Possible Solutions to Depression Using BCI Methods

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Abstract. According to the research results of 2022, the blue book of depression in China, there exists about 95,00,000 depression patients in China and the number is still growing. Depression is becoming an increasingly severe disease. As it is generally believed that the etiology of depression is multifaceted, related to gender differences, chronic stress, dietary behavior, and the abuse of drugs and alcohol. Clinical treatment is mainly on drugs, but BCI methods cannot be ignored. Compared to traditional methods, the BCI methods like Electroconvulsive therapy (ECT), repetitive Transcranial Magnetic Stimulation (rTMS) or Deep Brain Stimulation (DBS), DBS has many advantages, for patients whose physical conditions are not very ideal, the side effect of drugs may lead to serious conditions. in this paper is mainly focused on the use of BCI including technical background, applicable crowd, taboos and sequels. In the end of the passage some data from clinical cases would be discussed to give a specific impression about the methods. Then a possible scheme would be apposed about a possible solution to avoid triggering the side-effect of ECT in clinical conditions.

Keywords: Depression; Brain-Computer Interaction; Modified ECT.

1. Introduction

Depression is a common disease about psychiatric disorder [1]. Plant symptoms like lasting negative feelings, decreased interest and impaired cognitive function. World Health Organization (WHO) estimates that nearly 300 million people worldwide suffer from depression [2]. It is predicted that after the worldwide infections resulting from Covid-19, the prevalence of depression will further increase [3, 4]. Global burden of disease studies in 2019 showed that depression ranked first in the burden of mental illness (in disability-adjusted life years) [5, 6]. An American survey found that depression costs each worker an average of 27.2 working days [7] per year. However, the most severe social problem led by depression is suicide. It is estimated that 800,000 suicides worldwide, up to 50% occur during a depressive episode. People with depression are about 20 times higher risk of dying from suicide than the general population. Male depression life expectancy decreased by 10.6 years and women by 7.2 years [8, 9]. So, there is a significant need in finding new solutions to solve depression.

Depression is a disease of a variety of factors. Factors like genetics, stress, disease or drugs can lead to depression [11-14]. Depression episodes are clinically heterogeneous, the frequency and the conditions of which are hard to predict [15]. Population-based surveys have found that the lifetime prevalence of depression is about three times the rate of yearly prevalence, overall, at 15% - 18%, suggesting that one in five people experience depressive episodes at least once in their lifetime. The first episode of depression is most common between adolescence to their 40s. About 40% of patients had an episode [1, 16] onset before the age of 20. Each episode lasted an average of 13 weeks to 30 weeks [17]. Current clinical practice has a wide range of treatments, including pharmacotherapy, psychological intervention therapy, and neuroregulatory treatments [18, 19], medicinal and psychological intervention therapy is a common choice for antidepressants [20]. However, it takes several weeks to months for the treatment to work and there are about 30% of patients whose antidepressant treatment is ineffective, these patients are called TRD (Treatment-Resistant Depression) [21, 22].

For many patients suffering from severe mood and psychotic disorders, ECT remains an effective solution despite the impressive development in contemporary psychiatric medicine. Facing the patient population who are physically weak or have drug intolerance or allergy, no treatment has the same

efficiency as methods like ECT. As described in the research of Grzinger M [23] et, we still have limited understanding of the mechanism of ETC. Thurs the wide use of ETC is still hard to accomplish. in the early reports [24], the ETC is described as the final means and can only be used when there are no other solutions. However, with more clinical experiments, there is relatively straightforward stipulations to guide the clinical use of the ECT. It is believed that ECT may become a popular solution to depression soon.

This review mainly focuses on presenting the evidence using ECT as a standard, mainstream treatment for serious and treatment-resistant depression. The use of ECT for other indications, including schizophrenia, mania, and catatonia is also included. Recommendations about patient selection, treatment technique, and maintenance treatment are given in the end of the passage.

2. Related Works

2.1 Influence of Depression on Human Brains

Human brains can be generally divided into four different parts-frontal lobe, temporal lobe, occipital lobe, and parietal lobe. The frontal lobe, whose volume is about one-third of the brain, is located above the lateral fissure and in front of the central sulcus. According to the anatomical-functional partition of Patrick Chauvel, the frontal lobe can be divided into premotor area, prefrontal cortex, inner frontal lobe, and subside of the frontal lobe. The frontal lobe has four main functions:

(1) Movement: the frontal lobe is the cortical movement center and all the fibers moving with the limb are emitted by the frontal lobe. Apart from walking and crossing, dominating the voluntary movement of the contralateral limb is also one of the functions of frontal lobe.

(2) Coordination: The frontal lobe is also the center of the extra vertebral body. The extra vertebral body plays a coordinating role in limb activities. As the lateral vision center, frontal lobe is closely related to the middle frontal gyrus when the eyes can gaze together to one side.

(3) Writing: The frontal lobe is also the writing center, both the writing function and an essential function of the frontal lobe.

(4) Neuromovement: The frontal lobe may have significant relationships with mental movements in some areas. So, the frontal lobe supervises activity, movement coordination, writing, and eye coordination movement. In addition, the frontal lobe is related to mental and mutual exercise, causing frontal ataxia.

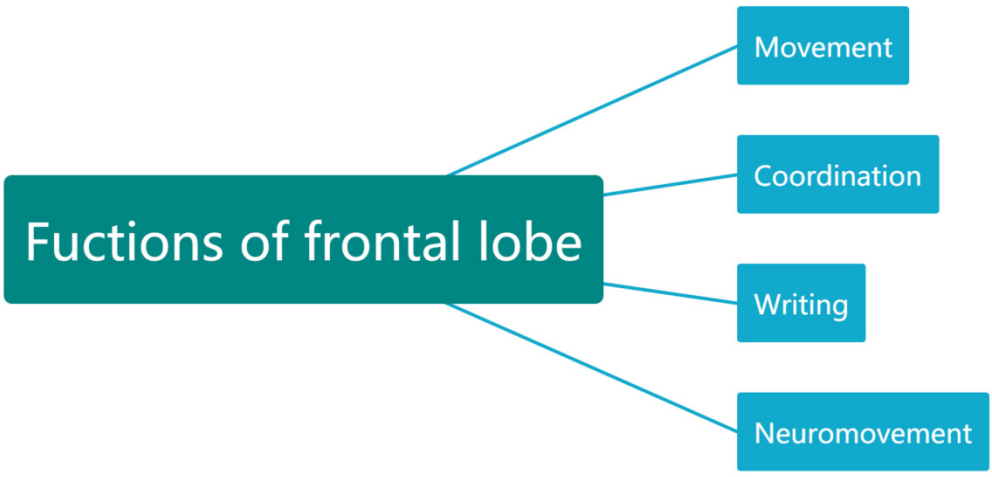


Fig 1. Functions of the frontal lobe

Depression can influence the normal function of the brain, which can be concluded in four aspects:

i) Brain morphological structure: Imaging of depressed patients' brains like CT or PET-CT reported that the brains of some patients with chronic depression had some non-specific changes

compared with normal brains. For example, some patients with depression get lateral ventricle enlargement, cerebellar atrophy or prefrontal cortex asymmetry on both sides.

ii) Neurobiochemistry: The secretion, distribution and effects of some central neurotransmitters, such as dopamine, nor-epinephrine, or serotonin of depressed patients are different from those of normal people. In some areas of the brain of depression patients, such as the hippocampus or limbic lobe of the serotonin content decline, or is related to the neurotransmitter receptor function loss. These factors have a certain correlation with the patient's depressive symptoms.

iii) Function of some parts of the brain: abnormal function of some parts of the brain of depressed patients is manifested as abnormal neuroendocrine diseases, such as abnormal pituitary function of the hypothalamus, which affects the humoral regulation of patients; such as abnormal melatonin secretion, which leads to disordered biological rhythm of patients, breaking the law of sleep and awakening, and causing sleep disorders of patients.

2.2 History of ECT

The history of ECT can be dated back to 1937. In 1937, Italian neuropsychiatrists Ugo Cerletti and Lucio Bini started to induce epilepsy with electric currents. After animal experiments, they could safely pass the electric current through the animal brain and achieve therapeutic purposes. In 1938, the first electric twitch treatment (electroconvulsive therapy, ECT) was used to treat a patient with a delusional behavioral disorder, whose symptoms resolved once and cured after 11 times of treatments. Electroconvulsive treatment is more reliable and takes less time than chemical drug-induced seizures. In the 1940s, electronic therapy replaced chemical tics, and it was introduced and first used in the United States in 1940. Lacking in other effective treatments, electroconvulsive treatment was the preferred treatment for mental disorders in the 1940s. But during electrical convulsions, the patient's systemic muscles may spasm, straighten, and contract. More complications, such as apnea, in serious case, can cause fractures, cardiovascular or cerebrovascular diseases. To address these problems, safer approaches are constantly being explored. In 1940, A.E.Bennett used arrow alkali as a releasing agent to prevent fractures. But in the middle of the twentieth century, with the advent of psychiatric drugs, the use of electropsychosive therapy decreased, and the rise of anti-psychotic movements was also imposed on the patient, which criticized the label of mental illness and the treatment that imprisoned human nature.

2.3 Definition of mECT

For patients with wild depression, clinical therapies mainly focus on pharmacology and psychological treatment. The ECT is introduced only if facing extreme situations like patients trying to suicide. Detailed inclusion criteria: Patients were diagnosed to fit the requirements of China Classification and Diagnosis of Mental Disorders (CCMD3), and had at least one of the following symptoms: severe depression, strong self-injury, suicide, obvious self-reproach, extreme excitement, agitation, impulse injury; food refusal, disobedience, nervous wood rigidity, ineffective psychotropic medication or refractory to drug treatment.

It’s still not clear how ECT relieves the symptoms of depression. One possible theory mentions that when we conduct ECT, the brain cells especially in the frontal lobe are stimulated, thus changing the internal environment which leads to the improvement of depression.

The effect of ECT is to induce total convulsive seizures through more minor electrical stimulation. The specific mechanism of electroconvulsive therapy is not particularly clear. From clinical and animal experiments, a small current to induce comprehensive convulsions may change the release of monoamines in the brain, such as serotonin and dopamine. Based on this experiment, this therapy can be applied to clinical practice. The electrodes are mainly attached to the frontal lobe, which leads to possible damage to frontal lobe functions.

ECT has always been criticized for its severe side-effect. Electroconvulsive shock may cause anxiety and headache even induce a transient degenerative memory deficit or memory loss within 30 minutes after the seizure onset. This memory deficit forms if the treatment is repeated for a short time.

This memory deficit would not have occurred if it was only treated two or three times a week. Some patients have side effect, including confusion, headache, nausea and vertigo for hours. Some modern measures can make theses side effects very mild and rather transient. Relatively fewer side effects occur after unilateral ECT but a few patients complained about muscle pain, especially in the lower jaw, and a few reports sporadic large seizures one month after ECT, but there may be other causes for this episode. Most side-effects occur within one year.

Actually, due to the possible side-effect and ethical controversy, people are strongly opposed to it in 20th century. Scientists never give it up in finding a way to improve ECT. In the 1960s, the modified ECT are introduced. Comparing to the tradition ECT, one of the significant differences is that modified ECT use muscle relaxants and anesthesia. Excessive anesthesia may cause problems such as prolonged coma and cardiovascular complications, while too little anesthesia can cause problems such as incomplete coma and autonomic arousal. The goal of anesthesia management during ECT including providing rapid anesthesia and minimal convulsive motor activity to prevent fractures, insuring the complete loss of consciousness of patients, minimizing anticonvulsant side effects, prevent hypoxia, and manage other side effects of ECT. In addition to muscle relaxants, short-acting anesthetics and dissociative hypnotics are always injected to prevent patients from being conscious and remembering during paralytic state. Another problem encountered by ECT is the impact on the cardiovascular system. As for the physiological changes accompanying ECT administration, cardiovascular events account for the majority of the morbidity associated with ECT. The current transmitted during the ECT passing through the vagus nerve stimulates the parasympathetic nervous system. This resulted in transient bradycardia or even cardiac arrest. With the release of catecholamines, a sympathetic response occurs leads to increased heart rate, increased blood pressure, and cardiac arrhythmia.

The collaboration of ECT with anesthesia provides additional protection for patients undergoing this procedure, not only for drug administration, but also for the presence of an anesthesiologist. In addition to ventilatory support, the anesthesiologist is responsible for cardiorespiratory monitoring of the patient during the perioperative period of treatment. This helps to reduce overall cardiovascular events, as real-time adversarial measures can be implemented. Therefore, the increased ECT safety due to anesthesia enables high-risk medical patients to receive modified ECT.

3. Limitation and Strength

As it has been already discussed in the passage, there is significant fall backs of modified ECT, which makes it convincing to set limitations on ECT. But if the misguiding influences of media can be removed, we are more likely to find that mECT deserves more trust. Despite its poor fame, the ECT still can't be ignored in the treatment concerning depression. To further understand mECT, more clinical data are needed to understand the principle of mECT. After that the next generation of mECT can be designed. Modified ECT can also be used as an assisted tool, combining with other BCI methods, the risk of ECT can be partly eliminated.

In conclusion, according to the research concerned [25], the death rate of ECT is about one case per 80,000 cases to one case per 10,000 patients. Under most of the conditions we believe it is safe. But there is also research reported that the clinical data is not convincing enough to prove the safety of modified ECT [26]. As a therapy initially accepted for complications, many issues were subsequently addressed through the development of anesthesiologists, improved techniques, and newer safer drugs. Today, many patients have access to relatively safe and effective treatment for mental illness, but are still affected by its past bad fame [27].

4. Conclusion

After getting rid of the misleading report from social media, modified ECT can be treated like traditional therapies. The largest barrier of ECT is prejudice from patients. The external social

problems that demonize technology also have an impact on treatment, leading to unbalanced technological development. However, in many ways, the development of modified ECT paralleled the advances in anesthesiology practice and contributed to the revival of improved ECT. Instead of eliminating the side-effect of mECT, using methods like transcranial direct current stimulation to improve cognitive function after modified ECT is operated is also a possible solution. In the end, the modified ECT still has a long way to go, but there is concrete evidence that it can be trust.

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