Case Report

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Comprehensive Rehabilitation for Postoperative Vegetative State Caused by Ruptured Cerebral Aneurysm with Subarachnoid Hemorrhage

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1. Abstract

The vegetative state refers to a state of the human body in a special kind of consciousness disorder, that is, a complete loss of awareness of oneself and the surrounding environment. Many patients cannot obtain active awakening results simply through drug treatment. However, comprehensive, precise and multi- method combined rehabilitation assessment and treatment are of great importance for the rehabilitation of those in a vegetative state. Here, we report a case where transcranial direct current stimulation (t DCS) of the cerebellum combined with median nerve electrical stimulation was used to improve the vegetative state. A 31-year- old male suddenly lost consciousness more than two months ago and was diagnosed with a complete vegetative state. He was then transferred to our department for rehabilitation treatment. We specifically carried out tDCS stimulation of the cerebellum combined with median nerve electrical stimulation for the patient, and performed PET-CT monitoring before and after the treatment. The patient fully recovered by the end of the treatment. Given the scarcity of cases regarding the treatment of the complete vegetative state and the difficulty of such treatment, it is necessary to report these cases to clarify the importance of comprehensive rehabilitation assessment and innovative, systematic rehabilitation treatment methods for the rehabilitation
of patients in a vegetative state.

2. Keywords: Consciousness disorder, Transcranial direct current stimulation (tDCS), Median nerve electrical stimulation, Cerebellum, Case report

3. Introduction

The incidence of consciousness disorders is on the rise globally, and the number of patients in a vegetative state is constantly increasing. Their rehabilitation treatment has become the focus of attention in the medical field. Currently, the awakening effect of simple drug treatment on many patients in a vegetative state is limited, and due to their inability to actively cooperate with the treatment, the rehabilitation process is slow. Comprehensive, precise and multi- method combined rehabilitation assessment and treatment strategies, as well as timely adjustment of the awakening plan according to the individual conditions of patients, are crucial for improving the prognosis of patients in a vegetative state.This case involves a patient with consciousness disorder after the rupture and bleeding of an aneurysm, who was in a vegetative state/ unresponsive wakefulness syndrome (VS/ UWS) state. Positive rehabilitation treatment achieved good curative effects. In- depth analysis of the treatment process and results of this case will help provide valuable experience for the rehabilitation treatment of patients in a vegetative state and further emphasize the importance of comprehensive rehabilitation assessment and individualized treatment.

4. Case Data

4.1. Case Details

The patient was a 31-year-old male. The chief was unconsciousness for more than 2 months. More than 2 months ago, the patient suddenly fainted without obvious precipitating factors after getting up in the morning. He didn't respond when called by his family. It was found that he had obvious shortness of breath, accompanied by nasal bleeding, vomiting of coffee-ground gastric contents, and incontinence of urine and feces. He was emergently sent to the local hospital. After a complete cranial CTA examination, it was indicated that there was diffuse subarachnoid hemorrhage, intraventricular hemorrhage, and an aneurysm in the A2 segment of the left anterior cerebral artery. That night, an "Intracranial Aneurysm Coil Embolization" was immediately performed, and on the second day, a "Bilateral Ventricular External Drainage by Drilling" was carried out. In addition, comprehensive treatments such as dehydration, relieving vascular spasms, anti-infection, and nerve nutrition were given. After the treatment, the patient's vital signs were stable. He could open his eyes spontaneously, but still couldn't understand or express language, couldn't execute commands, had no eye tracking, couldn't move his limbs spontaneously, and had

no emotional response. Since the onset of the disease, the patient

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had been in a vegetative state, was fed through a nasogastric tube, couldn't take care of his urination and defecation by himself, and his weight had decreased by about 5 kg compared with before.

Past Medical History: The patient had a smoking history of 15 years, smoking 1 pack per day. He also had a drinking history of 15 years, drinking 2 - 3 times a week, with 4 - 5 cans of beer each time.

Positive Signs: He was unconscious, could open his eyes spontaneously, his eyeballs were in the middle position. He didn't cooperate with the examination of bilateral eye movements. The bilateral pupils were equal in size and round, with a diameter of about 3 mm. The direct and indirect light reflexes were sluggish. He didn't cooperate with the rest of the cranial nerve examinations. He couldn't cooperate with the examination of limb muscle strength. The muscle tone of the right upper limb was slightly increased, with a modified Ashworth grade of 1 (manifested as a slight increase in muscle tone, showing the minimum resistance at the end of the range of joint motion during passive flexion and extension). The muscle tone of the left upper limb and both lower limbs was weakened. He didn't cooperate with the examination of deep and superficial sensations. The biceps tendon reflex on the right side was hyperactive (+++), and the rest of the tendon reflexes were weakened (+). The bilateral Babinski signs were positive (+) (manifested as the extension of the great toe and the fanning out of the other four toes). The neck had a slight resistance, and the Kernig sign and Brudzinski sign were negative (-).

Auxiliary Examinations: The head CTA showed: diffuse subarachnoid hemorrhage, intraventricular hemorrhage; an aneurysm in the A2 segment of the left anterior cerebral artery (Figure 1).

Disease Diagnosis:

1. Rupture of the anterior communicating artery aneurysm accompanied by subarachnoid hemorrhage (after transcatheter intracranial aneurysm bare coil embolization, in the recovery period)
2. Hypostatic pneumonia Functional Diagnosis:

1. Complete vegetative state / unresponsive wakefulness syndrome (UWS)
2. Complete dependence in daily life
3. Social participation disorder

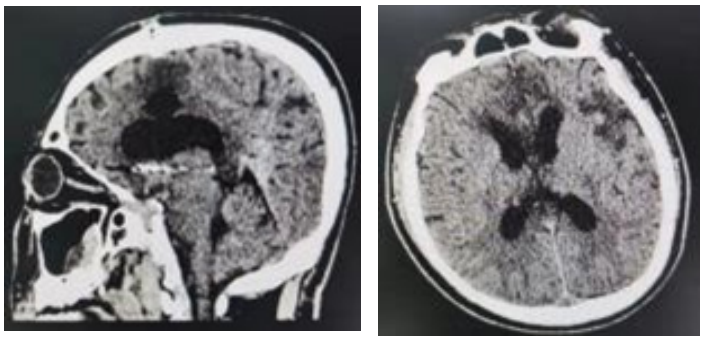

Figure 1: The head CTA showed diffuse subarachnoid hemorrhage, intraventricular hemorrhage and an aneurysm in the A2 segment of the left anterior cerebral artery.

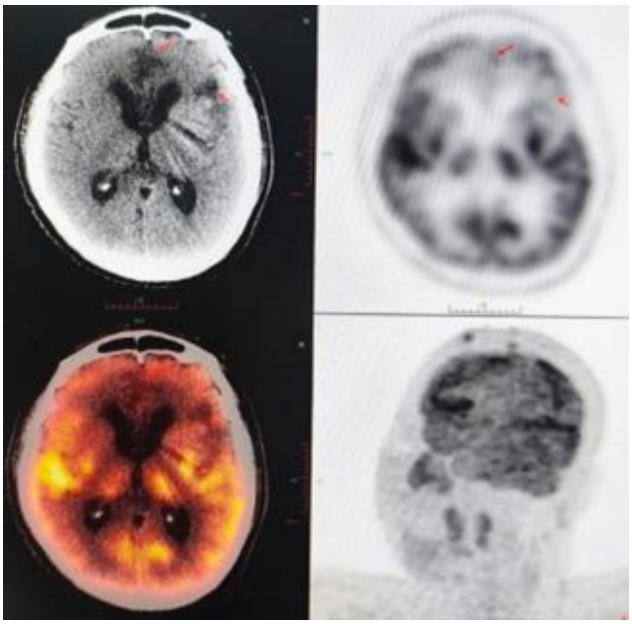

Figure 2: PET-CT showed that after the treatment for diffuse subarachnoid hemorrhage + intraventricular hemorrhage: Changes after coil embolization for the left anterior cerebral aneurysm; Multiple ischemic and degenerative lesions in the bilateral frontal lobes, the left centrum semiovale, the corona radiata and the bilateral periventricular areas, with partial encephalomalacia foci in the left frontal lobe; Symmetrical metabolic reduction in the bilateral frontal lobes, occipital lobes, bilateral basal ganglia and cerebellum, with partial atrophy of the brain parenchyma in the left frontal lobe; The metabolism of partial brain parenchyma in the bilateral parietal lobes and temporal lobes was relatively active; Hydrocephalus, and there was a high possibility of formation of a left porencephalic cyst. Please combine with enhanced CT.

4.2. Treatment Process

The patient was admitted to the hospital on July 7, 2023. Relevant assessment results were as follows:

The CRS-R score was 5 points (withdrawal flexion 2 points, reflexive oral movements 1 point, and eye opening without stimulation 2 points), suggesting unresponsive wakefulness syndrome.

The PVS score was 3 points (aimless voluntary movements 2 points, occasional tearing 1 point), indicating a complete vegetative state (Figure 3).

PET-CT showed (Figure 2): After the treatment for diffuse subarachnoid hemorrhage and intraventricular hemorrhage: changes after coil embolization of the left anterior cerebral aneurysm; multiple ischemic and degenerative lesions in the bilateral frontal lobes, the left centrum semiovale, the corona radiata and the bilateral periventricular regions, with partial encephalomalacia foci in the left frontal lobe; symmetrical metabolic reduction in the bilateral frontal lobes, occipital lobes, bilateral basal ganglia and cerebellum, with partial atrophy of the brain parenchyma in the left frontal lobe; relatively active metabolism of partial brain parenchyma in the bilateral parietal

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lobes and temporal lobes; hydrocephalus, and a high possibility of formation of a left porencephalic cyst. Please combine with enhanced CT.

Event-related potential (ERP) showed that the mismatch negative (MMN) was 1.306uv, suggesting a minimally conscious state - (close to the minimally conscious state but not yet reached), and the P300 was 2.972uv, indicating no cognitive function.

After admission, the following relevant treatments were given:

Medication Treatment: Citicoline (0.5g each time, 3 times a day) was used for nerve nutrition.Amantadine (the starting dose was 50mg each time, 2 times a day, and gradually increased to 200mg each time, 2 times a day) was used for arousal promotion.Piracetam (0.8g each time, 3 times a day) was used to improve cerebral metabolism.Levetiracetam (0.5g each time, 2 times a day) was used to prevent epilepsy.Donepezil hydrochloride (5mg each time, 1 time a day) was used to improve cognition, etc.

Basic Nursing: An air mattress was used to prevent pressure sores.Oral care was provided twice a day.Attention was paid to the cleanliness of the nasogastric tube, etc.

Passive Limb Movement: Passive joint activities were carried out 3 times a day, 20 minutes each time.Passive muscle stretching was performed 2 times a day, 15 minutes each time.Standing bed training was conducted (starting from an inclination of 30°, 15 minutes each time, 2 times a day, and the angle and time were gradually increased).The patient was encouraged to sit in a wheelchair as early as possible to reduce the time in bed.Regular turning over and back patting were carried out once every 2 hours.The proper positioning of limbs in bed was arranged, etc.

Cardiopulmonary Treatment: Thoracic relaxation training (intercostal muscle relaxation and thoracic loosening, 3 times a week, 20 minutes each time) was performed.Airway clearance techniques (postural drainage, percussion, vibration, etc., 3 times a day, 15 minutes each time) were applied.

Physical Factor Therapy:Pulmonary ultrashort wave therapy (with a wavelength of 7.37m, a frequency of 40.68MHz, a power of 80W, 15 minutes each time, 1 time a day) was used for the patient's hypostatic pneumonia.Low-frequency electrical stimulation was applied to the hemiplegic limbs (with a frequency of 30Hz, the current intensity was adjusted according to the patient's tolerance, 20 minutes each time, 1 time a day), etc.

Multisensory Stimulation: Relatives were encouraged to call and communicate with the patient (multiple times a day, 10 - 15 minutes each time).The music or videos that the patient liked were played (2 - 3 times a day, 30 minutes each time).The patient's limbs were stroked more often, etc.

Swallowing Treatment: Head and neck posture adjustment, oral ice stimulation (3 - 5 minutes each time, 3 times a day) and oral muscle relaxation training (2 times a day, 10 minutes each time), etc. were carried out.

Acupuncture Treatment: Acupuncture was applied at points such as Baihui, Shangxing, bilateral Neiguan, Renzhong, Sanyinjiao, and Jiquan (the needles were retained for 30 minutes, once every other day), etc.

Non-invasive Neuromodulation Treatment:An arousal promotion scheme combining central and peripheral nerve stimulation was adopted, that is, the scheme of transcranial direct current stimulation (tDCS) combined with median nerve electrical stimulation. In the tDCS treatment scheme, the anode was placed on the right cerebellum, the cathode was placed on the left supraorbital area, the current intensity was 2mA, and each stimulation lasted 20 minutes, 1 time a day. In the median nerve electrical stimulation treatment scheme, electrode patches were placed 2cm above the wrist crease of the right forearm, an asymmetric pulsed square wave with a width of 300μs and a frequency of 40Hz was used, and the current intensity was 20mA, for 6 hours a day.

The patient was discharged from the hospital on August 23, 2023. The assessment results at the time of discharge were as follows:

The CRS-R score was 17 points (auditory function 2 points, visual function 4 points, motor function 6 points, speech function 2 points, communication score 1 point, arousal level 2 points), suggesting that the patient had emerged from the minimally conscious state.

The PVS score was 14 points (intentional gaze 3 points, execution of simple commands 2 points, purposeful movements 3 points, ability to chew 3 points, normal emotional response 3 points), indicating that consciousness had basically recovered (Figure 4 - 6).

ERP: The MMN was 2.842uv, suggesting a minimally conscious state + (having reached the minimally conscious state and with certain improvement); the P300 was 3.528u, indicating the presence of cognitive function.

Coma Recovery Scale - Revised Record Sheet

Date	2023/7/7	2023/7/13	2023/7/21	2023/7/27	2023/8/2	2023/8/8	2023/8/14	2023/8/20	2023/8/23
AUDITORY FUNCTIONS									
4 Consistent Movement to Command *									
3 Reproducible Movement to Command *									
2 Localization to Sound			√	√	√	√	√	√	√
1 Auditory Startle		√							
0 None	√								
VISUAL FUNCTIONS									
5 Object Recognition*									
4 Object Localization:Reaching*				√	√	√	√	√	√
3 Visual Pursuit*			√						
2 Fixation*									
1 Visual Startle									
0 None	√	√							
MOTOR FUNCTIONS									
6 Functional Object Use **								√	√
5 Automatic Motor Response*			√	√	√	√	√		
4 Object Manipulation*									
3 Localization to Noxious Stimulation*		√							
2 Flexion Withdrawal	√								
1 Abnormal Posturing									
0 None/Flaccid									
OROMOTOR/VERBAL FUNCTIONS									
3 Intelligible Verbalization*									
2 Vocalization / Oral Movement				√	√	√	√	√	√
1 Oral Reflexive Movement	√	√	√						
0 None									
COMMUNICATION SCALE									
2 Functional: Accurate**									
1 Non-functional: Intentional*								√	√
0 None	√	√	√	√	√	√	√		
AROUSAL SCALE									
3 Attention									
2 Eye opening without stimulation	√	√	√	√	√	√	√	√	√
1 Eye opening with stimulation									
0 No arousal response									
TOTAL SCORE	5	7	13	15	15	15	15	17	17
Denotes emergence from MCS**									
Denotes MCS*									

Figure 3 Summary of the patient's CRS-R scale assessment results.

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Figure 4: The patient's condition at admission
(Involuntary movements, no speech, significantly decreased cognition, unable to communicate with family members, fed through a gastric tube, unaware of urination and defecation)

Figure 5: The patient's condition during treatment
(Can move independently, language communication begins to emerge, can write one's own name, the gastric tube has been removed and food is taken orally, is aware of urination and defecation)

Figure 6: The patient's condition at discharge
(Can walk independently, can communicate with family members, eat and manage bowel and bladder functions independently.)

5. Discussion

The diagnosis was clear when the patient was admitted. The consciousness disorder was mainly caused by cerebral hemorrhage and subarachnoid hemorrhage due to the rupture of a cerebral aneurysm. Although the patient's condition was stable after treatment in the local hospital, the cerebral hemorrhage was basically absorbed, cerebral edema was relieved, and there were no symptoms such as fever and dyspnea, the patient had severe brain damage and poor brain function, and was in a complete vegetative state / unresponsive wakefulness syndrome at admission.After the patient was transferred to our department, the doctors, therapists, and nurses in our hospital first carried out detailed examinations and evaluations of the patient's consciousness disorder. The main contents included:

1. Evaluation with the CRS - R scale, which is carried out once a week to dynamically evaluate the patient's consciousness state.
2. Brain PET - CT examination to evaluate the glucose metabolism of the whole brain. Through the examination, we found that the glucose metabolism of the bilateral frontal lobes of the patient was decreased symmetrically, while the important structural bases of the consciousness pathways such as the thalamus and the upper part of the brainstem (pons and diencephalon) remained relatively intact.
3. Evaluation of electroencephalogram ERP: including P300 and MMN. The MMN wave in the ERP of the patient at admission suggested that the patient was in a minimally conscious state, indicating that there was a possibility of further recovery of consciousness for this patient.

Regarding the drug treatment for accelerating the recovery of consciousness in patients in a vegetative state, evidence - based medicine supports that taking amantadine at a daily dose of 200 - 400mg can improve the cognitive and arousal levels of patients with traumatic brain injury, and it is recommended for use in patients with severe traumatic brain injury who have disorders of consciousness [1]. Based on the patient's brain PET - CT evaluation, we found a significant decrease in cerebral glucose metabolism. Therefore, we administered amantadine for arousal treatment because it can promote an increase in frontal lobe metabolism [1]. When using it, we started with a small dose and gradually increased it, being cautious about preventing adverse drug reactions such as epilepsy. The patient's level of consciousness and CRS - R score increased significantly after the initiation and dosage increase of amantadine. In addition, when the patient was admitted to our department, a relatively high dose of antiepileptic drugs was still being used, but the patient did not have any epileptic seizures throughout the entire course of the disease. This may be one of the factors affecting the patient's consciousness recovery. After a period of observation, we found that the patient showed no obvious signs of epileptic seizures, and electroencephalogram examination detected no epileptic waves. Subsequently, we gradually reduced the antiepileptic drugs. For other drug treatments, we continued to use the secondary prevention drugs for stroke in neurology, drugs for protecting the stomach, expectorant drugs, etc [2-4].

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Regarding the rehabilitation treatment for promoting the recovery of consciousness in a vegetative state, apart from basic arousal - promoting methods such as family members' calls and sensory stimulation, we have added non - invasive neuromodulation techniques, adopting a wake - promoting protocol that combines transcranial direct - current stimulation (tDCS) with median nerve electrical stimulation, which is a central - combined - with - peripheral nerve electrical stimulation [3] Median nerve electrical stimulation enables the electrical stimulation signals to be transmitted to the spinal cord, brainstem, cortex and other central nervous systems through the peripheral nerves. Since the conduction pathway structure of the patient is normal, the excitation can be transmitted to the brainstem reticular formation, increasing cortical electrical activity and cerebral blood flow, thus promoting the recovery of the patient's disorder of consciousness [4]. In recent years, research has found that the cerebellum is not only the basis of motor coordination but also plays an important role in cognition and emotion in higher - order brain functions [5]. We apply tDCS to regulate the neuroelectrical activity of the cerebellum through weak direct current, changing its excitability. It superimposes the excitatory effect on the brain with median nerve electrical stimulation. PET - CT examinations are conducted both before and after the treatment to monitor the patient's rehabilitation progress, ultimately achieving the goal of arousal. As a more mature technology for consciousness research, PET - CT uses different markers to measure glucose metabolism, oxygen consumption, regional cerebral blood flow, and the distribution of specific neurotransmitters [6]. These markers can be used to evaluate the degree of residual brain function in patients with disorders of consciousness [7]. The specific mechanism and effectiveness of this wake - promoting protocol still need further research.In addition to treatments related to promoting wakefulness, comprehensive rehabilitation therapies in various departments, including physical therapy (PT), occupational therapy (OT), speech therapy (ST), and cardiopulmonary therapy, are also essential. These therapies aim to improve limb movement, swallowing function, cardiopulmonary function, and prevent complications such as pulmonary infections and blood clots. In terms of rehabilitation nursing, management of the patient's diet and nutrition, oral care, body position management, and management of bowel and bladder functions all lay a good foundation for the overall functional rehabilitation of the patient. In addition, the patient's cranial imaging revealed hydrocephalus, which is also one of the important factors impeding the patient's cognitive recovery [8]. We invited consultations from relevant departments such as neurosurgery. Considering that the patient's conscious state is constantly improving, we plan to re - evaluate and address the hydrocephalus condition at an elective time after the conscious state has further improved. We will closely monitor the patient's neurological symptoms and signs, and regularly review the patient's cerebrospinal fluid pressure and cranial imaging examinations.

To sum up, in terms of the rehabilitation assessment and treatment for the recovery of consciousness in patients in a vegetative state, first of all, a systematic, standardized, precise, and whole - process assessment is required. Then, the obstructive factors affecting consciousness recovery should be removed to the greatest extent, while factors promoting consciousness recovery should be increased. At the same time, comprehensive rehabilitation treatments such as exercise, cardiopulmonary function improvement, and swallowing training, as well as rehabilitation nursing including nutrition management, oral care, and body position management, should be provided. Eventually, patients can progress from a complete vegetative state to a minimally conscious state, and then gradually transition from the minimally conscious state to emerging from the vegetative state and finally regain full consciousness.

However, this case study has certain limitations. For example, the sample size is small, the universality of the treatment plan has not been widely verified, and there is a lack of long - term follow - up results. Future research can carry out multi - center and large - sample studies, conduct long - term follow - up to observe the durability of treatment effects, and further explore the rehabilitation treatment strategies for patients in a vegetative state.

6. Summary

After the patient's aneurysm ruptured and bled, consciousness disorder occurred postoperatively, and the patient was diagnosed with a VS/UWS state. After a comprehensive evaluation of the patient, we targeted the application of transcranial direct current stimulation (tDCS) to stimulate the neural electrical activity of the cerebellum, combined with median nerve electrical stimulation, and promptly used arousal-promoting drugs based on the relevant results, and carried out comprehensive rehabilitation treatment for the patient, ultimately achieving successful arousal. Overall, this case fully demonstrates the crucial role of comprehensive and thorough rehabilitation assessment and innovative and systematic rehabilitation treatment methods in the rehabilitation of patients in a vegetative state, providing a useful reference for clinical treatment. At the same time, it also suggests that subsequent studies should further optimize treatment regimens and strengthen research on the rehabilitation mechanisms of patients in a vegetative state to improve the rehabilitation treatment effect for such patients.

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