Comparison of MRI measured mean micro-vessel segment length and micro-vessel radius and laser scan confocal microscopy after embolic Stroke

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Introduction: Magnetic resonance imaging (MRI) can non-invasively assess the evolution of several indices that characterize cerebral tissue after stroke with or without treatment. However, the dynamic changes of microvasculature during brain repair after stroke, which is crucial for recovery of neurological function, has not been investigated (1). The main objective of the present study was to noninvasively monitor the changes of microvasculature parameters such as mean segment length and vessel size index 6 weeks after the onset of stroke using magnetic resonance imaging (MRI) and correlate with 3D Laser Scanning Confocal Microscopy (LSCM).

Methods: Eight Male Wistar rats were subjected to embolic MCA occlusion. MRI measurements of T_2 and T_2* were obtained before and after intravascular injection of P904 (Guerbet Group Company, France) from 1 day to 6 weeks after stroke. The index $Q \equiv \Delta R_2/(\Delta R_2^*)^{2/3}$, where ΔR_2 and ΔR_2^* are changes in spin-echo and gradient-echo relaxation rates, respectively, caused by intravascular injection of a contrast agent (2,3). The microvessels perfused with FITC-dextran images were acquired from the LSCM and analyzed by a three dimensional (3-D**)** vessel quantification (3DVQ) program. The quantitative measurements of blood vessels performed by 3DVQ include measuring vessel diameters, vascular branching points, and lengths of vascular segments. The MRI parameters Q, ADC and CBV were used to derive the expression for the mean vessel size (VSI) and the mean segment length (MSL). Ischemic areas were determined using the threshold T_2 value of mean + 2 standard deviations from the T_2 value measured in the contralateral hemisphere on T_2 maps after stroke. Regions of ischemic recovery were identified by subtracting the ischemic core areas obtained 6 weeks after stroke from the ischemic area on the T_2 maps obtained 1 day after stroke. A 5 x 5 pixel region of interest (ROI) was selected from the center of each area.

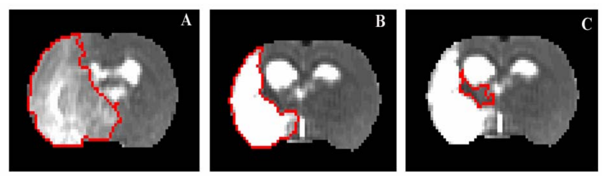

Fig. 1: T_2-maps at 24 hours (A), 6 weeks (B) after stroke show the evolution of the ischemic area and the recoveryregion (C)

Results: The results of the present study demonstrate that MRI Q-, MRI MSL- and MRI VSI- map measurements, based on CBV, ADC, ΔR_2 and ΔR_2^*, can be used to quantitatively investigate changes in the cerebral microvasculature induced by ischemia. Fig. 1 shows T_2 maps at 1 day (A), 6 weeks after stroke (B) and the recovery region (C) at 6 weeks after stroke. MRI MSL values for the same ROIs, were 16.61 ± 2.33 and 26.52 ± 3.20 µm, with corresponding LSCM MSL values of 21.44 ± 3.68 and 30.39 ± 3.94 µm, respectively. The MRI VSI values were 5.75 ± 0.54 µm and 4.81 ± 0.39 µm in the recovery and contralateral ROIs at 6 weeks after stroke. The corresponding VSI values measured by LSCM were 6.73 ± 0.71 µm in the recovery ROI and 4.51 ± 0.43 µm in the contralateral ROI. Fig. 2 indicates FITC-dextran images acquired from the original composite images from the microscope (A, B). A representative of skeleton plot of the microvasculature at 6 weeks after stroke generated from the 3-D vessel quantification (3DVQ) program (D,E). The histogram comparing the MRI measured MSL (C) and VSI (F) to data obtained from LSCM histology analysis for the recovery and the contralateral regions. The MRI results for both VSI and MSL correlated with corresponding LSCM VSI and MSL measurements in both the recovery region and contralateral normal tissue.

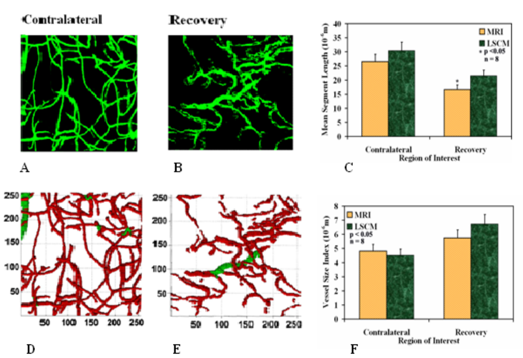

Fig. 2: FITC-dextran images from the original microscope (A, B) images. A representative of skeleton plot generated from the 3-D vessel quantification (3DVQ) program (D,E). The histogram comparing the MRI measured MSL (C) and VSI (F) to data obtained from LSCM histology analysis for the recovery and the contralateral regions.

Discussion and Conclusion: The average MRI VSI obtained for normal tissue in the current study (4.81 ± 0.39 µm) is consistent with the LSCM VSI measured by both Zhang (4.7 ± 0.1 µm) (4) and Morris (3.7 ± 2.50 µm) (5). The average MSL value of 26.52 ± 3.20 µm is also consistent with Morris's value of 29.7 ± 14.70 µm. In summary, this study demonstrates that the MRI MSL and VSI-maps are useful tool**s** for quantifying microvasculature *in vivo.* This study also validates a new MRI methodology to measure all the parameters of the microvasculature and also monitor the in vivo evolution of vascular remodeling.

References:

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