Experimental MR-guided cryoablation of the bone

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Introduction

Percutaneous treatment of circumscribed bone lesions is rare. In cases like osteoidosteomas, percutaneous bore drilling and additional injection of alcohol (1) under fluoroscopy or CT control is an alternative to surgery. In limited metastatic disease, percutaneous alcohol injection is recommended by some authors (2). The main disadvantages of this procedure, however, are poor visualization of the alcohol during injection and poor predictability of the therapeutic success. MR-guided cryotherapy does not have this limitation and offers a good predictability of lesion size in organs like prostate (3), liver (4), and brain (5). Thus, the purpose of this study was to develop and evaluate the feasibility of MR-guided percutaneous cryotherapy of the bone and to correlate the results with MR follow-up and histology.

Methods

In 7 pigs (mean body weight 50 kg), a 4 mm bore hole was drilled into the left distal femur metaphysis under combined MR and fluoroscopy control by use of a custom made nonferromagnetic drilling system in a dedicated 1.5 Tesla system (ACS NT, Philips) and a flexible surface coil. Using an over-the-wire-technique, a liquid nitrogen supplied glass-built cryoprobe with an outer diameter of 2.7 mm was inserted via a 9F introducer sheeth into the bore hole.

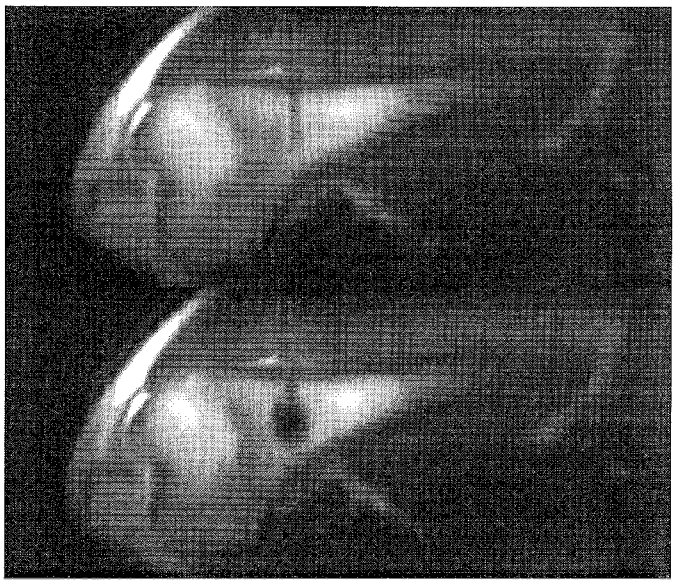

Fig A T2-weighted LoLo sequence. Coronal view of the inactive (above) and active probe (below) within the bone marrow.

Three "freeze-thaw" cycles with a duration of 3 minutes each were performed under MR control using a ultrafast high resolution T2-weighted LoLo TSE (TR/TE=800/77, scan duration 440 ms) sequence and a T1-weighted gradient echo sequence (TR/TE/FA = 16/6/20°, inversion time 100 ms, scan duration 4 sec). MR follow-up was performed immediately, 7 and 14 days after the intervention by T2-TSE, pre/post contrast T1-SE (0.1 mmol/kg bw gadopentetate dimeglumine) and T1-SE sequences with fat saturation. After 14 days, the animals were sacrificed, the femura resected, decalcified and HE-stained for histological examination.

Results

The ice was spherically shaped and well delineated in both sequences. The mean diameter of the iceball was 13.2 mm, the mean volume was 1.1 ml during the 3rd freezing cycle. There were no statistically significant differences in the maximum diameter of the iceball as imaged by the LoLo or the gradient echo sequence sequence. The difference in contrast between ice and bone marrow (expressed in percent to signal intensity of bone marrow =100%) was higher using the LoLo (mean 91% ±6%SD) than using the gradient echo sequence (84% ±10%SD). On follow-up examinations, the lesions were spherically shaped,hyperintense on T2-TSE and surrounded by a hypointense rim.

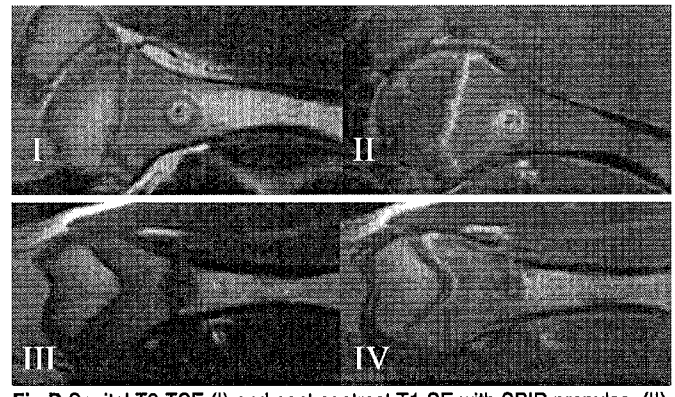

Fig.B Sagital T2-TSE (I) and post contrast T1-SE with SPIR prepulse. (II). Coronal pre- (II) and post-contrast T1-SE (IV). Spherically, sharply delineated necrosis. Contrast-enhancing rim surrounding the avascular center.

This transition zone was contrast enhancing on post contrast images. The mean volume of cryotherapy-induced necrosis 14 days after freezing on MR-follow-up was in good correlation to the iceball volume as seen during freezing. There was no statistically significant difference in lesion size as imaged by T2-TSE, post-contrast T1-SE and T1-SPIR. Histologically, the cryolesions consisted of coagulation necrosis with preserved but avital cellular architecture of the bone marrow, surrounded by a layer of granulation tissue and a transition zone of bone marrow edema.

Conclusion

MR-guided percutaneous cryotherapy of the bone is possible and permits a good predictability of the lesion size. By combining MR imaging and percutaneously performed cryotherapy, detection of lesions, therapy planning, monitoring and follow-up of different lesions of the bone marrow seems to be possible also clinically.

References

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