THE ROLE OF VAGUS NERVE STIMULATION IN THE CORRECTION OF SPEECH DISORDERS IN AUTISM SPECTRUM DISORDERS

Akhmatova Ezoza Alisher kizi
1st year master's student (Child Neurology)
Scientific advisor: PhD, assistant of the department
Khusenova Nadira Turgunovna
Tashkent State Technical University
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ABSTRACT

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition characterized by persistent deficits in social communication, restricted interests, repetitive behaviors, and varying degrees of language impairment. According to recent epidemiological studies, the prevalence of ASD has increased worldwide, making the development of effective therapeutic interventions a major public health priority. Speech and language disorders represent one of the most disabling manifestations of ASD, significantly affecting academic performance, social integration, emotional well-being, and overall quality of life. While conventional speech and language therapy remains the cornerstone of treatment, many individuals with ASD demonstrate limited progress, prompting the search for innovative therapeutic approaches. Among emerging neuromodulation techniques, vagus nerve stimulation (VNS) has gained increasing attention as a potential method for enhancing neuroplasticity and facilitating speech rehabilitation.

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The vagus nerve, the tenth cranial nerve, serves as a critical communication pathway between the brain and peripheral organs. Approximately 80% of its fibers are afferent,

transmitting sensory information from the body to the central nervous system. Through its extensive connections with the nucleus tractus solitarius, locus coeruleus, thalamus, amygdala, hippocampus, and cerebral cortex, the vagus nerve influences a wide range of physiological and cognitive functions, including attention, memory, emotional regulation, sensory processing, and learning. These neural mechanisms are particularly relevant to speech and language development, which depend on the coordinated functioning of multiple cortical and subcortical networks.

Vagus nerve stimulation is a neuromodulatory technique that delivers controlled electrical impulses to the vagus nerve. Traditionally, VNS has been used in the treatment of drug-resistant epilepsy and treatment-resistant depression, where it has demonstrated significant therapeutic benefits. More recently, researchers have investigated its application in neurorehabilitation, including recovery after stroke, motor learning enhancement, and cognitive improvement. The underlying rationale for using VNS in ASD is based on its ability to promote activity-dependent neuroplasticity, strengthen neural connections, and facilitate the reorganization of brain networks involved in communication and language processing.

The neurobiological effects of VNS are mediated through activation of several neurotransmitter systems. Electrical stimulation of the vagus nerve increases the release of norepinephrine from the locus coeruleus and acetylcholine from the basal forebrain. These neurotransmitters play essential roles in attention, memory consolidation, synaptic plasticity, and learning. Enhanced neurotransmitter release creates favorable conditions for the formation of new neural pathways and the strengthening of existing connections. Consequently, when VNS is paired with speech therapy exercises, auditory training, or language-learning tasks, it may reinforce the neural circuits activated during these activities, leading to improved speech and communication outcomes.

Individuals with ASD frequently exhibit abnormalities in neural connectivity, sensory integration, and autonomic nervous system regulation. Several studies have suggested that vagal dysfunction may contribute to impaired social engagement, emotional regulation, and communication difficulties in autism. The Polyvagal Theory proposes that vagal activity plays a central role in social behavior and communication by regulating physiological states associated with social interaction. According to this framework, enhancing vagal function may improve an individual's capacity for social engagement, emotional responsiveness, and verbal communication. Therefore, VNS may offer benefits that extend beyond speech production alone, potentially influencing broader aspects of social communication and interpersonal functioning.

Recent clinical and experimental studies have provided preliminary evidence supporting the use of VNS in individuals with ASD and other neurodevelopmental disorders. Research involving transcutaneous auricular vagus nerve stimulation (taVNS), a non-invasive method that stimulates the auricular branch of the vagus nerve through the external ear, has shown improvements in attention, emotional regulation, sensory processing, and social responsiveness. Some studies have reported enhanced auditory discrimination, increased responsiveness to speech stimuli, and improvements in language-related cognitive functions following repeated stimulation sessions. Although direct evidence specifically targeting

speech disorders in ASD remains limited, the observed improvements in neural processes underlying communication suggest a promising therapeutic potential.

One of the most important advantages of VNS is its ability to enhance the effectiveness of behavioral interventions. Modern neurorehabilitation approaches increasingly emphasize the importance of combining neuromodulation techniques with active training programs. When VNS is synchronized with speech-language therapy sessions, neural circuits involved in articulation, vocabulary acquisition, language comprehension, and social communication may undergo more robust and lasting plastic changes. This synergistic effect may be particularly valuable for children with ASD who experience significant delays in language development or who have shown limited response to conventional therapeutic methods.

The safety profile of VNS is another important consideration. While implanted VNS devices require surgical placement and may be associated with complications such as infection, voice alterations, or discomfort, non-invasive taVNS offers a safer alternative for pediatric populations. Reported side effects of taVNS are generally mild and may include temporary skin irritation, tingling sensations, or slight discomfort at the stimulation site. These characteristics make non-invasive VNS an attractive option for long-term therapeutic use in children and adolescents with ASD.

Despite encouraging findings, several limitations currently restrict the widespread adoption of VNS for speech rehabilitation in autism. Existing studies often involve small sample sizes, heterogeneous patient populations, and variable stimulation protocols. Furthermore, the long-term effects of VNS on speech development, language acquisition, and social communication remain insufficiently understood. Standardized clinical trials are needed to determine optimal stimulation parameters, treatment duration, patient selection criteria, and outcome measures. Future research should also explore the interaction between VNS and other therapeutic approaches, including behavioral therapy, occupational therapy, and educational interventions.

In summary, vagus nerve stimulation represents a promising and innovative approach to addressing speech and language disorders in Autism Spectrum Disorder. By modulating neural activity, enhancing neurotransmitter release, promoting neuroplasticity, and supporting the reorganization of communication-related brain networks, VNS may contribute to meaningful improvements in speech production, language comprehension, and social communication. Although additional research is required to establish its clinical efficacy and optimize treatment protocols, current evidence suggests that VNS has the potential to become an important adjunctive tool in comprehensive autism rehabilitation programs. The integration of neuromodulation techniques with traditional speech-language interventions may open new opportunities for improving communication outcomes and enhancing the quality of life of individuals with ASD.

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