Value of Semi-Quantitative Analysis of Dynamic Contrast-enhanced MRI for Diagnosing Staging of Nasopharyngeal Carcinoma, and Comparison with PET-CT

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Introduction:

Dynamic Contrast-enhanced MRI (DCE-MRI) consists of a series of rapid T1-weighted imaging (seconds per scan; tens of scans) performed before, during, and after the administration of an intravenous contrast agent that reduces the T1 value of blood and thereby enhances the signal intensity. It has become a useful tool to study the perfusion, permeability and angiogenesis property in tumor tissues [1-2]. While the value of DCE-MRI has been reported for many tumor types [3-5], its role in nasopharyngeal carcinoma (NPC), one of the leading cancer types in East Asia, has not been well established. It was reported that the staging of NPC patients has been shown to be critical for treatment and prognosis [6,7]. In this project we aimed to study the relationship between contrast enhancement parameters in dynamic DCE-MRI and the diagnosing staging of NPC, and the correlation between parameters from DCE-MRI and PET-CT scanning.

Materials and Methods:

Image Acquisition:

Newly-diagnosed NPC patients who have received both PET-CT and DCE MRI examinations in our PET-CT and MRI unit from August 2009 to May 2010 were included. The interval between PET-CT and MRI scans was less than 1 week, and the tumor size was larger than 1.5cm in any direction to avoid the partial volume effect in PET quantitation.

Routine MRI (T1W, T2W, post-contrast T1W) and DCE MRI scanning were acquired. The DCE MRI scanning parameters were: 3D FFE technique; TR/TE: shortest; 70 scans * 7.825 seconds/scan; FOV: 22*22*6 cm; Recon Matrix: 128*128*20; flip angle=15. Contrast agent was injected after routine T1W and T2W acquisition, at around the 10th scan.

DCE-MRI Semi-quantitative Analysis:

For each tumor, firstly a ROI was drawn on the slice showing the largest tumor dimension in T2 images. Then the ROI was projected from T2 image to DCE-MRI images by co-registration using SPM 8 (Wellcome Department of Imaging Neuroscience, UCL, London). For each tumor, a ime intensity curve (TIC) was acquired within this ROI from the DCE-MRI images, by plotting the average image intensity against the scanning time (70 time points). The semi-quantitative parameters were acquired by fitting the TIC to the following Equation (1) [8,9]:

$$S_n(t) = \frac{S(t) - S_0}{S_0} = \frac{E_R}{k_{el} - k_{ep}} [e^{-k_{ep}(t - t_{lag})} - e^{-k_{el}(t - t_{lag})}] \quad (1)$$

$S_n(t)$, relative enhancement normalized to baseline; $S(t)$, signal intensity at time t; S_0, baseline signal intensity; E_R, wash in rate (minute^{-1}); K_{ep}, the rate constant (minute^{-1}); K_{el}, wash out rate (minute^{-1}); t_{lag}, contrast arrival time (Fig. 1).

Statistical Analysis:

The relationships between semi-quantitative parameters from DCE-MRI and AJCC staging [6], and the correlations with PET parameters (SUV_{max}) were determined using Spearman's correlation and two-tailed Pearson correlation, respectively. All statistical analyses were performed using SPSS 16, and $p < 0.05$ was considered statistically significant.

Results:

A total of sixteen cases have been analyzed (T1 stage, 3 patients; T2 stage, 8 patients; T3 stage, 5 patients). No significant correlation was found between SUV_{max} and enhancement parameters. Wash-in (E_R) and wash-out rate (K_{el},) were found to be significantly correlated with T-stage, as shown in Fig.2a and Fig.2b, with r=-0.531 (p=0.034) and r=-0.576 (p=0.020) respectively. Besides, no significant correlation was found for enhancement parameters and N, M and AJCC stage.

Conclusion:

The wash-in rate and wash-out rate, acquired by semi-quantitative analysis of DCE-MRI imaging, significantly correlated with T staging of NPC tumors, but not with PET-CT parameters. These results suggested that DCE-MRI, with semi-quantitative analysis, is useful for NPC diagnosis, and is potentially useful for predicting the treatment outcome.

Reference:

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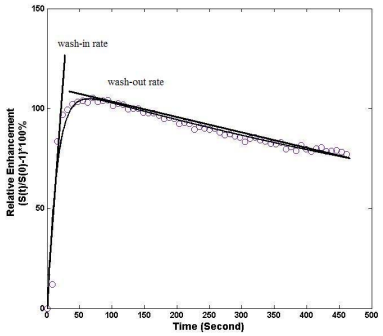

Fig. 1: Semi-quantitative analysis of DCE-MRI (time intensity curve fitted to Equation 1).

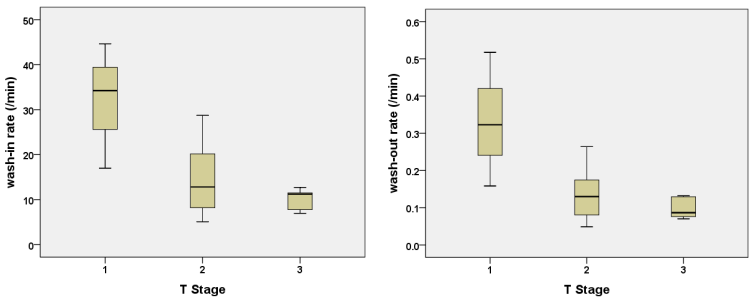

Fig. 2: a. wash-in rate of contrast significantly correlated with T-stage (r=-0.531, p=0.034) b. wash-out rate of contrast significantly correlated with T-stage (r=-0.576, p=0.020)