In vivo monitoring of radiofrequency thermal lesions in porcine livers: comparison of an extracellular and a SPIO contrast agent

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Introduction: Radiofrequency ablation of primary and secondary malignant liver lesions is a clinically well established supplementary method to surgical resection (1). Follow-up images are essential for control of complete or incomplete ablation and tumor recurrence. Magnetic resonance imaging (MRI) with its high soft tissue contrast and lack of radiation is a good method for follow-up. Aim of the study was to compare an extracellular and a small particle iron oxide (SPIO) contrast agent regarding monitoring of radiofrequency thermal lesions (RFLs) in porcine livers.

Methods: RF application was performed in twelve pigs (24 lesions) using the Starburst XL™ device (RITA Medical Systems, Mountain View, CA, USA) deployed to an ablation diameter of 3 cm. The generator (Model 1500™) is capable of a maximum power output of 150W. Follow-up MRI in a 1.5T whole body unit (ACS-NT Gyroscan, Philips, Medical Systems, Best, The Netherlands) was performed after 1 day, 2 and 4 weeks: transverse T2-weighted (w) ultra turbo spin-echo (UTSE) sequence (TE 90 ms, TR 2000 ms, NSA 4, matrix 256 x 256, section thickness 7 mm, gap 0.7 mm, FOV 350 mm), proton density-(PD) w sequence (TE 40 ms, TR 1666 ms, NSA 3, matrix 256 x 512, section thickness 7 mm, gap 0.7 mm, FOV 350 mm), T1-w fast field-echo sequence (FFE) (TE 4,6 ms, TR 165 ms, NSA 1, flip angle 60°, matrix 256 x 256, section thickness 7 mm, gap 0.7 mm, FOV 350 mm), and dynamic T1-w FFE sequence (TE 4,6 ms, TR 7,9 ms, NSA 1, flip angle 25°, matrix 256 x 256, section thickness 7 mm, gap 0,7 mm, FOV 350 mm, acquisition time 16 sec per volume of 24 slices). Dynamic images were acquired prior to, during, and for approximately 5 minutes following rapid bolus injection of Gd-DTPA (0.1 mmol Gd/kg, Magnevist®, Schering AG, Berlin, Germany) or SPIO (756 mg ferumoxide, Resovist®, Schering AG, Berlin, Germany). T1-w FFE sequence was repeated after Gd-DTPA administration and T2-w UTSE and PD-w sequences were repeated after SPIO administration. Signal intensities of the (uninvolved) liver, the RFLs, and the background (noise) were measured. The signal-to-noise ratios (SNRs) for uninvolved liver and RFLs and the liver-to-lesion contrast-to-noise ratios (CNRs) were calculated (2).

Results: RFLs sometimes revealed a zonal structure with a ring-like peripheral zone and a central core (Fig. 1b). Hemorrhage was present in many RFLs and improved the liver-to-lesion CNR in T1-w images (Fig. 1a). An hyperintense rim of edema surrounded the RFLs in some pigs and improved the liver-to-lesion CNRs in T2- and PD-w images (Fig. 1c). Without hemorrhage or edema, the precontrast sequences showed low liver-to-RFL CNRs. T1-w FFE images after Gd-DTPA administration demonstrated the highest liver-to-RFL CNRs (means: 11.6/15.6/12.7; ± SDs: 2.7/2.9/2.4) and the best RFL SNRs (38.7/29.8/29.6; SDs: 4.8/4.6/4.1) after 1 day (Fig. 1a), 2 and 4 weeks, respectively. T1-w FFE images after SPIO administration showed comparable high RFL SNRs (34.3/27.2/25.7; SDs: 4.5/3.2/2.6) but significantly lower liver-to-RFL CNRs (6.5/3.7/4.3; SDs: 2.9/1.6/1.1). T2-w UTSE (-6.5/-6.0/-5.6; SDs: 1.8/1.5/2.5) and PD-w (-9.5/-7.4/-5.4; SDs: 1.7/1.6/1.5) images after SPIO administration (Fig. 1b, c) and dynamic T1-w FFE images 2 minutes after Gd-DTPA administration (6.2/3.9/6.5; SDs: 1.2/0.6/0.9) also demonstrated high negative or high positive liver-to-RFL CNRs.

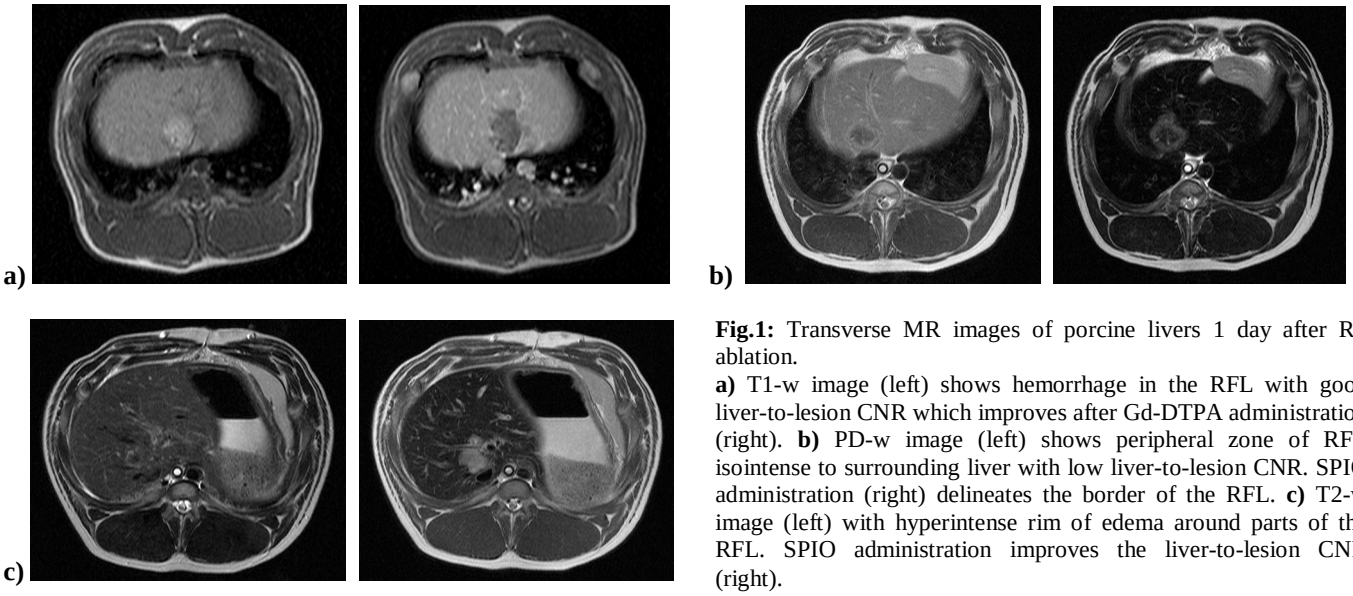

Fig.1: Transverse MR images of porcine livers 1 day after RF ablation.
a) T1-w image (left) shows hemorrhage in the RFL with good liver-to-lesion CNR which improves after Gd-DTPA administration (right). **b)** PD-w image (left) shows peripheral zone of RFL isointense to surrounding liver with low liver-to-lesion CNR. SPIO administration (right) delineates the border of the RFL. **c)** T2-w image (left) with hyperintense rim of edema around parts of the RFL. SPIO administration improves the liver-to-lesion CNR (right).

Conclusions: In case of hemorrhage within the RFLs or an hyperintense rim of edema around the RFLs, T1, T2 and PD-w sequences demonstrate good liver-to-lesion CNRs. Otherwise, unenhanced sequences show low liver-to-lesion CNRs. The use of Gd-DTPA or SPIO contrast agent improves the CNRs and SNRs of RFLs in porcine livers. Dynamic sequences with Gd-DTPA or SPIO contrast agent do not improve the CNRs or SNRs of RFLs compared to postcontrast images. The SPIO contrast agent is not superior to Gd-DTPA.

References: 1. Burdio F. et al. Radiology 2003, 229: 447-456. 2. Aschoff A.J. et al. JMRI 2001, 13: 57-63.