White Matter Ischemic Changes in Patients with Hyperacute Ischemic Stroke: A Voxel-Based Analysis Using Fractional Anisotropy and Dynamic Susceptibility Contrast Perfusion

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Purpose:

Using diffusion tensor imaging (DTI)-fractional anisotropy (FA), the ischemic microstructural changes can be heterogeneous and variable between the infarction core and ischemic regions (1). The purpose of this study was to evaluate the DTI-FA changes of white matter infarction and hypoperfusion in patients with acute ischemic stroke (AIS) using a quantitative voxel-based analysis.

Materials and Methods:

The inclusion criteria for this prospective study were: patients with AIS who presented within six hours from symptom onset with acquisition of both DTI and DSC perfusion on a 3 T MR scanner (Skyra, Siemens). Dynamic susceptibility contrast perfusion was performed using a gradient-EPI sequence (TR/TE: 1450/22 msec, FA 90º, FOV: 22×22-cm, matrix 128 mm, voxel size 1.7 x 1.7 x 4 mm^3, GRAPPA x3) after intravenous injection of 0.1 mmol/kg of Multihance-gadolinium contrast. Diffusion tensor imaging were acquired by using single-shot echo-planar imaging (TR/TE, 5500/82 ms; FOV: 22×22-cm; matrix 128 mm; voxel size 1.5 x 1.5 x 2 mm). Diffusion-sensitized gradients were applied along 20 noncolinear directions with a b-value of 1000 s/mm^2 resulting in four minutes acquisition time. The measured FA, apparent diffusion coefficient (ADC), and Tmax images were coregistered for voxel-based quantification using a region-of-interest (ROI) approach in the ipsilateral affected side and in the homologous contralateral white matter (WM). The infarction core and hypoperfusion were determined by threshold method defined as an ADC value less than 600 x 10−6 mm 2/s 2 and DSC-Tmax> 2 sec 3. A mask of the gray matter (FA threshold > 0.15) was generated for each patient to ensure extraction of voxel values is limited only to WM. The image analysis was performed by combination of FDA approved software (Olea Medical, La Ciotat, France) and Matlab. Data were analyzed by unpaired t-test.

Results:

Fifteen patients (9M, age 48-83 years old) met our inclusion criteria. The average time from onset to MR imaging was 4.3 hours and the NIH stroke scale range was 4-12. Total number of voxels included were 1100 for WM infarction, 5100 for WM hypoperfusion and 3300 for normal contralateral WM. The mean of FA values were significantly higher in the regions of WM hypoperfusion ($p<0.0001$, t: 7.90) and significantly lower in the regions of WM infarction ($p<0.0001$, t: 6.52), compared to FA values in the contralateral normal WM. In subanalysis of hypoperfused regions with different Tmax, the FA values were significantly higher ($p<0.0001$, t: 32.0) in the hypoperfused WM with Tmax ≥ 6 sec in comparison to regions with Tmax< 6 sec with a mean difference of 0.14 (see Figure 1). The mean of Tmax values was significantly higher in both WM hypoperfusion ($p<0.0001$, t: 58.31) and WM infarction ($p<0.0001$, t: 42.70), compared to Tmax values in the contralateral normal WM. The mean ADC values were significantly lower in the WM infarction ($p<0.0001$, t: 58.3) in comparison to hypoperfused WM and normal WM. There was no statistically significant difference between the mean ADC values in the WM hypoperfusion and normal WM ($p =0.07$, t: 2.1).

Conclusions:

Diffusion tensor imaging-FA is decreased in regions of WM infarction and increased in hypoperfused WM in

patients with AIS. The FA values are significantly higher in the hypoperfused WM with Tmax ≥ 6 sec suggestive of early microstructural changes related to ischemia.

Adult Brain:

Stroke

Anatomy - Secondary:

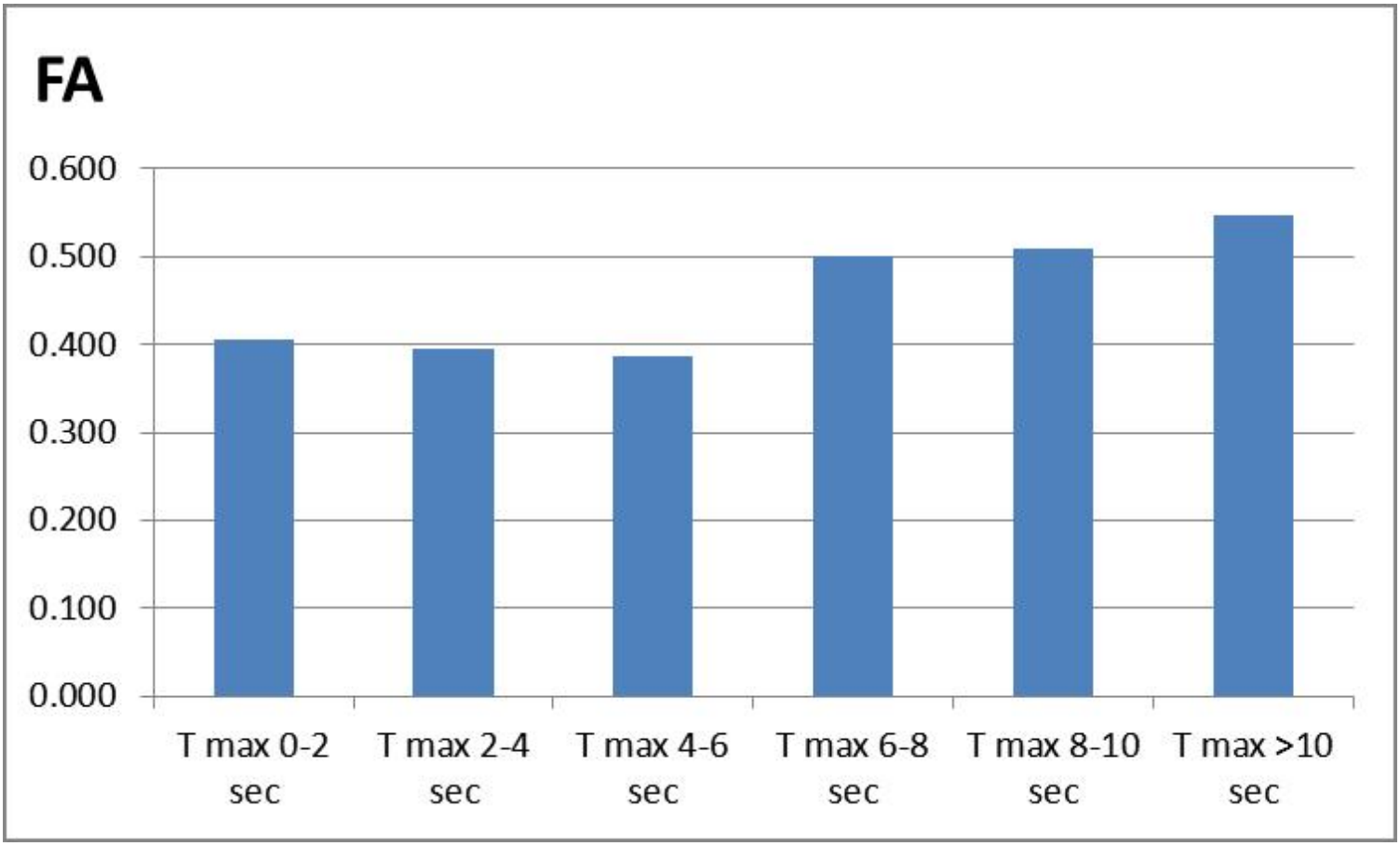
Brain

Keywords:

Actue Stroke

Diffusion Tensor Image

Dynamic Susceptibility Contrast-Enhanced



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