Dynamic Contrast Enhanced and Diffusion Weighted MRI from Primary Tumors and Metastatic Cervical Lymph Nodes in Squamous Cell Carcinomas of the Head and Neck

S. Chawla[1], S. Kim[1,2], L. Dougherty[1], S. Wang[1], L. A. Loevner[1], H. Quon[3], and H. Poptani[1]
[1]Radiology, University of Pennsylvania, Philadelphia, PA, United States, [2]Radiology, New York University, New York, NY, United States, [3]Radiation Oncology, University of Pennsylvania, Philadelphia, PA, United States

Introduction: Dynamic contrast-enhanced MRI (DCE-MRI) derived volume transfer constant (K^{trans}) and diffusion weighted imaging (DWI) has been used in characterization[1,2], monitoring treatment response[3-5] and in prediction of survival[6] in squamous cell carcinomas of head and neck (HNSCC) patients. However, majority of these studies have reported K^{trans} and ADC values from metastatic cervical lymph nodes[2-4]. In comparison to the metastatic node, K^{trans} and apparent diffusion coefficient (ADC) measurements from primary tumor are challenging, as these tumors are generally located in areas prone to artifacts induced by continuous physiologic motion. The current DCE-MRI study was performed using a radial imaging technique along with dynamic K-space weighted image reconstruction contrast (KWIC)[7] to reduce motion sensitivity and assess the primary tumor mass. In addition, motion correction algorithms[8] were performed to further reduce motion artifacts in the DCE-MRI and DWI data. Correlation analysis of K^{trans} and ADC from the primary tumor and metastatic node was then performed to assess the utility of these methods in the primary tumor site.

Methods: Twenty-eight patients with HNSCC underwent anatomical imaging, DCE-MRI and DWI. DCE-MRI was performed using a fast 3D spoiled gradient-echo sequence, which was modified to acquire eight angle-interleaved sub-aperture images from the full-echo radial data. The imaging parameters were: 256 readout points/view, 256 views (32 views/subaperture, 8 subapertures), fat saturation was applied once every 8 excitations. Spatial saturation was applied once every 32 excitations to minimize the flow effect while minimizing the scan time. This data acquisition scheme resulted in a temporal resolution of 2.5 s for each sub-aperture image with full spatial resolution of 256×256 by using KWIC algorithm.[3,9] Gd-DTPA was injected at a dose of 0.1 mmol/kg body weight at 1 ml/s followed by saline flush, during which scanning was continued for another 9 minutes. DWI was acquired using a pulsed gradient spin-echo/echo planar imaging sequence with three b values: 0, 500, and 1,000 s/mm^2. Pharmacokinetic model analysis of DCE-MRI data was performed to generate pixel vise K^{trans} maps using the generalized kinetic model[10]. Similarly, pixel by pixel ADC maps were also computed. All anatomical images, K^{trans} and ADC maps were co-registered using a two-step non-rigid image registration technique to minimize motion artifacts. First 3D registration with affine transformation was performed to minimize global misalignment. Subsequently, a fine 2D registration scheme were applied.[8,9] Furthermore, view dependent phase correction methods were applied to reduce both rotational and translational motions.[8] Median pretreatment K^{trans} and ADC values were computed from regions of interest on the primary tumors and largest nodal masses. Spearman's correlation analyses were performed for K^{trans} and ADC values between primary tumors and nodal masses. **Results:** Co-registered anatomical images, K^{trans} and ADC maps from a representative HNSCC patient are shown in Figure 1. We observed a significantly high correlation ($r=0.684$, $p<0.001$) for K^{trans} between primary tumors and nodal masses. Moderate but significant correlation ($r=0.407$, $p=0.031$) was also observed between ADC of primary tumors and lymph nodes (Fig. 2).

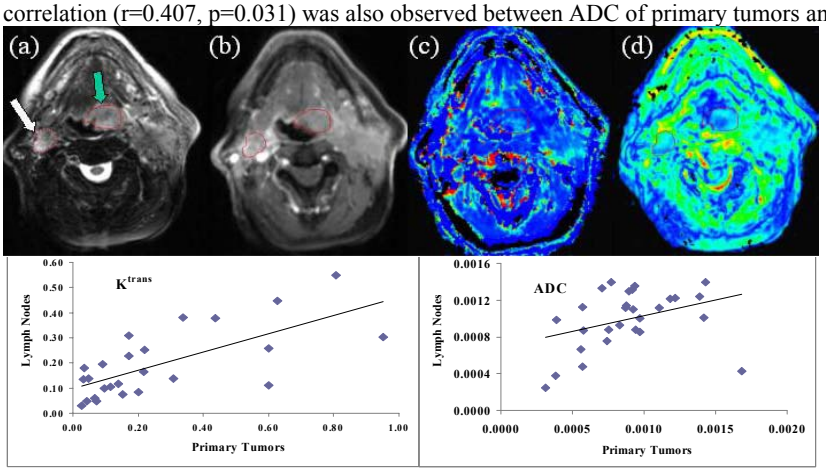

Figure1: Axial T2-weighted image (a) demonstrating heterogeneous hyperintense primary tumor (green arrow) and metastatic lymph node (white arrow) at level IIa of neck. These masses exhibit heterogeneous enhancement on post-contrast T1-weighted image (b). Corresponding DCE-MRI derived K^{trans} map (c) and ADC map (d) from these lesions. Figure 2: Scatter plots demonstrating strong positive correlation for K^{trans} and ADC between primary tumors and lymph nodes

Discussion and Conclusion: In spite of greater vulnerability of DCE-MRI being corrupted due to motion from primary tumors, we observed good quality of K^{trans} maps in 89.28% of the cases (only 3 of the 28 cases had to be dropped because of severe motion). We used radial pulse sequence to minimize motion artifacts as well as to achieve a high temporal resolution of 2.5s. Moreover, motion correction methods and non-rigid registration were also used to eliminate the misalignment among the anatomical images and parametric maps. We believe that combination of these two approaches substantially improves the estimation of K^{trans} from both primary tumors and nodal masses. Significant correlations of K^{trans} and ADC values between primary tumors and nodal masses suggest that both lesions have similar biological and physiological characteristics. As several head and neck cancer patients only have a lesion at the base of tongue (N=0 staging), the ability to achieve high quality K^{trans} and ADC maps from these regions may aid in evaluating diagnostic and prognostic role of DCE-MRI and DWI in primary tumors.

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