
Abstract:
A blood oxygenation level-dependent (BOLD)-based apparent relative oxygen extraction fraction (rOEF) as a semi-quantitative marker of vascular deoxygenation has recently been introduced in clinical studies of patients with glioma and stroke, yielding promising results. These rOEF measurements are based on independent quantification of the transverse relaxation times T2 and T2* and relative cerebral blood volume (rCBV). Simulations demonstrate that small errors in any of the underlying measures may result in a large deviation of the calculated rOEF. Therefore, we investigated the validity of such measurements. For this, we evaluated the quantitative measurements of T2 and T2* at 3 T in a gel phantom, in healthy subjects and in healthy tissue of patients with brain tumors. We calculated rOEF maps covering large portions of the brain from T2, T2* and rCBV [routinely measured in patients using dynamic susceptibility contrast (DSC)], and obtained rOEF values of 0.63 ± 0.16 and 0.90 ± 0.21 in healthy-appearing gray matter (GM) and white matter (WM), respectively; values of about 0.4 are usually reported. Quantitative T2 mapping using the fast, clinically feasible, multi-echo gradient spin echo (GRASE) approach yields significantly higher values than much slower multiple single spin echo (SE)
experiments. Although T2* mapping is reliable in magnetically homogeneous tissues, uncorrectable macroscopic background gradients and other effects (e.g. iron deposition) shorten T2*. Cerebral blood volume (CBV) measurement using DSC and normalization to WM yields robust estimates of rCBV in healthy-appearing brain tissue; absolute quantification of the venous fraction of CBV, however, is difficult to achieve. Our study demonstrates that quantitative measurements of rOEF are currently biased by inherent difficulties in T2 and CBV quantification, but also by inadequacies of the underlying model. We argue, however, that standardized, reproducible measurements of apparent T2, T2* and rCBV may still allow the estimation of a meaningful apparent rOEF, which requires further validation in clinical studies.

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