IVIM with simultaneous T2 mapping and relaxivity correction

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[Target audience] audience who are interested in diffusion, liver imaging, intravoxel incoherent imaging.

[Purpose] To determine whether T2 correction on diffusion weighted imaging (DWI) using intravoxel incoherent motion (IVIM) model can provide different perfusion fraction (*f*) on DWI without T2 correction in a tissue with long TE and to determine whether T2 correction sequence can be implemented within a DWI scan.

[Methods]

DWI using nine b values (15, 25.4, 42.9, 72.5, 122.5, 207.0, 350.0, 591.6, 1000 s/mm^2) were performed in two volunteers at a 1.5T MR scanner (Signa HDx, GE, WI). Before starting DWI, T2 map was obtained by T2WI spin echo EPI with various TEs (49.7ms, 54.7ms, 59.7ms, 64.7ms, and 69.7ms). IVIM parameters (D, D* and *f* were estimated pixel by pixel using the nonlinear least squared fitting algorithm[1] after pre-smoothing of the data. Using the extended IVIM signal model with T1 and T2 relaxation[2], it can be shown that the relationship between the perfusion fraction without T2 correction (f) and with T2 correction (f') can be expressed as $f = \frac{f' \exp\left(-\frac{TE}{T_{2bl}}\right)}{(1-f')\exp\left(-\frac{TE}{T_{2tiss}}\right)+f' exp\left(-\frac{TE}{T_{2bl}}\right)}$. Note that T1 relaxation effect can be ignored for long TR. The perfusion fraction with T2 correction (f') was calculated based on the *f*, measured T2 and blood T2 from literature (290ms for 1.5T[3]).

[Results] A significant over-estimation of *f* was expected on TEs ≥40ms (Fig. 1). The TE for the diffusion weighted acquisition was 59.7ms. In a 63 years-old patient with hepatocellular carcinoma (HCC) (Fig. 2), *f* were 13.9% in HCC and 32.5% in the liver parenchyma. After T2 correction, the values significantly decreased (f': 6.92% in HCC and 12% in the liver parenchyma).

[Discussion] We have obtained T2 map simultaneously, and achieved *f'* using the derived T2 correction relationship. The T2 information on T2 map itself would be helpful in understanding the tissue solidity while other IVIM parameters can provide information on tissue cellularity and perfusion. The relaxivity correction for the *f* will also help to predict tissue vasculature more accurately without T2 relaxivity contamination, since if TE is high, the T2 and T1 relaxation difference between tissue and blood will cause over-estimation of perfusion fraction on IVIM-DWI[2].

[Conclusion] T2 relaxation in a tissue was successfully measured and combined with the conventional IVIM signal model to produce relaxivity corrected perfusion fraction maps. *f'* was significantly lower than *f* in tissues with TEs ≥40ms.

[References] **1**.Luciani et al., Liver cirrhosis: Intravoxel Inconerent motion MR imaging – pilot study. Radiology 2008;249:891-899

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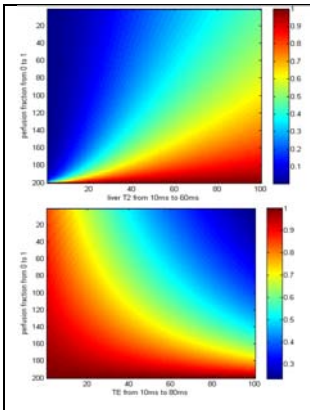

Figure 1. The ratio of *f'* to *f* when tissue T2 is varying (top) and when TE is varying (bottom).

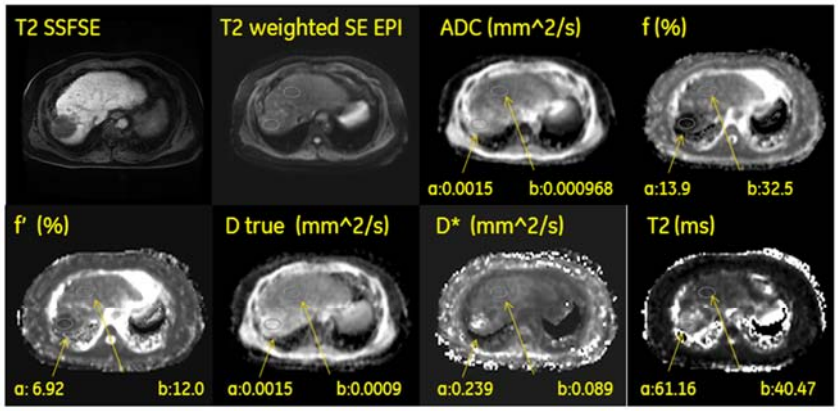

Figure 2. A sixty three years-old patient with HCC in the liver S7. On T2 map, both tumor and the liver parenchyma showed TE ≥ 40ms. *f* values were 13.9% in HCC and 32.5% in the liver parenchyma on perfusion map. **After T2 correction**, *f'* markedly decreased in HCC (6.92%) as well as in the liver parenchyma (12%).