The Local Image Variance - a Tool to Facilitate the Differentiation between Cerebral Lymphomas and High Grade Brain Gliomas

Günther Grabner[1], Sabine Goed[1], Christine Marosi[2], Stefan Wolfsberger[3], Aygül Mert[3], Georg Widhalm[3], Siegfried Trattnig[1], and Matthias Preusser[2]

[1]Department of Radiology, Medical University of Vienna, Vienna, Austria, [2]Institute of Neurology, Medical University of Vienna, Vienna, Austria, [3]Department of Neurosurgery, Medical University of Vienna, Vienna, Austria

Introduction:

The incidence of the comparatively rare cerebral lymphomas has increased within the last three decades. Due to their pleomorphic presentation, the differentiation to glial brain tumors can be challenging in routine clinical MR imaging. The purpose of this study was to analyze intratumoral structures of cerebral lymphomas and gliomas in a quantitative way using Susceptibility-Weighted Imaging (SWI) at 7 Tesla and the local image variance as measure. The local image variance is a measure of image variation in the vicinity of a pixel which is increased in case of a high density of blood vessels, intratumoral blood products and micro bleeds provided as signal loss on SWI images. In this work, we have used the local image variance in order to differentiate between cerebral lymphomas and gliomas.

Materials and Methods:

The patient cohort of this study included twenty-eight tumor patients; six patients with cerebral lymphoma, five patients with low grade gliomas (grade II) and 17 patients with high grade gliomas (grade III or IV). All tumors were histologically evaluated according to the WHO classification. All tumor patients underwent the following MR imaging protocol which included T1-weighted and SWI sequences. T1-weighted images were acquired before and after contrast agent (CA) administration using an MPRAGE sequence with the following imaging parameters: image-matrix = 320x320; resolution = 0.75x0.72x0.7mm; slices = 208; parallel imaging factor = 2, TR/TI/TE 3800/1700/3.55 ms, acquisition time = 10:29 min. Between the two T1 measurements SWI data were acquire using a fully first-order flow-compensated gradient-echo (SWI) sequence with a TE of 15 ms. Other sequence parameters were: TR = 28ms; image-matrix = 704x704 pixel; slices = 96; parallel imaging factor = 2, acquisition time = 10.18 min, resolution = 0.3x0.3x1.2mm.

In order to calculate robust and reliable local image variance maps SWI images were intensity corrected and rescaled in the arbitrary range between 0 and 100. The rescaling insures that no bias is introduced because of different image intensity ranges. The local image variance σ_{ij}^2 was then calculated using

$$\sigma_{ij}^2 = \frac{1}{(2L+1)^2} \sum_{k=i-L}^{i+L} \sum_{l=j-L}^{j+L} I_{kl}^2 - \left(\frac{1}{(2L+1)^2} \sum_{k=i-L}^{i+L} \sum_{l=j-L}^{j+L} I_{kl} \right)^2$$

where I_{kl} is the actual pixel intensity at the position ij. The area which contributes to the local variance is given by $(2L+1)$x$(2L+1)$ which was in our case a Gaussian filter kernel with a FWHM of 3mm.

Manual tumor segmentation was performed by a neuroanatomical expert on T1-weighted, contrast enhanced data. The tumoral regions of interest (ROIs) were afterwards transformed to the corresponding image variance maps. The mean local image variance was then calculated by using the ROIs.

Results:

Considering all lymphomas the mean value of local image variance was 63.3 with a standard deviation (SD) of 55.2.

High grade gliomas showed a mean local image variance of 132.35 (SD= 65.12) and low grade gliomas a mean variance of 44.7 (SD=19).

Cerebral lymphomas showed a significantly decreased local image variance (p= 0.015; t-test) compared to high grade gliomas. Compared to low grade gliomas, lymphomas did not show a significant difference in image variance (p= 0.2; t-test).

Discussion and Conclusion:

The local image variance can be used to facilitate the differentiation between cerebral lymphomas and high grade brain gliomas.

However, in order to provide reliable data all images should be acquired with the same resolution and an image intensity correction should be applied prior to the variance calculation.
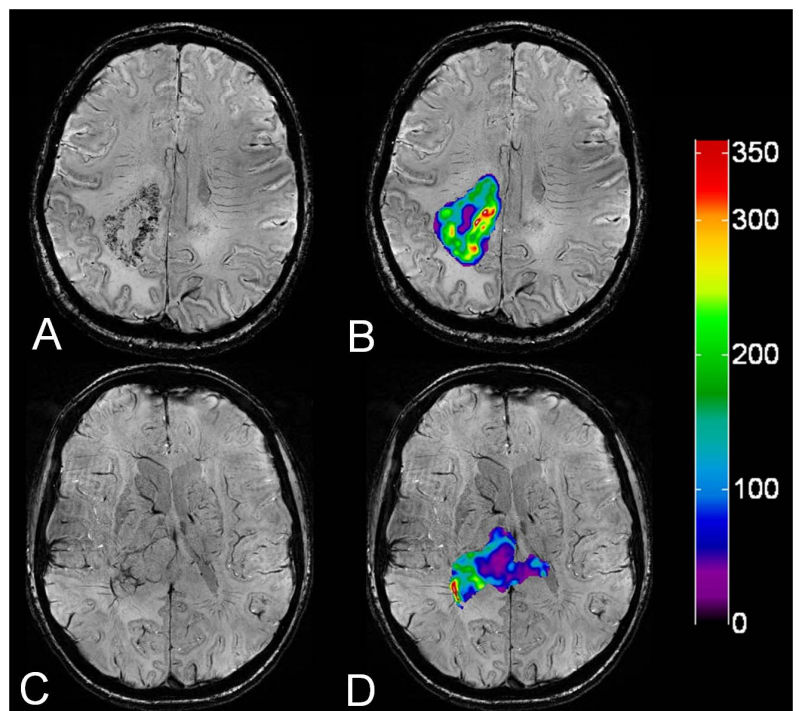

Figure 1: Intratumoral image variance; **A** represents a glioblastoma and in **B** the tumor is overlaid with corresponding local image variance. **C** and **D** represent a lymphoma. **C** represents the SWI image and in **D** the lymphoma is overlaid with corresponding local image variance. Note the higher variability in **B** compared to **D**.