Comparison of vascularity characteristics between primary tumor and metastatic nodes in head and neck cancer by DCE- and IVIM-MRI

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Introduction

Patients with advanced head and neck (HN) cancers often have tumor metastatic to local lymph nodes. Tumor characteristics such as perfusion and diffusion properties have been successfully measured in vivo using Dynamic Contrast Enhanced (DCE)- and Diffusion Weighted (DW)- MRI techniques respectively in primary HN cancer and neck nodal metastases. Intravoxel Incoherent Motion (IVIM)- MRI has shown potential to measure both perfusion and diffusion in DW-MRI studies. This is a pilot study that compares DCE- and IVIM- MRI derived parameters reflecting tumor vascularity between the primary tumor and neck nodal metatases.

Methods

MRI data acquisition: Twelve patients with both primary tumor and metastatic nodes were enrolled in this retrospective study approved by local institutional review board (age: 44-74 years, M/F: 11/1, and primary cancer: 5 base of tongue (BOT), 5 tonsil, 2 nasopharynx). All patients underwent both IVIM and DCE-MRI on a GE 1.5T Excite scanner with an 8-channel neurovascular phased-array coil prior to treatment, using identical spatial settings. For both techniques the acquisition parameters that were kept the same were: field of view = 20-26mm, slices= 4-6, thickness = 4-8mm depending on the tumor size. 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 for the T1 measurements. 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.

ROI based data analysis: IVIM based parameters (ADC-apparent diffusion coefficient, f-vascular volume fraction, D-pure diffusion coefficient and D*-pseudo-diffusion coefficient) were quantified by the two compartment model [1]. Kinetic parameters (K^{trans} - volume transfer constant and v_e- volume fraction of extravascular extracellular space) were estimated by the generalized kinetic model [2]. An ROI was drawn on each primary tumor and metastatic node (see Fig.1) by an experienced neuroradiologist. For each ROI, the values of all the parameter were calculated on a voxel-by-voxel basis, and summarized by the mean. The Spearman correlation coefficients (ρ) and the linear regression analysis were performed to analyze the correlation between parameters of the primary tumor and neck nodal metatases, and Rank sum test was used to compare the group difference.

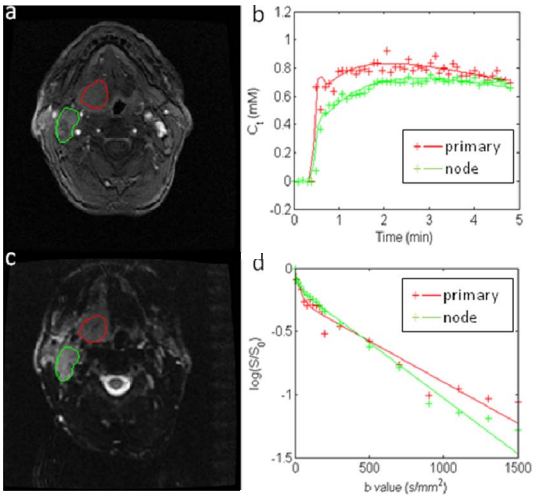


Fig.1 MR Images and model fittings of data from one representative patient (male, 53 years old, right BOT tumor): primary tumor (red) and a metastatic node (green) on T1W image (a) and DWI image b=0 (c). DCE (b) and IVIM (d) model fittings for the primary tumor and metastatic node (C_t, tissue concentration; log(S/S_0), logarithm of DWI signal).

Results

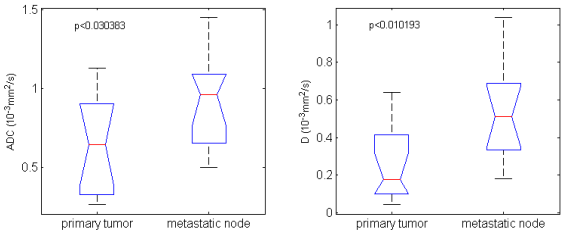
Fig. 1 shows DCE- and IVIM-MRI data with the model fittings from a representative patient with both primary BOT tumor and metastatic lymph node. The results for the 12 patients show that ADC and D were significantly different ($p<0.03$ and $p<0.01$ respectively) while other parameters showed no statistically significant difference for the primary (n=12) and metastatic tumors (n=12) (Table 1). Additionally, significant correlation of D and v_e between primary tumor and neck nodal metatases was observed ($\rho=0.57$, $p<0.05$; $\rho=0.65$, $p<0.03$ respectively). Fig 2 demonstrates Box plots using ADC and D to differentiate primary tumor and metastatic lymph nodes.

Table 1 Parameter comparison between 12 primary tumors and 12 metastatic nodes. *denotes $p<0.05$

	K^{trans} (min^{-1})	v_e	ADC (10^{-3} m^2/s)	f	D ($10^{-3}mm^2/s$)	D* (10^{-1} mm^2/s)
primary tumors	0.51±0.26	0.44±0.25	0.66±0.28	0.31±0.14	0.28±0.20	0.48±0.18
metastatic nodes	0.47±0.29	0.39±0.24	0.91±0.28	0.30±0.13	0.52±0.25	0.49±0.23
p-values of Rank sum test	0.62	0.66	0.03*	0.62	0.01*	0.89
ρ - correlation Coefficients (p- value)	0.51 (0.09)	0.57 (0.05) *	0.31 (0.33)	0.41 (0.18)	0.65 (0.03) *	0.16 (0.61)

Discussion and Conclusion

The results show that metastatic lymph nodes have significantly higher diffusion than primary tumors in HN cancer patients. Metastatic neck nodes are usually heterogeneous with areas of hypoxia and necrosis that may lead to lower cell density and augment diffusion. The changes in the tumor microenvironment have to be further elucidated by molecular marker studies. Significant correlation of D and v_e between primary tumor and neck nodal metatases suggests that the latter have a parametric relationship with the primary tumors. These findings after validation in larger patient population and with appropriate molecular correlates may provide better understanding of the underlying tumor biology, and help in treatment planning.



(a) (b)

Fig 2. Box plots illustrating ADC (a) and D (b) values for primary tumors and metastatic nodes

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References

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