Intravascular polarimetry in patients with coronary artery disease: a first-in-human pilot study

Authors:
K Otsuka¹, M Villiger¹, A Karanasos², LJC Van Zandvoort², P Doradla¹, J Daemen¹, R Diletti², RJ Van Geuns², F Zijlstra², G Van Soest², J Dijkstra³, SK Nadkarni¹, E Regar⁴, BE Bouma¹, ¹Massachusetts General Hospital, Wellman Center for Photomedicine - Boston - United States of America, ²Erasmus Medical Center, Department of Cardiology - Rotterdam - Netherlands (The), ³Leiden University Medical Centre - Leiden - Netherlands (The), ⁴University Hospital Zurich - Zurich - Switzerland,

Topic(s):
Imaging: Coronary Artery Disease

Citation:

Funding Acknowledgements:
The JSPS Overseas Research Fellowship, the Uehara Memorial Foundation, and the Japan Heart Foundation and Bayer Yakuhin

Background: Polarization-sensitive (PS-) optical frequency domain imaging (OFDI) measures polarization properties of tissue together with conventional cross-sectional OFDI images of subsurface microstructure. PS-OFDI offers refined insight into plaque morphology and composition, which are implicated in the pathogenesis of acute coronary syndromes (ACS).

Purpose: This first-in-human pilot study of intravascular polarimetry aimed to investigate birefringence and depolarization features of coronary plaques in patients and to examine the relationship of these features with established structural characteristics available to conventional OFDI and with clinical presentation.

Methods: 30 patients undergoing PS-OFDI (acute coronary syndrome; ACS, n=12 and stable angina pectoris; SAP, n=18) participated in this study. 342 cross-sectional images evenly distributed along all imaged coronary arteries were classified into one of seven plaque categories according to conventional OFDI. Polarization features averaged over the entire intimal area of each cross-section were compared between plaque types and with structural parameters. Further, we assessed the polarization properties in the fibrous caps of ACS and SAP culprit lesions and compared them with structural features using a generalized linear model.

Results: The median birefringence and depolarization showed statistically significant differences among plaque types (both p<0.001, one-way ANOVA). Depolarization significantly differed between individual plaque types (p<0.05), except between fibro-fatty and fibro-calcified plaques. Caps of ACS lesions and ruptured caps exhibited lower birefringence than caps of SAP lesions (p<0.01). In addition to clinical presentation, cap birefringence also associated with macrophage accumulation as assessed by normalized standard deviation.

Conclusions: Intravascular polarimetry provides quantitative metrics that help to characterize coronary arterial tissues and may offer refined insight into coronary arterial atherosclerotic lesions in patients (Figure). Quantitative assessment of plaque polarization properties by intravascular polarimetry may open new avenues for studying plaque progression and detecting high-risk patients.
Intravascular polarimetry in patients with coronary artery disease: a first-in-human pilot study

Authors: K Otsuka, M Villiger, A Karanasos, LJC Van Zandvoort, P Doradla, J Daemen, R Diletti, RJ Van Geuns, F Zijlstra, G Van Soest, J Dijkstra, SK Nadkarni, E Regar, BE Bouma

Massachusetts General Hospital, Wellman Center for Photomedicine - Boston - United States of America, Erasmus Medical Center, Department of Cardiology - Rotterdam - Netherlands (The), Leiden University Medical Centre - Leiden - Netherlands (The), University Hospital Zurich - Zurich - Switzerland

Topic(s): Imaging: Coronary Artery Disease

Background: Polarization-sensitive (PS-OFDI) measures polarization properties of tissue together with conventional cross-sectional OFDI images of subsurface microstructure. PS-OFDI offers refined insight into plaque morphology and composition, which are implicated in the pathogenesis of acute coronary syndromes (ACS).

Purpose: This first-in-human pilot study of intravascular polarimetry aimed to investigate birefringence and depolarization features of coronary plaques in patients and to examine the relationship of these features with established structural characteristics available to conventional OFDI and with clinical presentation.

Methods: 30 patients undergoing PS-OFDI (acute coronary syndrome; ACS, n=12 and stable angina pectoris; SAP, n=18) participated in this study. 342 cross-sectional images evenly distributed along all imaged coronary arteries were classified into one of seven plaque categories according to conventional OFDI. Polarization features averaged over the entire intimal area of each cross-section were compared between plaque types and with structural parameters. Further, we assessed the polarization properties in the fibrous caps of ACS and SAP culprit lesions and compared them with structural features using a generalized linear model.

Results: The median birefringence and depolarization showed statistically significant differences among plaque types (both p<0.001, one-way ANOVA). Depolarization significantly differed between individual plaque types (p<0.05), except between fibro-fatty and fibro-calcified plaques. Caps of ACS lesions and ruptured caps exhibited lower birefringence than caps of SAP lesions (p<0.01). In addition to clinical presentation, cap birefringence also associated with macrophage accumulation as assessed by normalized standard deviation.

Conclusions: Intravascular polarimetry provides quantitative metrics that help to characterize coronary arterial tissues and may offer refined insight into coronary arterial atherosclerotic lesions in patients (Figure). Quantitative assessment of plaque polarization properties by intravascular polarimetry may open new avenues for studying plaque progression and detecting high-risk patients.

In a less advanced stage of atherogenesis, birefringence and depolarization increase along with the proliferation of collagen, smooth muscle cells and lipid content (atherogenesis and progression). Birefringence of the plaques declines in hand with the reduction of interstitial collagen, and the development of the lipid/necrotic core, which in turn leads to a significant increase in depolarization, corresponding to the transition of pathological intimal thickening to a fibroatheroma (progression and destabilization). ACS = acute coronary syndrome, TCA = thin-capped fibroatheromas, and ThCFA = thick-capped fibroatheromas.