

Comparison of phase and magnitude images using PSIR sequence in the study of infarct size with delayed-enhancement cardiac magnetic resonance imaging at 3 Tesla

A. Lalande^{1,2}, A. Cochet², P. M. Walker^{1,2}, C. Boichot², Y. Cottin³, J-E. Wolf³, and F. Brunotte^{1,2}

¹Groupe Imagerie Médicale, LE2I (CNRS UMR 5158), Dijon, France, ²Service de Spectroscopie-RMN, CHU Dijon, Dijon, France, ³Service de Cardiologie, CHU Dijon, Dijon, France

Introduction

Delayed-Enhancement Cardiac Magnetic Resonance (DE-CMR) imaging with a gadolinium-based contrast agent strongly correlates with infarct size [1] and is a major tool for the assessment of myocardial viability [2]. A phase-sensitive inversion-recovery (PSIR) technique has been described at 1.5 T for assessment of myocardial infarct size [3]. With this technique, the signal polarity of the inversion recovery DE image is restored by using phase information provided by a reference image. The aim of the present study was to evaluate on a 3.0 T system the performance of the phase and magnitude images generated by the PSIR sequence for the determination of myocardial infarct size in DE-CMR imaging. The magnitude image acquired with an appropriate TI is equivalent to the conventional Turbo FLASH sequence [4].

Materials and methods

The study population consisted of 27 patients (18 men, 9 women, 60 ± 15 years, range: 35 to 89 years) with a history of myocardial infarction. In our protocol conceived for myocardial viability, DE-CMR short axis images were acquired on a 3 T whole body imager (Trio TIM, Siemens Medical Solutions, Germany) ten minutes after an injection of gadolinium-diethylenetriamine pentaacetic acid (Magnevist, Schering-AG, Berlin, Germany) using a phased-array thoracic coil. A breath-hold segmented T1-weighted PSIR sequence was used with the following parameters: TR = 3.5 ms, TE = 1.42 ms, $\alpha = 20^\circ$, matrix = 175×256 , FOV = 240×350 mm². TI was adjusted between 400 ms and 500 ms in order to obtain an optimal myocardial nulling in the magnitude images. Two images were generated per slice, one representing the phase component and the other magnitude. On each image, the healthy myocardium and hyperenhanced area (if present) were manually drawn by two independent observers. No-reflow zones characterized by a persistent hypoenhanced area even on delayed images were included in the extent of infarction. The left ventricle and the hyperenhanced area volumes were calculated as the sum of surfaces determined on each slice multiplied by the slice gap. The ratios of hyperenhanced myocardium obtained from magnitude and phase images were compared, as was the inter-observer variability for each method. The coefficient of correlation (r), the equation of the regression line and the associated p-value were reported. The concordance between methods for the assessment of extent of hyperenhancement was performed using the Bland-Altman method [5]. The signal to noise ratio and the contrast to noise ratio were also measured.

Results

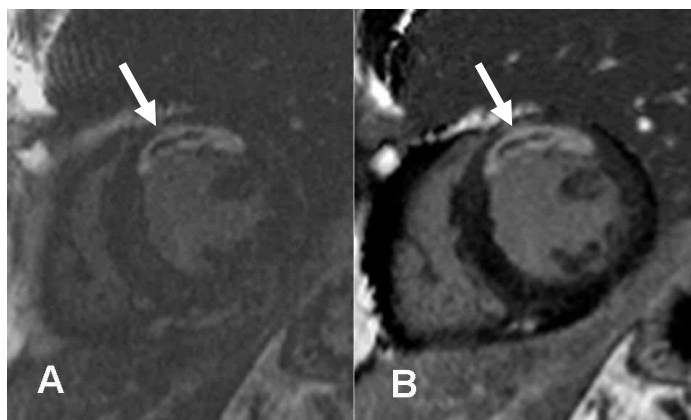
The mean (\pm SD) percentage of hyperenhanced myocardium was 25 ± 16 (respectively 29 ± 17) with the magnitude (respectively phase) images. There is an excellent correlation between the two approaches ($r = 0.97$; $y = 1.02x + 3.68$; $p < 10^{-3}$). The corresponding Bland-Altman study shows an excellent concordance between the two methods (standard deviation of the differences equal to 4.5), but there is a slight overestimation of hyperenhanced myocardium with phase images, compared with magnitude images (mean of the differences equal to 4.1 by choosing the magnitude image as the reference image). There are excellent inter-observer correlations with magnitude images ($r = 0.97$; $y = 0.9x + 1.51$; $p < 10^{-3}$) and phase images ($r = 0.98$; $y = 0.89x + 0.87$; $p < 10^{-3}$). The mean signal to noise ratio of hyperenhanced myocardium was significantly higher with phase images compared with magnitude images (63 ± 20 vs 12 ± 5 , $p < 10^{-3}$). The mean contrast to noise ratio between hyperenhanced and normal myocardium was significantly higher with phase images compared to magnitude images (11 ± 5 vs 6 ± 5 , $p < 10^{-3}$).

Conclusions

DE-CMR imaging with phase sensitive reconstruction at 3.0 T provides similar results to magnitude images in the calculation of the infarct size, with a significantly greater CNR between infarcted and normal myocardium. This improvement could partially compensate the sensitivity of the inversion pulse sequence to higher B₁ field heterogeneities at 3.0 T.

References

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Magnitude (A) and phase (B) short-axis images of a patient with anterior myocardial infarction showing a hyperenhanced zone surrounding a persistent hypoenhancement (“no-reflow” phenomenon).