

Review

DOPAMINE: HORMONE OF HAPPINESS OR SOURCE OF DISEASE?

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ABSTRACT

Dopamine, a critical neurotransmitter in both the central and peripheral nervous systems, plays a vital role in regulating physiological and psychological processes, including reward mechanisms, motivation, motor control, and cognitive functions. Imbalances in dopamine levels are associated with various neurological and psychiatric disorders, such as Parkinson's disease, schizophrenia, and attention deficit hyperactivity disorder (ADHD). This review comprehensively examines dopamine's biosynthesis, pharmacological effects, pharmacokinetics, and its impact on hormonal regulation and health. Dopamine's synthesis from tyrosine involves key enzymes, and its effects are mediated through dopamine receptors (D1-like [D1, D5] and D2-like [D2, D3, D4]), as well as adrenergic receptors, depending on the dosage. Low doses induce renal and mesenteric vasodilation, while higher doses stimulate cardiac contractility and systemic vasoconstriction. However, dopamine's pharmacokinetics exhibit significant interindividual variability, influenced by factors such as renal and hepatic function, complicating its clinical use. Dopamine also modulates hormonal release, including prolactin, oxytocin, and vasopressin, and plays a role in conditions like schizophrenia, depression, and anxiety. During pregnancy, dopamine regulates placental function, fetal development, and maternal hemodynamics, though its use requires caution due to potential fetal risks. This review highlights the need for personalized dosing strategies and further research to optimize dopamine's therapeutic applications while minimizing adverse effects. In addition, a clear distinction is made between physiological dopamine signaling and therapeutic dopamine administration, particularly in terms of pharmacokinetics and dosing considerations. This study is designed as a narrative review based on peer-reviewed literature indexed in major scientific databases, including PubMed, Scopus, and Web of Science, to provide a comprehensive overview of current knowledge on dopamine. Advances in receptor-selective therapeutic strategies, along with ongoing challenges related to optimal dosing and safety profiles, highlight the need for more precise and individualized approaches in dopamine-based treatments across neurological, psychiatric, and critical care settings.

KEYWORDS: Dopamine, Neurotransmitter, Central nervous system, Pregnancy, Pharmacokinetics, Therapeutic applications.

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1. Introduction

Dopamine is a neurotransmitter that plays important role in the central nervous system and the brain. Dopamine, which has a critical function in both physiological and psychological processes, is effective in many areas such as the reward mechanism, motivation, movement control and cognitive functions [1]. It should be noted that physiological dopamine acts as a localized neurotransmitter, whereas therapeutic dopamine is administered systemically as a dose-dependent pharmacological agent with distinct pharmacokinetic properties. It plays an important role in the formation of feelings of pleasure and enjoyment, especially in relation to the brain's reward system. In addition, imbalances in dopamine levels have been linked to various neurological and psychiatric disorders, such as Parkinson's disease, schizophrenia, and attention deficit hyperactivity disorder (ADHD) [2]. Excessive release or deficiency of dopamine can lead to behavioral and emotional changes, making it an important molecule in the context of both health and disease [3]. Therefore, research on dopamine is of great interest in the fields of neuroscience and psychiatry. Dopamine is a neurotransmitter produced naturally in the body and its main source is the brain. Synthesis of dopamine is carried out by dopaminergic neurons, which are located specifically in certain areas of the brain (such as the substantia nigra and the ventral tegmental area). These neurons convert an amino acid called tyrosine first into L-DOPA and then into dopamine [4]. Dopamine production can be affected by factors such as nutrition, sleep, exercise, and stress. For example, protein-rich foods (such as meat, eggs, and dairy products containing tyrosine) can support dopamine synthesis. However, dopamine levels are determined by external factors as well as genetic factors and various diseases. The balanced release of dopamine is of great importance for both physical and mental health [5]. In this study, a narrative review approach was adopted to provide a comprehensive overview of dopamine. The literature was systematically examined using major scientific databases, including PubMed, Scopus, and Web of Science. The review focuses on key aspects of dopamine, including its biosynthesis, receptor-mediated pharmacological effects, pharmacokinetics, hormonal interactions, and clinical relevance. Particular emphasis is placed on distinguishing physiological and therapeutic roles of dopamine, as well as current challenges related to dosing strategies and safety considerations.

2. Chemical structure and biosynthesis of dopamine

Dopamine is a molecule known as a neurotransmitter and belongs to the catecholamine family and is found in large quantities in the brains of mammals. Dopamine, which plays critical roles in various physiological processes in both the central nervous system and the peripheral system, is effective in basic functions such as endocrine regulation, cognitive functions, movement control, mood and food intake. It also plays important roles in peripheral processes such as kidney functions, cardiovascular system, gastrointestinal motility and hormone secretion [6-10]. The chemical structure of dopamine consists of ethylamine derivatives, benzene ring, hydroxyl, and its synthesis occurs via the amino acid tyrosine. This synthesis process involves two basic reactions catalyzed by the enzymes tyrosine hydroxylase and aromatic L-amino acid

decarboxylase. As a result of these reactions, L-DOPA and then dopamine are synthesized. This complex synthesis mechanism and functional diversity of dopamine make it a focus of great interest in both neuroscience and medicine. Research continues to illuminate the role that dopamine plays in both healthy individuals and neurological and psychiatric disorders, which increases the potential of dopamine as a therapeutic target [11-16].

This complex synthesis mechanism and functional diversity of dopamine reveal its central role in biological systems. Both central and peripheral effects of dopamine emphasize the importance of this molecule in healthy physiological processes. In addition, studies on the synthesis and functions of dopamine provide important contributions to understanding the role of this neurotransmitter in neurological and psychiatric disorders. These findings once again reveal the versatile and vital functions of dopamine in biological systems.

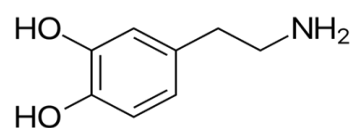


Fig. 1. Chemical structure of dopamine

3. Negative effects of dopamine deficiency or excess on health

Dopamine imbalance, including both deficiency and excess, is associated with a wide range of neurological and psychiatric conditions, reflecting the need for a tightly regulated dopaminergic system. While excessive dopaminergic stimulation has been linked to adverse effects such as peripheral edema and compulsive behaviors, dopamine deficiency is commonly associated with impaired motivation and dysfunction of reward-related pathways [21,23].

In psychiatric disorders such as schizophrenia, dopamine dysregulation – characterized by cortical hypodopaminergia and striatal hyperdopaminergia – has been widely implicated in disease pathophysiology. However, these alterations do not occur in isolation, as multiple neurotransmitter systems, including glutamatergic and GABAergic pathways, also contribute to disease progression [18,19,22,25,28-30]. Similarly, in mood disorders such as depression and anxiety, dopaminergic dysfunction interacts with other neurochemical systems and receptor subtypes, including D2/D3 receptors, influencing emotional regulation and behavioral responses [24-26].

Experimental and clinical studies further demonstrate that dopamine plays a key role in various neurobehavioral processes. For instance, reduced dopaminergic activity has been associated with motivational deficits, while excessive dopaminergic signaling has been linked to hallucinations and psychotic symptoms through alterations in brain circuit dynamics [23,27]. In addition, abnormalities in dopamine receptor function, particularly involving D2 receptors, have been observed in conditions such as insomnia, suggesting a broader role for dopamine in sleep regulation and neurophysiological stability [26].

Importantly, dopamine does not act independently; rather, it interacts dynamically with other neurotransmitter systems, including serotonergic, noradrenergic, and

GABAergic pathways. These interactions are essential for maintaining emotional and behavioral stability, and their disruption may contribute to complex neuropsychiatric manifestations [17].

Overall, these findings indicate that dopamine-related disorders should not be interpreted solely as a result of increased or decreased dopamine levels. Instead, they reflect complex, multifactorial processes involving interconnected neurochemical systems. Therefore, maintaining dopaminergic balance and developing targeted, system-level therapeutic approaches are critical for improving both neurological and psychiatric outcomes.

4. Dopamine-related diseases

Dopamine is a catecholamine neurotransmitter that has important functions in the brain and body. Particularly affecting vital functions such as attention, motivation, reward and movement control in the central nervous system, dopamine is also at the basis of many neurological and psychiatric disorders [31,32]. Dopamine-related diseases are shown in Table 1.

Dopamine is a basic neurotransmitter that regulates many critical functions in the central nervous system, and is associated with both deficiency and excess in different diseases. When we look at Table 1, we see that in addition to disorders related to dopamine deficiency, such as Parkinson's disease, there are also conditions characterized by excess or irregular dopamine, such as schizophrenia and Huntington's disease. This shows that dopamine should be considered not only as a neurotransmitter involved in reward and motivation but as a molecule that is effective in a much broader biological spectrum.

In Parkinson's disease in particular, the degeneration of dopamine-producing neurons leads to serious deterioration of motor functions, while the basic strategy in treatment is based on replacing the missing dopamine with L-DOPA or dopamine agonists. On the other hand, excessive dopamine activity in the mesolimbic pathway in schizophrenia is associated with psychotic symptoms, and treatment is usually aimed at suppressing this excessive activity with dopamine receptor antagonists. Interestingly, in diseases such as bipolar disorder, dopamine levels vary according to the episode, i.e. increase in manic periods and decrease in depressive periods. This underscores the dual role that dopamine plays in mood regulation.

Dopamine plays a critical role not only in neuropsychiatric diseases but also in behavioral and developmental disorders such as addiction, ADHD, and Tourette syndrome. While substance addiction is associated with excessive stimulation of the reward system, dopamine deficiency in ADHD is known to have significant effects on attention and impulse control. The use of dopamine system-regulating drugs in the treatment of these diseases reveals the importance of targeting disease-specific biochemical imbalances.

In general, balanced dopamine regulation is a critical requirement for both neurological and psychiatric health. The tailoring of treatment approaches to disease-specific patterns is causing pharmacogenetics and personalized medicine approaches to gain more importance. In the future, making dopamine-based treatments more sensitive and individualized may provide significant advances, especially for neurodegenerative and psychiatric diseases.

Table 1. Dopamine-related disorders and their multifactorial neurochemical mechanisms

Diseases	Neurochemical Mechanisms (Dopamine and other systems)	Symptoms	Treatment Approaches	Ref.
Parkinson's Disease	Degeneration of dopaminergic neurons with involvement of oxidative stress and mitochondrial dysfunction	Tremor, rigidity, bradykinesia, postural instability	L-DOPA, dopamine agonists, MAO-B inhibitors, physiotherapy	[33]
Schizophrenia	Dopamine dysregulation interacting with glutamatergic and GABAergic dysfunction	Hallucinations, delusions, thought disorders, social withdrawal	Antipsychotics (D2 receptor antagonists), psychosocial therapy	[34]
Bipolar Disorder	Dysregulation of dopaminergic pathways with interactions involving serotonergic and circadian systems	Mania: increased energy, reduced sleep; Depression: low mood, fatigue	Lithium, anticonvulsants, antipsychotics, antidepressants	[35]
Depression	Dysregulation of dopaminergic pathways along with serotonergic and neuroendocrine alterations	Persistent sadness, anhedonia, fatigue, sleep disturbances	Antidepressants (SSRI, SNRI), psychotherapy, adjunct dopaminergic agents	[36,37]
Substance Addiction	Dysregulation of reward circuitry involving dopamine, glutamate, and GABA systems	Substance seeking, loss of control, impaired functioning	Behavioral therapy, pharmacological interventions targeting reward pathways	[38]
Attention-Deficit/Hyperactivity Disorder (ADHD)	Dopaminergic dysfunction combined with noradrenergic imbalance	Attention deficit, hyperactivity, impulsivity	Stimulants (methylphenidate, amphetamines), non-stimulants (atomoxetine)	[39]
Huntington's Disease	Altered dopaminergic signaling with striatal neurodegeneration and neurotransmitter imbalance	Chorea, cognitive decline, behavioral changes	Dopamine receptor antagonists, symptomatic treatment	[40,41]
Tourette Syndrome	Dopaminergic hyperactivity with involvement of cortico-striatal-thalamo-cortical circuits	Motor and vocal tics	Antipsychotics (dopamine receptor antagonists), behavioral therapy	[42]
Anxiety Disorders	Dopamine imbalance interacting with serotonergic and GABAergic systems	Anxiety, fear, avoidance, autonomic symptoms	Antidepressants (SSRI, SNRI), anxiolytics, cognitive behavioral therapy	[43,44]

5. Pharmacokinetics of dopamine

Pharmacokinetic studies of dopamine consistently demonstrate substantial inter- and intraindividual variability in plasma concentrations, distribution, clearance, and volume of distribution (Vd), even under standardized dosing conditions. Clinical investigations have shown that dopamine is rapidly eliminated from plasma, extensively taken up by tissues, and exhibits dose-dependent pharmacokinetic behavior. Despite weight-based dosing strategies, plasma dopamine concentrations may vary widely – up to several-fold differences between individuals – indicating that conventional pharmacokinetic models are often insufficient for predicting therapeutic responses. This variability is influenced by multiple factors, including renal and hepatic function, enzymatic activity, receptor sensitivity, and overall physiological status. Mechanistically, dopamine is primarily metabolized by monoamine oxidase (MAO) and catechol-O-methyltransferase (COMT), resulting in the formation of inactive metabolites such as homovanillic acid (HVA). These metabolic pathways, together with rapid systemic clearance, further contribute to variability in plasma levels and complicate pharmacokinetic predictability. From a pharmacodynamic perspective, dopamine exerts complex hemodynamic effects that are closely related to its dose-dependent receptor activity. In addition to its direct cardiovascular actions, dopamine can be converted into norepinephrine within adrenergic nerve terminals, contributing to increased sympathetic activity, vasoconstriction, and associated adverse effects. Importantly, clinical responses do not consistently correlate with plasma dopamine concentrations, emphasizing that treatment should be guided primarily by hemodynamic response rather than measured drug levels. This is particularly relevant in critically ill and neonatal patients, where both pharmacokinetic variability and pharmacodynamic sensitivity are more pronounced. Overall, these findings highlight the need for individualized dose titration, continuous monitoring, and the integration of pharmacokinetic, metabolic, and pharmacodynamic considerations in optimizing dopamine therapy [45-48].

6. Pharmacological aspects of dopamine

Dopamine is a vasoactive catecholamine that directly or indirectly affects multiple organ systems and plays a critical role in maintaining hemodynamic stability under pathological conditions such as trauma, myocardial infarction, and septic shock. It has historically been used in various clinical settings, including congestive heart failure, trauma, renal failure, open heart surgery, and the maintenance of blood pressure in shock states [49]. However, current clinical guidelines have significantly limited its routine use, and dopamine is now primarily reserved for selected clinical scenarios, particularly in patients with bradycardic shock. Dopamine exhibits dose-dependent pharmacological effects mediated through D1-like (D1, D5) and D2-like (D2, D3, D4) receptor families, as well as β - and α -adrenergic receptors [50,51]. Activation of D1-like receptors leads to vasodilation in renal, mesenteric, coronary, and cerebral vascular beds, whereas D2-like receptor activation inhibits norepinephrine release at presynaptic sympathetic nerve terminals [51]. At moderate doses (approximately 2-5 $\mu\text{g/kg/min}$), stimulation of β_1 -adrenergic receptors increases cardiac contractility and cardiac output [52].

At higher doses ($\geq 10 \mu\text{g/kg/min}$), α -adrenergic receptor activation predominates, resulting in systemic vasoconstriction and increased vascular resistance [52].

Although low-dose dopamine (0.5-3.0 $\mu\text{g/kg/min}$) was previously used for its presumed renal vasodilatory and diuretic effects, including increases in renal blood flow and glomerular filtration rate, accumulating evidence has demonstrated that so-called “renal-dose dopamine” does not improve renal outcomes and is no longer recommended in clinical practice. Therefore, its use as a renal protective or diuretic agent has largely been abandoned. Pharmacokinetically, dopamine has a very short elimination half-life (approximately 1-2 minutes) and is rapidly metabolized through conjugation pathways, including sulfation and glucuronidation. Due to its inability to cross the blood-brain barrier, dopamine has no direct therapeutic effect in central nervous system disorders such as Parkinson’s disease. In contrast, its precursor L-DOPA (levodopa), which crosses the blood-brain barrier, is primarily administered orally and remains a cornerstone in the treatment of Parkinson’s disease; intravenous use is not standard clinical practice [53].

Overall, the dose-dependent pharmacological profile of dopamine, together with its significant interindividual pharmacokinetic variability, necessitates careful dose titration and close hemodynamic monitoring. These considerations highlight the importance of evidence-based, guideline-directed, and individualized approaches in the clinical use of dopamine.

7. Dopamine and hormonal changes

In one study, researchers placed tissue in a dopamine-containing medium and incubated it for a 10-minute test period. Then, it was observed that both arginine vasopressin (ADH) and oxytocin release increased during the 10-minute test incubation period, after allowing them to recover from the effects of the drug for 3 recovery periods. During the recovery process, when the secreted hormone was eliminated, it returned to its previous basal levels. It was observed that the maximum stimulation of hormone release stimulated by dopamine occurred at a concentration of 10^{-6} g/ml , and that the hormone release, i.e. the effect, decreased as the concentration increased. They particularly emphasized the point that dopamine and norepinephrine caused the release of neurohypophysial hormones. They stated that a dopamine receptor mediates the simultaneous release of vasopressin and oxytocin. They stated that norepinephrine was released from the isolated hypothalamus in much lower amounts than dopamine but at a much higher dose level (10^4 times more), which means that norepinephrine does not act on a specific norepinephrine receptor but somehow produces its effect. In the same study, dopamine was administered intravenously to anesthetized, lactating rats at a dose of 30 μg . As a result, a significant increase in mammary gland pressure was observed. Increased mammary gland pressure is an indicator of the release of oxytocin hormone. At the same time, 50 μg of Pimozide administered intravenously blocked the hormone release effect caused by dopamine and reversed the blood pressure increase effect caused by dopamine and a decrease in blood pressure was observed [54].

In a study conducted by Leblanc and colleagues, changes in pituitary hormones caused by dopamine infusion in humans were examined. For this purpose, 4 µg/kg/min infusion was applied to the subjects, and it was observed that PRL (prolactin) concentration was suppressed statistically significantly in men and women after 3 hours. It was stated that this suppression was greater in women than in men. It was stated that this result was consistent with the information that PRL release was inhibited by dopamine agonists and that it was evidence of the direct effect of dopamine infusion on the hypothalamus. Again, LH (luteinizing hormone) and FSH (follicle stimulating hormone) levels in the serum were examined after dopamine infusion. LH level decreased significantly and recovered rapidly after the infusion. No significant change was observed in FSH levels throughout the experiment. However, the researchers stated that studies should continue to determine the role of dopamine in the regulation of LH release [55].

Studies show that dopamine has important effects on the release of pituitary hormones. Dopamine plays a role in the regulation of neurohypophyseal hormones by increasing the release of arginine vasopressin (ADH) and oxytocin. It has also been observed that dopamine suppresses the release of prolactin (PRL), and this effect is more pronounced in women. Dopamine infusion caused a temporary decrease in luteinizing hormone (LH) levels, while it did not cause a significant change in follicle stimulating hormone (FSH) levels. These findings reveal the direct effects of dopamine on the hypothalamic-pituitary axis. However, more research is needed to fully understand the role of dopamine in LH release. These multifaceted effects of dopamine on hormone release indicate that it has an important role in the regulation of the endocrine system.

8. Dopamine during pregnancy

During pregnancy, dopamine has important physiological and hormonal effects on the health of both the mother and the fetus [56]. Dopamine controls the lactation process by regulating prolactin (PRL) secretion, especially via the hypothalamic-pituitary axis. Normally, dopamine suppresses prolactin secretion, preventing milk production. However, increasing estrogen levels during pregnancy can affect dopamine production and activity. This contributes to increased prolactin levels during pregnancy and to the preparation of breast tissue for milk production. The decrease in the suppressive effect of dopamine in the late stages of pregnancy and after birth allows milk production to begin [57]. Another important role of dopamine in pregnancy is its effects on the placenta. The placenta is an organ where dopamine is synthesized and metabolized. Dopamine may contribute to placental vascular regulation and function. In addition, placental dopamine may also have an effect on the development of the fetal nervous system [58]. However, excessive or insufficient activity of dopamine can lead to various complications during pregnancy. For example, dopamine signaling contributes to fetal brain development, but its long-term effects on neurological outcomes warrant further study [59]. Preeclampsia is a condition characterized by high blood pressure and organ damage and can pose a life-threatening risk to both the mother and the fetus [60]. The regulating effect of dopamine on

placental blood flow may play a potential role in preventing such complications. The effects of dopamine on the cardiovascular and renal systems during pregnancy are also important [61]. Dopamine can increase urine output by improving renal function and help relieve conditions such as edema [62]. This may be especially useful in the management of conditions such as edema and hypertension, which are common in pregnancy. However, the use of dopamine during pregnancy should be considered carefully, as it may have potential side effects on the fetus. High doses of dopamine in particular may negatively affect fetal development by reducing uteroplacental blood flow [63].

The neurological effects of dopamine during pregnancy should not be ignored. Dopamine plays an important role in fetal brain development. Dopamine deficiency or imbalance can negatively affect fetal neurological development and lead to neurological disorders in the postnatal period. In particular, the effects of dopamine on the dopaminergic system are critical for the motor and cognitive development of the fetus [56,64].

In conclusion, dopamine has a multifaceted role in hormonal regulation, placental function, cardiovascular and renal systems, and fetal neurological development during pregnancy. However, more clinical research is needed to fully understand the effects of dopamine during pregnancy and to ensure its safe use. The use of dopamine during pregnancy should be carefully evaluated for both maternal and fetal health and, if necessary, should be administered under specialist supervision.

9. Increasing dopamine naturally

One of the most effective ways to increase dopamine levels is through diet. It is very important to consume foods that contain amino acids such as tyrosine and phenylalanine, which are necessary for the synthesis of dopamine [65].

9.1. Foods that support dopamine production (Fig. 2).

- Banana: It is a natural source of tyrosine and supports the production of serotonin and dopamine [66].
- Avocado: Contains healthy fats, B vitamins, and tyrosine, which supports dopamine synthesis [67].
- Eggs: Rich in choline and tyrosine, they strengthen brain functions [68].
- Cheese: Contains high levels of tyrosine, contributing to dopamine production [69].
- Fish and chicken: Rich in protein and provide the amino acids necessary for dopamine synthesis [70].
- Nuts (almonds, walnuts, hazelnuts): Rich in omega-3 fatty acids and tyrosine, supporting brain health [71].
- Dark chocolate: Increases dopamine levels by containing polyphenols [72].
- Green leafy vegetables (spinach, cabbage): Support dopamine production by containing folic acid and iron [73].



Fig. 2. Foods that increase dopamine levels

9.2. Exercise and physical activity

Physical activities are one of the most effective methods to increase dopamine levels. Activities such as aerobic exercises, weight training and yoga increase dopamine release, making the person feel more energetic and motivated. In particular, movements such as running, swimming and cycling increase dopamine levels by positively affecting brain chemistry [74].

9.3. Sunlight and spending time in nature

Sunlight supports the production of vitamin D, which indirectly increases dopamine levels. Getting at least 15-30 minutes of sunlight daily both improves mood and supports brain health. In addition, walking in nature or spending time outdoors can reduce stress by increasing dopamine release [75].

9.4. Meditation and mindfulness practices

Meditation can reduce stress levels and support dopamine production. Regular meditation and breathing exercises can positively affect brain functions and increase happiness and motivation [76].

9.5. Sleep patterns and their effect on dopamine

Quality and sufficient sleep is a critical factor in maintaining dopamine balance. Sleeping at least 7-9 hours a night supports brain functions and increases dopamine production. Irregular sleep or lack of sleep can lead to decreased dopamine levels and increased fatigue [77].

In this context, it is possible to increase dopamine levels naturally. Paying attention to nutrition, exercising regularly, taking advantage of sunlight, managing stress, and getting quality sleep are effective methods to increase dopamine levels. Adopting a healthy lifestyle can improve overall mood and motivation by keeping brain chemistry balanced.

10. Conclusion and future perspectives

This review discusses the important role of dopamine in many physiological and psychological processes, including motivation, reward mechanisms, motor control, and cognitive functions. Dopamine is a complex neurotransmitter that is central to many critical physiological and psychological processes, including motivation, reward mechanisms,

motor control, and cognitive functions, beyond being just a “happiness hormone”. It contributes to the maintenance of homeostasis in a wide range of areas, from the central nervous system to the endocrine and cardiovascular systems. However, dopaminergic dysfunction contributes to the pathophysiology of disorders such as Parkinson's disease, schizophrenia, depression, and ADHD.

The effectiveness of dopamine-based treatments can be limited by the pharmacokinetic and pharmacodynamic properties that vary between individuals. In this context, personalized dosing strategies and targeted therapies are a critical approach to both increase treatment success and minimize possible side effects. In addition, the inability of dopamine to cross the blood-brain barrier necessitates the development of alternative therapeutic methods in the treatment of neurological diseases.

Future research should focus on optimizing dopamine-based therapies and should particularly focus on personalized approaches. Pharmacogenomic studies may help identify genetic factors influencing dopamine metabolism and receptor function, although their widespread clinical application remains under investigation. In addition, nanotechnology and strategies to overcome the blood-brain barrier may play an important role in more innovative drug development processes for neurodegenerative diseases.

It is seen that dopamine is not limited to its effects on neurological and psychiatric diseases, but also plays critical roles in areas such as immune regulation, metabolic processes and pregnancy. In particular, studies on its interactions with inflammation, oxidative stress and intestinal microbiota may expand the therapeutic use of dopamine and contribute to the identification of new treatment targets.

In conclusion, dopamine is of great clinical importance in terms of medicine and biomedical research due to its central role in the nervous system and its wide physiological effects. Interdisciplinary studies should be continued to develop more effective and safe dopamine-based therapies. In the future, advances in areas such as pharmacogenomics, nanotechnology, and targeted drug design may maximize the therapeutic potential of dopamine, offering breakthrough approaches to the management of many diseases.

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