Research Article / Araştırma Makalesi

A New Score for the Identification of Circadian Blood Pressure Pattern in Hypertensive Patients

Hipertansif Hastalarda Sirkadiyen Kan Basıncı Paterninin Belirlenmesi için Yeni Bir Skor

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Abstract

Background: Non-dipper hypertension is characterised by a decrease of less than 10% in nocturnal blood pressure compared to daytime levels. It is known that non-dipper hypertension is associated with higher mortality than dipper hypertension. Therefore, in this study, we aimed to investigate the correlation between the easily calculable LANR score in the diagnosis of non-dipper HT.
Materials and Methods: A total of 524 patients diagnosed with HT who were admitted to the a cardiology clinic were included in this study. Demographic data, 24-hour ambulatory blood pressure monitoring, echocardiographic, and laboratory data were obtained from hospital archives. The formula LANR = lymphocytes × albumin / neutrophils was used to calculate the LANR index. Patients were categorized into two groups, namely LANR<23 and LANR>23.
Results: When baseline demographic characteristics and laboratory parameters were compared, no significant difference was found between the two groups except neutrophils, lymphocytes and C reactive protein. CAR and NLR were found to be high in the non-dipper HT group, while HALP and LANR were found to be low. In addition, in stepwise multivariate analyses performed to determine the predictors of the prognostic process in non-dipper HT patients, CAR (odds ratio: 1.420, 95% confidence interval: 1.106-1.823, P<0.001) and LANR (odds ratio: 0.583, 95% confidence interval: 0.493-0.690, P<0.001) were identified as independent predictors of HT in non-dipper HT.
Conclusions: This study showed lower LANR, HALP scores and higher CAR, NLR scores in non-dipper HT patients compared with dipper HT patients. Furthermore, LANR and CAR were identified as independent predictors of non-dipper HT In addition, the rate of non-dipper hypertension was reported to be significantly higher in patients with LANR<23 than in individuals with LANR>23. In conclusion, a low LANR index can be used as an early warning model to identify patients with non-dipper HT.

Keywords: Lymphocytes, Albumin, Neutrophils, Dipper, Non-dipper, Hypertension

Öz

Amaç: Non-dipper hipertansiyon, gece kan basıncının gündüz seviyelerine kıyasla %10'dan daha az azalması ile karakterizedir. Non-dipper hipertansiyonun dipper hipertansiyona göre daha yüksek mortalite ile ilişkili olduğu bilinmektedir. Bu nedenle, çalışmamızda kolayca hesaplanabilen LANR skorunun non-dipper hipertansiyonun tanısındaki ilişkisinin araştırılması amaçlanmıştır.
Materyal ve Metod: Bu çalışmaya bir kardiyoloji kliniğine başvuran ve hipertansiyon tanısı almış toplam 524 hasta dahil edilmiştir. Hastaların demografik verileri, 24 saatlik ambulatuvar kan basıncı monitörizasyonu sonuçları, ekokardiyografi ve laboratuvar verileri hastane arşivlerinden elde edilmiştir. LANR indeksini hesaplamak için lenfosit × albümin / nötrofil formülü kullanılmıştır. Hastalar LANR<23 ve LANR>23 olacak şekilde iki gruba ayrılmıştır.
Bulgular: Başlangıçtaki demografik özellikler ve laboratuvar parametreleri karşılaştırıldığında, nötrofil, lenfosit ve C-reaktif protein düzeyleri dışında iki grup arasında anlamlı bir farklılık saptanmamıştır. Non-dipper hipertansiyon grubunda CAR ve NLR değerleri yüksek, HALP ve LANR değerleri ise düşük bulunmuştur. Ayrıca, non-dipper hipertansiyon hastalarında prognostik süreci öngören faktörleri belirlemek amacıyla yapılan aşamalı çok değişkenli analizlerde CAR (odds oranı: 1.420, %95 güven aralığı: 1.106–1.823, P<0.001) ve LANR (odds oranı: 0.583, %95 güven aralığı: 0.493–0.690, P<0.001) bağımsız öngörücüler olarak tanımlanmıştır.
Sonuç: Bu çalışma, non-dipper hipertansiyon hastalarında dipper hipertansiyon hastalarına kıyasla daha düşük LANR ve HALP skorları ile daha yüksek CAR ve NLR skorlarının bulunduğunu göstermiştir. Ayrıca, LANR ve CAR indeksleri non-dipper hipertansiyon için bağımsız öngörücüler olarak belirlenmiştir. Ek olarak, LANR<23 olan hastalarda non-dipper hipertansiyon oranının LANR>23 olan bireylere göre anlamlı derecede daha yüksek olduğu saptanmıştır. Sonuç olarak, düşük LANR indeksi, non-dipper hipertansiyon hastalarını erken dönemde tanımlamak için kullanılabilecek bir erken uyarı modeli olarak değerlendirilebilir.

Anahtar Kelimeler: Lenfositler, Albümin, Nötrofiller, Dipper, Non-dipper, Hipertansiyon

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Introduction

Hypertension (HT) is characterized by persistently elevated blood pressure measurements in the systemic arteries. It is a modifiable risk factor for mortality and morbidity from all causes and cardiovascular disease worldwide (1,2). The pathophysiology of HT is multifactorial in etiology, involving both behavioral and environmental factors, genes, endocrine pathways, and different organ types (kidney, cardiovascular, and neurological systems) (3). HT pathologies in these systems are the underlying cause of the disease. When HT is not effectively controlled, it may lead to HT induced end-organ damage and adverse cardiovascular diseases.

In a healthy population, arterial blood pressure demonstrates a diurnal pattern, reaching a maximum in the morning and undergoing a gradual decrease throughout the day until a minimum is reached at night. This phenomenon is a result of the influence of the circadian rhythm on human biology and pathology (3). A significant proportion of the functional units of human metabolism are under the control of the biological clock and demonstrate a circadian rhythm. The term "diurnally oscillating systems" is employed to denote the vascular and cardiovascular systems, as well as blood pressure.

Twenty-four-hour ambulatory blood pressure monitoring (ABPM) is a significant diagnostic tool for assessing the daily rhythm of arterial blood pressure. Compared to other blood pressure measurement methods, ABPM provides superior prognostic value. A dipper hypertension pattern is defined as a decrease of more than 10% in nocturnal blood pressure compared to daytime levels. In contrast, a non-dipper HT pattern is characterized by a nocturnal blood pressure decline of less than 10% (4,5). Non-dipper HT has been associated with a higher incidence of cardiovascular morbidity and mortality (6). Although the exact pathophysiological mechanisms of non-dipper HT are not fully understood, current evidence suggests that increased inflammation and elevated platelet activity may contribute to its adverse outcomes, including end-organ damage and cardiovascular events (5,6).

Serum albumin concentration, an established biomarker for nutritional status, has been shown to have prognostic value in non-dipper HT patients, as reported in previous studies (5,6). The LANR index is a newly developed biomarker calculated using serum albumin level and neutrophil-to-lymphocyte ratio (NLR) (7). A number of prior investigations have demonstrated that the LANR index functions as an independent prognostic index in patients diagnosed with different malignancies and chronic obstructive pulmonary disease (7,8).

The HALP score, an innovative biomarker calculated as hemoglobin (g/L) × albumin (g/L) × lymphocytes (10^9/L) / platelets (10^9/L), was developed by Chen et al. in 2015 to prognosticate patients with gastric cancer. The HALP score, which is comprised of hemoglobin, albumin, lymphocytes, and platelets, has recently been defined as a marker reflecting the state of nutrition and inflammation, especially in geriatric patients.

A substantial body of research has demonstrated its capacity to serve as a significant predictor of mortality, particularly among patients afflicted with cancers of the stomach, bladder, prostate, and kidney, as well as stroke. Anemia and hypoalbuminemia are indicators of malnutrition, lymphocytes are indicators of inflammation, and high platelets are indicators of the risk of thromboembolism and atherosclerotic lesions. These indicators have been shown to be associated with mortality. However, a review of the literature revealed no studies that have examined the prognostic value of LANR and HALP Score in non-dipper HT patients.

A review of the literature has previously demonstrated a significant correlation between inflammatory biomarkers and various indices, as well as patient prognosis, in patients with non-dipper HT. Concurrently, earlier studies have demonstrated the prognostic value of parameters such as the neutrophil-to-lymphocyte ratio (NLR), C-reactive protein (CRP) to albumin ratio (CAR) in patients with non-dipper HT (9–11). The aim of the present study was to investigate the association between the LANR index and HALP score and non-dipper HT.

Although inflammatory biomarkers such as the NLR and CAR have previously been studied in the context of non-dipper hypertension, there is currently a lack of evidence regarding the prognostic utility of more comprehensive nutritional and inflammatory indices, such as the LANR index and HALP score, in this patient population. To the best of our knowledge, no prior studies have specifically evaluated the relationship between these novel biomarkers and non-dipper HT.

Therefore, the present study aims to fill this gap by investigating the association between the LANR index, HALP score, and the non-dipper blood pressure pattern. By exploring these newly developed indices, this study seeks to provide additional prognostic tools that may enhance the risk stratification and management of patients with non-dipper hypertension.

Materials and Methods

Study design and subject

The study was administered at a single medical center between 2024 and 2025.The participants of the study were selected through a retrospective observational study. The inclusion criteria for the study population were patients who had been diagnosed with HT by ABPM. Finally, the total population of the study comprised 524 patients diagnosed with HT. Patients with coronary artery disease, active malignancy, hyperthyroidism, mild or severe valvular disease, heart failure, chronic renal failure, left ventricular hypertrophy, chronic obstructive pulmonary disease, congenital heart disease, or active infection were excluded from the study. Patients for whom data could not be accessed and whose analyses failed to converge were excluded from the study. The local ethics committee approved the study protocol. The protocol was

prepared in accordance with the ethical guidelines for human experimentation of the Declaration of Helsinki (2013).

Data collection

The diagnosis of hypertension was made on the basis of office blood pressure measurements in accordance with the ESC 2024 guidelines, with systolic blood pressure (SBP) defined as ≥ 140 mmHg and diastolic blood pressure (DBP) as ≥ 90 mmHg (1) . Patients whose nocturnal blood pressure physiologically decreased by more than 10% compared to daytime values were classified as having dipper hypertension, whereas patients whose nocturnal blood pressure decreased by less than 10% or never decreased were classified as having non-dipper hypertension. For the diagnosis of non-dipper hypertension, 24-hour ABPM devices were used and hypertension was defined by ABPM as 24-hour mean blood pressure ≥ 135/85 mmHg during the day or ≥ 120/70 mmHg at night (1). Daytime measurements were taken at 15-minute intervals between 6:00 am and 10:00 pm, while nighttime measurements were taken at 30-minute intervals between 10:00 pm and 6:00 am. Patients were instructed to continue their daily routine and to avoid excessive physical activity during ABPM follow-up. Nocturnal BP fall has been calculated using the following formula Nocturnal systolic or diastolic BP fall (%) = (mean waking SBP/DBP- mean sleeping SBP/DBP) × 100/mean waking systolic BP (12).

Laboratory parameters

Following the acquisition of patients' baseline characteristics, a range of blood tests were performed. These included assessments of haemoglobin, creatinine, sodium, potassium, urea, uric acid, fasting plasma glucose, aspartate and alanine aminotransferase, albumin, CRP and thyroid-stimulating hormone. Furthermore, the NLR (Neutrophil / lymphocyte [10^9/L]), CAR (CRP [mg/dl] and Alb [g/L]), HALP (Haemoglobin [g/L] × Albumin [g/L] × Lymphocyte count [10^9/L] / Platelet count [10^9/L]) and LANR (lymphocyte [10^9/L] × albumin [g/L] / neutrophil [10^9/L]) were calculated from the haemoglobin and biochemical parameters.

Statistical analysis

All statistical analyses were performed using SPSS 22.0. Descriptive statistics were generated for categorical variables, with the frequency (percentage) of each category being calculated. The Kolmogorov-Smirnov test was applied to determine the normality of data. The data, which was normally distributed, was presented as the mean ± standard deviation and compared using an independent sample t-test. Non-normally distributed continuous data was presented as median (25^{th}-75^{th} interquartile range) and compared with Mann-Whitney U test. Stepwise multivariable logistic regression analysis was performed using univariate and multivariate models. Possible risk factors and included into the full multivariate model, and independent predictors were determined according to the multivariate logistic regression analysis. The optimal cut-off value and area under curve (AUC) of the NLR, CAR, HALP and LANR was determined with receiver.

Results

The study included a total of 524 hypertensive patients. According to the 24h holter recording, 245 (46.7%) patients had dipper HT while 279 (53.2%) patients had non-dipper hypertension. It was observed that the main characteristics were similar between the two groups. Only BMI was found to be higher in the non-dipper hypertension group (25.77 ± 3.63 vs. 27.24±4.07, P<0.001). Furthermore, 24-hour SBP was found to be higher in the non-dipper hypertension group than in the dipper hypertension group (150.01±9.65 vs. 152.44±12.68, P=0.015) (Table 1).

Table 1. Comparison of baseline characteristics of the study groups

	Dipper (n= 245)	Non-dipper (n= 279)	P
Age, years	53.0 ± 12.5	52.9 ± 12.4	0.945
Gender, male (%)	94 (38.4)	121 (43.4)	0.245
Diabetes mellitus (%)	31 (12.7)	45 (16.1)	0.260
Smoking (%)	87 (35.5)	86 (30.8)	0.255
KAH (%)	18 (7.3)	15 (5.4)	0.354
CVO (%)	8 (3.3)	5 (1.8)	0.279
BMI, kg/m²	25.77 ± 3.63	27.24 ± 4.07	**<0.001**
Hearth rate, /dk	78.01 ± 12,69	78.89 ± 11.47	0.409
24-h SBP, mmHg	150.01 ± 9.65	152.44 ± 12.68	**0.015**
24-h DBP, mmHg	86.00 ± 10.62	87.62 ± 12.63	0.114

BMI: Body mass index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; CAD: Coronary artery disease; CVO: Serebrovasküler olay (Cerebrovascular event); LVEF: Left ventricular ejection fraction; LVMI: Left ventricular mass index.

Laboratory variables of the study groups are presented in Table 2. There was no statistically significant difference between the laboratory parameters except CRP, neutrophils, lymphocytes, NLR, CAR, HALP and LANR (Table 2). CRP (1.60 [0.80-3.45] vs. 2.10 [1.20-4.40], P=0.004) and neutrophils (4.54 ± 1.94 vs. 5.30 ± 2.15, P<0.001) were higher in the non-dipper hypertension group, whereas lymphocytes (2.37 ± 0.74 vs. 2.21 ± 0.91, P=0.032) were higher in the dipper hypertension group (Table 2). In addition, NLR (1.79 [1.36-2.34] vs. 2.26 [1.73-3.40], P<0.001) and CAR (0.34 [0.18-0.79] vs. 0.51 [0.30-1.18], P<0.001) calculated by simple biochemical parameters were higher in the non-dipper hypertension group, whereas HALP (56.60 [40.50-72.30] vs. 41.10 [28.00-58.90], P<0.001) and LANR (25.68 [19.39-34.68] vs. 17.02 [11.35-24.72], P<0.001) were higher in the dipper hypertension group. All of these values are statistically significant (Table 2).

Table 2. Comparison laboratory parameters of the study groups

	Dipper (n= 245)	Non-dipper (n= 279)	P
Urea, mg/dl	29.17 ± 10.47	31.06 ± 11.67	0.053
Uric acid, mg/dl	5.18 ± 1.55	5.25 ± 1.45	0.604
Creatinine, mg/dl	0.86 ± 0.19	0.88 ± 0.41	0.411
Sodium, mEq/L	140.1 ± 2.71	140.2 ± 2.69	0.657
Potassium, mEq/L	4.39 ± 0.38	4.35 ± 0.39	0.221
AST, U/L	18.00 (13.25-22.00)	17.00 (13.00-21.00)	0.096
ALT, U/L	17.00 (13.00-23.00)	12.00 (17.00-25.00)	0.882
Albumin, g/dl	4.61 ± 0.39	3.98 ± 0.82	0.268
CRP, mg/dl	1.60 (0.80-3.45)	2.10 (1.20-4.40)	**0.004**
TSH, mU/L	1.91 ± 1.23	1.78 ± 1.53	0.286
WBC, x10³/µL	7.75 ± 2.24	7.99 ± 2.26	0.226
Neutrophil, x10³/µL	4.54 ± 1.94	5.30 ± 2.15	**<0.001**
Lymphocyte, x10³/µL	2.37 ± 0.74	2.21 ± 0.91	**0.032**
Hemoglobin, g/dl	13.65 ± 1.71	13.78 ± 1.76	0.069
Platelets, x10³/µL	262 (222-308)	274 (228-321)	0.158
TSH, mU/L	1.91 ± 1.23	1.78 ± 1.53	0.286
NLR	1.79 (1.36-2.34)	2.26 (1.72-3.40)	**<0.001**
CAR	0.34 (0.18-0.79)	0.51 (0.30-1.18)	**<0.001**
HALP	56.60 (40.50-72.30)	41.10 (28.00-58.90)	**<0.001**
LANR	25.68 (19.39-34.68)	17.02 (11.35-24.72)	**<0.001**

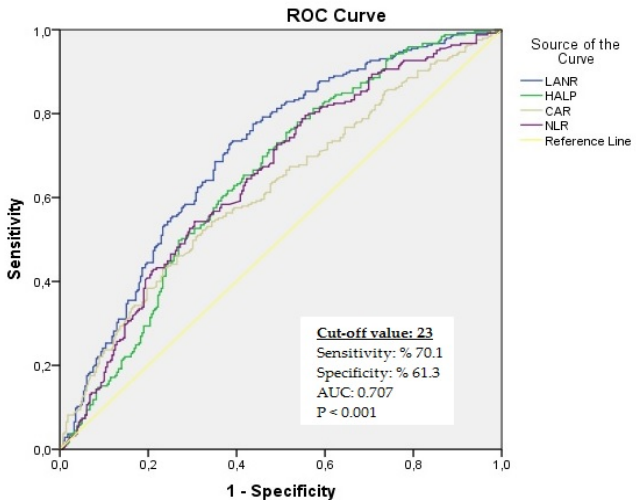
AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; CRP: C-reactive protein; TSH: Thyroid stimulating hormone; WBC: White blood cell; NLR: Neutrophil to lymphocyte ratio; CAR: C-reactive protein to albumin ratio; LANR: Lymphocyte × albumin / neutrophil ratio; HALP: Hemoglobin × albumin × lymphocyte / platelet score.

Table 3. Stepwise Multiple Linear Regression Analysis for Predictor of Non-dipper Hypertension

Variables	OR	95% confidence interval	P value
CAR	1.420	1.106-1.823	**0.006**
LANR	0.583	0.493-0.690	**<0.001**

CAR: C-reactive protein albumin ratio; LANR: Lymphocyte × albumin / neutrophil ratio

Stepwise multivariate analyses were used to determine the independent predictors of non-dipper status. Age, hemoglobin, smoking, NLR, CAR, HALP and LANR were included in stepwise multivariate regression analysis; only CAR (odds ratio: 1.420, 95% confidence interval: 1.106-1.823, P<0.001) and LANR (odds ratio: 0.583, 95% confidence interval: 0.493-0.690, P<0.001) were found to be independent predictors of non-dipper hypertension (Table 3). In addition, ROC analysis was performed to calculate the NLR, CAR, HALP and LANR cut off values and the best AUC to predict non-dipper hypertension. In the ROC analysis, LANR was found to be the best predictor of non-dipper hypertension. LANR ≤23 predicted the non-dipper status with a sensitivity of 71.9% and specificity of 61.3 (AUC:0.707, P<0.001) (Figure 1).



NLR: Neutrophil to lymphocyte ratio, CAR: C-reactive protein albumin ratio

Figure 1. ROC curve analysis of NLR, CAR, HALP, LANR scores for predicting the development of Non-dipper hypertension.

When our study population was divided into two groups according to this cut-off value (those patients with LANR ≤23 and LANR> 23), it was detected that the frequency of non-dipper status was significantly higher in patients with LANR ≤23 than in patients with LANR> 23 (P<0.001) (Figure 2).

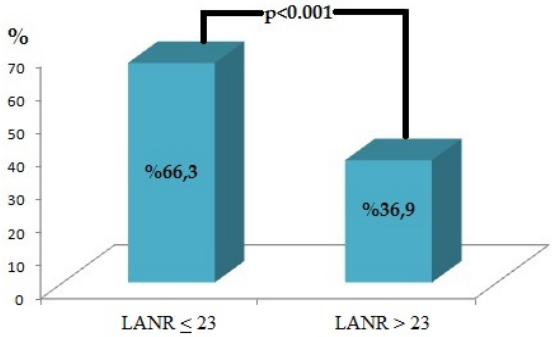


Figure 2. Comparison of the frequency of Non-dipper Hypertension between LANR score ≤23 and >23 groups.

Discussion

A comprehensive analysis of the study's outcomes revealed that patients with non-dipper hypertension exhibited significantly elevated levels of CRP, neutrophil, NLR, and CAR ratios, in contrast to those with dipper hypertension, who showed significantly lower levels of these indicators. Conversely, lymphocyte, HALP and LANR ratios were found to be significantly lower in non-dipper hypertensive patients when compared to dipper hypertensive patients. Using stepwise multivariable regression analysis, CAR and LANR were found to be independent predictors of non-dipper hypertension. In ROC analysis, a new immune-nutritional index LANR was found to be the best predictor of non-dipper hypertension with a sensitivity of 71.9% and specificity of 61.3% at a cut-off value of 23.

ABPM is a more valuable tool for demonstrating the diurnal rhythm of arterial blood pressure than conventional blood

pressure monitoring. The physiological dipper pattern is characterised by a mean decrease in nocturnal blood pressure of more than 10% relative to daytime blood pressure on a ABPM (4). A decrease of less than 10% in nocturnal blood pressure compared to daytime blood pressure is defined as non-dipper hypertension. This condition has been shown to be associated with a high incidence of cardiovascular mortality and morbidity (5,6). It is therefore important to reveal the pathophysiologic mechanisms that may be responsible for increased cardiovascular risk in order to prevent cardiovascular events, make early diagnoses and plan treatment. The primary pathophysiologic mechanism is thought to be platelet activation, atherosclerotic events and inflammatory responses. LANR, comprising lymphocytes, albumin and neutrophils, has been defined as a rapidly available, cost-effective laboratory hematology marker and an index of the immune system and inflammatory process. The present study shows that the LANR index is a powerful predictive parameter in patients with non-dipper hypertension. To the best of our knowledge, this is the first study to evaluate the prognostic significance of the LANR index in patients with non-dipper hypertension. However, given the rapidly evolving nature of scientific research, the possibility of prior unpublished or less widely recognized studies cannot be entirely excluded.

The term 'LANR' was first defined by Liang X. et al. (7), who demonstrated its value as a prognostic indicator in patients with resectable colorectal cancer. The study concluded that LANR may serve as a useful reference to help these patients decide on a treatment plan. Serum albumin levels have been shown to influence the circadian rhythm of blood pressure (13). Serum albumin levels are a vital indicator for assessing nutritional status and are negatively correlated with C-reactive protein levels. C-reactive protein has been identified as a significant inflammatory risk marker in the process of vascular atherosclerosis (3,13).

The HALP score was first introduced in 2015 by Chen et al (14) to prognostically predict gastric cancer patients. This score is a valuable tool in the field of oncology, providing researchers and clinicians with a novel method to assess the inflammatory status of patients. The study showed that the HALP score decreased significantly with poor immune response, suggesting that the HALP score may

be an important marker for assessing the inflammatory status of patients. A number of studies have previously examined the HALP score in cardiovascular patient groups. These studies have shown that a low HALP score has prognostic significance in predicting in-hospital mortality in cases of ST-elevation myocardial infarction, mortality in acute heart failure patients and overall mortality in cardiovascular diseases (15-17).

Previous studies have found that patients with non-dipper HT exhibit high CAR values and that CAR is independently correlated with non-dipper hypertension (10,18). Concurrently, one study revealed that patients diagnosed with non-dipper hypertension showed significantly higher NLR levels than cases of dipper hypertension (10). In addition, a separate relationship between HT and neutrophil levels was shown in one study (19). In our study, the fact that neutrophils and CRP were high in the non-dipper HT group and that NLR and CAR were high in the non-dipper HT group is an indicator of increased inflammation in the non-dipper HT group. Accordingly, the increased mortality in the non-dipper HT group can be attributed to this increased inflammation. All these parameters are in line with the literature (10,18,19). In addition, albumin shows antioxidant and anti-inflammatory properties (20,21). In our study, albumin was found to be lower in the non-dipper HT group, but this was not statistically significant.

As demonstrated in the present study, these results are consistent with the findings of preceding research. Specifically, the study found that neutrophil, NLR, CRP, and CAR levels were significantly elevated, while lymphocyte levels were reduced, in the non-dipper HT group. In fact, all these findings support the increased inflammatory response in non-dipper HT patients as suggested by studies in the literatüre (5,9,10,11,13). Due to the complex pathophysiology of non-dipper HT, the more inflammatory parameters are included in the scores used, the more accurate the results. In this context, neither NLR nor HALP seems to be an independent predictor of non-dipper HT. When CAR and LANR scores, which were found to be independent predictors of non-dipper HT in our study, were analysed, we found that LANR score showed non-dipper HT with a better sensitivity and specificity in the ROC analysis. Our study shows that LANR score, which is an inflammatory indicator in non-cardiac diseases and is associated with mortality, is a good indicator of inflammation in non-dipper HT patients. Thus, we think that the LANR score, which is calculated with simple biochemical parameters, will enable the early recognition of non-dipper HT patients and the related increase in mortality can be prevented.

In clinical practice, the LANR index may be considered an additional prognostic tool in the evaluation of hypertensive patients undergoing ambulatory blood pressure monitoring. Based on our findings, a LANR value below 23 could suggest a higher likelihood of exhibiting a non-dipper blood pressure pattern. Therefore, we propose that the LANR index could be particularly useful in hypertensive patients with suspected non-dipper profiles or those presenting with high cardiovascular risk. Patients with a LANR score below this threshold might benefit from closer monitoring, early therapeutic interventions, and more aggressive cardiovascular risk management strategies. Future prospective studies are warranted to further validate the clinical applicability of this cut-off value.

The present study was subject to some limitations. First, it was performed retrospectively with a relatively small number of patients. Retrospective studies inherently carry the risk of selection bias and information bias. Although strict inclusion and exclusion criteria were applied and patients were selected consecutively, the potential for unrecognized

confounding factors that may affect the results cannot be entirely excluded. Second, a longer follow-up period and collection of data on long-term prognosis could have provided additional information that would have increased the value of our study. Third, although chronic inflammatory disease, malignancy, and hematologic diseases were excluded, there may be patients who have not yet been diagnosed and these could not be excluded. Fourthly, the study did not include detailed data regarding the medical treatments received by the patients, such as antihypertensive therapies, statins, or anti-inflammatory agents. The absence of this information is a notable limitation, as certain medications could potentially influence systemic inflammation markers, serum albumin levels, or other laboratory parameters assessed in this study. Consequently, the lack of medication data may have introduced a degree of confounding that could affect the interpretation of the association between LANR and HALP scores and non-dipper hypertension. Nevertheless, considering that no statistically significant differences were observed in the demographic characteristics between groups, it is likely that the distribution of medical treatments was relatively balanced across the study groups. Finally, more detailed echocardiographic parameters and their correlation with the LANR index could have increased the clinical significance of the study.

In conclusion, the LANR score is a cost-effective, widely implemented, readily accessible, and reproducible test that has emerged as a marker of systemic inflammatory response. This evaluation may facilitate the diagnosis of non-dipper HT patients at elevated risk of cardiovascular incidents in the early stages, thereby enabling the implementation of an early treatment strategy to reduce complications. Although the predictive value of the LANR index demonstrated only moderate-to-high discriminatory power, it remains clinically significant and valuable when used in conjunction with other clinical parameters. In addition, we think that our study will shed light on prospective and large studies to be conducted in the future.

Ethical Approval: *Ethical approval of the study was obtained with the decision of Izmir Bozyaka Training and Research Hospital Health Research Ethics Committee dated 06.02.2025 and numbered 2025/14.*

Author Contributions:
Concept: H.F., A.N.E.
Literature Review: H.F., A.N.E.
Design : H.F, A.N.E., L.D.
Data acquisition: H.F, A.N.E., L.D.
Analysis and interpretation: H.F., A.N.E
Writing manuscript: H.F., A.N.E
Critical revision of manuscript: H.F., A.N.E
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