Intravoxel incoherent motion MR imaging: diffusion and perfusion characteristics in early assessment of chemotherapy response in nasopharyngeal carcinoma

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Target Audience: Radiologists

Introduction: Nasopharyngeal carcinoma (NPC) is the most common cancer originating in the nasopharynx. It is vastly more common in certain regions of East Asia and Africa than elsewhere, with viral, dietary and genetic factors implicated in its causation. Diffusion weighted imaging (DWI) is increasingly used to evaluate NPC, with the better contrast and sensitivity to delineate tumors as compared to routine T2-W imaging. Quantitation of diffusion usually entails mono-exponential fitting, which does not account for the contribution from intra-voxel incoherent motion (IVIM). A bi-exponential model was proposed which allowed the fast IVIM component to be separated from the slower component to reveal the volume fraction of microvasculature within a voxel and the 'true' molecular diffusion coefficient and showed promising results in human brain and prostate cancer. But it is still unclear whether the bi-exponential model works well in NPC. The purpose of this study is to detect the early response of NPC to chemotherapy by recording the IVIM characteristics, i.e., diffusion and perfusion characteristics before and during the therapy and to compare those parameters between patients of different response groups as well.

Methods: 43 consecutive patients with NPC confirmed by pathology were examined using a 3.0T Philips MR system (Achieva TX, Best, the Netherlands). Diffusion weighted images (DWIs) were performed with 14 b values (0, 10, 20, 30, 40, 50, 100, 150, 200, 350, 500, 650, 800, 1,000 s/mm²) on every patient at pre-chemotherapy, the 3rd and 21st day of each cycle of the two-cycle chemotherapy. Therefore, in total of 5 time points (marked as pre, day3, day21, day24 and day42) were monitored. The IVIM diffusion and perfusion characteristics (D, true diffusion; D*, pseudo-diffusion; f, perfusion fraction) were analyzed on post-processing software using bi-exponential model $S = S_0\{(1-f)\cdot e^{-b\cdot D} + f\cdot e^{-bD^*}\}$. In addition, the pre-and post-chemotherapy tumor size of each case were measured by the maximum diameter.

Results: IVIM was successfully conducted in 39 cases, while 4 cases failed because of severe image degradation resulting from magnetic field heterogeneities at the air-bone and air-soft tissue interfaces and from physiological motion artifacts. As were showed in the figure 2，D was ascending continually from the beginning to the end of the chemotherapy (P<0.001) and the earliest significant increasing happened at day 3(P<0.001). D* appeared a short fluctuation at the first cycle of chemotherapy (P<0.05). But f didn't show significant change (P>0.05). After two cycle of chemotherapy, 21 Patients were considered responders and 18 were considered non-responders according to the alterations in tumor size according to the Response Evaluation Criteria In Solid Tumors (RECIST) criteria. D and f of the responders were higher than those of the non-responders and significant differences were observed at day 24, day 21 separately (P<0.05), at other time points, though significance hadn't been reached, both D and f values of responders still appeared higher than that of non-responders. On the contrary, D* did not exhibit any discrimination ability.

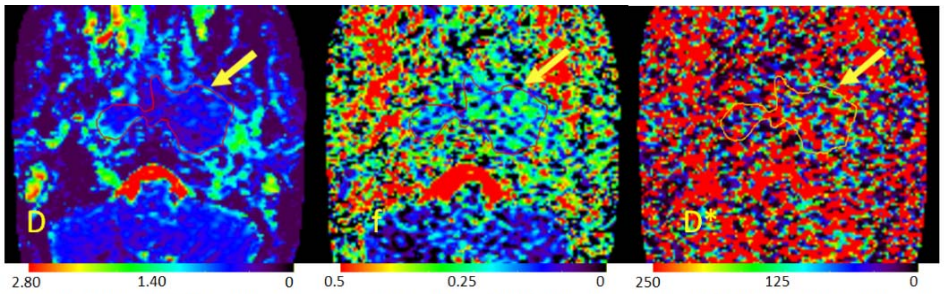

Figure 1. Representative parametric image of a 47-year-old female with NPC . Presentation of the D, f and D* parameters on the intravoxel incoherent motion MR image . Regions of interest(ROIs) were circled in same shape and areas.

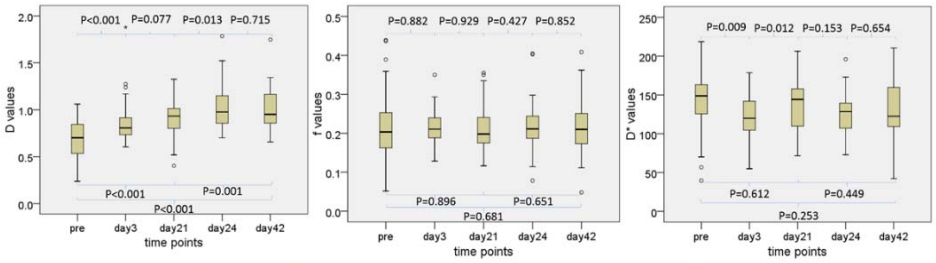

Figure 2. Box plots of D, f and D* values of 39 cases at each time point. The significances of statistical difference between every adjacent time point were showed above the boxes , and those between pre ,day21 and day24 were under the boxes.

Discussion: The IVIM parameter D reflects the diffusion change at the 3rd day of the first cycle of chemotherapy, a quite early stage. The pseudo-diffusion D* was also sensitively affected by chemotherapy. But f is not responsive. The differences of D and f between responders and non-responders may prompt a more active water diffusion and higher blood volume in responsive cases, while D* didn't contribute to the prognosis. However, there are some limitations in this study. Firstly, the number of samples was not big enough. Secondly, both D* and f could be affected by varieties of T_2,blood volume and blood flow[1] , leading to poor reproducibility of D*[2] and overestimation of f[3].

Conclusion: IVIM DWI is a feasible technique in detecting early diffusion and perfusion changes in nasopharyngeal carcinoma tissues responding to the chemotherapy. D and f are prospectively potential in prognosis determination which might be helpful with optimal treatment regimens.

References: 1. Zhang SX, Jia QJ, Zhang ZP, et al.: Intravoxel incoherent motion MRI: emerging applications for nasopharyngeal carcinoma at the primary site. Eur Radiol. 2014; 24:1998 – 2004. 2. Koh DM, Collins DJ, Orton MR: Intravoxel incoherent motion in body diffusion-weighted MRI: reality and challenges. AJR Am J Roentgenol. 2011;196:1351-61. 3. Lemke A, Laun FB, Simon D, et al.: An in vivo verification of the intravoxel incoherent motion effect in diffusion-weighted imaging of the abdomen. Magn Reson Med. 2010;64:1580-5.