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Characteristic of 24-Hour Blood Pressure Dipping Patterns in Hypertensive Stroke Patients

Linh Tran Pham[1], Si Dung Chu[2,3], Hien Van Hoang[4]

[1]Department of C5, Vietnam Heart Institute, Bach Mai Hospital, Hanoi, Vietnam; [2]Training and Direction of Healthcare Activities Center, Bach Mai Hospital, Hanoi, Vietnam; [3]Hospital of Vietnam National University (VNU), VNU, Hanoi, Vietnam; [4]Master of Cardiology in the Course of 27st, Hanoi Medical University, Hanoi, Vietnam

Correspondence: Si Dung Chu, Hospital of Vietnam National University, Vietnam National University, Hanoi, Vietnam, Tel +84 906086168, Email sichu.bvbachmai@gmail.com; dr.swiss.zhu@gmail.com

Objective: We conducted a study titled for Investigation on the characteristics of 24-hour blood pressure (BP) dipping patterns in hypertensive stroke patients.

Methods: Descriptive research, analysis, and comparison, the research was conducted from July 2019 to September 2020 at the Vietnam Heart Institute - Bach Mai Hospital. There are 100 patients diagnosed with idiopathic hypertension who were divided into two groups (without stroke complications and another group with chronic stroke complications > 6 weeks), both groups were similar in age (45–64 years old).

Results: The daytime systolic BP (SBP) indices, 24-hour BP including SBP, diastolic BP (DBP), and mean arterial pressure (MAP), and particularly night-time BP indices were elevated in the stroke group compared with those without stroke complications ($p < 0.05$); there were no significant differences observed in daytime DBP and MAP between the two groups. SBP indices were higher in those with hemorrhage stroke compared with those with ischemic stroke, albeit without statistical significance. The prevalence of non-dipper was significantly higher in the stroke group compared with the non-stroke group ($p < 0.001$).

Conclusion: The daytime SBP indices, 24-hour BP (SBP, DBP, MAP), and particularly night-time BP indices were elevated in the stroke group compared with those without stroke complications. The prevalence of non-dipper was significantly higher in the stroke group compared with the non-stroke group.

Keywords: characteristic, dipper, hypertension, stroke complications, 24-hour BP

Introduction

Hypertension is a critical cardiovascular condition that poses a significant threat to global health.[1] The prevalence of hypertension appears to be on the rise and is affecting younger demographics.[1,2] Hypertension is a significant risk factor for serious cardiovascular events, including stroke. Stroke represents a cardiovascular-neurological emergency that is frequently severe, life-threatening, and results in significant long-term consequences for patients. Numerous studies worldwide indicate a marked increase in the incidence of stroke among hypertension patients. According to statistics from Kannel et al, individuals with no prior health issues experience stroke rates of 1.7% in men and 0.8% in women, which rise to 5.2% in men and 3.5% in women among those with hypertension.[1,3]

Controlling blood pressure (BP) in stroke patients during the acute phase significantly affects treatment outcomes and long-term prognosis because elevated BP during this period[4] can exacerbate the severity of damage to the brain. During the chronic stage of stroke (> 6 weeks), it is crucial to maintain optimal control of BP to mitigate the risk of stroke recurrence or deterioration, and to enhance long-term prognosis.

Continuous monitoring of BP in stroke patients using a Holter BP monitor for 24 hours is a convenient and compact method that enables close monitoring of BP parameters, identifying peak levels during the daytime and night-time, as well as night-time dipper patterns (an average decrease in BP at night of 10.0–20.0% compared with daytime levels).[5–10]

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Accordingly, physicians can assess the patient's BP rhythm, enabling effective management to enhance treatment efficacy and long-term prognosis for patients.[11–13]

Numerous studies have highlighted the advantages of dipping in reducing cardiovascular events.[14,15] This indicator has also been examined in acute stroke patients, aiding in more precise BP regulation to mitigate widespread damage during this critical stage. So we conducted a study on "characteristics of 24-hour blood pressure (BP) dipping patterns in hypertensive stroke patients" to evaluate this indicator during the chronic stage of stroke, which is crucial for physicians to develop an optimal BP management plan and reduce the risk of complications recurring.

Materials and Methods

Research Design

Descriptive research with analysis and comparison. The research was conducted from July 2019 to September 2020 at the Vietnam National Heart Institute - Bach Mai Hospital.

Research Subjects

Patients diagnosed with idiopathic hypertension were divided into two groups at Bach Mai Hospital: one group without stroke complications and another group with chronic stroke complications (> 6 weeks). Both groups were similar in age (45–64 years old), which is the most common age range for idiopathic hypertension. The target BP for both groups was < 130/80 mmHg, and they were receiving the same combination treatment of amlodipine and Angiotensin-converting enzyme (ACE) inhibitors, ranging from 5–10 mg.

Sample Size

A convenient sample size of 100 hypertension patients can be chosen, comprising 50 patients with a history of chronic cerebrovascular accident (> 6 weeks) as the case group and 50 patients without cerebrovascular accident complications as the control group.

According to the WHO (World Health Organization) and CDC (Centers for Disease Control and Prevention) – National Center for Health Statistics most recently, the rate of hypertension surveyed in 2017–2018 year in adults was about 45.4%.[16] According to the same size calculation formula of the cross-sectional descriptive study and the allowable error d = 0.15 (15.0%),[17,18] the minimum sample size for a meaningful study is n = 43. Therefore, the sample size for the analysis in this study of ours is to ensure a meaningful algorithm.

Conducted Method

Patients with idiopathic hypertension are divided into two groups: Disease group (chronic stroke) and control group (without stroke) as above, wearing a Holter BP monitor for 24 hours which was set with continuous measurement of 30 minutes/time - day, 60 minutes/time during night-time.

Daytime BP readings are calculated between 6:00 (AM) and 9:59 (PM), while night-time BP readings are calculated from 10:00 PM to 5:59 AM. The thresholds for hypertension are predefined in the BP analysis program as follows: for 24-hour BP, the threshold is 130/80 mmHg, for daytime BP it is 135/85 mmHg, and for night-time BP it is 120/70 mmHg.[19–23]

Objective: To investigate dipper characteristics in hypertension patients with stroke complications using 24-hour Holter BP monitoring.

Research Variables and Indicators

Record measurements for systolic BP (SBP), diastolic BP (DBP), mean arterial pressure (MAP), and take MAP:[5,6,8–10] Daytime BP (Including mean SBP, DBP, MAP, calculated from 6:00 (AM) to 21:59 (PM), Night-time BP (Including mean SBP, DBP, MAP, calculated from 22:00 (PM) to 5:59 (AM), 24-hour BP (Include mean SBP, DBP, and MAP over 24 hours).[19–23]

Observation: Dipper (Patients whose night-time SBP and DBP decrease by ≥ 10% compared with their daytime SBP and DBP), Extreme dipper (Patients whose night-time SBP and DBP decrease by more than 20.0% compared with their

daytime SBP and DBP), Non-dipper (Patients whose night-time SBP and DBP decrease by less than 10.0% compared with their daytime SBP and DBP), Reverse dipper (Patients whose night-time SBP and DBP are higher than those during the daytime), Morning BP surge (Patients whose SBP and DBP increase by at least 20/15 mmHg from their lowest BP during sleep to the average of the first 2 hours after awakening).[19–23]

Data Analysis

Data analysis was conducted using IBM SPSS 25.0 software. Qualitative variables were presented as percentages. Differences were assessed using the chi-square test (x^2) when expected frequencies were ≥ 5, and Fisher's exact test for frequencies < 5. Quantitative variables were described using mean values and standard deviations. Comparisons between control and disease groups were performed using the *T*-test. Logistic regression models were utilized to explore relationships between independent and dependent variables. Statistical significance was set at $p < 0.05$ for all tests.

Results

General Characteristics of the Research Subjects

Out of the total 100 research participants, 53 were in the 45–54 age range, comprising 53.0% of the cohort, while 47 were in the 55–64 age range, accounting for 47.0%. Among the control group of 50 hypertension individuals without stroke complications, 76.0% were aged 45–54, and 24.0% were aged 55–64. Conversely, in the case group with stroke complications, 70.0% of individuals were in the 55–64 age range, with the remaining 30.0% in the 45–54 age range. Therefore, the proportion of participants aged 55–64 was higher in the case group compared with those aged 45–54.

The average age of participants in the stroke group was 57.0 ± 6.7 years, which was significantly higher than the average age of 53.2 ± 4.6 years in the control group ($p < 0.05$), indicating a significant age difference between the two groups.

In the research, women constituted a higher proportion than men in both groups: 45.0% men and 55.0% women, $p = 0.84$ (> 0.05).

Body Mass Index (BMI) rates were relatively similar across the research groups. The proportion of participants with normal BMI (18.5–22.9) was 50.0% in the control group, 46.0% in the stroke group, and 48.0% overall.

The rate of overweight and obesity combined was 43.0%. Specifically, the stroke group had a higher rate of 48.0% compared with 38.0% in the control group, although this difference was not statistically significant, $p = 0.295$ (> 0.05).

Abdominal obesity was more prevalent in the stroke group (66.0%) compared with the control group (46.0%), $p = 0.044$ (< 0.05).

The prevalence of diabetes was significantly higher in the stroke group (64%) compared with the control group (24.0%) ($p < 0.001$). Dyslipidemia was more prevalent in the case group (76.0%) compared with the control group (30.0%) ($p < 0.001$).

Brain Damage Imaging

Among patients with hypertension and stroke complications, 66% had ischemic stroke, which was higher than the 34% with hemorrhagic stroke.

NIHSS Scores of Subjects in the Group with Complications

The study subjects having NIHSS scores in the mild and moderate groups are at virtually the same rate with mild severity (< 5 points) at 48.0% and moderate severity (5–9 points) iat 52.0%.

Detailed characteristics of night-time dipper in hypertension patients with chronic stroke complications using 24-hour BP monitoring

The BP indices of the disease group were all higher than the control group. Only daytime diastolic BP and MAP between the two groups did not have a statistically significant difference ($p > 0.05$). Daytime SBP, 24-hour BP indices (SBP, DBP, MAP) and especially night-time BP indices of the disease group all increased significantly compared with the control

group with $p < 0.05$. Except for daytime DBP and MAP between the two groups, there was no statistically significant difference ($p > 0.05$).

There was no statistically significant difference in BP indices between subjects with hemorrhagic stroke and those with chronic hemorrhagic stroke within the disease group ($p > 0.05$).

The prevalence of non-dipper in the stroke complications group was 86.0%, significantly higher compared with 22.0% in the control group ($p < 0.05$). However, there were no statistically significant differences between the control and case groups in terms of depression index (control group 4.0%, disease group 2.0%), reverse dipper (control group 10.0%, case group 24.0%), and morning BP surge (control group 60.0%, disease group 46.0%) ($p > 0.05$).

There was no statistically significant difference between patients with hemorrhagic stroke and ischemic stroke ($p > 0.05$) in terms of BP depression, reverse dipper, and morning BP surge characteristics.

Discussion

24-Hour BP results of Two Disease and Control Groups

The research findings presented in Table 1 indicate that aside from daytime diastolic BP and MAP, where no statistically significant difference was observed between the disease group and the control group ($p > 0.05$), all other BP indices such as maximum daytime BP, 24-hour BP (systolic, diastolic, MAP), and particularly night-time BP, were significantly higher in the case group compared with the control group ($p < 0.05$).

Following a stroke, patients frequently experience increased pressure hindering blood flow due to brain parenchymal damage, which elevates resistance and triggers a hypertension response to maintain adequate blood perfusion. Both clinical observations and experimental research indicate that damage to cortical structures and the brain's amygdala plays a pivotal role in this process. Such damage disrupts the balance between sympathetic and parasympathetic nervous system activities, leading to heightened levels of circulating catecholamines, thereby contributing to hypertension.[24]

These findings align with the pathophysiology of stroke and the study by Castilla-Guerra.[25] In that study, which monitored 101 stroke patients using 24-hour BP Holter monitoring at 24 hours, 6 months, and 12 months post-stroke, it was observed that MAP levels remained elevated above normal levels in 74.6% of the patients.

24-Hour BP Monitoring of Two Groups of Hemorrhagic Stroke and Ischemic Stroke

The research findings (Table 2) indicated that the BP levels in the hemorrhagic stroke group were higher than those in the ischemic stroke group, although this difference was not statistically significant ($p > 0.05$). According to research by Avraham Weiss et al,[26] during the acute phase, BP tends to be higher in the hemorrhagic stroke group compared with the ischemic stroke group, which is considered a beneficial response to maintain perfusion because hemorrhagic stroke

Table 1 24-Hour BP Monitoring Results of Stroke and Control Group

Hypertension Time \ Group		Control Group (n = 50)	Disease Group (n = 50)	P (*T*-test)
Daytime BP (mmHg)	Systolic BP	120.3 ± 12.1	125.8 ± 13.5	0.034
	Diastolic BP	78.2 ± 10.3	81.7 ± 10.9	0.108
	Mean arterial pressure	92.3 ± 10.5	96.4 ± 10.9	0.057
Night BP (mmHg)	Systolic BP	109.0 ± 15.4	122.0 ± 15.4	<0.001
	Diastolic BP	69.8 ± 10.9	78.4 ± 11.7	<0.001
	Mean arterial pressure	82.3 ± 12.0	92.9 ± 11.9	<0.001
24h-hour BP (mmHg)	Systolic BP	117.7 ± 13.4	121.4 ± 14.5	0.019
	Diastolic BP	76.6 ± 9.9	81.8 ± 13.9	0.033
	Mean arterial pressure	90.4 ± 10.5	96.0 ± 13.1	0.018

Table 2 24-Hour BP Monitoring of 2 Groups: Hemorrhagic Stroke and Ischemic Stroke

Hypertension Time \ Disease Group		Hemorrhagic Stroke (n = 17)	Ischemic Stroke (n = 33)	P (*T*-test)
Daytime BP (mmHg)	Systolic BP	125.9 ± 12.0	125.7 ± 14.4	0.958
	Diastolic BP	84.1 ± 11.1	84,4 ± 10.7	0.257
	Mean arterial pressure	98.0 ± 11.0	95.5 ± 11.0	0.445
Night BP (mmHg)	Systolic BP	121.8 ± 12.7	122.1 ± 16.9	0.950
	Diastolic BP	80.0 ± 12.2	77.6 ± 10.7	0.473
	Mean arterial pressure	93.9 ± 12.0	92.4 ± 11.9	0.673
24-hour BP (mmHg)	Systolic BP	124.7 ± 11.8	124.2 ± 15.8	0.911
	Diastolic BP	86.4 ± 18.2	79.5 ± 10.6	0.099
	Mean arterial pressure	99.1 ± 15.5	94.4 ± 11.5	0.229

typically results in increased intracranial pressure more than ischemic stroke.[26] However, our research specifically focused on subjects in the chronic stage of stroke, where we did not observe a significant difference in BP between the hemorrhagic stroke and ischemic stroke groups. This can be attributed to the stabilization of brain damage in the chronic stage, absence of cerebral edema causing intracranial pressure elevation, and gradual repair of the central autonomic nervous system, leading to adaptive responses to chronic brain injury.

Characteristics of Non-Dipper and Reverse Dipper in Control and Disease Groups

The comparison of non-dipper characteristics between the disease and control groups (Table 3) reveals a significant difference. In the disease group, 86% of patients exhibited non-dipper, whereas in the control group, this proportion was much lower at 22.0% ($p < 0.001$). This disparity can be attributed to the presence of brain damage in the case group, which disrupts the normal circadian rhythm of BP regulation through the central autonomic nervous system. Typically, physiological BP during night-time is 10–20.0% lower than during daytime due to increased parasympathetic activity during sleep, resulting in reduced heart rate, muscle relaxation, and lowered BP.

The finding of non-dipper in the control group is in alignment with the research of Thomas G. Pickering et al,[27] where 20.0% of hypertension individuals experienced non-dipper. Disruptions in the diurnal BP rhythm among patients with brain damage carry significant implications. Disturbances in this circadian rhythm can predispose to recurrent damage.

Table 3 Comparison of BP Characteristics in Disease and Control Group

Variable \ Group		Control Group (n = 50)	Disease Group (n = 50)	P (*T*-test)
Non-dipper	n	11	43	<0.001
	%	22.0	86.0	
Extreme dipper	n	2	1	0.558
	%	4.0	2.0	
Reverse dipper	n	5	12	0.062
	%	10.0	24.0	
Morning BP surge	n	30	23	0.161
	%	60.0	46.0	

The disease group exhibits a high prevalence of non-dipping patterns, totaling 86.0%. Within this group, 88.2% of patients with hemorrhagic stroke and 84.4% with ischemic stroke display non-dipping patterns, indicating a similar prevalence between the two types of stroke ($p > 0.05$). This similarity suggests that both hemorrhagic and ischemic strokes result in damage to the central nervous system, disrupting the biological regulation of circadian blood pressure rhythms. Non-dipping patterns in stroke patients can be attributed to impaired central autonomic nervous system function, where night-time blood pressure regulation, normally controlled by reduced sympathetic activity and increased parasympathetic activity, is compromised. The imbalance between sympathetic and parasympathetic systems due to damage to autonomic control centers or neurotransmitter systems contributes to this phenomenon. The clinical implications of these disruptions on stroke outcomes and prognosis remain a subject of ongoing debate and study in the medical community.[18,25,28]

The prevalence of day-night BP reversal in the case group was 24.0%, which was higher than the control group's rate of 10.0%, though not statistically significant ($p > 0.05$). Specifically within the disease group, subjects with hemorrhage stroke and ischemic stroke exhibited reverse dipper rates of 17.6% and 27.3%, respectively, also not statistically significant ($p > 0.05$). In contrast, other studies such as that by Castilla-Guerra et al reported changes in diurnal rhythm with 85.4% of patients with lacunar infarction showing systolic blood pressure (SBP) fluctuations and 94.4% with other types of ischemic stroke.[29] For diastolic BP, the figures were 69.3% for lacunar infarction and 91.6% for other types of ischemic stroke, demonstrating significant differences with $p < 0.05$. The higher rate of BP inversion in their study compared with ours could be attributed to Castilla-Guerra et al focusing exclusively on elderly individuals (> 65 years old), while our research was confined to individuals aged 45–64 years old.[29]

Although the rate of diurnal BP fluctuations was higher in the stroke group compared with the group without stroke complications in our research, particularly in the stroke group, this rate was higher in patients with ischemic stroke than in those with cerebral hemorrhage. However, no statistically significant difference was observed, possibly due to the relatively small sample size. With a larger sample size, this percentage might show a more pronounced difference.

Characteristics of Low Nocturnal BP in Two Control and Disease Groups

Extreme dipping refers to a condition where BP at night drops to 20.0% of the daytime BP value. This state is not only non-beneficial but also harmful because excessively low BP fails to ensure adequate blood perfusion for vital organs. Consequently, it can lead to symptoms such as fainting or coma due to organ ischemia during sleep.[30]

Research results (Table 4) show that the rate of night-time dipper in hypertension patients in both the group with stroke complications (disease group) and the group without stroke complications (control group)) are all low, this rate in the disease group is 2.0% and the control group is 4.0%, although the control group is higher, it is not statistically significant with $p > 0.05$.

Table 4 Comparison of BP Characteristics in Two Groups with Hemorrhagic – Ischemic Stroke

Brain Stroke / Variable		Hemorrhagic Stroke (n = 17)	Ischemic Stroke (n = 33)	p
Non-dipper	n	15	28	0.744
	%	88.2	84.8	
Extreme dipper	n	1	0	0.159
	%	5.8	0	
Reverse dipper	n	3	9	0.450
	%	17.6	27.3	
Morning BP surge	n	7	16	0.623
	%	41.2	48.5	

Extreme dipping is frequently observed in individuals without signs of vascular sclerosis. However, in hypertension patients, particularly those with stroke complications, vascular sclerosis is a predominant manifestation. Therefore, occurrences of low BP in hypertension patients with stroke complications are quite rare, aligning with physiological expectations.[30]

Characteristics of Morning BP Surge in Two Control and Case Groups

Morning BP surge refers to a rapid increase in BP within the initial two hours after awakening, where systolic blood pressure (SBP) and diastolic blood pressure (DBP) elevate by 20/15 mmHg from the lowest recorded values during sleep. This phenomenon, also known as morning BP surge or morning hypertension, poses a risk factor for heightened mortality from cardiovascular events during the early morning hours.[18,29,31]

The incidence of morning BP surge in the control group was 60.0%, which was notably higher compared with the stroke group at 46.0%. However, this difference did not reach statistical significance with $p > 0.05$ (Table 4). The lack of statistical significance may be attributed to the relatively small sample size, warranting caution in interpreting these findings. Morning hypertension occurs due to the body's release of hormones like adrenaline and noradrenaline in the morning, which enhance energy levels but also elevate BP. When these hormone releases are dysregulated, it can lead to increased morning BP, thereby increasing the risk of cardiovascular events. In stroke patients, the morning hypertension response may be influenced by central lesions, affecting the regulation of these hormonal releases.

The comparison of morning BP surge between the groups with hemorrhage stroke and ischemic stroke (rates of 41.2% and 48.5%, respectively) revealed no significant difference ($p > 0.05$). Research conducted by Kario et al in Japan (2006)[32] demonstrated that elderly individuals with ischemic stroke experienced early morning BP surge at a high rate of 57.0%. However, this study specifically targeted elderly individuals aged 65 years and older, whereas our research included a broader age range, resulting in inconsistent findings compared with our research.

Conclusions

The research reveals: The daytime SBP indices, 24-hour BP (SBP, DBP, and MAP), and particularly night-time BP indices were elevated in the stroke group compared with those without stroke complications ($p < 0.05$). However, there were no significant differences observed in daytime DBP and MAP between the two groups. SBP indices were higher in those with hemorrhage stroke compared with those with ischemic stroke, albeit without statistical significance.

The prevalence of non-dipper was significantly higher in the stroke group compared with the non-stroke group ($p < 0.001$); The rates of BP non-dipping were similar between ischemic stroke and hemorrhage stroke.

The occurrence of extreme dipper among hypertension patients in both stroke and control groups was low, the difference among patients with hemorrhagic stroke and ischemic stroke in the stroke group was not statistically significant.

Reverse dipper was more common in the case group than in the control group, with patients with ischemic stroke showing a slightly higher rate than those with hemorrhagic stroke in the disease group, though not statistically significant.

The rate of morning BP surge was higher in the non-stroke group than in the stroke group, and patients with ischemic stroke exhibited a higher rate than those with hemorrhagic stroke, but without statistical significance.

Recommendations

Holter BP monitors should be more widely recommended for hypertension patients to detect abnormalities in day-night BP fluctuations tailored to each patient, enabling personalized BP management strategies aimed at effectively preventing and reducing stroke risk.

Abbreviations

ACE, Angiotensin-converting enzyme; AM, Ante Meridiem; BMI, Body Mass Index; BP, Blood Pressure; DBP: Diastolic Blood Pressure; MAP: Mean Arterial Pressure; SBP, Systolic Blood Pressure; MAP: Mean Arterial Pressure; PM: Post Meridiem; VNU, Vietnam National University.

Data Sharing Statement

The original contributions presented in this study are included in the article. Further inquiries can be directed to the correspondence author.

Ethics Approval and Informed Consent

The author confirmed that the guidelines in the Declaration of Helsinki were followed and informed consent was obtained from each participant. The research was approved by the Medical Ethics Committee of Bach Mai Hospital. Research subjects were completely voluntary and were fully informed about all aspects related to the research.

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Disclosure

The authors report no conflicts of interest in this work.

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