Assessment of vessel permeability by combining DCE and ASL MRI

Ting-Ting Chang¹, Alex M. Wong², Feng-Xian Yan¹, Yu-Shi Lin¹, and Ho-Ling Liu¹,²

¹Department of Medical Imaging and Radiological Sciences, Chang Gung University, Kwei-Shan, Tao-Yuan, Taiwan, ²Department of Medical Imaging and Intervention, Chang Gung Memorial Hospital, Kwei-Shan, Tao-Yuan, Taiwan

Introduction

Dynamic Contrast Enhanced (DCE) MRI has been widely applied to investigate the vascular properties of tumor (1). In particular, the transfer constant (K\text{trans}) obtained from pharmacokinetic modeling of the DCE-MRI data is commonly used as a indicator for vessel permeability. However, K\text{trans} is known to be also weighted by tissue perfusion (2, 3). In theory, it approximates permeability surface area product per unit mass of tissue (PS) in the PS-limited model and tissue blood flow in the flow-limited model (3). This study propose to combine the cerebral blood flow (CBF) measurement, by using the pseudo-continuous arterial spin labeling (PCASL) technique (4), and the DCE-MRI to estimate PS in brain tumors.

Methods

Eleven pediatric patients with brain tumors (age: 8.78±3.93y) participated in this study. The CBF maps were acquired at a 3T clinical scanner using a 3D FSE PCASL sequence with spiral acquisition (TR/TE = 4500ms/10 ms, post-labeling delay = 1525 ms, in-plane matrix = 128 x 128, slice thickness = 5mm, 23 slices) to cover the whole brain. Before the DCE-MRI, T\text{1} maps were acquired by using a 3D SPGR sequence with multiple flip angles. DCE-MRI were performed by using a T\text{1}-weighted 3D SPGR sequence (TR/TE/FA=4.9ms/1.3ms/30°, in-plane matrix = 256 x 256, slice thickness = 5mm, 8 slices, 60 dynamics). The K\text{trans}, V\text{e}, and V\text{p} maps were obtained by using the mTK model (5). For each subject, the CBF map was spatially coregistered with the K\text{trans} map, and spatially smoothed using a Gaussian kernel of FWHM = 5mm using the spm8 (http://www.fil.ion.ucl.ac.uk/spm/). The PS map was then calculated using the equation PS = -CBFxln(1-K\text{trans}/CBF). The tumor ROI was drawn by an experienced neuroradiologist, from which mean tumor K\text{trans}, CBF, and PS values were obtained for each patient.

Results

Table 1 lists the mean tumor K\text{trans}, CBF, and PS values of each patient. The mean value of K\text{trans} was approximately the same but slightly lower than PS, with a 6% difference. Figure 1 shows significant positive correlations between K\text{trans} and PS (the dash line denotes the line of equality between x- and y-axes), which is expected from the nature of the calculation. For small K\text{trans} values they were approximately equal to the resulted PS values. When K\text{trans} values were greater, they became increasingly underestimated than the PS values. The largest discrepancy between K\text{trans} and PS in this study was 13% in a patient with mean tumor K\text{trans} of 0.10 min⁻¹. No significant correlations were found between CBF and either K\text{trans} or PS. Figure 2 demonstrates the post T\text{1}, K\text{trans}, CBF, and PS maps of two patients. Similar patterns were found between K\text{trans} and PS maps, with slightly higher PS values for the second patient (bottom row).

Conclusion

This study proposed to utilize the PCASL technique for separating the flow weighting from the K\text{trans} measurement by DCE-MRI of brain tumors. The results demonstrated that the K\text{trans} well approximated vessel permeability with the PS-limited condition.

References