Computer-aided Diagnosis Scheme for Detecting Significant Stenosis on Whole Heart Coronary MR Angiography Based on Signal Intensity and Luminal Diameter

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Target audience
Scientists and clinicians who aim to expand the use of coronary magnetic resonance angiography (MRA) for non-invasive diagnosis of coronary artery disease

Purpose
Identification of significant coronary artery stenoses on whole-heart coronary MRA remains observer dependent. The purpose of this study was to develop a computer-aided diagnosis (CAD) scheme for detection of coronary artery stenoses on MRA images.

Methods
Whole-heart coronary MRA images were retrospectively analyzed in 34 patients with suspected coronary artery disease. Free-breathing coronary MRA was acquired by using 32-channel cardiac coils (16 patients with 1.5 T and 18 patients with 3.0 T systems). All patients underwent X-ray coronary angiography and luminal diameter reduction of >=50% was defined as significant. In our CAD scheme, coronary arteries were enhanced by using a 3-D top-hat transformation and were then segmented by a region-growing technique analyzing the signal intensity. Based on the curvatures and the lengths from orifices and bifurcations of the major coronary arteries, the segmented arteries were classified according to the American Heart Association (AHA) model. The signal intensity at each voxel of centerline of the segmented artery was defined by the maximum signal intensity within a circle with a radius of 3 voxels centered at the voxel in the original MRA image. While tracing the centerline, we evaluated alterations in the signal intensity as well as the luminal diameter. At each voxel on the centerline, a classifier based on the Mahalanobis distance for the changes of signal intensity and luminal diameter was finally employed for distinguishing between arteries with and without stenosis. The classifiers were defined in RCA, LMT+LAD, and LCX.

Results
Significant stenosis was observed in 70 vessels on X-ray angiography. Figure 1 shows the relationship between the changes of signal intensity and luminal diameter in RCA, LMT+LAD, and LCX on coronary MRA. Both the signal intensity and the luminal diameter analyzed by CAD demonstrated apparent reduction in the vessels with significant stenosis on X-ray angiography. The CAD scheme correctly worked for both 1.5T and 3.0T coronary MRA, with the overall sensitivity and specificity of 80% and 81% by vessel-based analysis (81% and 75% for 1.5T; 79% and 85% for 3.0T). The sensitivity and specificity assessed in each major coronary artery were 81% and 92% for RCA, 89% and 83% for LMT+LAD, and 67% and 69% for LCX, respectively. Figure 2 shows an example of automated identification of coronary artery tree according to AHA segmentation, with small circle indicating the position of significant stenosis identified by the CAD.

Discussion
With our CAD scheme, RCA, LMT and LAD were correctly identified and adequately segmented in all subjects. Segmentation of LCX was more difficult due to reduced signal to noise ratios on whole heart coronary MRA in LCX territories.

Conclusion
Our CAD scheme achieved high sensitivities and specificity in detecting significant stenosis on whole heart coronary MRA, and will have a substantial impact on interpretation of coronary MRA.

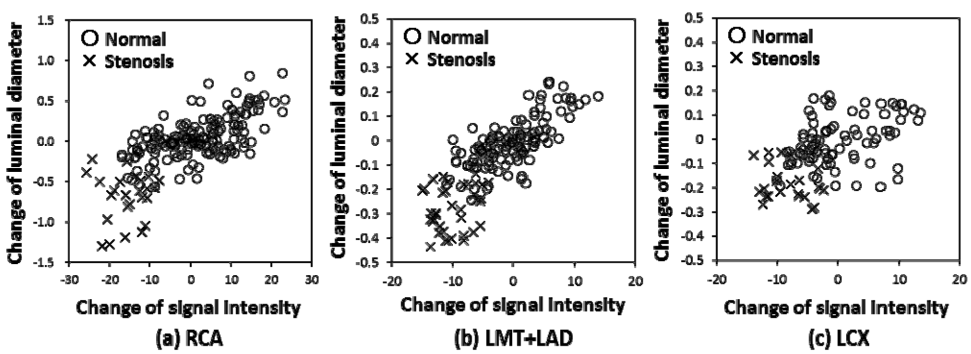

Figure 1: Relationship between the change of signal intensity and that of luminal diameter

Figure 2: Example of identification result for AHA classifications and detection result by our CAD scheme