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Forensic Identification of a Traffic Accident Caused by Epilepsy: A Case Report

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Abstract: Epileptic seizures have typical characteristics including the sudden arrest of movement and being transient and self-limiting, which will lead to corresponding restrictions on daily related behaviors and career choices of those with epilepsy, such as whether a driving license is revoked or its issuance is limited. In China, the patient of epilepsy is absolutely cannot drive a vehicle, this also is a content that of Road Traffic Safety Law of our country. In many U.S. states, a person must be seize-free for six months to a year to get a driver's license. In the UK, patients need to be symptom-free for at least a year before they can apply for a driving licence. Japan for epilepsy patients to apply for a driver's license requires drug control without disease for two years. So, the definition of epilepsy is crucial for drivers. In order to find out the root cause of the accident, this paper is committed to determining whether the driver had seizures that led to a severe traffic accident. The concept, diagnostic criteria, diagnostic elements, clinical classification and imaging results associated with epilepsy can be used to make a preliminary diagnosis of epileptic seizures. The onset of the disease plays a decisive role in judging the nature of traffic accidents.

Keywords: Forensic Identification, Epilepsy, Epileptic Seizures, Traffic Accident

1. Introduction

Epilepsy [1] is a group of chronic brain diseases caused by different factors. It is a syndrome characterized by paroxysmal, transient, repetitive and stereotyped central nervous system dysfunction caused by highly synchronized brain neuronal activity and often self-limiting abnormal discharges. The International League Against Epilepsy (ILAE) pointed out that the new definition of epilepsy has three elements [2]: (1) At least one epileptic seizure, (2) Persistent brain lesions that increase the likelihood of future attacks, (3) Concomitant states of physical, cognitive, psycho-psychological, and social functioning. The World Health Organization estimated that there are about 50 million people worldwide with epilepsy. In China, there are about 6 million active epilepsy patients, while there are about 400,000 new epilepsy patients every year. Epilepsy has serious negative effects on individuals, families and society. Diagnosed epilepsy can cause serious psychological disorders in patients and their families. Therefore, epilepsy is not only a medical problem, but also an important public health and social problem. Due to the unpredictability and paroxysmal nature of epileptic seizures, the relevant behaviors and career choices of epileptic patients in daily life will be limited by the uncontrollable characteristics of the disease. ILAE [3] has revised the classification of epileptic seizures types. Although there is no stable multivariable model to predict the risk of traffic accidents in patients with epilepsy, this risk has been demonstrated to be related to the frequency of epileptic seizures [4]. So, epilepsy as a epileptic seizure disease, in the case of uncontrolled epileptic seizures, will certainly affect driving, and even in driving epileptic seizures and lead to serious traffic accidents. Based on this, China, the United Kingdom, the United States, Japan and other countries have

introduced legal regulations on whether people with epilepsy can drive. Harden et al. [5] provided information on childhood diseases, seizures, and treatment by studying children's cognition and communication methods on epilepsy. It has been reported that a patient with the coronavirus infection showed new focal epilepsy, which may be related to related pneumonia in the absence of other risk factors [6]. Rubio et al. [7] conducted a bibliometric analysis of Mexican neurologic research literature in the past 52 years, pointing out that the current progress needs to be applied to innovative research, which will further help to understand the mechanism of epilepsy history and formulate treatment plans. At the same time, there is also a study involving epileptic psychosis during pregnancy, and epileptic psychosis can have a variety of manifestations [8]. This paper will identify whether the driver had epileptic seizures leading to a serious traffic accident.

2. Case Report

2.1. Basic Case Information

The suspect, a 63-year-old man, drove from south to north on a downtown road on 9:25 a.m. October 24th, 2019. After hitting passers-by on the way, he accelerated to escape and successively hit other vehicles. Then, he accelerated to approximately 160 kilometers per hour. When going through a red light at the intersection, he hit a right-turning vehicle and several pedestrians and was finally controlled by the police. His driving behavior caused five deaths and eight injuries at the scene. The suspect was also injured during the accident. During the investigation of the case, some witnesses reported that the suspect showed "epilepsy"-like changes.

2.2. Treatment Summary

The suspect was sent to the hospital on the same day due to left clavicle fracture and right olecranon fracture caused by the car accident. The suspect did not experience coma, vomiting, headache, chest tightness, shortness of breath, abdominal pain and other discomfort after injury. Physical examination revealed that the suspect was conscious and answered questions to the point. At present, the patient's vital signs are stable, blood pressure 70/50mmHg, heart rate 92 times/min, and three venous access was opened for expansion.

On October 24th, computed tomography (CT) imaging showed lacunar infarction of the bilateral basal ganglia, part of it was old-fashioned.

On October 25th, CT imaging showed senile brain and lacunar infarction in bilateral basal ganglia and paraventricular areas, senile brain changes.

On November 6th, electroencephalogram (EEG) reports showed:

Video EEG background activity: the electrical activity of the two hemispheres was 8-10 times/second α rhythm with low and middle amplitude. The parietal occipital was obvious, bilateral symmetry, poor waveform differentiation and general amplitude modulation. Partial reaction of open and close eyes, and hyperventilation is basically the same as background rhythm.

Abnormal wave: the comprehensive 4.5-7.5Hz wave amplitude was observed in both hemispheres, and the slow wave was scattered or paroxysmal, and the amplitude was basically symmetric on both sides. Small spiky waves (70-100ms, 15-50μV) were seen scattered in the whole guide pair.

Episode stage: no clinical episode was observed during the examination.

Impression diagnosis: abnormal EEG, follow-up is recommended.

On November 6th, CT imaging showed a few lacunar cerebral infarction focal ischemia, mild senile brain.

On November 6th, MRI imaging showed lacunar ischemic foci scattered in the brain.

On November 11th, the MRI examination of the head did not show acute cerebral infarction lesions, and a high signal at the edge of the bilateral cortex was found on the DWI sequence.

2.3. Forensic Identification Process

2.3.1. Investigation Video

On the morning of October 24th, 2019, the suspect drove his vehicle north along the road, and first he hit victim A who was riding an e-bike on the roadside. By identification, the average speed at this time was approximately 40 kilometers per hour. Then, he accelerated to escape suddenly and had the behavior of avoiding other vehicles to the left and right along the way, damaged the bumper of a normally running taxi when going through a red light at the intersection. Then, he knocked down victim B, who was riding a bicycle. The speed at the intersection was approximately 121 kilometers. After that, he continued to accelerate his speed to approximately 160 kilometers per hour. When he reached another intersection, he crashed into victim C who was passing through the intersection (died on the spot), then damaged a vehicle and e-bike, and finally hit a vehicle awaiting passage at the intersection (at this time, the speed is approximately 123 kilometers). Five people were killed and eight others were injured in this traffic accident.

2.3.2. Joint Police Questioning of Witnesses

1) Respondent 1 (suspect's neighbor) stated that he had seen the suspect at 8:00 a.m. on the day of the incident, nothing unusual was found when he greeted the suspect at the time. The suspect had not seen anything unusual in the days leading up to the incident.
2) Respondent 2 (witness) stated that they came forward to ask the suspect if he was injured, but the driver was a little confused and did not answer the question. Then, the witness asked the suspect where he was going. The driver raised his right hand, pointed in a particular direction and vaguely said “here, here.” At that time, the door of the car, which had been in an accident, was seriously damaged. When the witness talked to the driver, the driver was still

in the car, and the door did not open.

3) Respondent 3 (Mahjong player) stated that they saw a sudden cramp of the suspect's right hand and his dull eyes when playing mahjong with the respondent's family. Then, they gave the suspect a drink of water, and the symptoms disappeared. The whole process lasted 2-3 minutes. They had seen this situation about three times.
4) Respondent 4 (Mahjong player) stated that the suspect would suddenly lose consciousness, tremble all over, sweat, be short of breath and have glazed eyes while playing mahjong. They had seen this situation 2-3 times.
5) Respondent 5 (Mahjong player) stated that he had seen the suspect have two or three attacks while playing mahjong. The convulsions and shortness of breath occurred suddenly and lasted approximately one minute. He said the suspect did not remember the experience afterward. It was described as being similar to epilepsy, although the convulsions were not significant: his eyes remained straight, there was shortness of breath, but there was no foaming in the mouth or falling to the ground. The attack lasted approximately half a minute, and there was no irritation before onset. The respondent had not previously heard of his serious illness.
6) The suspect's family stated that the suspect often mistakenly used the accelerator rather than the brake. Where there was a speed limit of 70 km/h, the suspect might drive at 120 km/h. They said he had a bad memory and could not differentiate the brake and accelerator. He once had a car accident in which he used the accelerator instead of the brake, which caused a rear-end collision. There was no history of epilepsy, epileptic episodes, or family history of psychosis.
7) The suspect stated that he had not been to the hospital due to brain injury or mental illness and had no family history of mental illness. He also had no serious infectious diseases or other chronic diseases.
8) The suspect's son stated that the suspect did not have epilepsy or diseases that would lead to sudden unconsciousness or uncontrollable physical movements. During co-living period with the suspect, he did not find that the suspect had sudden loss of consciousness, confusion, convulsions and other uncontrollable symptoms, and nobady in the family had similar symptoms.

2.4. Physical Examination

The suspect entered the examination room under the leadership of the police in the detention center. He was clear-headed, answered the question to the point, cooperated in the examination, and was alert and sensitive to the surrounding environment. He was still focused and responsive. During the physical examination, his mood was basically stable and irritable, and he appeared impatient and emotional during repeated physical examinations.

There were no abnormalities in the appearance of his head, cranial nerve signs (-). After removing his coat, there were no obvious abnormalities in the appearance of the left shoulder joint and right elbow joint, and tests of local tenderness (+), percussion pain (+), and thoracic compression (+) were positive. Muscle strength of the limbs and muscle tension were normal. A neurophysiological reflex was apparent, and the pathological reflex was not drawn out. No tremor attacks were observed during the examination.

2.5. Blood Test

After the traffic accident, a blood sample was extracted from the driver. No ethanol or standard drug components were detected in the blood sample.

2.6. Imaging Findings

October 24th, 2019 10:30 a.m. the head CT film of a central hospital showed: no swelling in the head soft tissue, no traumatic changes in the skull and brain parenchyma, and the midline structure is in the middle, there were no imaging signs of acute cerebral infarction or cerebral hemorrhage in the brain in the scanning range; there were multiple scattered speckled low-density shadows in the bilateral basal ganglia and lateral ventricles, which were consistent with the imaging changes of old lacunar cerebral infarction; cerebral sulci, fissure widening, in line with senile brain changes.

November 3rd, 2019 the head CT film of a university affiliated hospital showed: no traumatic changes were found in the skull and brain parenchyma, and the midline structure was in the middle; the bilateral basal ganglia and the lateral ventricle were old lacunar Compared with the previous film, the cerebral infarction has no dynamic changes; the senile brain changes.

November 6th, 2019 the head MRI film of a university affiliated hospital showed: there were multiple abnormal signal shadows scattered in the bilateral fronto-parietal cortex, semiovale area and lateral ventricle, showing low signal on T1WI, low signal on T2WI and FLAIR high signal shadow, no abnormal signal shadow on DWI sequence, consistent with the imaging changes of old lacunar infarction scattered in the brain (Figure 1).

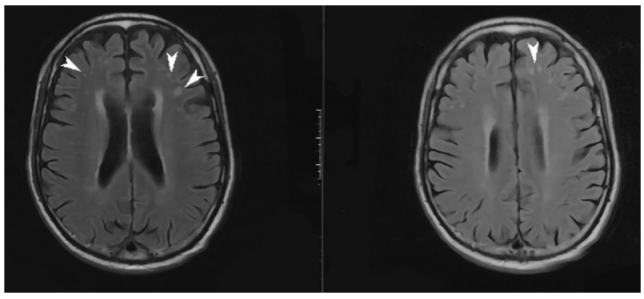

Figure 1. *There are many divergent old lacunar cerebral infarcts in the subcortical area of the bilateral frontal-parietal lobes.*

3. Discussion

3.1. The Concept and Diagnostic Criteria of Epilepsy and Epileptic Seizures

Epilepsy [9] is a chronic brain disease with many causes and is characterized by sudden, repeated and transient central

nervous system dysfunction caused by excessive activity of brain neurons. According to the location of the impacted neurons and the diffusion range of this activity, dysfunction can manifest and cause different problems, involving motor, sensory, consciousness, behavior, and autonomic nerve function. Epileptic seizures can be divided into generalized epileptic seizures and focal epileptic seizures according to epileptic seizures' clinical and EEG manifestations. Epileptic seizures is a transient clinical manifestation caused by abnormal excessive and synchronized discharge activity of brain neurons. The diagnosis of epileptic seizures should have the following three elements: (1) clinical manifestations: there must be clinical manifestations such as sensory, motor, autonomic, consciousness, emotion, memory, cognition and behavior disorders *et al*; (2) the form of initiation and termination: Generally, it has common characteristics such as sudden stop, short-term transient and self-limiting; (3) abnormal excessive synchronous discharge in the brain: confirmed by EEG and EEG topographic examination. Clinically, the EEG diagnosis of epilepsy mainly depends on epileptiform discharges in these intermittent periods. The main manifestations are transient EEG activities that are clearly distinct from the background and may primarily be single or isolated and repeated. Sharp waves or composite waves are more common and include sharp waves, spike waves, spike slow composite waves and multispike slow composite waves.

Establishing a causal relationship between abnormal electroencephalography and clinical manifestations during epileptic seizures is the gold standard for the diagnosis of epilepsy. The diagnosis of epilepsy can be divided into five steps [2]: (a) Determine whether the paroxysmal event is epileptic seizures. This involves the identification of paroxysmal events, including induced epileptic seizures and noninduced epileptic seizures. Traditionally, epilepsy can be diagnosed when two noninduced epileptic seizures occur clinically at least 24 hours apart. (b) Determine what type of epileptic seizures they are according to the ILAE epileptic seizures classification. (c) Systematically determine the classification of epilepsy using the ILAE epilepsy and epilepsy syndrome classification system. Some cases cannot be classified as a specific epilepsy syndrome. (d) Determine whether there is associated disability and comorbidity. (e) Determine what the etiology of the epileptic seizures are. Epilepsy diagnosis must have the following three elements at the same time: (1) Basic condition: at least one epileptic seizure without fixed inducement; (2) Pathogenesis basis: persistent brain changes that increase the likelihood of future episodes; (3) Accompanying state: adverse effects on many aspects of physical, cognitive, mental and social functions [10]. The EEG diagnosis of epilepsy mainly depends on epileptiform discharges in intermittent periods, manifested primarily in transient EEG activities that protrude from the background and common sharp waves or composite waves. The main manifestations are: transient EEG activity that clearly stands out from the background, most of which are single or isolated and repeated; sharp-like waves or complex waves are more common, such as sharp waves, spike waves, spike-slow complex waves, and multi-spike-slow waves compound etc. Therefore, a patient with one or occasional epileptic seizures and clinically asymptomatic patients with only abnormal EEG discharge cannot be diagnosed with epilepsy. Epileptic seizures is a transient clinical manifestation caused by abnormal excessive and synchronous discharge of brain neurons. At the same time, epileptic seizures need to be distinguished from a variety of non-epileptic seizures, such as syncope, infection, metabolic poisoning, and psychogenic epileptic seizures [2].

3.2. Correlation Analysis Between "Epilepsy" and Traffic Accident

In this case, there was no medical record of the suspect's past and current traffic injury due to "epileptic seizures". There was no sudden loss of consciousness, general convulsions, or uncontrollable body movements caused by epilepsy. Within approximately two weeks after the traffic accident, the suspect underwent an EEG examination without anti-epileptic drug control. The results showed scattered slow-wave or paroxysmal release and scattered small sharp-wave release occasionally in full conduction, which did not belong to the typical EEG changes of epileptic seizures. A sharp wave in epileptiform discharge has the characteristics of repeated occurrence, stereotype suppression of waveform and relatively fixed location. The suspect's EEG report indicated only the existence of potential brain lesions but no definite epileptiform discharge. During the investigation, the suspect stated that he was conscious and had no epileptic seizures while driving on the day of the accident. The witness did not see the suspect vomiting, foaming at the mouth or convulsing at the time of the injury. The suspect was sluggish after the accident, but there was no clear evidence of tetany. The suspect would lose the ability to drive if he had sudden cardiovascular and cerebrovascular disease leading to mild paralysis and loss of consciousness. In addition, according to the driving video of the suspect on October 24th, 2019 provided by the police, after the first collision, the suspect had the behavior and ability to immediately accelerate the vehicle and continuously avoid other vehicles. This is not consistent with the behavioral ability and clinical manifestations after "epileptic seizures". In addition, according to the analysis of the existing materials submitted for examination, there is no basis for the suspect to have persistent brain changes in "epilepsy".

According to the head CT on the day of the accident and a CT nearly two weeks after the accident, there were no fresh traumatic changes in the skull and brain parenchyma, although changes in old lacunar cerebral infarction in the bilateral basal ganglia and paraventricular region were found. The results showed that the suspect had old brain lesions, such as old lacunar infarction and senile brain changes. However, such diseases would not lead to loss of consciousness on the day of the accident. There was no pathogenesis basis of persistent brain changes associated with epilepsy. In the investigation with witnesses, it was

found that there had been right-hand cramps, dull eyes, loss of consciousness and other signs, which were similar to complex partial epileptic seizures. However, the situation involving trembling, weakness, and recovery after drinking water was inconsistent with epileptic seizures' clinical manifestations. The duration of the epileptic seizures described by the witnesses was different, which is inconsistent with epileptic seizures. During the investigation, it was found that the suspect could recall the driving route and the experience of the injury during the accident and actively avoided the vehicle in front of the suspect while driving during the incident of the accident. The suspect's consciousness while driving the vehicle was clear. The disordered memory in the later investigation was a performance of deliberate sophistry and self-protection, which has nothing to do with mental disorders. During the interview, it was learned that the suspect is usually irritable and has a strange temper. The performance after the traffic accident could have been a stress response.

In conclusion, the analysis shows that the diagnostic basis of this case regarding epileptic seizures is insufficient, and the symptoms do not meet the diagnostic criteria of epilepsy. There is no evidence to prove that the traffic accident was caused by epileptic seizures. The suspect described the driving behavior after the accident, so the suspect's awareness of the behavior and the ability to control behavior were not significantly damaged, and he should bear full criminal responsibility. The suspect escaped after the accident, knowing that this behavior would have serious consequences. Yet he continued to drive at a high speed on the road, which seriously endangered public safety and caused many casualties and property losses. His behavior constituted the crime of endangering public safety by dangerous means.

3.3. Forensic Identification of Epilepsy in Traffic Accidents

Regarding the forensic identification of epilepsy in a traffic accident, the following steps should be taken seriously: (a) conduct a detailed investigation of all the processes involved in the case and the suspect's past medical history; (b) look for evidence of epileptic seizures through an investigation of the witnesses, surveillance videos at the scene of the accident, and medical records of the suspect, especially, clinical auxiliary examinations such as EEG, CT, MRI and hematology; (c) make a diagnosis and identify the type of epilepsy and epileptic seizures by assessing the suspect's state according to the witness testimony, road and vehicle monitoring, the suspect's current performance and medical records *et al*; (d) make a judgment according to diagnostic criteria and based on the different clinical manifestations of all kinds of epilepsy to judge whether the parties involved in the accident has epileptic seizures and the classification of epilepsy; (e) Clinically, there are a variety of epileptic events, including both epileptic seizures and non-epileptic seizures. Non-epileptic seizures can be seen in any age group, and their pathogenesis is completely different from that of epileptic seizures, but the clinical manifestations of the two are similar. Therefore, it is important to distinguish between epileptic seizures and non-epileptic seizures in the diagnosis of epilepsy.

Regarding the forensic significance of judging whether the driver had epileptic seizures at the time of the accident, the following should be considered.

The appraisal result is directly related to the legal treatment result. For example, suppose that a traffic accident was caused by epilepsy, and the suspect had a history and knew that there are risks associated with epilepsy. In this case, there is the deliberate concealing of the medical record to defraud the driver's license agency. The suspect should bear the crime of endangering public security with the dangerous method in China. If the driver had epileptic seizures for the first time and did not know he was ill, it was a general traffic accident. The driver is incompetent and not criminally responsible because he loses consciousness and cannot control his behavior. If the suspect had no epileptic seizures and was escaping after causing a hit and run, which in this case resulted in many deaths, this constitutes the crime of endangering public security in a dangerous way.

A forensic diagnosis is different from a clinical diagnosis. The purpose of the clinical diagnosis of epilepsy is to determine the classification of patients with epilepsy, standardize the diagnosis and treatment approach, enable patients to receive formal treatment in a timely manner, reduce the economic and psychological burden of patients and families, improve the level of epilepsy prevention, control and management, and promote the healthy development of people. The purpose of forensic diagnosis of epilepsy is to provide corresponding evidence for the public security and judicial departments for assisting judges in convicting and sentencing, provide case investigation ideas, and play an essential auxiliary role in the judgment of the nature of the case. At the same time, due to the tendency of the identified person to avoid responsibility, it is necessary to identify and screen relevant data during the investigation.

The number of casualties in traffic accidents is increasing daily. Detailed medical, toxicological and psychological research and investigation are required before drivers obtain a license. Driving risk assessment is necessary to determine whether a driver is associated with potential safety hazards such as epilepsy, mental illness, or drug abuse [11]. Drivers with a history of epilepsy are limited in their daily lives. On the one hand, drivers with a history of epilepsy face certain traffic hazards, including a higher likelihood of being involved in an accident than the average person. On the other hand, the cognitive ability of drivers will be affected by epileptic drugs. Reductions in attention, coordination and response times will increase the risk of traffic accidents. Studies have found that epilepsy-related accidents have corresponding characteristics, which require the cooperation of forensic doctors, epilepsy physicians, driving license authorities and accident investigators to conduct a comprehensive assessment of traffic accidents [12]. The implementation of driving restrictions on patients with epilepsy is the result of continuous balance between road

safety and personal quality of life [13]. Studies have shown that approximately 15% of epilepsy patients frequently drive without permission, potentially increasing the risk of traffic accidents [14]. Strengthening vocational guidance and counseling education for patients with epilepsy and other mental illnesses plays an important role in maintaining road traffic safety. The problems are mainly related to the diagnosis of epilepsy, family, employment and social and medical assistance of the authorities [15]. The implementation of a policy needs to be supported by the corresponding security of the economy, life and social employment. The driving behavior of those with epilepsy and other mental illnesses cannot be entirely and effectively eliminated by a single legal restriction. Therefore, it is necessary to publicize and become familiar with relevant laws and regulations and strengthen personal audits when issuing driver licenses, which applies to most conditions.

4. Conclusion

According to concepts of epilepsy and epileptic seizures, diagnostic criteria, diagnostic elements, clinical classification and imaging finds, it is possible to diagnose whether an individual had epileptic seizures at the time of an accident. Furthermore, artificial intelligence technology, such as machine learning, can be used to automatically detect the risk of epileptic seizures from clinical data analysis and imaging data, which will be of profound significance to the development of epilepsy diagnosis in forensic medicine.

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Conflicts of Interest

The authors declare no competing interests.

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