

Fusion and combined evaluation of 3D-CMR-perfusion with 3D-MR-coronary angiography

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Introduction

Myocardial perfusion and the status of the coronary arteries are the two major parameters for the characterization of coronary artery disease (CAD) and for guiding therapeutical interventions. It has been shown that hybrid imaging strategies to acquire both parameters such as SPECT with CT-angiography provide an added value for clinical decision making in the treatment of CAD[1]. Thus the 2014 ESC Guidelines for the first time recommend hybrid imaging for planning myocardial revascularization[2]. However, SPECT and CT expose the patient to ionizing radiation and, in large prospective trials, SPECT showed inferior sensitivity to detect CAD when compared with CMR-perfusion[3]. Therefore, the aim of this study was to investigate the feasibility and potential added value of MR-based hybrid imaging by the combined assessment and fusion of 3D-MR coronary angiography (MRCA) with a 3D-CMR perfusion sequence.

Methods

Eleven patients with suspected CAD (see Table 1 for patient characteristics) had an invasive X-ray coronary angiography (XA) and underwent a CMR examination including a stress-rest 3D-CMR perfusion (Saturation-recovery GRE sequence: TR=1.8 ms, TE=0.7 ms, FA=15°, sat.-prepulse delay= 150 ms, FOV = 350x350 mm², voxel size = 2.3 x 2.3 x 10 mm³, reconstructed to 2.3 x 2.3 x 5 mm³, slices 16) with partial Fourier acquisition and k-t-undersampling, MRCA (T2-prep 3D GRE, reconstructed voxel size: 0.75 x 0.75 x 0.75 mm³) and late gadolinium enhancement (LGE) examination. Perfusion scans were obtained under adenosine stress (140 µg/kg/min for 6 min; 0.075mmol/kg Gd-DTPA) and at rest. All examinations were performed on a 3T clinical scanner. In XA, coronary stenosis ≥50% was classified as significant. In the 3D-CMR perfusion scans, the myocardial ischemic burden (MIB) was measured by determining hypoperfused areas which were not scar tissue as determined from LGE images and normalized to left-ventricular myocardial volume (MIB,%)[4]. MIB>4% was considered significant ischemia. MRCA scans were evaluated by an experienced reader and each vessel was graded as no/low-grade stenosis or significant stenosis. Additional 3D reconstruction and fusion of 3D-MRCA and 3D-CMR-perfusion was performed.

Results

All MIB data and 91% of the vessels in the MRCA could be evaluated successfully. CAD prevalence as defined by XA was 73% (8 of 11 patients, 16 of 33 vessels). In a vessel-based analysis, MRCA had 75% sensitivity, 79% specificity, positive predictive value of 80%, and negative predictive value of 73%. CMR-MIB/LGE measurements had 75% sensitivity, 100% specificity, positive predictive value of 100%, and negative predictive value of 81%. The combined evaluation of MRCA with CMR-MIB/LGE resulted in 94% sensitivity, 82% specificity, positive predictive value of 83%, and negative predictive value of 93% (Fig.1 A-C). Additional fusion of MRCA with CMR-perfusion allowed to display the coronary anatomy in relation to perfusion deficits in different myocardial layers (Fig. 1 D-E).

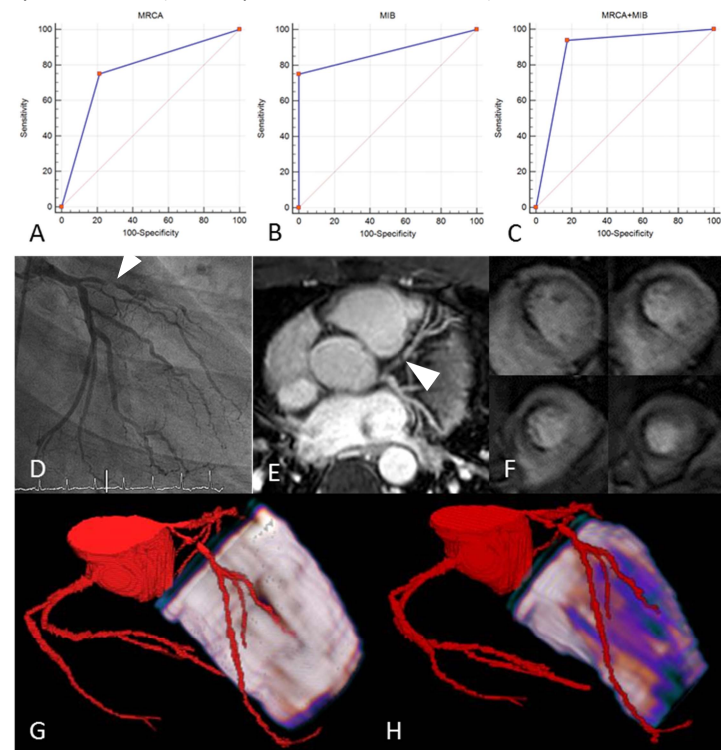


Figure 1: ROC-Curves of MRCA (A), CMR-perfusion (B) and the combined evaluation (C). In an exemplary patient X-ray coronary angiography (D) and MRCA (E) reveal a high grade LAD stenosis (white arrows). 3D fusion of MRCA with CMR-perfusion shows no distinct perfusion deficit in the epicardial layer (G) but large subendocardial ischemia in the LAD territory (H) which can also be seen in the 3D-CMR perfusion raw data (F).

Patients (m/f)	11 (11/0)
age [years]	59 ± 14
range	32 - 79
BMI [kg/m ²]	28 ± 5
EF [%]	64 ± 7
Heart rate [1/min]	67 ± 9
Risk factors	
Hypertension	6/11
Hypercholesterolemia	7/11
Diabetes	2/11
Smoking	5/11
Positive family history	3/11
CAD in the CathLab	
3-vessel-disease	3/11
2-vessel-disease	2/11
1-vessel-disease	3/11
no CAD	3/11

Table 1 Patient characteristics (mean ± SD)

CMR-MIB/LGE measurements had 75% sensitivity, 100% specificity, positive predictive value of 100%, and negative predictive value of 81%. The combined evaluation of MRCA with CMR-MIB/LGE resulted in 94% sensitivity, 82% specificity, positive predictive value of 83%, and negative predictive value of 93% (Fig.1 A-C). Additional fusion of MRCA with CMR-perfusion allowed to display the coronary anatomy in relation to perfusion deficits in different myocardial layers (Fig. 1 D-E).

Discussion

In previous trials the combined determination of anatomical and functional data obtained with MSCT and MRI proved to provide complementary information for the assessment of CAD[5]. In our study functional and anatomical information was obtained in a single MR examination and the feasibility of 3D reconstruction and fusion of both examinations as well as the visualization of different myocardial layers could be shown. Combined evaluation of 3D-MRCA with 3D-CMR perfusion had superior sensitivity at the cost of a loss in specificity when compared to CMR-MIB/LGE alone in a vessel-based approach. The additional fusion of both modalities can provide information on the position of the coronary arteries to correlate coronary stenoses with non-distinct perfusion deficits. The interpretation of this study must consider the limitation that a relatively small number of patients was studied which allowed only for vessel-based analyses. However the results stress the need for further studies to investigate the prognostic value of “hybrid”-CMR.

References

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