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ORIGINAL ARTICLE

Clinical use of xenon-oxygen therapy to restore neuropsychological and adaptive status in young women with hormone-dependent breast cancer after total ovarian suppression

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ABSTRACT

Purpose of the study. The objective of this study is to evaluate the clinical effectiveness of activation xenon-oxygen therapy (XOT) in correcting neuropsychological and adaptive status in patients diagnosed with hormone-dependent breast cancer who have undergone total ovariectomy.

Patients and methods. We analyzed data on the intensity of clinical symptoms, the dynamics and intensity of adaptive responses (AR) with calculation of the anti-stress/stress ratio, as well as the bioelectric brain activity of 36 young patients diagnosed with hormone-dependent breast cancer, presenting with clinical signs of post-mastectomy syndrome (PMES) and early signs of post-ovariectomy syndrome (POES).

Results. In determining the distribution of stress and anti-stress reactions, a postoperative phase transition from a physiological to a pathological state was reliably established. In the postoperative period following ovariectomy, normal reaction types were observed in 11.3 % of cases. The predominant response was the stress reaction. Analysis of AR structure in patients with PMES and POES manifestations demonstrated a clear advantage for XOT. During rehabilitation, patients in the non-XOT group did not achieve full restoration of AR structure to baseline values, with the stress response persisting in 58.7 % of cases. In contrast, the XOT group demonstrated anti-stress reactions, with no stress reactions detected. Furthermore, analysis of the bioelectric activity of the brain in patients after two hormone-reducing surgeries revealed significant alterations in the spectral power of the electroencephalogram (EEG). These changes were indicative of a balanced state of excitation and inhibition, suggesting an equilibrium in neural processes underlying cognitive function.

Conclusion. Xenon, as a biologically active factor, functions as a catalyst for complex functional transformations within the body's regulatory systems. Xenon-based therapy induces a substantial reduction in stress reactions, highlighting the pronounced biotropic effect of xenon in restoring the adaptive status of the female body.

Keywords: xenon-oxygen therapy, hormone-dependent breast cancer, post-mastectomy syndrome, postovariectomy syndrome

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ОРИГИНАЛЬНАЯ СТАТЬЯ

Клиническое применение ксенон-кислородной терапии в коррекции нарушений нейропсихологического и адаптационного статуса молодых пациенток с диагнозом гормонозависимый рак молочной железы в условиях тотальной овариальной супрессии

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РЕЗЮМЕ

Цель исследования. Оценить клиническую эффективность применения активационной ксенон-кислородной терапии (ККТ) в коррекции нейропсихологического и адаптационного статуса у пациенток с диагнозом гормонозависимый рак молочной железы (РМЖ) в условиях овариоэктомии.

Пациенты и методы. Проанализировали данные интенсивности клинических симптомов, динамику адаптационных реакций (АР) с расчетом коэффициента соотношения антистресс/стресс, а также биоэлектрическую активность мозга 36 пациенток молодого возраста с диагнозом гормонозависимый РМЖ с клиническими признаками постмастэктомического (ПМЭС) и ранними признаками постовариоэктомического синдрома (ПОЭС).

Результаты. При определении структуры частоты встречаемости стресса и антистрессорных реакций достоверно установлено, что после овариоэктомии, нормотипы наблюдались в 11,3 % случаях. Основная выборка представлена реакцией стресс. Анализ структуры АР у пациенток с проявлениями ПМЭС и ПОЭС продемонстрировал явное преимущество применения ККТ. На этапе реабилитации у пациенток в группе без ККТ не выявлено полного восстановления структуры АР до исходных цифр. Реакция стресс составляла 58,7 % случаев. В группе с ККТ в эти же сроки преобладали антистрессорные реакции. Реакция стресс не зафиксирована вовсе. При анализе биоэлектрической активности мозга у больных РМЖ после двух гормонредуцирующих операций отмечали значительные изменения спектральной мощности электроэнцефалографии (ЭЭГ) с формированием сбалансированного состояния процессов возбуждения и торможения мозга.

Заключение. Несомненно, ксенон в качестве биологически активного фактора служит триггером запуска каскада сложных функциональных преобразований на уровне регуляторных систем организма. Сформированный после терапии пул антистрессорных реакций ярко демонстрировал высокую значимость биотропного действия ксенона в нормализации адаптационного статуса организма женщин.

Ключевые слова: ксенон-кислородная терапия, гормонозависимый рак молочной железы, постмастэктомический синдром, постовариоэктомический синдром

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Соблюдение этических стандартов: в работе соблюдались этические принципы, предъявляемые Хельсинкской декларацией Всемирной медицинской ассоциации (World Medical Association Declaration of Helsinki, 1964, ред. 2013). Исследование проведено с разрешения Комитета по Этике ФГБУ «Национальный медицинский исследовательский центр онкологии» Министерства здравоохранения Российской Федерации (протокол № 5 от 14.09.2019). Информированное согласие получено от всех участников исследования

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Конфликт интересов: все авторы заявляют об отсутствии явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи

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BACKGROUND

In Russia, as worldwide, breast cancer (BC) ranks first in incidence and mortality among malignant tumors in women. It is evident that providing comprehensive specialized care plays a crucial role in increasing survival and improving the quality of life of cancer patients. According to standard treatment protocols, antitumor therapy for BC includes surgery, chemotherapy, and hormone therapy, the latter being determined by the tumor's surrogate phenotype and the expression of estrogen and progesterone receptors. In premenopausal patients, hormone therapy is aimed at complete or partial suppression of ovarian function. Methods include the use of tamoxifen, aromatase inhibitors, surgical castration, radiation ablation, and luteinizing hormone–releasing hormone agonists [1].

In clinical situations where hormone-dependent BC is combined with genital pathology, bilateral ovariectomy remains the method of choice. However, despite full-scale antitumor treatment, these patients often experience significant psychological and functional disturbances. Several factors contribute to this: it is known that women with BC and/or pelvic tumors often exhibit a so-called "feminine factor," characterized by negative reactions in the intimate sphere and family relationships [2]. Furthermore, after undergoing a mutilating and often aesthetically unsatisfactory mastectomy, patients must face castration surgery. Ovariectomy causes abrupt hormonal deprivation, provoking severe cardiovascular and neurovegetative disorders. According to V. A. Kulavsky (2016), post-ovariectomy syndrome (POES) develops in 75–90 % of patients, manifesting as maladaptive functional disorders and intense psychoemotional stress, with marked suppression of the body's protective reactions to internal and external stressors [3]. Consequently, many women develop a negative psychological pattern with impaired communication, inadequate responses to therapy, and heightened pain perception.

The main hormone replacement therapy (HRT) capable of correcting hormonal deficiency involves agents with estrogenic, androgenic, and progestogenic activity. However, in patients with estrogen-dependent malignant breast tumors, HRT is essentially contraindicated [4]. This creates a dilemma: how to provide safe rehabilitation therapy for women with hormone-dependent BC under conditions of total ovarian suppression.

Given current possibilities in oncological care, it is important to introduce concomitant therapies with predominantly protective mechanisms of action, aimed at correcting stress reactions, normalizing neuroendocrine and cardiovascular function, and providing psychosocial rehabilitation [2]. Russian research continues to prioritize the theoretical foundation and practical implementation of activation therapy technologies based on the patterns of nonspecific antistress adaptive reactions.

In this context, the inert gas xenon should be considered a promising component of rehabilitation therapy. Due to its diverse biological properties and unique clinical effects, xenon is increasingly used in medicine as both a preventive and therapeutic agent. Depending on the composition of the gas mixture, xenon-oxygen therapy (XOT) can normalize the psychoemotional state, attenuate the emotional component of pain, and exert anti-inflammatory, immunostimulatory, antihypoxic, and nootropic effects [5]. In oncology, xenon-based concomitant therapy has demonstrated its effectiveness in improving functional status at various stages of antitumor treatment, as well as in advanced disease with severe pain syndrome [6, 7].

However, the dynamics of neuropsychological and adaptive changes in reproductive-age patients with hormone-dependent BC under conditions of total ovarian suppression and the potential to mitigate negative symptoms through XOT require further investigation.

Purpose of the study was to evaluate the clinical effectiveness of activated XOT in correcting neuropsychological and adaptive status in patients with hormone-dependent BC following total ovarian suppression and surgical menopause.

PATIENTS AND METHODS

This study was carried out in compliance with the ethics protocol of the National Medical Research Center for Oncology (Protocol No. 5, dated September 14, 2019). All participants were informed about the procedure, potential benefits, and contraindications of XOT, after which they provided written

informed consent for rehabilitation therapy and personal data processing in accordance with generally accepted ethical standards.

Neuropsychological and adaptive status was assessed in 36 patients aged 36–45 years with a primary diagnosis of hormone-dependent breast cancer (BC) and concomitant genital pathology, all undergoing surgical treatment at the National Medical Research Center of Oncology. All participants had clinical signs of post-mastectomy syndrome (PMES) and early signs of post-ovariectomy syndrome (POES). Given the combination of hormone-dependent BC and genital pathology, as well as the desire for early termination of fertility, all patients underwent bilateral ovariectomy.

The XOT group included 19 patients with hormone-dependent breast cancer (BC), post-mastectomy syndrome (PMES), and post-ovariectomy syndrome (POES) who received XOT as part of early postoperative rehabilitation. The median age in this group was 37 years, with a mean age of 39.7 ± 1.3 years. The comparison group consisted of 17 patients with similar diagnoses who received standard postoperative care without XOT. The median age in this group was 36 years, with a mean age of 37.1 ± 1.7 years.

Exclusion criteria were respiratory center disorders, mental illness, decompensated comorbidities, and ongoing chemotherapy. According to the TNM-8 classification (2015), tumor stage distribution was as follows: XOT group: pT1N1M0–3 patients (15.7 %), pT2N1M0–11 (57.9 %), pT3N0M0–5 (26.4 %). Comparison group: pT1N1M0–2 patients (11.8 %), pT2N1M0–10 (58.7 %), pT3N0M0–5 (29.5 %).

The groups were comparable in age and clinical parameters; differences were not statistically significant ($p < 0.2$). The XOT procedure consisted of five sequential inhalation sessions starting on postoperative day 3 after ovariectomy, using a mixture of oxygen and Xemed® (xenon medical device No. LS-000121). The initial inert gas concentration was determined based on the patient's minimum clinical perception threshold. Each subsequent session was characterized by a gradual decrease in exposure time from 25 minutes (first session) to 10 minutes (final session). At the same time, in accordance with an exponential dependence and a coefficient of 0.8, the calculated xenon concentration was increased from 15 % to 25 %. All XOT procedures were performed by anesthesiologists under active monitoring of cardiovascular and respiratory parameters.

To assess the neuropsychological and adaptive status of patients before ovariectomy, and on the 3rd and 9th postoperative days, the following parameters were determined:

1. Menopausal Index (MPI) (Kupperman N), which accounts for various neurovegetative manifestations on a point scale. A mild form (12–34 points) was characterized by a satisfactory condition; a moderate form (35–58 points) by decreased work capacity and deterioration in general condition; and a severe form (> 58 points) by pronounced neurovegetative and emotional symptoms [8].
2. Dynamics of clinical symptom intensity were assessed using the standardized Edmonton Symptom Assessment System (ESAS), recommended for evaluating the functional state of cancer patients. The following symptoms were scored from 1 to 10: impaired general condition, sleep disturbance, appetite loss, nausea, weakness, depression, anxiety, dyspnea, and pain [9].
3. Type of general nonspecific adaptive reactions (AR) was determined by evaluating the Schilling leukogram with lymphocyte (Lph) percentage as the key indicator: stress – < 20 %, training reaction – 21–27 %, calm activation – 28–33 %, increased activation – 33–40 %, and reactivation – > 40 %. The counts of monocytes, eosinophils, neutrophils, and total leukocytes were used to assess AR tension and to calculate the antistress/stress ratio [10].
4. Functional state of the central nervous system (CNS) was assessed in patients with hormone-dependent BC before and after total ovarian suppression using electroencephalography (EEG) with an Encephalan EEGR 19/26 multichannel device in 19 standard monopolar leads. The spectral power of the EEG was calculated using Fourier transform in the frequency range 0.5–18.0 Hz during calm wakefulness with eyes closed. Spectral power data were logarithmized and analyzed using repeated-measures ANOVA (rANOVA).

Statistical analysis

Statistical data processing was performed using SPSS Statistics version 10.0 for Windows. Differences were considered statistically significant at $p < 0.05$.

STUDY RESULTS

When analyzing subjective data using the MPI questionnaire, it was found that on the 3rd day after ovariectomy, depressive symptoms prevailed in all 36 patients. Anxiety was observed in 35 patients (95.4 %), apathy in 32 (86.5 %), and sleep disorders in 32 (86.5 %) cases. Vegetative symptoms were pronounced, including a transient increase in blood pressure in 22 patients (61.6 %), sweating and hot flashes in 24 (67.2 %), and headache or dizziness in 28 (78.4 %) patients.

At the same time, mild POES occurred with the lowest frequency (7.4 %), while severe POES predominated, accounting for 72.8 % of cases. After XOT, there was a statistically significant decrease in moderate and severe MPI scores (by 4.8 and 2.4 times, respectively), with noticeable reductions in numerical values ($p < 0.05$) (Table 1).

It was determined that the change in the MPI coefficient showed a clear dependence on the use of XOT, as observed in comparison with the group that underwent standard treatment.

According to the results of the standardized Edmonton Symptom Assessment System (ESAS) questionnaire for cancer patients, women diagnosed with hormone-dependent breast cancer (BC) who had undergone ovariectomy demonstrated various clinical manifestations depending on the treatment method, including XOT (Table 2).

According to the results, there was a 3.2-fold decrease in symptoms of poor health, a 5.8-fold decrease in weakness, and a 2.8-fold decrease in the frequency of anxiety, depression, and sleep disorders ($p < 0.05$) compared with the group without XOT.

Analysis of the AR structure in patients with hormone-dependent breast cancer (BC) and clinical manifestations of PMES and POES demonstrated a clear advantage of using XOT. When determining the initial (pre-ovariectomy) adaptive status in patients with BC, it was found that reactions of increased activation and calm activation accounted for 33.4 % and 22.4 %, respectively. The training reaction was detected in 33.4 % of patients, and the acute stress reaction was detected in 11.2 % of patients. The group-wide integral antistress/stress coefficient was 8 units. Thus, the preoperative condition of patients who had already undergone radical breast surgery had a relatively balanced functional character. With further determination of the frequency structure of stress and antistress reactions, a postoperative phase transition from a physiological state to a pathological one was reliably established. Immediately after surgery, such normotypes as calm and increased activation were absent, and the training reaction was observed in only 11.3 % of cases. The main pattern was a stress reaction cluster – 88.7 % of cases – with a correspondingly low antistress/stress coefficient of 0.12 reference units. On the 9th postoperative day, patients in the group with-

Table 1. Indicators of POES severity in the postoperative period in patients with hormone-dependent breast cancer, depending on the therapy used

POES severity	3rd day after ovariectomy, *n* = 36		XOT group 9th day after ovariectomy, *n* = 19		No XOT group 9th day after ovariectomy, *n* = 17	
	%	score	%	score	%	score
Mild	7.4	22.5 ± 3.4	74.5	19.2 ± 2.6	11.9	24.3 ± 2.8 *p* = 0.8
Moderate	19.8	41.1 ± 3.1	12.9	37.1 ± 1.2	58.6	48.7 ± 1.3* *p* = 0.02
Severe	72.8	61.2 ± 4.1	12.6	54.0 ± 1.1	29.5	68.1 ± 2.2* *p* = 0.001

Note: * – statistically significant difference between indicators in the study groups ($p < 0.05$); XOT – xenon-oxygen therapy

out XOT did not show complete restoration of the AR structure to baseline values. The stress reaction accounted for 58.7 % of cases, while 40 % of cases demonstrated antistress reactions (increased activation and training). The antistress/stress coefficient remained very low – 0.68 units – which is 12.2 times lower than the initial level.

In the group receiving rehabilitation treatment in the XOT regimen, antistress reactions of calm activation predominated (52.7 % of cases), followed by the training reaction (26.3 %) and increased activation (21.1 %). The stress reaction was not recorded at all (Fig. 1). The antistress/stress coefficient was high, reaching 10 units, its maximum value, and exceeding the indicators in the group without XOT by 15.2 times.

These changes in AR structure and the magnitude of the antistress/stress coefficient reflected both the dynamics of pathological process development within the integral stress response and the normalization of functional changes, with the formation of stable antistress reactions under the influence of XOT.

Evaluation of the transformation of EEG frequency parameters under the influence of negative factors during antitumor therapy and the active restorative effects of XOT showed a systemic response of the patient's body to the correction of two pathological syndromes. In previous studies, Rozenko LYa, et al. (2017) found that, in patients with removed cerebral metastases at the stage of radiation therapy, xenon exposure improved the functional state of the central nervous system (CNS) and reduced the pronounced adverse reactions of antitumor therapy [7].

According to the results of our study, in patients with breast cancer who underwent ovariectomy, a significant decrease in the power of theta and delta rhythms was noted on EEG, along with a moderate increase in beta rhythm power relative to pre-ova-

Table 2. Indicators of the standardized ESAS questionnaire in patients with hormone-dependent breast cancer under conditions of total ovarian suppression

Indicator	3rd day after ovariectomy, *n* = 36		XOT group 9th day after ovariectomy, *n* = 19		No XOT group 9th day after ovariectomy, *n* = 17	
	%	score	%	score	%	score
Poor wellness	78.4	5.8 ± 2.4	26.3	1.1 ± 0.1	86.0	5.6 ± 0.2* *p* = 0.02
Pain	67.2	5.2 ± 2.6	13.2	1.1 ± 0.3	34.2	4.8 ± 0.2* *p* = 0.8
Dyspnea	5.6	1.7 ± 0.1	5.2	1.4 ± 0.2	5.6	1.7 ± 0.1 *p* = 0.01
Nausea	25.2	2.2 ± 0.5	5.2	1.1 ± 0.2	11.8	2.6 ± 0.8 *p* = 0.8
Weakness	25.2	3.9 ± 1.1	13.2	1.2 ± 0.1	75.4	6.8 ± 0.2* *p* = 0.03
Weakness	78.4	5.9 ± 2.5	13.2	1.9 ± 0.2	34.2	2.2 ± 1.2* *p* = 0.01
Sleep disturbance	100	6.2 ± 2.9	36.8	3.7 ± 0.2	87.0	4.9 ± 2.8* *p* = 0.04
Appetite disturbance	25.2	2.7 ± 1.9	36.8	3.6 ± 1.2	34.8	3.8 ± 1.2 *p* = 0.8
Anxiety	95.2	5.9 ± 2.7	26.3	1.9 ± 0.1	58.8	6.5 ± 0.2* *p* = 0.01

Note: * – statistically significant difference between indicators in the XOT and no-XOT groups ($p < 0.05$); XOT – xenon-oxygen therapy

riectomy values (Table 3). Changes included an increase in the spectral power of the alpha rhythm in the high-frequency subband (10.3–11.3 Hz) and a decrease in the low-frequency and mid-frequency subbands of the alpha rhythm. These findings indicated poor stress tolerance and increased functional load in the early postoperative period.

The data from our study correlate with established findings (Rodriguez-Larios J, et al., 2019) and characterize the changes in our patients as reflecting an anxious state with pronounced psychoemotional stress, which was confirmed by subjective survey data [11].

At the end of treatment, rANOVA analysis showed statistically significant differences in the bioelectric activity of the brain in patients with PMES and POES ($F(25) = 5.7$, $p = 0.001$) under conditions of restorative XOT and without it. In the XOT group, EEG spectral power was significantly higher in the theta rhythm frequency range of 5.6–7.8 Hz (df = 94; $p < 0.001$), the delta rhythm frequency range of 2.5–2.9 Hz (df = 94; $p < 0.001$), and the alpha rhythm frequency range of 8.1–9.8 Hz (df = 94; $p < 0.001$), and lower in the alpha rhythm frequency range of 11.0–11.5 Hz (df = 94; $p < 0.001$).

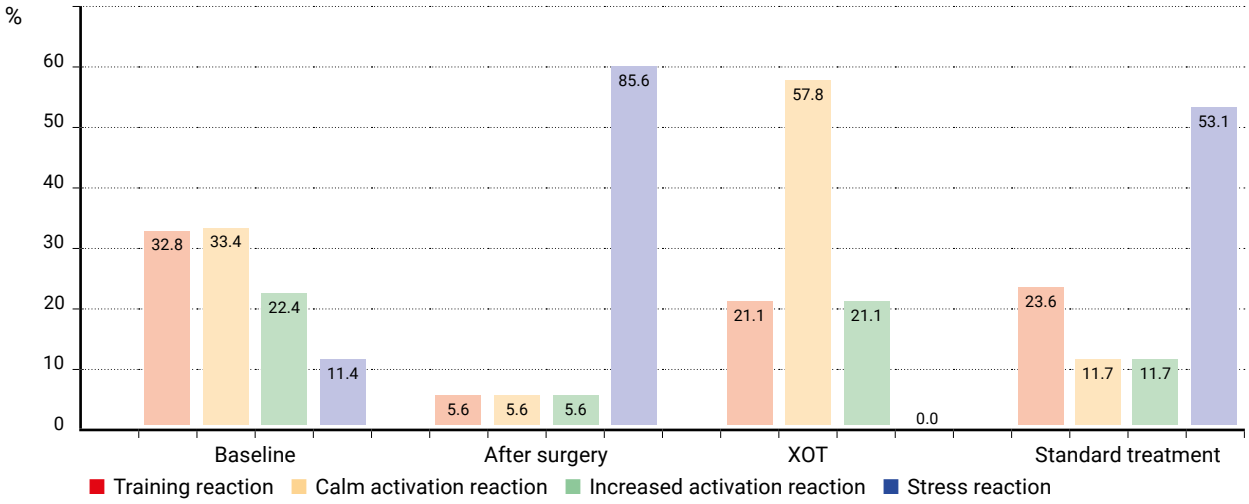

Fig. 1. Dynamics of the ratio of stress and antistress reactions in patients with hormone-dependent breast cancer under conditions of simultaneous PMES and POES

Table 3. Indicators of average EEG spectral power values in patients diagnosed with hormone-dependent breast cancer under conditions of total ovarian suppression

Indicators	XOT group, $n = 19$			Non-XOT group, $n = 17$		
	Baseline	3rd day after surgery	9th day after surgery	Baseline	3rd day after surgery	9th day after surgery
Alpha	348.5 ± 2.7	187.5 ± 17.2* $p = 0.02$	327.6 ± 34.1* $p = 0.02$	273.5 ± 17.4	180.4 ± 16.1* $p = 0.02$	156.1 ± 23.4 $p = 0.4$
Beta	27.8 ± 1.6	43.4 ± 2.1* $p = 0.03$	22.1 ± 1.8* $p = 0.05$	27.1 ± 2.7	46.3 ± 2.4* $p = 0.05$	21.3 ± 1.7* $p = 0.05$
Delta	56.3 ± 5.1	33.6 ± 4.7* $p = 0.03$	85.1 ± 8.5* $p = 0.02$	53.6 ± 5.7	36.7 ± 4.7* $p = 0.05$	41.5 ± 4.2 $p = 0.08$
Theta	45.7 ± 6.2	26.7 ± 4.1* $p = 0.05$	65.4 ± 4.1* $p = 0.03$	46.4 ± 3.1	28.2 ± 3.1* $p = 0.05$	33.8 ± 3.6 $p = 0.2$

In the group of patients without XOT, at the end of treatment, compared with EEG data after ovariectomy, a statistically significant decrease in spectral power was observed in the delta rhythm at 2.2 Hz, the theta rhythm at 6.9 and 7.8 Hz, and the alpha rhythm at 8.1–12.5 Hz.

The effect of XOT was most clearly demonstrated by a significant increase in the spectral power of the functionally important midrange alpha rhythm at 9.6 Hz and a decrease in the power of the beta rhythm at frequencies of 12.3 and 12.5 Hz. Slowing of beta rhythm activity was clinically manifested by marked psychoemotional relaxation in patients with PMES and POES.

DISCUSSION

This study analyzes the treatment results of a complex clinical group of reproductive-age patients diagnosed with hormone-dependent breast cancer (BC) under conditions of total ovarian suppression, with manifestations of post-mastectomy syndrome (PMES) and early signs of post-ovariectomy syndrome (POES).

It has previously been established that the negative psychological state in BC patients is often due to the anticipation of adverse aesthetic outcomes of surgery and the side effects of antitumor therapy. These are manifested by increased fatigue, memory impairment, irritability, marked emotional lability, and a prolonged course of psychological dysfunction requiring extended correction [12]. At the same time, in conditions of total ovarian suppression, artificially induced hypoestrogenism triggers complex metabolic changes in a woman's body long before the natural onset of menopause. This is accompanied by profound neurovegetative and psychoemotional changes mediated by the GABAergic, acetylcholine, dopamine, serotonin, norepinephrine, and opioid systems [3, 4].

It is known that the main mechanisms limiting or suppressing the development of acute stress reactions are directly activated in the higher regulatory centers of the central nervous system (CNS), forming systemic immune-hormonal relationships, regulating metabolic processes, and influencing proliferation and apoptosis [6].

Xenon, as a biologically active agent, has been shown to trigger complex functional changes in self-organization processes at both regulatory and executive levels. Its properties such as modulation of apoptosis, effects on various parts of the immune system, reduction of oxidative stress, and cytoprotective effects in ischemia of the heart, brain, liver, and kidneys are actively studied and applied in clinical practice. The exceptional qualities of xenon make it possible to fully utilize its therapeutic potential. Incorporating xenon into treatment regimens for adaptive disorders, including states of chronic psychoemotional stress, is based on its influence on both stress-realizing and stress-limiting systems of the body [5].

The above facts determined the concept of a safe and effective rehabilitation therapy for patients with PMES and POES presenting with depression and an imbalance in adaptive status. The results of our study demonstrated convincing clinical efficacy of XOT. Data from the cancer patient quality of life questionnaire and the menopausal index clearly showed regression of depressive and vegetative symptoms in the group receiving restorative XOT. XOT also contributed to the formation of new, stable antistress reactions. In the XOT group, 50 % of patients exhibited calm activation reactions a cluster characterized by moderate activation of immune and neuroendocrine systems, along with balanced regulation of energy, hormonal, plastic, and biochemical processes at all hierarchical levels. The antistress/stress coefficient in the XOT group reached its highest possible value, with no cases of stress reactions recorded.

Analysis of EEG bioelectric activity in BC patients after two hormone-reducing surgeries revealed significant changes in spectral power. XOT led to a slowing of rhythmic brain activity, with increased power in the slow-frequency theta, delta, and alpha rhythms, and decreased power in the fast-frequency alpha and beta rhythms. These changes reflected a balanced state between excitation and inhibition processes in the brain.

CONCLUSION

It follows from the above that xenon, as a biologically active factor, triggers a cascade of complex functional transformations at the level of the body's regulatory systems. The pool of antistress reactions formed after therapy clearly demonstrates the significant biotropic effect of xenon in normalizing the adaptive status of the female body.

Furthermore, the use of XOT for hormone-dependent subtypes of breast cancer in women of reproductive age under conditions of total ovarian suppression produced a pronounced clinical effect, expressed as positive dynamics in the psychoemotional state. Under these conditions, it becomes possible to mitigate the manifestations of surgical menopause, thereby improving the quality of life and promoting the social rehabilitation of young patients undergoing hormone-reducing surgery.

References

1. Tyulandin SA, Artamonova EV, Zhigulev AN, Zhukova LG, Koroleva IA, Parokonnaya AA, et al. Practical recommendations for the drug treatment of breast cancer. Practical recommendations of RUSSCO, part 1. Malignant Tumours. 2023;13(3s2-1):157–200. (In Russ.). https://doi.org/10.18027/2224-5057-2023-13-3s2-1-157-200, EDN: VMPFLQ
2. Pestereva EV, Chulkova VA, Semiglazova TY, Ulrich EG, Pestereva OA. Assessment of the psychological status of patients with gynecological cancer in the process of psychological rehabilitation. The Scientific Notes of the Pavlov University. 2018;25(1):62–67. (In Russ.). https://doi.org/10.24884/1607-4181-2018-25-1-62-67, EDN: XMRNPF
3. Kulavskii VA, Kulavskii EV, Ziganshin AM. Surgical menopause in women of reproductive age. Obstetrics, Gynecology and Reproduction. 2016;10(4):105–113. (In Russ.). https://doi.org/10.17749/2313-7347.2016.10.4.105-1133, EDN: YIFCZF
4. Yureneva SV, Ermakova EI. Menopause and menopause in a woman. Obstetrics and Gynecology. 2018;(7):32–38. (In Russ.). https://dx.doi.org/10.18565/aig.2018.7.32-38, EDN: UVBYVM
5. Ushakov IB, Pyatibrat AO. Prospects of Xenon Application in Functional Recovery and Rehabilitation of Patients Working in Extreme Occupational Environments. Medico-Biological and Socio-Psychological Problems of Safety in Emergency Situations. 2022;(4):40–54. (In Russ.). https://doi.org/10.25016/2541-7487-2022-0-4-40-54, EDN: OMGXNR
6. Kit OI, Frantsiyants EM, Men'shenina AP, Moiseenko TI, Ushakova ND, Popova NN, et al. The role of plasmapheresis and xenon therapy in the correction of acute consequences of surgical menopause in patients with cervical cancer. KubGAU Scientific Journal. 2016;117(03):1–15. (In Russ.). Available at: https://www.med-press.ru/upload/iblock/423/gbf72s0gxmdva923r9zgvdfup3tb7190/818964ae-1ce0-11dd-9939-001e8c162cbd_6ee11f24-ece9-11ee-8107-0c9d92c6800d.pdf, Accessed: 06/30/2025.
7. Rozenko LYa, Zinkovich MS, Arapova YuYu, Protasova TP, Shikhlyarova AI, Popova NN, Korobeynikova EP, Vashchenko LN, Ushakova ND. The effect of xenon on the spatial organization of the bioelectric activity of the brain. Izvestiya Vuzov. The North Caucasus Region. Natural Sciences. 2017;(4-2(196-2)):111–118. (In Russ.). https://doi.org/10.23683/0321-3005-2017-4-2-111-118, EDN: YLSFLJ
8. Vikhlyaeva EM. Postmenopausal therapy. Effects on menopause-related symptoms, the course of chronic diseases, and quality of life. Moscow: MEDpress inform, 2008, 448 p. (In Russ.). Available at: https://ej.kubagro.ru/2016/03/pdf/29.pdf, Accessed: 06/30/2025.
9. Ionova TI, Nikitina TP, Novik AA, Snegovoy AV. Practical recommendations for the assessment of weakness syndrome in cancer patients. Malignant Tumors: Practical Recommendations RUSSCO. 2017;7(3S2):586–591. (In Russ.). https://doi.org/10.18027/2224-5057-20l7-7-3s2-582-585, EDN: XMKEUX
10. Shikhlyarova AI, Zhukova GV, Mashchenko NM. Some recommendation and examples in the activation therapy practical implementation (according to L. K. Garkavi, E. B. Kvakina, M. A. Ukolova's research studies). Cardiometry. 2015;(7):57–62. (In Russ.). https://doi.org/10.12710/cardiometry.2015.7.6469
11. Rodriguez-Larios J, Alaerts K. Tracking Transient Changes in the Neural Frequency Architecture: Harmonic Relationships between Theta and Alpha Peaks Facilitate Cognitive Performance. J Neurosci. 2019 Aug 7;39(32):6291–6298. https://doi.org/10.1523/JNEUROSCI.2919-18.2019
12. Rozenko DA, Shikhlyarova AI, Vashchenko LN, Popova NN, Arapova YuYu, Ardzha AYu, et al. Neuropsychological features of patients of reproductive age diagnosed with breast cancer at the stage of surgical treatment using xenon-oxygen therapy. Research and Practical Medicine Journal. 2021;8(3):10–20. (In Russ.). https://doi.org/10.17709/2410-1893-2021-8-3-1, EDN: ZRPKRL

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