MR-guided Radiofrequency Ablation of Hepatocellular Carcinoma: Long-term Clinical Effectiveness

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Introduction

Image-guided radiofrequency (RF) ablation has gained increased attention as minimal invasive therapy option in the treatment of hepatocellular carcinoma (HCC). Image guidance should ensure a precise ablation therapy leading to a complete coagulation of the tumor tissue with a safety margin without injury of critical structures. Therefore, the capabilities of the imaging technique during the ablation procedure have an important impact on the accuracy and efficacy of image guided RF ablation [1]. Interventional MR-systems can fulfill all capabilities for guidance of RF ablation [2-3]

Purpose

To evaluate technique effectiveness and long-term clinical efficiency of magnetic resonance (MR)-guided RF ablation of HCC.

Materials and Methods:

In 20 patients (female: 3; male: 17) 28 HCCs (mean diameter: 28.0 mm; range: 6 – 58 mm) were treated with 25 sessions of MR-guided RF ablation. The entire ablation procedure was performed at an interventional 0.2-Tesla MR-system (Concerto, Siemens Medical Solutions, Germany). During the placement of the RF electrode, fast gradient echo sequences (TR/TE: 45ms/13ms) were applied. These facultative multiplanar images had an acquisition time of 2.2 seconds. Subsequent to confirmation of a correct applicator placement (**Figure 1**), RF energy was applied by using MR-compatible internally cooled single or cluster electrodes. T2-weighted sequences (TR/TE: 3500ms/110ms) were used to monitor therapy effects during a procedure and to guide repositioning of the RF electrode if necessary (**Figure 2**). Repositioning of the RF electrode was performed until T2-weighted imaging indicated coverage of the target tissue. Therapeutic assessment was based on high-field (1.5-Tesla) dynamic MR-imaging (Magnetom Sonata, Siemens Medical Solutions) at a mean follow-up of 24.2 months (6 – 52 months).

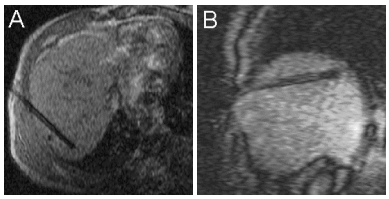

Figure 1: Verification of the applicator position below the diaphragm. The images show an oblique transversal (**A**) and oblique coronar plane (**B**) along the RF electrode by using T1-weighted spoiled [FLASH] gradient echo sequences under breath-hold.

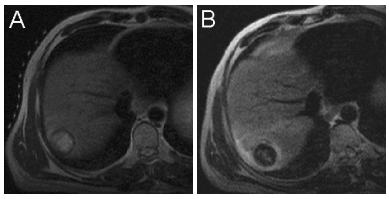

Figure 2: T2-weighted turbo spin echo sequence before (**A**) and after (**B**) application of RF energy. The HCC shows a hyperintense signal before ablation therapy. In contrast, the zone of coagulation is characterized by a decrease of signal on T2-weighted images.

Results:

MR-guided RF ablation was technical successful in 25/25 (100%) assessed at the end of each session. T2-weighted sequences were accurate to near-online monitor the extent of coagulation and were supportive to guide overlapping ablation if necessary. Technique effectiveness, defined as complete coagulation evidenced at MR-imaging within four months after RF ablation, was achieved in 27/28 (96.4%) HCCs (**Figure 3**). To achieve complete coagulation 25/27 (92.6%) tumors were treated in a single session and two tumors were treated twice. In three tumors 3/27 (11.1%), initially defined as technique effective RF ablation, a local tumor progression was detected more than four months after ablation procedure. Two of these local tumor recurrences were successfully treated by an additional session RF ablation. Consequently, the available follow-up indicated complete coagulation in 26/28 (92.9%) HCCs. There were 1/25 (4.0%) major complication (bowel perforation) and 1/25 (4.0%) minor complication (intrahepatic haematoma). Heterotopic hepatic or extrahepatic tumor progression was detected in 11/20 (55.0%) patients. Disease-free were 9/20 (45.0%) patients during a mean follow-up of 28.8 months in these patients.

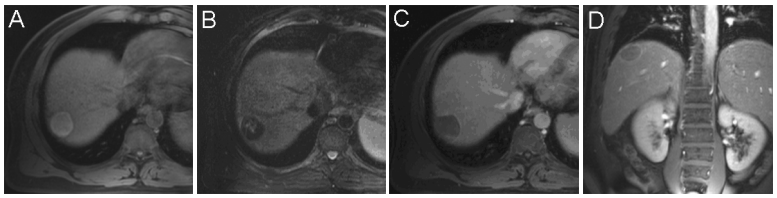

Figure 3: Images show a complete coagulation of HCC four months after RF ablation. On native T1-weighted images the induced coagulation is hyperintense (**A**). On T2-weighted images the zone of coagulation is hypointense (**B**). Contrast enhanced T1-weighted images show an ablation zone without enhancement (**C** + **D**).

Conclusion:

MR-guided RF ablation is a safe and effective therapy in the treatment of HCC. MR imaging offers an accurate monitoring of thermally induced coagulation. Consequently, overlapping ablations have to be adjusted to the actual size and shape of the individual zones of coagulations. MR imaging can fulfill the conditions for precise overlapping ablation and complete tumor coagulation in a single session.

References:

1. Goldberg SN, Grassi CJ, Cardella JF, et al. Image-guided tumor ablation: standardization of terminology and reporting criteria. Radiology 2005;235:728-739.

2. Lewin JS, Connell CF, Duerk JL, et al. Interactive MRI-guided radiofrequency interstitial thermal ablation of abdominal tumors: clinical trial for evaluation of safety and feasibility. Magn Reson Imaging 1998;8:40-47.

3. Clasen S, Boss A, Schmidt D, et al. MR-guided radiofrequency ablation in a 0.2-T open MR system: technical success and technique effectiveness in 100 liver tumors. J Magn Reson Imaging 2007;26:1043-1052.