Perfusion Measurement of Brain Tumors:Comparison Between IVIM and DSC

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Purpose:

Intravoxel Incoherent Motion (IVIM) model [1] is a method for separating the capillary perfusion and diffusion from multiple b diffusion weighting imaging. The derived perfusion fraction, D and D* are used to evaluate prostate tumors [2] and brain perfusion [3]. This capillary perfusion, which mechanism is different from traditional contrast based perfusion, is dependent on the flowing blood and vascular architecture. In order to clearly understand the IVIM based capillary perfusion, in this study, we evaluated this IVIM based capillary perfusion in 3 types of brain tumors (meningiomas, gliomas, metastatic tumors) by comparing with the traditional perfusion calculated from dynamic susceptibility contrast MRI measurement.

Methods:

Diffusion weighted imaging and dynamic susceptibility contrast imaging were acquired from 11 patients (5 with gliomas, 4 with meningiomas and 2 with metastatic tumors) on MAGNETOM Symphony 1.5T and Trio 3.0T (Siemens Healthcare, Erlangen, Germany) MR scanners. A same FOV (230mm×230mm) is used for both acquisitions. The diffusion weighting imaging was performed by applying 9 b values (b = 0, 50, 100, 150, 200, 400, 600, 800, 1000 s/mm^2) with 3 orthogonal directions, TR/TE = 3300ms/91ms, and 2 averages. Dynamic susceptibility imaging was obtained with TR/TE = 1480ms/32ms. The bi-exponential IVIM model is used in a pixel wise manner. The perfusion fraction f, D* and D maps were calculated by using a home written 2 segment linear fitting algorithm. The b = 200 ~ 1000 s/mm^2 were firstly used for D and f calculation, then D* was obtained by linear fitting within the range of b = 0 ~ 200 s/mm^2. The IVIM derived relCBF (relCBF$_{IVIM}$) is calculated from the equation (a), where the parameters which are used in reference [4] is taken into one 'factor' in this study:

$$relCBF_{IVIM} = factor \times f \times D^* \qquad (a).$$

Results:

In the enrolled patients, for the indicated tumors as shown in Fig.1, we have observed: 1) the IVIM based relCBF map shows similar pattern as DSC based relCBF map, which are shown in Fig.1 a) Glioma, b) Metastatic and c) Meningiomas; 2) 9 of 11 (star dot without circle in Fig. 1d): 82%) shows that the relCBF derived from IVIM is consistent with relCBF calculated from DSC, where 2/11 (star dot with circle in Fig. 1d): 18%) have large deviation, where IVIM derived relCBF are overestimated.
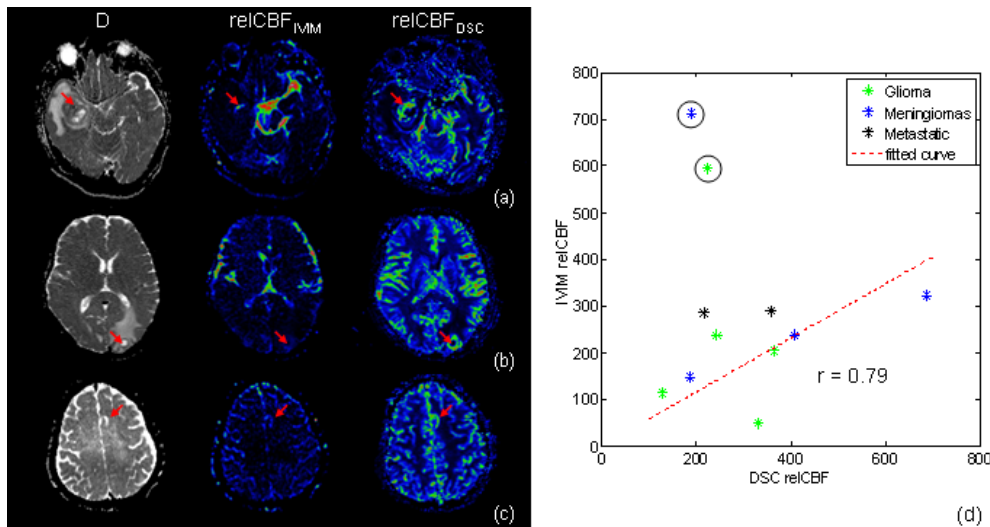

Figure 1: (a – c) D, CBF$_{IVIM}$ and relCBF maps for (a) Glioma, (b) Metastatic and (c) Meningiomas. The red bar indicates the tumor location. (d) IVIM based relCBF versus conventional DSC based relCBF for different types of brain tumors. The red line was obtained by linear regression of star dot without circle (9/11 tumors), which gives correlation factor of 0.79.

Discussion and Conclusion:

In this study, we did not calculate the absolute CBF from IVIM measurement because we do not yet measure the tumor sepcific MR water fraction F_W and mean diffusion length. But for understanding the CBF relationship calculated from IVIM and DSC, the relCBF is enough for this purpose. One of the two deviations is shown in Fig. 1 a), but relCBF from IVIM and DSC look paternally similar. One possible reason for this deviation could be that IVIM is sensitive to flow while DSC is suffering the time resolution. Although this study has only 11 cases, but 82% consistent cases have shown the potentials of IVIM in brain tumor applications because the IVIM sequence is able to generate CBF, CBV, and ADC in one measurement without contrast.

References:

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