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Preoperative Prognostic Nutritional Index (PNI) Predicts Better Prognosis than Neutrophil Lymphocyte Ratio (NLR) in Patients with Gastric Cancer

Jie Li, Haozong Zhao, Cong Xia, Qianshi Zhang and Shuangyi Ren**

Department of Gastrointestinal Surgery, The Second Affiliated Hospital of Dalian Medical University, PR China

Abstract

Background: Systemic inflammation and nutritional status have been implicated as predictors of cancer outcome. As indicators of systemic inflammatory response, Neutrophil/Lymphocyte Ratio (NLR) and Prognostic Nutritional Index (PNI) have been proposed to predict the clinical outcome of certain cancers. The purpose of this study was to investigate the effect of PNI and NLR on the prognosis of gastric cancer.

Methods: From 2010 to 2018, 559 consecutive patients undergoing radical surgery for gastric cancer were enrolled. The optimal cut-off values for PNI and NLR were determined according to the receiver operating characteristic analysis. According to the cut-off value, we categorized the patients into the high or low PNI and NLR groups, and the clinical characteristics of the two groups were compared and analyzed.

Results: PNI was an independent prognostic factor for overall survival in patients with gastric cancer, while NLR was not.

Conclusion: Although both PNI and NLR reflect prognosis, PNI is a better predictor of overall survival in patients with gastric cancer than NLR.

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Correspondence:

Shuangyi Ren, Department of Gastrointestinal Surgery, The Second Affiliated Hospital of Dalian Medical University, Dalian, Liaoning, 116023, PR China, Tel: +86 0411-84671291-5132; Fax: (0411)84672130; E-mail: renshuangyidl@163.com

Qianshi Zhang, Department of Gastrointestinal Surgery, The Second Affiliated Hospital of Dalian Medical University, Dalian, Liaoning, 116023, PR China, Tel: +86 0411-84671291-5132; Fax: (0411)84672130; E-mail: zhangqianshi1987@qq.com

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Introduction

Gastric Cancer (GC) is one of the most common tumors worldwide and is associated with poor prognosis, with treatment pathways depending on tumor stage. Tumor stage can be used to predict the prognosis of GC and determine the optimal treatment strategy; However, prognosis varies even among patients with the same stage of cancer [1,2]. In addition, the pathologic stage, number of metastatic lymph nodes, and depth of tumor infiltration obtained by postoperative pathology are often used to predict gastric cancer prognosis, but this data can only be obtained accurately after surgery. Since there is often a deviation between the TNM staging (cTNM) obtained from the preoperative evaluation and the TNM staging (pTNM) obtained from the postoperative pathology, we cannot accurately predict the postoperative survival rate before surgery [3], which makes it difficult to provide a more accurate and individualized treatment plan for each patient. If we could identify more patients with potential poor prognosis preoperatively and prepare them earlier with more accurate and individualized treatment plans, the likelihood of poor prognosis would be greatly reduced. Therefore, it is crucial to find easy and reliable preoperative indicators to predict the prognosis of gastric cancer.

Therefore, we have carefully sorted out some markers that are considered to perform better in the field of predicting tumor prognosis in recent years. Of course, these markers should be inexpensive, easy to obtain and objective so that they can be widely used in clinical practice. Previous studies have shown that tumor markers can be used as indicators for the diagnosis, treatment, and prognosis of gastric cancer patients. Carcinoembryonic Antigen (CEA) was discovered in 1965 by Gold and Freedman [4]. As a common serum marker for malignant gastrointestinal tract tumors, CEA is useful for the diagnosis of gastric cancer. In addition, CEA expression is an independent risk factor for poor prognosis in gastric cancer [5,6]. However, the ideal tumor marker should be able to be detected at any stage of the disease. However, because most tumor markers lack sufficient sensitivity and specificity, it is not uncommon in clinical work for tumor markers to remain in the normal range even in many patients with advanced cancer, so that cancer prognosis cannot be judged solely on the basis of preoperative tumor marker levels, and it is therefore clinically important to establish

an independent, complementary prognostic indicator that is different from conventional tumor markers. In recent years, the relationship between cancer prognosis and systemic inflammatory response and preoperative nutritional status has also been explored in depth. In terms of systemic inflammation, the immunocellular component of a Complete Blood Count (CBC) provides a particularly attractive measure of inflammation that is both applicable and practical because of the routine preoperative whole blood cell testing performed on every patient and because it is inexpensive and readily available. The Neutrophil-to-Lymphocyte Ratio (NLR) is one of the markers of systemic inflammation provided by CBC, and NLR has a significant relationship with prognosis in various cancers [7-10]. However, its study in gastric cancer still needs further refinement. In terms of cancer prognosis and preoperative nutritional status, previous studies have demonstrated that nutritional status before surgery is also associated with prognosis in various cancers [11-13]. PNI is one of the better indicators of patients' nutritional status and is calculated from the albumin content and lymphocyte count in patients' preoperative blood results, which is defined as absolute value of lymphocyte (10^9/L) × 5 + serum albumin (g/L). The predictive value of PNI for surgical outcomes is widely accepted in cancers of various organs, including esophageal [14], colorectal [15], liver [16] and pancreatic cancers [17], and also as an independent risk factor for predicting prognosis in gastric cancer [18,19]. However, very few studies have included both PNI and NLR for observation and comparison.

Therefore, the purpose of this study was to compare the value of the clinical application of these two factors, PNI and NLR, based on a large amount of data after radical surgery for gastric cancer.

Patients and Methods

This paper reviews the clinical data of gastric cancer patients who underwent radical surgery for gastric cancer at the Second Affiliated Hospital of Dalian Medical University between 2010 and 2018. Among these patients, 559 gastric cancer patients who underwent radical intent surgery were included in this study. The exclusion criteria for this study were as follows: Residual gastric cancer, neoadjuvant chemotherapy, combination of other malignancies, preoperative imaging of organ metastases such as liver, intraoperative examination of distant metastases, emergency surgery, palliative surgery, combined cirrhosis, severe renal insufficiency, evidence of severe inflammatory symptoms, hematologic malignancies or diseases, autoimmune diseases, and recent steroid treatment, and incomplete/inaccurate medical records. Institutional Review Board approval has been obtained.

Blood sample analysis

Preoperative blood was collected to determine white blood cell, neutrophil, lymphocyte, and platelet counts, serum albumin, and carcinoembryonic antigen.

Definition and detection of optimal cutoffs for PNI and NLR

PNI = Absolute value of lymphocyte (10^9/L) × 5 + serum albumin (g/L), using overall survival as the endpoint, the area under the Receiver Operating Characteristic (ROC) curve for the PNI was 0.66. The Youden index was greatest when the PNI was 47.96. Therefore, we set the PIN cut-off value at 47.96 (Figure 1). Patients with PNI greater than the threshold were defined as High PNI (HPNI) and those with PNI less than the threshold were defined as Low PNI (LPNI).

NLR = Neutrophil count/Lymphocyte count. Similar to PNI, the cut-off value was analyzed and the cut-off value of NLR was set at 2.16 (Figure 1). Patients were divided into High NLR group (HNLR) and Low NLR group (LNLR) according to the NLR threshold level.

Statistical analysis

To assess the sensitivity and specificity of Overall Survival (OS), ROC was calculated and the Youden index was estimated to determine the optimal cut-off values of PNI and NLR. Categorical variables were compared using the chi-square test. For OS, Kaplan-Meier curves were used for survival analysis, and the difference in survival between the two groups was compared using the log-rank test. Variables affecting OS were analyzed using the COX regression model. Multivariate analysis was performed using variables that had a significant independent relationship with OS.

All statistical analyses were performed using SPSS 26.0, and the graphing software was GraphPad Prism 7.0. Significance was defined as $p<0.05$.

Results

Clinicopathologic characteristics

Of the 559 patients, 387 (69.2%) were male and 383 (68.5%) were over 60 years of age (Table 1). Partial gastrectomy was performed in 463 cases (82.8%), and postoperative pathological stage III-IV was performed in 285 cases (51.0%). The presence of nerve invasion was confirmed postoperatively in 234 cases (41.7%) and the presence of cancer embolism in 315 cases (56.2%), and other clinical

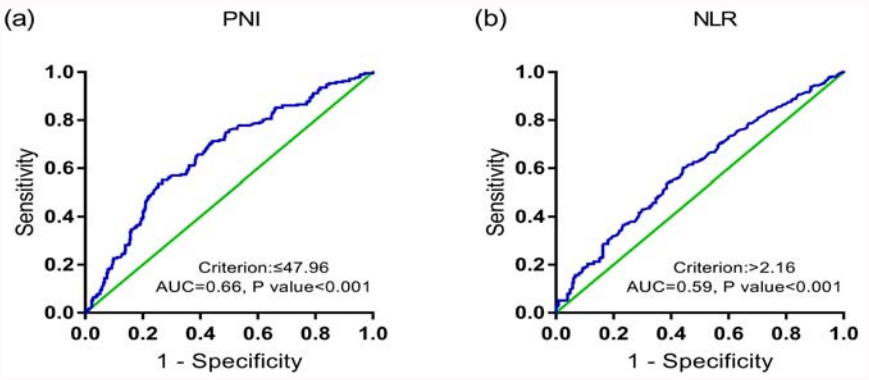

Figure 1: ROC curves for the PNI and NLR. a Overall survival (cutoff value of PNI: 47.96; sensitivity: 73.20%; specificity: 55.10%). b Overall survival (cutoff value of NLR: 2.16; sensitivity: 60.20%; specificity: 55.70%).
Abbreviations: PNI: Prognostic Nutrition Index; NLR: Neutrophil-To-Lymphocyte Ratio

Table 1: Association of the patients' characteristics with the prognostic nutrition index and neutrophil-to-lymphocyte ratios.

Factors	Total	PNI		P value	NLR		P value
	N=559 (%)	≤ 47.96	>47.96		≤ 2.16	>2.16	
Sex				0.581			0.21
Female	172 (30.8)	62	110		93	79	
Male	387 (69.2)	149	238		187	200	
Age (years)				<0.001			<0.001
≤ 60	176 (31.5)	38	138		108	68	
>60	383 (68.5)	173	210		172	211	
Extent of resection				0.024			0.042
Partial gastrectomy	463 (82.8)	165	298		241	222	
Total gastrectomy	96 (17.2)	46	50		39	57	
Differentiation				0.008			0.354
Well/Moderate	211 (37.7)	65	146		111	100	
Poor	348 (62.3)	146	202		169	179	
Cancer embolism				<0.001			0.001
None	244 (43.8)	64	180		142	102	
Yes	315 (56.2)	147	168		138	177	
Never invasion				<0.001			0.005
None	325 (58.3)	91	234		179	146	
Yes	234 (41.7)	120	114		101	133	
pTNM				<0.001			<0.001
I-II	274 (49.0)	63	211		163	111	
III-IV	285 (51.0)	148	137		117	168	
Depth of invasion				<0.001			<0.001
T1-T2	222 (39.7)	42	180		136	86	
T3-T4	337 (60.3)	169	168		144	193	
LN metastasis				<0.001			0.001
N0	233 (41.7)	55	178		136	97	
N1/N1/N2	326 (58.3)	156	170		144	182	
CEA levels (ng/ml)				0.023			0.008
≤ 5	468 (83.7)	167	301		246	222	
>5	91 (16.3)	44	47		34	57	
ALB levels (g/L)				<0.001			<0.001
<40	220 (39.4)	180	40		80	140	
≥ 40	339 (60.6)	31	308		200	139	
WBC counts (× 10^6/L)				0.001			<0.001
<4000	58 (10.4)	33	25		44	14	
4000–10,000	474 (84.8)	163	311		233	241	
>10,000	27 (4.8)	15	12		3	24	
Lymphocyte (%)				<0.001			<0.001
<20	94(16.8)	70	24		2	92	
20–44	434 (77.6)	136	298		249	185	
>44	31 (5.5)	5	26		29	2	
Neutrophil (%)				<0.001			<0.001
<50	51 (9.1)	9	42		50	1	
50–75	449 (80.3)	157	292		230	219	
>75	59 (10.6)	45	14		0	59	

Platelet counts (× 10^6/L)				0.003			0.113
<150,000	34 (6.4)	21	13		16	18	
150,000–450,000	509 (90.7)	181	328		260	249	
>450,000	16 (2.9)	9	7		4	12	
Survival status				<0.001			<0.001
Survival	343 (61.4)	92	251		192	151	
Death	216 (38.6)	119	97		88	128	

Abbreviations: WBC: White Blood Cell; PNI: Prognostic Nutrition Index; NLR: Neutrophil-To-Lymphocyte Ratio; Ptnm: According to the 7th Edition of AJCC TNM Classification

characteristics of the participants in this study are summarized in the table (Table 1).

Relationship between clinicopathologic characteristics and inflammation-based score

When OS was used as the endpoint, 211 patients were in the low PNI group and 348 in the high PNI group. The number of patients with low NLR and high NLR was 280 and 279, respectively (Table 1). Factors such as advanced age, higher T or N stage, and advanced stage were significantly associated with the low PNI and high NLR groups (Table 1).

Prognostic factors for OS

The OS of the HPNI and LNLR groups was significantly higher than that of the LPNI and HNLR groups (Figure 2). In terms of OS, although both HNLR and LPNI were risk factors for poor prognosis of gastric cancer in univariate analysis (Figure 3), the presence of nerve invasion, cancer embolism, and high preoperative level of CEA, advanced stage, and LPNI were identified as significant independent risk factors in multivariate analysis (Figure 4). However, HNLR was not an independent risk factor (Table 2).

Discussion

Our current study focused on two factors, NLR and PNI, which reflect the systemic inflammatory response and nutritional status, respectively. These two factors are also generally considered as predictors of gastric cancer prognosis. Many previous studies have previously shown that NLR and PNI are predictors of cancer prognosis [20-24]. NLR, as a new indicator of systemic inflammation, has received much attention since its introduction, especially in the field of predicting the prognosis of malignant tumors [25,26]. Some of these studies have been conducted with large sample sizes, but studies on gastric cancer still need further improvement. However, studies in gastric cancer still need to be further improved. And as one of the indicators that can better reflect the nutritional status of patients, PNI can be used as a prognostic predictor for gastric cancer, which has also received some recognition [27,28]. Therefore, this study aimed to further compare and explore the prognostic evaluation effect of both based on a large amount of data, which is rare in previous studies of gastric cancer. Ultimately, we came to the interesting conclusion that although both PNI and NLR reflect prognosis, PNI is an independent prognostic factor for overall survival, while NLR is not.

The systemic inflammatory response promotes tumor proliferation, angiogenesis, and tumor cell migration; it is closely associated with tumorigenesis and progression; and it is an essential factor in the tumor cell microenvironment [29]. Inflammatory cells are involved in cell proliferation, invasion, migration, angiogenesis, and metastasis. At the same time, tumors may be caused by sites of inflammation and recruit inflammatory cells, chemokines, and cytokines. At the same time, this inflammatory response again promotes the progression of the tumor. The inflammatory response can lead to leukocytosis, neutrophilia, thrombocytosis, and lymphocytopenia [30]. Platelets can act as reservoirs for the secretion of multiple growth factors that can further increase angiogenesis, tumor growth and metastasis [31]. Neutrophils may be involved in the inflammatory response through the release of reactive oxygen species or nitric oxide and remodeling of the extracellular matrix [32]. Lymphocytes are involved in the inflammatory response by inhibiting tumor proliferation and inducing cytotoxic cell death for antitumor activity [33]. Previous studies have also shown that WBC counts also have an independent prognostic role in some tumors. In addition, decreased preoperative nutritional status is also a common symptom in cancer patients, most visibly reflected by a decrease in serum albumin levels. Albumin is the most abundant protein in plasma and is often used in clinical practice to assess the nutritional status of patients. Hypoalbuminemia indicates poor nutritional status, which in turn leads to decreased immune function in cancer patients and increases the risk of postoperative complications and tumor progression [34]. Moreover, some previous studies have shown

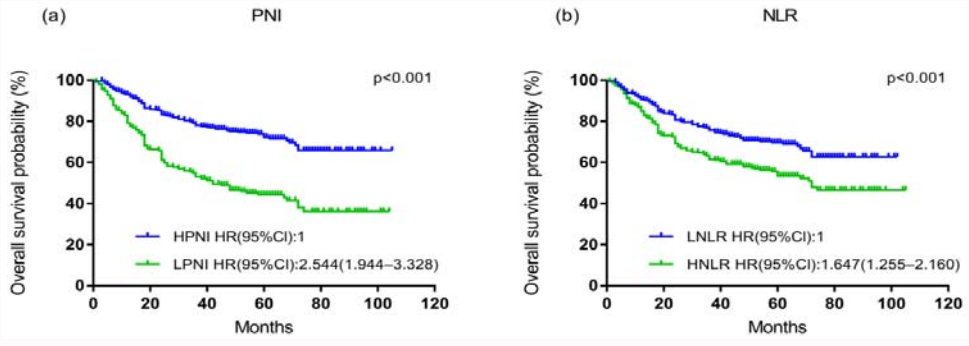

Figure 2: Survival analysis. a) Overall survival analysis according to the PNI. b) Overall survival analysis according to NLR.
Abbreviations: PNI: Prognostic Nutrition Index; NLR: Neutrophil-To-Lymphocyte Ratio; HR: Hazard Ratio; CI: Confidence Interval

Table 2: Univariate and multivariate analyses of factors for the prediction of overall survival.

	Univariate analysis		Multivariate analysis	
	HR (%95 CI)	P value	HR (% 95 CI)	P value
Sex				
Female	1.000			
Male	1.085 (0.810–1.453)	0.584		
Age (years)				
≤60	1.000			
>60	1.497 (1.103–2.031)	0.01		
Extent of resection				
Partial gastrectomy	1.000			
Total gastrectomy	1.339 (0.959–1.871)	0.087		
Differentiation				
Well/Moderate	1.000			
Poor	1.808 (1.342–2.436)	<0.001		
Cancer embolism				
None	1.000		1.000	
Yes	4.911 (3.455–6.981)	<0.001	2.058 (1.378–3.072)	<0.001
Never invasion				
None	1.000		1.000	
Yes	3.223 (2.438–4.262)	<0.001	1.602 (1.182–2.171)	0.002
pTNM				
I-II	1.000		1.000	
III-IV	6.409 (4.525–9.076)	<0.001	3.080 (2.063–4.600)	<0.001
Depth of invasion				
T1-T2	1.000			
T3-T4	6.140 (4.124–9.140)	<0.001		
LN metastasis				
N0	1.000			
N1/N1/N2	6.263 (4.255–9.219)	<0.001		
CEA levels (ng/ml)				
≤ 5	1.000		1.000	
>5	2.814 (2.091–3.787)	<0.001	1.779 (1.314–2.410)	<0.001
ALB levels (g/L)				
≥ 40	1.000			
<40	2.296 (1.755–3.004)	<0.001		
WBC counts (× 10^6/L)				
<4000	1.023 (0.657–1.593)	0.921		
4000–10,000	1.000			
>10,000	2.015 (1.224–3.318)	0.006		
Lymphocyte (%)				
<20	1.627 (0.841–3.146)	0.148		
20–44	1.129 (0.613–2.080)	0.697		
>44	1.000			
Neutrophil (%)				
<50	0.753 (0.450–1.257)	0.277		
50–75	1.000			
>75	1.768 (1.211–2.581)	0.003		

Platelet counts (× 10^6/L)				
<150,000	0.755 (0.400–1.426)	0.438		
150,000–450,000	1.000			
>450,000	0.924 (0.410–2.082)	0.825		
PNI				
High PNI	1.000		1.000	
Low PNI	2.544 (1.944–3.328)	<0.001	1.502 (1.135–1.987)	0.004
NLR				
Low NLR	1.000			
High NLR	1.647 (1.255–2.160)	<0.001		

Abbreviations: HR: Hazard Ratio; CI: Confidence Interval; WBC: White Blood Cell; PNI: Prognostic Nutrition Index; NLR: Neutrophil-To-Lymphocyte Ratio; Ptnm: According to the 7th Edition of AJCC TNM Classification

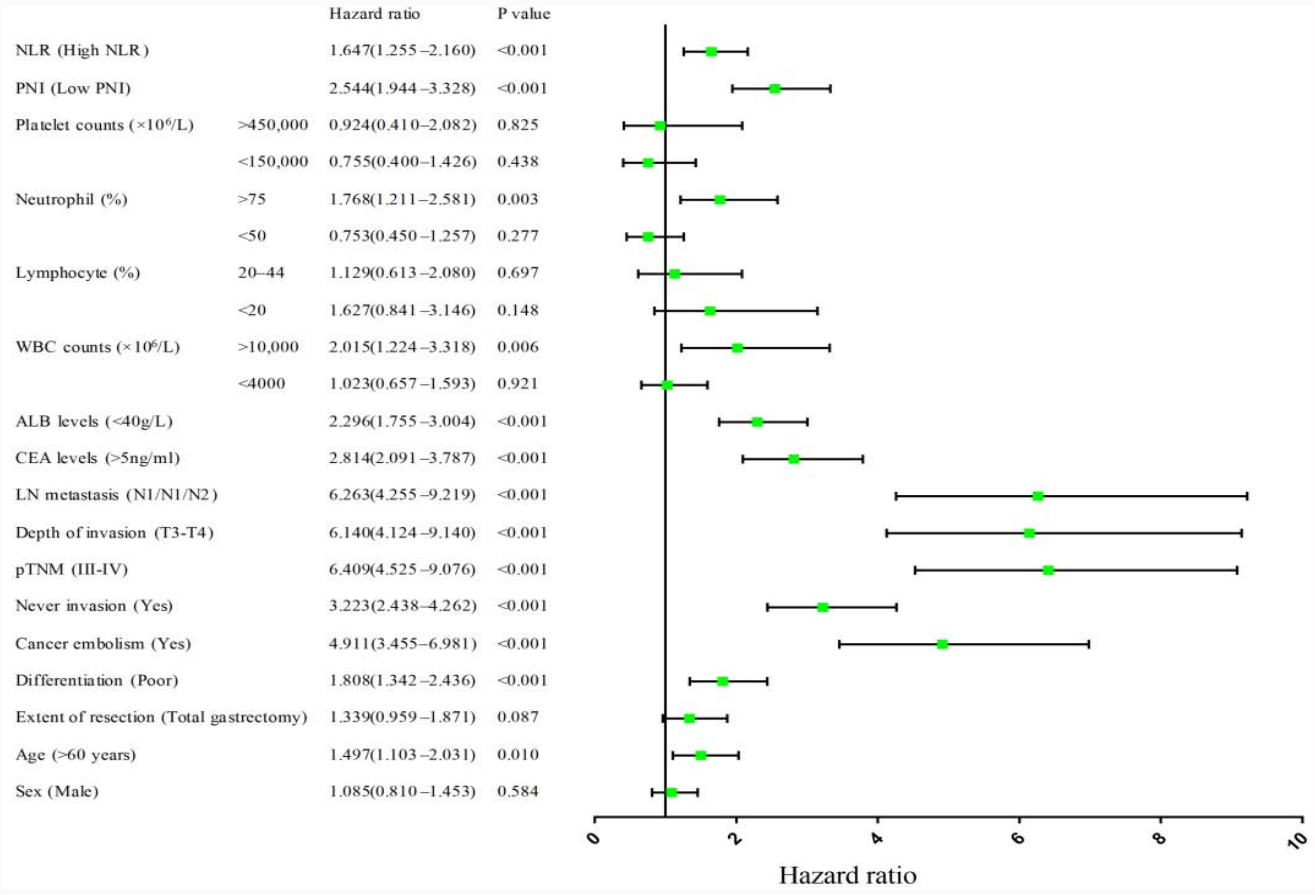

Figure 3: Forest plots of the hazard ratio for assessing the prognostic value of gastric cancer. The univariate Cox regression analysis.
Abbreviations: HR: Hazard Ratio; CI: Confidence Interval; WBC: White Blood Cell; PNI: Prognostic Nutrition Index; NLR: Neutrophil-to-Lymphocyte Ratio; Ptnm: According to the 7th Edition of AJCC TNM Classification

that systemic inflammation decreases albumin concentrations, and hypoalbuminemia also reflects an increased systemic inflammatory response [35,36]. While PNI is based on albumin concentrations and lymphocyte counts, it is more commonly considered as one of the indicators of nutritional status, but in a way, it also reflects both nutritional status and inflammation level to some extent. PNI has also been previously reported to be a marker of systemic inflammation associated with cancer [37]. Possibly because of this particular "dual status," PNI has been shown to be an independent prognostic factor for many cancers. This trend led to a keen interest in the question of which is more representative of PNI or NLR as a prognostic factor in postoperative gastric cancer, and we then conducted experiments that led to the interesting conclusion that although both PNI and NLR reflect prognosis, PNI is a better predictor of overall patient survival than NLR.

Although more studies on NLR as a prognostic factor for various cancers have been conducted in recent years, relatively few have been conducted in the field of gastric cancer, and after reviewing these studies; we found that most of the findings concluded that NLR could be an independent prognostic factor for gastric cancer. However, there are some studies that have come to the opposite conclusion. For example, in gastric cancer, Han et al. reported that NLR was not an independent prognostic factor for gastric cancer [38]. Zhu et al.

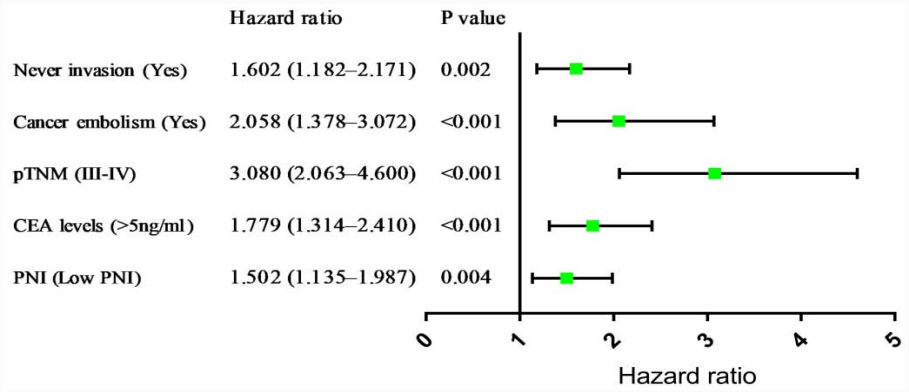

Figure 4: Forest plots of the hazard ratio for assessing the independent prognostic value of gastric cancer. The multivariate Cox regression analysis.
Abbreviations: PNI: Prognostic Nutrition Index; NLR: Neutrophil-To-Lymphocyte Ratio; Ptnm According to the 7th Edition Of AJCC TNM Classification

[39] reported that preoperative NLR did not predict lymph node metastasis or prognosis in patients with early gastric cancer. The results from various centers also suggest that more studies are needed to support and report the results of NLR studies. The same is true for PNI studies. Therefore, we validated the predictive efficacy of these two factors on the prognosis of gastric cancer and concluded as described above. However, this study is a single-center, retrospective study, and therefore the sample size is small. In the future, it is hoped that more multicenter, prospective, and large sample size studies will be available to compensate for the shortcomings of this study.

Conclusion

PNI and NLR are associated with survival in patients with gastric cancer. PNI is a better predictor of OS in patients with gastric cancer than NLR.

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Author Contributions

Jie Li and Shuangyi Ren conceptualized the study. Data curation was performed by Cong Xia and Haozong Zhao. The formal analysis was done by Haozong Zhao, Qianshi Zhang, and Jie Li. Cong Xia and Haozong Zhao are responsible for project administration and methodology. Resources and supervision were given by Shuangyi Ren. Standard software was used. The original draft was written by Jie Li and Haozong Zhao. All authors validated, reviewed, and edited the manuscript.

References

1. Smyth EC, Nilsson M, Grabsch HI, van Grieken NC, Lordick F. Gastric cancer. Lancet (London, England). 2020;396(10251):635-48.
2. Peng CW, Wang LW, Zeng WJ, Yang XJ, Li Y. Evaluation of the staging systems for gastric cancer. J Surg Onco. 2013;108(2):93-105.
3. Gao Y, Huang D. The value of the systematic inflammation-based Glasgow Prognostic Score in patients with gastric cancer: A literature review. J Cancer Res Ther. 2014;10(4):799-804.
4. Gold P, Freedman SO. Demonstration of tumor-specific antigens in human colonic carcinomata by immunological tolerance and absorption techniques. J Exp Med. 1965;121(3):439-62.
5. Feng F, Tian Y, Xu G, Liu Z, Liu S, Zheng G, et al. Diagnostic and prognostic value of CEA, CA19-9, AFP and CA125 for early gastric cancer. BMC cancer. 2017;17(1):737.
6. He CZ, Zhang KH, Li Q, Liu XH, Hong Y, Lv NH. Combined use of AFP, CEA, CA125 and CAl9-9 improves the sensitivity for the diagnosis of gastric cancer. BMC Gastroenterol. 2013;13:87.
7. Kim EY, Lee JW, Yoo HM, Park CH, Song KY. The platelet-to-lymphocyte ratio versus neutrophil-to-lymphocyte ratio: Which is better as a prognostic factor in gastric cancer? Ann Surg Oncol. 2015;22(13):4363-70.
8. Zhu M, Feng M, He F, Han B, Ma K, Zeng X, et al. Pretreatment neutrophil-lymphocyte and platelet-lymphocyte ratio predict clinical outcome and prognosis for cervical Cancer. Clin Chimica Acta. 2018;483:296-302.
9. Yodying H, Matsuda A, Miyashita M, Matsumoto S, Sakurazawa N, Yamada M, et al. Prognostic significance of neutrophil-to-lymphocyte ratio and platelet-to-lymphocyte ratio in oncologic outcomes of esophageal cancer: A systematic review and meta-analysis. Ann Surg Oncol. 2016;23(2):646-54.
10. Miyahara Y, Takashi S, Shimizu Y, Ohtsuka M. The prognostic impact of Neutrophil-to-Lymphocyte Ratio (NLR) and Lymphocyte-to-Monocyte Ratio (LMR) in patients with distal bile duct cancer. W J Surg Onco. 2020;18(1):78.
11. Miyazaki T, Sakai M, Sohda M, Tanaka N, Yokobori T, Motegi Y, et al. Prognostic significance of inflammatory and nutritional parameters in patients with esophageal cancer. Anticancer Res. 2016;36(12):6557-62.
12. Kang SH, Cho KH, Park JW, Yoon KW, Do JY. Onodera's prognostic nutritional index as a risk factor for mortality in peritoneal dialysis patients. J Korean Med Sci. 2012;27(11):1354-8.
13. Gao ZM, Wang RY, Deng P, Ding P, Zheng C, Hou B, et al. TNM-PNI: A novel prognostic scoring system for patients with gastric cancer and curative D2 resection. Cancer Manag Res. 2018;10:2925-33.
14. Nozoe T, Kimura Y, Ishida M, Saeki H, Korenaga D, Sugimachi K. Correlation of pre-operative nutritional condition with post-operative complications in surgical treatment for oesophageal carcinoma. Eur J Surg Oncol. 2002;28(4):396-400.
15. Mohri Y, Inoue Y, Tanaka K, Hiro J, Uchida K, Kusunoki M. Prognostic nutritional index predicts postoperative outcome in colorectal cancer. WJS. 2013;37(11):2688-92.
16. Pinato DJ, North BV, Sharma R. A novel externally validated inflammation-based prognostic algorithm in hepatocellular carcinoma: The Prognostic Nutritional Index (PNI). Br J Cancer. 2012;106(8):1439-45.
17. Kanda M, Fujii T, Kodera Y, Nagai S, Takeda S, Nakao A. Nutritional predictors of postoperative outcome in pancreatic cancer. Br J Surg. 2011;98(2):268-74.

18. Watanabe M, Iwatsuki M, Iwagami S, Ishimoto T, Baba Y, Baba H. Prognostic nutritional index predicts outcomes of gastrectomy in the elderly. World J Surg. 2012;36(7):1632-9.

19. Migita K, Takayama T, Saeki K, Matsumoto S, Wakatsuki K, Enomoto K, et al. The prognostic nutritional index predicts long-term outcomes of gastric cancer patients independent of tumor stage. Ann Surg Onco. 2013;20(8):2647-54.

20. Li S, Xu X, Liang D, Tian G, Song S, He Y. Prognostic value of blood Neutrophil-to-Lymphocyte Ratio (NLR) and Platelet-to-Lymphocyte Ratio (PLR) in patients with gastric cancer. Zhonghua Zhong Liu Za Zhi. 2014;36(12):910-5.

21. Peng D, Gong YQ, Hao H, He ZS, Li XS, Zhang CJ, et al. Preoperative prognostic nutritional index is a significant predictor of survival with bladder cancer after radical cystectomy: A retrospective study. BMC cancer. 2017;17(1):391.

22. Shao N, Cai Q. High pretreatment neutrophil-lymphocyte ratio predicts recurrence and poor prognosis for combined small cell lung cancer. Clin Transl Oncol. 2015;17(10):772-8.

23. Hua X, Long ZQ, Huang X, Deng JP, He ZY, Guo L, et al. The value of Prognostic Nutritional Index (PNI) in predicting survival and guiding radiotherapy of patients with T1-2N1 breast cancer. Front Oncol. 2019;9:1562.

24. Mjaess G, Chebel R, Karam A, Moussa I, Pretot D, Abi Tayeh G, et al. Prognostic role of Neutrophil-to-Lymphocyte Ratio (NLR) in urological tumors: an umbrella review of evidence from systematic reviews and meta-analyses. Acta Oncol. 2021;60(6):704-13.

25. Lian L, Xia YY, Zhou C, Shen XM, Li XL, Han SG, et al. Application of platelet/lymphocyte and neutrophil/lymphocyte ratios in early diagnosis and prognostic prediction in patients with resectable gastric cancer. Cancer Biomarkers. 2015;15(6):899-907.

26. Zhang Y, Lu JJ, Du YP, Feng CX, Wang LQ, Chen MB. Prognostic value of neutrophil-to-lymphocyte ratio and platelet-to-lymphocyte ratio in gastric cancer. Medicine. 2018;97(12):e0144.

27. Luo Z, Zhou L, Balde AI, Li Z, He L, ZhenWei C, et al. Prognostic impact of preoperative prognostic nutritional index in resected advanced gastric cancer: A multicenter propensity score analysis. Eur J Surg Oncol. 2019;45(3):425-31.

28. Hirahara N, Tajima Y, Fujii Y, Yamamoto T, Hyakudomi R, Taniura T, et al. Preoperative prognostic nutritional index predicts long-term outcome in gastric cancer: A propensity score-matched analysis. Anticancer Res. 2018;38(8):4735-46.

29. Wen L, Guo L, Zhang W, Li Y, Jiang W, Di X, et al. Cooperation between the inflammation and coagulation systems promotes the survival of circulating tumor cells in renal cell carcinoma patients. Frontiers Onco. 2019;9:504.

30. Ikeda M, Furukawa H, Imamura H, Shimizu J, Ishida H, Masutani S, et al. Poor prognosis associated with thrombocytosis in patients with gastric cancer. Ann Surgical Oncol. 2002;9(3):287-91.

31. Ariad S, Seymour L, Bezwoda WR. Platelet-Derived Growth Factor (PDGF) in plasma of breast cancer patients: Correlation with stage and rate of progression. Breast cancer research and treatment. 1991;20(1):11-7.

32. De Larco JE, Wuertz BR, Furcht LT. The potential role of neutrophils in promoting the metastatic phenotype of tumors releasing interleukin-8. Clin Cancer Res. 2004;10(15):4895-900.

33. Mantovani A, Allavena P, Sica A, Balkwill F. Cancer-related inflammation. Nature. 2008;24;454(7203):436-44.

34. Nazha B, Moussaly E, Zaarour M, Weerasinghe C, Azab B. Hypoalbuminemia in colorectal cancer prognosis: Nutritional marker or inflammatory surrogate? World J Gastrointest Surg. 2015;7(12):370-7.

35. Jensen GL, Mirtallo J, Compher C, Dhaliwal R, Forbes A, Grijalba RF, et al. Adult starvation and disease-related malnutrition: A proposal for etiology-based diagnosis in the clinical practice setting from the International Consensus Guideline Committee. Clinical nutrition (Edinburgh, Scotland). 2010;29(2):151-3.

36. Marcason W. Should albumin and prealbumin be used as indicators for malnutrition? J Acad Nutr Diet. 2017;117(7):1144.

37. Onodera T, Goseki N, Kosaki G. Prognostic nutritional index in gastrointestinal surgery of malnourished cancer patients. Nihon Geka Gakkai zasshi. 1984;85(9):1001-5.

38. Han Y, Zhu Z, You Q. The survival relationship between preoperative inflammation markers and patients with special pathological types of gastric cancer. Can J Gastroenterol Hepatol. 2022;2022:5715898.

39. Zhu GS, Tian SB, Wang H, Ma MG, Liu Y, Du HS, et al. Preoperative neutrophil lymphocyte ratio and platelet lymphocyte ratio cannot predict lymph node metastasis and prognosis in patients with early gastric cancer: A single institution investigation in China. Current Med Sci. 2018;38(1):78-84.