Assessment of vessel permeability by combining DCE and ASL MRI

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Introduction

Dynamic Contrast Enhanced (DCE) MRI has been widely applied to investigate the vascular properties of tumor (1). In particular, the transfer constant (K^{trans}) obtained from pharmacokinetic modeling of the DCE-MRI data is commonly used as a indicator for vessel permeability. However, K^{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_1 maps were acquired by using a 3D SPGR sequence with multiple flip angles. DCE-MRI were performed by using a T_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^{trans}, V_e, and V_p maps were obtained by using the mTK model (5). For each subject, the CBF map was spatially coregistered with the K^{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^{trans} /CBF). The tumor ROI was drawn by an experienced neuroradiologist, from which mean tumor K^{trans}, CBF, and PS values were obtained for each patient.

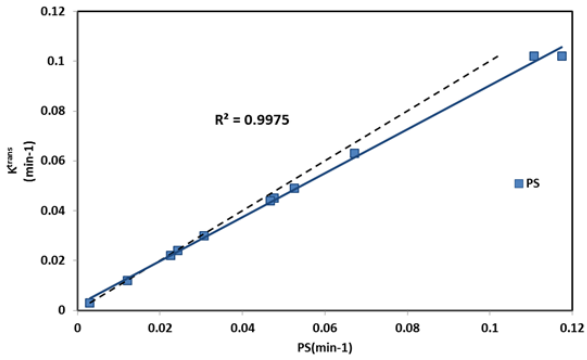
Results

Table 1 lists the mean tumor K^{trans}, CBF, and PS values of each patient. The mean value of K^{trans} was approximately the same but slightly lower than PS, with a 6% difference. Figure 1 shows significant positive correlations between K^{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^{trans} values they were approximately equal to the resulted PS values. When K^{trans} values were greater, they became increasingly underestimated than the PS values. The largest discrepancy between K^{trans} and PS in this study was 13% in a patient with mean tumor K^{trans} of 0.10 min^{-1}. No significant correlations were found between CBF and either K^{trans} or PS. Figure 2 demonstrates the post T_1, K^{trans}, CBF, and PS maps of two patients. Similar patterns were found between K^{trans} and PS maps, with slightly higher PS values for the second patient (bottom row).

Table 1.

patient no.	K^{trans}(min^{-1})	CBF(ml/100g/min)	PS(min^{-1})
1	0.030	63.4	0.031
2	0.045	40.7	0.047
3	0.044	38.1	0.046
4	0.063	51.1	0.067
5	0.003	44.4	0.003
6	0.012	45.9	0.012
7	0.102	66.2	0.111
8	0.024	111.0	0.024
9	0.102	40.6	0.117
10	0.049	36.4	0.052
11	0.022	38.0	0.023
Mean±S.D	0.045±0.031	52.348±20.893	0.048±0.036

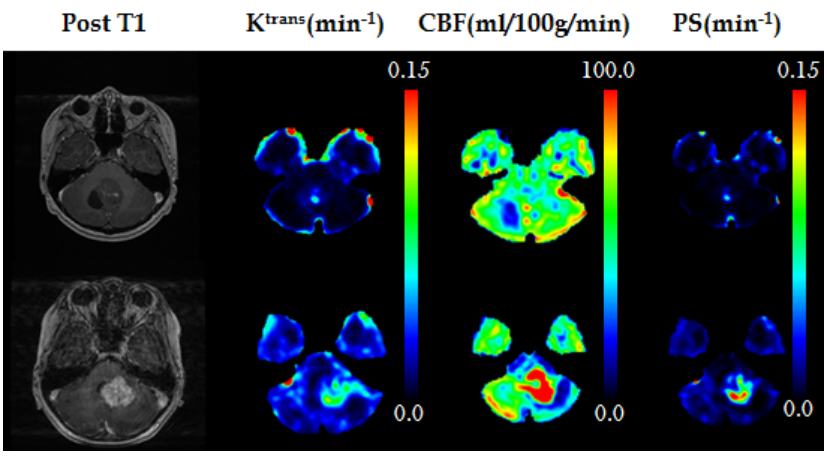
Figure 1



Conclusion

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

Figure 2



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