Border sharpness of scar tissue after myocardial infarction as determined by self-navigated free-breathing isotropic 3D whole-heart inversion recovery magnetic resonance

Tobias Rutz1*, Giulia Ginami2, Davide Piccini2,3, Jérôme Chaptinel2,4, Simone Coppo2,4, Gabriella Vincenti1, Matthias Stuber2,4, Juerg Schwitter1

From 19th Annual SCMR Scientific Sessions
Los Angeles, CA, USA. 27-30 January 2016

Background
The border zone of myocardial scar after myocardial infarction (MI) plays an important role for arrhythmia formation. For this reason, high-resolution 3D information of scar tissue for planning of electrophysiological interventions after MI is highly desirable. This study evaluates sharpness of the borders (SB) of scar after MI by a self-navigated isotropic 3D free-breathing whole-heart magnetic resonance with inversion recovery (3DSN-IR) in comparison to a standard 2D inversion recovery sequence.

Methods
Patients after MI detected by 2D late gadolinium enhancement (2D LGE) on a standard 2D inversion recovery sequence (resolution 1.3 mm², 8 mm slice thickness) underwent 3DSN-IR on a 1.5T cardiac magnetic resonance scanner (MAGNETOM Aera, Siemens). Data acquisition was performed during the most quiescent systolic phase with a prototype 3D radial trajectory with self-navigation [1] after administration of 0.2 mmol/kg of Gadobutrol. A non-selective IR pulse was added prior to each acquired k-space segment to the segmented, ECG-triggered, fat-saturated radial SSFP imaging sequence with an isovolumetric resolution of 1.15 mm³. Inversion time was assessed with a 2D radial scout scan prior to 3DSN-IR. To determine SB, a customized software was used to calculate signal intensity gradients between two regions [2]. SB in mm⁻¹ of borders “blood pool to scar”, “blood pool to non-infarcted myocardium” and “scar to non-infarcted myocardium” were compared between a 2D LGE short-axis slice with 8 mm slice thickness and two corresponding reconstructed 3DSN-IR short-axis slices, one with isovolumetric voxel size (1.15 mm³) and the second interpolated to 8 mm slice thickness, all at the same anatomical location.

Results
Thirteen patients (5 females, 58 ± 10 y, time between 2D LGE and 3D LGE 59 ± 64 days) were included. All scars visualized by 2D LGE could be identified by 3DSN-IR. SB was significantly better in 3DSN-IR compared to 2D LGE for the borders “blood pool to non-infarcted myocardium” and “scar to non-infarcted myocardium”. There was a trend to a better SB for 3DSN-IR images for the border “blood pool to scar” (see table and figure).

Conclusions
High resolution 3DSN-IR improves delineation of myocardial scar after MI as expressed by increased border sharpness in comparison to 2D LGE.

Authors’ details
1Division of Cardiology and Cardiac MR Center, University Hospital of Lausanne, Lausanne, Switzerland. 2Center for Biomedical Imaging (CIBM) & Center for Cardiovascular Magnetic Resonance Research (CVMR), University of Lausanne, Lausanne, Switzerland. 3Advanced Clinical Imaging Technology, Siemens Healthcare IM BM PI, Lausanne, Switzerland. 4Department of Radiology, University Hospital and University of Lausanne, Lausanne, Switzerland.

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Table 1 Border sharpness of 2D LGE and 3DSN-IR images. Border sharpness of “blood pool to non-infarcted myocardium”, “blood pool to scar” and “non-infarcted myocardium to scar” in mm⁻¹. Data are mean ± standard deviation or range (interquartile) where appropriate.

|                          | 2D LGE  | 3DSN-IR isovolumetric voxel (1.15 mm) | 3DSN-IR 8 mm slice thickness | p       |
|--------------------------|---------|---------------------------------------|-----------------------------|---------|
| Blood pool - non-infarcted myocardium | 0.029 (0.022, 0.058)* | 0.067 (0.04, 0.095) | 0.071 (0.051, 0.10) | 0.037   |
| Blood pool - scar        | 0.083 ± 0.056 | 0.121 ± 0.070 | 0.124 ± 0.070 | 0.176   |
| Scar - non-infarcted myocardium | 0.079 ± 0.034† | 0.171 ± 0.086 | 0.172 ± 0.074 | <0.001  |

* p = 0.011 2D LGE to 3DSN-IR 8 mm slice thickness, † p < 0.006 2D LGE vs. 3DSN-IR isovolumetric voxel and 3DSN-IR 8 mm slice thickness

Figure 1 Analyses of sharpness of the borders “blood pool to non-infarcted myocardium”, “blood pool to scar” and “scar to non-infarcted myocardium” for 2D LGE short-axis slices (resolution 1.3 mm², slice thickness 8 mm) and the two respective reconstructed 3DSN-IR short-axis slices, one slice with isovolumetric resolution of 1.15 mm³ (3DSN-IR isovolumetric) and a second slice interpolated to 8 mm slice thickness (3DSN-IR 8 mm slice).

Published: 27 January 2016

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doi:10.1186/1532-429X-18-S1-P74

Cite this article as: Rutz et al. Border sharpness of scar tissue after myocardial infarction as determined by self-navigated free-breathing isotropic 3D whole-heart inversion recovery magnetic resonance. *Journal of Cardiovascular Magnetic Resonance* 2016 18(Suppl 1):P74.