Analysis of the impact of rCBV map threshold to predict tumor recurrence in high-grade gliomas

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Résumé

Introduction: Patients suffering from high-grade gliomas currently have a median survival time of 14 months despite treatment. Our purpose was to investigate whether MR perfusion and relative Cerebral Blood Volume (rCBV) maps could help to predict tumor recurrence areas and improve treatment outcome. This study investigates the impact of rCBV map thresholds on the ability of MR perfusion to predict tumor recurrence.
Methods: This retrospective study included 17 patients suffering from high grade gliomas who received standard chemo-radiation (30 x 2 Gy/fraction, Temodal). Subjects underwent pre-treatment CT, gadolinium-enhanced T1-weighted, T2 FLAIR acquisitions and a DSC-MR scan. rCBV maps were calculated with GE READE View Advantage Workstation and normalized to the contralateral normal white matter perfusion. The PLANET software (DOSIsoft) was used to register MR images to the CT. A senior radiologist and a senior radiotherapist delineated conventionally GTV on anatomical MR images. PTV were defined by a physicist. Thresholds t of 1.5 to 2.5 were applied to the normalized rCBV maps to define hyper-perfused volumes (Vperf,t). Follow-up anatomical MR images were used to localize recurrence areas (GTV'). Correlations between all volumes were analyzed using six indexes. I1,t was the percentage of Vperf,t not included in the GTV. I2,t, I3 and I4 were respectively the percentages of GTV' included in Vperf,t, GTV, and PTV. I5,t was the percentage of Vperf,t included in GTV'. I6,t was the percentage of Vperf,t not included in the GTV which was predictive of tumor recurrence outside GTV.

Results: Index evolution when t rises is slow and no obvious break in slope suggests an optimal threshold. Whatever t (1) I1,t is higher than 20% for 14 patients, suggesting that Vperf,t and GTV as defined using anatomical images are distinct volumes (2) I2,t shows that the proportion of relapse volumes characterized by high rCBV is between 2% and 63% (3) I5,t indicates that hyper-perfused areas will not necessary lead to relapse ($1\% < I5,t < 98\%$) (4) I6,t is lower than 5% for 8 patients and greater than 40% for 5 patients: perfusion may help to predict relapse outside GTV in about half of the cases. Based on I3 value analysis,

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two groups can be distinguished: The first (9 patients) shows a high overlap between GTV and GTV' (I3 $>$ 80%) while this overlap is moderate in the second (30% $<$ I3$<$ 50%). I4 is almost always equal to 100%: recurrence occurs inside the PTV.
Conclusions: Recurrence areas are always located in the PTV: an improvement of treatment planning will consist in defining boost areas rather than modifying the GTV. The impact of the threshold used to define hyper-perfused area is low. Although 17 cases only were studied, our results suggest that MR perfusion is neither specific nor sensible enough for defining by itself recurrence (hence potential boost) areas. Multi-modality imaging such as PET-MR might help identify tissues with a high risk of recurrence.

Mots-Clés: glioma, rCBV, radiotherapy