMS equivalent (BMS vs. DES, 45.0% vs. 80.0%, $p < 0.01$; 51.7% vs. 85.0%, $p = 0.008$; 33.3% vs. 65.0%, $p < 0.01$, respectively).
Conclusions: IB-IVUS assessment of the ISR neointima pattern appears to provide similar information as the gold-standard OCT in patients with stable angina. Both modalities suggested that late DES restenosis is characterized by a non-homogeneous lipid-laden neointima.

Introduction

Optical coherence tomography (OCT) and integrated backscatter intravascular ultrasound (IB-IVUS) can provide excellent tissue characterization of coronary plaque morphology [1,2]. In vivo OCT images can provide more detailed structural information of coronary atherosclerotic plaques as compared to conventional intravascular ultrasound (IVUS). Previous studies have demonstrated that the OCT findings regarding atherosclerotic plaque composition correlate well with those obtained from histological samples [2]. Attempts to characterize the coronary atherosclerotic plaque composition have also been made with other modalities including IB-IVUS [3,4]. A prior OCT study by our group has demonstrated that the differences in the neointima exist at different restenotic phases and between different stent types [5,6]. However, quantitative evaluation of the neointima morphology at early and late restenosis and according to stent type [bare-metal stent (BMS) vs. drug-eluting stent (DES)] has not been well characterized by IB-IVUS. The purpose of this study was to examine the role of IB-IVUS in characterizing the neointima of in-stent restenotic (ISR) segments according to the time at which the restenosis was identified

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(early <12 months or late phase ≥12 months) and the stent type and compare these findings to those obtained by the gold-standard OCT.

Methods

Study patients

The study population was recruited from a total of 194 patients with stable angina who were admitted to Fukuyama Cardiovascular Hospital from June 2009 to November 2011 for target lesion revascularization (TLR). Among them, 24 consecutive patients who subsequently underwent TLR using both IB-IVUS and OCT were enrolled in this study. All patients had ischemic symptoms or evidence of myocardial ischemia in the presence of ≥75% diameter stenosis at follow-up angiography. We excluded patients with acute coronary syndrome necessitating primary percutaneous intervention and stent edge restenosis. The study protocol was approved by the institutional ethics committee of Fukuyama Cardiovascular Hospital, and written consent was obtained from all patients prior to the procedure.

Gray-scale IVUS and IB-IVUS measurements

IB-IVUS and gray-scale IVUS examinations for ISR lesions were performed before any intervention and after the intracoronary administration of isosorbide dinitrate (1–2 mg). The transducer was advanced into the distal reference segment, and an imaging run was performed back through the stent to coronary ostium using a motorized transducer pullback (0.5 mm/s) system.

Gray-scale IVUS and ultrasound signals were acquired with a commercially available IVUS imaging system (VISIWAVE, Terumo, Tokyo, Japan) using a 43-MHz mechanically rotating IVUS catheter (View IT, Terumo). During the pullback, images were obtained at 30 frames/s. All IVUS imaging data were stored in the console. For offline analysis, digital copies of the IVUS images were saved on a CD-ROM. The data were quantitatively analyzed by two independent observers with two off-line computer-based software systems (VISIATLAS, Terumo). Tissue characterization of neointimal composition was achieved on IB-IVUS using VISIATLAS™. The excellent correlation of IB-IVUS and histology has been reported previously [7–11]. After tracing vessel area, lumen area, and stent area, grayscale IVUS images and IB-IVUS color-coded maps were displayed side-by-side on a monitor. A neointima was defined as the area between the lumen border and the inner border of the stent struts to avoid stent strut artifacts (Fig. 1A3). The images were analyzed by two observers who were blinded to the clinical and procedural characteristics. We applied the manufacturer's default settings on the basis of previous data [9,10,12] to define a range of IB values for neointimal tissue components. According to the signal level, the IB-IVUS analysis classified the color-coded tissue into

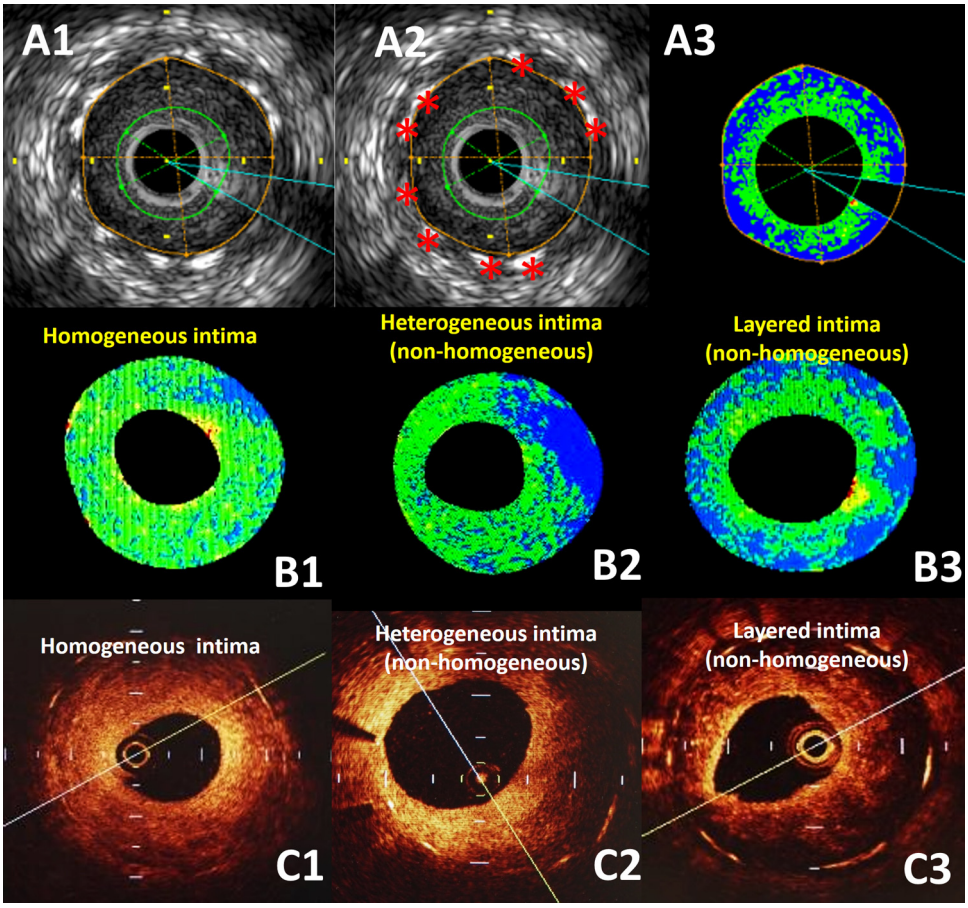

Fig. 1. Gray scale and integrated backscatter intravascular ultrasound (IB-IVUS) and optical coherence tomography (OCT) of in-stent neointima at the area of in-stent restenosis (ISR). (A) Neointima (A3) was defined as the area between the lumen border and the inner border of the stent struts (asterisk) to avoid stent strut artifacts. (B) IB-IVUS analysis: fibrous area (green), lipid area (blue), mixed area (yellow), and calcification (red). The pattern of neointima tissue component was classified into two groups: homogeneous pattern (B1) and non-homogeneous pattern (B2 and B3) according to neointima lipid distribution. (C) Pattern of ISR neointima as assessed by OCT. The pattern of neointima tissue component was classified into two groups: homogeneous pattern (C1) and non-homogeneous pattern (C2 and C3) according to neointima lipid distribution. Both the (B) and (C) images were obtained at the same cross-section. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)