The Effect of the Apparent Transverse Relaxation Time on Cerebral Blood Flow Values obtained at 1.5 and 4.0 Tesla

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Introduction: With arterial spin tagging methods, tracer kinetic models have predicted that the capillary space contains a significant fraction of the tagged water due to the rapid relaxation of the tag (1-3). As a result, differences in the relaxation times, either T1 or T2, between the tissue and blood compartments can affect the CBF measurements. It was predicted that reduced T2* of deoxygenated blood at magnetic fields ≥ 4 T (5,6) can lead to underestimations of CBF (7). The objective of this study was to compare the model predictions to CBF values collected at various echo times and at two field strengths (1.5 and 4.0 T).

Methods: Data were collected at two field strengths (1.5 and 4 T, GE Medical Systems) using the identical FAIR sequence (6), which included a saturation pulse applied 800 ms after the labelling pulse and another delay of 800 ms prior to imaging. The acquisition delay allowed sufficient time for all of the tagged water to flow into the brain tissue. Images were acquired using an EPI sequence with 8 slices (8 mm each & 2 mm gap), a FOV = 240 x 160 mm^2, and a matrix = 64 x 40. Basal CBF was measured in four healthy volunteers at both field strengths and at four echo times (19, 32, 45, 58 ms). Eighty perfusion-weighted images were collected at each TE and converted to CBF images.

Using a previous model (7), simulated AST data were generated for grey matter with CBF = 60 ml/100g/min, T1 = 1.0 s and 1.2 s for grey matter and blood respectively at 1.5 T (4), and 1.3 and 1.6 at 4.0 T (6). T2* values for grey matter, arterial and venous blood were 100, 200 and 100 ms at 1.5 T (8). At 4.0 T, grey matter T2* = 40 ms (5), and T2* for arterial and venous blood were varied over a range. Simulations were conducted for the four echo times list above.

Results: Grey matter CBF values measured at four echo times are illustrated in Fig. 1. The results from the simulations are given by the solid lines. At 1.5 T, CBF showed a slight increase with TE, which the model predicts is due to the higher average T2* in capillary blood compared to tissue T2*. At 4.0 T, the observed CBF decreases with TE due to the sizable reduction in blood T2*. However, the theoretical results in Fig. 1 indicate that this effect is very sensitive to the specific values of T2* in arterial and venous blood.

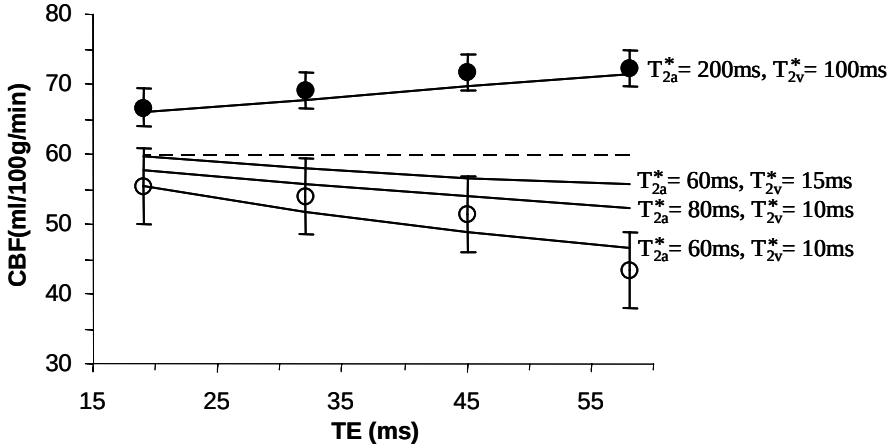

Fig.1 Measured CBF versus TE. Filled and open circles are data collected at 1.5T and 4T respectively. Solid lines are generated from the model with the T2* values given on the right. These values represent T2* in the capillary space at the arterial and venous ends.

Conclusion: The data demonstrated that CBF measured at 4T depends on echo time, which agrees with a model that included T2* effects in blood and tissue. This data is direct evidence that, as previously predicted (1-3), a significant fraction of the AST signal originates from tagged water in the capillary blood.

References:

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