Purpose: To investigate if MRI of the liver can be used for in-vivo dose verification in proton therapy. Recently it was shown that irradiated healthy liver tissue shows a strong systematic decrease in uptake of a hepatobiliary-directed contrast agent (Gd-EOB-DTPA) six weeks after brachytherapy. In this study it is investigated, if the radiation-related effect is also detectable for hypo-fractionated proton therapy.

Methods: For patients who receive liver lesion directed hypo-fractionated proton therapy (5 fractions within 2 weeks) Gd-EOB-DTPA enhanced MRI is performed 10-12 weeks after treatment. MR images are registered to the planning CT and the planned dose map by non-rigid image registration. The reviewer contours the border of hypointensity on T1-w images that indicates the hepatocyte function loss. The threshold dose for this function loss is evaluated as the D90, the dose achieved in at least 90% of the pseudolesion volume. Moreover, irradiated-to-non-irradiated liver contrast and the correlation of detected signal change in MRI with the planned dose map are analyzed.

Results: Gd-EOB-DTPA enhanced T1-w MR images taken after hypo-fractionated proton therapy show a hypo-intense area that is correlated to the area of high dose deposition in shape and volume with small deviations in location (up to 5-6 mm) giving information on the actual distal edge position. With Gd-EOB-DTPA enhanced MRI, irradiated-to-non-irradiated contrast is superior to MRI enhanced with extracellular, nonspecific contrast agents used in a previous study.

Conclusions: A biomarker for radiation induced changes in liver tissue was identified and promising post-treatment MRI data have been acquired and are currently evaluated. For the next step, a pilot patient study has been set up to investigate, if radiation-induced changes using Gd-EOB-DTPA enhanced MRI can be detected prospectively during fractionated proton therapy and therefore would allow for an immediate assessment of the proton therapy with direct impact on patient safety.

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