

Improved identification of *true* hot-spots in intra-axial neoplasms by coregistration of blood volume maps and morphological data

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Purpose: Relative cerebral blood volume maps (rCBV) in tumor derived from perfusion MRI have shown its potential with respect to detection of the most aggressive portions of the tumor, based on areas of elevated rCBV (hot-spots) [1]. One challenge with this method is to identify the appropriate region of interest of the tumor (avoiding large vessels and edema) as well correct identification of unaffected reference tissue. The purpose of the current study was to improve the identification and geometric accuracy of *true* hot-spots in intra-axial neoplasms by coregistration of cerebral blood volume maps and morphological images.

Methods: Nine patients with histologically confirmed brain tumors have so far been included. All imaging was performed at 1.5 T (Siemens Sonata) prior to surgery. rCBV maps were generated using established tracer kinetic models [2] applied to the first-pass data obtained by i.v. bolus injection of 0.1 mmol/kg of Gadovist (Schering AG). The time resolution of the first-pass gradient echo (GRE)-EPI sequence was 1.5 s and the voxel size was 1.8 x 1.8 x 6.5 mm³. In addition, axial T1-w SE and T2-w FSE images were acquired in all patients. The T1-w images were acquired after the first-pass data to provide standard contrast enhanced information. The rCBV maps were coregistered to the morphological data in two steps. First, an automatic coregistration was performed based on the DICOM geometry information in the respective datasets [3]. In a second step the overlay was manually adjusted by an experienced operator to optimally match the morphological underlay. The transparency of the overlay was interactively adjusted to identify large vessels as well as regions of contrast enhancement and edema from the T1-w and T2-w underlay data. Regions of interest (ROI's) were drawn directly on the rCBV overlays according to the combined overlay/underlay information in multiple slices including the entire tumor volume. Correct placement of the ROI's was confirmed by an experienced neuroradiologist (P.D-T). Tumor hot-spots were identified by automatic segmentation of the ROI-values to include the 20% highest values in each ROI. The segmented hot-spots were saved for all slices and the global maximum for each tumor was used as the true hot-spot. As reference rCBV, unaffected grey- or white matter ROI's were used as identified on the T2-w images. Normalized CBV (nCBV) values were then calculated as the ratio of the hot-spot value and the mean value of the unaffected reference tissue. All image analysis was performed using nICE™ (NordicIceMedical, Norway).

Results: The following tumor types were identified by histology in the nine patients: glioblastoma (n=3), astrocytoma (n=2), oligoastrocytoma (n=1), germinoma (n=1), solitary metastasis (n=1), unspecified low grade (n=1). All glioblastomas as well as the metastasis had an nCBV value > 4 whereas all other tumors had nCBV < 3.3. The use of coregistration of rCBV maps to morphological data was found to be a significant aid in differentiating blood vessels from true high blood volume regions. Figure 1 shows a sample case of the importance of identifying vessels when selecting tumor ROI's. The red arrow indicates area of true hot spot whereas the black arrow indicates a large vessel mimicking elevated tumor rCBV regions.

Discussion: The use of rCBV maps to differentiate high-grade from low-grade malignant tumors has been shown in multiple studies [1]. In our experience, the main challenge of this new and promising method is to identify appropriate tumor ROI's as well as the correct reference ROI's representing unaffected tissue. The use of coregistration and image fusion of rCBV maps with morphological data was found to aid significantly in this process, minimizing the problem with false positives due to incorrect inclusion of vessels in tumor ROI [4]. The ability to identify vessels is of particular importance when GRE based EPI sequences are used due to the larger sensitivity of this sequence to macrovascular structures in GRE-based compared to SE based sequences. In the present study, GRE-EPI was used due to higher achievable temporal resolution. By providing user friendly methods to coregister functional and anatomical data we hypothesize that the specificity of this method can be improved. This, however, needs to be verified in larger patient groups.

Conclusion: An nCBV cutoff value of 4 was found to uniquely identify high grade malignant brain tumors in the current study. The use of coregistration of rCBV maps to morphological T1-w and T2-w images was found to be an important aid in differentiating vessels from true high rCBV regions.

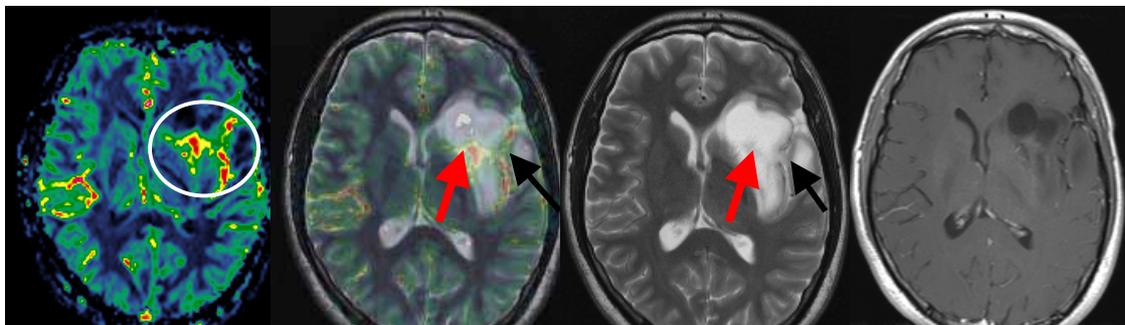


Figure 1 Sample case demonstrating the use of rCBV overlays to identify vessels within the tumor region (white circle). The images shown are (left to right): rCBV map, coregistered rCBV maps overlaid on T2-w FSE image, T2-w FSE and T1-w SE. The red arrow indicates the 'true' hot spot region and the black arrow shows the area of falsely elevated rCBV due to infiltrating vessel. The identification of the vessel location is significantly aided by the fused morphological/functional image.

References

- [1] Covarrubias DJ et al, *The Oncologist*, 2004;9:528-537
- [2] Ostergaard L et al, *Magn Reson Med*, 1996;36:715-725
- [3] Bjornerud A et al, *Proc Human Brain Mapping*, 2003;10:18 p
- [4] Lev MH et al, *Am J Neuroradiol*, 2004;25:214-221