The relationship between neutrophil to lymphocyte ratio and blood pressure variability in hypertensive and normotensive subjecs

Hipertansiyonlu ve normal tansiyonlu kişilerde kan basıncı değişkenliği ile nötrofil/lenfosit oranı arasındaki ilişki

Barış Kılıçaslan, M.D., Hüseyin Dursun, M.D., Sermin Kaymak, M.D.,# Mehmet Aydın, M.D., Cenk Ekmekçi, M.D., İbrahim Susam, M.D., Öner Özdoğan, M.D.

Department of Cardiology, Izmir Tepecik Training and Research Hospital, Izmir;
#Department of Internal Medicine, Izmir Tepecik Training and Research Hospital, Izmir

ABSTRACT

Objectives: Blood pressure (BP) variability is associated with hypertensive (HT) target organ damage and cardiovascular events. The aim of this study was to investigate the relation between neutrophil to lymphocyte ratio (NLR) and BP variability in hypertensive and normotensive subjects.

Study design: In this cross-sectional study, 150 subjects (63 male, mean age 52.1±5.2 years) were enrolled. In all patients, blood samples and 24-hour ambulatory blood pressure (BP) monitoring were obtained. According to 24-hour ambulatory BP results, participants were divided into four investigation categories. Group 1= Normotensive dipper (ND), Group 2= Normotensive non-dipper (NN), Group 3= HT dipper (HD), Group 4= HT non-dipper (HN).

Results: Highest NLR values were determined in the HN group (p=0.005 *vs.* ND, p=0.046 *vs.* NN and p<0.01 *vs.* HD). NLR values were similar among the ND, NN and HD groups (p>0.05, for all). NLR was correlated with night systolic blood pressure (SBP) (r=0.178, p=0.031), night diastolic blood pressure (DBP) (r=0.176, p=0.032) and BP variation rate (r=-0.246, p=0.003). Multiple linear regression analysis showed BP variation rate to be an independent predictor of high NLR value (β=0.186, 95% CI=0.918-0.982, p=0.044). In ROC analysis, a level of NLR>2.7 predicted non-dipper HT with 83% sensitivity and 65% specificity (ROC area under curve: 0.653, 95% CI=0.565-0.741, p=0.001).

Conclusion: In the present study, we found that NLR levels were significantly correlated with BP variability. The measurement of NLR may be used to indicate increased risk of HT-related adverse cardiovascular events.

ÖZET

Amaç: Kan basıncı (KB) değişkenliği hipertansiyonda (HT) hedef organ hasarı ve kardiyovasküler olaylarla ilişkilidir. Bu çalışmanın amacı KB normal olan kişiler ve yeni tanı konmuş hipertansiyonlu olgularda KB değişkenliği ile nötrofil/lenfosit oranı (N/L oranı) arasındaki ilişkiyi araştırmaktır.

Çalışma planı: Bu kesitsel çalışmaya yeni tanı konan hipertansiyonlu ve KB normal 150 kişi (63 erkek, ortalama yaş 52.1±5.2 yıl) alındı. Tüm hastalara 24 saat tansiyon Holter cihazı (24s-THC) ile KB izlemi, transtorasik ekokardiyografi tetkiki ve biyokimyasal kan testi yapıldı. 24s-THC'dan elde edilen verilere göre hastalar dört gruba ayrıldı. Grup 1= Normal tansiyonlu dipper (ND), Grup 2= Normal tansiyonlu non-dipper (NN), Grup 3= Hipertansiyonlu dipper (HD), Grup 4= Hipertansiyonlu non-dipper (HN).

Bulgular: En yüksek N/L oranı değeri HN grubunda elde edildi (p=0.005 ve ND, p=0.046 ve NN ile p<0.001 ve HD). N/L oranı ND, NN ve HD gruplarında benzer bulundu. N/L oranı ile gece sistolik KB (r=0.178, p= 0.031), gece diyastolik KB (r=0.176, p=0.032) ve ortalama KB değişimi (r=-0.246, p=0.003) arasında korelasyon saptandı. Çoklu doğrusal regresyon analizinde ortalama KB değişkenliği yüksek N/L oranının bağımsız öngördürücüsü olarak saptandı (β=0.186, %95 GA=0.918-0.982 , p=0.044). ROC eğrisi analizinde N/L oranı >2.7 seviyesi, non-dipper HT'yi %83 duyarlılık ve %65 özgüllükle tahmin ettirmektedir (ROC eğrisi altındaki alan=0.653, %95 GA=0.565- 0.741, p=0.001).

Sonuç: Bu çalışmada, N/L oranı KB değişkenliği ile ilişkili bulunmuştur. N/L oranı HT'ye bağlı artmış kardiyovasküler olayları öngörmede kullanılabilecek bir parametre olarak ön plana çıkmaktadır.

Presented at the TSC 29th Turkish Cardiology Congress with International Participation (October 26-29, 2013, Antalya, Turkey).

Received: January 06, 2014 *Accepted:* June 06, 2014

Correspondence: Dr. Barış Kılıçaslan. Manavkuyu Mahallesi, 249/4 Sokak, No: 2-A-16, Bayraklı, İzmir.
Tel: 444 35 60 e-mail: kilicaslanbaris@yahoo.com

Hypertension (HT) is a well-known risk factor for cardiovascular disease.[1] Blood pressure (BP) is a continuous variable. During sleep, mental and physical activity, BP changes in a manner unique to each individual, from moment to moment in response to autonomic, humoral, mechanical, myogenic, and environmental stimuli.[2,3] During sleep, a normal fall (or "dip") in BP is considered to be a dip of no more than 10%, and those whose BP dips more than 10% have been termed 'dippers'. Those whose reduction ranges remain under 10% have been termed "non dippers".[4]

Abbreviations:

BP	*Blood pressure*
HD	*Hypertensive Dipper*
HN	*Hypertensive Non-dipper*
hs-CRP	*High-sensitive C-reactive protein*
HT	*Hypertension*
LVM	*Left ventricular mass*
ND	*Normotensive Dipper*
NLR	*Neutrophil/lymphocyte ratio*
WBC	*White blood cell*

Decreased BP variability has been reported to be associated with hypertensive target organ damage and cardiovascular events.[5] The pathologic and molecular mechanisms by which BP variability leads to vascular disease are controversial. It has been suggested that BP variability may promote endothelial expression of cytokines and stimulate inflammation.[6] Some different inflammatory markers (RDW, hs-CRP and mean platelet volume) were found to be related with BP variability in hypertensive patients.[7,8] The total white blood cell (WBC) count and its subtypes, such as neutrophil, lymphocyte and neutrophil/lymphocyte ratio (NLR) can be used as an indicator of systemic inflammation.

NLR is an inexpensive, easy to obtain, widely available new addition marker, which is calculated from complete blood count with differential.[6,7] NLR has prognostic importance in cardiovascular disease and heart failure.[9-11] However, there is not sufficient knowledge about the possible relationship between NLR and BP variation in hypertensive and normotensive subjects. The aim of this study was to investigate the relation between NLR and BP variability in hypertensive and normotensive subjects.

PATIENTS AND METHODS

Study population

Participants were recruited from the hypertension outpatient clinic at Tepecik Research Hospital. Candidates were those subjects who met the criteria of essential hypertension, and age-, sex-, biochemical- and anthropometric- matched normotensive individuals were enrolled as controls in this cross-sectional study (Table 1). In order to exclude pharmacological effects on hemodynamics or ventricular hypertrophy and function, hypertensive patients had three clinic BP measurements (>140/90 mmHg) taken at 1-week intervals in the absence of any previous antihypertensive treatment. Exclusion criteria included the presence of the following: Known coronary artery disease, chronic renal failure, chronic liver disorders, moderate, or severe valvular disease, diabetes mellitus, congenital heart disease, LV systolic dysfunction

Table 1. Comparison of baseline characteristic parameters of patients

	Prehypertensive (n=69)			Normotensive (n=81)			*p*
	n	%	Mean±SD	n	%	Mean±SD	
Age (Years)			50.7±16.51			52.6±15.22	0.471
Gender (Female)	41	59		43	53		0.402
Smoking	22	31		23	28		0.383
Glucose (mg/dl)			96.3±18.23			103±33.22	0.112
BUN (mg/dl)			29.2±9.56			32.7±11.47	0.005
Creatinine (mg/dl)			0.9±0.19			0.9±0.33	0.182
Total cholesterol (mg/dl)			202.3±51.82			203.8±48.71	0.854
Trygliseride (mg/dl)			149.3±76.82			164.3±74.33	0.245
HDL (mg/dl)			44.5±8.29			44.8±11.91	0.881
LDL (mg/dl)			131.2±41			126.3±43.84	0.493

BUN: Blood urine nitrate; HDL: High density lipoprotein; LDL: Low density lipoprotein; SD Standard deviation.

on echocardiography (ejection fraction <50%), recent acute coronary syndrome, anemia, hyperthyroidism, pregnancy, obstructive sleep apnea, secondary HT, hematological disorders, known malignancy and drug history including anti-gout agent, WBC count >12 000 cells per µL or <4000 cells per µL, and high body temperature >38 ºC. Also, patients who had a recent history of acute infection or inflammatory disease were excluded from the study. The institutional ethics committee approved the study and written informed consent for participation in the study was obtained from all individuals.

Following history and physical examination, 24-hour ambulatory BP monitoring, transthoracic echocardiography examination and blood samples were obtained for all patients.

According to 24-hour ambulatory BP results, participants were divided into four investigation categories on the basis of dipping status (dipper *vs.* non-dipper) and ambulatory BP (normal ambulatory BP if waking SBP/DBP means were <135/85 mmHg and sleeping SBP/DBP means were <120/70 mmHg), and elevated ambulatory BP otherwise. Group 1= Normotensive dipper (ND), Group 2= Normotensive non-dipper (NN), Group 3= Hypertensive dipper (HD), Group 4= Hypertensive non-dipper (HN).

Echocardiography

Echocardiographic examination was performed in all study subjects using a commercially available system (Vivid 7R GE Medical System, Horten, Norway) with a 2.0-3.5MHz transducer (ZE and MG). M-mode echocardiography measurements were obtained on the basis of the standards of the American Society of Echocardiography.[12] LV ejection fraction (EF) was determined by the biplane Simpson's method.[13] Left ventricular mass (LVM, g) was calculated using the Devereux formula: LVM (g) = 0.8 x 1.04 x [(LviDD + IVS + PWT)^3 – LviDD^3] + 0.6.[11,14] LV mass index (LVMI, g/m^2) was obtained with the following formula: LVM/body surface area.

All echocardiography studies were carried out by the same observer, who was unaware of the clinical data in order to avoid intra-reader variability. Each examination was recorded and two other cardiologists, blinded to the HT status of the patients, interpreted the results off-line. Intra-observer variability was <5%.

Table 2. Comparison of baseline, clinical and ambulatory blood pressure characteristics

Variables	Normotensive dipper (n=32)	Normotensive non-dipper (n=37)	Hypertensive dipper (n=39)	Hypertensive non-dipper (n=42)	*p*
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	
Age (year)	50.3±17.92	52.3±15.03	48.8±14.55^{d}	57.3±14.26	0.091
Gender (female)	21 (66%)	21 (57%)	24 (62%)	21 (51%)	0.632
LVEF (%)	62.3±4.31	61.1±3.77	61.3±6.81	61.1±2.92	0.574
LVMass (g)	147.1±40.32^{cd}	171.6±58.26	183.5±53.54	180.7±47.23	0.072
LVMI (g/m^2)	83.6±20.21^{cd}	97.8±31.64	103.6±27.51	101.5±24.60	0.061
Day SBP (mmhg)	124.5±6.97^{bcd}	118.6±6.45^{cd}	144.7±10.11	148.4±13.26	**<0.001**
Day DBP (mmhg)	80.9±5.83^{bcd}	77.1±5.01^{cd}	91.8±9.89	91.4±11.24	**<0.001**
Night SBP (mmhg)	110.8±6.95^{cd}	109.4±25.42^{cd}	132.4±9.80^{d}	146.2±15.49	**<0.001**
Night DBP (mmhg)	67.4±5.13^{bcd}	72.9±5.43^{cd}	77.8±8.21^{d}	87.3±10.31	**<0.001**
SBP (mmhg)	121.4±6.94^{cd}	118.6±6.48^{cd}	143.6±8.92	148.3±13.37	**<0.001**
DBP (mmhg)	78.0±5.28^{cd}	76.1±4.74^{cd}	90.4±9.47	91.1±10.99	**<0.001**
BP variability (%)	-14.7±41^{bd}	-4.2±5.60^{c}	-13.5±3.40^{d}	-4.12±4.68	**<0.001**

LVMaas: Left ventricle mass; LVMI: Left ventricle mass index; LVEF: Left ventricle ejection fraction; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; SD: Standard deviation.

p<0.05 was considered statistically significant; ^{b}p< 0.05 *vs.* normotensive non-dipper group; ^{c}p<0.05 *vs.* HT dipper group; ^{d}p<0.05 *vs.* HT non-dipper group.

Ambulatory 24-hour blood pressure monitoring

24-hour ambulatory BP was obtained using a non-invasive oscillometric system (Physo Quant win 6.2, Envite C- Wismar G mbH, Wisman, Germany). Automatic BP recordings were obtained regularly every 30 minutes during the 24-hour period. The cuff was placed around the non-dominant arm of the subjects. Sleep and wakefulness periods were assessed based on the information obtained from the patients. BP variability was calculated using the following formula: (%) 100x[1 – (sleep systolic BP/awake systolic BP)]. Detection of blood variability of more than 10% was regarded as Dipper HT, and detection of less than 10% was regarded as non-dipper HT.[4]

Blood samples

Blood samples were drawn in the morning after a 20-minute rest following a fasting period of 12 h. Glucose, blood urine nitrate (BUN), creatinine and lipid profiles for blood samples were analyzed for each patient. Total and differential leukocyte counts were measured by an automated hematology analyzer. Absolute cell counts were used in the analyses.

Statistical analysis

All analyses were conducted using SPSS 17. 0 (SPSS for Windows 17.0, Chicago, IL). Comparison of categorical variables between the groups was performed using the chi square (χ^2) test. The Kolmogorov–Smirnov test was performed to evaluate normality of distribution of all continuous variables. Analysis of variance (ANOVA) was used in the analysis of continuous variables. Correlations between NLR and laboratory, hemodynamic and echocardiographic parameters were assessed by the Pearson correlation test. All significant ($p<0.05$) parameters in the bivariate analysis were selected in the multivariate model. To avoid over-fitting and co-linearity in assessing the multivariate model, independent variables have been tested for inter-correlation. A stepwise multiple linear regression analysis was performed to identify the independent associations of NLR. A two-tailed $p<0.05$ was consid-

Table 3. Comparisson of laboratory characteristics of patients

Variables	Normotensive dipper (n=32)	Normotensive non-dipper (n=37)	Hypertensive dipper (n=39)	Hypertensive non-dipper (n=42)	*p*
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	
Glucose (mg/dl)	96.2±19.94	98.3±17.72	102.0±28.75	107.3±40.92	0.402
BUN (mg/dl)	28.1±9.41[d]	30.7±10.01	30.8±8.04	35.5±14.554	0.051
Creatinine (mg/dl)	0.9±0.15	0.9±0.12	0.97±0.25	1.0±0.24	0.453
T. Chol. (mg/dl)	198.9±40.22	196.2±52.14	209.0±58.76	198.9±40.49	0.714
Triglyceride (mg/dl)	141.3±71.72	158.6±81.18	165.3±86.25	152.1±57.07	0.621
HDL-C (mg/dl)	44.6±7.32	43±8.57	45.4±12.79	45.6±12.23	0.756
LDL-C (mg/dl)	125.9±34.21	127.6±40	130.7±49.06	122.8±37.87	0.881
HBG (mg/dl)	13.6±1.54	13.3±1.65	13.9±1.85	13.2±1.58	0.232
HTC (%)	40.1±4.43	41.2±4.62	41.2±4.63	39.8±7.89	0.491
WBC (K/ul)	7.4±1.91	8.3±3.01	8.0±2.79	7.8±1.97	0.533
Neutrophils (mm^3)	4.3±1.52	4.9±1.51	4.7±1.94	4.9±1.51	0.411
Lymphocytes (mm^3)	2.3±0.62	2.5±1.64	2.5±0.90[d]	2.0±0.77	0.179
NLR	2.02±0.83	2.23±0.91	1.88±0.60	2.71±1.18[abc]	0.001
PLATELET ($\times10^9$/L)	246.4±65.91	283.4±79	263.9±58	251.6±72.74	0.113
MPV (fL)	8.4±1.01	8.8±1.51	8.8±1.01	8.8±0.98	0.474

BUN: Blood urea nitrogen; T. Chol.: Total cholesterol; HDL-C: High density lipoprotein cholesterol; LDL-C: Low density lipoprotein cholesterol; HBG: Hemoglobuline; HTC: Hemotocrite; WBC: White blood cell; NLR: Neutrophil lymphocyte ratio; MPV: Mean platelet volume.
$p<0.05$ was considered statistically significant; [a]$p< 0.05$ *vs.* normotensive dipper group; [b]$p< 0.05$ *vs.* normotensive non-dipper group; [c]$p<0.05$ *vs.* HT dipper group; [d]$p<0.05$ *vs.* HT non-dipper group.

ered statistically significant. The cut-off value of NLR for predicting non-dipper HT with corresponding sensitivity and specificity was assessed by receiver operating characteristic (ROC) curve analysis.

RESULTS

Four different TA patterns were determined according to the basis of BP variability and ambulatory BP; 1) 32 patients with ND status 2) 37 patients with NN status 3) 39 patients with HD status 4) 42 patients with HN status. Comparison of baseline, clinical and 24-hour ambulatory BP monitoring results are shown in Table 2. Laboratory characteristics are showed in Table 3. The highest NLR values were determined in the HN group compared with ND, NN and HD groups ($p=0.005$ *vs*. ND, $p=0.046$ *vs*. NN and $p<0.01$ *vs*. HD). NLR values were similar among the ND, NN and HD groups ($p>0.050$, for all).

Pearson correlation analyses showed that NLR was correlated with night SBP ($r=0.178$, $p=0.031$), night DBP ($r=0.176$, $p=0.032$), BP variation rate ($r=-0.246$, $p=0.003$) and triglyceride (TG) levels ($r=-0.19$, $p=0.030$).

Stepwise multiple linear regression analysis showed that BP variation rate was an independent predictor of high NLR value ($\beta=0.186$, 95% CI=0.918-0.982, $p=0.044$). The relationships between NLR with BP variation rate are shown in Figure 1.

In ROC curve analysis, a level of NLR >2.7 predicted non-dipper HT with 83% sensitivity and 65% specificity (ROC area under curve: 0.653, 95% CI= 0.565- 0.741, $p=0.001$) (Figure 2).

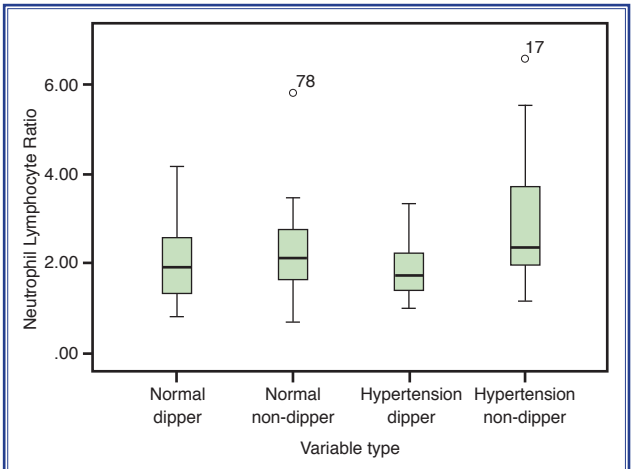

Figure 1. Neutrophil to lymphocyte ratio levels along with four investigated categories on the basis of dipping status and ambulatory blood pressure.

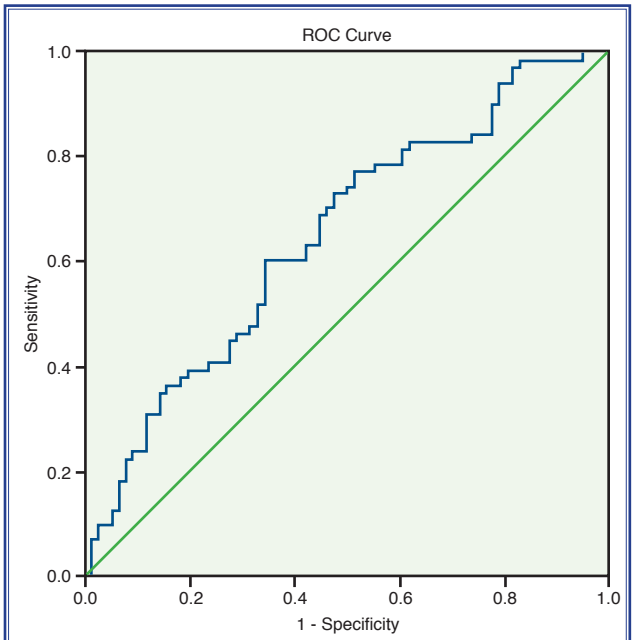

Figure 2. ROC curve analysis of NLR predicting the non-dipper status in patients with untreated essential hypertension.

DISCUSSION

In the present study, we found that NLR levels were significantly correlated with BP variation. NLR was higher among subjects with non-dipper HT compared with dipper HT and normotensive persons.

BP variability was reported to be associated with hypertensive target organ damage and cardiovascular events.[5] Mancia at al.[15] demonstrated that arterial BP fluctuations are related with increased carotid intima-media thickness. It is recognized that BP variability has prognostic significance in determining cardiovascular mortality and morbidity.[16] One mechanism may be the relationship between BP variability and target organ damage in inflammatory response.[6,17] It has been suggested that elevated BP and decreased BP variability may promote endothelial expression of cytokines and stimulate inflammation.[6] Kwang-Il Kim et al.[17] demonstrated that inflammatory markers (IL-6, high-sensitive C-reactive protein (hs-CRP) and TNF-α) were associated with BP variability in HT patients. Some different inflammatory markers (RDW,

hsCRP and mean platelet volume) have been found increased in non-dipper hypertensive patients compared with dippers.[7,8] According to previous data, decreased BP variability might be a stimulus for inflammation and that this might be a possible mechanism underlying the well-established role of BP variability as a risk factor for atherosclerotic disease.[7,8,17] There is not sufficient knowledge on the possible relationship between NLR and BP variability. Recently, Demir[18] demonstrated in his study that NLR was elevated in non-dipper HT patients, and NLR had a positive correlation with BP. Differently from his study, we tested NLR in normotensive subjects edition to hypertensive patients. In our study, NLR was increased in non-dipper HT patients when compared with dipper and normotensive subjects. NLR was significantly correlated with BP variation rate, and NLR was found to be an independent predictor of BP variability. According to our data, NLR was also correlated with night DBP and SBP levels. Cardiac metabolic gene expression exhibits a circadian variation that anticipates changes in myocardial workload and accordingly synchronizes substrate availability.[19] Thus, if the fall in BP with sleep is attenuated or absent, adverse cardiac consequences would be anticipated.

The interaction between BP variability and inflammation in HT patients has been investigated before.[7,8,17] However, there is little evidence to demonstrate an association between inflammation and BP variability in normotensive subjects.[20] We included normotensive patients along with HT patients in this study. While levels of NLR showed a stepwise increase from NN group to DN and DH groups, this it was not significant. Our ability to observe associations of greater magnitude may have been limited by the fact that our healthy subjects had relatively normal inflammatory and BP variability values that lay within fairly narrow ranges.

Limitations

The present study has several limitations. It was based on a relatively small number of participants, so it is unclear whether the results can be applied to other populations. Our analyses are based on single measurements of blood test markers, which may not reflect these relationships over time. In addition, lack of the assessment of other inflammatory markers like hs-CRP is another limitation of the current study.

In conclusion, despite these limitations, we believe that the study provides new scientific information, as it reports statistically significant positive associations between BP variability and NLR. The measurement of NLR may be used to indicate increased risk of HT-related adverse cardiovascular events. Further prospective studies with larger sample sizes are needed to shed light on the mechanism underlying this association.

Conflict-of-interest issues regarding the authorship or article: None declared

REFERENCES

1. Lewington S, Clarke R, Qizilbash N, Peto R, Collins R; Prospective Studies Collaboration. Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. Lancet 2002;360:1903-13. CrossRef
2. Floras JS, Hassan MO, Jones JV, Osikowska BA, Sever PS, Sleight P. Factors influencing blood pressure and heart rate variability in hypertensive humans. Hypertension 1988;11:273-81. CrossRef
3. Floras JS. Blood pressure variability: a novel and important risk factor. Can J Cardiol 2013;29:557-63. CrossRef
4. Verdecchia P, Porcellati C, Schillaci G, Borgioni C, Ciucci A, Battistelli M, et al. Ambulatory blood pressure. An independent predictor of prognosis in essential hypertension. Hypertension 1994;24:793-801. CrossRef
5. Mancia G, Parati G. Ambulatory blood pressure monitoring and organ damage. Hypertension 2000;36:894-900. CrossRef
6. Chae CU, Lee RT, Rifai N, Ridker PM. Blood pressure and inflammation in apparently healthy men. Hypertension 2001;38:399-403. CrossRef
7. Ozcan F, Turak O, Durak A, Işleyen A, Uçar F, Giniş Z, et al. Red cell distribution width and inflammation in patients with non-dipper hypertension. Blood Press 2013;22:80-5. CrossRef
8. Kaya MG, Yarlioglues M, Gunebakmaz O, Gunturk E, Inanc T, Dogan A, et al. Platelet activation and inflammatory response in patients with non-dipper hypertension. Atherosclerosis 2010;209:278-82. CrossRef
9. Işık T, Ayhan E, Uyarel H, Tanboğa IH, Kurt M, Uluganyan M, et al. Association of neutrophil to lymphocyte ratio with presence of isolated coronary artery ectasia. Turk Kardiyol Dern Ars 2013;41:123-30. CrossRef
10. Arbel Y, Finkelstein A, Halkin A, Birati EY, Revivo M, Zuzut M, et al. Neutrophil/lymphocyte ratio is related to the severity of coronary artery disease and clinical outcome in patients undergoing angiography. Atherosclerosis 2012;225:456-60.
11. Uthamalingam S, Patvardhan EA, Subramanian S, Ahmed W, Martin W, Daley M, et al. Utility of the neutrophil to lymphocyte ratio in predicting long-term outcomes in acute decom-

pensated heart failure. Am J Cardiol 2011;107:433-8. CrossRef

12. Lang RM, Bierig M, Devereux RB, Flachskampf FA, Foster E, Pellikka PA, et al. Recommendations for chamber quantification: a report from the American Society of Echocardiography's Guidelines and Standards Committee and the Chamber Quantification Writing Group, developed in conjunction with the European Association of Echocardiography, a branch of the European Society of Cardiology. J Am Soc Echocardiogr 2005;18:1440-63. CrossRef
13. Schiller NB, Shah PM, Crawford M, DeMaria A, Devereux R, Feigenbaum H, et al. Recommendations for quantitation of the left ventricle by two-dimensional echocardiography. American Society of Echocardiography Committee on Standards, Subcommittee on Quantitation of Two-Dimensional Echocardiograms. J Am Soc Echocardiogr 1989;2:358-67.
14. Devereux RB, Reichek N. Echocardiographic determination of left ventricular mass in man. Anatomic validation of the method. Circulation 1977;55:613-8. CrossRef
15. Mancia G, Parati G, Hennig M, Flatau B, Omboni S, Glavina F, et al. Relation between blood pressure variability and carotid artery damage in hypertension: baseline data from the European Lacidipine Study on Atherosclerosis (ELSA). J Hypertens 2001;19:1981-9. CrossRef
16. Eguchi K, Hoshide S, Schwartz JE, Shimada K, Kario K. Visit-to-visit and ambulatory blood pressure variability as predictors of incident cardiovascular events in patients with hypertension. Am J Hypertens 2012;25:962-8. CrossRef
17. Kim KI, Lee JH, Chang HJ, Cho YS, Youn TJ, Chung WY, et al. Association between blood pressure variability and inflammatory marker in hypertensive patients. Circ J 2008;72:293-8.
18. Demir M. The relationship between neutrophil lymphocyte ratio and non-dipper hypertension. Clin Exp Hypertens 2013;35(8):570-3. CrossRef
19. Young ME. The circadian clock within the heart: potential influence on myocardial gene expression, metabolism, and function. Am J Physiol Heart Circ Physiol 2006;290:1-16.
20. Abramson JL, Lewis C, Murrah NV, Anderson GT, Vaccarino V. Relation of C-reactive protein and tumor necrosis factor-alpha to ambulatory blood pressure variability in healthy adults. Am J Cardiol 2006;98:649-52. CrossRef

Key words: Blood pressure; blood pressure monitoring, ambulatory; hypertension; inflammation; N/L ratio.

Anahtar sözcükler: Kan basıncı; kan basıncı izlemesi, ambulatuvar; hipertansiyon; enflamatuvar; N/R oranı.