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Application and Value of Evoked Potential Technique in Diagnosis of Patients with Consciousness Disorder

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Abstract: ***Consciousness disorder is a common nervous system disease, its etiology is complicated, diagnosis and treatment is difficult. In recent years, evoked potential technology, as a non-invasive neuroelectrophysiological method, provides objective evaluation indicators by recording the brain's electrical activity to stimulation, provides opportunities for early diagnosis and treatment, evaluates the therapeutic effect and guides rehabilitation training. This article will discuss the application and value of evoked potential technology in the diagnosis of patients with consciousness disorders.***

Keywords: Evoked potential technology, Brainstem auditory evoked potential, Somatosensory evoked potential, Disturbance of consciousness**.**

1. Introduction

With the progress of emergency medicine and critical medical technology in recent years, the treatment rate of stroke and traumatic brain injury patients has been increasing, so that the incidence rate of patients with consciousness disorders has increased [1] at an average annual rate of 6.37% in China, and the current methods for the evaluation of consciousness disorders are mostly behavioral, imaging and electrophysiological technology. Due to the strong subjectivity of behavioral science and the complex and expensive operation of imaging, neuroelectrophysiological technology is gradually widely used in terms of convenient operation and low price. Among them, clinical induced potential, as an important method to detect the nervous system function of coma patients, has the advantages of low incidence of adverse reactions, not easy to be affected by external interference, and strong stability. It can provide a reliable basis [2] for doctors to evaluate the coma condition of patients. Evoked potential techniques can be divided into two types: brainstem auditory evoked potential (BAEP) and somatosensory evoked potential (SEP), in which the auditory evoked potential mostly changes when the brain stem is injured, and is mainly used to evaluate the brain stem function [3]. Somatosensory evoked potentials can reflect the activation [4] of subcortical somatosensory pathways and the original somatosensory cortex. This article will discuss the application and value of evoked potential technique in the diagnosis of consciousness disorder, in order to provide guidance for the prognosis evaluation of consciousness disorder.

2. Overview of Disorders of Consciousness

Disturbance of consciousness refers to an altered state of consciousness, including symptoms such as coma, drowsiness, and confusion. Its causes include a variety of factors such as cerebrovascular disease, brain trauma, and poisoning. Patients who survive various types of brain injury may first be in the coma stage, which is caused by structural or metabolic damage of brain stem reticular system and extensive damage of bilateral cerebral cortex. Most patients have no sleep-wake cycle, and no stimulus can induce spontaneous behavioral response, basic physiological functions such as breathing and temperature regulation are gradually lost, and the level of whole brain metabolism is significantly reduced. Coma usually lasts for several weeks [5]. If consciousness level gradually increases, patients can enter mini mally conscious state (MCS), that is, patients show fluctuating and repeatable responses to verbal or written instructions, visual tracking, pain localization, speech understanding, intentional communication and other signs. As well as certain emotional responses. Further aggravation of consciousness can lead to unre sponsive wakefulness syndrome (UWS), formerly known as vegetative state (VS). UWS/VS refers to the restoration of a certain level of arousal, However, the behavioral response is still reflexivity, lack of awareness of the surrounding environment and oneself, decreased metabolic level of the whole brain, damage to the cortical-thalamic-cortical circuit, but relatively retained brainstem function, the main metabolic disorders exist in the frontoparietal network and thal [6] amus. After that, if they are still unable to wake up, they will appear brain death [7] with permanent loss of brain stem function.

3. Methods of Monitoring Evoked Potentials

BEAP can record the electrical stimulation on the auditory conduction pathway, reflect the functional status of the brain stem auditory conduction pathway, fully reveal the physiological process and pathological phenomenon of brain stem and nerve function, and effectively predict the adverse outcome [8] of patients with consciousness disorder after excluding peripheral auditory impairment and other factors. The methods for performing auditory evoked potentials in patients were as follows: During BAEP testing, the indoor temperature was controlled between 20℃ and 24℃, and the environment was assessed to be quiet. All BAEP examiners had received professional and systematic instrument operation training. The patient was supine, and the BAEP

examination placed the electrodes according to the electroencephalogram International 10-20 system electrode placement method, the reference electrode was placed on the same mastoid of the test patient, the recording electrode was located in the middle of the head (Cz), the ground was located in the forehead (Fpz), the impedance was < 5 K ohms, and the stimulation was sent to the ear through the earphone (air conduction). The test ear was stimulated by a 120 and 100 dBnHL click, respectively, and for acoustic stimulation, a 40-dBnHL white noise mask was given to one ear to reduce interference from other factors. The sound stimulation is superimposed 1000 times, repeated at least 2 times in each ear and stimulated [9] separately in one ear. Wave I, III and V were recorded, and the peak latency of each wave I, III and V, and the peak latency between I and III and III and V were analyzed. The results were graded. Relevant studies have shown [10] that BAEP can dynamically monitor the consciousness level of patients with consciousness disorder in clinical combination with behavioral assessment (especially CRS-R scale), which can reduce the misdiagnosis rate of single behavioral assessment, and thus improve the accuracy of consciousness level assessment of patients with consciousness disorder. SEP refers to electrical stimulation, magnetic stimulation or natural stimulation of peripheral nerves or skin, which is transmitted to the sensory cortex of the brain along the nerve conduction pathway and triggers potential changes. To a certain extent, it reflects the specific somatosensory afferent pathway, the brain stem reticular structure and the functional state [11] of the cerebral cortex. The specific operation methods are as follows: On the upper limb SEP, the recording electrodes were placed on the top of the head (C3', C4'), Erb's point, the 7th cervical spine spina process (C7), referring to the electric pole forehead (FPz), the square wave pulse electrical stimulation of the bilateral median wrist nerve and the lateral musculocutaneous nerve of the elbow joint. The stimulation intensity was 5~15mA, superimposed 250 times, and the scanning duration was 50ms. Lower limbs SEP, the recording electrode was placed on the top of the head (Cz), the reference electrode of the forehead (FPz), and the square wave pulse electrical stimulation was performed on the medial tibial nerve of the bilateral ankle joint. The stimulation intensity was 15~25mA, 250 times superimposed, and the scanning duration was 50ms. Each monitoring was repeated for two rounds to verify the feasibility of the results. The study confirmed [12] that the combination of SEP and diffusion tensor can effectively predict the recovery potential of limb dysfunction in patients with cerebral infarction, and provide a theoretical basis for the recovery of limb function in patients with brain injury.

4. The Value of Evoked Potentials in the Prognostic Evaluation of Consciousness Disorders

Evoked potentials can be used to detect the integrity of brain stem and brain pathways in patients with consciousness disorders. Although it cannot provide accurate location information of brain stem injury, it can provide relevant information for the prognosis of patients with consciousness disorders. According to relevant reports [13], in patients in coma due to accidental head injury, the normal BEAP detection results can predict the awakening accuracy of 90%, and the probability of predicting a good prognosis is 75% to 80%. In patients with typical BEAP waveform of pontine injury, more than 90% of the patients end up in death or vegetative state. In Estraneo et [14] al., 43 patients with chronic UWS/VS caused by hypoxia were studied. Medical history information, clinical features and neurophysiological evaluation indicators were collected within 1-6 months after the onset of the disease, and follow-up was conducted for 24 months. The results showed that the presence of N20 and CRS-R≥6 were reliable predictors of cognitive recovery in patients with hypoxic chronic UWS/VS. Hu Huihua [15] used SEP and BAEP to detect the prognosis of 40 patients with cerebrovascular disease, and the results were sensitivity 96.0%, specificity 100.0% and accuracy 97.5%. The sensitivity, specificity and accuracy of Glasgow Coma score for the prognosis of cerebrovascular disease were 72.0%, 60.0% and 67.5%, respectively. Therefore, evoked potential technique can effectively predict the prognosis of patients with brain injury. In the Andre-Obadia [16] study, retention of brainstem auditory evoked potentials is a good prognostic indicator for traumatic brain injury. At the same time, a large number of studies have analyzed the clinical value of evoked potential technology in the prognosis of consciousness disorders. For example, in monitoring BEAP and SEP in 80 patients with persistent vegetative state, Chen Xing [17] found that brainstem auditory evoked potential and somatosensory evoked potential could effectively predict the prognosis of patients. In Wang Lei [18] 's assessment of Bauditory evoked potential and midbrain shape for the prognosis of coma patients with severe craniocerebral injury, it was found that the sensitivity and specificity of the first combined application of BAEP and the ratio of anterior and posterior brain diameter to transverse diameter of skull CT were 73.7% and 82.6%, respectively, and the ratio of the second BAEP to the ratio of anterior and posterior brain diameter to transverse diameter of skull CT were 73.7% and 82.6% respectively The sensitivity and specificity of combined application of BAEP to detect the prognosis of patients with severe craniocerebral injury were 88.2% and 100.0% respectively.

5. Mechanism Analysis of Evoked Potential

BAEP is the 6-7 positive waves recorded within 10ms after the short sound stimulus is delivered through the earphone, and the monitoring meanings of different waveforms are also different [19]. It can be simply understood that wave I is the action potential of the auditory nerve, wave II originates from the cochlear nerve nucleus, wave III comes from the suprapontine olivary-olivary complex nucleus and the trapezoid body, wave IV and wave V represent the lateral colliculus and the middle inferior colliculus nucleus [20-21], wave VI and wave VII are the action waveform of the geniculate body of the thalamus and the auditory radiation. Therefore, wave I and wave II actually represent the peripheral wave group of auditory afferent pathway, and the subsequent waves represent the central segment action potential. The first 5 waves, such as wave I to wave V, are the most stable, and wave V has the highest amplitude, which can be used as a sign to identify the BAEP waves. Under normal circumstances, wave II and wave I, or wave VI and wave VII are often fused to form a composite waveform. Therefore, BAEP can effectively reflect the damage of brain stem and auditory nerve. When the brain stem or auditory nerve is

injured, BAEP can record the amplitude change of I ~ V wave, so as to know the location and severity of the lesion. When the amplitude disappears, it indicates that the patient's brain stem is seriously damaged. Therefore, understanding the specific changes of wave amplitude through BAEP is helpful to determine the specific location of early brain stem lesions in patients. At the same time, BEAP is not susceptible to the interference of other factors, and is more simple, convenient and fast, which is of great significance in the diagnosis and prognosis evaluation of brain stem lesions [22], hearing damage [23], neonatal bilirubin encephalopathy [24] and other diseases. SEP transmits deep somatosensory information to the posterior central gyrus of cerebral cortex through special sensory conduction pathways.

According to the time of abnormal appearance, the damaged site was located. The presence of N13 indicated that the evoked potential caused by stimulation had been transmitted to the spinal cord level; The absence of N20 indicated that the brain stem above the spinal cord level and the cerebral cortex and subcortical axonal functions were impaired. In the SEP output pattern, P9 originated from the brachial plexus and P20 originated from the anterior central gyrus motor cortex [25-26]. The components recorded on the top of the head are P14, N20, P25, N35, P45 and N60. The abnormality of SEP in the short incubation period may reflect proprioceptive abnormality, and the somatosensory evoked potentials disappear completely, which has a high possibility of complete spinal cord injury. The prolongation of incubation period and the decrease of amplitude may reflect the dysfunction of sensory nerve conduction function in different degrees, especially when the lesions are located in the brain stem and spinal cord. Through the changes of SEP waveform, the specific lesions can be effectively located, so as to identify the injury site and improve the treatment plan. Especially, it is widely used in the fields of nervous system diseases [27] and intraoperative monitoring [28]. Therefore, evoked potential technology can provide reference value for the evaluation of consciousness disorders.

6. Summary

As a non-invasive neuroelectrophysiological method, evoked potential technology has important application value in the diagnosis of patients with consciousness disorders. By recording the electrical activity of the brain in response to stimulation, evoked potential technology can provide objective assessment indicators, provide opportunities for early diagnosis and treatment, evaluate treatment effects and guide rehabilitation training. At the same time, the existing evaluation methods are relatively simple, and it is suggested that neuroelectrophysiological technology should be combined with behavioral evaluation, neuroimaging, serum markers and other evaluation methods to improve the accuracy of evaluation. Therefore, the future application of multimodal assessment methods to predict the prognosis of patients with consciousness disorders will become a hot topic in the future.

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