European Review for Medical and Pharmacological Sciences 2019; 23: 10964-10969

# Analysis of EEG abnormalities of cognitive impairment and epileptic seizures in patients with epilepsy

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**Abstract. – OBJECTIVE: We conducted this study to analyze the EEG abnormalities of cognitive impairment and epileptic seizures in patients with epilepsy, as well as to investigate the application value of EEG in the diagnosis of epilepsy with cognitive impairment.**

**PATIENTS AND METHODS: 62 cases of patients that were admitted to our hospital for the first diagnosis as status epilepticus were selected. Of those, 20 cases were accompanied by cognitive impairment. The America Biology Graphene type 24 leads channel video EEG was applied to monitor staging, index, frequency, and distribution range of epileptic discharge. The revised Wechsler Adult Intelligence Scale-Revised in China (WAIS-RC) and Wechsler Memory Scale-Revised in China (WMS-RC) were adopted to test cognitive function.**

**RESULTS: The epileptic discharge index, discharge frequency and discharge distribution range of the conscious period, sleep I-II period and sleep III-IV period of epilepsy with the cognitive impairment group were evidently higher than those of epilepsy without cognitive impairment group. The differences were statistically significant ($p<0.05$). Intelligence Quotient (IQ) and Memory Quotient (MQ) level of the cognitive impairment group were the lowest in sleep III-IV period, with the next being the sleep I-II period; the highest was the conscious period, and the differences were statistically significant ($p<0.05$). With an increase of the epileptic discharge index, the discharge range, IQ and MQ level of cognitive impairment group decreased; differences were statistically significant ($p<0.05$). Therefore, the discharge index, frequency, and distribution range of epileptic discharge of epilepsy with cognitive impairment in different periods differed from epilepsy patients without cognitive impairment. According to the extent of cognitive impairment in different stages, discharge index, frequency, and distribution range were also different.**

**CONCLUSIONS: The 24 h video EEG, which was used to monitor epileptic discharge characteristics, has a great application value for early identification of epilepsy with cognitive impairment.**

*Key Words:*
Epilepsy, Cognitive impairment, Epileptic seizures, EEG.

## Introduction

As a common neurological disease, epilepsy is caused by an abnormal discharge of brain neurons, which manifests as recurrent, chronic, and transient brain dysfunction. According to the different discharge parts, it can be divided into the temporal lobe, frontal lobe, occipital lobe and central-temporal region benign epilepsy. If it was classified according to the cause of disease, it can be divided into primary and secondary epilepsy; the reasons of secondary epilepsy may include surgery, cancer, ischemia, poisoning, etc.[1-3]. During the epilepsy attack and interictal period, consciousness, cognitive impairment, and dyssomnia may appear, while duration and frequency may aggravate cognitive impairment and cause malignant epilepsy syndrome[4]. The single EEG monitoring shows that the epileptic discharge was random; moreover, the detection rate was lower, and the false negative rate was higher. The 24 h video EEG monitoring applies data playback to quantify EEG; also, combined with


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using tendency chart, it can enhance the diagnostic sensitivity of epilepsy, which is conducive to the universal application for non-professional medical staff[5]. This study was designed to analyze the characteristics of EEG abnormalities in patients with epilepsy and with cognitive impairment, to provide a reference basis for early intervention of cognitive impairment.

## Patients and Methods

### Patients

62 cases of patients that were admitted to our hospital for the first diagnosis as status epilepticus from January 2013 to January 2016 were continuously selected. Of those, 20 cases were accompanied with cognitive impairment. Inclusion criteria: 1- conformation to the diagnosis criteria of epilepsy, and in a period of 6 months, the attack occurred more than 3 times; 2-24 h video EEG monitoring manifested the appearance of typical epileptic waves; 3- the age range was 18-70 years old. Exclusion criterion: 1- presence of other diseases that affect cognitive function, such as senile vascular dementia and Alzheimer's disease; 2- recently suffered major stimulus, such as traffic accidents, accompanied by anxiety or depression, which may affect the judgment of cognitive function; 3- transience and non-convulsibility seizures; 4- patients who have poor compliance, while participating in other intervention studies cannot complete the examination of cognitive function scale. The study obtained the approval of the Ethics Committee at our hospital and gained informed consent right of patients and their families. There were 25 cases of males in epilepsy without cognitive impairment group, while there were 17 cases of females. The average age was (43.5±8.2) years old. There were 18 cases of temporal lobe epilepsy, 7 cases of frontal lobe, 5 cases of occipital lobe, and 12 cases of central-temporal region benign epilepsy. The average of epilepsy frequency was (3.6±0.8) times/6-month, and the average of duration was (2.4±0.7) min/time. The average education time was (15.6±5.7) years. There were 13 cases of males in epilepsy with cognitive impairment group, while there were 7 cases of females. The average age was (44.7±6.9) years old. There were 7 cases of temporal lobe epilepsy, 3 cases of frontal lobe, 4 cases of occipital lobe, and 6 cases of central-temporal region benign epilepsy. The average of epilepsy frequency was (3.7±0.9) times/6-month, and the average of duration was (2.8±0.9) min/time. The average education time was (14.7±6.2) years. The baseline data of both groups have comparability.

### Methods

According to international 10-20-system placement principle, the silver disk electrode was placed on patients by two experienced physicians, at the position of frontal region, temporal region, sphenoid bone of temporal region, parietal region, and occipital region. The 24 h EEG monitoring was performed at a paper speed of 10 mm/s. The 24 leads channel America Biology Graphene was used as EEG recording machine (sample rate: 250 Hz, low frequency filtering: 0.3 Hz, high frequency filtering: 70 Hz). The excessive ventilation, flash stimulation and induced experiment were taken for patients in the monitoring process; then the epileptic discharge of sharp wave, spike wave, sharp slow wave, spike slow wave and multiple spine slow waves were identified and classified by the means of playback function of the EEG machine, including: 1- conscious period: patients were in normally active status, with more nictation, 2- sleep I-II period: rapid eye movement sleep, the background activity became slowly and evolved into low amplitude mixing frequency, and the sleep spindle and vertex sharp wave can be seen, also can see eye movement become slowly and myoelectricity become weakened, 3- sleep III-IV period: sleep period, the background activity slows, with slow eye movement and loss of potential of myoelectricity. The epileptic discharge of EEG was qualified, while continuing for 1 s was recorded as 10%; therefore 1 s=10%. The epileptic discharge index can be divided into: 1- grade I: epileptic discharge index is less than or equal to 1%, 2- grade II: epileptic discharge index is between 1% to 10%, 3- grade III: epileptic discharge index is between 10% to 50%, 4- grade IV: epileptic discharge index is more than or equal to 50%. The division of epileptic discharge distribution and location includes: 1- focal: frontal lobe, temporal lobe, occipital lobe and central-temporal region epileptic discharge, 2- multifocality: discharge was involved in multiple sites, such as frontal-temporal lobe, temporal-occipital lobe and parietal-occipital lobe discharge, and 3- universality: all leads were affected, and the discharge presented bilaterally synchronous symmetry. Relevant psychological tests of cognition were adopted for patients in the monitoring. The revised WAIS-RC and WMS-RC were used to test cognitive function. WAIS-RC, verbal scale and performance scale were included. A total of 6

**Table I.** The analysis of characteristics of epileptic discharge of two groups in different periods [n (%)].

| Groups | Epilepsy without cognitive impairment group (n=42) | | | Epilepsy with cognitive impairment group (n=20) | | |
|---|---|---|---|---|---|---|
| | Conscious period | Sleep I-II period | Sleep III-IV period | Conscious period | Sleep I-II period | Sleep III-IV period |
| Epileptic discharge Grade I | 2 (4.8) | 12 (28.6) | 14 (33.3) | 4 (20.0) | 8 (40.0) | 10 (50.0) |
| Grade II | 0 | 9 (21.4) | 8 (19.0) | 2 (10.0) | 6 (30.0) | 3 (15.0) |
| Grade III | 0 | 0 | 5 (11.9) | 0 | 2 (10.0) | 3 (15.0) |
| Grade IV | 0 | 0 | 1 (2.4) | 0 | 0 | 3 (15.0) |
| Discharge frequency (time/24h) | 0.5±0.2 | 1.2±0.4 | 1.4±0.5 | 0.8±0.3 | 1.6±0.5 | 2.0±0.6 |
| Focal | 2 (4.8) | 18 (42.9) | 20 (47.6) | 4 (20.0) | 8 (40.0) | 9 (45.0) |
| Mulifocality | 0 | 3 (7.1) | 6 (14.3) | 2 (10.0) | 5 (25.0) | 6 (30.0) |
| Universality | 0 | 0 | 2 (4.8) | 0 | 3 (15.0) | 4 (20.0) |

subtests were included in verbal scale: knowledge, comprehension, arithmetic, similarity, digit span and vocabulary, while the performance scale included digital symbol, picture filling, block pattern, figure arrangement and figure assembly, a total of five subtests. The test materials included a manual, a copy of recording form, a piece of vocabulary card, a drawing test card, a book of block pattern test, a book of figure arrangement test card, a box of red and white cubes, four boxes of pieces of figure assembly, a card of pieces of figure placement location and a piece of digital symbol score. The original points were converted to scale scores, while the intelligence quotient was expressed by IQ, and an average score was 100 points, 50-69 points of mild mental retardation, 35-49 points of moderate, 20-34 points of severe, and 0-19 points represented very severe. The WMS-RC test items included experience, orientation, number order relation, recognition, picture memory, visual reproduction, associative learning, tactile memory, logic memory and reciting the number a total of 10 items, while the memory quotient was expressed by MQ, with 80 points below regarded as memory disorders, 70-79 points of poor and the 69 points below represented very poor.

### Research Index

The characteristics of epileptic discharge of both groups in different periods as well as IQ and MQ level of cognitive impairment group in different periods were compared.

### Statistical Analysis

The SPSS20.0 software (SPSS Inc., Chicago, IL, USA) was applied for statistical analysis. The measurement data was expressed as mean±standard deviation. The independent sample *t*-test was used for comparison between both groups, and the single factor ANOVA analysis was used for comparison among groups, with LSD test adopted for pairwise comparison. The count data was expressed by case or (%), and $\chi^2$-test was used for comparison among groups (correction). $p<0.05$ means the difference was statistically significant.

## Results

### The Analysis of Characteristics of Epileptic Discharge of Both Groups in Different Periods

The epileptic discharge index of epilepsy with cognitive impairment group in conscious period, sleep I-II period and sleep III-IV period were evidently higher than those of epilepsy without cognitive impairment group. The difference was statistically significant [30.0% (6/20) *vs.* 4.8% (2/42), correction $\chi^2=5.597$, $p=0.018$; 50.0% (21/42) *vs.* 80.0% (16/20), $\chi^2=5.067$, $p=0.024$; 66.7% (28/42) *vs.* 95.0% (19/20), correction $\chi^2=4.486$, $p=0.034$]. The discharge frequency of epilepsy with cognitive impairment group in the conscious period, sleep I-II period and sleep III-IV period were evidently higher than those of epilepsy without cognitive impairment group; differences were statistically significant ($t=3.628$, $p=0.040$; $t=4.237$, $p=0.036$; $t=4.627$, $p=0.033$). The distribution range of epileptic discharge of epilepsy with cognitive impairment group in conscious period, sleep I-II period and sleep III-IV period were evidently higher than those of epilepsy without cognitive impairment group; differences were statistically significant (correction $\chi^2=5.597$, $p=0.018$; correction $\chi^2=11.000$, $p=0.004$; correction $\chi^2=9.969$, $p=0.007$) (Table I).

**Table II.** The analysis of IQ and MQ level of cognitive impairment group in different periods.

| | Conscious period | Sleep I-II period | Sleep III-IV period | F | *p* |
|---|---|---|---|---|---|
| IQ | 68.6±7.2 | 64.3±9.3 | 60.6±10.4 | 7.132 | 0.005 |
| MQ | 78.4±4.6 | 75.3±6.8 | 71.3±7.5 | 7.524 | 0.003 |

**Table III.** The analysis of IQ and MQ level of different epileptic discharge index of cognitive impairment group.

| | Epileptic discharge Grade I | Grade II | Grade III | Grade IV | F | *p* |
|---|---|---|---|---|---|---|
| IQ | 68.9±6.3 | 66.7±8.2 | 65.4±9.3 | 62.3±10.4 | 6.534 | 0.018 |
| MQ | 77.8±5.2 | 74.6±5.6 | 72.2±6.2 | 70.5±6.5 | 6.635 | 0.016 |

**Table IV.** The analysis of IQ and MQ level of different epileptic discharge range of cognitive impairment group.

| | Focal | Multifocality | Universality | F | *p* |
|---|---|---|---|---|---|
| IQ | 67.8±8.2 | 63.4±10.3 | 59.8±12.4 | 8.623 | 0.000 |
| MQ | 75.9±6.9 | 70.3±8.4 | 68.7±9.7 | 9.230 | 0.000 |

### The Analysis of IQ and MQ Level of Cognitive Impairment Group in Different Periods

The IQ and MQ level of cognitive impairment group was the lowest in sleep III-IV period, with the next sleep being I-II period. The highest was conscious period, and the difference was statistically significant ($p<0.05$) (Table II).

### The Analysis of IQ and MQ Levels of Different Epileptic Discharge Index of Cognitive Impairment Group

With the increase of epileptic discharge index, IQ and MQ level of cognitive impairment groups decreased, and the difference was statistically significant ($p<0.05$) (Table III).

### The Analysis of IQ and MQ Level of Different Epileptic Discharge Range of Cognitive Impairment group

With an increase of epileptic discharge range, the IQ and MQ level of cognitive impairment group decreased, and the differences were statistically significant ($p<0.05$) (Table IV).

## Discussion

### Characteristics and Influencing Factors of Epilepsy with Cognitive Impairment

Epilepsy is caused by an abnormal discharge of the brain neurons, which mainly manifests as limb tic, syncope, headache and sleep disorders, and has the characteristics of sudden and transient onset. The recurrent or prolonged seizures of patients can lead to hypoxia, lactic acidosis and neurotransmitter excessive excitability, secondary neuronal metabolism and structural damage, all of which eventually leads to cognitive dysfunction[6]. The factors that can promote cognitive dysfunction include age of onset, psychological factors (such as depression), intracranial primary diseases, antiepileptic drugs, surgical complications and social factors (such as social discrimination, educational limitation, etc.)[7]. An EEG is often used for record and analysis due to the state of attack is usually difficult to be directly witnessed by physicians.

### EEG Monitoring in Different Ways

The traditional routine EEG monitoring has some problems, such as the numbers of electrode placement are more and the operation is complex. Also, there is a high requirement for specialty of the operating professional, a large amount of data to be recorded, more spurious interference, and relatively cumbersome and time-consuming reading diagram method. Recently, the trend chart method of EEG is used, taking the advantages of relatively few electrode placements, simple operation, a low requirement for the operating professional, with the simple and intuitive chart for the data of record, which is facilitated for identification of seizure and higher sensitivity for the dia-

gnosis of epilepsy. Even the non-professional staff can operate it after the simple training, which is conducive to the rational allocation of human medical resources and universal application of equipment[8]. Through 24 h video EEG monitoring, epileptic discharge forms can be divided into: sharp wave, sharp slow wave, generalized 3 Hz spike slow wave, focal spike slow wave and generalized 3-4 Hz multiple spike slow waves. The performance can be single, sporadic or continuous. Moreover, the continuous time of once epileptic discharge is also different, and may be sustainable for several minutes[9]. Epileptic discharge can be accompanied with corresponding clinical symptoms[10], such as the epileptic discharge of temporal lobe manifests as spontaneous movement of the distal limb or partes oralis, the epileptic discharge of frontal lobe manifests transient limb shake, head eye deflection, body shake, etc. The epileptic discharge of occipital lobe manifests visual aura, and central-temporal region benign epileptic discharge usually attacks during sleep, manifesting as one side limb or a mouth twitch.

### The Significance of Epileptic Discharge in Epilepsy with Cognitive Impairment

The quantitative evaluation of epileptic discharge can be carried out, according to discharge time, and the percentage is converted to a discharge index, which can be divided into four grades. Of those, the discharge index is 10% with the minimal threshold of the negative effects of cognitive function in epilepsy[11]. When the frequent epileptic discharges appear in EEG monitoring, and with the discharge index more than 1%, the speed of information integration of patients slows down. When the discharge index was more than 10%, the short-term vocabulary memory, information transmission and visual motor integration occurred disorders[12]. The study also indicates that[13] the epileptic discharge of the left hemisphere of brain can affect language learning ability, and the epileptic discharge of occipital region or the right hemisphere of brain can affect visual-spatial sense. The epileptic discharge of the posterior part of the head can affect visual integration. The sleep spindle is 12-14 Hz, with left-right symmetry, and is an important factor for the inhibition of epileptic discharge and maintaining the stability of human sleep[14]. Epileptic discharge can change the sleep structure of patients, affect the quality of sleep and aggravate the seizures of patients with epilepsy. Therefore, to effectively inhibit epileptic discharge, not only it can improve the quality of sleep, but also help control seizures. For patients with less frequency of epileptic discharge, early medication or surgery to inhibit epileptic discharge, it can reduce the damage of cognitive function[15]. With frequent epileptic discharge and long duration, epilepsy can easily become a neurological emergency. If it is not controlled and treated in time, it may lead to permanent brain damage, and even death[16].

## Conclusions

The discharge index, frequency and distribution range of epileptic discharge of epilepsy with cognitive impairment in different periods is higher than those of epileptic patients without cognitive impairment. According to the extent of cognitive impairment in different stages, discharge index, frequency, and distribution range were also different. The 24 h video EEG, which was used to monitor epileptic discharge characteristics, has great application value for early identification of epilepsy with cognitive impairment.

### Conflict of interest

The authors declare no conflicts of interest.

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