Correlation of Intravoxel Incoherent Motion with Dynamic Contrast Enhanced MRI Derived Parameters in Neck Nodal Metastases

Y. Lu[1], J. F. Jansen[2], H. E. Stambuk[1], Y. Tehrani-Mazaheri[1], N. Lee[1], J. A. Koutcher[1], and A. Shukla-Dave[1]
[1]Memorial Sloan-Kettering Cancer Center, New York, NY, United States, [2]Maastricht University Medical Center, Maastricht, Netherlands

Introduction

Intravoxel Incoherent Motion (IVIM)- and Dynamic Contrast Enhanced (DCE)- MRI are two promising techniques to investigate tumor blood microcirculation, but with different physical mechanisms and interpretation of derived parameters [1-2]. IVIM-MRI technique measures both the water molecular diffusion and perfusion in the capillary network noninvasively without contrast agent injection. DCE-MRI measures a combination of tumor perfusion and vessel permeability by using dynamic sequential images with contrast agent injection. Both IVIM- and DCE -MRI are related to blood perfusion. The ability to detect diverse aspects of angiogenesis and angiogenesis-related processes makes in vivo MR imaging attractive for following the entire time course of drugs' anti-angiogenic activity in head and neck cancers [3]. Clinically, IVIM- and DCE-MRI can be applied before, during, and after anti-angiogenic treatment to monitor response. In this pilot study, correlation of quantitative parameters derived from IVIM- and DCE- MRI techniques was performed in neck nodal metastases for their potential use in monitoring therapeutic efficacy.

Methods

Image acquisition: Thirteen patients with neck nodal metastases were enrolled in this retrospective study approved by local institutional review board (age: 44-67 years, M/F: 10/3, primary cancer: 1 oropharynx, 9 tonsil, 3 nasopharynx). All patients underwent pretreatment IVIM- and DCE-MRI on a GE 1.5T Excite scanner with an 8-channel neurovascular phased-array coil, using identical spatial settings. For both techniques, the entire metastatic neck lymph node was covered and the acquisition parameters that were kept the same were: field of view = 20-26mm, slices= 4-6, thickness = 4-8mm. IVIM-MRI was acquired prior to DCE MRI. A single-shot echo planar imaging (SSEPI) spin echo sequence was used for diffusion weighted imaging with b values (b=0, 10, 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 300, 500, 700, 900, 1100, 1300, 1500 s/mm^2), TR = 3000 ms, TE= minimum, NEX=4, matrix=128 x 128. For DCE-MRI, proton density images were acquired initially using spin echo pulse sequence. A 2D multi-phase spoiled gradient echo sequence was then used for fast contrast enhanced T1 weighted imaging. The contrast of Gd-DTPA was delivered at a bolus of 0.1 mmol/kg and 2 cc/s, followed by saline flush, TR = 7.8 ms, TE=1.9 ms, temporal resolution = 3.75-7.5 seconds, phases = 40-60, NEX=1, matrix=256 x 128.

Image analysis: The IVIM- and DCE- MRI images were registered using an image registration algorithm based on B-spline free form deformation method [4]. DWI images with b=0 images and T1W contrast images were first aligned using rigid registration separately, and then DWI images with b=0 images were co-registered with T1w contrast images using non-rigid registration. Quantitative IVIM-MRI analysis was performed using the two compartment model [2] ($S/S_0=(1-f)\exp(-bD)+f\exp(-bD^*)$) with the derived parameters of ADC-apparent diffusion coefficient, f-vascular fraction, D-pure diffusion coefficient and D*-pseudo-diffusion coefficient. The generalized kinetic model [1] was used for quantitative DCE-MRI analysis and calculated parameters such as K^{trans} (volume transfer constant), v_e (extravascular extracellular space volume fraction) and v_p(blood plasma volume fraction). ROI was drawn on each metastatic neck node (see Fig.1) by an experienced neuroradiologist. For each parameter, ROIs were analyzed and summarized using mean over the ROIs. The Spearman correlation coefficient (ρ) and the linear regression analysis were performed between parameters derived from IVIM- and DCE- MRI.

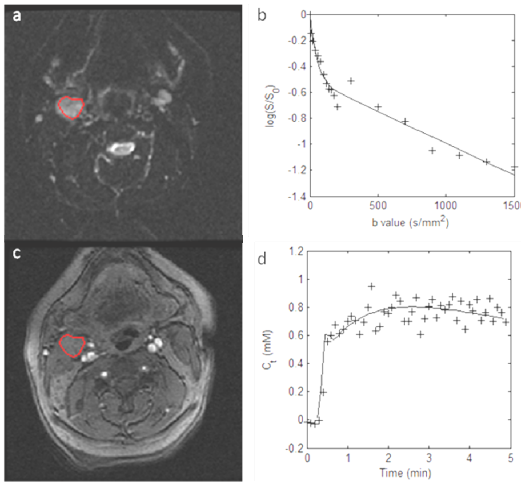

Fig.1 MR Images and model fittings of data from one representative patient (male, 44 years old, right tonsil tumor): (a) metastatic node outlined as red on DWI image (b=0) and (c) T1W image; (b) IVIM and (d) DCE model

Results

Fig. 1 shows IVIM- and DCE-MRI data with the model fittings from a representative patient with metastatic neck lymph node. The Spearman correlation coefficients (ρ) between parameters derived from IVIM- and DCE- MRI showed positive correlation between K^{trans} and D*, v_e and ADC, v_p and D* (Table 1).

Table 1 The Spearman correlation coefficients (ρ) between parameters derived from IVIM- and DCE-MRI. Values are shown as ρ (p value), * denotes p<0.05.

	K^{trans}(min^{-1})	v_e	v_p
f	0.07	0.20	-0.12
D(10^{-3}mm^2/s)	0.08	0.34	-0.09
D*(10^{-1} mm^2/s)	0.64(0.017) *	0.05	0.54(0.046) *
ADC(10^{-3}mm^2/s)	0.08	0.56(0.04) *	-0.13

Discussion and Conclusions

The study revealed that there was significant relationship between parameters derived from IVIM- and DCE- MRI. Both D* and K^{trans} were thought to measure blood perfusion and have shown a positive correlation in neck nodal metastases. Also, parameter v_e positively correlated with ADC. Increased v_e would facilitate the random water movement due to the lower interaction with cellular membranes. No significant relationship was found between perfusion parameter K^{trans} and pure diffusion D. These initial results demonstrate the feasibility of characterizing diffusion and perfusion using IVIM- and DCE- MRI in neck nodal metastases. In future, after appropriate validation these techniques alone or in combination may be used to assess early treatment response after anti-angiogenic therapy in patients with advanced head and neck cancers.

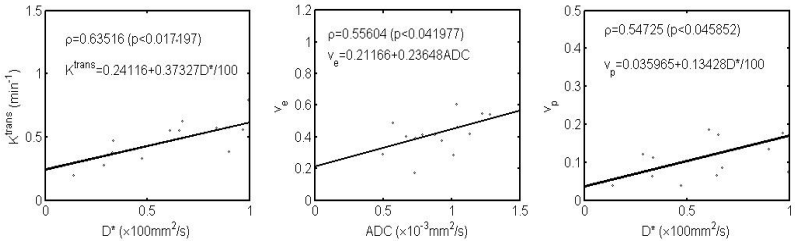

Fig 2. The linear regression analysis for MR derived parameters with significant correlation.

Acknowledgments

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