

Kuzminova N.V., Romanova V.O., Ivankova A.V., Lozinsky S.E., Shkarivskiy Yu.L.,
Savytska O.O., Kedyk I.O.

National Pirogov Memorial Medical University, Vinnytsya, Ukraine

24-HOUR BLOOD PRESSURE PROFILE PARAMETERS IN PATIENTS WITH STAGE III ESSENTIAL HYPERTENSION ACCORDING TO COMPLICATION TYPE

e-mail: kuzminova5517@gmail.com

This article presents the results of a study of 24-hour blood pressure profile parameters in patients with stage III essential hypertension according to complication type. The 24-hour blood pressure profile was assessed using ambulatory blood pressure monitoring data. Most patients with stage III essential hypertension were found to have abnormal 24-hour blood pressure profiles characterized by an insufficient or excessive nocturnal blood pressure decline or, conversely, a nocturnal blood pressure rise. Patients with higher blood pressure levels (grade 3 arterial hypertension) had more pronounced disturbances in the circadian pattern of diastolic blood pressure, accompanied by a greater increase in pulse pressure. A positive correlation was found between pulse pressure levels and a history of stroke in patients with stage III essential hypertension. The highest overall 24-hour and, in particular, nighttime systolic blood pressure levels were observed in patients with a history of stroke, whereas the lowest levels were recorded in patients with a history of both complications (myocardial infarction and stroke). Thus, patients with stage III essential hypertension exhibit altered 24-hour blood pressure regulation regardless of complication type, characterized by increases in the absolute values of systolic blood pressure, diastolic blood pressure, and pulse pressure, as well as in their variability and the proportion of abnormal 24-hour blood pressure profiles.

Key words: arterial hypertension, essential hypertension, 24-hour blood pressure profile, blood pressure variability, pulse pressure, complications of essential hypertension.

Кузьміна Н.В., Романова В.О., Іванкова А.В., Лозинський С.Е., Шкарівський Ю.Л.,
Савицька О.О., Кедик І.О.

ПОКАЗНИКИ ДОБОВОГО ПРОФІЛЮ АРТЕРІАЛЬНОГО ТИСКУ У ХВОРИХ НА ГІПЕРТОНІЧНУ ХВОРОБУ ІІІ СТАДІЇ, В ЗАЛЕЖНОСТІ ВІД ВИДУ УСКЛАДНЕННЯ

В статті представлені результати дослідження показників добового профілю артеріального тиску у хворих на гіпертонічну хворобу ІІІ стадії в залежності від виду ускладнення. Добовий профіль артеріального тиску вивчали за допомогою даних добового моніторингу артеріального тиску. Встановлено, що більшість хворих на гіпертонічну хворобу ІІІ стадії мають патологічні добові профілі артеріального тиску, які характеризуються недостатнім чи надмірним зниженням тиску вночі або навпаки його нічним підвищенням. Пацієнти з вищими значеннями артеріального тиску (з третім ступенем артеріальної гіпертензії) мають більш виразні порушення циркадності діастолічного артеріального тиску, що супроводжувалися суттєвішим зростанням пульсового артеріального тиску. Встановлений прямий кореляційний зв'язок між рівнем пульсового артеріального тиску у пацієнтів з ІІІ стадією гіпертонічної хвороби та наявністю мозкового інсульту в анамнезі. Найвищі рівні систолічного артеріального тиску загалом за добу і вночі зокрема відмічені у пацієнтів після мозкового інсульту, найнижчі ж – у хворих з «подвійним» ускладненням (інфаркт міокарда та мозковий інсульт) в анамнезі. Таким чином, у пацієнтів з гіпертонічною хворобою ІІІ стадії незалежно від наявного ускладнення спостерігаються зміни добової регуляції артеріального тиску, що характеризуються зростанням не лише абсолютних значень систолічного, діастолічного і пульсового тисків, а також їх варіабельності та збільшення частки патологічних добових профілів артеріального тиску.

Ключові слова: артеріальна гіпертензія, гіпертонічна хвороба, добовий профіль артеріального тиску, варіабельність артеріального тиску, пульсовий артеріальний тиск, ускладнення гіпертонічної хвороби.

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Arterial hypertension (AH) is a pathological condition characterized by a sustained elevation in systolic and/or diastolic blood pressure (BP). It represents not only an elevation above the accepted thresholds for normal BP but also a major risk factor for atherosclerotic cardiovascular disease and related mortality, making it one of the most pressing public health problems worldwide [7, 14].

Essential hypertension (EH) is the most common noncommunicable disease worldwide, including in Ukraine. According to WHO data from the large-scale STEPS epidemiological survey (2019), the age-standardized prevalence of AH among adults aged 30-79 years in Ukraine is 43 %,

corresponding to approximately 13.2 million people in this age range [1].

Blood pressure fluctuations over the course of 24 hours depend on numerous hormonal, metabolic, and neurohumoral factors [2]. Understanding these fluctuations in individual patients may help tailor antihypertensive therapy and identify the optimal timing of antihypertensive medication administration, taking drug pharmacodynamics into account, to improve the prevention of cardiovascular complications.

In their study, Sideris K et al. (2026) found that sustained systolic BP control and maintenance within the normal range were associated with lower risks of

all-cause mortality, cardiovascular events, heart failure, and composite cardiovascular outcomes across different populations and BP monitoring strategies [11].

As early as 2001, Elliot WJ reported meta-analysis findings demonstrating significant increases in the risks of myocardial infarction by 40 %, stroke by 49 %, and sudden cardiovascular death by 29 % between 6:00 and 12:00 compared with other time intervals [5]. However, the role of BP variability and the characteristics of the 24-hour BP profile in patients who have already experienced cardiovascular events remain insufficiently studied.

The purpose of the study was to assess the characteristics of 24-hour blood pressure profile parameters in patients with stage III essential hypertension according to complication type.

Materials and methods. We recruited patients between 2018 and 2024 during consultations at the Vinnytsia Regional Clinical Hospital n.a. M.I. Pirogov and Vinnytsia City Clinical Hospital No. 1, after they provided written informed consent to participate in the study.

The study included 150 patients with stage III EH (107 men and 43 women; mean age was 54.8 ± 0.7 years) and a control group of 30 apparently healthy individuals matched for age and sex, with no family history of AH. The basis for classifying EH as stage III was hypertension-related stage II-A of chronic heart failure (CHF) according to the Strazhesko–Vasilenko classification in 34 patients, previous myocardial infarction (MI) in 71 patients, previous stroke in 28 patients, and a history of both myocardial infarction and stroke (MI + stroke) in 17 patients. Only patients whose vascular complications (MI and/or stroke) had occurred more than 6 months previously were included in the study.

EH was diagnosed following a detailed inpatient clinical and instrumental assessment, including additional investigations to exclude secondary AH, in accordance with Guideline 00069, “Hypertension: investigations and initial treatment,” dated 7 March 2017; Order No. 384 of the Ministry of Health of Ukraine, “On the approval and implementation of medical and technological documents for the standardization of medical care for arterial hypertension,” dated 24 May 2012; and the European Society of Hypertension clinical guidelines (2023).

The exclusion criteria were severe cardiac rhythm and conduction disorders; stage II-B–III CHF according to the M.D. Strazhesko and V.Kh. Vasilenko classification; diabetes mellitus; kidney or liver disease with impaired function; III degree of obesity (BMI greater than 40 kg/m^2); heart defects with significant hemodynamic impairment; and chronic respiratory disease with respiratory failure. Following the assessment, patients with confirmed

secondary AH and those with uncomplicated EH (stages I and II) were excluded.

Ambulatory blood pressure monitoring (ABPM) was performed using an ABPM-04 device (Meditech, Hungary), programmed to measure BP every 15 minutes during the active daytime period (07:00–22:00) and every 30 minutes during the inactive nighttime period (22:00–07:00). The following ABPM parameters were assessed: mean 24-hour systolic BP (24-h SBP); mean 24-hour diastolic BP (24-h DBP); BP load, or the time index of elevated systolic and diastolic BP (SBP TI and DBP TI), expressed as the percentage of readings exceeding the BP thresholds (140/90 mmHg during the day and 120/80 mmHg at night); the diurnal indices of systolic and diastolic BP (SBP DI and DBP DI); 24-hour systolic and diastolic BP variability (SBP VAR and DBP VAR, respectively); and the rate of the morning BP surge (SBP MS and DBP MS) between 05:00 and 10:00, defined as the difference between the maximum and minimum values. ABPM parameters were analyzed in accordance with the recommendations of the European Society of Cardiology [12].

The results were analyzed using parametric and nonparametric statistical methods in Microsoft Excel and Statistica for Windows 10.0. The findings are presented as the median and interquartile range, Med (kvar_1; kvar_3), where Med denotes the median and kvar_1 and kvar_3 denote the first and third quartiles and percentiles, respectively. Categorical variables (%) were compared between groups using the χ^2 test, and sample values were compared using the nonparametric Mann–Whitney test. Relationships between individual parameters were assessed using nonparametric Kendall correlation analysis.

Results of the study. In patients with stage III EH, daytime SBP and DBP were significantly higher than nighttime values ($p < 0.001$). Marked 24-hour fluctuations in SBP and DBP did not result in substantial changes in pulse pressure (PP), whose mean 24-hour value was 63.0 (55.0; 70.0) mmHg. There was no significant difference in PP between daytime and nighttime ($p > 0.05$), although PP was significantly higher than in the control group ($p < 0.001$).

Daytime SBP and DBP variability was slightly higher than nighttime variability. The 24-hour SBP variability values were slightly higher than those for DBP. The DBP diurnal index exceeded the SBP diurnal index by 57.1 % ($p < 0.001$).

Analysis of the circadian SBP pattern showed a normal profile (dipper) in slightly more than one-third of patients (36.0 %). An insufficient nocturnal decline (non-dipper) was the most common pattern (45.3 %); a nocturnal SBP rise (night-peaker) was observed in 12.7%, and an excessive nocturnal decline (over-dipper) in 6.0 % of patients.

Assessment of the 24-hour DBP profile identified a normal type (dipper) in 27.3 % of patients. The vast majority of patients (46.7%) had an insufficient nocturnal DBP decline (non-dipper), 11.3 % had a nocturnal DBP rise (night-peaker), and 14.7 % had an excessive nocturnal decline (Fig. 1).

Grade 2 AH predominated among the patients examined, occurring in 103 (68.7 %) patients; grade 3 AH was present in 42 (28.0 %) and grade 1 AH in 5 (3.3 %) patients. Increasing AH grade was accompanied by increases in 24-hour SBP, PP, and SBP and DBP variability, together with disturbances in the 24-hour BP rhythm. ABPM assessment in patients with grade 3 AH showed a significant elevation in BP, predominantly in systolic values (24-hour, daytime, and nighttime), resulting in a substantial increase in PP, particularly at night (by 13.6 %, $p<0.05$). SBP and DBP variability in patients with grade 3 AH exceeded that in patients with grade 2 AH; nighttime SBP variability was significantly

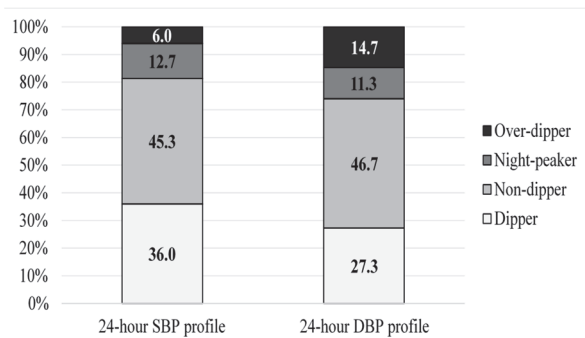


Fig. 1. 24-hour blood pressure profile in patients with stage III essential hypertension.

Analysis of ABPM parameters in patients with stage III EH according to complication type showed that the highest 24-hour, daytime, and nighttime SBP and DBP levels occurred in patients with a history of stroke. Patients with hypertension-related stage II-A CHF also had higher SBP and DBP values throughout the 24-hour period ($p<0.05$) than patients with previous MI or both MI and stroke. The lowest 24-hour SBP and nighttime SBP and DBP values were recorded in the most severely affected group, namely patients with a history of both complications. A history of a cerebrovascular event was associated with higher SBP and DBP values, the highest PP values, reflecting the so-called “hemodynamic impact,” and more substantial disturbances in the 24-hour BP profile.

Assessment of PP according to EH complication type showed elevated values in all patient groups compared with controls ($p<0.05$). The highest levels were observed in patients with previous stroke and the lowest in those with previous MI. In addition, positive correlations were found between 24-hour and daytime PP and a history of stroke ($r=0.33$, $p=0.007$ and $r=0.35$, $p=0.001$, respectively).

higher in the grade 3 group (by 14.3 %, $p<0.05$) than in the grade 2 group.

Most patients had an abnormal 24-hour profile of both SBP and DBP regardless of the degree of BP elevation; however, disturbances in the circadian DBP pattern were more pronounced in grade 3 AH (Fig. 2). In patients with grade 3 AH, an adequate nocturnal decline in SBP and DBP (dipper profile) was found in only 40.5 % and 23.8 % of cases, respectively; an insufficient decline (non-dipper) in 42.9 % and 50.0 %; an excessive decline (over-dipper) in 2.4 % and 19.1%; and a nocturnal BP rise (night-peaker) in 14.3 % and 7.1 % of patients, respectively. In patients with grade 2 AH, the SBP and DBP dipper profiles were observed in 35.0 % and 28.2 % of cases, respectively; non-dipper profiles in 47.6 % and 46.6 %; over-dipper profiles in 6.8 % and 13.6 %; and night-peaker profiles in 10.7 % and 11.6 % of cases, respectively.

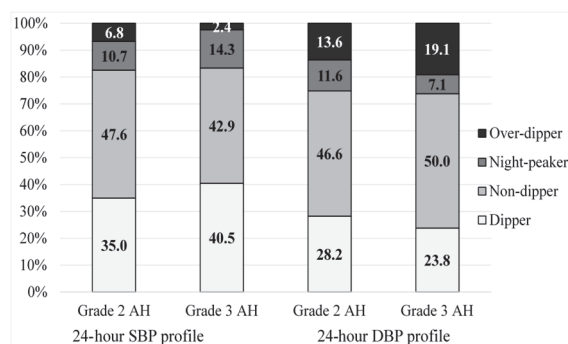


Fig. 2. 24-hour blood pressure profile in patients with stage III essential hypertension according to arterial hypertension grade.

SBP variability did not differ significantly between groups according to complication type, unlike DBP variability: the highest nighttime DBP variability was observed in patients with previous MI and the lowest in those with a history of both vascular events (MI and stroke). The SBP and DBP diurnal indices were highest in patients with a history of both MI and stroke, at 13.5 (7.5; 19.0) and 15.5 (9.5; 25.5), respectively.

Regardless of complication type, patients with an insufficient nocturnal decline in SBP and DBP (non-dipper profile) predominated in the study population. Among the distinctive features of the 24-hour BP profile in patients with different EH complications, approximately one in two patients (52.9 %) in the group with both vascular conditions (MI and stroke) had an insufficient nocturnal SBP decline (non-dipper profile), whereas no patients (0 %) had a nocturnal SBP rise (night-peaker profile). By contrast, the group with a history of stroke included a substantial proportion of patients with a nocturnal SBP rise (night-peaker profile) and an excessive nocturnal DBP decline (over-dipper profile), each accounting for 21.4 % of patients (Figs. 3A and 3B).

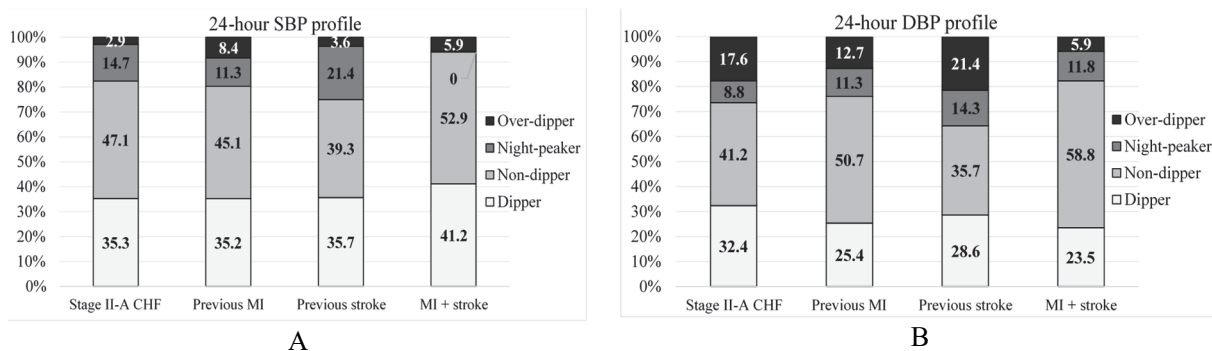


Fig. 3. A – 24-hour systolic blood pressure profile in patients with stage III essential hypertension according to complication type. B – 24-hour diastolic blood pressure profile in patients with stage III essential hypertension according to complication type.

Discussion. As noted above, patients with stage III EH had elevated SBP and DBP levels, resulting in a substantial increase in PP, an indicator of increased large-artery stiffness and pressure loading of the left ventricular myocardium. PP showed little variation over the course of 24 hours and exceeded 60 mmHg. According to the literature, this may contribute to myocardial ischemia and heart failure and increase the risks of all-cause and cardiovascular mortality, thereby worsening patient prognosis [9, 15].

Increased BP variability, the degree of BP elevation, and the absence of an adequate nocturnal BP decline affect the structural and functional status of target organs, primarily the heart and blood vessels. These factors contribute to endothelial dysfunction, hypertrophy of the large-artery walls and myocardium, and the development and progression of atherosclerosis in major arterial territories, collectively leading to cardiovascular events and death [4, 6, 8, 10, 13].

Circadian BP changes in patients with EH are related not only to daily fluctuations in the biochemical and physiological processes that directly determine BP but also to the effectiveness of drug therapy. All 4 processes underlying drug pharmacokinetics (absorption, distribution, metabolism, and excretion) exhibit circadian rhythms

that may influence therapeutic efficacy and toxicity depending on the timing of administration [2].

Analysis of ABPM parameters in patients with stage III EH according to complication type showed the most pronounced abnormalities in the group with a history of stroke. A previous cerebrovascular event was associated with higher absolute SBP, DBP, and PP values and a higher frequency of abnormal 24-hour BP profiles. The positive correlations identified between 24-hour and daytime PP and a history of stroke ($r=0.33$, $p=0.007$ and $r=0.35$, $p=0.001$, respectively) may indicate a role for PP in cerebral vascular remodeling and the development of cerebrovascular complications, as also suggested by other authors [3, 16].

Thus, patients with stage III essential hypertension exhibit altered 24-hour BP regulation regardless of complication type, characterized by increases in the absolute values of SBP, DBP, and PP, as well as in their variability and the proportion of abnormal blood pressure profiles. Identifying the characteristics of blood pressure variability in each patient with essential hypertension may improve cardiovascular risk stratification and enable antihypertensive treatment regimens to be individualized with consideration of drug pharmacokinetics.

Conclusion

In patients with stage III essential hypertension, analysis of ABPM parameters reveals increases in absolute SBP and DBP values and their variability, as well as elevated PP, which may contribute to structural and functional changes in target organs, primarily the heart and large arteries.

Patients with complicated hypertension have an increased proportion of abnormal 24-hour BP profiles. An adequate nocturnal SBP decline was observed in slightly more than one in three patients (36.0 %), whereas an adequate DBP decline was observed in approximately one in four (27.3 %).

Increasing AH grade in patients with stage III essential hypertension is characterized predominantly by higher SBP levels, resulting in a greater increase in PP, particularly at night. Patients with grade 3 AH exhibited more pronounced disturbances in the circadian DBP pattern.

The highest 24-hour, daytime, and nighttime SBP and DBP levels were found in patients with a history of stroke, resulting in the highest PP levels, supported by the positive correlation identified between PP and a history of stroke. The lowest 24-hour SBP and nighttime SBP and DBP values were recorded in the most severely affected group, namely patients with a history of both complications.

Future research directions. Further research in this area will improve cardiovascular risk stratification in patients with complicated essential hypertension and enable their antihypertensive therapy to be individualized by synchronizing drug pharmacokinetic characteristics with the patient's 24-hour BP profile.

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Conflict of interest. The authors have no conflicts of interest to declare.

ORCID: Kuzminova N.V. <https://orcid.org/0000-0003-4718-8218>, Romanova V.O. <https://orcid.org/0000-0002-1881-2811>, Ivankova A.V. <https://orcid.org/0000-0001-7344-6503>, Lozinsky S.E. <https://orcid.org/0000-0003-2401-5402>, Shkarivskyi Yu.L. <https://orcid.org/0000-0003-3005-4280>, Savyt'ska O.O. <https://orcid.org/0009-0005-0327-4634>, Kedyk I.O. <https://orcid.org/0000-0001-6420-6583>.

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