Improve lateralizing sensitivity in temporal lobe epilepsy by combining structural MRI with regional cerebral blood flow and apparent diffusion coefficient

Xiaoqin GUO[1,2], Shangchen XU[3], Guangbin WANG[1], Yi ZHANG[4], Lingfei GUO[1], and Bin ZHAO[1]

[1]MRI, Shandong Medical Imaging Research Institution, Jinan, Shandong, China, [2]Medicine, Shandong University, Jinan, Shandong, China, [3]Neurosurgery, Shandong Provincial Hospital, Shandong, China, [4]Medical Imaging Processing Center, Shandong Medical Imaging Research Institution, Shandong, China

Target Audience: Radiologists and neurologists interested in lateralizing temporal lobe epilepsy (TLE) by using arterial spin labeling (ASL) or DWI techniques.

Purpose: Structural MRI (sMRI) contributes a lot in the lateralization of TLE with mesial temporal sclerosis (MTS). However, nearly 30% TLE patients appear normal on sMRI[1], which is worthless under this condition. MRI perfusion and DWI were helpful for lateralizing non-MTS TLE patients.[2,3] Our study aims to explore their performance on lateralization in TLE using ASL and DWI techniques by calculating asymmetry indices (AI) of regional cerebral blood flow (rCBF) and apparent diffusion coefficient (rADC).

Methods: Twenty-seven TLE patients (14M, 33±10 years, age range 16-55, duration of epilepsy 9.7±8 years, duration range 1-35, all well-lateralized by ictal video or scalp EEG and 6 MTS have been confirmed by pathology) and 30 normal controls (14M, 35±11 years, range16-55) underwent MRI examination with a 3.0 T scanner (Signa HDxt, GE Healthcare) using an 8-channel phased-array head coil in the steady state. The distribution of age in TLE and controls was not different (p=0.291). There were no significant differences in sex between groups ($\chi 2$ test, p=0.696). The sMRI included an axial 3D T1-weighted sequence (TR/TE/TI 7.6/3.3/450 ms, 60 slices, -2.0ov), an axial T2 FLAIR sequence (TR/TE/TI 8002/152.2/2250 ms) and three orientations T2WI sequences for mesial temporal lobes evaluation. ASL perfusion imaging was performed with a stack-of-spirals 3D-fast-spin echo pCASL sequence with background suppression. The parameters were as follows: TR/TE/Post Label Delay 4521/9.8/1525 ms, NEX 3, spiral readout of 8 arms ×512 samples, 30 slices with whole brain coverage. DWI with TR/TE 5300/74.5 ms, b-values 0 and 1000. The slice thickness (4 mm), slice gap (0 mm), FOV (240×240 mm) and scanning angle were consistent in axial sequences. ROIs were placed at bilateral hippocampal heads (H), amygdalas (A) and thalami (T) (Fig 1). The measurement of rCBF and rADC values was operated on CBF, ADC maps and T1 images (as references) by ImageJ 1.46r software (NIH, USA) to keep ROIs consistency on different images of one subject. The final rCBF and rADC values at T were the average acquired on three continuous slices. AI=100×(contralateral-ipsilateral)/(contralateral+ipsilateral) in patients. AI=|100×(left-right)/(left+right)| in controls. The intraclass and interclass differences were tested by Wilcoxon Signed Ranks Test and Mann-Whitney U Test. Logistic regression analysis was used to calculate the predicted probability combining the outcome on sMRI and the AI of rCBF and rADC as covariates. Receive operating curves (ROC) were produced to compare the lateralizing sensitivity and specificity of rCBF and rADC (SPSS and Medcalc).

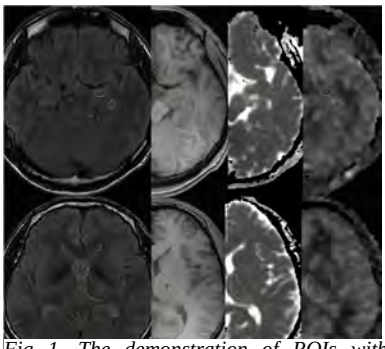

Fig 1. The demonstration of ROIs with images (FLAIR/T1/ADC/CBF) of a right-sided MTS patient.

Results: All rCBF and rADC values of three different ROIs except the rADC values of T had significant differences in ipsilateral and contralateral ROIs in TLE patients, while only the rCBF values of H and T had significant differences in right and left side in controls. The ipsilateral values except the ipsilateral rADC values of T in TLE were lower than average values of right-and left-side ROIs in controls statistically. Moreover, only the AI of rADC values of T had no difference between patients and controls (Fig 2). The ROC outcomes were displayed in Fig 3.

Discussion: Although a previous study reported that seizure propagation from the presumed epileptogenic focus or regions close to it into the thalamus occurs in TLE and results in circumscribed neuronal loss in the thalamus[4], in our study the rADC values of ipsilateral T had no significant decreased and AI of rADC in T of patients closed to controls'. It had been studied that MTS patients showed significant changes in all DTI parameters with small increases of mean diffusivity. In contrast, no significant difference was found between non-MTS patients and healthy controls.[5] This may be the main reason why the indices in T was not significant different between TLE and controls in our study, since the patient group included both MTS and non-MTS patients. According to our results, AI of rADC did not perform as well as AI of rCBF. For similarly reasons, rADC had less increase in non-MTS patients, but rCBF changes were same as MTS patients and different from that of controls, which was confirmed by our former study.

Conclusion: Combining AI of rCBF with sMRI performs better in improving lateralizing sensitivity in TLE than rADC.

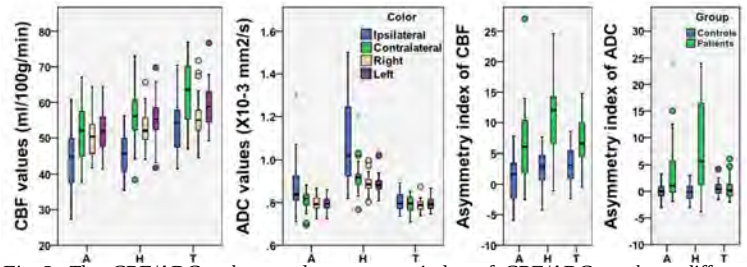

Fig 2. The CBF/ADC values and asymmetry index of CBF/ADC at three different locations in patients (ipsilateral, contralateral) and controls (right, left). H, hippocampal head; A, amygdala; T, thalamus.

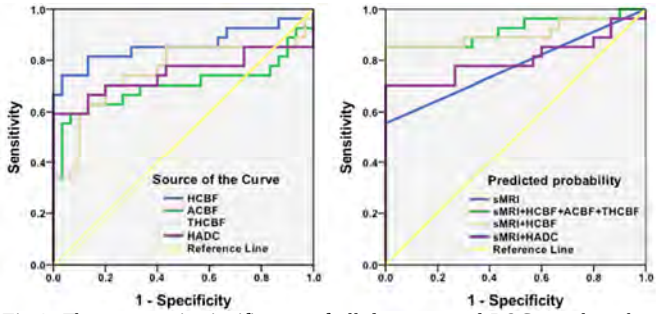

Fig 3. The asymptotic significance of all demonstrated ROC was less than 0.001. The area under curve (AUC) of ROC in left picture was 0.859, 0.704, 0.756 and 0.749 from the top down. According to the right picture, the lateralizing sensitivity and specificity of sMRI were 55.6% and 100% (AUC of ROC1=0.778). Combining AI of rCBF in three ROIs with sMRI, the lateralizing sensitivity and specificity could up to 85.2 and 100% (AUC of ROC2=0.919). Combining HCBF with sMRI, the lateralizing sensitivity and specificity could also up to 85.2 and 100% (AUC of ROC3=0.904), while they could only up to 70.4% and 100% (AUC of ROC4=0.806) combining HADC. Only ROC2 and ROC3 were different from ROC1 (p=0.0046 and 0.0171 respectively).
HCBF, AI of rCBF in hippocampal head; ACBF, AI of rCBF in amygdala; THCBF, AI of rCBF in thalamus; HADC, AI of rADC in hippocampal head.

References: 1. Kendall, Robertson NP. Neuroimaging. J Neurol. 2012;259:2009-2011.
2. Lim YM, Cho YW, Shamim S, et al. Usefulness of pulsed arterial spin labeling MR imaging in mesial temporal lobe epilepsy. Epilepsy Res. 2008;82:183-189.
3. Goncalves PM, Pereira, Oliveira E, et al. Apparent diffusion coefficient mapping of the hippocampus and the amygdala in pharmaco-resistant temporal lobe epilepsy. AJNR Am J Neuroradiol. 2006;27:671-683.
4. Susanne GM, Kenneth DL, Jerome B, et al. Involvement of the thalamocortical network in TLE with and without mesiotemporal sclerosis. Epilepsia. 2010;51:1436-1445.
5. Gaolang G, Luis C, Christian B, et al. Thalamic diffusion and volume in temporal lobe epilepsy with and without mesial temporal sclerosis. Epilepsy Res. 2008;80:184-193.