MR Guided Percutaneous Intramyocardial Injection of Contrast Medium Solution to Infarct Borders after Delineation of the Infarct with High Molecular Contrast Media: Measurement of T1 Values

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Introduction

Molecular interventions, targeted at the myocardium in order to initialize angioneogenesis or to increase the amount of contractile myocytes, have recently been introduced and are already used in patients. The substances are injected directly into the myocardium in order to reach high local concentrations and to minimize systemic side-effects. Injections have been performed during bypass-surgery. However, a catheter-based approach can render this new therapy available for a broader range of patients and would allow for repeated interventions. For this purpose, MRI guidance is advantageous over fluoroscopy, since MRI provides for delineation of the myocardium and ischemically injured regions. Accordingly, the aim of this study was to develop a protocol for catheter-based MRI-guided intramyocardial injection of Gd-DTPA-BMA to target regions at the border of infarcted myocardium and to trace the distribution of the injected fluid.

Methods

In 12 pigs reperfused myocardial infarction was induced by occluding the left anterior coronary artery for 45 minutes using a balloon-catheter. Two hours after reperfusion MRI was started at a 1.5 T closed bore system (Intera, Philips, Best, The Netherlands). In order to delineate the infarcted myocardium, in 7 animals SHU555A (Schering, Berlin, Germany)—a small particle of iron oxide (SPIO)—was injected intravenously, at a dose of 1.4 ml. In the remaining 5 animals MS325, a gadolinium-containing blood pool contrast medium was intravenously injected to delineate the infarct. T1 values of ischemically injured and remote myocardium were measured with the Look-Locker technique. As soon as sufficient contrast between both regions was achieved, a 0.1 mmol/ml Gd-DTPA-BMA solution, mixed with blue dye for tissue staining, was injected intramyocardially at two regions on the border of the infarct. For real-time image guidance, a radial steady-state free-precession sequence with a frame rate of 15/sec was applied (TR 2.5 ms, TE 1.2 ms, 45° flip angle, 80 radials, 8 mm slice thickness, matrix 128 x 128, FOV 320 x 320 mm², sliding window reconstruction). A 3 mm long stainless steal needle, mounted on a 5 F catheter (Cook, Denmark), was repeatedly guided from a carotid artery sheath into the left ventricle and inserted into the myocardium. 2 ml of Gd-DTPA-BMA (Omniscan, Amersham Bucheler, Braunschweig, Germany) were injected at concentrations of 0.1 or 0.4 mmol/ml.
After the interventions were finished, the hearts were excised and stained with 2,3,5-triphenyltetrazolium chloride (TTC), to delineate the infarct.

Results

In all animals with MI, injection of SHU 555A caused a significant decrease of the T1 value of the infarct (778 ± 63 ms before, and 641 ± 67 ms 2 h after injection of SHU 555A). The contrast between the infarct and remote myocardium was sufficient for delineating the infarct on real-time images (T1 remote myocardium 2 h after injection: 702 ± 19 ms). After the intravenous injection of MS 325 the T1-value of the ischemically injured myocardium rapidly decreased.
In all animals, the catheter could be directed into the border region of the infarct. Two intramyocardial injections were performed at different locations. Injection sites, infarct region, and remote myocardium, could clearly be differentiated over the course of the observation period.

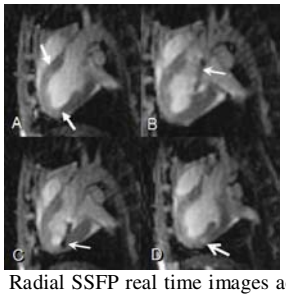

Figure 1: Radial SSFP real time images acquired in a long axis view of LV. After intravenous injection of SHU 555 A, the infarct was hyperenhanced and could clearly be distinguished from remote myocardium (top, left, arrows). The catheter could be guided and inserted in the myocardium at the border of the infarct (top right and bottom left, arrows). After intramyocardial injection of the Gd-DTPA-BMA solution, there was an area of high signal intensity visible at the injection site on real time images (bottom right, open arrow).

Discussion

The technique described here may be used for the minimally invasive delivery of substances, such as gene-constructs, to the myocardium. If a high molecular contrast medium is intravenously injected, the infarct can stably be delineated over the course of the intervention. By using extracellular contrast medium as tracer, intramyocardial injection sites remain visible for a sufficient long period of time, so that repeated injections into the same region with consecutive local overdosing during an intervention with multiple injections can be avoided.

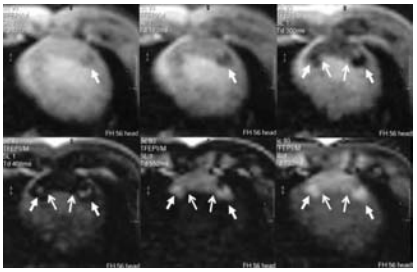

Figure 2: Selected Look-Locker Images. After intra-venous injection of SHU 555A, the T1 value of the infarcted tissue was significantly decreased (open arrows). Gd-DTPA-BMA could be intramyocardially injected at two locations on the border of the infarct (closed arrows).