DOI: https://doi.org/10.54393/pjhs.v7i3.3773

PAKISTAN JOURNAL OF HEALTH SCIENCES
(LAHORE)
https://thejas.com.pk/index.php/pjhs
ISSN (E): 2790-9352, (P): 2790-9344
Volume 7, Issue 03 (March 2026)

Original Article

OPEN ACCESS

The Role of Neutrophil to Lymphocyte Ratio in Predicting the Response to Neoadjuvant Targeted Therapies in HER2-Positive Breast Cancer

Maryam Bibi[1], Muhammad Tariq[1*], Nasir Mehmood[2], Bushra Malik[1], Faryal Alam[1], Masroor Hassan[3] and Qazi Muhammad Farooq[4]

[1]Department of Oncology, Khyber Teaching Hospital, Peshawar, Pakistan
[2]Department of General Medicine, Khyber Teaching Hospital, Peshawar, Pakistan
[3]Department of Pathology, Northwest School of Medicine, Peshawar, Pakistan
[4]Department of Internal Medicine, Mercy Fitzgerald Hospital, Pennsylvania, United States of America

ARTICLE INFO

Keywords:
Neutrophil-to-Lymphocyte Ratio, HER2-Positive Breast Cancer, Neoadjuvant Therapy, Pathologic Complete Response, Adjusted Odds Ratios

How to Cite:
Bibi, M., Tariq, M., Mehmood, N., Malik, B., Alam, F., Hassan, M., & Farooq, Q. M. (2026). The Role of Neutrophil to Lymphocyte Ratio in Predicting the Response to Neoadjuvant Targeted Therapies in HER2-Positive Breast Cancer: Predictive Value of NLR in HER2-Positive Breast Cancer. Pakistan Journal of Health Sciences, 7(3), 149-154. https://doi.org/10.54393/pjhs.v7i3.3773

***Corresponding Author:**
Muhammad Tariq
Department of Oncology, Khyber Teaching Hospital, Peshawar, Pakistan
tariq16864@gmail.com

Received Date: 2nd January, 2026
Revised Date: 19th January, 2026
Acceptance Date: 16th February, 2026
Published Date: 31st March, 2026

ABSTRACT

The neutrophil-lymphocyte ratio (NLR) is a basic systemic inflammatory biomarker, previously associated with treatment response in different forms of cancer. Its predictive importance on response to neoadjuvant HER2-targeted therapies in HER2-positive breast cancer has not been well-established, especially in Pakistani patients. **Objectives:** To identify the relationship between pretreatment NLR and response to neoadjuvant HER2-targeted therapy in women with HER2-positive breast cancer. **Methods:** This was a descriptive study carried out in Khyber Teaching Hospital. Non-probability consecutive sampling was used to enroll 120 patients. Standard neoadjuvant HER2-targeted therapy was given to patients, and after 12 weeks, treatment response was evaluated based on Miller-Payne criteria. SPSS version 25.0 was used to analyze data. Chi-square/Fisher exact tests were used to establish associations between NLR and treatment response, and multivariate logistic regression was used to determine independent predictors of complete response. **Results:** Out of the 120 patients, 70 (58.3%) patients had low NLR, and 50 (41.7%) patients had high NLR. Full response was obtained in 16 (22.9%) low (NLR) and 4 (8%) high (NLR) (p=0.004) patients, respectively. High NLR was an independent predictor of reduced odds of complete response using logistic regression (p=0.035). **Conclusions:** A low pretreatment NLR is linked to better response rates to neoadjuvant HER2-targeted therapy, which indicates its potential use as a cost-efficient biomarker in informing decisions on the use of treatment strategies in the management of patients with HER2-positive breast cancer.

INTRODUCTION

The most common cancer that is diagnosed in women worldwide is breast cancer. It is estimated that this disease will cause hundreds of thousands of cases and that by 2022 alone, around 2.3 million new cases will have been linked to this disease, with 670,000 patients expected to die, highlighting the significant impact that this disease has on the issue of public health [1, 2]. One subtype worth mentioning is the HER2-positive breast cancer that occurs in approximately 15-20% of all cases of breast cancer occurrence [3]. The subtype is defined by abnormal expression of the HER2 protein, which results in more aggressive disease progression and worse outcomes in the past than the other subtypes [4]. The introduction of specific neoadjuvant regimens, especially anti-HER2 drugs, has significantly enhanced patient response rates and survival rates in those patients with HER2-positive disease [5]. Pathologic complete response (pCR) in the neoadjuvant setting has become a strong surrogate

DOI: https://doi.org/10.54393/pjhs.v7i3.3773

outcome in long-term prognosis, with the latest reports suggesting up to and over 57% in HER2-positive groups using modern regimens [6]. In spite of these, a large percentage of patients fail to respond to pCR or have an optimal benefit with targeted therapies [7]. Simple, inexpensive peripheral blood biomarkers have become of growing interest in cancer research, particularly the neutrophil to lymphocyte ratio (NLR), which is a biomarker of systemic inflammatory state. Higher NLR has been linked to adverse outcomes and decreased pCR rates after neoadjuvant chemotherapy in different types of breast cancer. The meta-analytic findings indicate that low pretreatment NLR is associated with increased chances of success in pCR following neoadjuvant breast cancer therapy [8]. Nevertheless, the evidence is not consistent, especially when considering contemporary targeted therapy of the HER2-positive disease. A few studies in reality have shown that some traditional inflammatory indicators, such as NLR, have only moderate predictive capacity with pCR, in a mix with clinicopathological variables [9]. Moreover, numerous studies have been conducted to examine the prognostic value of NLR in breast cancer in general, but very few have examined the predictive value of NLR in HER2-positive patients undergoing neoadjuvant targeted therapies [10, 11].

Neutrophils can facilitate pro-tumoral inflammation and angiogenesis, whereas lymphocytes play key roles in anti-tumor immunity that can potentially be reinforced by HER2-targeted agents. However, it is still unclear what the best NLR cutoff is, how it can be used together with other immune markers, and how it can be applied to optimize individualized treatment strategies. Therefore, the needs of the scientific gap are to determine the validity of pretreatment NLR as an indicator of response to neoadjuvant targeted therapy in HER2-positive breast cancer, and how it can be applied to clinical decision-making to more effectively customize therapy. This study aimed to test the response to neoadjuvant HER2-targeted therapies in patients with HER2-positive breast cancer and to investigate whether pretreatment NLR is related to the variable response to treatment.

METHODS

The study was conducted as a descriptive study in the Department of Oncology, Khyber Teaching Hospital, Peshawar, over six months, between 1st December 2024 and 31st May 2025, once the study synopsis had been approved. Ethical approval (Institutional Research and Ethical Review Board) of Khyber Medical College (KMC), approval no: 940/DME/KMC, for the study was granted. The calculation of sample size was developed following the WHO formula, but expected frequency of high pretreatment NLR (18.8%) of full response to treatment, and using other published data having lower rates of pCR in high baseline NLR receiving neoadjuvant therapy (14.3% pCR in high-NLR group), which yielded a final sample size of 120 patients [12]. Patients were selected using the non-probability consecutive sampling technique. Patients who were diagnosed with HER2-positive breast cancer based on operational criteria were included as participants, with the inclusion criteria of between 18 and 60 years. The exclusion criteria included bilateral invasive carcinoma of different subtypes, acute or chronic active inflammatory disease, primary metastatic breast cancer, secondary malignancy, severe cardiopulmonary compromise, pregnancy or lactating patients, and patients who had been treated elsewhere. Eligible patients were recruited, and informed consent was provided following explanations on the purpose of the study, risks, and benefits. The baseline demographic was noted. All patients were diagnosed with pathological changes, and positive HER2 immunohistochemistry with a score of 3+ or positive HER2 FISH was considered positive. Peripheral blood samples were taken and sent to the hospital laboratory to identify neutrophil and lymphocyte counts before treatment was initiated. NLR was determined by the formula: NLR = Number of neutrophils/ Number of lymphocytes. A cutoff value of 2.75 was used to group the patients into high and low NLR [13]. Neoadjuvant chemotherapy (NAC) was performed according to the standard protocols: six to eight cycles of anthracyclines + cyclophosphamide to four cycles of taxanes + cyclophosphamide served as a full-course chemotherapy, four to four cycles of anthracyclines + cyclophosphamide to four cycles of taxanes + cyclophosphamide served as a half-course chemotherapy. Guidelines were followed to administer trastuzumab to the HER2-positive patients over one year. After 12 weeks, all patients were followed up to determine the response to treatment based on operational definitions. The researcher used a specially designed proforma to record the data. The identification of HER2-positive breast cancer was done on clinical, histopathological, and molecular measures. Women appeared clinically with a palpable lump in the breast. The histopathological analysis of a tissue biopsy of the lump showed a heterogeneous growth pattern with diffuse sheets, nests, or cords of pleomorphic undifferentiated cells with prominent nucleoli, many mitoses, variable stromal components, and foci of necrosis and calcifications. HER2 positivity was also confirmed by immunohistochemistry with a 3+ result or positive HER2 amplification with Fluorescence in Situ Hybridization (FISH). NLR was calculated using a 0.5 mL of peripheral blood sample on a hematology analyzer. The NLR was determined by the formula NLR=amount of neutrophils/number of lymphocytes, with a value of <2.75

DOI: https://doi.org/10.54393/pjhs.v7i3.3773

considered low NLR and ≥2.75 considered high NLR. The response to treatment 12 weeks post-therapy was measured using histopathological examination of tumor tissue with regard to the Miller-Payne grading system [14]. Grade 1 showed no considerable tumor cellularity change; grade 2 showed that there was some loss of tumor cellularity (up to 30%); grade 3 showed that there was 30 to 90% loss; grade 4 showed marked loss, with more than 90% of the loss; and grade 5 showed no identifiable malignant cells, with only stromal elements left, but ductal carcinoma in situ can still exist. To perform the analysis, patients with grade 5 were defined as having a complete response, those with grades 3 and 4 were defined as partial response, and those with grades 1 and 2 were defined as no response.

The data were analyzed by IBM SPSS version 25.0. The Shapiro-Wilk test was used to test whether continuous variables were normally distributed. Descriptive statistics were reported in mean value with SD as computed values of the variables that were normally distributed, and in the case where the variables were non-normally distributed, the median and the interquartile range were reported. Categorical variables were tabulated in frequency counts and percentages, respectively. Categorical data analysis was done through Chi-square tests and Fisher's exact tests. The stratified analyses were done to quantify the potential effect modifiers, and the post-stratification Chi-square or Fisher's exact test were applied in each subgroup. Multivariate binary logistic regression was conducted in order to reveal the independent predictive value of NLR in the complete response. The Variance Inflation Factor (VIF) was used to determine the presence of multicollinearity among the predictors prior to the regression being run, and a value below 5 was considered acceptable, indicating no extreme cases of multicollinearity were present. Regression results were reported in adjusted odds ratios (aOR) with 95 percent confidence intervals. The significance level of 0.05 was taken as significant.

RESULTS

The study involved 120 breast cancer patients who were HER2-positive. The average age of the respondents was 45.2 ± 9.1 years, and the average BMI was 27.8 ± 3.5 kg/m2. The majority of patients lived in urban settings (56.7%), and 60% of the patients had stage II tumors. Additionally, the NLR was <2.75 in 70 (58.3%) patients and ≥ 2.75 in 50 (41.7%) patients with a total neural of NLR 2.62 + 1.1. The mean of low NLR patients was 2.01 ± 0.50, and that of high NLR patients was 3.38 ± 0.60 (Table 1).

Table 1: Baseline Demographic and Presenting Clinical Features

Variables	Categories	n (%)	Mean ± SD	Median (IQR)
Demographic and Clinical Characteristics				
Age	Years	–	45.2 ± 9.1	–
BMI (kg/m^2)	–	–	27.8 ± 3.5	
Residence	Urban	68 (56.7%)	–	–
	Rural	52 (43.3%)	–	
Education	Illiterate	22 (18.3%)	–	–
	Primary/ Secondary	50 (41.7%)	–	
	Higher	48 (40%)	–	
Socioeconomic Status	Low	34 (28.3%)	–	–
	Middle	60 (50%)	–	
	High	26 (21.7%)	–	
Tumor Laterality	Right Breast	66 (55%)	–	–
	Left Breast	54 (45%)	–	
Tumor Stage	II	72 (60%)	–	–
	III	48 (40%)	–	
Duration of Complaints (months)	–	–	–	5 (3-6)
Baseline NLR	–	–	2.50 (1.8-3.3)	–
Neutrophil-to-Lymphocyte Ratio (NLR) Distribution				
Low	<2.75	70 (58.3%)	2.01 ± 0.50	2.05 (1.7-2.3)
High	≥2.75	50 (41.7%)	3.38 ± 0.60	3.40 (3.0-3.8)
Overall	–	120 (100%)	2.62 ± 1.1	2.50 (1.8-3.3)

In the neoadjuvant HER2-targeted therapy, 20 (16.7%) patients had a complete response, 60 (50%) had a partial response, and 40 (33.3%) had no response by the Miller-Payne criteria after 12 weeks (Table 2).

Table 2: Treatment Response (Miller-Payne Criteria)

Response Categories	Miller-Payne Grade	n (%)	Cumulative %
No Response	1-2	40 (33.3%)	33.3%
Partial Response	3-4	60 (50%)	83.3%
Complete Response	5	20 (16.7%)	100%

The response rate was significantly different between NLR groups: the patients with low NLR responded with higher rates of complete response (22.9% vs. 8%), lower rates of no response (20% vs. 52%) than those with high NLR (p=0.004) (Table 3).

Table 3: Treatment Response by NLR Category

NLR Categories	Complete Response, n (%)	Partial Response, n (%)	No Response, n (%)	p-value
Low (<2.75)	16 (22.9%)	40 (57.1%)	14 (20%)	0.004*
High (≥2.75)	4 (8%)	20 (40%)	26 (52%)	

Multivariate logistic regression revealed that high NLR was independently related to a lower chance of complete response (p=0.035) after controlling for age, BMI, and tumor stage. The other variables, such as age, BMI, and the tumor stage, were not significantly correlated with complete response (Table 4).

DOI: https://doi.org/10.54393/pjhs.v7i3.3773

Table 4: Logistic Regression for Predictors of Complete Response

Variables	Adjusted or (95% CI)	p-value
High NLR (≥2.75)	0.31 (0.10–0.92)	0.035*
Age (>45 years)	0.68 (0.25–1.84)	0.440
BMI (≥28 kg/m^2)	0.72 (0.26–1.97)	0.530
Tumor Stage (III vs II)	0.55 (0.19–1.60)	0.270

Stratified analyses have shown that the low NLR/high complete response relationship was still significant in subgroups of age, tumor laterality, tumor stage, and BMI. Indicatively, the complete response rate (NLR ≤45 years) was 28.6% compared to 9% in NLR high patients (p=0.030) (Table 5).

Table 5: Stratified Analysis of NLR and Complete Response

Stratification Variables	Categories	NLR Complete Response, n (%)		p-value
		Low	High	
Age	≤45 years	10 (28.6%)	3 (9%)	0.030*
	>45 years	6 (17.1%)	1 (7%)	
Tumor Laterality	Right	9 (25.7%)	2 (6%)	0.020*
	Left	7 (20%)	2 (8%)	
Tumor Stage	II	12 (24%)	3 (9%)	0.010*
	III	4 (18.2%)	1 (5%)	
BMI	<28 kg/m^2	9 (25.7%)	2 (8%)	0.040*
	≥28 kg/m^2	7 (20%)	2 (8%)	

DISCUSSION

In the current research, it was determined that low pretreatment NLR had a strong correlation to high likelihood of complete pathological response (pCR), and a high NLR was significantly related to decreased probability of complete pathological response (p=0.004). Logistic regression demonstrated that high NLR had independent odds of lowering the chances of obtaining pCR following adjustment of age, BMI, and tumor stage (p=0.035). These findings confirm the hypothesis that neoadjuvant treatment efficacy in HER2-positive disease is associated with systemic inflammatory status as indicated by the NLR. A meta-analysis with a narrow focus that considered patients receiving neoadjuvant chemotherapy with breast cancer established that lower baseline neutrophil to the lymphocyte ratios (NLR) were related to high complete pathological response (pCR) rates (odds ratio = 1.62) and better disease-free survival and overall survival in various types of breast cancer; even in the presence of non-HER2-based cohorts as the majority of included studies. A second multicenter real-world study of HER2-positive patients undergoing anti-HER2 therapy has shown that traditional inflammatory indicators such as NLR did not significantly predict pCR, implying that traditional systemic immune-nutritional indicators such as the prognostic nutritional index (PNI) could provide supplemental prognostic data [9]. This gap underscores the heterogeneous nature of the relationship between inflammation and various patient groups and justifies the desire to study it in more depth, depending on molecular subtypes. The systematic review comparing NLR and pCR following neoadjuvant treatment in breast cancer revealed that there was a statistically significant association of low NLR and a higher rate of pCR across studies, which suggests that it may have a predictive value [8]. Also, other luminal subtype and triple negative disease studies have demonstrated that baseline NLR can be correlated to treatment results; however, the direction can be different depending on the subtype and therapy [15]. Indicatively, there is evidence to indicate that lower NLR is correlated with better treatment response and survival, but other studies in luminal breast cancer subgroups indicated inconsistent prognostic effects of NLR when assessing survival outcomes as opposed to pCR [16]. A cross-sectional study with a large cohort was carried out in Karachi, which has recorded correlations between NLR and clinicopathological characteristics in breast cancer, but did not directly test the response to neoadjuvant treatment [17]. Treatment outcome-focused studies are less common and more localized, but there is an emerging body of evidence that measures systemic inflammatory signatures in metastatic patients, and that lower NLR could be associated with better PFS and OS even in non-neoadjuvant settings [18]. In a retrospective study of patients with nonmetastatic breast cancer, NLR was not a significant predictor of complete pathological response, with conventional tumor characteristics, such as subtype and grade, showing to be more predictive [19]. Another large group found no relationship between high NLR and pCR or disease-free survival, and poorer overall survival in some subsets [20]. These inconsistent findings can be due to varying study designs, patient groups, cutoff values, and treatment regimens.

Overall, current findings add to a larger body of literature to indicate that inflammatory indicators like NLR have the potential to be useful, cheap, and readily available biomarkers of neoadjuvant therapy response in breast cancer. However, the diversity in the studies, the differences in cutoff values, patient demographics, co-occurring therapies, etc., warrant the need to conduct future, subtype-specific studies in other clinical settings, particularly in low and middle-income countries such as Pakistan, where most data is least recorded.

CONCLUSIONS

In situations of breast cancer in HER2-positive patients, low pretreatment NLR was strongly correlated with the higher occurrence of complete responses and partial responses to neoadjuvant targeted therapies, and high NLR value was correlated with reduced therapeutic

DOI: https://doi.org/10.54393/pjhs.v7i3.3773

efficacy. Such results indicate the possible value of NLR as a no-cost, simple, and easily accessible biomarker to identify patients potentially responding to neoadjuvant HER2-targeted treatment. The use of NLR in clinical decision making may turn out to be a personalized treatment plan, maximized therapeutic benefit, and closer monitoring in high-risk patients.

Authors' Contribution

Conceptualization: MB
Methodology: MB, NM, BM, FA
Formal analysis: MB, MT, MH
Writing and Drafting: MB, MT, NM
Review and Editing: MB, MT, NM, BM, FA, MH, QMF

All authors approved the final manuscript and take responsibility for the integrity of the work.

Conflicts of Interest

All the authors declare no conflict of interest.

Source of Funding

The author received no financial support for the research, authorship and/or publication of this article.

REFERENCES

[1] Arnold M, Morgan E, Rumgay H, Mafra A, Singh D, Laversanne M *et al.* Current and future burden of breast cancer: Global statistics for 2020 and 2040. The Breast. 2022 Dec; 66: 15-23. doi: 10.1016/j.breast.2022.08.010.

[2] Freihat O, Sipos D, Kovacs A. Global Burden and Projections of Breast Cancer Incidence and Mortality to 2050: A Comprehensive Analysis of GLOBOCAN Data. Frontiers in Public Health. 2025 Oct; 13: 1622954. doi: 10.3389/fpubh.2025.1622954.

[3] Ferrando-Díez A, Felip E, Pous A, Bergamino Sirven M, Margelí M. Targeted Therapeutic Options and Future Perspectives for HER2-Positive Breast Cancer. Cancers. 2022 Jul; 14(14): 3305. doi: 10.3390/cancers14143305.

[4] Corti C, Giugliano F, Nicolo E, Tarantino P, Criscitiello C, Curigliano G. HER2-low Breast Cancer: A New Subtype? Current Treatment Options in Oncology. 2023 May; 24(5): 468-478. doi: 10.1007/s11864-023-01068-1.

[5] Gunasekara AD, Anothaisintawee T, Youngkong S, Ha NT, McKay GJ, Attia J *et al.* Neoadjuvant Treatment with HER2-Targeted Therapies in HER2-Positive Breast Cancer: A Systematic Review and Network Meta-Analysis. Cancers. 2022 Jan; 14(3): 523. doi: 10.3390/cancers14030523.

[6] Conforti F, Pala L, Sala I, Oriecuia C, De Pas T, Specchia C *et al.* Evaluation of Pathological Complete Response as Surrogate Endpoint in Neoadjuvant Randomised Clinical Trials of Early-Stage Breast Cancer: Systematic Review and Meta-Analysis. British Medical Journal. 2021 Dec; 375: 1-13. doi: 10.1136/bmj-2021-066381.

[7] Bestvina CM, Waters D, Morrison L, Emond B, Lafeuille MH, Hilts A *et al.* Cost of Genetic Testing, Delayed Care, And Suboptimal Treatment Associated with Polymerase Chain Reaction Versus Next-Generation Sequencing Biomarker Testing for Genomic Alterations in Metastatic Non-Small Cell Lung Cancer. Journal of Medical Economics. 2024 Dec; 27(1): 292-303. doi: 10.1080/13696998.2024.2314430.

[8] Cullinane C, Creavin B, O'Leary DP, O'Sullivan MJ, Kelly L, Redmond HP *et al.* Can The Neutrophil-To-Lymphocyte Ratio Predict Complete Pathologic Response to Neoadjuvant Breast Cancer Treatment? A Systematic Review and Meta-Analysis. Clinical Breast Cancer. 2020 Dec; 20(6): 675-681. doi: 10.1016/j.clbc.2020.05.008.

[9] Birsin Z, Nazlı İ, Alkan O, Odabaşı Bükün H, Günaltılı M, Çerme E *et al.* Inflammatory and Nutritional Markers Predicting Pathological Complete Response to Neoadjuvant Therapy in HER2-Positive Breast Cancer: A Multicenter Real-World Study. Journal of Clinical Medicine. 2025 Oct; 14(20): 7271. doi: 10.3390/jcm14207271.

[10] Chen X, Cai Q, Deng L, Chen M, Xu M, Chen L *et al.* Association of Inflammatory Blood Markers and Pathological Complete Response in HER2-Positive Breast Cancer: A Retrospective Single-Center Cohort Study. Frontiers in Immunology. 2024 Nov; 15: 1465862. doi: 10.3389/fimmu.2024.1465862.

[11] Dowling GP, Daly GR, Hegarty A, Hembrecht S, Bracken A, Toomey S *et al.* Predictive Value of Pretreatment Circulating Inflammatory Response Markers in the Neoadjuvant Treatment of Breast Cancer: Meta-Analysis. British Journal of Surgery. 2024 May; 111(5): 132. doi: 10.1093/bjs/znae132.

[12] Chen Y, Chen K, Xiao X, Nie Y, Qu S, Gong C *et al.* Pretreatment Neutrophil-To-Lymphocyte Ratio Is Correlated with Response to Neoadjuvant Chemotherapy as an Independent Prognostic Indicator in Breast Cancer Patients: A Retrospective Study. BioMed Center Cancer. 2016 May; 16(1): 320. doi: 10.1186/s12885-016-2352-8.

[13] Gomes LT, Morato-Conceição YT, Gambati AV, Maciel-Pereira CM, Fontes CJ. Diagnostic Value of the Neutrophil-To-Lymphocyte Ratio in Patients with Leprosy Reactions. Heliyon. 2020 Feb; 6(2): 1-6. doi: 10.1016/j.heliyon.2020.e03369.

DOI: https://doi.org/10.54393/pjhs.v7i3.3773

[14] Wang W, Liu Y, Zhang H, Zhang S, Duan X, Ye J *et al.* Prognostic value of residual cancer burden and Miller-Payne system after neoadjuvant chemotherapy for breast cancer. Gland surgery. 2021 Dec; 10(12): 3211. doi: 10.21037/gs-21-608.

[15] Zhou Q, Dong J, Sun Q, Lu N, Pan Y, Han X. Role of Neutrophil-To-Lymphocyte Ratio as a Prognostic Biomarker in Patients with Breast Cancer Receiving Neoadjuvant Chemotherapy: A Meta-Analysis. British Medical Journal open. 2021 Sep; 11(9): 1-10. doi: 10.1136/bmjopen-2020-047957.

[16] Grassadonia A, Graziano V, Iezzi L, Vici P, Barba M, Pizzuti L *et al.* Prognostic Relevance of Neutrophil to Lymphocyte Ratio in Luminal Breast Cancer: A Retrospective Analysis in the Neoadjuvant Setting. Cells. 2021 Jul; 10(7): 1685. doi: 10.3390/cells10071685.

[17] Soomro R and Cho N. Association of Neutrophil to Lymphocyte Ratio with Clinicopathological Features in Breast Cancer. 2021; 33(14): 93-100. doi: 10.9734/jammr/2021/v33i1430975.

[18] Saleem W, Zaidi SS, Rizwan S, Naviwala MS, Ahmed F, Zehra N *et al.* Single Center Study: Using Pre-Treatment Neutrophil to Lymphocyte Ratio as a Predictor of Outcome in Metastatic Breast Cancer Patients Treated with Cyclin Dependent Kinase 4/6 Inhibitors. Indus Journal of Bioscience Research. 2025 Jul; 3(7): 344-350. doi: 10.70749/ijbr.v3i7.1877.

[19] Dogan E, Akay E, Eren SK, Turk G. Impact of Neutrophil to Lymphocyte Ratio on Pathological Response to Neoadjuvant Chemotherapy in Nonmetastatic Breast Cancer. Eurasian Journal of Medical Investigation. 2023 Oct; 7(4): 482. doi: 10.14744/ejmi.2023.51016.

[20] Muñoz-Montaño W, Cabrera-Galeana P, Alvarado-Miranda A, Villarreal-Garza C, Mohar A, Olvera A et al. Prognostic Value of the Pretreatment Neutrophil-To-Lymphocyte Ratio in Different Phenotypes of Locally Advanced Breast Cancer During Neoadjuvant Systemic Treatment. Clinical Breast Cancer. 2020 Aug; 20(4): 307-316. doi: 10.1016/j.clbc.2019.12.011.