

Value of diffusion-weighted MR imaging as an early surrogate parameter for the response of colorectal metastases to interstitial ¹⁹²Ir-High-dose-rate brachytherapy

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Introduction:

Image guided single fraction high dose rate ¹⁹²Ir-High-dose-rate (HDR) brachytherapy is a high precision percutaneous ablation technique that has been shown to yield promising results with regards to safety and efficacy in the treatment of irresectable liver metastases [1]. Goal of this study was to investigate the value of changes of the apparent diffusion coefficient (ADC) as an early surrogate parameter for the response of colorectal metastases following CT- and MRI-guided HDR brachytherapy. Diffusion-weighted imaging (DWI) is an imaging method to supply information of water proton mobility, which can be employed to assess the microstructural organization of tissue [2]. Preclinical and clinical studies revealed DWI to represent a sensitive biomarker for the early detection of cellular changes in treated tumors, which closely correlated with macroscopic volumetric responses [3].

Material and methods:

We evaluated 40 colorectal liver metastases in 30 patients treated with CT- and MR-guided HDR brachytherapy. Pre- and post interventional imaging included fat saturated T2w FSE and Gd-EOB-DTPA enhanced T1w GRE sequences for the evaluation of tumor morphology as well as diffusion-weighted echoplanar (EPI-DWI) sequences. Imaging was performed in median 1 day before (baseline MRI) as well as 2 (early MRI) and 90 days (follow-up MRI) after ablation. Tumor diameter (TD) and ADC were evaluated independently by two experienced radiologists. Changes of TD and ADC on follow-up were assessed with use of the Wilcoxon test, the relationship of TD and ADC with the Pearson correlation coefficient. A p value of 0.05 was considered statistically significant.

Results:

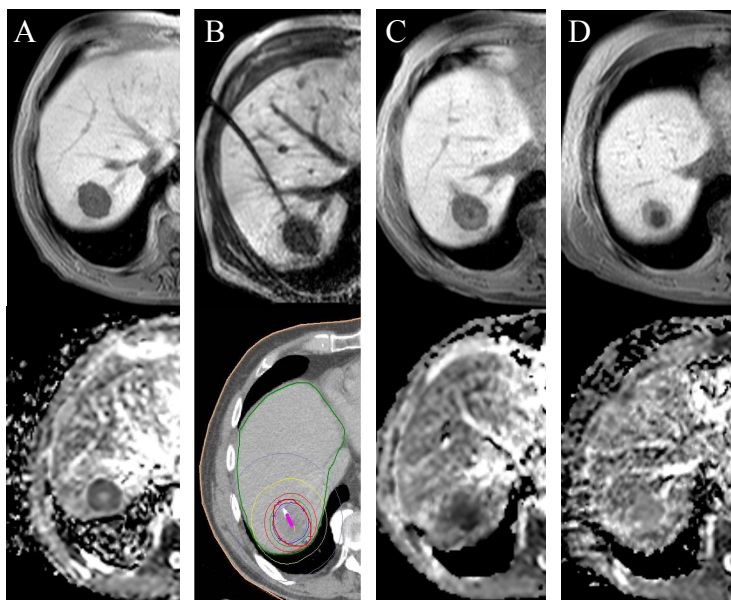
Tumor response in treated lesions was 100% with no local progression being noted within the follow-up interval. Mean TD and ADC at baseline MRI were 38±25 mm as well as $1.78 \pm 0.46 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$. On early MRI, mean TD was 39±26 mm, which resembled an increase by 1±2 mm (p=0,012). At the same time mean ADC decreased significantly by $-0.09 \pm 0.13 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$ to $1.60 \pm 0.42 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$ (p<0,001). On follow-up MRI, a decrease in mean TD of -8±10 mm to 30±21 mm was noted (p<0,001), while mean ADC increased by $0.27 \pm 0.32 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$ to $2.22 \pm 0.51 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$ (p<0,001). The Pearson correlation coefficient of changes in TD and ADC was -0,565.

Conclusions:

Changes in ADC can be assessed as soon as 2 days following interstitial ¹⁹²Ir-HDR brachytherapy. This early decrease most likely reflected therapy induced cell swelling, while late increase was the result of apoptotic cell death and reduced tumor cell density.

References:

1. Ricke J, Wust P, Wieners G, Hengst S, Pech M, Lopez Hänninen E, Felix R. CT-guided interstitial single-fraction brachytherapy of lung tumors: phase I results of a novel technique. *Chest* (2005) 127:2237-42
2. Koh DM, Collins DJ. Diffusion-weighted MRI in the body: applications and challenges in oncology. *AJR Am J Roentgenol.* 2007 188:1622-35
3. Ross BD, Moffat BA, Lawrence TS, Mukherji SK, Gebarski SS, Quint DJ, Johnson TD, Junck L, Robertson PL, Muraszko KM, Dong Q, Meyer CR, Bland PH, McConville P, Geng H, Rehemtulla A, Chenevert TL. Evaluation of cancer therapy using diffusion magnetic resonance imaging. *Mol Cancer Ther.* 2003 Jun;2(6):581-7



A: Gd-EOB-DTPA enhanced T1w GRE image prior to HDR brachytherapy displays a liver metastasis in segment 7 with a diameter of 31 mm (top) and a mean ADC of $1.32 \pm 0.9 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$ (bottom).
B: A single applicator is positioned percutaneously by MR-guidance within the lesion (top). HDR brachytherapy dose planning is performed by means of computed tomography data (bottom; red circle indicates 20 Gy isodose).
C: Early Gd-EOB-DTPA enhanced T1w GRE image obtained 3 days after HDR brachytherapy reveals a tumor diameter of 32 mm (top), while mean ADC decreases to $1.07 \pm 0.6 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$ (bottom).
D: Follow-up Gd-EOB-DTPA enhanced T1w GRE image after 90 days shows a shrinkage of tumor diameter to 22 mm (top), which correlates with an increase to $2.21 \pm 1.5 \times 10^{-3} \text{ mm}^2 \text{ s}^{-1}$ of mean ADC (bottom).