Assessment of the Vascularity of Glioblastoma Multiforme using Alternate-Echo Multislice Perfusion-Weighted MRI with the First-Pass Pharmacokinetic Model

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Purpose: Application of perfusion-weighted MR imaging (PW-MRI) with single-echo acquisition for enhancing brain tumors is hampered by contamination due to the T1-shortening effect caused by the leakage of contrast agent. Therefore, tumor vascularity using single-echo PW-MRI is underestimated (1-4). However, T2*-shortening due to contrast material present in the extravascular space causes overestimation of tumor vascularity. To incorporate the effects of the extravascular compartment containing contrast material residue, pharmacokinetic modeling using two compartments, the intravascular space and the extravascular space, is required (5). We demonstrate here that the combination of an alternate-echo, single shot SPIRAL acquisition and first-pass pharmacokinetic model can correct for the T1-shortening effect due to the leakage of contrast agent, as well as for T2*-shortening due to contrast material present in the extravascular space facilitating precise evaluation of tumor vascularity in enhancing glioblastoma multiforme (GBM).

Materials and Methods: PW-MRI was acquired in eighteen patients with GBMs using a single-shot, alternate-echo, GRE-SPIRAL-out sequence to simultaneously determine tumor blood volume without T1- and T2*- shortening correction (V_U) and tumor blood volume with both T1- and T2*-shortening correction (V_C). The image parameters were as follows: FOV=24 cm^2, matrix=128 x 128, slice thickness=5 mm, TE_1=16.2 ms, TE_2=45 ms, TR=800 ms, number of slices=7-10. A standard dose of contrast agent (0.1mmoL/kg) was injected. We compared V_C with V_U for quantitative analysis. P<.05 was considered significant.

Results: In this study, all GBMs showed contrast effect. Effects of contrast agent extravasation were apparent after the first pass of contrast agent (Figure 1, left). The first-pass pharmacokinetic model effectively compensates for both T1- and T2*-shortening effect due to contrast material present in the extravascular space (Figure 1, right). Similar results were obtained for all patients. For quantitative analysis, the mean Vu of the GBMs was significantly lower than the mean Vc (mean ± SD, 274.4 ± 31.3 for Vu vs. 329.5 ± 37.6 for Vc; *P*< .01). The difference between Vc and Vu of normal white matter was not significant. The blood volume of the tumor is much more prominent on the Vc map compared with that on the Vu map in all cases (Figure 2).

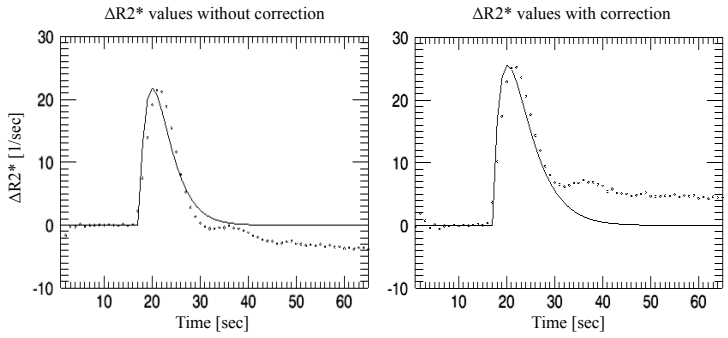

Figure 1. Representative case of GBM. (74-year-old man)
The time course of ΔR2* values with and without correction are shown. The ΔR2* values of the GBM are represented by open circles and its gamma-fitted curve is represented by a line. In this case, the Vu (163.2) was lower than the Vc (235.7).

Discussion and Conclusion: In this study, the mean Vu was significantly underestimated than the mean Vc. Therefore, careful attention must be paid to prevent inaccurate assessment of tumor blood volume in enhancing brain tumors, unless some technique that can correct for the T1- and T2*-shortening effect is used. The combination of an alternate-echo, single shot SPIRAL acquisition and first-pass pharmacokinetic model may be a more accurate method of multislice PW-MRI in GBMs.

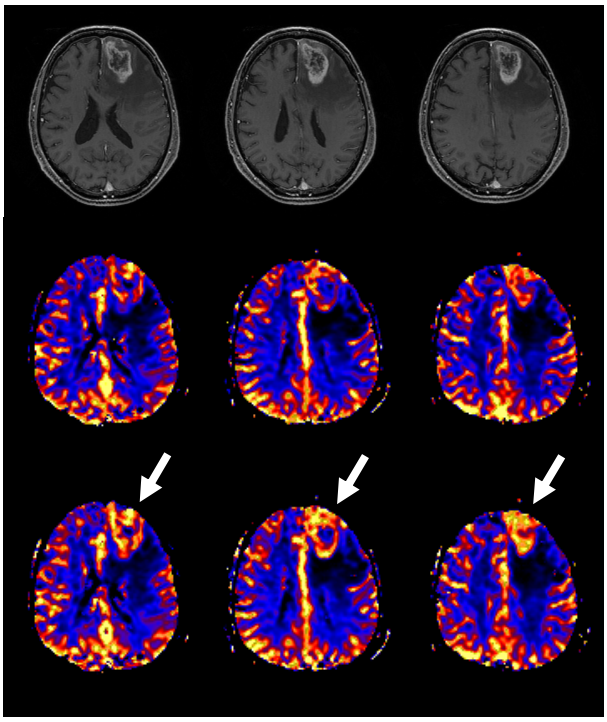

Figure 2. The GBM shows inhomogeneously dense contrast enhancement in the left frontal lobe (top). Corresponding Vu (middle) and Vc (bottom) maps are shown. Note that blood volume of the tumor is much more prominent on the Vc map (white arrows) than on the Vu map.

References

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