Indian J Med Res 150, October 2019, pp 399-406
DOI: 10.4103/ijmr.IJMR_1234_17

Quick Response Code:

Association between neutrophil-lymphocyte & platelet lymphocyte ratios with prognosis & mortality in rapidly progressive glomerulonephritis

Aysun Toraman[1], Nalan Neşe[2], Beyhan Cengiz Özyurt[3] & Seyhun Kürşat[1]

Divisions of [1]Nephrology, [2]Pathology & [3]Public Health, Department of Medicine, University of Celal Bayar, Manisa, Turkey

Received July 28, 2017

***Background & objectives*: Rapidly progressive glomerulonephritis (RPGN) is a clinical syndrome manifested by features of nephritic syndrome and progressive loss of renal function over a short time. The objective of this study was to investigate the relationship between neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR) and prognostic factors and pathological findings of renal biopsy in RPGN.**

***Methods*: Consecutive newly diagnosed RPGN patients who had follow up for at least six months were retrospectively analyzed. The estimated glomerular filtration rate (eGFR) was calculated. Albumin, C-reactive protein (CRP) levels and CRP/albumin ratio were also calculated.**

***Results*: Fifty four patients were included in the study. The mean age was 48.92±20.12 years. Clinicopathological diagnosis was pauci-immune glomerulonephritis (GN) in 40 while two had postinfectious GN, six systemic lupus erythematosus, three IgA nephropathy, two Henoch-Schönlein purpura and one membranoproliferative GN. The mean NLR was 7.02±6.34 and mean PLR was 273.90±39.15. Positive correlations between NLR and CRP levels (P=0.009, r=0.511) and CRP/albumin ratios (P=0.005, r=0.542) were observed. PLR and CRP/albumin ratios (P=0.041, r=0.412) were correlated positively. The per cent of fibrocellular crescents was negatively correlated with NLR (P=0.019, r=−0.291), and positively correlated with the lymphocyte count (P=0.05, r=0.256). In secondary crescentic subgroup, the per cent of fibrinoid necrosis had a positive correlation with PLR (P=0.013, r=0.642). Both NLR (P=0.036) and PLR (P=0.051) detected at the first month of the treatment period, were observed to be significantly correlated with mortality.**

***Interpretation & conclusions*: This study showed that NLR could predict mortality in patients with RPGN; correlated with systemic inflammation; showed a negative correlation with the per cent of fibrocellular crescents and could be regarded as a measure of glomerular inflammatory state. Moreover, PLR may be considered to be an indicator of disease severity in acute phase of crescentic GN.**

Key words Crescentic glomerulonephritis - neutrophil-to-lymphocyte ratio - platelet-to-lymphocyte ratio - renal pathology - RPGN

Rapidly progressive glomerulonephritis (RPGN) is a rare clinical condition, and its incidence varies between 4 and 10 per cent in all renal biopsy series[1]. It is commonly characterized morphologically by the extensive crescent formation in the Bowman's space[2]. Crescentic glomerulonephritis (GN) histopathologically consists of three types on immunofluorescent microscopy; type 1, linear deposition of immunoglobulin G (IgG) throughout the glomerular basement membrane (GBM; anti-GBM disease); type 2, granular deposits (immune complex disease); and type 3, absence of immunoglobulins is characteristic of pauci-immune GN seen in patients with systemic vasculitis[3]. The severity of the disease is related to the degree of crescent formation; patients with circumferential crescents in more than 80 per cent of the glomeruli tend to present with advanced renal failure and may not respond to immunosuppressive therapy. On the other hand, patients with crescents in <50 per cent of the glomeruli, particularly if the crescents are non-circumferential, typically follow a more indolent cruising and may even undergo a remission. The stage of active inflammation characterized by cellular crescents is often followed by the development of fibrocellular and fibrous crescents[3]. This transition is important clinically because fibrous crescents represent a stage of the disease that is not likely to respond to immunosuppressive therapy. If left untreated, crescentic GN has an invariably poor outcome, most of the patients' progress to end-stage renal disease (ESRD) or death within months. Therefore, the process from diagnosis to treatment must be rapidly and carefully planned. However, despite aggressive treatment, development of ESRD and dependence on dialysis are likely to occur.

The current knowledge about the factors affecting renal prognosis guides the physicians to further individualize the treatment and by this way, ameliorate the treatment-related morbidity and mortality. Factors deemed to be predictive of prognosis are time interval from the beginning of complaints to diagnosis, presence of oliguria or anuria, increased serum creatinine level at admission, dialysis dependence on admission, a crescent rate higher than 80 per cent of glomeruli, fibrinoid necrosis, anti-GBM antibodies in GBM, tubular atrophy and interstitial fibrosis[1,4]. However, there is no consensus on prognostic factors that would predict renal outcome.

Total leucocyte count provides a crude but sensitive assessment of inflammatory status, with low cost and wide availability. It has been demonstrated that some specific subtypes of leucocytes have higher predictive value in assessing cardiovascular risk and poor prognosis in several disorders than total white blood cell (WBC) count itself. The neutrophil-to-lymphocyte ratio (NLR) is a marker of poor prognosis in several disorders such as malignancies, chronic kidney disease and myocardial infarction[5-8]. Besides, the platelet-to-lymphocyte ratio (PLR) is associated with poor prognosis in many diseases such as acute coronary syndrome and breast cancer[9-11]. Previous studies showed that both NLR and PLR were markers of inflammation in ESRD patients[11-13].

Erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) are the acute phase reactants used in the clinical evaluation of disease activity in crescentic GN; however, their roles in predicting the extent of disease involvement or prognosis are limited. This study was aimed to investigate the roles of NLR and PLR in predicting the extent of clinical involvement and prognosis of patients with RPGN.

Material & Methods

Consecutive newly diagnosed RPGN patients who had a follow up for at least six months between January 2005 and June 2016 at Manisa Celal Bayar University, Internal Medicine-Nephrology Clinic, Manisa, Turkey were retrospectively analyzed. The control group consisted of age- and sex-matched normotensive patients who presented to the same clinic during the same period with non-inflammatory conditions and without kidney disease.

Renal biopsy and laboratory parameters: Renal biopsy reports of all the 578 biopsy-proven patients were screened. The presence of at least one cellular or fibrocellular crescent was an inclusion criterion for the study. Standard processing of renal biopsies included light microscopy and immunofluorescence. The diagnosis was established by clinicopathologic correlation. The medical records of the patients were examined and clinical data including demographic details, presenting clinical and laboratory findings, treatment, and follow up data were obtained. Details of treatment and clinical outcomes (including renal function, proteinuria, dialysis status, inflammatory markers, and mortality) were collected at admission, after one, six months and one and five years and at the last follow up. The estimated glomerular filtration rate (eGFR) was calculated by the Modification of Diet in

Renal Disease Study equation[14]. Decreased eGFR was defined as <60 ml/min/1.73 m^2.

In addition to inflammation, the assessment of patient nutritional status could also aid in assessing disease activity[15,16]. For this reason, besides the albumin and CRP values, the CRP albumin ratio of the patients was also calculated.

The study was approved by the Ethics Committee of Manisa Celal Bayar University.

Statistical analysis: Statistical analysis was conducted using Statistical Package for the Social Sciences version 15.0 (SPSS Inc., Chicago, IL, USA) Frequencies for categorized data type (qualitative) variations and standard error of mean for continuous data type (quantitative) variation were calculated. In case of categorized data type variations (renal biopsy histopathological findings), Chi-square test [if one of the variables was continuous variable (haematological parameters) and distribution was appropriate], *t* test or one-way ANOVA parametric tests were used. If the distribution was inappropriate non-parametric tests (Kruskal–Wallis and Mann–Whitney U-test) were used. If both variables had continuous data, considering the distribution of variable, parametric (Pearson 'r') or non-parametric (Spearmen p) correlation tests were used.

Results

A total of 54 patients [19 women (35%) and 35 men (65%)] were included in the patient group. The mean age of the patients was 48.92±20.12, and that of control group (n=44) was 49.16±10.59 years. Clinicopathological diagnosis was pauci-immune GN in 40 cases (74%) while two had post-infectious GN, six systemic lupus erythematosus, three IgA nephropathy, two Henoch–Schönlein purpura, and one had membranoproliferative GN. Twenty three (42%) patients needed haemodialysis at the time of diagnosis. During five years of follow up, 18 (33%) patients developed ESRD. As comes to mortality five of total six patients died in the first year. Three had a diagnosis of Wegener granulomatosis, one had microscopic PAN, in two cases mortality was considered to be due to extrarenal systems involvement.

Correlations of NLR, PLR and laboratory parameters: NLR and PLR were significantly higher in the patients group compared with the control group. The mean NLR was 7.02±0.86 versus 1.74±0.11 (P<0.001) and mean PLR was 273.90±39.15 versus 99.68±5.26 (P<0.05), respectively. Baseline characteristics of the patients and control groups are shown in Table I. Positive correlations were observed between NLR and CRP levels (P=0.009, r=0.511) and CRP/albumin ratios (P=0.005, r=0.542). While PLR and CRP/albumin ratios (P=0.041, r=0.412) were correlated positively, PLR and albumin (P=0.032, r=−0.293) had a negative correlation.

Primary and secondary crescentic glomerulonephritis (*GN*) *subgroup analysis*: The subgroup analysis was performed with respect to the aetiopathogenesis as primary and secondary crescentic GN. There were 40 patients in the primary crescentic GN and 14 in the secondary crescentic GN subgroup. ESR and CRP were the acute phase reactants used in the clinical evaluation of disease activity in primary crescentic GN. Due to the retrospective nature of the study, ESR values could not be obtained in all patients. In primary crescentic GN group, 15 patients were cytoplasmic antineutrophil cytoplasmic antibodies (C-ANCA) positive, 14 patients were perinuclear antineutrophil cytoplasmic antibodies (P-ANCA) positive and 11 patients were ANCA negative. There was a significant difference between the primary and secondary crescentic GN groups with respect to the baseline neutrophil, WBC and CRP levels. However, there was not any significant difference in NLR and PLR values between the subgroups (Table II).

Renal biopsy histopathological findings: According to the renal biopsy histopathological findings, 25 patients had diffused crescentic GN (crescents in more than 50% of the glomerulus). Twenty three of them were in the primary crescentic GN subgroup. While the percentage of crescents was 49 per cent in primary crescentic GN cases, this ratio was 31 per cent in secondary GN cases. There was no correlation between crescent ratio and haematological parameters in subgroups. In primary crescentic group, 23 patients had diffused crescentic and 17 had focal crescentic GN. There was no significant difference in the haematological parameters according to the diffuse-focal crescentic GN.

There was no correlation between renal biopsy histopathological findings and gender, age, progression to ESRD and mortality. There were significant correlations between the per cent of both sclerotic and fibrocellular crescents and dialysis dependency at the admission. The per cent of cellular crescents

Table I. Demographic, clinical and laboratory features of the patients with rapidly progressive glomerulonephritis and control group

Variables	Mean±SE	
	Patients (n=54)	Control (n=44)
Age (yr)	48.92±2.73	49.16±2.12
Systolic blood pressure (mmHg)	128.98±2.61	117.60±4.96
Diastolic blood pressure (mmHg)	79.16±1.47	77.16±1.76
White blood cell (10^3/µl)	9720.18±587.70***	6455.60±310.15
Neutrophil (10^3/µl)	7420.93±395.17***	4050.83±218.18
Lymphocyte (10^3/µl)	1401.48±91.20***	2466.80±127.96
Platelet count (10^3/µl)	277962.96±13749.66	234920.00±10361.94
Haemoglobin (g/dl)	10.04±0.24***	13.92±0.36
Haematocrit (%)	30.07±0.71***	42.13±0.92
NLR	7.02±0.86***	1.74±0.11
PLR	273.90±39.15*	99.68±5.26
Glucose (mg/dl)	101.37±2.84	102.60±7.36
Blood urea nitrogen (mg/dl)	50.74±3.05***	12.25±0.60
Creatinine (mg/dl)	4.09±0.36***	0.78±0.32
Albumin (g/dl)	2.76±0.10***	4.28±0.76
CRP (mg/dl)	61.97±14.39***	2.70±0.24
CRP/albumin ratio	24.22±5.94***	0.64±0.60
MDRD-GFR	34.39±4.05***	103.55±4.33
Ferritin (ng/ml)	375.12±64.61	-
Proteinuria (mg/gün)	4327.33±682.02	-
Haematuria (/HPF)	185.76±50.67	-

*P<0.05, ***<0.001 compared to control. NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; CRP, C-reactive protein; MDRD, modification of diet in renal disease; GFR, glomerular filtration rate; SD, standard deviation, HPF, high-power field

and dialysis dependency had nearly significant correlation. The relationship between renal biopsy histopathological findings and dialysis dependency is shown in Table III.

While the per cent of fibrocellular crescents and NLR (P=0.033, r=−0.291) were negatively correlated, the same histopathological finding showed a positive correlation with the lymphocyte count (P=0.042, r=0.256). There was significant negative correlation between cellular crescent per cent and haematocrit (P=0.049, r=−0.269) (Table IV). In primary crescentic subgroup NLR showed a negative correlation with the per cent of fibrocellular crescents (P=0.041, r=−0.324). In secondary crescentic subgroup the per cent of fibrinoid necrosis had a positive correlation with PLR (P=0.013, r=0.642) and negative correlation with the lymphocyte count (P=0.011, r=−0.657) and haematocrit value (P=0.043, r=−0.548).

The neutrophil score (based on neutrophil count per crescentic glomerulus) was divided into three subgroups: 0, 1-2 and ≥3. The neutrophil score was found to be higher in cases with higher creatinine (P<0.05) and ferritin (P<0.05) levels and lower plasma sodium (P<0.05) concentrations at the time of diagnosis. Interstitial inflammation was graded into three subgroups: <25, between 25 and 50 and, >50 per cent. As interstitial inflammation increased, ferritin levels (P<0.01) were higher while plasma sodium (P<0.05) concentrations were lower. A significant (P<0.01) relationship was observed between interstitial inflammation and dialysis need at the time of admission. While dialysis need was 30.4 per cent in <25 per cent interstitial inflammation, it increased to 33.3 per cent in the 25-50 per cent and 76.9 per cent in the >50 per cent interstitial inflammation subgroups, respectively. The degree of haematuria was highest in <25 per cent and lowest in 25-50 per cent interstitial inflammation subgroups (P<0.05).

Table II. Comparison of patients in the primary and secondary crescentic glomerulonephritis sub-groups at baseline

Variables	Mean±SE	
	Primary crescentic (n=40)	Secondary crescentic (n=14)
Age (yr)	52.22±2.83**	36.64±5.76
White blood cell (10^3/µl)	10337.50±652.78*	7957.14±1206.68
Neutrophil (10^3/µl)	7919.50±620.04*	5996.42±1027.67
Lymphocyte (10^3/µl)	1457.50±106.01	1241.42±178.34
Platelet count (10^3/µl)	286400.00±18012.20	253857.14±11474.22
Hemoglobin (g/dl)	9.89±0.25	10.49±0.60
Haematocrit (%)	29.57±0.72	31.53±1.81
NLR	6.77±0.70	7.74±2.73
PLR	244.17±23.58	358.84±136.35
Blood urea nitrogen (mg/dl)	53.22±3.42	43.64±6.38
Creatinine (mg/dl)	4.49±0.40**	2.97±0.72
Albumin (g/dl)	2.89±0.11*	2.42±0.22
CRP (mg/dl)	72.89±16.09*	4.62±4.17
CRP/albumin ratio	28.41±6.71*	2.24±1.65
MDRD-GFR	26.62±4.01**	56.64±8.27
Ferritin (ng/ml)	453.58±79.54**	131.00±31.16
Proteinuria (mg/gün)	4027.33±803.12	3912.32±1325.78
Haematuria (/HPF)	165.76±68.88	157.54±32.05

*P**<0.05, ***<0.01 compared to secondary crescentic patients

Table III. Relationship between renal biopsy histopathological findings and dialysis dependency at admission

Histopathology findings	Dialysis dependency	Mean±SE
Sclerotic glomeruli	Dependent (n=23)	3.30±1.32
	Independent (n=31)	1.61±0.34
Cellular crescent	Dependent (n=23)	39.39±6.69
	Independent (n=31)	16.70±3.36
Fibrosellular crescent	Dependent (n=23)	19.17±5.45
	Independent (n=31)	10.51±2.49
Fibrous crescent	Dependent (n=23)	3.17±1.63
	Independent (n=31)	4.25±1.82
Fibrinoid necrosis	Dependent (n=23)	19.52±6.06
	Independent (n=31)	10.45±3.54

*P**<0.05, ***<0.01, ****<0.001 compared to dialysis independent group

On the basis of renal biopsy features, corticosteroid-cyclophosphamide was co-administered in 41 patients, sole corticosteroid treatment was given in 12 while to one patient no treatment was given because of established chronic changes in renal biopsy specimen. Twenty (37%) patients were observed to enter into remission and five who needed dialysis initially became independent from dialysis at the sixth month. Both NLR and PLR detected at the first month of the treatment period, were observed to be significantly (P<0.05) correlated with mortality.

Discussion

This study demonstrated that NLR could predict mortality in patients with RPGN, correlated with systemic inflammation, showed a negative correlation with the per cent of fibrocellular crescents. In secondary crescentic subgroup fibrinoid necrosis showed a positive correlation with PLR and negative correlation with the lymphocyte count and haematocrit value. PLR can be an indicator of disease severity in acute phase of crescentic GN. A negative correlation between NLR and the per cent of fibrocellular crescents was supported by a positive correlation between the per cent of fibrocellular crescents and lymphocyte count which itself is a measure of chronic inflammation. The positive correlation between neutrophil count in crescentic glomeruli and ferritin concentration shows that glomerular inflammation in RPGN is so severe that it

Table IV. Correlation between renal biopsy histopathological findings and haematological parameters

Histopathological Parameters	Sclerotic glomeruli		Cellular crescent		Fibrocellular crescent		Fibrous crescent		Fibrinoid necrosis	
	r	*P*	*r*	*P*	*r*	*P*	*r*	*P*	*r*	*P*
White blood cell	−0.026	0.850	0.040	0.775	−0.128	0.356	0.023	0.868	−0.015	0.912
Neutrophil	0.049	0.728	0.053	0.753	−0.186	0.185	0.017	0.903	0.037	0.793
Lymphocyte	0.178	0.198	0.021	0.879	0.256	0.042	0.192	0.164	−0.229	0.096
Platelet	0.084	0.545	0.098	0.481	0.039	0.780	0.021	0.878	−0.006	0.966
Haemoglobin	0.151	0.275	−0.210	0.127	−0.096	0.491	0.007	0.962	−0.238	0.083
Haematocrit	0.132	0.343	−0.269	0.049	−0.105	0.449	−0.026	0.850	−0.217	0.115
RDW	−0.310	0.023	0.021	0.882	−0.185	0.181	−0.223	0.106	−0.047	0.735
NLR	−0.186	0.178	−0.006	0.966	−0.291	0.033	−0.068	0.625	0.140	0.312
PLR	−0.177	0.200	−0.005	0.970	−0.136	0.327	−0.128	0.356	0.218	0.114

RDW, red cell distribution width

can cause systemic inflammation and activates acute phase reactants.

RPGN is a rare but severe clinical condition. Although prognosis in some RPGN subtypes has improved, yet progression to ESRD is frequent. This figure was 33 per cent in our study. Since RPGN is both a glomerular and systemic inflammatory process, activation of systemic inflammatory markers is accompanied by inflammatory findings in renal biopsy specimens. In our study, patients had prominent hypoalbuminemia, exhibited increased CRP levels and CRP/albumin ratios. Anaemia was also evident in our patients and accompanied by increased ferritin levels reflecting systemic inflammation. NLR and PLR values were significantly higher in comparison to control group. In a study conducted by Aydın *et al*[17], NLR was found to be 1.94±0.98 in men, 2.05±1.05 in women aged between 40 and 49 in healthy group. These ratios tended to be higher in older individuals and reached 2.5-3 in those >70 years of age. In comparison to reference values and control group, our ratios showed two-three fold increase. Nagy *et al*[18] have found the median NLR ratio as 5.9 (4.3-7.1) in cases with systemic involvement while cases with non-systemic involvement median NLR was only 2.6 (1.6-3) (P<0.001) in a retrospective study of involving 40 IgA vasculitis patients. Their patients were divided into three subgroups; renal involvement, gastrointestinal (GI) tract involvement and combined renal and GI tract involvement. The highest NLR was found in combined renal and GI tract involvement (7.4±3.4) subgroup. Emiroglu *et al*[19] compared NLR values of 45 vasculitic cases (cutaneous or combined cutaneous and systemic) at the time of cutaneous biopsy-proven with the values of 40 healthy cases. NLR, CRP, and ESR values were found to be higher in the vasculitis group. Ozcicek *et al*[20] showed that NLR levels were significantly higher in haemodialysis patients than in the healthy control group and it was found to be an independent predictor of epicardial adipose tissue in haemodialysis patients. Küçük *et al*[21] found NLR significantly correlated with ESR and CRP levels and related to disease activity in a study of 53 granulomatosis with polyangiitis patients.

In our study, NLR and CRP-CRP/albumin ratio were found to be positively correlated. Nagy *et al*[18] have detected positive correlations between NLR and CRP, ESR. In many studies, NLR and PLR were positively correlated with inflammation in ESRD patients[12,13].

NLR has been demonstrated to be an independent risk factor for cardiovascular diseases. Turkmen *et al*[22] have shown significant correlation between NLR and coronary artery and thoracic peri-aortic calcification score (TACS) in 56 ESRD patients. Inflammation has been found to be an important contributor of increased atherosclerosis and vascular calcification in previous studies which is frequently seen in ESRD patients[23-25]. Turkmen *et al*[22] also demonstrated that NLR and age were independent predictors of TACS. No correlation was observed between renal biopsy histopathological findings and gender, age, progression to ESRD and death. While the per cent of both sclerotic glomeruli and fibrocellular crescents were significantly related to dialysis dependency at the time of admission, the relationship was not significant between the number of cellular crescents and dialysis dependency at the time of admission. It can be speculated that increased numbers of fibrocellular and sclerotic glomeruli reflect more severe and irreversible disease state thus

necessitating dialysis, while cellular crescents reflect severe inflammatory disease but implying a component of reversibility thus a lesser degree of relationship with the dialysis need at the time of admission. Fibrocellular crescent number positively correlated with lymphocyte count, negatively correlated with NLR suggesting that increased numbers of fibrocellular crescents reflected the underlying chronic inflammatory state. A significant negative correlation between cellular crescent count and haematocrit can be a reflection of the severity of the underlying inflammation. In the secondary crescentic subgroup fibrinoid necrosis positively correlated with PLR. This showed that PLR might be a predictor of the acute stage of the disease. The PLR was found to be a better predictor of mortality than NLR due to all causes in chronic haemodialysis patients in the context of inflammation and renal failure[26]. In the present study significant positive correlations were found between NLR ($P<0.05$), PLR ($P<0.05$) values and death at the end of the first month.

Interstitial inflammation was positively correlated with hyperferritinemia and hyponatremia, strongly correlated with dialysis need at the time of admission. The positive correlation between interstitial inflammation and hyperferritinemia might be explained by more intense systemic inflammation related to interstitial inflammation. Increased degrees of interstitial inflammation might have resulted in severe kidney dysfunction thus necessitating dialysis.

Our study had two main limitations. First, primary and secondary crescentic glomerulonephritis patients evaluated together and a relatively small number of secondary subgroup existed. Second, the sample was not homogeneous, and the sample size was relatively small. Another limitation was that because of retrospective nature of the study ESR values could not be obtained.

Prospective studies with a higher number of patients and subgroups (primary, secondary, comprising patients due to vasculitis, glomerular disease, and drug-induced) are needed to assess PLR and NLR value in severity scaling, predicting response to treatment and disease progression of the RPGN. Additional studies investigating the possible association with inflammatory cytokines could be designed.

To conclude, our findings showed that the NLR-PLR markers might be used to grade glomerular inflammation, NLR and PLR correlated with histopathological findings obtained from renal biopsy specimens, and most importantly NLR was associated with mortality in RPGN cases. Although cause-effect relationship between NLR and prognosis could not be substantiated, this ratio might be considered as an economic marker-epiphenomenon that could predict clinical hard-points in RPGN cases.

***Financial support & sponsorship*:** None.

***Conflicts of Interest*:** None.

References

1. Jennette JC. Rapidly progressive crescentic glomerulonephritis. *Kidney Int* 2003; *63* : 1164-77.
2. Couser WG. Rapidly progressive glomerulonephritis: Classification, pathogenetic mechanisms, and therapy. *Am J Kidney Dis* 1988; *11* : 449-64.
3. Atkins RC, Nikolic-Paterson DJ, Song Q, Lan HY. Modulators of crescentic glomerulonephritis. *J Am Soc Nephrol* 1996; *7* : 2271-8.
4. Sanavi S, Afshar R. An unusual presentation of antineutrophil cytoplasmic antibody-associated vasculitis: Discrepancy between histopathology and clinical presentation. *Iran J Kidney Dis* 2011; *5* : 347-50.
5. Azab B, Bhatt VR, Phookan J, Murukutla S, Kohn N, Terjanian T, *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* : 217-24.
6. Jung MR, Park YK, Jeong O, Seon JW, Ryu SY, Kim DY, *et al.* Elevated preoperative neutrophil to lymphocyte ratio predicts poor survival following resection in late stage gastric cancer. *J Surg Oncol* 2011; *104* : 504-10.
7. Kocyigit I, Eroglu E, Unal A, Sipahioglu MH, Tokgoz B, Oymak O, *et al.* Role of neutrophil/lymphocyte ratio in prediction of disease progression in patients with stage-4 chronic kidney disease. *J Nephrol* 2013; *26* : 358-65.
8. Núñez J, Núñez E, Bodí V, Sanchis J, Miñana G, Mainar L, *et al.* Usefulness of the neutrophil to lymphocyte ratio in predicting long-term mortality in ST segment elevation myocardial infarction. *Am J Cardiol* 2008; *101* : 747-52.
9. Oylumlu M, Yıldız A, Oylumlu M, Yüksel M, Polat N, Bilik MZ, *et al.* Platelet-to-lymphocyte ratio is a predictor of in-hospital mortality patients with acute coronary syndrome. *Anatol J Cardiol* 2015; *15* : 277-83.
10. Ayça B, Akin F, Çelik Ö, Yüksel Y, Öztürk D, Tekiner F, *et al.* Platelet to lymphocyte ratio as a prognostic marker in primary percutaneous coronary intervention. *Platelets* 2015; *26* : 638-44.
11. Krenn-Pilko S, Langsenlehner U, Thurner EM, Stojakovic T, Pichler M, Gerger A, *et al.* The elevated preoperative platelet-to-lymphocyte ratio predicts poor prognosis in breast cancer patients. *Br J Cancer* 2014; *110* : 2524-30.
12. Turkmen K, Guney I, Yerlikaya FH, Tonbul HZ. The relationship between neutrophil-to-lymphocyte ratio and

inflammation in end-stage renal disease patients. *Ren Fail* 2012; *34* : 155-9.

13. Turkmen K, Erdur FM, Ozcicek F, Ozcicek A, Akbas EM, Ozbicer A, *et al.* Platelet-to-lymphocyte ratio better predicts inflammation than neutrophil-to-lymphocyte ratio in end-stage renal disease patients. *Hemodial Int* 2013; *17* : 391-6.
14. Levey AS, Stevens LA, Schmid CH, Zhang YL, Castro AF 3rd, Feldman HI, *et al.* A new equation to estimate glomerular filtration rate. *Ann Intern Med* 2009; *150* : 604-12.
15. Qin G, Tu J, Liu L, Luo L, Wu J, Tao L, *et al.* Serum albumin and C-reactive protein/Albumin ratio are useful biomarkers of Crohn's disease activity. *Med Sci Monit* 2016; *22* : 4393-400.
16. Kaplan M, Ates I, Akpinar MY, Yuksel M, Kuzu UB, Kacar S, *et al.* Predictive value of C-reactive protein/albumin ratio in acute pancreatitis. *Hepatobiliary Pancreat Dis Int* 2017; *16* : 424-30.
17. Aydın I, Ağıllı M, Aydın FN, Kurt YG, Tuncer Çaycı T, Taş A, *et al*. The reference ranges of neutrophil-lymphocyte ratio in different age groups. *Gülhane Tıp Derg* 2015; *57* : 414-8.
18. Nagy GR, Kemény L, Bata-Csörgő Z. Neutrophil-to-lymphocyte ratio: A biomarker for predicting systemic involvement in adult İgA vasculitis patients. *J Eur Acad Dermatol Venereol* 2017; *31* : 1033-7.
19. Emiroglu N, Cengiz FP, Bahalı AG, Ozkaya DB, Su O, Onsun N, *et al.* Red blood cell distribution width and neutrophil-to-lymphocyte ratio in patients with cutaneous vasculitis. *Ann Clin Lab Sci* 2017; *47* : 162-5.
20. Ozcicek A, Ozcicek F, Yildiz G, Timuroglu A, Demirtas L, Buyuklu M, *et al.* Neutrophil-to-lymphocyte ratio as a possible indicator of epicardial adipose tissue in patients undergoing hemodialysis. *Arch Med Sci* 2017; *13* : 118-23.
21. Küçük H, Göker B, Varan Ö, Dumludag B, Haznedaroğlu Ş, Öztürk MA, *et al.* Predictive value of neutrophil/lymphocyte ratio in renal prognosis of patients with granulomatosis with polyangiitis. *Ren Fail* 2017; *39* : 273-6.
22. Turkmen K, Ozcicek F, Ozcicek A, Akbas EM, Erdur FM, Tonbul HZ. The relationship between neutrophil-to-lymphocyte ratio and vascular calcification in end-stage renal disease patients. *Hemodial Int* 2014; *18* : 47-53.
23. Stenvinkel P. Inflammatory and atherosclerotic interactions in the depleted uremic patient. *Blood Purif* 2001; *19* : 53-61.
24. Dai L, Golembiewska E, Lindholm B, Stenvinkel P. End-stage renal disease, inflammation and cardiovascular outcomes. *Contrib Nephrol* 2017; *191* : 32-43.
25. Maraj M, Kuśnierz-Cabala B, Dumnicka P, Gala-Błądzińska A, Gawlik K, Pawlica-Gosiewska D, *et al*. Malnutrition, inflammation, atherosclerosis syndrome (mia) and diet recommendations among end-stage renal disease patients treated with maintenance hemodialysis. *Nutrients* 2018; *10* : pii. E69.
26. Yaprak M, Turan MN, Dayanan R, Akın S, Değirmen E, Yıldırım M, *et al.* Platelet-to-lymphocyte ratio predicts mortality better than neutrophil-to-lymphocyte ratio in hemodialysis patients. *Int Urol Nephrol* 2016; *48* : 1343-8.

For correspondence: Dr Aysun Toraman, Division of Nephrology, Department of Medicine, University of Celal Bayar, Manisa, Turkey
e-mail: aystoraman@hotmail.com