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## **Post-COVID syndrome and its effects on a woman's body**

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The article is devoted to the study of post-COVID syndrome (PCS) as a current medical and social problem and its consequences for the human body, in particular, the female body. Based on the analysis of modern scientific sources, the main clinical manifestations, pathogenetic mechanisms, and the most common symptoms after COVID-19 have been considered. It has been established that PCS is a multisystem condition with long-term manifestations that significantly affect physical, psychoemotional and reproductive health, reduce the quality of life and working capacity of patients.

**Aim** – to generalize and analyze modern scientific data on clinical manifestations, pathogenetic mechanisms, and long-term consequences of PCS, as well as to assess its impact on the functional state and health of the female body, taking into account physical, psychoemotional, and reproductive aspects.

As a result of the analysis of scientific publications, it was established that PCS is characterized by multisystem damage to the body with a predominance of asthenic, neurological, cardiorespiratory, and psychoemotional manifestations. In women, PCS is more often accompanied by chronic fatigue, sleep disorders, anxiety and depression, autonomic dysfunction and decreased performance. A connection has been found between the development of PCS and prolonged immune activation, endothelial dysfunction and hormonal imbalance, which can lead to menstrual cycle disorders, deterioration of reproductive health and exacerbation of concomitant somatic and gynecological pathologies. The data obtained indicate a significant negative impact of PCS on the quality of life of women and their social activity.

**Conclusion.** PCS is a complex multifactorial condition with long-term consequences for the female body, which requires a comprehensive, interdisciplinary approach to diagnosis, treatment, and rehabilitation. Taking into account the gender characteristics of the course of PCS is a necessary condition for increasing the effectiveness of medical care. Further research should be aimed at clarifying the mechanisms of development of post-COVID complications in women and developing standardized patient management protocols to improve long-term clinical outcomes and quality of life.

The authors declare the absence of a conflict of interest.

**Keywords:** post-COVID syndrome, COVID-19, immune disorders, hormonal imbalance, reproductive health, female body, menstrual cycle disorders, psychoemotional disorders, rehabilitation.

### **Постковідний синдром та його наслідки на організм жінки**

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Стаття присвячена дослідженню постковідного синдрому (ПКС) як актуальної медико-соціальної проблеми та його наслідків для організму людини, зокрема жіночого організму. На основі аналізу сучасних наукових джерел розглянуто основні клінічні прояви, патогенетичні механізми та найбільш поширені симптоми після перенесеного COVID-19. Встановлено, що ПКС є мультисистемним станом із тривалими проявами, які суттєво впливають на фізичне, психоемоційне та репродуктивне здоров'я, знижують якість життя та працездатність пацієнтів.

**Мета** – узагальнення та аналіз сучасних наукових даних щодо клінічних проявів, патогенетичних механізмів і довгострокових наслідків постковідного синдрому, а також оцінка його впливу на функціональний стан і здоров'я жіночого організму з урахуванням фізичних, психоемоційних та репродуктивних аспектів.

Унаслідок аналізу наукових публікацій встановлено, що постковідний синдром характеризується мультисистемним ураженням організму з переважанням астеничних, неврологічних, кардіореспіраторних та психоемоційних проявів. У жінок ПКС частіше супроводжується хронічною втомою, порушеннями сну, тривожно-депресивними станами, вегетативною дисфункцією та зниженням працездатності. Виявлено зв'язок між розвитком ПКС і тривалою імунною активацією, ендотеліальною дисфункцією та гормональним дисбалансом, що може зумовлювати порушення менструального циклу, погіршення репродуктивного здоров'я та загострення супутньої соматичної й гінекологічної патології. Отримані дані свідчать про значний негативний вплив ПКС на якість життя жінок та їхню соціальну активність.

**Висновок.** Постковідний синдром є складним мультифакторним станом із тривалими наслідками для жіночого організму, що потребує комплексного міждисциплінарного підходу до діагностики, лікування та реабілітації. Урахування гендерних особливостей перебігу ПКС є необхідною умовою підвищення ефективності медичної допомоги. Подальші дослідження повинні бути спрямовані на уточнення механізмів розвитку постковідних ускладнень у жінок і розробку стандартизованих протоколів ведення пацієнток із метою покращення довгострокових клінічних результатів і якості життя.

Автори заявляють про відсутність конфлікту інтересів.

**Ключові слова:** постковідний синдром, COVID-19, імунні порушення, гормональний дисбаланс, репродуктивне здоров'я, жіночий організм, порушення менструального циклу, психоемоційні розлади, реабілітація.

The COVID-19 pandemic, caused by the SARS-CoV-2 virus, has become one of the largest medical and social crises of our time and has significantly affected the global healthcare system. Despite the reduction in mortality rates and improvements in approaches to treating the acute phase of the disease, a significant number of patients who, after an infection, experience various symptoms for a long time, persisting for weeks or months, remains a pressing problem. This condition is called post-COVID syndrome (PCS) or Long COVID and is characterized by persistent functional impairments that negatively affect the quality of life, working capacity, and social activity of the population [12].

Post-COVID syndrome is defined as a complex of symptoms that arise or persist after COVID-19 and cannot be explained by other diseases. Most often, patients complain of general weakness, chronic fatigue, shortness of breath, cognitive impairment, muscle and joint pain, sleep disorders, anxiety, and depressive states. According to scientific research, PCS is multisystemic in nature and may be accompanied by damage to the cardiovascular, respiratory, nervous, endocrine and immune systems, which makes its diagnosis and treatment difficult.

The study of PCS in women attracts particular attention in modern medical science, since this category of patients often demonstrates a higher frequency of prolonged symptoms and more pronounced psychoemotional and asthenic manifestations. Researchers note that post-infectious changes can affect hormonal balance, reproductive function, and the course of gynecological diseases. Cases of menstrual cycle disorders, changes in the duration and intensity of menstruation, exacerbation of endocrine disorders, and deterioration of general well-being have been described. At the same time, the mechanisms of such changes remain poorly understood, which complicates the formation of standardized clinical approaches [8].

The pathogenesis of PCS is considered a multifactorial process, in the development of which residual inflammation, prolonged immune dysregulation, autoimmune reactions, endothelial dysfunction, microcirculatory disorders, and neurohumoral disorders may participate. The combination of these mechanisms contributes to the formation of persistent clinical manifestations that require a comprehensive and interdisciplinary approach to medical care, rehabilitation, and prevention of complications.

Thus, PCS is a significant public health problem that requires further in-depth study, especially in the context of gender-specific characteristics of the course and impact on the female body. Analysis of current data on clinical manifestations, mechanisms of development, and consequences of PCS will allow improving approaches to early diagnosis, treatment, and rehabilitation of patients, and will also contribute to reducing the socio-economic burden on the healthcare system.

*The aim* of this study is to conduct a comprehensive study of the features of PCS as a multisystem pathological condition that develops after COVID-19 infection, which is aimed at analyzing the main clinical manifestations, possible pathogenetic mechanisms, and risk factors for the formation of post-COVID complications, as well as determining their impact on the functional state of the female body.

The use of the analytical method in the study of PCS involved a systematic review of scientific sources and clinical data of women who had COVID-19. A comprehensive review of domestic and foreign publications for 2020–2025 was conducted, covering the clinical, pathophysiological, and epidemiological aspects of post-COVID conditions. The analysis of the literature made it possible to identify key trends in the interpretation of PCS, in particular regarding its role in the development of chronic pathology among the female population.

The results of the study showed that PCS in women is characterized by long-term changes in the general functional state of the body and is manifested by multisystem damage. The generalization of the obtained data indicates that PCS has a complex effect on the somatic and psychoemotional health of women, forming persistent functional disorders and increasing the risk of exacerbation of chronic diseases [2]. The main systemic manifestations of PCS and their generalized characteristics are given in Table 1.

**Impact on the cardiovascular system.** The impact of COVID-19 and PCS on the cardiovascular system of women is an important clinical problem, since SARS-CoV-2 is capable of causing both acute and long-term cardiovascular complications. After infection, women often develop persistent functional disorders of the heart and blood vessels, manifested by decreased tolerance to physical exertion, shortness of breath, palpitations, instability of blood pressure, and pain in the heart area. One of the key mechanisms of damage to the cardiovascular system is

Table 1

**Main manifestations of post-COVID syndrome in women: systemic lesions, mechanisms and clinical consequences**

| Organ/system                     | Main clinical manifestations in women   | Probable pathogenetic mechanisms  | Possible long-term consequences  |
|----------------------------------|---|---|--|
| Cardiovascular system            | tachycardia, cardialgia, blood pressure instability, shortness of breath on exertion, postural orthostatic tachycardia syndrome | endothelial dysfunction, microthromboses, myocardial inflammation, dysautonomia | arterial hypertension, rhythm disturbances, decreased tolerance to physical exertion |
| Nervous system                   | «brain fog», headache, dizziness, memory impairment, paresthesia  | neuroinflammation, blood-brain barrier disorders, microcirculatory disorders    | cognitive deficit, chronic asthenia, neuropathies                                    |
| Psychoemotional sphere           | anxiety, depression, panic attacks, emotional lability, insomnia  | neurotransmitter imbalance, chronic inflammation, stress reaction               | post-traumatic disorders, chronic depression, decreased social activity              |
| Respiratory system               | shortness of breath, cough, decreased saturation, weakness  | residual inflammation, fibrotic changes, gas exchange disorders                 | post-traumatic pneumopathy, decreased lung function                                  |
| Immune system                    | frequent infections, subfebrile temperature, exacerbation of chronic diseases   | cytokine imbalance, immune exhaustion, autoimmunization                         | autoimmune diseases, chronic systemic inflammation                                   |
| Endocrine system                 | weight fluctuations, weakness, appetite disorders, thyroid symptoms   | thyroid dysfunction, cortisol secretion disorders, insulin resistance           | metabolic syndrome, hypothyroidism, type 2 diabetes                                  |
| Reproductive system              | menstrual cycle disorders, dysmenorrhea, increased premenstrual syndrome, decreased libido                                      | hormonal imbalance, effects on the hypothalamic-pituitary-gonadal axis          | fertility disorders, exacerbation of gynecological pathology                         |
| Musculoskeletal system           | myalgia, arthralgia, weakness, back pain  | systemic inflammation, microcirculatory disorders, myositis                     | chronic pain syndrome, limited mobility  |
| Gastrointestinal tract and liver | nausea, diarrhea, abdominal pain, discomfort after eating   | dysbiosis, immune disorders, inflammatory response                              | irritable bowel syndrome, exacerbation of chronic gastrointestinal diseases          |

endothelial dysfunction, since the virus affects endothelial cells through angiotensin-converting enzyme type 2 (ACE2) receptors. This causes impaired vascular tone, microcirculation, and increases the risk of thrombosis. In women, such changes may have a longer course, which is associated with the peculiarities of the immune response and hormonal regulation. Increased activation of the blood coagulation system can lead to the development of thromboembolic complications, including deep vein thrombosis and pulmonary embolism, and also contribute to the occurrence of microthromboses in the vessels of the myocardium [18].

COVID-19 is also associated with the risk of developing myocarditis, pericarditis, and cardiomyopathy. Even after a mild course of the disease, women may still have signs of inflammatory damage to the myocardium, manifested by arrhythmias, a feeling of heart failure, tachycardia, and cardialgia. A separate place is occupied by post-COVID dysautonomia, which is often found in women and is manifested by

postural orthostatic tachycardia syndrome (POTS), dizziness, fainting, palpitations, and sharp fluctuations in blood pressure.

An important aspect is the impact of COVID-19 on the risk of exacerbation of pre-existing cardiovascular diseases, such as arterial hypertension, coronary heart disease, and heart failure. In women, especially in the perimenopausal and postmenopausal period, a decrease in estrogen levels reduces the cardioprotective effect, which can enhance the negative impact of viral infection and contribute to the progression of atherosclerotic changes.

The impact of COVID-19 and PCS on the nervous system of women is one of the most common and clinically significant manifestations, which significantly reduces the quality of life and work capacity. In women, neurological and psychoemotional symptoms after infection are recorded more often than in men, which is associated with the characteristics of the immune response, hormonal background, and increased susceptibility to autoimmune reactions [16].

**Impact on the nervous system.** The most characteristic manifestations of damage to the nervous system in PCS are chronic fatigue, headache, dizziness, sleep disturbances, cognitive disorders (decreased concentration, memory impairment, the so-called «brain fog»), as well as emotional lability. Women often experience anxiety and depression, panic attacks, and increased irritability, which can form persistent disorders of psychoemotional balance. Such symptoms often have a long course and require comprehensive medical care. The pathogenesis of neurological complications of COVID-19 is multifactorial. Neuroinflammatory processes that arise as a result of the systemic immune response and cytokine imbalance play an important role. An increase in the level of pro-inflammatory cytokines can lead to impaired blood-brain barrier function, which contributes to the penetration of inflammatory mediators into the central nervous system and the formation of functional changes in neuronal structures. In addition, the role of autoimmune mechanisms that can cause long-term neurological manifestations and sensory disorders is described [4].

Women also often experience manifestations of autonomic dysfunction, including instability of blood pressure, tachycardia, shortness of breath, sweating, tremor, thermoregulation disorders, and a tendency to faint. These symptoms may be associated with dysfunction of the autonomic nervous system and disorders of neurohumoral regulation. One of the characteristic manifestations is POTS, which is more often recorded in women after a coronavirus infection.

The impact of COVID-19 on the peripheral nervous system attracts special attention. Patients may experience paresthesias, numbness of the extremities, neuropathic pain, decreased sensitivity, and muscle weakness, which are associated with impaired microcirculation, inflammatory processes, and metabolic changes. Cases of impaired sense of smell and taste are also described, which can persist for a long time and indicate damage to sensory nerve pathways [20].

The psychoemotional consequences of COVID-19 in women can be exacerbated by hormonal fluctuations, especially during perimenopause or with concomitant endocrine disorders. Changes in estrogen and progesterone levels can affect the neurotransmitter systems of the brain, which increases the risk of developing depressive and anxiety disorders. Additional factors are social stress, chronic overload,

sleep disorders, and reduced physical activity during the illness.

The impact of COVID-19 and PCS on the immune system of women is one of the key pathogenic factors in the development of long-term complications after infection. SARS-CoV-2 is capable of causing profound disorders of immune regulation, manifested both by excessive activation of inflammatory reactions in the acute period and by the formation of an immune imbalance in the future. In women, immune changes may be more prolonged and pronounced, which is associated with the peculiarities of the hormonal background and the specifics of the immune response of the female body [7].

**Impact on the immune system.** One of the main mechanisms is prolonged immune activation, which can persist even after clinical recovery. Increased levels of pro-inflammatory cytokines (interleukins, tumor necrosis factor) contribute to the maintenance of chronic low-intensity inflammation, which is a characteristic feature of PCS. This condition can cause prolonged weakness, subfebrile temperature, muscle and joint pain, sleep disorders, and cognitive disorders.

An important feature of post-COVID immune changes is impaired cellular immunity, in particular the function of T-lymphocytes, which leads to a decrease in the body's ability to effectively control infectious agents. This may explain the increased susceptibility to repeated respiratory infections, exacerbation of chronic inflammatory processes and slow recovery from the disease. In some cases, signs of immune exhaustion are observed, which is manifested by a decrease in the body's adaptive capabilities and increased sensitivity to stress factors [17].

Autoimmune mechanisms play a separate role in pathogenesis. As a result of impaired immune tolerance after a previous infection, the formation of autoantibodies that attack the body's own tissues may occur. The female body is generally more prone to the development of autoimmune processes; therefore, after COVID-19, the risk of the debut or exacerbation of diseases such as autoimmune thyroiditis, systemic lupus erythematosus, rheumatoid arthritis, and other immune-dependent pathologies increases. This may be accompanied by endocrine disorders, chronic pain, metabolic disorders, and changes in reproductive function.

Women also experience changes in the humoral link of immunity, including fluctuations in antibody levels and an imbalance of immunoglobulins. The

presence of residual viral fragments in the tissues can support the immune response and contribute to the persistence of inflammation. This explains the prolonged course of symptoms and the difficulty in determining clear recovery times.

**Impact on the endocrine system.** The COVID-19 pandemic has highlighted the issue of systemic damage to the human body, in particular the endocrine system, which is an important component of the regulation of metabolic processes, immune response, and adaptive reactions. SARS-CoV-2 is characterized by pronounced tropism for tissues expressing ACE2, as well as the transmembrane serine protease TMPRSS2, which ensures the penetration of the virus into cells. ACE2 receptors are widely represented in the organs of the endocrine system, including the thyroid gland, pancreas, adrenal glands, hypothalamus, pituitary gland, ovaries, and adipose tissue, which justifies the potential of COVID-19 to cause both acute and long-term endocrine disorders [9].

One of the most studied areas is the impact of COVID-19 on the functional state of the thyroid gland. In women after a coronavirus infection, manifestations of thyroid dysfunction are often observed, in particular the development of subacute thyroiditis, transient thyrotoxicosis, or the formation of hypothyroidism. The pathogenetic mechanisms of such changes are direct viral invasion of thyrocytes, systemic inflammation, cytokine-induced tissue damage, as well as activation of autoimmune reactions. In women with a genetic predisposition to autoimmune diseases, COVID-19 may trigger the debut or exacerbation of autoimmune thyroiditis (Hashimoto's thyroiditis), which is accompanied by a violation of hormonal homeostasis and a decrease in the quality of life. Of significant clinical importance is the impact of COVID-19 on the pancreas and the regulation of carbohydrate metabolism. The pancreas is characterized by high expression of ACE2, which creates conditions for possible damage to  $\beta$ -cells of the islets of Langerhans. Inflammatory response, endothelial dysfunction, and microthrombosis can worsen tissue perfusion, contributing to dysfunction of insulin secretion. As a result, some patients after COVID-19 develop transient hyperglycemia, insulin resistance, and progression of metabolic syndrome. Women with excess body weight, obesity, polycystic ovary syndrome, and a history of gestational diabetes are particularly vulnerable [3]. PCS may be accompanied by increased dyslipidemia, appetite disorders and decreased physical activity, which further con-

tribute to the formation of metabolic complications. An important pathogenetic component is dysfunction of the hypothalamic-pituitary-adrenal axis, which provides neuroendocrine regulation of the stress response. The infectious process, systemic hypoxia, psychoemotional stress, and prolonged inflammation can disrupt the secretion of corticotropin and cortisol. Cortisol imbalance can cause asthenic syndrome, chronic fatigue, emotional instability, anxiety, sleep disorders, and decreased cognitive functions. In some cases, secondary adrenal insufficiency or functional disorders of the body's adaptive mechanisms may develop. In women, such manifestations may have a longer course, which is associated with the influence of sex hormones on the regulation of the neuroendocrine system. The impact of COVID-19 on the reproductive endocrine system of women deserves special attention. Scientific studies indicate possible disruption of ovarian function due to inflammatory reactions, immune dysregulation, and changes in gonadotropic regulation. Women after an infection often experience menstrual cycle disorders, changes in the duration and intensity of menstruation, dysmenorrhea, increased premenstrual syndrome (PMS), as well as signs of anovulatory cycles. It is believed that such changes may be associated with both the direct effect of the virus on ovarian tissue and secondary neuroendocrine disorders resulting from stress and prolonged inflammation [10].

In addition, PCS may exacerbate manifestations of hypoestrogenic states in perimenopausal and postmenopausal women. A decrease in estrogen levels contributes to the deterioration of vascular reactivity, the development of metabolic changes, impaired thermoregulation, and increased psychoemotional disorders. In such patients, COVID-19 may accelerate the progression of cardiovascular and metabolic disorders, which complicates the rehabilitation process.

An important role in the formation of endocrine disorders is played by the relationship between immune and hormonal regulation. The female body is characterized by a more active immune response, which, on the one hand, contributes to better control of viral infection, but on the other hand, increases the risk of developing autoimmune reactions. That is why women after COVID-19 are more likely to experience autoimmune endocrinopathies, including thyroiditis, glucose dysregulation, and potential changes in reproductive function [5,14].

Post-COVID syndrome in women is a multisystem condition characterized by prolonged clinical

Table 2

## Algorithm for managing women with post-COVID syndrome

| Stage   | Actions  | Aim / Result   | Responsible specialist  |
|---|--|--|---|
| 1. Initial screening (2–4 weeks after COVID-19)     | - Collection of anamnesis regarding the course of COVID-19.<br>– Identification of the main symptoms of ACS (asthenia, shortness of breath, tachycardia, cognitive impairment, menstrual disorders).<br>– Initial physical examination | Identification of patients at high risk of developing post-COVID complications | Therapist / family doctor   |
| 2. Basic laboratory and instrumental diagnostics    | - General and biochemical blood test.<br>– Thyroxine, TSH, cortisol, glucose, HbA1c.<br>– electrocardiography, echocardiography for cardiac symptoms.<br>– Spirometry for respiratory disorders  | Identification of systemic disorders, initial monitoring of organ functions    | Therapist, endocrinologist, cardiologist, pulmonologist                             |
| 3. Multisystem assessment (if symptoms are present) | - Neurological examination for cognitive or sensory impairment.<br>– Psychological assessment/testing for anxiety and depression.<br>– Gynecological examination for menstrual or fertility disorders                                  | Identification of organ disorders and psychoemotional problems                 | Neurologist, psychiatrist / psychologist, gynecologist                              |
| 4. Rehabilitation strategy                          | - Physical therapy and moderate cardio.<br>– Breathing exercises.<br>– Psychological support, cognitive training.<br>– Nutritional and endocrine correction (as indicated)   | Restoration of functional status, improvement of quality of life               | Rehabilitation doctor, physiotherapist, psychologist, nutritionist, endocrinologist |
| 5. Dynamic observation (3–12 months)                | - Monitoring of cardiovascular, endocrine, immune and reproductive indicators.<br>– Correction of treatment and rehabilitation as needed   | Prevention of progression of complications and recurrence of symptoms          | Family doctor, narrow specialists by profile  |
| 6. Education and prevention                         | - Advice on healthy lifestyle, physical activity, nutrition.<br>– Information on early signs of relapse or exacerbation  | Increased patient self-control and prevention of long-term complications       | Family doctor, nurse, psychologist  |

manifestations after COVID-19, including asthenia, cognitive impairment, cardiorespiratory symptoms, endocrine and reproductive dysfunctions. Due to the high risk of complications and the variety of clinical manifestations, we have developed an algorithm for the management of patients with PCS (Table 2). The algorithm consists of six stages and provides for a multistage approach aimed at early detection of disorders, assessment of functional status, differentiated examination, comprehensive rehabilitation, and long-term follow-up.

The *first stage* includes initial screening within 2–4 weeks after COVID-19. At this stage, a history is taken, clinical symptoms of ACS are assessed, such as shortness of breath, tachycardia, menstrual irregularities, and cognitive disorders, as well as an initial physical examination is performed. The goal of this stage is to identify patients at high risk of developing post-COVID complications.

The *second stage* involves basic laboratory and instrumental diagnostics. The examination includes a general and biochemical blood test, determination

of thyroid and adrenal hormones, assessment of carbohydrate metabolism, electrocardiography, echocardiography for cardiac symptoms, and spirometry for respiratory disorders. This allows you to identify systemic disorders and create an initial monitoring of the functional state of organs.

At the *third stage*, a multisystem assessment is performed in patients with existing symptoms. It includes neurological examination for cognitive and sensory disorders, psychological assessment for anxiety and depression, and gynecological examination for menstrual or fertility disorders. The purpose of this stage is to identify organ disorders, assess the psychoemotional state, and develop an individual management plan.

The *fourth stage* involves comprehensive rehabilitation, which includes physical therapy, moderate-intensity cardio, breathing exercises, cognitive training, psychological support, and nutritional and endocrine correction as indicated. The goal of this stage is to restore physiological and psychoemotional balance, improve quality of life, and work capacity.

The *fifth stage* is dynamic observation for 3–12 months. Patients are monitored for cardiovascular, endocrine, immune, and reproductive parameters, and treatment and rehabilitation measures are adjusted if necessary. This helps prevent the progression of complications and recurrence of symptoms.

The *sixth stage* includes educational work and prevention. Patients receive information about a healthy lifestyle, physical activity, nutrition, as well as early signs of relapse or exacerbation, which increases self-control and helps prevent long-term complications.

The proposed algorithm allows for a systematized approach to the management of women with PCS, integrating multidisciplinary assessments, laboratory and instrumental studies, and physical and psychological rehabilitation. Its implementation contributes to increasing the efficiency of medical care, improving the quality of life of patients, and reducing the socio-economic burden of the pandemic.

Post-COVID syndrome in women is a complex medical and social problem, characterized by multi-system damage to the body and prolonged clinical manifestations. The results of modern studies indicate that women after COVID-19 are more likely to experience psychoemotional disorders, dysfunction of the endocrine and reproductive systems, as well as manifestations of cardiovascular and nervous pathology. This is explained by the peculiarities of the immune and hormonal regulation of the female body, including a more active immune response and sensitivity to neuroendocrine imbalance [11].

One of the key aspects of PCS is the relationship between residual inflammation, immune dysregulation, and hormonal instability. Inflammatory cytokines remaining in the blood after the acute phase of COVID-19 can provoke dysfunction of the thyroid gland, pancreatic  $\beta$ -cells, adrenal glands, and ovaries. This is confirmed by numerous clinical observations indicating a high risk of developing transient thyrotoxicosis, insulin resistance, dysmenorrhea, and anovulatory cycles in women after infection [13].

Psychoemotional and cognitive disorders in women, which are a frequent component of PCS, are due to the complex effect of the virus on the central nervous system and the body's systemic response to chronic stress. Cognitive deficit («brain fog»), anxiety, depression, and sleep disorders create an additional burden on physiological systems and can exacerbate endocrine and cardiovascular disorders [1,19].

The development of an algorithm for managing women with PCS proposed in this work allows for the systematization of a multidisciplinary approach: from early screening and basic laboratory and instrumental diagnostics to comprehensive rehabilitation, dynamic observation, and educational work. Such approaches are supported by current Long COVID guidelines, which emphasize the importance of early identification of symptoms and individualized management of patients, including women at high risk of endocrine and reproductive disorders [15].

Despite progress in the study of PCS, significant gaps remain in understanding the long-term consequences for the female body, especially regarding the long-term impact on reproductive function, endocrine balance, and cognitive abilities. Further research is needed to identify risk markers, develop standardized observation and rehabilitation protocols, and evaluate the effectiveness of integrated treatment programs [6].

Thus, the discussion confirms that PCS in women is a complex and multifactorial syndrome that requires a systemic approach. The use of a management algorithm integrating multidisciplinary assessment, early diagnosis, and comprehensive rehabilitation can reduce the risk of symptom chronicity, improve the quality of life of patients, and reduce the socio-economic burden of the consequences of the COVID-19 pandemic.

## Conclusions

Post-COVID syndrome in women is a complex multisystem phenomenon, which is caused by the interaction of residual inflammatory processes, immune response disorders and dysregulation of the neuroendocrine and hormonal systems. The impact of COVID-19 on the female body is manifested not only in physical symptoms, such as tachycardia, asthenia, and respiratory function disorders, but also in cognitive, psychoemotional, and reproductive disorders, which leads to a complex decrease in the quality of life and work capacity. The key factor in long-term consequences is the integration of systemic inflammatory reactions with hormonal instability, which particularly significantly affects the function of the thyroid gland, gonads, and adrenal glands, disrupting the metabolic balance and the body's recovery cycle.

The formation of a systemic algorithm for the management of women with PCS, which combines early diagnosis, multidisciplinary assessment, com-

prehensive rehabilitation, and long-term observation, allows for timely detection of organ disorders and adjustment of treatment. This approach not only improves the physical condition and psychoemotional well-being of patients, but also reduces the risk of chronicity of symptoms, which is often a source of socio-economic burden. Despite progress in the study of PCS, significant uncertainties remain regarding the long-term effects on the female body,

in particular regarding the long-term impact on reproductive function and metabolic profile. Further studies aimed at identifying pathogenetic risk markers, developing standardized management protocols, and assessing the effectiveness of rehabilitation programs are necessary to optimize medical care and improve the quality of life of women who have suffered from COVID-19.

*The authors declare no conflicts of interest.*

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