ЗДОРОВ'Я ЛЮДИНИ, ФІТНЕС І РЕКРЕАЦІЯ, ФІЗИЧНЕ ВИХОВАННЯ РІЗНИХ ГРУП НАСЕЛЕННЯ

IMPROVING PATIENT CARE PROTOCOLS: IMPORTANCE OF NUTRITIONAL SUPPORT IN BREAST CANCER TREATMENT

УДОСКОНАЛЕННЯ ПРОТОКОЛІВ ПАЦІЄНТСЬКОГО ДОГЛЯДУ: ВАЖЛИВІСТЬ НУТРИТИВНОЇ ПІДТРИМКИ В ЛІКУВАННІ РАКУ МОЛОЧНОЇ ЗАЛОЗИ

Bogdanovska N.[1], Moroz O.[2], Li X.[3]
[1]*Zaporizhzhia National University, Zaporizhzhia, Ukraine*
[2,3] *Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China*
[1] *ORCID: 0000-0002-2410-845X*
[2] *ORCID: 0000-0003-4314-4939*
[3] *ORCID: 0000-0002-6572-7740*

DOI https://doi.org/10.32782/2522-1795.2025.19.4.7

Abstracts

Background. While advancements in drug therapies, surgical techniques, and clinical skills have significantly improved breast cancer treatment outcomes, the nutritional care of patients has remained largely unchanged. This stagnation fails to address the critical role of nutrition in patient recovery and quality of life. Neoadjuvant chemotherapy is a cornerstone in managing locally advanced breast cancer, but it often negatively impacts patients' nutritional status. Improving nutritional interventions is essential to achieving better patient care and treatment outcomes.

Objectives. This study aimed to evaluate the impact of neoadjuvant chemotherapy on the nutritional status of breast cancer patients, identify key nutritional challenges during treatment, and emphasize the need for integrating nutritional support into patient care protocols.

Methods. A retrospective analysis was conducted on 121 breast cancer patients treated with neoadjuvant chemotherapy at a tertiary hospital between 2008 and 2024. Nutritional indicators, including the prognostic nutritional index, serum albumin levels, and body mass index were assessed at three time points: before neoadjuvant chemotherapy, before surgery, and after surgery. Statistical analyses, including t-tests and generalized linear models, were used to determine the significance of changes associated with the neoadjuvant chemotherapy in these indicators.

Results. The study revealed that neoadjuvant chemotherapy significantly reduced pre-surgery prognostic nutritional index (mean difference: −2.91, $p = 0.0072$), indicating a negative impact on nutritional reserves. However, no significant differences were observed post-surgery ($p = 0.8507$), suggesting recovery of nutritional status within a week. Serum albumin levels were consistently affected during treatment, correlating with reduced immune function. Body mass index and chemotherapy complications had a weaker association with nutritional outcomes.

Conclusions. Neoadjuvant chemotherapy adversely affects nutritional status during the preoperative period, underscoring the importance of targeted nutritional interventions. Integrating personalized nutritional support into patient care protocols can mitigate these effects, enhance treatment tolerance, and improve overall outcomes. Addressing nutritional needs is a critical component of optimizing breast cancer care and improving patients' quality of life.

Key words: nutritional support, nutritional status, quality of life, breast cancer, neoadjuvant chemotherapy.

Вступ. Тоді як прогрес у медикаментозній терапії, хірургічних техніках і клінічних навичках значно покращив результати лікування раку молочної залози, догляд за харчуванням пацієнтів залишився в основному незмінним. Ця стагнація не враховує критичну роль харчування у відновленні пацієнтів і якості життя. Неоад'ювантна хіміотерапія є наріжним каменем у лікуванні локально поширеного раку молочної залози, але вона часто негативно впливає на стан харчування пацієнтів. Поліпшення харчових втручань має велике значення для досягнення кращого догляду за пацієнтами та результатів лікування.

Мета. Дослідження мало на меті оцінити вплив неоад'ювантної хіміотерапії на стан харчування пацієнтів з раком молочної залози, визначити ключові проблеми з харчуванням під час лікування та підкреслити необхідність інтеграції харчової підтримки в протоколи догляду за пацієнтами.

Матеріал. Ретроспективний аналіз було проведено на 121 пацієнтці з раком молочної залози, які отримували неоад'ювантну хіміотерапію в лікарні між 2008 і 2024 роками. Нутритивні показники, включаючи прогностичний індекс харчування, рівень сироваткового альбуміну та індекс маси тіла, оцінювали в три моменти часу: до неоад'ювантної хіміотерапії, перед операцією та після операції. Статистичний аналіз, включаючи t-тести та узагальнені лінійні моделі, використовувався для визначення значущості змін, пов'язаних з неоад'ювантною хіміотерапією, у цих показниках.

Результати. Дослідження показало, що неоад'ювантна хіміотерапія значно знизила прогностичний індекс харчування перед операцією (середня різниця: −2.91, $p = 0.0072$), що вказує на негативний вплив на нутритивні резерви. Однак після операції не спостерігалося істотних відмінностей ($p = 0.8507$), що свідчить про відновлення нутритивного стану протягом тижня. Рівень сироваткового альбуміну був стабільно зниженим під час лікування, що корелювало зі зниженням імунної функції. Індекс маси тіла та ускладнення хіміотерапії мали слабший зв'язок із нутритивними результатами.

Висновки. Неоад'ювантна хіміотерапія негативно впливає на нутритивний статус у передопераційний період, підкреслюючи важливість цілеспрямованих втручань у харчуванні. Інтеграція персоналізованої нутритивної підтримки в протоколи догляду за пацієнтами може пом'якшити ці ефекти, підвищити переносимість лікування та покращити загальні результати. Вирішення нутритивних потреб є критично важливим компонентом оптимізації лікування раку молочної залози та покращення якості життя пацієнтів.

Ключові слова: нутритивна підтримка, якість життя, рак молочної залози, неоад'ювантна хіміотерапія.

Introduction. Breast cancer remains a significant public health challenge globally, being the most prevalent cancer among women and a leading cause of cancer-related mortality [1]. The epidemiological data provided by the "International Agency for Research of Cancer" indicate that the incidence and mortality of breast cancer among all age groups are rising, particularly in developing countries, where the disease is often diagnosed at more advanced stages [2]. Neoadjuvant chemotherapy has emerged as a critical component in breast cancer management, primarily aimed at reducing tumor size and facilitating breast-conserving surgeries. This approach not only facilitates breast-conserving surgeries but also provides valuable insights into the tumor's biological behavior and response to treatment [11].

Over the last decade, significant advancements have been made in diagnostic methods, anti-tumor drug guidelines, and surgical techniques, all contributing to improved cancer treatment outcomes [14; 18]. However, while these clinical protocols have evolved, nutritional strategies for patients have largely remained unchanged failing to ensure sufficient intake of essential nutrients that could enhance patients' nutritional health and improve recovery [10]. This stagnation is particularly concerning given the widespread use of neoadjuvant chemotherapy, which, despite its therapeutic benefits, is accompanied by numerous adverse effects, such as bone marrow suppression, reduced immunity, and malnutrition [12]. These side effects severely impact patients' quality of life, with symptoms like loss of appetite, weight loss, and muscle wasting further reducing physical function and increasing treatment risks [16]. The existing literature suggests that certain nutritional indices, such as the prognostic nutritional index, can serve as valuable markers for predicting treatment outcomes and survival in breast cancer patients [18; 19].

Objectives. This study aims to explore the specific impacts of neoadjuvant chemotherapy

on key nutritional indicators such as the Prognostic Nutritional Index during different treatment phases. By analyzing data connected to the results presented in Tables 2–4, the study seeks to quantify the extent of these effects and identify critical time points for nutritional intervention. Additionally, it emphasizes the importance of incorporating targeted nutritional support into patient care protocols to mitigate the adverse effects of neoadjuvant chemotherapy and improve therapeutic outcomes for breast cancer patients.

Methods. This study focused on 140 patients who received scandalized breast cancer treatment (anthracycline-based, taxane-based, or platinum-containing chemotherapy regimens and surgery) at a tertiary hospital between 2008 and 2024. Patients were randomly selected from a larger pool of individuals diagnosed with breast cancer during this period. All patients included in the study were hospitalized under the supervision of the authors (board-certified physicians with 20+ years of experience), and the research was conducted retrospectively using existing clinical data. No experimental therapies or interventions were applied; treatment plans followed institutional protocols and were regularly reviewed by the department team, with cross-disciplinary consultations (e.g., oncology, pathology, hematology, etc.) obtained as needed.

Research results. This study highlights the significant influence of neoadjuvant chemotherapy (NAC) on the nutritional status of breast cancer patients, measured through the Prognostic Nutritional Index (PNI). The findings address the primary research questions and underline critical considerations for patient care [8; 18; 19].

Inclusion criteria were patients diagnosed with breast cancer and treated with neoadjuvant chemotherapy (NAC), while exclusion criteria included those without preoperative Prognostic Nutritional Index (PNI) measurements or incomplete clinical data. Ultimately, 121 patients met the study criteria. Comprehensive clinical data were collected for each patient, with particular attention to the following key variables: age; NAC status; prognostic nutritional index at three time points, namely the day before the first NAC session (PNI1), the day before surgery (PNI2), and more than seven days after surgery (PNI3); other clinical nariables including body mass index (BMI), albumin levels (ALB1–ALB3), neutrophil-to-lymphocyte ratio (NLR1–NLR3) at three time points, occurrence of chemotherapy complications, specific chemotherapy regimens used, and length of stay for surgery admission. The corresponding data, stratified by NAC and non-NAC groups in 2008 and 2024, are summarized in Table 1.

Table 1

Clinical and nutritional characteristics of patients stratified by NAC status and year of treatment (2008 vs. 2024)

Indicator		2008		2024	
		NAC	Non-NAC	NAC	Non-NAC
Amount of patients		18	–	53	50
Age (years)		48.94 ± 8.03	–	44.45 ± 9.94	49.60 ± 9.03
BMI		–	–	22.16 ± 2.64	23.02 ± 3.57
Total length of stay for surgery admission (days)		19 ± 5	–	12 ± 5	13 ± 7
Prognostic Nutritional Index	PNI1	51.42 ± 4.94	–	51.33 ± 4.12	–
	PNI2	49.27 ± 5.82	–	48.51 ± 7.06	51.61± 3.99
	PNI3	46.07 ± 4.33	–	46.77 ± 5.28	46.76 ± 4.14
Albumin levels (g/L)	ALB1	43.95 ± 3.49	–	43.11 ± 3.61	–
	ALB2	44.43 ± 5.19	–	41.05 ± 3.63	43.02 ± 3.48
	ALB3	40.58 ± 3.97	–	40.74 ± 4.37	39.32 ± 3.26
Neutrophil-to-lymphocyte ratio	NLR1	2.26 ± 0.84	–	2.30 ± 1.40	–
	NLR2	3.27 ± 2.80	–	2.73 ± 2.64	1.87 ± 0.86
	NLR3	2.66 ± 1.20	–	3.64 ± 4.04	2.34 ± 1.49

All statistical analyses were conducted using SAS® OnDemand for Academics (Release 3.81, Enterprise Edition). Independent samples t-tests or Mann-Whitney U test were used to compare continuous variables, and Chi-square and Fisher's exact tests were employed for categorical variables [13; 15].

First, descriptive statistical analysis was conducted on the key variables, presenting the distribution of each variable using mean, standard deviation, minimum, and maximum values. Next, a General Linear Model (GLM) was applied to assess the impact of NAC on PNI, with a significance level set at $p < 0.05$.

First of all, we checked if there exist any changes in nutritional indicators due to NAC, corresponding information is provided in the Table 2. NAC significantly reduced pre-surgery PNI (PNI2) levels (mean difference: −2.91, $p = 0.0072$), indicating a notable depletion in nutritional reserves before surgery. In contrast, there weren't seen any significant differences for PNI1 (pre-NAC; $p > 0.05$) or PNI3 (post-surgery; $p = 0.8507$), suggesting that NAC's impact on nutritional status is transient and primarily concentrated during the pre-surgical phase. Correlation analysis demonstrated a negative influence of age on PNI2 ($r = −0.1817$, $p = 0.0461$), with older patients exhibiting poorer nutritional status. BMI and chemotherapy complications showed no significant correlations with PNI indicators ($p > 0.05$). These results underscore the critical periods during which nutritional interventions can mitigate the adverse effects of NAC. Pre-surgical nutritional optimization is essential to enhance patient resilience and improve therapeutic outcomes, highlighting the necessity of integrating robust nutritional strategies into breast cancer care protocols.

Effect of Tumor Stage, Age, BMI, and Chemotherapy Regimens Generalized Linear Model (GLM) analyses revealed that neither the treatment year (2008 vs. 2024) nor NAC status had a statistically significant impact on nutritional indicators across the three time points (PNI1, PNI2, PNI3; $p > 0.05$). These findings suggest that, regardless of the year in which patients received treatment or whether they underwent NAC, the overall differences in nutritional status were not statistically significant (Table 3).

The comparative analysis of patients treated in 2008 and 2024 is presented in the Table 4. The analysis revealed no significant differences in PNI values across the treatment years. This consistency underscores persistent challenges in mitigating NAC's nutritional impact despite evolving medical practices. Notably, the negative effect of NAC on PNI2 remained consistent across both time periods ($p = 0.0076$), reinforcing the need for targeted interventions during the pre-surgical phase.

Discussion. NAC has emerged as a cornerstone in the management of locally advanced breast cancer, offering a dual advantage of direct cytotoxic effects on rapidly dividing cancer cells and modulation of the tumor microenvironment and systemic immune response [3]. By inducing

Table 2

Comparison and statistical results of indicators between groups under NAC for breast cancer

Time Point	NAC Status	Sam-ple Size (N)	Mean ± Stan-dard Devia-tion (PNI)	Test Value (p-value)	Significance	Related Variables
PNI1 (Pre-NAC)	NAC Group	71	51.35 ± 4.31	> 0.05	None	ALB1, NLR1(significant predictors)
	Non-NAC Group	50	–			
PNI2 (Pre-surgery)	NAC Group	71	48.70 ± 6.73	0.0072	Significant	NAC, ALB2, NLR2
	Non-NAC Group	50	51.61 ± 3.99			
PNI3 (Post-surgery)	NAC Group	71	46.60 ± 5.03	0.8507	None	ALB3, NLR3 (significant predictors)
	Non-NAC Group	50	46.76 ± 4.14			

Table 3

The impact of NAC status and other indicators on PNI indicators during 2008 and 2024

Indicator	PNI1 (Pre-NAC)	PNI2 (Pre-surgery)	PNI3 (Post-surgery)
Treatment year	F = 0, Not Statistically Significant	F = 0, Not Statistically Significant	F = 0, Not Statistically Significant
NAC status	F = 0, Not Statistically Significant	F = 0, Not Statistically Significant	F = 0, Not Statistically Significant
ALB	F = 181.28, p < 0.0001	F = 149.31, p < 0.0001	F = 387.86, p < 0.0001
NLR	F = 23.14, p < 0.0001	F = 8.58, p = 0.0045	F = 26.19, p < 0.0001
BMI	F = 0.62, p = 0.4380	F = 0.44, p = 0.5092	F = 1.00, p = 0.3199

Table 4

Effect of NAC on PNI index among patients in 2024

Time Point	NAC Group (n = 53)	Non-NAC Group (n = 50)	Mean Difference	t-test (p-value)	Cohen's d	Significance
PNI2	48.51 ± 7.06	51.61 ± 3.99	-3.10	0.0076	-0.54	Moderate
PNI3	46.77 ± 5.28	46.76 ± 4.14	0.01	0.9916	0.01	None

apoptosis and inhibiting proliferation, NAC enhances the immunogenicity of tumors, making them more susceptible to immune-mediated destruction. This combination of cytotoxicity and immune modulation has been associated with increased rates of pathological complete response (pCR), a key marker linked to improved long-term survival [4]. The type and timing of chemotherapy regimens also play a significant role in optimizing these outcomes, with some strategies demonstrating superior efficacy in tumor shrinkage and metastasis control [7].

The impact of NAC on tumor size and metastasis control is well-documented [5; 7; 9; 17]. Studies consistently show its efficacy in achieving substantial tumor reduction prior to surgical resection, correlating with improved surgical outcomes and better overall survival rates [5]. Achieving a pCR not only signifies the absence of residual disease at surgery but also serves as a strong prognostic indicator for favorable outcomes [17]. Moreover, NAC's ability to address micrometastatic disease is critical in reducing distant recurrences, further emphasizing its value in managing high-risk breast cancer cases [7].

A particularly vital aspect of NAC's clinical success is its influence on surgical outcomes. By facilitating significant tumor shrinkage, NAC often enables less invasive surgical options, such as breast-conserving surgery instead of mastectomy [9]. This downstaging of tumors improves not only surgical success rates but also the quality of life and psychological well-being of patients. Patients achieving a pCR post-NAC demonstrate lower local recurrence rates and enhanced survival [4], underscoring the role of NAC in advancing both therapeutic and holistic care outcomes.

Despite these benefits, NAC is not without its challenges, particularly regarding its impact on patients' nutritional status. Beyond its tumor-targeting mechanisms, NAC can significantly alter key nutritional indicators, including the PNI, serum albumin levels, BMI and others. These factors are critical in shaping the overall prognosis and quality of life for breast cancer patients undergoing treatment [8; 18; 19].

Our analysis revealed that NAC significantly reduced pre-surgery PNI (PNI2) levels ($p = 0.0076$). Patients undergoing NAC exhibited a moderate decline in nutritional reserves (Cohen's $d = -0.54$), likely attributable to the toxic effects of chemotherapy agents and associated side effects such as reduced appetite and gastrointestinal discomfort. This decline highlights the critical need for nutritional interventions during the NAC phase to mitigate

its adverse effects and support patients through the demanding preoperative period.

Interestingly, no significant difference was observed between NAC and non-NAC groups in post-surgery PNI (PNI3; $p = 0.9916$). This suggests a recovery of nutritional status within a week following surgery, indicating that while NAC temporarily compromises preoperative nutritional reserves, these effects do not persist postoperatively. This finding underscores the importance of focusing nutritional support on the NAC period to ensure patients maintain adequate physical and metabolic reserves prior to surgery.

Our study also found that treatment year (2008 vs. 2024) and NAC status did not have a statistically significant impact on PNI indicators ($F = 0$, $p > 0.05$). In other words, there were no statistically significant differences in overall nutritional status based on the year of treatment or NAC administration. This result may suggest that there were no major changes in treatment protocols or nutritional management strategies at the hospitals included in this study between 2008 and 2024.

The findings of this study emphasize the pivotal role of nutritional support as a component of comprehensive cancer care. During the NAC period, patients experience significant nutritional challenges, including declines in key markers such as PNI and albumin. Addressing these challenges through personalized nutritional interventions can enhance treatment tolerance, reduce complications, and improve overall therapeutic outcomes. While long-term nutritional intervention may not be necessary for all breast cancer patients, timely support during NAC can prevent the deterioration of nutritional status and promote recovery.

Moreover, the recovery of nutritional status postoperatively suggests that short-term, focused nutritional interventions can yield significant benefits. By prioritizing the NAC period for nutritional support, healthcare providers can better prepare patients for surgery and subsequent treatments, ultimately enhancing quality of life and survival outcomes. Future studies should explore the integration of advanced nutritional strategies, such as tailored supplementation and close monitoring of nutritional markers, into cancer care protocols.

Conclusion. The findings of this study highlight the critical role of nutritional support in optimizing outcomes for breast cancer patients undergoing neoadjuvant chemotherapy. Key conclusions are as follows:

1. Despite advancements in breast cancer treatment between 2008 and 2024, absence of significant difference in prognostic nutritional index of patients from 2008 and 2024 shows that nutritional management strategies remained unchanged, revealing a gap in integrating evolving nutritional science into clinical practice.

2. Neoadjuvant chemotherapy significantly impairs nutritional status before surgery, as demonstrated by reductions in the prognostic nutritional index and serum albumin levels. This decline underscores the necessity of proactive nutritional interventions during this phase to maintain patient health and treatment efficacy.

3. Integrating individualized nutritional support into neoadjuvant chemotherapy protocols can enhance treatment tolerance, reduce adverse effects, and improve patients' quality of life.

4. Unlike other nutritional markers, body mass index and chemotherapy-related complications had minimal influence on overall nutritional outcomes, reinforcing the need to focus on dynamic biochemical indicators for assessment.

These results emphasize that nutritional care is not merely supportive but a fundamental component of breast cancer therapy. Future research should focus on developing standardized, evidence-based nutritional guidelines to further refine patient care protocols.

Bibliography

1. Bray F., Laversanne M., Sung H., Ferlay J., Siegel R.L., Soerjomataram I., Jemal A. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin*. 2024 May–Jun;74(3):229–263. doi: 10.3322/caac.21834.

2. Cancer tomorrow, Estimated numbers from 2022 to 2050, Females, age (0–85+), International Agency for Research on Cancer. World Health Organization. Breast. 2024. URL: https://gco.iarc.fr/tomorrow/en/dataviz/trends?multiple_populations=1&sexes=2&cancers=20&age_end=17.

3. Cleator S., Parton M., Dowsett M. The biology of neoadjuvant chemotherapy for breast cancer. *Endocr Relat Cancer*. 2002 Sep;9(3):183–95. doi: 10.1677/erc.0.0090183.

4. Cortazar P., Zhang L., Untch M., Mehta K., Costantino J.P., Wolmark N., Bonnefoi H., Cameron D., Gianni L., & Valagussa P. Pathological complete response and long-term clinical benefit in breast cancer: the CTNeoBC pooled analysis. *The Lancet*, 2014, 384(9938), 164–172. doi: 10.1016/S0140-6736(13)62422-8.

5. Derks M.G.M., van de Velde C.J.H. Neoadjuvant chemotherapy in breast cancer: more than just downsizing. *Lancet Oncol*. 2018 Jan, 19(1), 2–3. doi: 10.1016/S1470-2045(17)30914-2.

6. Duan S., Buxton I.L.O. Evolution of Medical Approaches and Prominent Therapies in Breast Cancer. *Cancers (Basel)*. 2022 May 16;14(10):2450. doi: 10.3390/cancers14102450.

7. Guarneri V., & Conte P.F. The curability of breast cancer and the treatment of advanced disease. *European journal of nuclear medicine and molecular imaging*, 2004, 31(Suppl 1), S149-S161. doi: 10.1007/s00259-004-1538-5.

8. Jang M.K., Park S., Park C., Doorenbos A.Z., Go J., & Kim S. Body composition change during neoadjuvant chemotherapy for breast cancer. *Frontiers in Oncology*, 2022, 12, 941496. doi: 10.3389/fonc.2022.941496.

9. Killelea B.K., Yang V.Q., Mougalian S., Horowitz N.R., Pusztai L., Chagpar A.B., & Lannin D.R. Neoadjuvant chemotherapy for breast cancer increases the rate of breast conservation: results from the National Cancer Database. *Journal of the American College of Surgeons*, 2015, 220(6), 1063–1069. doi: 10.1016/j.jamcollsurg.2015.02.011.

10. Limon-Miro A.T., Lopez-Teros V., & Astiazaran-Garcia H. Dietary guidelines for breast cancer patients: a critical review. *Advances in Nutrition,* 2017, 8(4), 613–623. doi: 10.3945/an.116.014423.

11. Masood S. Neoadjuvant chemotherapy in breast cancers. *Womens Health* (Lond). 2016 Sep;12(5):480–491. doi: 10.1177/1745505716677139.

12. Miyata H., Yano M., Yasuda T., Hamano R., Yamasaki M., Hou E., Motoori M., Shiraishi O., Tanaka K., & Mori M. Randomized study of clinical effect of enteral nutrition support during neoadjuvant chemotherapy on chemotherapy-related toxicity in patients with esophageal cancer. *Clinical nutrition*, 2012, 31(3), 330–336. doi: 10.1016/j.clnu.2011.11.002.

13. Neely J.G., Hartman J.M., Forsen Jr J.W., & Wallace M.S. Tutorials in clinical research: VII. Understanding comparative statistics (contrast) – part B: Application of T-test, Mann-Whitney U, and Chi-Square. *The Laryngoscope*, 2003, 113(10), 1719–1725. doi: 10.1097/00005537-200310000-00011.

14. Noor F., Noor A., Ishaq A.R., Farzeen I., Saleem M.H., Ghaffar K., Muhammad Farhan Aslam M.F., Aslam S. and Jen-Tsung Chen J.T. Recent Advances in Diagnostic and Therapeutic Approaches for Breast Cancer: A Comprehensive Review. *Current Pharmaceutical Design*, Volume 27, Issue 20, Jun 2021, p. 2344–2365. doi: https://doi.org/10.2174/1381612827666210303141416.

15. Riina M.D., Stambaugh C., Stambaugh N., & Huber K.E. Continuous variable analyses: T-test, Mann–Whitney, Wilcoxin rank. In Translational radiation oncology, 2023, pp. 153–163. Elsevier. doi: 10.1016/B978-0-323-88423-5.00070-4.

16. Souza A.P.S., Silva L.C.D., Fayh A.P.T. Nutritional Intervention Contributes to the Improvement of Symptoms Related to Quality of Life in Breast Cancer Patients Undergoing Neoadjuvant Chemotherapy: A Randomized Clinical Trial. *Nutrients.* 2021, 13(2), 589. doi: 10.3390/nu13020589.

17. Schott A.F., & Hayes D.F. Defining the Benefits of Neoadjuvant Chemotherapy for Breast Cancer. *Journal of Clinical Oncology*, 2012, 30(15), 1747–1749. doi: 10.1200/jco.2011.41.3161.

18. Wang M.-D., Duan F.-F., Hua X., Cao L., Xia W., & Chen J.-Y. A Novel Albumin-Related Nutrition Biomarker Predicts Breast Cancer Prognosis in Neoadjuvant Chemotherapy: A Two-Center Cohort Study. *Nutrients,* 2023, 15(19), 4292. doi: 10.3390/nu15194292.

19. Zhang X., Liu Y., & Mu D. Influence of prognostic nutritional index on the surveillance after surgery-based systematic therapy for breast cancer. *The American Surgeon™*, 2023, 89(12), 6157–6171. doi: 10.1177/00031348231191200.

References

1. Bray, F., Laversanne, M., Sung, H., Ferlay, J., Siegel, R.L., Soerjomataram, I., & Jemal, A. (2024). Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA: a cancer journal for clinicians*, 74(3), 229–263. doi: 10.3322/caac.21834.

2. Cancer tomorrow C. (2024). Estimated numbers from 2022 to 2050, Females, age [0-85+]. Breast. The International Agency for Research on

Cancer. Retrieved 2024.12.12 from: https://gco.iarc.fr/tomorrow/en/dataviz/trends?multiple_populations=1&sexes=2&cancers=20&age_end=17.

3. Cleator, S., Parton, M., & Dowsett, M. (2002). The biology of neoadjuvant chemotherapy for breast cancer. *Endocrine-related cancer*, 9(3), 183–195. doi: 10.1677/erc.0.0090183

4. Cortazar, P., Zhang, L., Untch, M., Mehta, K., Costantino, J. P., Wolmark, N., Bonnefoi, H., Cameron, D., Gianni, L., & Valagussa, P. (2014). Pathological complete response and long-term clinical benefit in breast cancer: the CTNeoBC pooled analysis. *The Lancet*, 384(9938), 164–172. doi: 10.1016/S0140-6736(13)62422-8.

5. Derks, M.G., & van de Velde, C.J. (2024). Neoadjuvant chemotherapy in breast cancer: more than just downsizing. *The Lancet Oncology*, 19(1), 2–3. doi: 10.1016/S1470-2045(17)30914-2.

6. Duan, S., & Buxton, I.L. (2022). Evolution of medical approaches and prominent therapies in breast cancer. *Cancers*, 14(10), 2450. doi: 10.3390/cancers14102450.

7. Guarneri, V., & Conte, P.F. (2004). The curability of breast cancer and the treatment of advanced disease. *European journal of nuclear medicine and molecular imaging*, 31(Suppl 1), S149–S161. doi: 10.1007/s00259-004-1538-5.

8. Jang, M.K., Park, S., Park, C., Doorenbos, A.Z., Go, J., & Kim, S. (2022). Body composition change during neoadjuvant chemotherapy for breast cancer. *Frontiers in Oncology*, 12, 941496. doi: 10.3389/fonc.2022.941496.

9. Killelea, B.K., Yang, V.Q., Mougalian, S., Horowitz, N.R., Pusztai, L., Chagpar, A.B., & Lannin, D.R. (2015). Neoadjuvant chemotherapy for breast cancer increases the rate of breast conservation: results from the National Cancer Database. *Journal of the American College of Surgeons*, 220(6), 1063–1069. doi: 10.1016/j.jamcollsurg.2015.02.011.

10. Limon-Miro, A.T., Lopez-Teros, V., & Astiazaran-Garcia, H. (2017). Dietary guidelines for breast cancer patients: a critical review. *Advances in Nutrition*, 8(4), 613–623. doi: 10.3945/an.116.014423.

11. Masood, S. (2016). Neoadjuvant chemotherapy in breast cancers. *Women's Health*, 12(5), 480–491. doi: 10.1177/1745505716677139.

12. Miyata, H., Yano, M., Yasuda, T., Hamano, R., Yamasaki, M., Hou, E., Motoori, M., Shiraishi, O., Tanaka, K., & Mori, M. (2012). Randomized study of clinical effect of enteral nutrition support during neoadjuvant chemotherapy on chemotherapy-related toxicity in patients with esophageal cancer. *Clinical nutrition*, 31(3), 330–336. doi: 10.1016/j.clnu.2011.11.002.

13. Neely, J.G., Hartman, J.M., Forsen Jr, J.W., & Wallace, M.S. (2003). Tutorials in clinical research: VII. Understanding comparative statistics (contrast) – part B: Application of T-test, Mann-Whitney U, and Chi-Square. *The Laryngoscope*, 113(10), 1719–1725. doi: 10.1097/00005537-200310000-00011.

14. Noor, F., Noor, A., Ishaq, A.R., Farzeen, I., Saleem, M.H., Ghaffar, K., Aslam, M.F., Aslam, S., & Chen, J.-T. (2021). Recent advances in diagnostic and therapeutic approaches for breast cancer: A comprehensive review. *Current Pharmaceutical Design*, 27(20), 2344–2365. doi: 10.2174/1381612827666210303141416.

15. Riina, M.D., Stambaugh, C., Stambaugh, N., & Huber, K.E. (2023). Continuous variable analyses: T-test, Mann–Whitney, Wilcoxin rank. In Translational radiation oncology (pp. 153–163). Elsevier. doi: 10.1016/B978-0-323-88423-5.00070-4.

16. Souza, A.P.S., Silva, L.C.D., Fayh, A.P.T. (2021). Nutritional Intervention Contributes to the Improvement of Symptoms Related to Quality of Life in Breast Cancer Patients Undergoing Neoadjuvant Chemotherapy: A Randomized Clinical Trial. *Nutrients*, 13(2), 589. doi: 10.3390/nu13020589.

17. Schott, A. F., & Hayes, D. F. (2012). Defining the Benefits of Neoadjuvant Chemotherapy for Breast Cancer. *Journal of Clinical Oncology*, 30(15), 1747–1749. doi: 10.1200/jco.2011.41.3161.

18. Wang, M.-D., Duan, F.-F., Hua, X., Cao, L., Xia, W., & Chen, J.-Y. (2023). A Novel Albumin-Related Nutrition Biomarker Predicts Breast Cancer Prognosis in Neoadjuvant Chemotherapy: A Two-Center Cohort Study. *Nutrients*, 15(19), 4292. doi: 10.3390/nu15194292.

19. Zhang, X., Liu, Y., & Mu, D. (2023). Influence of prognostic nutritional index on the surveillance after surgery-based systematic therapy for breast cancer. *The American Surgeon™*, 89(12), 6157–6171. doi: 10.1177/00031348231191200.

Прийнято до публікації: 17.11.2025
Опубліковано: 31.12.2025
Accepted for publication on: 17.11.2025
Published on: 31.12.2025