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Citation for published version (APA):

Giessen, van der, A. G., Gijzen, F. J. H., Wentzel, J. J., Mieghem, van, C. A. M., Steen, van der, A. F. W., Feyter, de, P. J., & Vosse, van de, F. N. (2005). *MSCT derived atherosclerotic plaque distribution in human coronary bifurcations*. Poster session presented at Mate Poster Award 2005 : 10th Annual Poster Contest.

Document status and date:

Published: 01/01/2005

Document Version:

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

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MSCT derived atherosclerotic plaque distribution in human coronary bifurcations

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Introduction

Although atherosclerosis is a systemic disease, the formation of plaques is favoured at low hemodynamic wall shear stress (ss) regions such as the outer wall of vessel bifurcations [1] (figure 1). High shear stress is thought to be atheroprotective, however angiography sometimes reveals lumen intruding plaques at the inner wall of bifurcations.

We hypothesize that plaque located at the high shear stress inner wall, extends from plaque at the outer wall, because observations have shown that plaques grow circumferentially [2].

Conventional angiography provides detailed information on the lumen of coronary arteries, but it cannot visualize plaque that does not protrude into the lumen. However, multislice computed tomography (MSCT) of the coronary arteries is an emerging technique, which permits non-invasive visualization of lumen and plaque (figure 2, 3).

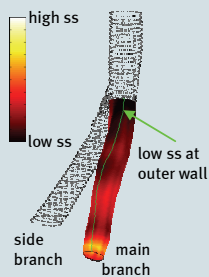


Figure 1 Low shear stress profiles at main branch outer wall of a bifurcation.

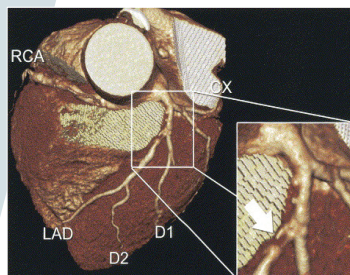


Figure 2 A volume rendered MSCT-image showing a significant stenosis (arrow) in the left ascending artery (LAD) [3].

Aim of the study

Demonstrate by MSCT that plaque at the inner wall of a coronary bifurcation is the result of plaque growth from the outer wall.

Methods

Patients

Patients who underwent MSCT coronary angiography prior to PCI and had at least one significant (>50% lumen occlusion) bifurcation lesion and a non-significant bifurcation stenosis are included in the study.

Patients are scanned with a 64-slice MSCT scanner (Sensation 64, Siemens, resolution: 0.49 x 0.49 x 0.49 mm), while injected with contrast. Images are reconstructed during mid- to end-diastolic phase using ECG-gating.

Measurements

In each patient a significant and non-significant bifurcation lesions are analyzed in longitudinal and cross-sectional views. Guided by contours around the lumen, plaque location, dimensions and area, lumen diameter and area are measured at plaque and reference locations in main branch (MB) and side branch (SB).

Results

A selection of measurements in a significant bifurcation lesion of a first patient are presented in figure 3.

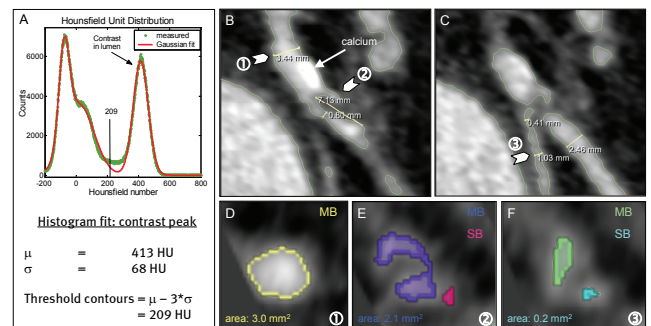


Figure 3 A: Based on fitting of the Hounsfield Unit (HU) distribution, contours are drawn in the MSCT images at 209 HU for guidance of the measurements. B: MB reference and minimal lumen diameter and plaque length. C: SB reference and minimal lumen diameter and distal MB reference. D-F: Cross-sections at locations 1-3, with lumen area.

Discussion

MSCT is a promising technique for the evaluation of lumen and plaque in the coronary arteries [3]. Bifurcation lesions in 30 patients will be analyzed.

Different tissues have overlapping attenuation values (figure 3A). This, besides limited spatial and temporal resolution, complicates assignment of the different Hounsfield Units (HU) to lumen, plaque and epicardial fat. Calcium in plaques is larger depicted by MSCT, which easily causes overestimation of plaque dimensions.

Future Work

- Segmentation of lumen and wall to reconstruct 3D geometry, and to generate a mesh for computational fluid dynamics (CFD).
- Association between CFD-derived parameters and plaque characteristics will be studied to investigate the influence of hemodynamic parameters on plaque growth and rupture.

References:

- [1] Malek AM et al. *JAMA* 1999; 282 (21):2035-2042
- [2] Glagov S et al. *Hum Atheroscl Cor Dis* 1987; 316 (22):1371-1375
- [3] Mollet NR et al. *J Am Coll Cardiol* 2005; 45: 128-132