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Transcranial Magnetic Stimulation as a Therapeutic Modality in Neuropsychiatric Disorders

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Abstract

Introduction: Transcranial magnetic stimulation therapy is a noninvasive form of stimulation of the cerebral cortex and is emerging as a technical tool that expands the possibilities for study and research in neuroscience and in the treatment of various neuropsychiatric disorders.

Objective: To analyze the use of transcranial magnetic stimulation therapy in neuropsychiatric disorders.

Method: The search and evaluation of information was limited to the last five years, using the MeSH descriptors: transcranial magnetic stimulation; neuropsychiatric disorder; central nervous system. Based on the information obtained, a total of 43 articles published in the MEDLINE/PubMed, SciELO, Elsevier, and LILACS databases were reviewed, without language restrictions, along with reports from the World Health Organization and the U.S. Centers for Disease Control and Prevention.

Results: TMS primarily targets the dorsolateral prefrontal cortex, a brain area associated with attention, self-regulation, and impulse control. Furthermore, it represents a novel treatment strategy to reduce some of the core and associated symptoms of ASD.

Conclusions: Transcranial magnetic stimulation (TMS) in neuropsychiatric disorders involves the use of an innovative therapeutic modality that has been shown to be effective as a treatment for various neurological and psychiatric disorders.

Keywords: Transcranial magnetic stimulation, Neuropsychiatric disorders.

Introduction

The emergence of transcranial magnetic stimulation (TMS) therapy, dating back to the mid-1980s, has evolved from being considered a tool for studying the brain to becoming a therapeutic reality for certain neuropsychiatric disorders. The basis of this neurorehabilitation therapy is based on the idea that the brain is a dynamic entity adaptable to internal and external homeostatic changes. This adaptive capacity, or neuroplasticity, is also present in people with brain damage [1,2].

TMS is conceptualized as a noninvasive form of stimulation of the cerebral cortex, establishing itself as a technical tool that expands the range of possibilities for study and research in neuroscience, and in the treatment of various neuropsychiatric disorders. It allows for safe, painless, and benign stimulation of nervous tissue (cerebral cortex, spinal cord, central motor pathways, and peripheral nerves), in addition to controlling brain activity [1].

Among the changes resulting from the interaction of TMS with the brain's cellular-functional unit, which possesses electrical activity, the neuron as its primary structure are the following: electrophysiological (membrane potentials), biochemical and molecular (signaling, neurotransmitters, genes), and cellular (growth, differentiation). TMS also exerts effects on behavior, mood, memory, and myelination, allowing us to harmonize these neuronal changes [1].

Disorders affecting the central nervous system are broadly classified as psychiatric or neurodegenerative, with a significant degree of overlap in symptoms. Therefore, neurodegenerative disorders also have a high incidence of psychiatric comorbidities, including anxiety and depression. Psychiatric illness includes a variety of disorders such as schizophrenia, bipolar affective disorder, depression, obsessive-compulsive disorder, attention-deficit/hyperactivity disorder, autism spectrum disorder, among others.

The underlying pathology is generally considered the result of synaptic dysfunction driven by dysregulation of neurotransmitter availability or signaling, the latter at the receptor level and its signal transduction. The net result is an alteration in neuronal circuits involving multiple neurotransmitter/neuromodulatory systems [3].

Methods

The search and evaluation of information was restricted to the last five years, using the MeSH descriptors: transcranial magnetic stimulation; neuropsychiatric disorder; central nervous system. Based on the information obtained, a total of 743 articles published in the Medline/PubMed, SciELO, Elsevier, and Lilacs databases were reviewed, without language restrictions, along with reports from the World Health Organization and the United States Centers for Disease Control and Prevention. Duplicate articles and those unrelated to the study objective were removed using the reference manager in Mendeley Desktop 1.19.4. Forty-six articles relevant to the current review were selected.

Development

It is a noninvasive brain stimulation technique that uses local magnetic field pulses to stimulate the cerebral cortex through an intact skull. TMS creates an intense magnetic field by passing a strong current through an electromagnetic coil placed on the scalp. The generated magnetic field passes through the skull unhindered, inducing microscopic currents in the cortical tissue, which in turn stimulate brain cells. When a train of single TMS pulses is applied continuously at a constant stimulus intensity, the procedure is called repetitive TMS (rTMS). Repeated pulses can have a longer-lasting effect on improving brain function [4].

Frequency refers to the stimulation rate of rTMS; stimulation below 1 Hz is classified as low frequency, and stimulation above 1 Hz is classified as high frequency. In general, high-frequency rTMS stimulation increases cortical excitability, while low-frequency rTMS stimulation decreases it. Therefore, stimulation frequency is an important parameter for cortical activity regulated by rTMS [4].

Among the main childhood neuropsychiatric disorders where TMS could be of great help in treatment are attention-deficit/hyperactivity disorder (ADHD) and autism spectrum disorder (ASD). Both disorders develop at a relatively early age and persist into adulthood as chronic disorders. There is significant comorbidity between the two. While ADHD is the most common disorder, ASD is arguably the most severe, often associated with substantially lower IQs and significant deficits in social behavior due to the presence of restricted and repetitive behaviors, interests and activities, and abnormalities in sensory reactivity. Transcranial magnetic stimulation (TMS) is a promising and emerging tool for the study and potential treatment of ASD [5,6].

Furthermore, while various therapeutic options exist for the treatment of ADHD, including stimulant and non-stimulant medications, there are currently no therapies that can substantially improve the core symptoms of ASD. Consistent with the significant comorbidity between ADHD and ASD, there is significant overlap in neurobiology, including the prefrontal and orbitofrontal cortex, as well as the caudate putamen. However, while dopamine and norepinephrine appear to play an important role in ADHD, serotonin appears to be more involved in ASD [5,7].

Regarding the etiology of these disorders, there is substantial genetic evidence for the involvement of the dopaminergic system in ADHD, particularly alterations in the dopamine transporter and dopamine D4 and D5 receptors. Furthermore, several studies have implicated neurodevelopmental genes (such as BDNF and SNAP-25) in the etiology of ADHD. Genes involved in neurodevelopment have also been linked to ASD, particularly reelin, SHANK, and neuroligin, although these mutations are rare. Since both disorders develop relatively early in life, little attention has been paid to non-genetic factors and, in particular to the interaction between genetic and environmental factors [8].

In ADHD, TMS primarily targets the dorsolateral prefrontal cortex, a brain area associated with attention, self-regulation, and impulse control. Several studies support the use of magnetic stimulation for ADHD. Clinical research has demonstrated significant improvements in executive functions, academic performance, and impulsive behaviors after several TMS sessions. Furthermore, these improvements are generally maintained over time, especially when combined with a comprehensive intervention [9,10]. Recent studies suggest that TMS measurements provide rapid, noninvasive pathophysiological biomarkers of ASD. Furthermore, repetitive TMS (rTMS) may represent a novel treatment strategy to reduce some of the core and associated symptoms of ASD. However, the available literature on the use of TMS in ASD is preliminary, consisting of studies with methodological limitations.

Therefore, the off-label clinical use of rTMS for therapeutic interventions in ASD without an investigational device exemption is prohibited. and outside of an IRB-approved research trial it is premature to await additional, adequately powered, controlled trials [11].

In this article, we review the literature on the use of TMS in ASD, considering the unique challenges required for the study and exploration of treatment strategies in this population. We also suggest future lines of research for this field. While its true potential in ASD remains to be defined, TMS represents an innovative research tool and a novel, potentially transformative, approach to the treatment of neurodevelopmental disorders [12].

Conclusion

Transcranial magnetic stimulation (TMS) in neuropsychiatric disorders includes the use of an innovative therapeutic modality, proven effective as a treatment for various neurological and psychiatric disorders. Its use is supported in patients diagnosed with attention-deficit/hyperactivity disorder and autism spectrum disorder.

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