An ictal epilepsy case monitored by resting-state fMRI

Peng-Fei Qiao, MD, Guang-Ming Niu, MD.

ABSTRACT

تجرى أكثر دراسات التصوير بالرنين المغناطيسي في حالة الراحة في مرحلة مابين النوبات الصرعية وذلك لأن التصوير خلال حدوث النوبات الصرعية يعد غير مناسباً. نستعرض في هذا التقرير حالة مريضة مصابة بالصرع تبلغ من العمر 13 عاماً، وقد أُجريت لها الاختبارات أثناء حدوث النوبات الصرعية. لقد كان تشخيص الحالة على أنها حالة نوبات صرعية جزئية بسيطة، وكانت تأخذ عقاقير مضادة للصرع. ولم تتعرض المريضة إلى أي من الأعراض الشديدة بعد العلاج. ونستنتج من هذه الحالة بأن تحليل سعة تذبذب الترددات الدنيا قد يكون وسيلة فعالة أثناء عمل التصوير بالرنين المغناطيسي لمرضى الصرع.

Most resting-state functional MRI studies of epilepsy are conducted in the interictal phase as the ictal phase is not suitable. We report and discuss a 13-year-old female epilepsy patient who had ictal examination. She was diagnosed with simple partial seizure epilepsy and on regular anti-epileptic drugs. There were no significant symptoms after careful treatment. We conclude that analysis of the amplitude of low frequency fluctuations may provide a useful tool in the functional MRI study of epilepsy.

Neurosciences 2012; Vol. 17 (3): 256-258

From the Department of Radiology (Qiao, Niu), Beijing Tiantan Hospital, Capital Medical University, Beijing, and the Department of Radiology (Qiao, Niu), The Affiliated Hospital of Inner Mongolia Medical College, Hohhot, China.

Received 30th November 2011. Accepted 20th February 2012.

Address correspondence and reprint request to: Dr. Guang-Ming Niu, Department of Radiology, Beijing Tiantan Hospital, Capital Medical University, Beijing 100050, China. Tel. +86 (471) 6637992. Fax. +86 (471) 6284555. E-mail: niugming@gmail.com

Disclosure. The authors declare no conflicting interests, support or funding from any drug company.

Epilepsy is a common neurological syndrome; the essence is a brain dysfunction caused by the abnormal discharge of the neuron pool. Approximately 60-90% of idiopathic intractable epilepsy can be cured by surgical operation. Successful outcome following resective surgery for epilepsy depends on accurate localization of the epileptogenic zone. However, there are many obscurities of the pathophysiological mechanisms. At present, there are several methods of neural imaging in epilepsy research. 1. Measuring the hippocampal volume and carrying out hippocampal magnetic resonance spectroscopy (MRS). 2. Using positron emission tomography (PET) or single-photon emission computed tomography (SPECT) to reflect the blood flow and metabolization of the abnormal region. 3. Undertaking a certain task to induce blood oxygenation level dependent (BOLD) signals of some brain tissue to change, which indirectly reflects the neuronal activity called "event-related functional MRI (fMRI)". However, some drawbacks exist in each method. The first method is not objective because of different researcher bias. The second method is invasive and radioactive. In the third method, the researcher must design the task carefully, the patient must be involved, and they have to work well together.

Currently, the resting-state functional MRI (rfMRI) further enriches the content and means of fMRI research, and also provides a new effective non-invasive idea for the exploration of the working mechanisms and laws of epilepsy in the resting state.¹ Based on the fact that there are coherent low frequency fluctuated BOLD signals in widespread, but functionally related brain regions,² the amplitude or power (square of amplitude) of low frequency fluctuations can provide both the nature and extent of signal changes underlying spontaneous neuronal activities.³ Recently, an approach that can directly measure the amplitude of low frequency fluctuation (ALFF), which is thought to directly reflect the spontaneous activity of neurons, was used to investigate brain functions of both healthy subjects and clinical patients.⁴ Although epileptic discharges reflect abnormal spontaneous activities, they have been assumed to be equivalent to the activities associated

with an "external task."⁵ Here, we report our initial findings after applying this ALFF analysis to the rfMRI data collected from an ictal epilepsy patient in order to explore the ALFF alteration related to epileptic events, and to tentatively determine the localization, or at least, lateralization of the epileptogenic zone.

Case Report. A 13-year-old girl with a 9-year epileptic history was admitted for grand mal seizures. Most of her semiology was the typical idiopathic simple partial seizure (SPS), such as the right lower limb twitched, and occasionally SPS with spasm of the whole body leading to generalized tonic-clonic seizures (GTCS). The EEG reported the main epileptic zone located in the left temporal and parietal lobe, accompanied by nonsynchronous and frequent 3.5-4.5 c/s spikes and slow waves of the bilateral hemispheres. Conventional MRI scan appeared normal.

She then underwent 2 EEG-fMRI examinations continuously. The EEG signals were recorded with a 5,000 Hz sampling rate by a 32-channel Ag/AgCl electrode in an MRI compatible EEG system (VR Brain Products, Munich, Germany). The data were filtered using BrainVision Analyzer 1.05 software (VR Brain Products, Munich, Germany) to detect the epileptic spike waves. The MRI data were collected using a 3.0 Tesla MR scanner (GE-Signa HDx, Milwaukee, WI, USA). Functional scanning was performed using gradient echo echo-planar imaging sequences (field of view 24x24cm, 64x64 matrix, flip angle 90°, repetition time 2000 ms, echo time 30 ms) with whole brain coverage using 38 oblique axial 4mm slices with 0mm spaces between the slices. The scanning lasted for 512 seconds, producing 256 brain volume data sets. The first 10 images were excluded owing to T1 equilibrium effects. Finally, the data preprocessing and analyzing were performed using the Statistical Parametric Mapping software package.

On analysis of the procedure of head motion rectification and simultaneous EEG results, we found the patient experienced several slight clinical epileptogenic events during the examination. We used t-test to observe the brain activation under the conditions of relatively good data quality. Two results basically looked the same: 1. Bilateral cerebral cortexes activated generally, distributed symmetrically (Figure 1). 2. The response-signal curve showed it was the classic BOLD reaction (Figure 2).

During a 12 months follow-up period, she took her anti-epileptic drugs regularly and no significant symptoms were observed. She is currently healthy.



Figure 1 - Ictal epilepsy caused general bilateral cerebral cortex activationA) bilateral parietal lobe, B) bilateral temporal lobe, C) bilateral frontal lobe. The strongest activated point was located in the paracentral gyrus of the left parietal lobe (arrow).



Figure 2 - The response-signal curve showing classic blood oxygen level reaction (the peak point appeared in the fifth second).

Discussion. The EEG-fMRI, which combines the high time resolution EEG and high space resolution fMRI technique, can effectively observe the brain activities caused by epilepsy. However, carrying out an MRI EXAM in the ictal phase is not suitable due to unconscious movement of the patient, and so most EEG-fMRI studies are conducted in the interictal phase. At present, there are limited EEG-fMRI studies during the ictal phase.^{6,7} The seizures in our patient were typical, and the clinical information was also complete. For the influenced data, which was caused by head moving during the ictal phase, 2 results were consistent, and the response-signal curve showed it was the typical BOLD signal rather than the movement, all of which indicated the activated brain regions were caused by epileptogenesis. It is commonly thought that focal epilepsy originates in the cerebral cortex.8 Our patient had typical SPS features in line with focal epilepsy. Furthermore, our study also found that the maximum point of activation was located in the left parietal cortex, which is close to movement regions in the left side of the brain. The abnormal discharges also lead to the right motor dysfunction. These findings indicated that the areas were the epileptic sources. Epileptic seizure leads to widespread activation of the cerebral cortexes,

and may be related to epileptic activities broadcasted and disseminated in the cortexes in various ways. It is now believed that the seizure spreads mainly within the cortex fibers, and passes to the contralateral side through the corpus callosum, then after the adjustment of subcortical structures, diffused general cortices and causes the grand mal seizure.⁹

In conclusion, compared with the indirect results of interictal epilepsy, our study directly reflected the ictal propagation and diffusion reaction of the brain activity caused by epilepsy seizure. The ALFF analysis is important as a new data-driven tool for the detection of ictal epileptiform abnormality, and possibly as an additional non-invasive tool for detecting epileptogenic foci. The results also strengthen the idea that alterations in amplitude play a central role in epileptogenesis.

References

- 1. Qiao PF, Gao PY, Dai JP, Niu GM. Research progress on resting state fMRI of epilepsy. *Brain Dev* 2012; 34: 8-12.
- 2. Fox MD, Raichle ME. Spontaneous fluctuations in brain activity observed with functional magnetic resonance imaging. *Nat Rev Neurosci* 2007; 8: 700-711.

- Duff EP, Johnston LA, Xiong J, Fox PT, Mareels I, Egan GF. The power of spectral density analysis for mapping endogenous BOLD signal fluctuations. *Hum Brain Mapp* 2008; 29: 778-790.
- Yang H, Long XY, Yang Y, Yan H, Zhu CZ, Zhou XP, et al. Amplitude of low frequency fluctuation within visual areas revealed by resting-state functional MRI. *Neuroimage* 2007; 36: 144-152.
- Zang YF, He Y, Zhu CZ, Cao QJ, Sui MQ, Liang M, et al. Altered baseline brain activity in children with ADHD revealed by resting-state functional MRI. *Brain Dev* 2007; 29: 83-91.
- 6. Laufs H, Hamandi K, Walker MC, Scott C, Smith S, Duncan JS, et al. EEG-fMRI mapping of asymmetrical delta activity in a patient with refractory epilepsy is concordant with the epileptogenic region determined by intracranial EEG. *Magn Reson Imaging* 2006; 24: 367-371.
- Salek-Haddadi A, Merschhemke M, Lemieux L, Fish DR. Simultaneous EEG-Correlated Ictal fMRI. *Neuroimage* 2002; 16: 32-40.
- Pereira FR, Alessio A, Sercheli MS, Pedro T, Bilevicius E, Rondina JM, et al. Asymmetrical hippocampal connectivity in mesial temporal lobe epilepsy: evidence from resting state fMRI. *BMC Neurosci* 2010; 11: 66-78.
- Bettus G, Bartolomei F, Confort-Gouny S, Guedj E, Chauvel P, Cozzone PJ, et al. Role of resting state functional connectivity MRI in presurgical investigation of mesial temporal lobe epilepsy. *J Neurol Neurosurg Psychiatry* 2010; 81: 1147-1154.

Related topics

Nandhagopal R, Al-Asmi A. A young adult with seizure and visual field defect. *Neurosciences* 2011; 16: 389-390.

Tian Y, Yang S, Zhang L, Shi Z, Bao S. Enhanced expression of glial fibrillary acidic protein in the hippocampus one month after whole brain irradiation of adult rats. *Neurosciences* 2011; 16: 114-119.