

# The Position of Neutrophils-To-Lymphocytes and Lymphocytes-To-Platelets Ratio as Predictive Markers of Progression and Prognosis in Patients with Non-Small Cell Lung Cancer

Plamen Minkov<sup>1\*</sup>, Maya Gulubova<sup>2</sup>, Petar Chilingirov<sup>1</sup>, Julian Ananiev<sup>2</sup>

<sup>1</sup>Trakia University, Stara Zagora, Bulgaria; <sup>2</sup>Department of General and Clinical Pathology, Forensic Medicine and Deontology, Trakia University, Stara Zagora, Bulgaria

## Abstract

**Citation:** Minkov P, Gulubova M, Chilingirov P, Ananiev J. The Position of Neutrophils-To-Lymphocytes and Lymphocytes-To-Platelets Ratio as Predictive Markers of Progression and Prognosis in Patients with Non-Small Cell Lung Cancer. Open Access Maced J Med Sci. 2018 Aug 20; 6(8):1382-1386. <https://doi.org/10.3889/oamjms.2018.210>

**Keywords:** Lung cancer; NLR; PLR; Prognosis

**\*Correspondence:** Plamen Minkov, Trakia University, Stara Zagora, Bulgaria. E-mail: [uki\\_duki@abv.bg](mailto:uki_duki@abv.bg)

**Received:** 18-Jan-2018; **Revised:** 15-Jun-2018; **Accepted:** 18-Jun-2018; **Online first:** 04-Aug-2018

**Copyright:** © 2018 Plamen Minkov, Maya Gulubova, Petar Chilingirov, Julian Ananiev. This is an open-access article distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (CC BY-NC 4.0).

**Funding:** This research did not receive any financial support.

**Competing Interests:** The authors have declared that no competing interests exist.

**BACKGROUND:** Non-small cell lung cancer (NSCLC) is an insidious metastasis condition of the lungs often presenting no symptoms at the onset. Defining markers for quick determination of prognosis is essential for building up a treatment strategy.

**AIM:** The aim of this study is to define the role of the Neutrophils-to-Lymphocytes ratio (NLR) and Platelets-to-Lymphocytes ratio (PLR) as biomarkers in patients with NSCLC, according to the stage and prognosis of the disease.

**METHODS:** We investigated 20 patients with NSCLC. NLR and PLR are calculated and are evaluated according to the presence or absence of metastasis, stage of the disease, histological type and survival rate.

**RESULTS:** We found that thirteen of the patients had low NLR, while the rest 7 had high NLR (mean 3.15). By analysing PLR we found that 11 patients have low and 9 have high level of PLR (mean 1.42). After the correlations have been made we discovered that in 90.1% of the patients with low PLR no lymph metastasises were detected, while in 50% of the patients with high PLR lymph metastasises were observed ( $\chi^2 = 3.99$ ;  $P = 0.046$ ). We also discovered that in 84.6% of the patients with low NLR lymph metastasises were absent, while in 42.9% with high NLR lymph metastasises were present ( $\chi^2 = 1.83$ ;  $P = 0.176$ ).

**CONCLUSION:** In conclusion, NLR and PLR were discovered as prominent biomarkers which provide relatively fast determination for prognosis in patients with NSCLC.

## Introduction

Lung cancer (LC) is one of the leading causes of cancer related mortality [1]. Non-small cell lung cancer (NSCLC) accounts almost 85% of all LCs, while small cell lung cancer (SCLC) accounts nearly 13% [1]. There are many prognostic factors that are associated with development and progression of LC: TNM status, age, stage, performance, gender, histological variant, serum levels of lactate dehydrogenase LDH, carcinoembryonic antigen CEA and others [2] [3] [4] [5]. Some newer biomarkers like epidermal growth factor receptor EGFR mutations and anaplastic lymphoma kinase ALK rearrangements provide useful information for determining the

prognosis and building up a treatment strategy. Unfortunately, these tests are expensive, they can only be evaluated in a small subset of patients and the results take time [6] [7].

The validation of new biomarkers could ease the stratification of high risk patients and could also help make more accurate treatment plan. The relation between the immune response of the patients and the progression and prognosis of the neoplasms is confirmed by multiple analyses [8] [9]. It is known that the tumor microenvironment, which is conditioned by the immune response of the patient and also by the cancer itself, plays a crucial role in the processes of angiogenesis, metastasis and proliferation of the cancer cells [10]. Very important role of the

development of these processes is given to the cells of the extracellular matrix, the cells of the connective tissue and especially to cells such as: lymphocytes, neutrophils, macrophages, dendritic cells, platelets and others.

Lymphocytes are the main cells of the antitumor immune response. Their antitumor capabilities are carried out by cytotoxic T-lymphocytes [11]. The tumor cells are vanished by cytolytic reactions or by induction of apoptosis via membrane receptor of the programmed death. To be effective, the antitumor response requires antigen presentation from the tumor cells or from the antigen presenting cells like macrophages and dendritic cells [12]. Antitumor capabilities of the lymphocytes are ineffective in clinically detectable cancer and are inversely proportional to the tumor size [13]. The cells of the NSCLC escape these immune mechanisms by expression of unstable or bad presented antigens as result of genetic or epigenetic mutations in course of oncogenesis [14].

Neutrophils play main role in the processes of inflammation or antibacterial defense. Chronic inflammation is an established factor that increases the risk of cancer development. Examples are hepatitis B and the inflammatory bowel diseases, which could lead to development of hepatocellular and colorectal carcinoma respectively [15] [16]. The neutrophils take place in the processes of angiogenesis by secretion of pro-angiogenic factors. They directly affect the tumor progression by proteolytic release of epidermal growth factor, transforming growth factor beta and platelet derived growth factor [17]. Furthermore, neutrophils have the capability to influence other tumor promoting cells as T-lymphocytes and NK-cells [18]. Neutrophils have also direct or antibody dependent cytotoxic effect on the cancer cells [17]. It is known that there is neutrophilic polarization, which is caused by different cytokines (TGF-beta, INFs). Polarization defines the development of subpopulations of neutrophils that have antitumor properties as well as subpopulations that support the tumor progression [19]. A high number of neutrophils favor the prognosis according to a number of studies and exactly the opposite effect according to others [20].

Thrombocytes have central place in the processes of growth, progression and metastasis of neoplasms [21]. A hyper coagulation is related to more aggressive cancer disease and even more to thromboembolism, which in turn is one of the leading causes of death in patients with cancer [22] [23]. Platelets release many factors as PDGF, thrombospondin and thrombocytic factor 4 (which favor the hematogenic cancer spread), the adhesion of the tumor cells, invasion, the angiogenesis and in that way the tumor progresses. The prognostic significance of the platelets count in subsets of patients with NSCLC is known for a long time but it has unknown correlation [24] [25] [26] [27] [28].

Many inflammatory indicators attract attention because of their accessibility and prognostic efficacy when determining the prognosis in cancer patients. Such indicators are Neutrophil-to-Lymphocyte ratio (NLR) and Platelets-to-Lymphocyte ratio (PLR). The NLR is an important marker of systemic inflammation. Neutrophils, T- and B-lymphocytes have central role in the antitumor immune response [29]. The disturbance of the normal NLR is considered to be a consequence of the tumor related hypoxia and/or necrosis and is associated with anti- apoptosis effect [30]. The NLR is proven as a prognostic biomarker for determination of the prognosis of patients with different kind of cancer, including colorectal, breast cancer, gastric cancer, pancreatic cancer and esophageal cancer [31] [32] [33] [34] [35]. Many studies try to define the exact place of NLR as a prognostic biomarker in patients with NSCLC. The known evidences show unstable and discrepant results [36]. The prognostic value of the PLR is also associated with some kinds of cancer including gastric, breast, colorectal cancer and NSCLC [37] [38] [39] [40]. The prognostic value of PLR for determining the prognosis of patients with NSCLC is contrary [40] [41]. According to some authors, the high PLR has a negative prognostic value, while others do not succeed to establish clear correlation between prognosis and PLR [42] [43].

The objective of this study is to define the role of the NLR and PLR as biomarkers in patients with NSCLC, according to the stage and prognosis of the disease.

## Materials and Methods

This is a retrospective analysis of NLR and PLR in patients with NSCLC at the time of diagnosis and before treatment. Twenty (20) patients with NSCLC were sampled between 2007 and 2016. Their respective NLR and PLR were calculated and evaluated accordingly with emphasis on the presence or absence of metastasis, stage of the disease, histological variants and survival.

NLR and PLR are calculated and are evaluated according to the presence or absence of metastasis, stage of the disease, histological variant and survival.

The study participants comprise of 19 men and 1 woman aged 24 to 75 years (mean  $60.7 \pm 11.9$  years). The patients were initially operated in the thoracic surgery clinic in Stara Zagora between 2007 and 2016. Fifteen percent (15.0%) of the patients were diagnosed in stage T1 and T2; 75% in T3 and T4; lymphatic metastasises were detected in 5 patients; distant metastasises were found in 4 patients (20%). Lung adenocarcinoma was diagnosed in 7 patients, the other 13 patients were diagnosed with

squamous cell lung cancer.

The Statistical Package for the Social Sciences SPSS 16.0 program for Windows was used for statistical analysis. The descriptive statistical tests, including the mean, standard deviation, and median, were calculated according to the standard methods. The frequency of distribution of NLR and PLR and the clinico-pathological parameters in 2x2 contingency tables was analyzed by  $\chi^2$ -test. For all statistical analysis,  $p < 0.05$  was considered to be statistically significant.

The study was approved by the local Ethical Committee.

## Results

Thirteen of the patients had low NLR, while the rest 7 had high NLR (mean 3.15). By analyzing PLR we found that 11 patients have low and 9 have high level of PLR (mean 1.42). After the correlation has been made we found that in 90.1% of the patients with low PLR no lymph metastases were detected, while in 50% of the patients with high PLR lymph metastasizes were observed ( $\chi^2 = 3.99$ ;  $P = 0.046$ ). In 84.6% of the patients with low NLR lymph metastasizes were absent, while in 42.9% with high NLR lymph metastasizes were present ( $\chi^2 = 1.83$ ;  $P = 0.176$ ) (Table 1).

**Table 1: Correlations between NLR, PLR and clinico-morphological factors**

Parameter		NLR		p	PLR		p
		Low	High		Low	High	
Age	> 60.7	5	5	0.515	6	4	0.463
	< 60.7	7	3		5	5	
Sex	M	12	7	0.452	10	9	0.381
	F	1	0		1	1	
Tumor (T)	T1-2	2	1	0.948	2	2	0.737
	T3-4	11	6		9	7	
Nodulus (N)	N0	11	4	0.176	10	4	0.046
	N1-3	2	3		2	4	
Metastasis (M)	M0	11	5	0.482	10	5	0.134
	M1	2	2		1	3	
Histology type	Adenocarcinoma	4	3	0.589	4	3	0.599
	Squamous cell carcinoma	9	4		7	6	

## Discussion

The definition of prognosis is crucial for determination of the treatment strategy in patients with neoplasia. Many studies have tried to discover

biomarkers, which could be used for defining the prognosis of patients with NSCLC [44]. The role of development and progression of cancers is the subject of research by many authors. The ratios NLR and PLR are very intensively investigated biomarkers, because of their accessibility and easy interpretation. The important place that NLR and PLR takes in the processes of cancerogenesis is evaluated by comparison of NLR and PLR in healthy persons compared to lung cancer patients. In one of the studies, significantly higher NLR and PLR are found in patients with LC (NLR: 4.42 vs 2.45. PLR: 245.1 vs 148.2) [45].

Our data gained from the small group of patients show that higher NLR and PLR correlate with advanced disease and respectively worse prognosis. Similar results were observed in other studies involving more patients [41] [45] [46] [47] [48] [49].

Increased NLR and PLR calculated from peripheral blood samples are proved as independent predictive marker which is associated with worse prognosis in patients suffering from different kind of cancer including NSCLC [45]. Close to our results were seen in studies which evaluate cancers at different stages. These studies demonstrate that higher NLR and PLR are associated with worse outcome and advanced disease. Increased NLR and PLR determined at the time of diagnosis in non-treated patients are associated with significantly worse survival in a study that includes 94 patients with NSCLC [50].

Even more interesting is the fact that the lower NLR and PLR are associated with better prognosis in patients with NSCLC. Our results show lower NLR and PLR in patients with no lymph metastasis and lack or in smaller degree distant metastasis. A similar conclusion was reported in earlier studies which investigated the combination of both NLR and PLR as prognostic biomarkers as one study that includes 366 patients with NSCLC in advanced stages. The patients were divided in three groups: worse prognosis NLR > 2.68 in the middle NLR < 2.68, PLR > 119.5 and better prognosis NLR < 2.68, PLR < 119.5 [43].

It is observed that the NLR and PLR could change in course of therapy which supposes their estimation in each stage of treatment. In a study that evaluates the change of the values of NLR and PLR show that permanent elevated ratios are associated with worse prognosis and worse survival after treatment [51] [52] [53]. Despite these observations the place of NLR and PLR is not fully defined. Some authors have not managed to find association of the prognosis and the value of NLR in patients with NSCLC [42]. Some data demonstrated lacks correlation between prognosis and the value of PLR in patients with NSCLC [43].

In conclusion, it can be noted that NLR and PLR are very accessible biomarkers and could be

very useful for relatively fast determination of the prognosis in patients with NSCLC. According to our data, only PLR can be used for prognosis determination, although very small subset of patients was investigated. Usually, higher NLR and PLR are associated with worse prognosis. Unfortunately, the reliability of these biomarkers is not well defined. More investigations are needed to clarify the place of these ratios as biomarkers.

## References

- Siegel R, Naishadham D, Jemal A. Cancer statistics. 2013. *CA Cancer J Clin.* 2013; 63(1):11-30. <https://doi.org/10.3322/caac.21166>
- Albain KS, Swann RS, Rusch VW, Turrisi III AT, Shepherd FA, Smith C, Chen Y, Livingston RB, Feins RH, Gandara DR, Fry WA. Radiotherapy plus chemotherapy with or without surgical resection for stage III non-small-cell lung cancer: a phase III randomised controlled trial. *The Lancet.* 2009; 374(9687):379-86. [https://doi.org/10.1016/S0140-6736\(09\)60737-6](https://doi.org/10.1016/S0140-6736(09)60737-6)
- Riquet M, Bagan P, Barthes FL, Banu E, Scotte F, Foucault C, Dujon A, Danel C. Completely resected non-small cell lung cancer: reconsidering prognostic value and significance of N2 metastases. *The Annals of thoracic surgery.* 2007; 84(6):1818-24. <https://doi.org/10.1016/j.athoracsur.2007.07.015>
- Simon GR, Sharma S, Cantor A, Smith P, Bepler G. ERCC1 expression is a predictor of survival in resected patients with non-small cell lung cancer. *Chest.* 2005; 127(3):978-83. <https://doi.org/10.1378/chest.127.3.978>
- Hoang T, Xu R, Schiller JH, Bonomi P, Johnson DH. Clinical model to predict survival in chemonaive patients with advanced non-small-cell lung cancer treated with third-generation chemotherapy regimens based on eastern cooperative oncology group data. *J Clin Oncol.* 2005; 23(1):175-83. <https://doi.org/10.1200/JCO.2005.04.177> PMID:15625371
- Rosell R, Bivona TG, Karachaliou N. Genetics and biomarkers in personalisation of lung cancer treatment. *Lancet.* 2013; 382: 720-731. [https://doi.org/10.1016/S0140-6736\(13\)61715-8](https://doi.org/10.1016/S0140-6736(13)61715-8)
- Molina JR, Yang P, Cassivi SD, Schild SE, Adjei A. Non-small cell lung cancer: epidemiology, risk factors, treatment, and survivorship. *Mayo Clin Proc.* 2008; 83(5):584-94. [https://doi.org/10.1016/S0025-6196\(11\)60735-0](https://doi.org/10.1016/S0025-6196(11)60735-0)
- Hanahan D, Weinberg RA. Hallmarks of cancer: the next generation. *Cell.* 2011; 144(5):646-74. <https://doi.org/10.1016/j.cell.2011.02.013>
- Grivennikov SI, Greten FR, Karin M. Immunity, inflammation, and cancer. *Cell.* 2010; 140(6):883-99. <https://doi.org/10.1016/j.cell.2010.01.025> PMID:20303878  
PMCID:PMC2866629
- Mantovani A, Allavena P, Sica A, Balkwill F. Cancer-related inflammation. *Nature.* 2008; 454(7203):436-44. <https://doi.org/10.1038/nature07205> PMID:18650914
- Aerts JG, Hegmans JP. Tumor-specific cytotoxic T cells are crucial for efficacy of immunomodulatory antibodies in patients with lung cancer. *Cancer Res.* 2013; 73(8):2381-8. <https://doi.org/10.1158/0008-5472.CAN-12-3932>
- Vermaelen K, Pauwels R. Pulmonary dendritic cells. *Am J Respir Crit Care Med.* 2005; 172(5):530-51. <https://doi.org/10.1164/rccm.200410-1384SO>
- Tartour E, Zitvogel L. Lung cancer: potential targets for immunotherapy. *Lancet Respir Med.* 2013; 1:551-63. [https://doi.org/10.1016/S2213-2600\(13\)70159-0](https://doi.org/10.1016/S2213-2600(13)70159-0)
- Kris MG, Natale RB, Herbst RS, Lynch TJ Jr, Prager D, Belani CP, Schiller JH, Kelly K, Spiridonidis H, Sandler A, Albain KS, Cella D, Wolf MK, Averbuch SD, Ochs JJ, Kay AC. Efficacy of gefitinib, an inhibitor of the epidermal growth factor receptor tyrosine kinase, in symptomatic patients with non-small cell lung cancer: a randomized trial. *JAMA.* 2003; 290(16):2149-58. <https://doi.org/10.1001/jama.290.16.2149>
- Nakamoto Y, Guidotti LG, Kuhlen CV, Fowler P, Chisari FV. Immune pathogenesis of hepatocellular carcinoma. *J Exp Med.* 1998; 188(2):341-50. <https://doi.org/10.1084/jem.188.2.341>
- Rogler G. Chronic ulcerative colitis and colorectal cancer. *Cancer Lett.* 2014; 345(2):235-41. <https://doi.org/10.1016/j.canlet.2013.07.032>
- van Egmond M, Bakema JE. Neutrophils as effector cells for antibody-based immunotherapy of cancer. *Semin Cancer Biol.* 2013; 23(3):190-9. <https://doi.org/10.1016/j.semcancer.2012.12.002>
- Jin H, Zhang G, Liu X, Liu X, Chen C, Yu H, Huang X, Zhang Q, Yu J. Blood neutrophil-lymphocyte ratio predicts survival for stages III-IV gastric cancer treated with neoadjuvant chemotherapy. *World J Surg Oncol.* 2013; (11):112. <https://doi.org/10.1186/1477-7819-11-112>
- Sagiv JY, Michaeli J, Assi S, Mishalian I, Kisos H, Levy L, Danti P, Lumbroso D, Polyansky L, Sionov RV, Ariel A, Hovav AH, Henke E, Fridlender ZG, Granot Z. Phenotypic diversity and plasticity in circulating neutrophil subpopulations in cancer. *Cell Rep.* 2015; 10(4):562-73. <https://doi.org/10.1016/j.celrep.2014.12.039> PMID:25620698
- Sionov RV, Fridlender ZG, Granot Z. The Multifaceted Roles Neutrophils Play in the Tumor Microenvironment. *Cancer Microenviron.* 2015; 8(3):125-58. <https://doi.org/10.1007/s12307-014-0147-5> PMCID:PMC4714999
- Unsal E, Atalay F, Atikcan S, Yilmaz A. Prognostic significance of hemostatic parameters in patients with lung cancer. *Respir Med.* 2004; 98(2):93-8. <https://doi.org/10.1016/j.rmed.2003.07.001>
- Komurcuoglu B, Ulusoy S, Gayay M, Guler A, Ozden E. Prognostic value of plasma D-dimer levels in lung carcinoma. *Tumori.* 2011; 97(6):743-8. <https://doi.org/10.1177/030089161109700611> PMID:22322841
- Van Doormaal FF, Raskob GE, Davidson BL, Decousus H, Gallus A, Lensing AW, Piovello F, Prins MH, B?ller HR. Treatment of venous thromboembolism in patients with cancer: subgroup analysis of the Matisse clinical trials. *Thromb Haemost.* 2009; 101(4):762-9. <https://doi.org/10.1160/TH08-09-0563>
- Gonzalez Barcala FJ, Garcia Prim JM. Platelet count: association with prognosis in lung cancer. *Med Oncol.* 2010; 27:357-62. <https://doi.org/10.1007/s12032-009-9217-9>
- Aoe K, Hiraki A, Ueoka H. Thrombocytosis as a useful prognostic indicator in patients with lung cancer. *Respiration.* 2004; 71:170-3. <https://doi.org/10.1159/000076679>
- Gislason T, Nu E. Sedimentation rate, leucocytes, platelet count and hemoglobin in bronchial carcinoma: an epidemiological study. *Eur J Respir Dis.* 1985; 66:141-6.
- Pedersen LM, Milman N. Prognostic significance of thrombocytosis in patients with primary lung cancer. *Eur Respir J.* 1996; 9:1826-30. <https://doi.org/10.1183/09031936.96.09091826>
- Cox G, Walker RA, Andi A. Prognostic significance of platelet and microvessel counts in operable non-small cell lung cancer. *Lung Cancer.* 2000; 29:169-77. [https://doi.org/10.1016/S0169-5002\(00\)00124-0](https://doi.org/10.1016/S0169-5002(00)00124-0)
- Schreiber RD, Old LJ, Smyth MJ. Cancer immunoeediting: integrating immunity's roles in cancer suppression and promotion. *Science.* 2011; 331(6024):1565-70. <https://doi.org/10.1126/science.1203486>
- Roxburgh CS, McMillan DC. Role of systemic inflammatory response in predicting survival in patients with primary operable cancer. *Future Oncol.* 2010; 6(1):149-63. <https://doi.org/10.2217/fon.09.136>
- Cook EJ, Goulder F, Justin TA, Keeling NJ. Neutrophil-

- lymphocyte ratio as a prognostic factor in colorectal cancer. *Walsh J Surg Oncol.* 2005; 91(3):181-4. <https://doi.org/10.1002/iso.20329> PMID:16118772
32. Azab B, Bhatt VR, Phookan J, Murukutla S, Kohn N, et al. Usefulness of the neutrophil-to-lymphocyte ratio in predicting short- and long-term mortality in breast cancer patients. *Ann Surg Oncol.* 2012; 19(1):217-24. <https://doi.org/10.1245/s10434-011-1814-0>
33. Gwak MS, Choi SJ, Kim JA, Ko JS, Kim TH, Lee SM, et al. Effects of gender on white blood cell populations and neutrophil-lymphocyte ratio following gastrectomy in patients with stomach cancer. *J Korean Med Sci.* 2007; 22(Suppl):S104-8. <https://doi.org/10.3346/jkms.2007.22.S.S104> PMID:17923734
34. Stotz M, Gerger A, Eisner F, Szkandera J, Loibner H, Ressa AL, Kornprat P, AlZoughbi W, Seggewies FS, Lackner C, Stojakovic T, Samonigg H, Hoefler G, Pichler M. Increased neutrophil-lymphocyte ratio is a poor prognostic factor in patients with primary operable and inoperable pancreatic cancer. *Br J Cancer.* 2013; 109(2):416-21. <https://doi.org/10.1038/bjc.2013.332>
35. Sharaiha RZ, Halazun KJ, Mirza F, Port JL, Lee PC, Neugut AI, et al. Elevated preoperative neutrophil: lymphocyte ratio as a predictor of postoperative disease recurrence in esophageal cancer. *Ann Surg Oncol.* 2011; 18(12):3362-9. <https://doi.org/10.1245/s10434-011-1754-8> PMID:PMC3192937
36. Yin Y, Wang J, Wang X, Gu L, Pei H, Kuai S, Zhang Y, Shang Z. *Clinics (Sao Paulo).* 2015; 70(7):524-530. [https://doi.org/10.6061/clinics/2015\(07\)10](https://doi.org/10.6061/clinics/2015(07)10)
37. Aliustaoglu M, Bilici A, Ustaalioglu BB, Konya V, Gucun M, Seker M, Gumus M. The effect of peripheral blood values on prognosis of patients with locally advanced gastric cancer before treatment. *Med Oncol.* 2010; 27(4):1060-5. <https://doi.org/10.1007/s12032-009-9335-4>
38. Azab B, Shah N, Radbel J, Tan P, Bhatt V, Vonfrolio S, Habeshy A, Picon A, Bloom S. Pretreatment neutrophil/lymphocyte ratio is superior to platelet/lymphocyte ratio as a predictor of long-term mortality in breast cancer patients. *Med Oncol.* 2013; 30(1):432. <https://doi.org/10.1007/s12032-012-0432-4>
39. He W, Yin C, Guo G, Jiang C, Wang F, Qiu H, Chen X, Rong R, Zhang B, Xia L. Initial neutrophil lymphocyte ratio is superior to platelet lymphocyte ratio as an adverse prognostic and predictive factor in metastatic colorectal cancer. *Med Oncol.* 2013; 30(1):439. <https://doi.org/10.1007/s12032-012-0439-x>
40. Liu H, Wu Y, Wang Z, Yao Y, Chen F, Zhang H, Wang Y, Song Y. Pretreatment platelet-to-lymphocyte ratio (PLR) as a predictor of response to first-line platinum-based chemotherapy and prognosis for patients with non-small cell lung cancer. *J Thorac Dis.* 2013; 5(6):783-9.
41. Cannon NA, Meyer J, Iyengar P, Ahn C, Westover KD, Choy H, Timmerman R. Neutrophil-lymphocyte and platelet-lymphocyte ratios as prognostic factors after stereotactic radiation therapy for early-stage non-small-cell lung cancer. *J Thorac Oncol.* 2015; 10(2):280-5. <https://doi.org/10.1097/JTO.0000000000000399> PMID:25299234
42. Pinato DJ, Shiner RJ, Seckl MJ, Stebbing J, Sharma R, Mauri FA. Prognostic performance of inflammation-based prognostic indices in primary operable non-small cell lung cancer. *Br J Cancer.* 2014; 110(8):1930-5. <https://doi.org/10.1038/bjc.2014.145> PMID:PMC3992503
43. Wu G, Yao Y, Bai C, Zeng J, Shi D, Gu X, Shi X, Song Y. Combination of platelet to lymphocyte ratio and neutrophil to lymphocyte ratio is a useful prognostic factor in advanced non-small cell lung cancer patients. *Thorac Cancer.* 2015; 6(3):275-87. <https://doi.org/10.1111/1759-7714.12178> PMID:26273373
44. Douillard JY, Shepherd FA, Hirsh V, Mok T, Socinski MA, Gervais R, Liao ML, Bischoff H, Reck M, Sellers MV, Watkins CL, Speake G, Armour AA, Kim ES. Molecular predictors of outcome with gefitinib and docetaxel in previously treated non-small-cell lung cancer: data from the randomized phase III INTEREST trial. *J Clin Oncol.* 2010; 28(5):744-52. <https://doi.org/10.1200/JCO.2009.24.3030>
45. Kemal Y, Yucel I, Ekiz K, Demirag G, Yilmaz B, Teker F, Ozdemir M. Elevated serum neutrophil to lymphocyte and platelet to lymphocyte ratios could be useful in lung cancer diagnosis. *Asian Pac J Cancer Prev.* 2014; 15(6):2651-4. <https://doi.org/10.7314/APJCP.2014.15.6.2651>
46. Wang L, Liang D, Xu X, Jin J, Li S, Tian G, Gao Z, Liu C, He Y. The prognostic value of neutrophil to lymphocyte and platelet to lymphocyte ratios for patients with lung cancer. *Oncol Lett.* 2017; 14(6):6449-6456. <https://doi.org/10.3892/ol.2017.7047>
47. Liu D, Huang Y, Li L, Song J, Zhang L, Li W. High neutrophil-to-lymphocyte ratios confer poor prognoses in patients with small cell lung cancer. *BMC Cancer.* 2017; 17(1):882. <https://doi.org/10.1186/s12885-017-3893-1>
48. Liu D, Jin J, Zhang L, Li L, Song J, Li W. The Neutrophil to Lymphocyte Ratio May Predict Benefit from Chemotherapy in Lung Cancer. *Cell Physiol Biochem.* 2018; 46(4):1595-1605. <https://doi.org/10.1159/000489207> PMID:29694985
49. Kang MH, Go SI, Song HN, Lee A, Kim SH, Kang JH, Jeong BK, Kang KM, Ling H, Lee GW. The prognostic impact of the neutrophil-to-lymphocyte ratio in patients with small-cell lung cancer. *Br J Cancer.* 2014; 111(3):452-60. <https://doi.org/10.1038/bjc.2014.317>
50. Unal D, Eroglu C, Kurtul N, Oguz A, Tasdemir A. Are neutrophil/lymphocyte and platelet/lymphocyte rates in patients with non-small cell lung cancer associated with treatment response and prognosis? *Asian Pac J Cancer Prev.* 2013; 14(9):5237-42. <https://doi.org/10.7314/APJCP.2013.14.9.5237> PMID:24175807
51. Zhang H, Gao L, Zhang B, Zhang L, Wang C. Prognostic value of platelet to lymphocyte ratio in non-small cell lung cancer: a systematic review and meta-analysis. *Sci Rep.* 2016; (6):22618. <https://doi.org/10.1038/srep22618> PMID:26939789
52. Gu XB, Tian T, Tian XJ, Zhang XJ. Prognostic significance of neutrophil-to-lymphocyte ratio in non-small cell lung cancer: a meta-analysis. *Sci Rep.* 2015; (5):12493. <https://doi.org/10.1038/srep12493> PMID:26205001 PMID:PMC4513342
53. Pinato DJ, Shiner RJ, Seckl MJ, Stebbing J, Sharma R, Mauri FA. Prognostic performance of inflammation-based prognostic indices in primary operable non-small cell lung cancer. *British Journal of Cancer.* 2014; 110(8):1930-1935. <https://doi.org/10.1038/bjc.2014.145>