

IDENTIFYING INFARCT LESION USING DIFFUSION KURTOSIS MODEL WITH MULTI-BAND EPI SEQUENCE IN ACUTE ISCHEMIC STROKE PATIENTS

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Target audience: Radiologists, neurologists, scientists and MRI researchers interested in stroke and diffusion weighted imaging.

Introduction: The key to thrombolytic therapy in acute ischemic stroke is identifying the areas of infarct lesion in acute stage. Despite being the gold standard technique for stroke assessment, conventional diffusion magnetic resonance imaging (DWI) based on Gaussian model provides only partial information about tissue microstructure. As an emerging diffusion model, Diffusion kurtosis imaging (DKI) could be used for stratifying the heterogeneously damaged DWI lesion using the non-Gaussian water diffusion model^{1,2}. However, the total acquisition time of a DKI protocol with standard EPI sequences is relative long and does not fit the requirement for scanning patients with acute stroke. By using a prototype simultaneous multi-slice accelerated (SMS) EPI sequence for DKI data recording, the total acquisition time could be cut down to 1/2~1/3 of standard EPI-based DKI without losing SNR. So in this study, we collected DKI data with the SMS EPI technique and compared the volumes of the lesion areas measured from routine ADC and mean kurtosis (MK) map in patients with acute ischemic stroke (3-8h from onset).

Materials and method: 6 patients in acute ischemic stroke stage (3-6h from onset) were included in this study. All data were collected on a MAGNETOM Trio Tim 3T MR scanner (Siemens AG, Erlangen, Germany) using a 32-channel head coil. Besides general protocols for brain vascular disease, the exam of acute stage includes a standard DWI protocol and a a prototype SMS DKI protocol with the following parameters. DWI: b-values: 0, 1000s/mm², 3-scan Trace mode, TR/TE=4200/93 ms, flip angle=90°, 24 slices, slice thickness=5 mm, distance factor=30%, FOV=230×230 mm², matrix=192×192, iPAT=2, averages=2, total acquisition time 1min. SMS DKI three b-values: 0, 1000, 2000 s/mm², 30 directions, TR/TE=3000/133 ms, flip angle=60°, 60 slices, slice thickness=2 mm, distance factor=0%, FOV=220×220 mm², matrix= 110×110, slice accelerate factor=4, iPAT=2, average=1, total acquisition time 3min. There was another follow-up MR exam using a volumetric magnetization-prepared rapid gradient echo (MPRAGE) T1-weighted sequence (TR=2300 ms; TE=3.01 ms; TI=900 ms; flip angle=15°, FOV=256×256 mm², matrix size=256x 256, slice thickness=1 mm, slice number=176, voxel size=1×1×1 mm³) executed 7 days after the first exam. The DKI data were post processed using Diffusion Kurtosis Estimator (DKE) pipeline. The lesion areas were manually drawn on ADC, MK and MPRAGE maps by two experienced neuro-radiologists independently. The volume of each lesion area was calculated by using Mricron.

Results:

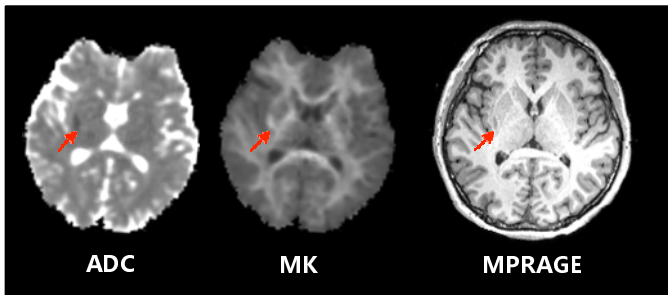


Figure1. 32y male patient with infarct in the right external capsule. DWI and DKI were acquired at 3h after onset. The infarct lesion shows a low ADC value and a high MK value.

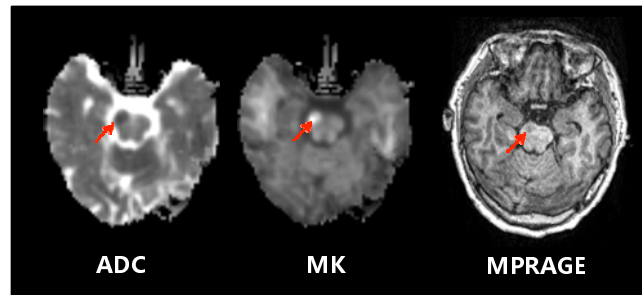


Figure2. 65y female patient with infarct lesion in left cerebral peduncle. Images (ADC and MK) were acquired at 5h after onset of infarction. The infarction shows a very high MK value and a low ADC value.

As shown in Fig.1 and Fig.2, the lesion size on the MK map is slightly bigger than on MPRAGE, while the lesion size on the ADC map looks much larger. Using the lesion volume measured on the MPRAGE image in the follow-up scan as reference (100%), the volume of lesions measured from MK map in acute stage is 117% and 163% compared to the ADC map. The statistic results (Fig.3) demonstrate the volumes of the infarct areas measured by SMS DKI are much closer to the real size than routine DWI (paired t-test, $p=0.0034$).

Conclusions and Discussion:

In the identification of the final infarct size in acute ischemic stroke, the volume measurements by SMS DKI in the acute-phase is more reliable than that of ADC, and the DKI data could be acquired in a reasonable time with the SMS EPI sequence.

References: 1. Cheung J S, et al., Stroke, 2012, 43(8):2252–2254. 2. Jensen J H, et al., NMR Biomed, 2010, 23(7):698–710.

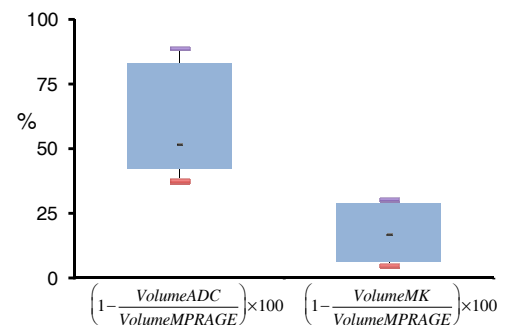


Figure3. The statistic results of the volume differences among all acute-stroke patients.