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The Correlation Between Serum Uric Acid/Albumin Ratio and Circadian Rhythm of Blood Pressure in Patients with Hypertension

Hipertansif Hastalarda Serum Ürik Asit/Albümin Oranı ile Kan Basıncının Sirkadiyen Ritmi Arasındaki İlişki

ABSTRACT

Objective: A non-dipping blood pressure (BP) pattern is commonly associated with an increased risk of adverse cardiovascular events. This study aimed to examine the relationship between a non-dipper circadian pattern and the serum uric acid/albumin ratio (UAR) in individuals with hypertension.

Method: This study included 340 consecutive patients who underwent ambulatory blood pressure monitoring (ABPM) from June 2022 to June 2023. Based on the circadian BP pattern obtained from 24-hour ABPM, patients were classified into two groups: dipper and non-dipper. The non-dipper group was defined based on a nighttime blood pressure decline of less than 10%.

Results: UAR levels were significantly higher in patients exhibiting a non-dipper pattern compared to those in the dipper group. Higher UAR rates were independently associated with the presence of a non-dipper pattern, as determined by multivariate logistic regression analysis. Receiver operating characteristic (ROC) curve analysis showed that UAR values above 1.30 had a sensitivity of 66.5% and a specificity of 65.9% for predicting the non-dipper pattern [area under the curve (AUC): 0.738, 95% confidence interval: 0.688 - 0.790; P < 0.001].

Conclusion: UAR is a readily obtainable and calculable biomarker for identifying patients prone to hypertensive patterns that do not decline at night. Thus, hypertensive patients at increased risk for future adverse atherosclerotic events can be identified and closely monitored, allowing for the application of more intensive treatment strategies.

Keywords: Circadian pattern, hypertension, non-dipper, uric acid/albumin ratio

ÖZET

Amaç: Non-dipper kan basıncı paterninin varlığı, artmış olumsuz kardiyovasküler hastalık riski ile ilişkilidir. Bu çalışmada, hipertansif hastalarda non-dipper sirkadiyen patern ile serum ürik asit/albümin oranı (ÜAR) arasındaki ilişkiyi değerlendirmeyi amaçladık.

Yöntem: Bu çalışmaya, Haziran 2022 ve Haziran 2023 tarihleri arasında ambulatuvar kan basıncı (KB) takibi yapılan toplam 340 ardışık hasta dahil edildi. Hastalar, 24 saatlik ambulatuvar kan basıncı ölçümünden elde edilen sirkadiyen kan basıncı paternine göre dipper ve non-dipper olarak iki gruba ayrıldı. Non-dipper grup, gece ölçülen kan basıncı değerinde %10'dan az düşme olarak tanımlandı.

Bulgular: Non-dipper paterne sahip hastaların ÜAR düzeyleri dipper gruba göre anlamlı derecede yüksek bulunmuştur. Çok değişkenli lojistik regresyon analizinde, daha yüksek ÜAR seviyelerinin, non-dipper paternin varlığıyla bağımsız olarak ilişkili olduğu bulunmuştur. ROC analizinde, 1,30'un üzerindeki ÜAR değerlerinin, non-dipper paternin öngörülmesinde sensitivitesi %66,5, spesifisitesi %65,9 olarak bulunmuştur [EAA(Eğri Altında Alan): 0,738, %95 Güven Aralığı: 0,688-0,790; P < 0,001].

Sonuç: ÜAR, dipper olmayan sirkadiyen KB modelini değerlendirmek için basit ve kolayca hesaplanabilir bir biyobelirteç olabilir. Böylece gelecekte istenmeyen aterosklerotik olaylar açısından yüksek risk taşıyan hipertansif hastalar tespit edilip yakından gözlemlenebilir ve bu hastalara daha yoğun tedavi seçenekleri uygulanabilir.

Anahtar Kelimeler: Sirkadiyen patern, hipertansiyon, non-dipper, ürik asit/albümin oranı

ORIGINAL ARTICLE
KLİNİK ÇALIŞMA

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Hypertension (HT) is widely recognized as the leading cause of preventable death worldwide.[1] The diagnosis of hypertension is typically based on repeated office blood pressure (BP) measurements; however, 24-hour ambulatory BP monitoring (ABPM) provides valuable data on circadian BP variations, including the prediction of cardiovascular (CV) events. Normally, nocturnal BP is expected to fall by more than 10% compared to daytime BP, a pattern known as "dipper BP." On the other hand, the non-dipper BP profile is characterized by a nighttime BP decline of less than 10%. High rates of endothelial dysfunction and inflammation are observed in non-dipper hypertension patients, leading to hypertension-mediated target organ damage, such as microalbuminuria, heart failure, left ventricular hypertrophy, and CV mortality.[2]

Since uric acid (UA) is a marker of inflammation, high serum uric acid levels increase vascular inflammation and oxidative stress, reduce nitric oxide bioavailability, and consequently lead to endothelial dysfunction.[3] These mechanisms can result in subclinical organ damage, as demonstrated by several studies indicating that elevated UA levels are correlated with atherosclerosis, which signifies vascular damage and serves as an independent prognosis factor for CV cases. Increased uric acid levels are widely recognized as a contributing factor to coronary artery diseases, atrial fibrillation, stroke, and heart failure, especially in hypertensive patients.[4] Serum albumin (SA), known as a negative acute-phase protein, plays a crucial role in maintaining oncotic plasma pressure and providing anti-inflammatory effects. An elevated inflammatory response has been linked to decreased SA synthesis and increased catabolism.[5] Thus, reduced SA levels can trigger blood viscosity and impair endothelial function.[6] Several studies have indicated a connection between low serum albumin levels and the non-dipper BP pattern.[7]

The serum uric acid to albumin ratio (UAR) has recently emerged as a novel indicator related to CV diseases.[8] Nonetheless, the association between serum UAR and the circadian rhythm of BP in patients with hypertension has yet to be explored. Consequently, this study aims to examine the relationship between the serum uric acid to albumin ratio and the circadian BP pattern in individuals with hypertension.

Materials and Methods

Study Population

Our single-center retrospective study included a total of 340 consecutive patients who presented to the cardiology department due to hypertension and underwent ABPM from June 2022 to June 2023. Patients were divided into two groups based on the circadian rhythm of BP obtained through 24-hour ABPM (dipping and non-dipping groups). Patients with a history of coronary artery disease, systemic inflammatory disease, chronic liver or kidney failure, those using pharmacological drugs that could affect serum uric acid levels, those with a history of secondary hypertension, and those with prior heart failure (ejection fraction [EF] < 50%) were excluded from the study.

Our study was conducted in accordance with the principles of the Helsinki Declaration, updated in 2013, and its protocol was approved by the Clinical Research Ethics Committee of Yozgat Bozok University (Approval Number: 2017-KAEK-189_2023.12.04_02, Date: 04.12.2023). Written consent could not be obtained from the participants since the study was designed retrospectively.

ABBREVIATIONS

ABPM	Ambulatory BP monitoring
AUC	Area under the curve
BP	Blood pressure
CV	Cardiovascular
EF	Ejection fraction
HT	Hypertension
NSTEMI	Non-ST-segment elevation myocardial infarction
ROC	Receiver operating characteristic
SA	Serum albumin
SBP	Systolic blood pressure
UAR	Uric acid/albumin ratio
WBC	White blood cell count

Ambulatory Blood Pressure Monitoring

Following the completion of 24-hour ABPM using the Schiller BR-102 plus (Switzerland), the findings were analyzed with the appropriate program. Daytime was defined as the period from 08:00 to 22:00, while nighttime was defined as the period from 22:00 to 08:00. Blood pressure measurements were recorded at fifteen-minute intervals during the day and thirty-minute intervals at night. Patients with valid measurements below 80% were excluded from the study.

Results obtained through ambulatory blood pressure measurement were evaluated based on the hypertension guidelines established by the European Society of Cardiology in 2018.[9] Thus, individuals with an average 24-hour systolic blood pressure (SBP) greater than 130 mmHg and/or diastolic blood pressure (DBP) exceeding 80 mmHg, an average daytime SBP over 135 mmHg and/or DBP above 85 mmHg, and an average nighttime SBP higher than 120 mmHg and/or DBP beyond 70 mmHg were diagnosed with hypertension.[9] The dipper and non-dipper patterns were defined as a nighttime blood pressure decrease of ≥ 10% and < 10%, respectively.

Laboratory Analysis

Details regarding patients' age, gender, cardiovascular risk factors, and laboratory evaluations (including complete blood counts and standard biochemical indicators) were documented from clinic records. Glucose, uric acid, albumin, sodium, and creatinine were measured using the Beckman Coulter AU 5800 autoanalyzer (Beckman Coulter Inc., USA). Complete blood count variables, including white blood cell count (WBC), platelet count, and hemoglobin, were analyzed using an automated blood cell counter (Beckman Coulter LH 750; Beckman Coulter, Inc., USA). The serum uric acid/albumin ratio was calculated by comparing the serum uric acid concentration to albumin levels.

Statistical Analysis

Statistical analysis of the study data was performed using the Statistical Package for the Social Sciences (SPSS) version 23.0 (IBM Corp, Armonk, NY, USA). The Kolmogorov-Smirnov test was used to assess the normal distribution of the data. Categorical variables were presented as percentages and numbers, while numerical

Table 1. Comparison of Baseline Characteristics and Laboratory Parameters Between Study Groups

Variables	Dipper Group (n = 170)	Non-Dipper Group (n = 170)	P
Baseline characteristics			
Age (years)	50.6 ± 13.2	55.0 ± 14.0	0.006*
Female gender, n (%)	104 (61.2)	106 (62.4)	0.823
Diabetes mellitus, n (%)	21 (12.4)	28 (14.5)	0.280
Smoking status (current), n (%)	78 (45.9)	90 (52.9)	0.193
Laboratory parameters			
FBG, mg/dL	97 (89-109)	101 (92-114)	0.035*
BUN, mg/dL	28 (22-34)	28 (24-36)	0.252
Creatinine, mg/dL	0.78 (0.65-0.91)	0.75 (0.62-0.91)	0.392
Uric acid, mg/dL	5.1 (4.5-5.7)	5.7 (5.0-6.7)	<0.001*
Sodium, mEq/L	139 (138-141)	140 (139-142)	0.001*
Potassium, mEq/L	4.3 (4.1-4.6)	4.4 (4.2-4.6)	0.532
Albumin, mg/dL	4.2 (4.0-4.4)	4.0 (3.8-4.2)	<0.001*
Triglycerides, mg/dL	134 (90-190)	132 (89-192)	0.730
Total cholesterol, mg/dL	208 ± 43	205 ± 51	0.626
HDL-C, mg/dL	49 (43-58)	49 (42-58)	0.727
LDL-C, mg/dL	126 ± 36	125 ± 42	0.775
WBC, 10^3/uL	7.3 (6.1-8.7)	7.4 (6.1-9.1)	0.539
Hemoglobin, g/dL	14.2 ± 1.3	13.9 ± 1.6	0.029*
Platelets, 10^3/uL	262 (228-321)	275 (232-316)	0.759
UAR	1.23 (1.04-1.34)	1.45 (1.22-1.65)	<0.001*

All values are expressed as mean ± standard deviation, median (25^{th}-75^{th} interquartile range), or number (%). *P < 0.05 indicates statistical significance. BUN, Blood Urea Nitrogen; FBG, Fasting Blood Glucose; HDL-C, High-Density Lipoprotein Cholesterol; LDL-C, Low-Density Lipoprotein Cholesterol; UAR, Uric Acid to Albumin Ratio; WBC: White Blood Cell Count.

variables were expressed as mean ± standard deviation or median (interquartile range 25-75), depending on the distribution pattern. The Chi-square test was used for categorical data analysis, while numerical variables between groups were compared using the Mann-Whitney U test and Student's t-test. After identifying variables through univariate analysis, multivariate regression analysis was performed using logistic regression to determine independent predictors of the non-dipper pattern. Additionally, receiver operating characteristic (ROC) curve analysis was conducted to identify the optimal cut-off value of the uric acid/albumin ratio in detecting the non-dipper pattern and to evaluate its sensitivity and specificity using the Youden index. A two-sided p value of less than 0.05 was considered statistically significant.

Results

A total of 340 patients [38.2% male (n = 130), 61.8% female (n = 210), mean age: 52.8 ± 13.8] were included in our study. The target population was divided into two groups based on circadian BP rhythm: dipper [61.2% female (n = 104), mean age: 50.6 ± 13.2] and non-dipper [62.4% female (n = 106), mean age: 55.0 ± 14.0]. Table 1 presents the comparison of laboratory results and clinical characteristics of each group. The average age of the non-dipping group was found to be higher than that of the dipping group (Table 1). No statistically significant differences were detected between the two groups in terms of diabetes mellitus and tobacco use. Fasting blood glucose, sodium, and uric acid levels were higher, while hemoglobin and albumin levels were lower in the non-dipping group compared to the dipping group. Additionally, UAR levels [1.45 (1.22 - 1.65) vs. 1.23 (1.04 - 1.34); P < 0.001] were found to be higher in the non-dipping group compared to the dipping group (Figure 1).

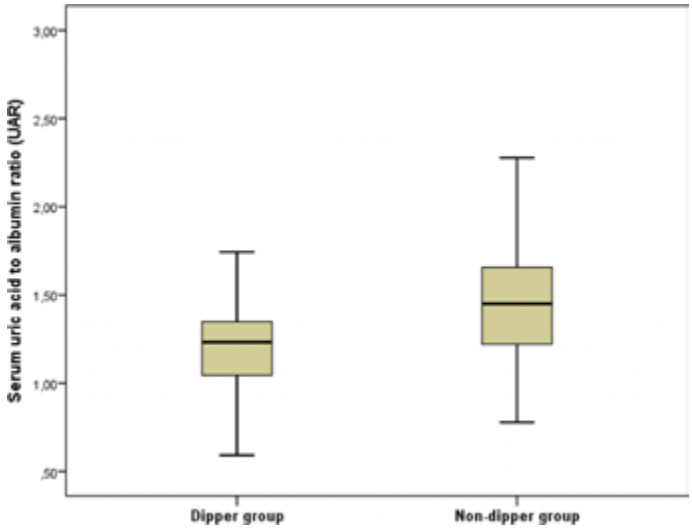

Figure 1. Comparison of the serum uric acid to albumin ratio (UAR) between the study groups.

Table 2. 24-Hour Ambulatory Blood Pressure Values of the Study Groups

Variables	Dipper Group (n = 170)	Non-Dipper Group (n = 170)	P
Daytime SBP (mmHg)	128 (121-139)	128 (122-137)	0.856
Nighttime SBP (mmHg)	111 (105-120)	125 (116-134)	<0.001
Daytime DBP (mmHg)	81 (75-89)	80 (74-88)	0.289
Nighttime DBP (mmHg)	68 (61-74)	75 (67-82)	<0.001
24-hour SBP (mmHg)	124 (117-133)	127 (121-136)	0.018
24-hour DBP (mmHg)	78 (72-85)	79 (73-86)	0.496

All values are expressed as median (25th-75th interquartile range). DBP, Diastolic Blood Pressure; SBP, Systolic Blood Pressure.

Table 3. Univariate and Multivariate Logistic Regression Analysis for Predictors of Non-Dipper Circadian Pattern in Hypertensive Patients

Variables	Univariate Analysis		Multivariate Analysis	
	OR (95% CI)	P	OR (95% CI)	P
Age	1.024 (1.008-1.041)	0.003	1.019 (0.998-1.041)	0.078
Hemoglobin	0.854 (0.740-0.985)	0.031	0.921 (0.783-1.082)	0.315
Fasting glucose	1.006 (1.000-1.012)	0.050	1.002 (0.996-1.009)	0.469
BUN	1.017 (0.997-1.038)	0.089	1.003 (0.978-1.028)	0.824
UAR	3.661 (2.644-9.612)	<0.001	2.007 (1.764-7.083)	<0.001

BUN, Blood Urea Nitrogen; CI, Confidence Interval; OR, Odds Ratio; UAR, Uric Acid to Albumin Ratio.

Table 2 presents the comparison of 24-hour ABPM values between the groups. The non-dipping group exhibited higher nighttime SBP, 24-hour SBP, and nighttime DBP levels compared to the dipping group (Table 2).

Multivariate logistic regression analysis identified the uric acid/albumin ratio (odds ratio: 2.007, 95% confidence interval: 1.764 - 7.083; P < 0.001) as an independent predictor of the non-dipper pattern (Table 3).

Following the evaluation with ROC analysis, the uric acid/albumin ratio was found to have diagnostic value in predicting the non-dipper pattern [AUC (area under the curve): 0.738, 95% confidence interval: 0.688 - 0.790; P < 0.001]. The sensitivity of the uric acid/albumin ratio in detecting the non-dipper pattern was 66.5%, the specificity was 65.9%, and the optimal cut-off value was 1.30 (Figure 2).

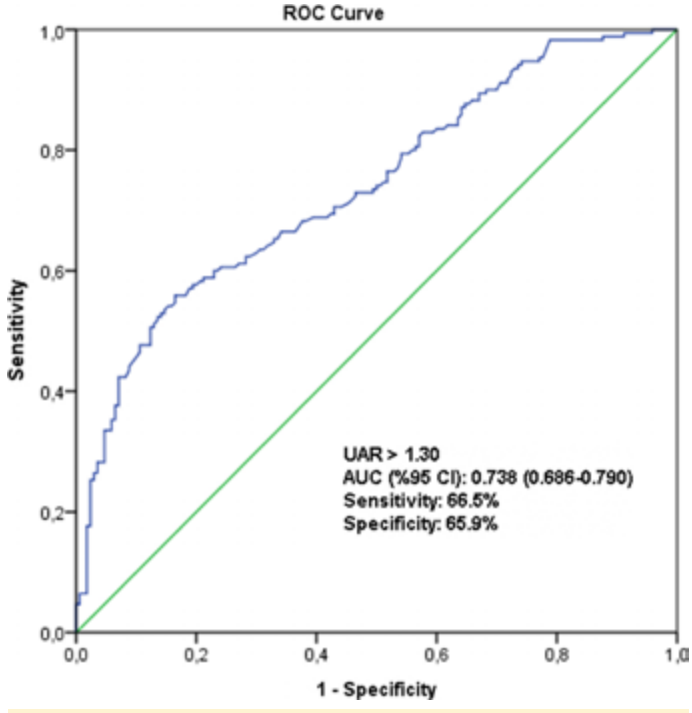

Figure 2. Receiver operating characteristic (ROC) curve analysis for predicting the non-dipper pattern using the serum uric acid to albumin ratio (UAR).

Discussion

UAR levels, which serve as an inflammation marker and can be easily calculated, were found to be significantly higher in individuals exhibiting a non-dipping pattern compared to those with a dipping pattern. Higher UAR levels in hypertensive patients were independently associated with the occurrence of the non-dipper pattern.

Blood pressure, heart rate, and heart tone exhibit circadian variations over a 24-hour cycle. Circadian BP patterns are classified as dipper and non-dipper based on whether there is a > 10% decrease in BP during the night. It is well established that the non-dipper blood pressure pattern is associated with target organ damage, including congestive heart failure, left ventricular hypertrophy, kidney damage (albuminuria), myocardial infarction, stroke, and increased CV mortality.[10] The negative impact of non-dipper blood pressure may be linked to endothelial dysfunction. High blood pressure triggers endothelial damage and promotes a pro-inflammatory state. As suggested by previous research, endothelial progenitor cell levels, which play a role in vascular repair and endothelial homeostasis, were lower in non-dipping patients compared to dipping hypertensive patients.[11]

Albumin has several important physiological functions in the body, including transporting various physiologically active substances, pH buffering, and providing antioxidant and anti-inflammatory effects.[12] A higher serum albumin level may protect against the development of hypertension and CV diseases, as hypertension is associated with endothelial damage, inflammation, and oxidative stress, while albumin has anti-inflammatory and antioxidant properties.[13] Several studies have shown that reduced serum albumin levels are associated with CV disorders such as coronary artery disease and atrial fibrillation.[14,15] In a study conducted by Ahbap et al.,[7] serum albumin levels were found to be independently associated with the occurrence of the non-dipper pattern. In our study, albumin levels in patients with a non-dipper blood pressure pattern were significantly lower than those in dipper patients.

Serum uric acid, another component of UAR, is the final oxidation product of endogenous purine metabolism.[16] High serum uric acid levels are associated with an increased risk of developing hypertension, independent of other risk factors.[17] Several mechanisms may contribute to the predictive value of uric acid in individuals with hypertension. First, elevated uric acid can promote the atherosclerotic process due to oxidative stress and inflammation.[18] Second, uric acid may induce a prothrombotic state and endothelial damage.[19] Both prothrombotic state and endothelial damage are key factors that accelerate the progression of hypertension. Uric acid is a strong predictor of all-cause mortality and future CV disorders in patients with acute hypertension.[20] In a study by Afsar et al.,[21] serum uric acid levels were found to be elevated in the non-dipping group compared to the dipping group. As a result of our research, similar to the literature, uric acid levels in individuals with a non-dipper blood pressure pattern were found to be significantly higher than those in the dipping group.

UAR has been investigated as a novel inflammatory and oxidative stress marker in cardiovascular disorders. In a study by Kalkan et al.,[8] UAR was identified as an independent predictor of mortality in individuals with ST-segment elevation myocardial infarction (STEMI). In research conducted by Çakmak et al.,[22] UAR was shown to be associated with the severity of coronary artery disorder and SYNTAX score (Synergy Between Percutaneous Coronary Intervention With Taxus and Cardiac Surgery Score) in patients with non-ST-segment elevation myocardial infarction (NSTEMI). In another study of NSTEMI patients by Nurkoç et al.,[23] serum UAR levels were suggested as an independent indicator of no-reflow occurrence in NSTEMI patients. These findings suggest that UAR may be a practical and accessible biomarker for determining the severity and prognosis of various diseases, particularly cardiovascular diseases.

However, this study had a few limitations. Due to its cross-sectional design, we were not able to obtain any follow-up data. Since the study was conducted retrospectively, factors such as missing data and selection bias may have influenced the results. Additionally, only a single measurement of uric acid and albumin levels, along with the uric acid/albumin ratio, was included in the analysis rather than serial measurements. This may be insufficient to assess the persistence of UAR over time. Finally, we were unable to include additional oxidative stress markers or inflammation-related conditions, such as insulin resistance and prediabetes, which could have strengthened the study's findings.

Conclusion

UAR may serve as an easily obtained and calculated biomarker for identifying patients prone to hypertensive patterns that do not decrease at night. Thus, hypertensive patients at high risk for future adverse atherosclerotic events can be identified, closely monitored, and considered for more intensive treatment options.

Ethics Committee Approval: Ethics committee approval was obtained from Clinical Research Ethics Committee of Yozgat Bozok University (Approval Number: 2017-KAEK-189_2023.12.04_02, Date: 04.12.2023).

Informed Consent: Written consent could not be obtained from participants since the study was designed retrospectively.

Peer-review: Externally peer-reviewed.

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