Voxelwise analysis of myocardial blood flow from DCE-MRI data

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Purpose:

Absolute quantification of myocardial perfusion is commonly based on a region-of-interest (ROI) analysis [1] in order to achieve a sufficient signal to noise ratio (SNR). With the availability of 3 Tesla scanners, dynamic contrast enhanced (DCE) MRI can be acquired with higher SNR compared to 1.5 T.
Thus, it was the goal if this study to calculate voxelwise myocardial perfusion maps from 3T DCE-MRI data.

Materials and Methods:

Cardiac first-pass perfusion examinations were performed on 9 healthy volunteers and one patient with acute myocardial infarction using an ECG triggered, SR prepared SSFP-sequence (TR=2.8ms, TE=1.4ms, GRAPPA R=3, α=50°, spatial resolution: 1.8x2.1x10mm^3) on a 3T scanner (Siemens MAGNETOM Trio). For absolute quantification of myocardial perfusion a prebolus technique [2] was used with standard boli (1cc/4cc contrast agent, flow: 4cc/s, followed by a flush of NaCl).
Additional proton weighted images were used for surface coil sensitivity correction. Subsequently, a fully automatic, unsupervised non-rigid image registration was performed inline on the scanner to correct for cardiac motion [3].
During postprocessing myocardial perfusion was quantified in every voxel and compared to the values obtained from ROI based analysis. Specifically, voxelwise perfusion values were averaged for each ROI and compared to the values obtained from ROI based analysis using a Bland-Altman analysis [4].
To estimate the error of measurement the standard deviation of the perfusion values of each slice was calculated in the healthy volunteers for all myocardial voxel and the eight ROIs, respectively.

Results:

Mean perfusion values of ROI based analysis of the volunteers was 0.80 ± 0.27 cc/g/min (mean ± s.d.). Averaged values of the maps were 0.83 ± 0.23 cc/g/min. Bland-Altman analysis of the two techniques delivered a mean difference of -0.03 cc/g/min and an interval of confidence ranging from -0.62 cc/g/min to 0.55 cc/g/min.
The mean standard deviation per slice was 0.19 cc/g/min in ROI based analysis and 0.21 cc/g/min in voxelwise analysis. Figure 1 shows the quantitative perfusion map (middle) of the patient suffering from an extensive perfusion defect in the lateral wall. The visible hypoperfused area corresponds well with one late measurement of DCE-MRI (left) series and a delayed gadolinium enhancement image (right). Figure 2 shows the comparison of the values of the slice shown in figure 1. Voxelwise values were averaged over the ROIs and the error bars show the standard deviation in the ROI.

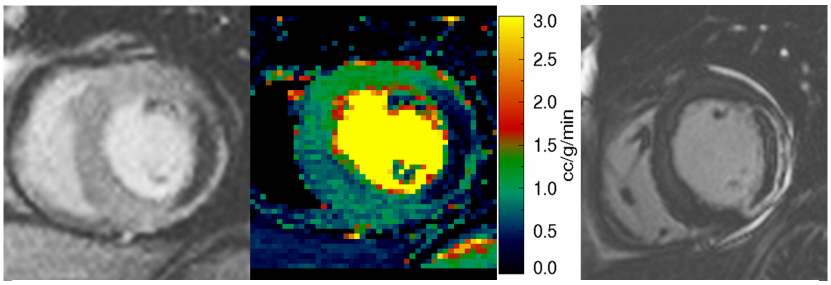

Figure 1. One midventricular timeframe of DCE-MRI series (left), corresponding MBF map (middle) and delayed gadolinium enhancement with an expansive no- reflow zone of the lateral wall (right).

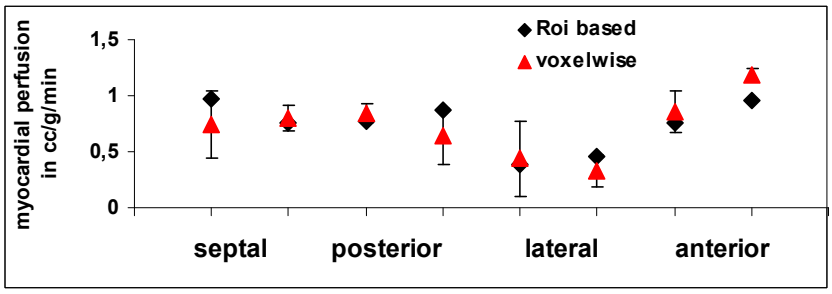

Figure 2. Comparison of ROI based and voxelwise values of the slice shown in figure 1.

Discussion:

The higher SNR provided at 3T combined with automatic image registration allows the quantification of myocardial perfusion in every voxel of the myocardium. Volunteer results show good agreement between ROI based and voxelwise analysis and provide comparable values to DCE-MRI obtained perfusion values at 1.5T [6]. The absolute quantitative map of the patient clearly shows the perfusion defect also revealed by delayed gadolinium enhancement imaging.

Conclusion:

Quantitative voxelwise analysis of myocardial perfusion from DCE-MRI is feasible and may provide deeper insight into regional myocardial perfusion.

References:

[1] Jerosch-Herold et al., JMRI (2004), 19:758-770 [2] Köstler et al., Magn Reson Med (2004), 52:296:299; [3] Chefd'hotel et al., Proc ISBI (2002), 753-756; [4] Bland and Altman, Stat Methods Med Res (1999), 8:135-160; [5] Sourbon et al., Proc ISMRM (2011), 1336; [6] Pack et al., Magn Reson Med, (2010), 64:125-137