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NEUROCHEMICAL MECHANISMS OF DOPAMINE AND SEROTONIN IN DEPRESSION AND NEUROLOGICAL PATHOLOGIES

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Abstract. *Neurotransmitters are chemical mediators responsible for communication between neurons and the regulation of physiological and psychological functions. Dopamine and serotonin play important roles in emotional stability, cognition, motivation, and motor activity. The aim of this article is to analyze the biochemical characteristics of dopamine and serotonin and their role in depression and neurological diseases based on contemporary scientific literature. The study is based on an analytical and comparative review of scientific publications in neurochemistry and molecular neurology. Dopamine is synthesized from tyrosine, whereas serotonin is synthesized from tryptophan. Disturbances in their metabolism and function are associated with depression, Parkinson's disease, schizophrenia, and anxiety disorders. Neuroinflammation, oxidative stress, neuroplasticity, and the gut-brain axis may also influence neurotransmitter metabolism. Understanding these neurochemical mechanisms is important for the development of modern diagnostic and therapeutic approaches in neurology and psychiatry.*

Keywords: *neurotransmitters, dopamine, serotonin, depression, neuroplasticity.*

DEPRESSIYA VA NEVROLOGIK KASALLIKLARDA DOPAMIN VA SEROTONINNING NEYROKIMYOVIY MEXANIZMLARI

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Annotatsiya. *Neyrotransmitterlar neyronlar o'rtasida axborot uzatilishini hamda fiziologik va psixologik funksiyalarni boshqarishni ta'minlovchi kimyoviy mediatorlardir. Dopamin va serotonin emotsional barqarorlik, kognitiv jarayonlar, motivatsiya va harakat faoliyatida muhim rol o'ynaydi. Ushbu maqolaning maqsadi dopamin va serotoninning biokimyoviy xususiyatlarini hamda ularning depressiya va nevrologik kasalliklardagi rolini zamonaviy ilmiy adabiyotlar asosida tahlil qilishdan iborat. Tadqiqot zamonaviy neyrokimyo va molekulyar nevrologiyaga oid ilmiy manbalarni tahliliy va qiyosiy ko'rib chiqishga asoslangan. Dopamin tirozin, serotonin esa triptofandan sintezlanadi. Ularning metabolizmi va faoliyatidagi buzilishlar depressiya, Parkinson kasalligi, shizofreniya va xavotir buzilishlari bilan bog'liq. Neyroinflammasiya, oksidlovchi stress, neyroplastiklik hamda ichak-miya o'qi ham neyrotransmitterlar almashinuviga ta'sir qilishi mumkin. Neyrokimyoviy mexanizmlarni chuqur o'rganish nevrologiya va psixiatriyada zamonaviy diagnostik va terapevtik yondashuvlarni ishlab chiqish uchun muhim ahamiyatga ega.*

Kalit so'zlar: *neyrotransmitterlar, dopamin, serotonin, depressiya, neyroplastiklik.*

НЕЙРОХИМИЧЕСКИЕ МЕХАНИЗМЫ ДОФАМИНА И СЕРОТОНИНА ПРИ ДЕПРЕССИИ И НЕВРОЛОГИЧЕСКИХ ЗАБОЛЕВАНИЯХ

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Аннотация. *Нейромедиаторы являются химическими посредниками, обеспечивающими передачу сигналов между нейронами и регуляцию физиологических и психологических функций. Дофамин и серотонин играют важную роль в эмоциональной стабильности, когнитивных процессах, мотивации и двигательной активности. Цель статьи — проанализировать биохимические особенности дофамина и серотонина и их роль при депрессии и неврологических заболеваниях на основе современных научных данных. Исследование основано на аналитическом и сравнительном обзоре современной литературы по нейрохимии и молекулярной неврологии. Дофамин синтезируется из тирозина, а серотонин — из триптофана. Нарушения их метаболизма и функции связаны с депрессией, болезнью Паркинсона, шизофренией и тревожными расстройствами. Нейровоспаление, окислительный стресс, нейропластичность и ось кишечник–мозг также могут влиять на обмен нейромедиаторов. Понимание нейрохимических механизмов имеет важное значение для разработки современных диагностических и терапевтических подходов в неврологии и психиатрии.*

Ключевые слова: *нейромедиаторы, дофамин, серотонин, депрессия, нейропластичность*

Introduction.

Neurotransmitters are biologically active compounds that ensure transmission of signals between neurons through synaptic connections. The normal functioning of the nervous system depends on balanced synthesis, release, receptor interaction, and degradation of neurotransmitters. Alterations in these processes may lead to significant psychiatric and neurological disturbances.

Dopamine and serotonin are monoamine neurotransmitters that regulate emotional state, behavior, cognition, and motor activity. In recent years, scientific interest in neurotransmitter biochemistry has increased because depression and neurodegenerative diseases have become major global health problems. According to modern neurochemical concepts, neurotransmitter imbalance affects not only neuronal communication but also inflammatory and metabolic processes within the brain.

Recent studies suggest that chronic stress may alter synaptic plasticity and reduce neurotransmitter production. Furthermore, disturbances in intestinal microbiota composition have been linked with impaired serotonin metabolism through the gut-brain axis. These discoveries have expanded understanding of the pathogenesis of depression and neurological disorders.

Purpose of the study.

The purpose of this study is to investigate the biochemical characteristics of dopamine and serotonin and analyze their involvement in depression and neurological diseases based on contemporary scientific concepts.

Materials and methods.

The article was prepared using analytical review and comparative evaluation of modern scientific publications related to neurochemistry, molecular neurology, psychiatry, and neurotransmitter metabolism. Scientific journals, educational literature, and contemporary neurobiological studies published during recent years were analyzed and systematized.

Results and discussion.

Dopamine: Synthesis and Physiological Role

Dopamine belongs to the catecholamine family and is synthesized from tyrosine within dopaminergic neurons.

Its synthesis pathway is represented below:

Tyrosine→L-DOPA→Dopamine

The rate-limiting step of dopamine synthesis is catalyzed by tyrosine hydroxylase. Dopamine formed in neurons is accumulated in synaptic vesicles and released during neuronal stimulation.

Dopamine regulates:

- voluntary movement;
- reward and pleasure mechanisms;
- emotional reactions;
- attention and cognition;
- endocrine activity.

Modern investigations demonstrate that dopamine also influences neuroplasticity, which represents the ability of the brain to reorganize neural connections. Reduced dopaminergic activity may impair learning and adaptive behavior.

Dopamine deficiency is strongly associated with Parkinson's disease due to degeneration of neurons in the substantia nigra. Patients develop resting tremor, muscle rigidity, and impaired coordination. Conversely, excessive dopaminergic stimulation in mesolimbic pathways may contribute to psychotic symptoms observed in schizophrenia.

Recent molecular studies indicate that oxidative stress can accelerate degeneration of dopaminergic neurons. Excessive production of reactive oxygen species damages mitochondrial function and promotes neuronal apoptosis.

Serotonin and the Gut-Brain Axis

Serotonin is synthesized from the amino acid tryptophan and functions as an important regulator of emotional and physiological processes.

The synthesis pathway includes:

Tryptophan→5-Hydroxytryptophan→Serotonin

Serotonin participates in regulation of:

- emotional stability;
- sleep and circadian rhythm;
- appetite;
- behavioral responses;
- pain perception.

Approximately 90% of serotonin is produced in the gastrointestinal tract. Contemporary research highlights the importance of the gut-brain axis, demonstrating that intestinal microbiota can influence serotonin production and emotional state.

Disturbances in intestinal bacterial balance may alter tryptophan metabolism and contribute to depressive symptoms. Chronic inflammation within the body may also reduce serotonin synthesis through activation of inflammatory cytokines.

Deficiency of serotonin is associated with depression, anxiety disorders, insomnia, and obsessive-compulsive disorder. Reduced serotonergic activity negatively affects emotional resilience and stress adaptation.

Depression and Modern Neurochemical Concepts

Depression is a multifactorial psychiatric disorder characterized by persistent sadness, emotional exhaustion, sleep disturbances, reduced concentration, and loss of motivation.

The monoamine hypothesis explains depression through decreased serotonin and dopamine activity. However, modern scientific concepts additionally emphasize the importance of neuroinflammation, impaired neuroplasticity, and hypothalamic-pituitary-adrenal axis dysfunction.

Reduced dopamine activity contributes to:

- anhedonia;
- fatigue;

- impaired motivation;
- decreased cognitive performance.

Low serotonin levels are associated with:

- anxiety;
- emotional instability;
- sleep disorders;
- suicidal ideation.

Modern antidepressants primarily act through modulation of neurotransmitter systems. Selective serotonin reuptake inhibitors increase serotonin concentration in synaptic clefts. Novel pharmacological approaches are currently being investigated, including agents affecting glutamate receptors and inflammatory mediators.

Recent studies suggest that regular physical activity may naturally increase dopamine and serotonin levels by stimulating neuroplasticity and brain-derived neurotrophic factor production.

Neurological Disorders and Neurotransmitter Dysfunction

Neurotransmitter imbalance contributes to development of various neurological disorders. Parkinson's disease remains the most recognized disorder associated with dopamine deficiency.

Therapeutic administration of L-DOPA enhances dopamine synthesis in surviving neurons.

L-DOPA→Dopamine

Serotonergic dysfunction is observed in migraines, anxiety disorders, and sleep abnormalities. Altered serotonin signaling has also been implicated in Alzheimer's disease and age-related cognitive decline.

Current neurochemical research demonstrates that inflammatory mediators and oxidative stress may interact with neurotransmitter systems, accelerating neurodegeneration. This has encouraged development of antioxidant and anti-inflammatory therapeutic strategies in modern neurology.

Conclusion.

Dopamine and serotonin are fundamental neurotransmitters that regulate a wide range of physiological and psychological processes, including mood, cognition, behavior, motor control, and emotional responses. Maintaining an appropriate balance between these neurotransmitters is essential for normal brain function and overall mental health. Alterations in their synthesis, release, or metabolism are closely associated with the development of numerous neurological and psychiatric disorders, including Parkinson's disease, depression, schizophrenia, anxiety disorders, and other neurodegenerative conditions.

Recent advances in neuroscience have significantly improved our understanding of the complex mechanisms underlying neurotransmitter function. Studies investigating neuroplasticity, oxidative stress, neuroinflammation, and the gut-brain axis have demonstrated that dopamine and serotonin interact with multiple biological systems beyond traditional synaptic signaling. These discoveries have provided valuable insights into disease pathogenesis and identified promising biomarkers and therapeutic targets for clinical intervention.

Continued research on the biochemical pathways regulating dopamine and serotonin metabolism is essential for advancing the diagnosis, prevention, and treatment of neurological and psychiatric diseases. Future studies integrating molecular biology, genetics, pharmacology, and personalized medicine are expected to facilitate the development of more effective and targeted therapeutic strategies. A deeper understanding of neurotransmitter regulation will ultimately contribute to improved patient care, enhanced treatment outcomes, and a better quality of life for individuals affected by disorders of the nervous system.

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