T2 component "area fractions": a possible marker for ischemic penumbra

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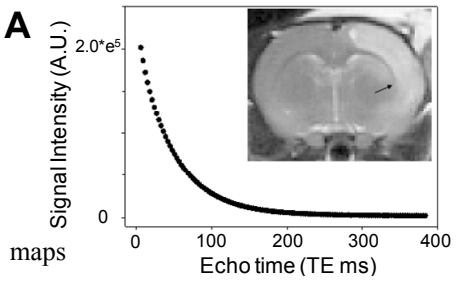
INTRODUCTION: Multiexponential quantitative T2 (qT2) analysis was largely pioneered to study white matter degeneration and myelin water fraction in multiple sclerosis [1, 2]. The method involves inverting multiecho data into the T2 components to generate a T2 distribution. A major area of interest in infarction is the identification of penumbra, or the volume of brain peripheral to the infarct which is potential recoverable with treatment. The penumbra may be identifiable using the perfusion/diffusion mismatch but there remains uncertainty [3]. Multi-echo T2 values have been reported for stroke [4] but the regions were analysed as average values of an ROI. This project applies voxel based analysis of T2 to study "within voxel" heterogeneity of pathophysiology in ischemia.



METHODS: Infarcts were induced using a clip model with one hour of reversible occlusion of the middle cerebral artery. MR imaging on Wistar rats (n=5) was conducted at 9.4T using a Bruker console and a 35 or 45mm quadrature birdcage coil 1 day after transient ischemia. A multi-echo spin echo sequence was used (TR=1.5s, TE=3ms, 128 echoes, FOV=3x3 cm, matrix=128x128 pixels, slice=1.5 mm, NA=4). Voxel based multicomponent analysis was done using a non-negative least squares fitting routine in Matlab. Data was smoothed using a cross-regularization approach[5]. qT2 visualization maps were created by performing pixel-wise NNSL within the brain[6].

Figure 1. Multiecho data analysis of rat brain. A. T2w MRI of a representative stroke region imaged 24 hrs after a 1hr reversible ischemia. The infracted area is hyperintense (arrow) on T2w MRI. Subjects also showed hyperintense regions in the thalamus. A representative multiecho dataset is also shown, collected as average SI at each TE from an ROI in the contralateral cortex. B. T2 distribution of the contralateral region. C. T2 distribution of an ROI within the infarct.

RESULTS: Figure 1 shows the method and the separation of the short component (<10ms) and the intermediate component. Fig. 2 shows a representative example of the infarct displayed as a T2 map and of different water fraction components. The "edge" of the infarct is highlighted in "C" and is clearly differentiated from the main core of the infarct shown in "D". This pattern was observed in each of the 5 infarcts examined.

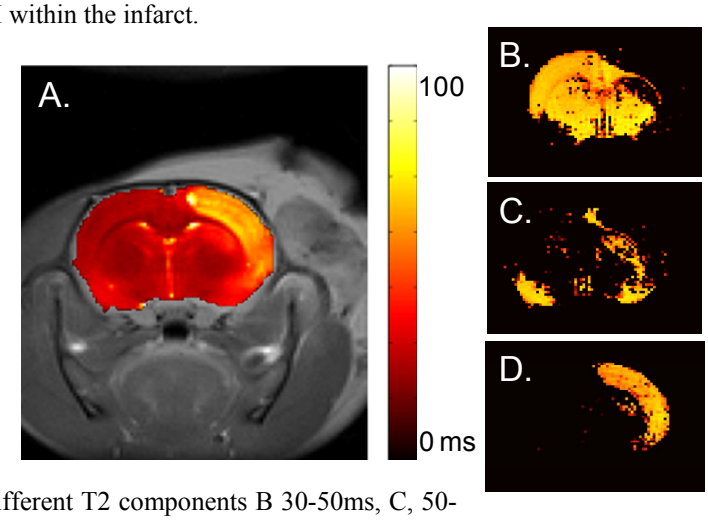


Figure 2. Visualization of infarct heterogeneity. A. T2 map overlaid on a T2w MRI of the rat head. The map clearly shows the infarct as a region with higher T2 values. B-D Area fractions of different T2 components B 30-50ms, C, 50-60ms and D. 60-200ms.

DISCUSSION: We have data showing that a qT2 approach, with voxel by voxel analysis of multi-echo data is sensitive to the core and periphery of an infarct. By analyzing within a voxel, we were able to visualize the proportion (area fraction) of T2 assigned to any range of T2. These data are consistent between subjects and show a high potential of being specific to pathophysiological changes in a region that may correspond to penumbra.

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