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Association Between Pretreatment White Blood Cell Count and Early Progression in Non-small Cell Lung Cancer

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Abstract

Background/Aim: Elevated white blood cell (WBC) counts, frequently observed in patients with non-small cell lung cancer (NSCLC), are associated with poor prognosis; however, their relevance in the era of immune checkpoint inhibitor (ICI)–based therapy remains unclear.

Patients and Methods: We retrospectively analyzed 103 patients with advanced or recurrent NSCLC. Patients were stratified according to the presence of leukocytosis (WBC ≥10,000/μl). Clinical characteristics, treatment responses, progression-free survival (PFS), and overall survival (OS) were compared between groups. Multivariate Cox proportional hazards models were used to identify independent prognostic factors.

Results: Patients with elevated WBC counts were younger, had higher C-reactive protein (CRP) levels, tended to have a higher frequency of PD-L1 tumor proportion score (TPS) positivity at baseline, and exhibited a significantly lower objective response rate to first-line therapy (p=0.044). Kaplan–Meier analysis showed that elevated WBC counts were significantly associated with shorter PFS (p<0.001). In multivariate Cox analysis, an elevated WBC count remained independently associated with poorer PFS [hazard ratio (HR)=4.625, 95% confidence interval (CI)=1.969-10.864, p<0.001]. An optimal CRP cutoff value of 0.555 mg/dL was identified *via* receiver operating characteristic analysis. Elevated CRP levels were independently associated with worse OS (HR=2.251, 95%CI=1.110-4.567, p=0.025) and PFS (HR=1.729, 95%CI=1.080-2.769, p=0.023).

Conclusion: Pretreatment leukocytosis was associated with early disease progression in NSCLC, even in PD-L1-positive cases. Furthermore, elevated CRP levels provided additional prognostic stratification for PFS and OS. Thus, WBC count and CRP may serve as practical and readily accessible tools for early treatment evaluation and risk stratification in the management of NSCLC in the ICI era.

Keywords: Non-small cell lung cancer, white blood cell count, leukocytosis, immune checkpoint inhibitors, prognosis.

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Introduction

Tumor-associated leukocytosis (TAL) is a well-recognized paraneoplastic syndrome in lung cancer and is considered to be induced by tumor-derived cytokines, including granulocyte colony-stimulating factor (G-CSF) and other inflammatory mediators (1, 2). In patients with non-small cell lung cancer (NSCLC), the presence of TAL has been reported to be associated with poorer survival and increased biological aggressiveness of tumors in previous studies (1, 3, 4).

In routine clinical practice, elevated white blood cell (WBC) counts are frequently encountered in patients with lung cancer. Approximately 14-15% of patients with newly diagnosed lung cancer present with leukocytosis at baseline (2, 5). However, the precise prevalence of tumor-related leukocytosis (TRL), defined as leukocytosis driven by tumor-derived cytokines rather than infection or other secondary causes, remains unclear owing to a lack of well-established epidemiological data (6).

Notably, most previous studies investigating the prognostic impact of leukocytosis in NSCLC were conducted in an era when cytotoxic chemotherapy alone constituted the standard of care for systemic treatment. With the widespread adoption of immune checkpoint inhibitors (ICIs) as a standard treatment option, either as monotherapy or as part of combination regimens with chemotherapy, the clinical significance of pretreatment WBC counts in the current therapeutic landscape has not been fully elucidated.

Given the growing importance of immunotherapy in the management of advanced NSCLC, clarifying the prognostic and clinical implications of baseline WBC counts in patients treated with contemporary ICI-based regimens is of substantial clinical relevance. Therefore, in this study, we retrospectively investigated the association between pretreatment WBC counts and clinical characteristics, as well as survival outcomes, in patients with NSCLC who received standard treatments including ICIs.

Patients and Methods

Study population. We conducted a retrospective analysis of patients with NSCLC who initiated systemic anticancer therapy for stage IIIB disease, stage IV disease, or postoperative recurrence at Kanazawa Medical University Hospital between January 2014 and January 2024. Patients were excluded if they had received systemic antibiotic therapy for suspected infection within one week prior to the initiation of anticancer treatment, were receiving systemic corticosteroid therapy at baseline, or experienced recurrence after definitive chemoradiotherapy. After applying these exclusion criteria, a total of 103 patients were included in the final analysis.

Definition of leukocytosis and clinical variables. Leukocytosis was defined as a baseline white blood cell (WBC) count of ≥10,000/μl measured before the initiation of systemic therapy. This cutoff value has been widely used in previous oncological studies and pooled analyses of cohorts of patients with lung cancer (2, 7, 8). Patients were stratified into high-WBC count (WBC ≥10,000/μl) and low-WBC count (WBC <10,000/μl) groups, and clinical characteristics were compared between the two groups.

Statistical analysis. All statistical analyses were performed using SPSS software, version 26.0 (IBM Corp., Armonk, NY, USA). Categorical variables were compared using the chi-square test or Fisher's exact test when expected cell counts were less than five. Continuous variables were compared between groups using the independent *t*-test. Cox proportional hazards regression models were used to identify independent prognostic factors for progression-free survival (PFS) and overall survival (OS). Survival curves were estimated using the Kaplan–Meier method and compared using the log-rank test.

Receiver operating characteristic (ROC) curve analysis was performed to determine the optimal C-reactive protein (CRP) cutoff value for predicting OS. Cox proportional hazards models were used to identify independent prognostic factors for PFS and OS. Variables

Table I. *Baseline characteristics of patients with non-small cell lung cancer stratified by pretreatment white blood cell (WBC) count.*

	High-WBC count group	Low-WBC count group	*p*-Value
n (%)	20 (19.4%)	83 (80.6%)	
Age (years), mean (range)	66.7 (45-83)	71.8 (33-83)	0.026
Sex (male/female)	2/18	15/68	0.972
Smoking history (never/prior, current)	19/1	72/11	0.453
ECOG PS (0-1/2-4)	18/2	77/6	0.643
Tumor type (adenocarcinoma/non-adenocarcinoma)	12/8	46/37	0.804
PD-L1 expression (22C3) (%) (0/≥1/ untested)	1/15/4	12/67/4	0.05
Clinical stages (IV, postoperative recurrence/III)	13/7	46/37	0.464
Tumor size (mm)	44.9 (10.6-88.8)	36.5 (14.0-51.0)	0.115
Brain metastasis (yes/no)	1/19	9/70	0.418
Liver metastasis (yes/no)	3/17	6/73	0.351
Initial treatment response (yes/no)	7/13	51/32	0.044
Received second-line therapy (yes/no)	10/10	48/34	0.696
Platinum agent (yes/no)	15/5	51/32	0.308
ICI therapy (yes/no)	13/7	54/29	1.000
BEV (yes/no)	2/18	8/75	1.000
Ipilimumab (yes/no)	2/18	7/76	1.000
BMI, no. (range)	21.8 (16.3-26.2)	22.3 (15.3-38.5)	0.438
NLR	7.48 (1.20-49.14)	3.45 (1.04-9.29)	0.099
CRP	4.59 (0.11-19.19)	1.39 (0.03-18.31)	0.012‡
LD	306.2 (161.0-1,008.0)	221.1 (132.0-560.0)	0.113
Albumin	3.43 (2.40-4.40)	3.66 (2.10-4.80)	0.136

Data are presented as n (%) unless otherwise indicated. ‡Based on the unpaired *t*-test. ECOG: Eastern Cooperative Oncology Group; PD-L1: programmed death-ligand 1; TPS: tumor proportion score; ICI: immune checkpoint inhibitor; BEV: bevacizumab; BMI: body mass index; NLR: neutrophil-to-lymphocyte ratio; CRP: C-reactive protein; LD: lactate dehydrogenase.

with clinical relevance were included in the multivariate analysis. For all analyses, a two-sided *p*-value <0.05 was considered statistically significant.

Ethics statement. This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of Kanazawa Medical University Hospital (approval number: *I812*).

Results

Patient characteristics. Among the 103 patients included in the analysis, 20 (19.4%) were classified into the high-WBC count group. Baseline patient characteristics are summarized in Table I. Patients in the high-WBC count group were significantly younger than those in the low-WBC count group (66.7 *vs*. 71.8 years, p=0.026) and had significantly higher baseline CRP levels (4.59 *vs*. 1.39 mg/dl, p=0.012). PD-L1–positive tumors were more frequently observed in the leukocytosis group (p=0.05). The proportion of patients who achieved an objective response to first-line treatment was significantly lower in the high-WBC count group compared to that in the low-WBC count group (p=0.044). Additionally, the interval from the initiation of first-line therapy to the commencement of second-line treatment was significantly shorter for patients with leukocytosis (129.6 *vs*. 336.0 days, p<0.001). There were no significant differences between the two groups with respect to sex, histological subtype, metastatic pattern, tumor size, body mass index, Eastern Cooperative Oncology Group performance status, or the use of platinum-based chemotherapy or ICIs.

ROC analysis of CRP. ROC curve analysis was performed to determine the optimal CRP cutoff value for predicting OS (Figure 1). The area under the curve (AUC) was 0.544 [95% confidence interval (CI)=0.427–0.660]. The optimal cutoff value was identified as 0.555 mg/dl, yielding a sensitivity of 62.9% and a specificity of 53.7%.

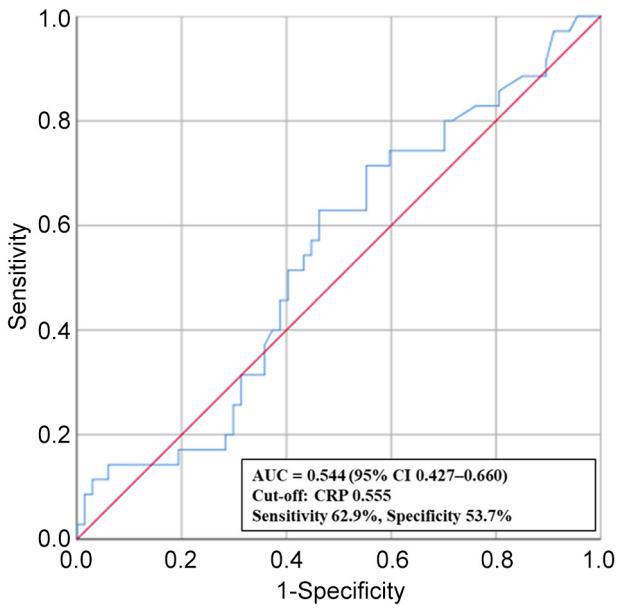

Figure 1. *Receiver operating characteristic (ROC) curve of baseline C-reactive protein (CRP) for overall survival. The area under the curve (AUC) was 0.544 (95% confidence interval=0.427–0.660). A CRP cutoff value of 0.555 mg/dl yielded a sensitivity of 62.9% and a specificity of 53.7%.*

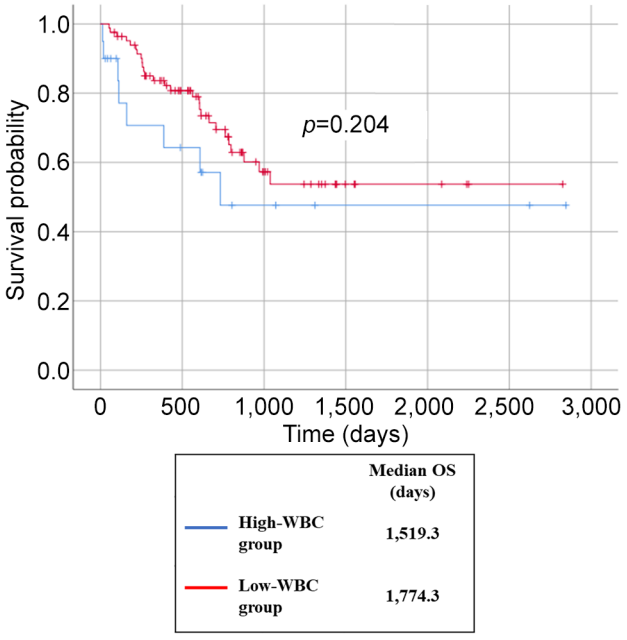

Figure 2. *Kaplan–Meier survival curves for progression-free survival (PFS) in patients with elevated versus normal white blood cell (WBC) counts. Patients in the high-WBC count group (≥10,000/μl) have significantly shorter PFS (p=0.000439, log-rank test).*

Survival analysis. The results of Kaplan–Meier analysis demonstrated that elevated baseline WBC counts were significantly associated with shorter PFS (p<0.001) (Figure 2), whereas no significant difference in OS was observed between the two groups (p=0.204) (Figure 3).

Multivariate analysis. In the multivariate Cox proportional hazards model, leukocytosis was independently associated with shorter PFS [hazard ratio (HR)=4.625; 95%CI=1.969-10.864; p<0.05). A baseline CRP level ≥0.555 mg/dl independently predicted worse OS (HR=2.251; 95%CI=1.110-4.567; p=0.025) and worse PFS (HR=1.729; 95%CI=1.080-2.769; p=0.023). Age and PD-L1 TPS were not identified as significant prognostic factors in the multivariate models (Table II).

Discussion

To the best of our knowledge, this study is the first to comprehensively evaluate the prognostic significance

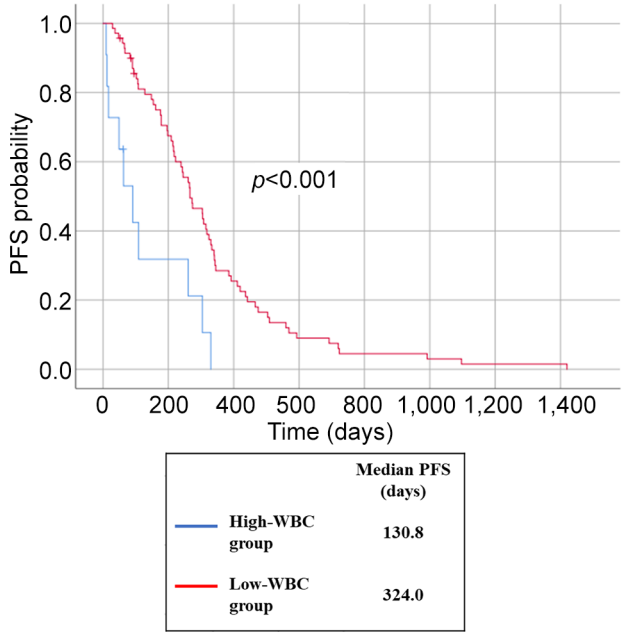

Figure 3. *Kaplan–Meier survival curves for overall survival (OS) in patients with elevated versus normal pretreatment white blood cell (WBC) counts. Patients in the high-WBC count group show a trend toward shorter OS (p=0.204, log-rank test).*

Table II. *Multivariate Cox proportional hazards analysis for overall survival (OS) and progression-free survival (PFS).*

Variable	OS HR (95%CI)	*p*-Value	PFS HR (95%CI)	*p*-Value
Age	1.023 (0.978-1.071)	0.326	1.000 (0.966-1.034)	0.983
High WBC count	1.366 (0.558-3.343)	0.494	4.625 (1.969-10.864)	<0.001
High CRP (≥0.555 mg/dl)	2.251 (1.110-4.567)	0.025	1.729 (1.080-2.769)	0.023
PD-L1 TPS (0% *vs.* ≥1%)	1.035 (0.356-3.007)	0.950	1.005 (0.521-1.936)	0.989

HR: Hazard ratio; CI: confidence interval; WBC: white blood cell count; CRP: C-reactive protein; PD-L1: programmed death-ligand 1; TPS: tumor proportion score. Variables included in the multivariate model were age, WBC category, CRP category, and PD-L1 TPS.

of pretreatment WBC counts in a real-world cohort of patients with NSCLC treated during the era when ICIs have been established as standard therapy. Our analysis showed that an elevated pretreatment WBC count was significantly associated with shorter PFS, while dichotomized CRP, rather than CRP as a continuous variable, served as an independent predictor of both OS and PFS. These findings underscore the potential clinical utility of routinely available inflammatory markers as practical and easily accessible prognostic indicators in the management of NSCLC.

Although tumors with positive PD-L1 expression were more frequently observed in the high-WBC count group and the use of ICIs as first-line therapy was comparable between the two groups, patients with leukocytosis exhibited a tendency toward earlier disease progression. This suggests that elevated WBC counts may reflect an underlying tumor-associated inflammatory or immunosuppressive state that limits the effectiveness of ICI-based treatment, even in the presence of favorable predictive biomarkers such as PD-L1 expression.

Tumor-associated leukocytosis is linked to increased neutrophil counts and expansion of myeloid-derived suppressor cells, mediated by tumor-derived cytokines such as G-CSF, thereby potentially promoting the formation of an immunosuppressive tumor microenvironment (6). These immunosuppressive mechanisms can impair T-cell–mediated antitumor immunity and reduce responsiveness to ICIs. The findings of the present study are consistent with those previously reported biological mechanisms and suggest that elevated WBC counts serve as a clinical surrogate marker of early resistance to ICI-based therapy.

In contrast, no significant difference in OS was observed between the high-WBC count and low-WBC count groups in this study, for which several explanations should be considered. First, although treatment allocation was well balanced between the two groups, the widespread use of ICIs may have attenuated the prognostic impact of pretreatment WBC counts on OS. In the ICI era, prolonged survival has been reported in a subset of patients who achieve durable disease control despite the absence of an objective tumor response (9, 10), which might have obscured differences in OS between the groups. Second, in the high-WBC count group, the majority of patients who did not receive ICIs as first-line therapy (6 of 7 patients) subsequently received ICIs as second-line treatment. Therefore, the early adverse prognostic signal associated with pretreatment leukocytosis might have been modified by the effects of subsequent ICI therapy.

Additionally, the relationship between WBC counts and immunological prognostic markers should be interpreted in light of the distinction from the neutrophil-to-lymphocyte ratio (NLR). NLR is considered to reflect more directly the balance between immunosuppressive conditions and antitumor immune activity (11), whereas the absolute WBC count does not necessarily capture these immune characteristics in a direct manner. This difference partly explains why elevated WBC counts were associated with PFS but not with OS in the present study.

In the present study, dichotomized CRP was identified as an independent prognostic factor for both OS and PFS. CRP is an acute-phase protein produced by the liver and is primarily regulated by the inflammatory cytokine interleukin-6 (IL-6); it is widely used as a nonspecific marker of systemic

inflammation (12, 13). Elevated serum CRP levels in patients with cancer have been reported to correlate with tumor cell proliferation as well as with the production of inflammatory cells and related inflammatory mediators (14). A meta-analysis focusing on patients with NSCLC treated with ICIs has also shown that an elevated pretreatment CRP level is a significant adverse prognostic factor for both OS and PFS (15). In the present cohort, more than half of the patients (69 of 103, 67%) received treatment regimens including ICIs as first-line therapy. Consistent with previous reports, our findings suggest that an elevated CRP level acts as a predictor of poor prognosis in patients with lung cancer receiving ICI-based therapy. Notably, although a proportion of patients in the present study did not receive ICIs as first-line treatment, a meta-analysis conducted in the pre-immunotherapy era likewise showed that an elevated serum CRP level was an independent adverse prognostic factor in patients with NSCLC (16). Taken together, these findings suggest that CRP functions as a prognostic biomarker reflecting systemic inflammatory status in NSCLC, irrespective of the specific treatment regimen employed. Importantly, this concept appears to remain valid in the immunotherapy era. Recent evidence published in 2025 demonstrated that inflammatory markers, including CRP and NLR, are significantly modulated by PD-1/PD-L1 inhibitor therapy in advanced NSCLC, with responders showing reductions in CRP from baseline (17). These findings suggest that dynamic monitoring of CRP may provide additional prognostic information and further refine risk stratification in the ICI setting.

In addition to CRP, our findings also highlight the clinical relevance of pretreatment leukocytosis in the ICI era. Pretreatment leukocytosis was associated with limited efficacy of ICI therapy in patients with NSCLC, even among those with PD-L1–positive tumors. These results suggest that treatment strategies aimed at reversing the immunosuppressive tumor microenvironment – such as combination therapy with chemotherapy, dual ICI therapy including CTLA-4 inhibition, or regimens incorporating anti–vascular endothelial growth factor antibodies – are theoretically more appropriate for this patient population (18, 19). However, in the present cohort, the number of patients treated with bevacizumab or ipilimumab was very limited, precluding a meaningful comparison of the efficacy or superiority of these combination strategies.

Study limitations. First, this was a single-center retrospective analysis, which might have introduced selection bias and been influenced by incomplete or unrecorded clinical data. Second, treatment regimens and sequencing were determined at the discretion of the attending physicians, resulting in heterogeneity in therapeutic approaches that might have affected the outcomes. Third, although infectious and drug-related causes of leukocytosis were excluded as thoroughly as possible, serum G-CSF levels were not routinely measured; therefore, it was not possible to confirm tumor-associated leukocytosis in all cases. To overcome these limitations and validate our findings, prospective multicenter studies are warranted.

Conclusion

This study demonstrates that pretreatment leukocytosis is associated with early disease progression in patients with NSCLC, even among those with PD-L1–positive tumors. Furthermore, an elevated CRP level was identified as an independent prognostic factor for both OS and PFS. These findings suggest that routinely available inflammatory markers, such as WBC count and CRP, serve as practical tools for risk stratification and early treatment assessment in the era of ICI therapy for NSCLC.

Conflicts of Interest

The Authors declare no conflicts of interest related to this study.

Authors' Contributions

All Authors had full access to the study data and took responsibility for the integrity of the data and the accuracy of the data analysis. All the Authors have

read and approved the submission of this manuscript. Conceptualization: Y. T.; Resources: Y. T., R. A., S. N., T. T., Y. I., I. S., K. Y., M. N., and M.I.; Investigation: R. A., S. N., T. T., Y. I., I. S., K. Y., M. N., and M.I.; Methodology: Y. T. and M. I.; Writing – original draft: Y. T., with support from M.I.

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Artificial Intelligence (AI) Disclosure

No artificial intelligence (AI) tools, including large language models or machine learning software, were used in the preparation, analysis, or presentation of this manuscript.

References

1 Sreevatsa A, Babu SMC, Babu GK, Suresh TM: Hyperleukocytosis, an unusual paraneoplastic manifestation of lung cancer. J Cancer Res Ther 11(3): 669, 2015. DOI: 10.4103/0973-1482.151865
2 Kasuga I, Makino S, Kiyokawa H, Katoh H, Ebihara Y, Ohyashiki K: Tumor-related leukocytosis is linked with poor prognosis in patients with lung carcinoma. Cancer 92(9): 2399-2405, 2001. DOI: 10.1002/1097-0142(20011101)92:9<2399::aid-cncr1588>3.0.co;2-w
3 Tomita M, Shimizu T, Hara M, Ayabe T, Onitsuka T: Preoperative leukocytosis, anemia, and thrombocytosis are associated with poor survival in non-small cell lung cancer. Anticancer Res 29(7): 2687-2690, 2009.
4 Mandrekar SJ, Schild SE, Hillman SL, Allen KL, Marks RS, Mailliard JA, Krook JE, Maksymiuk AW, Chansky K, Kelly K, Adjei AA, Jett JR: A prognostic model for advanced stage nonsmall cell lung cancer. Cancer 107(4): 781-792, 2006. DOI: 10.1002/cncr.22049
5 Granger JM, Kontoyiannis DP: Etiology and outcome of extreme leukocytosis in 758 nonhematologic cancer patients. Cancer 115(17): 3919-3923, 2009. DOI: 10.1002/cncr.24480
6 Tavakkoli M, Wilkins CR, Mones JV, Mauro MJ: A novel paradigm between leukocytosis, G-CSF secretion, neutrophil-to-lymphocyte ratio, myeloid-derived suppressor cells, and prognosis in non-small cell lung cancer. Front Oncol 9: 295, 2019. DOI: 10.3389/fonc.2019.00295
7 Zhang H, Lv H, Weng M, Wang H, Cata JP, Chen W, Miao C: Preoperative leukocytosis is associated with increased tumor-infiltrating neutrophil extracellular traps and worse outcomes in esophageal cancer. Ann Transl Med 8(7): 441, 2020. DOI: 10.21037/atm.2020.03.190
8 Hu X, Li YQ, Li QG, Ma YL, Peng JJ, Cai SJ: Baseline peripheral blood leukocytosis is negatively correlated with T-cell infiltration predicting worse outcome in colorectal cancers. Front Immunol 9: 2354, 2018. DOI: 10.3389/fimmu.2018.02354
9 Gettinger S, Horn L, Jackman D, Spigel D, Antonia S, Hellmann M, Powderly J, Heist R, Sequist LV, Smith DC, Leming P, Geese WJ, Yoon D, Li A, Brahmer J: Five-year follow-up of nivolumab in previously treated advanced non–small-cell lung cancer: results from the CA209-003 study. J Clin Oncol 36(17): 1675-1684, 2018. DOI: 10.1200/jco.2017.77.0412
10 Hellmann MD, Ma J, Garon EB, Hui R, Gandhi L, Soria J, Anderson KM, Lubiniecki GM, Piperdi B, Herbst RS: Estimating long-term survival of PD-L1-expressing, previously treated, non-small cell lung cancer patients who received pembrolizumab in KEYNOTE-001 and -010. J Clin Oncol 35(7_suppl): 77-77, 2017. DOI: 10.1200/JCO.2017.35.7_suppl.77
11 Nguyen CTT, Van TNK, Huong PT: Predictability of neutrophile to lymphocyte ratio and platelet to lymphocyte ratio on the effectiveness of immune checkpoint inhibitors in non-small cell lung cancer patients: a meta-analysis. Cancer Control 31: 10732748241285474, 2024. DOI: 10.1177/10732748241285474
12 Shimura T, Shibata M, Gonda K, Murakami Y, Noda M, Tachibana K, Abe N, Ohtake T: Prognostic impact of interleukin-6 and C-reactive protein on patients with breast cancer. Oncol Lett 17(6): 5139-5146, 2019. DOI: 10.3892/ol.2019.10183
13 May A, Wang TJ: Evaluating the role of biomarkers for cardiovascular risk prediction: focus on CRP, BNP and urinary microalbumin. Expert Rev Mol Diagn 7(6): 793-804, 2007. DOI: 10.1586/14737159.7.6.793
14 He D, Yang Y, Yang Y, Tang X, Huang K: Prognostic significance of preoperative C-reactive protein to albumin ratio in non-small cell lung cancer patients: A meta-analysis. Front Surg 9: 1056795, 2023. DOI: 10.3389/fsurg.2022.1056795
15 Wang H, Yang R, Zhou K, Wang S, Cheng C, Liu D, Li W: Association between pretreatment C-reactive protein level and survival in non-small cell lung cancer patients treated with immune checkpoint inhibitors: A meta-analysis. Int Immunopharmacol 124(Pt B): 110937, 2023. DOI: 10.1016/j.intimp.2023.110937
16 Jing X, Huang C, Zhou H, Li C, Fan L, Chen J, Zhang G, Liu Y, Cui Z, Qi D, Ma J: Association between serum C-reactive protein value and prognosis of patients with non-small cell lung cancer: a meta-analysis. Int J Clin Exp Med 8(7): 10633-10639, 2015.

17 Zhang Y, Yan N, Feng Y, Wu Y, Sun Y, Gao X, Gu C, Ma X, Gao F, Zhang H, Zhou J: Inflammatory markers predict efficacy of immunotherapy in advanced non-small cell lung cancer: a preliminary exploratory study. Discov Oncol 16(1): 8, 2025. DOI: 10.1007/s12672-025-01753-7
18 Yi M, Jiao D, Qin S, Chu Q, Wu K, Li A: Synergistic effect of immune checkpoint blockade and anti-angiogenesis in cancer treatment. Mol Cancer 18(1): 60, 2019. DOI: 10.1186/s12943-019-0974-6
19 Cheng W, Kang K, Zhao A, Wu Y: Dual blockade immunotherapy targeting PD-1/PD-L1 and CTLA-4 in lung cancer. J Hematol Oncol 17(1): 54, 2024. DOI: 10.1186/s13045-024-01581-2