AN ALTERNATIVE APPROACH FOR ESTIMATION OF VASCULAR PERMEABILITY TO GD-DTPA AND CEREBRAL BLOOD VOLUME FROM DYNAMIC T2* WEIGHTED CONTRAST-ENHANCED MRI

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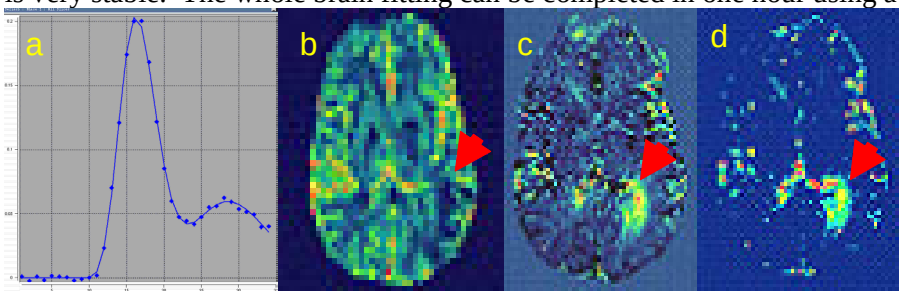
INTRODUCTION Interest in estimating the vascular permeability of Gd-DTPA from dynamic T2*-weighted images has risen recently (1), given that it may be possible to estimate CBV, CBF and vascular permeability from a single set of dynamic images. To date, however, obtaining highly stable and reproducible voxel-by-voxel estimates from T2*-weighted images remains a challenge, due to low SNR and difficulty in determining the input function. We propose a method that estimates voxel-by-voxel permeability and CBV using dynamic T2*-weighted images. The method is assessed for stability and applied to estimates of BBB permeability in 11 patients with high-grade gliomas.

METHODS The total tissue concentration of an extracellular contrast can be described as $C_t(t) = v_p C_p(t) + v_{ees} C_{ees}(t) = v_p C_p + K_{trans} \int_0^t C_p(\tau) \exp(-k_{ep}(t-\tau)) d\tau$. The bolus shape function for the first pass has been taken to be a gamma-variate function g(t) plus an integral term (1,2). However, a significant second-pass component closely follows the first pass is often observed (Fig a). Fitting only the first pass does not reliably estimate K_{trans}. Thus, the second pass, $s_{inp}^{2nd}(t) = A'[(t-t_0')/t_{half}]^{\alpha} \exp(-\beta(t-t_0')/t_{half})$, is added to the initial bolus, resulting in a total of 8 free parameters. Our numerical algorithm consists of 5 steps. (1) Eight parameters in the bolus shape function are determined by fitting the normal white matter (NWM) data in a VOI while assuming K_{trans}=0 and v_p =1%. (2) We obtain an initial estimate of v_p and time shift of the bolus in each voxel by assuming that the C_t increase up to the peak of the first pass is predominately due to the intravascular contrast contribution, and the shape of the input function is not changed from that in NWM except for a possible time shift. (3) Prior to computing K_{trans}, whether vascular leakage (or extravascular contrast concentration) in a voxel is significant is tested (t-test, $p<0.05$). If it is not significant, K_{trans} and k_{ep} are assigned to be 0 and the program stops. (4) Fit K_{trans} and K_{ep} from the second half of the curve with fixed v_p and time shift of the bolus. (5) Re-fit the whole curve for K_{trans}, K_{ep}, and v_p by allowing perturbations of the values obtained from steps 2 and 4 with fixed time shift of the bolus.

RESULTS AND DISCUSSION Fig a shows the result of fitting a WM curve from a VOI (line). Figs b, c and d show a CBV map reconstructed by our algorithm, a difference map between CBV reconstructed by conventional and our methods, and a K_{trans} map, respectively. The pattern of K_{trans} is similar to the difference map between the two CBV, due to the contrast leakage is accounted for in our algorithm. In the tumor regions of the 11 patients with high-grade gliomas, the mean K_{trans} was estimated to be 0.07 min^{-1}±0.03 min^{-1}, and the mean v_p was 2.4%±0.7%, consistent with the values in literature. When reducing the number of voxels in the NWM VOI to one quarter of the original one, fitting yielded K_{trans} and v_p only 1.7% and 1.3% respectively different from the original fittings, suggesting our algorithm is very stable. The whole brain fitting can be completed in one hour using a LINUX workstation.



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