First Clinical Evaluation of Vessel Size Imaging in Human Glial Brain Tumors

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Introduction

Glial tumors of different gradings have a variable extent of microvascular density which is a prognostic factor on the survival in patients (1,2) Thus, a non-invasive quantitative assessment of the microvasculature might have an important impact on differential diagnosis, tumor grading, and prognosis. Dynamic perfusion measurements can be performed together with the conventional post contrast examinations during contrast agent administration and therefore do not require additional scan time or contrast agent. Voxelwise, the vessel size index (VSI) can be calculated as presented in (3) that is closely related to the mean vessel caliber. However, as pointed out in (3), the VSI is semiquantitative, as it fails to provide an absolute quantification of the vessel caliber. Despite the relatively low resolution of fast dynamic perfusion scans, spatial information on tumor microvascularization may improve grading and biopsy accuracy. Therefore VSI maps were acquired to evaluate their diagnostic use.

Methods

In five patients with glial brain tumors the vessel-size-index was measured on a 3T TRIO scanner before neurosurgery. One patient with astrocytoma°II (A°II), one with astrocytoma°III (A°III), two patients with oligoastrocytoma °III (OA°III), and one patient with glioblastoma multiforme°IV (GBM), all histologically confirmed, were investigated. Dynamic perfusion measurement was performed during a constant intravenous gadolinium contrast bolus injection at 4 ml/s of 0.1 mmol/kg body weight. The data acqusition was performed using a multiecho EPI sequence (TE_{GE} = 23ms, TE_{SE} = 95 ms, TR = 1800 ms), giving rise to a GE and SE map of the brain at a resolution of 64x64x16 voxels every 1.8 seconds. The long TR strongly damps T1 saturation effects as often found in solid tumors where leakage occurs. VSI-maps were calculated based on the different transverse relaxation rates of vessels in spin-echo (T2) versus gradient-echo (T2*) measurements during the first bolus passage of contrast as published previously (3). Region of interest (ROI) analyses were performed of normal appearing white matter (WM), normal appearing gray matter (GM), thalamus (TH) and cerebrospinal fluid (CSF), and solid tumor.

Results

The VSI in solid tumors was twofold increased compared to normal appearing WM without overlap of the standard deviations (Figure1). This plot shows that the VSI of WM and TH is within a very small range between all patients, whereas tumor tissue, GM and CSF showed higher variability. In Figure 4, the particular values for each measurement are displayed. The highest graded tumor (GBM) showed the highest VSI, and over all patients, tumor VSI was twofold higher than VSI of normal WM. The VSI maps displayed in Figure 2 and 3 show a rim of higher VSI reflecting larger mean vessels diameters around a solid tumor center with smaller diameters in one representative patient with oligoastrocytoma °III as displayed on corresponding T1w images in Figure 5 and 6.

Discussion

The ROI evaluation is limited by the spatial resolution at the given temporal resolution (1.8s per volume). This leads especially at GM to partial volume effects of WM and CSF, which explains the higher variability. The lower varibility of WM and TH is attributed to the purity of the ROIs. This problems can only be overcome by higher resolution measurements. However the requirements on the speed of the measurements (approx. 5 volume scans per first ca bolus passage) are the limiting factor for the currently available spacial resolution. As displayed in Figures 2 and 3, a rim of higher VSI (→) indicates a higher vessel caliber as expected in this higher graded tumor (histologically OA°III). The regions of increased vessel caliber do not exhibit capillar leakage on T1w contrast enhanced images (Figures 5 and 6). As depicted in Figures 2 and 3, VSI allows a localization of altered vascularization which may reflect more malign sites within the solid tumor. Larger mean vessel diameters in the outer zone of a tumor may reflect tumor angiogenesis and recruitment of former small capillaries by the tumor. Thus, this new method being performed within an unused time slot during the investigation provides additional and valueable diagnostic information on the static images of brain tumor patients and devotes further investigation.

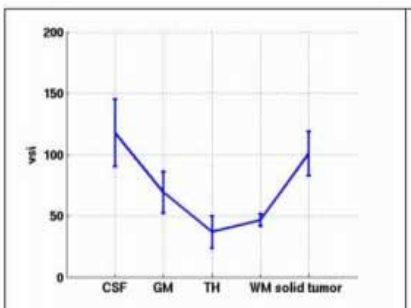

Figure 1:
Mean ± SD in different ROIs

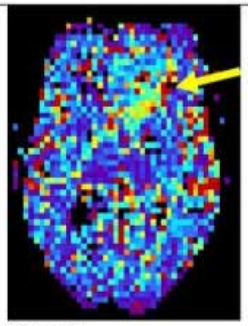

Figure 2:
VSI map of an OA°III

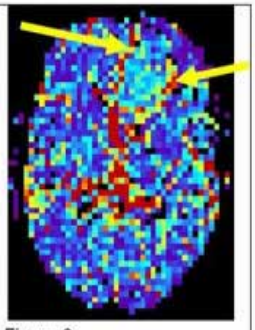

Figure 3:
VSI map of an OA°III

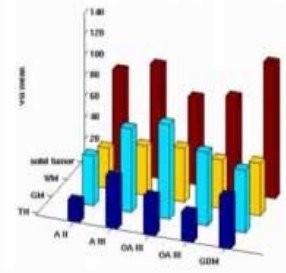

Figure 4:
VSI values of particular tumors

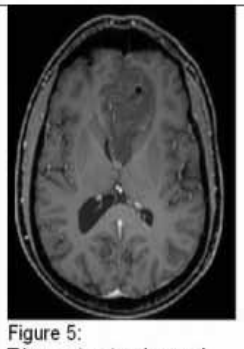

Figure 5:
T1w contrast enhanced image of an OA°III

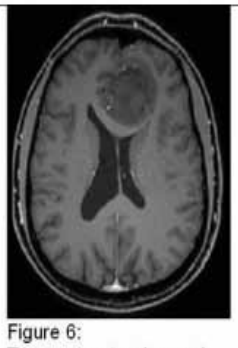

Figure 6:
T1w contrast enhanced image of an OA°III

References

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