Effect of iron oxides on tag MRI at 1.5T in a rat myocardial infarct model

J-L. Daire[1], J-N. Hyacinthe[1], K. Montet-Abou[1], J-P. Jacob[1], D. Morel[2], J-P. Vallée[1], and X. Montet[1]

[1]Radiology, Geneva University Hospital, Geneva, Switzerland, [2]Anesthsiology, Pharmacology and Intensive Care in Surgery, Geneva University Hospital, Geneva, Switzerland

Introduction: With the development of molecular imaging, iron oxides based contrast agents are becoming a real alternative to gadolinium chelates. Iron oxides have been used to delineate myocardial infarct[1], to follow stem cell therapy[2] or graft rejection[3] or to target neo-angiogenesis[4]. One advantage of iron oxides particles is their long life time by comparison to Gd. However, high concentrations of iron oxides could interfere with image quality in particular with tag preparation compromising strains analysis. Therefore, the aim of this study was to determine if myocardial function assessment by tag MRI is still feasible after iron oxides injection.

Materials and methods: Sprague Dawley rats (n=5) were used in this study. The left anterior descending coronary artery was occluded for 30 min and reperfused. Iron oxide nanoparticles (10 mg/kg) were injected after reperfusion. Tagged MR images were obtained by using a 1.5T MR scanner (Philips, Best, The Netherlands) and a C-SPAMM tag preparation segmented cine fast field echo sequence, TR/TE 7.8/3.6 ms, tag spacing 1.25 mm, acquired voxel size 0.63x1.79x3 mm, FA 10°. Tagged MR images were analysed with ETC (Extrema Temporal Chaining)[5]. GRE-FFE images (TE/TR 7/350ms, acquired voxel size 0.3x0.3x2 mm FA 50°) were performed for iron oxide particles detection. Classical Hematoxilin and Eosine was realized, as well as Masson staining (fibrosis) and Prussian Blue (iron).

Results: All images were of good quality and were analyzed. Myocardial infarction appeared hypointense in all cases (figure 1 and 4) and correlated well with histology (figure 2). Ejection fraction was measured as 55% ± 14%. All tagged images were successfully analysed with ETC without any automatic tag tracking problem. The signal in line (myocardial bright lines) was found lower in iron area but the persistence and relative tag contrast ((line-tag)/line) was similar in infarcted or remote area (figure 5). The regions appearing hypointense on the GRE FFE sequences showed a clear diminution of the heart contractility by circumferential strains analysis ($p<0.01$)(figure 3). The hypointense region correlated well with the infarcted myocardium at histology.

Conclusion: This paper demonstrates that despite very low signal intensity in the infarcted myocardium after iron oxide nanoparticles injection, tag acquisition can be realized and that automatic tracking can be realized. The hypointense region (corresponding to the infarct in histology) showed a significant contraction defect in all cases. Nevertheless, the hypointensity does not preclude realizing tag analysis.

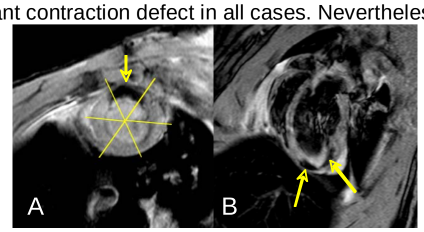

Figure 1: GRE FFE sequence in axial (A) and coronal oblique (B) plane showing accumulation of the iron oxide nanoparticles in the antero-lateral wall of the left ventricle (arrows). The yellow line in (A) represent the delimitation of the sector used for tag analysis (figure 3).

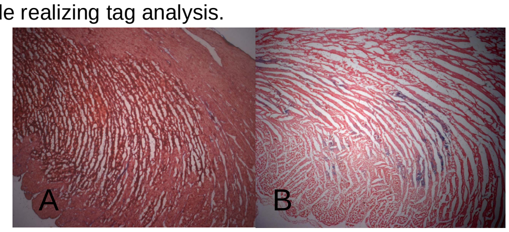

Figure 2: Masson staining (A) proves the presence of myocardial infarction without fibrosis. Prussian blue staining (B) proves the presence of iron in this region

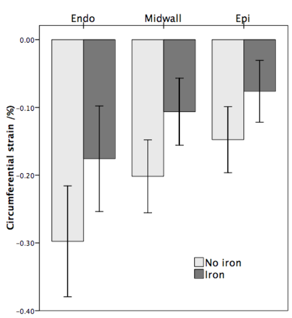

Figure 3: Circumferential shortening at endocardial, midwall and epicardial levels. The myocardial areas exhibiting hyposignal on GRE-FFE sequence have a significant decrease of circumferential shortening in comparison to the remote myocardium ($p<0.01$).

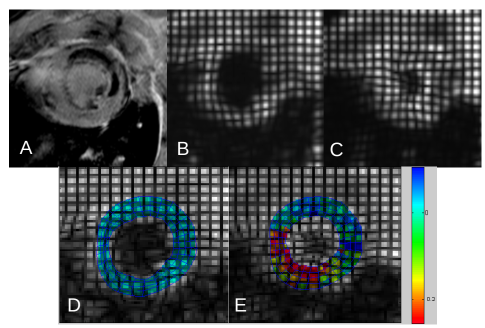

Figure 4: Example of MR images: Presence of iron in antero-lateral sector (A), tagged images at diastolic and systolic phases (B and C) and circumferential strain maps for this phases (D and E, blue: low circumferential shortening; red: maximum shortening)

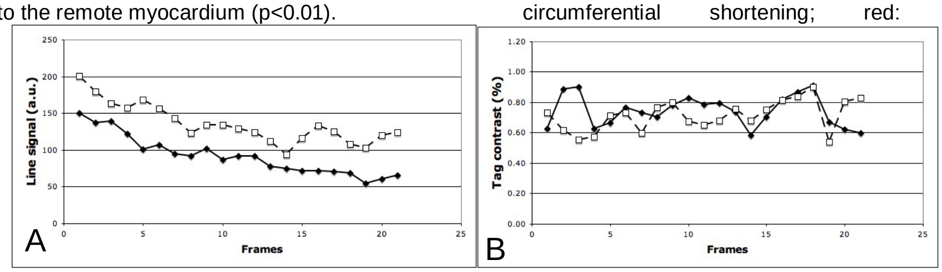

Figure 5: example of signal within the lines (A) and relative tag contrast (B) in region with iron accumulation (black) and in remote (white)

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