Fast and Automatic Quantification of Cardiac Perfusion MRI

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Introduction

Up to now myocardial perfusion MRI examinations are mostly evaluated visually, because of the very time consuming postprocessing for quantitative evaluation. Thus, it was the goal of this study to evaluate an automatic quantification of cardiac perfusion MRI.

Methods

75 datasets including 37 patients (25 after revasculated infarctions, 12 after radiation therapy in the treatment of Hodgkin's disease) and 38 healthy volunteers were evaluated. 18 examinations were performed under adenosine induced stress. Perfusion series were acquired in a 1.5T scanner (Siemens) using an ECG-gated saturation recovery true-FISP sequence with the following parameters: Repetition time: 2.5 ms - 2.6 ms, echo time: 1.1 ms, inversion time: 108 ms – 110 ms, flip angle: 48° - 50°, field of view: 340 mm – 360 mm, slice thickness = 8mm. The contrast agent (CA) bolus was tracked by acquisition of 40 consecutive images over 40 heartbeats. All images were reconstructed to a 256 x 256 matrix.

For quantification of myocardial blood flow the prebolus technique [1] with 1ml / 4 ml Gd-based CA was applied.

The series were automatically motion corrected using the algorithm based on the technique proposed Adluru et al. [2]. This algorithm circumvents the problem of varying contrast by calculating a model image for each single original image. The original images were registered to the corresponding model images by minimizing the mean square difference between original and model through rigid transformation. This process was performed iteratively.

The motion corrected images were segmented automatically using the software Developer Life (Definiens, Munich, Germany). One segmentation template for 8 myocardial sectors and two ROIs in the ventricles was determined and was applied to all motion corrected images. These signal intensity time courses have been evaluated using baseline- and contamination correction [3].

For comparison all datasets were segmented manually to obtain the signal intensity time courses from 8 sectors in the myocardium and from the blood pools. The signal intensity time courses were evaluated the same way as the automatically obtained signal intensity time courses.

For investigation of the interobserver variability 10 representative datasets were manually evaluated by two different observers.

Results

Manual evaluation of a single slice typically lasted 25 minutes for image-segmentation and the subsequent quantification of myocardial blood flow. In contrast the user-interaction time for the automatic algorithm was below one minute. The values for myocardial perfusion were 0.91 ± 0.59 ml/g/min for manual and 0.89 ± 0.63 ml/g/min for automatic evaluation. The variability of the two methods (calculated as the standard deviation of the differences) was 0.34 ml/g/min. A Bland-Altman-test showed a mean difference of 0.02 ml/g/min and a confidence interval from -0.64 ml/g/min to 0.61 ml/g/min. Figure 1 shows the comparison of the two evaluations in a Bland-Altman-Plot for all 1760 myocardial sectors. The black dashed line shows the mean difference of the two methods (0.02 ml/g/min). The upper (lower) red dashed line marks the upper (lower) boarder of the 95%-confidence interval: 0.68 ml/g/min (-0.64 ml/g/min). In the Interobserver variability study perfusion values obtained by observer1 were 1.06 ± 0.69 ml/g/min and 1.01 ± 0.68 ml/g/min by observer2. The interobserver variability was 0.35 ml/g/min.

Figure 1.

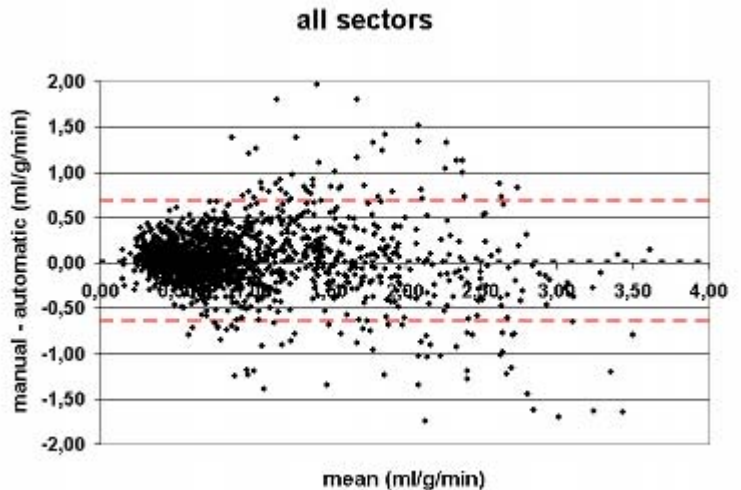Bland-Altman-Plot of quantitative myocardial perfusion values obtained by automatic and manual evaluation.

Conclusion

It was possible to evaluate all datasets with the proposed algorithm. The quality of the results matches the one from manual evaluation. The fact that image segmentation is performed completely automatic makes this technique less user dependent.

By reducing the user interaction time automatic postprocessing may allow the quantification of myocardial perfusion from MR first pass perfusion studies in clinical routine in future.

References

[1] Köstler et al, MRM, 2004, 52: 296 - 299
[2] Adluru et al, JMRI, 2006, 24: 1062-1070
[3] Köstler et al, MRM, 2004; 51: 848 - 852