Original Article

Patterns of nocturnal dipping in patients undergoing ambulatory blood pressure monitoring in BPKIHS, Dharan: A Cross Sectional Study

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Abstract

Background: Ambulatory blood pressure monitoring (ABPM) provides important information about circadian blood pressure variation. Normally, blood pressure declines by 10–20% during sleep (nocturnal dipping). Abnormal patterns such as non-dipping, extreme dipping, and reverse dipping are associated with increased cardiovascular risk. Data regarding nocturnal dipping patterns in the Nepalese population are limited.

Aims: To evaluate the prevalence of nocturnal dipping patterns and their association with cardiovascular risk factors among patients undergoing ABPM.

Methods: This observational cross-sectional study was conducted in the Department of Cardiology at B. P. Koirala Institute of Health Sciences (BPKIHS), Dharan. A total of 66 patients aged ≥18 years undergoing ABPM were included. Twenty-four-hour ABPM was performed using a validated oscillometric device. Patients were categorized into normal dipper, non-dipper, extreme dipper, and reverse dipper based on the percentage decline in nighttime systolic blood pressure. Demographic variables and cardiovascular risk factors were recorded. Statistical analysis was performed using descriptive statistics and chi-square test.

Results: Among 66 patients in the study, reverse dipping was the most common pattern observed in 26 patients (39.4%), followed by non-dipping in 24 patients (36.4%), normal dipping in 13 patients (19.7%), and extreme dipping in 3 patients (4.5%). In this study reverse dipping was more frequently observed in the 41–49 and 50–59 year age groups, although the association between age groups and dipping pattern was not statistically significant ($p = 0.216$). Similarly, there was no significant association between dipping patterns and cardiovascular risk factors including diabetes mellitus ($p = 0.39$), hypertension ($p = 0.36$), and smoking ($p = 0.24$).

Conclusion: Reverse dipping and non-dipping patterns were highly prevalent among patients undergoing ABPM in this study. However, no statistically significant association was found between dipping patterns and age groups or major cardiovascular risk factors in this study.

Introduction

Ambulatory blood pressure (BP) monitoring (ABPM) has been increasingly used in clinical management of hypertension. It has been typically demonstrated that ambulatory 24-hour BPs are better cardiovascular risk predictors than office BPs and that average nighttime sleep BPs are usually better predictors of adverse cardiovascular outcomes than average daytime awake BP levels on ABPM.[1]

The circadian fall in blood pressure during sleep has been properly examined after the development of ambulatory blood pressure monitoring (ABPM) and its occurrence in white coat hypertension (WCH) has not been generally clear.[2] It was First described in 1988 and night time dip has become an accepted measure of cardiovascular risk.[3-5] The dip is defined as the difference between the mean systolic pressure in the day and mean systolic pressure during the night, and is expressed as a percentage of the day time mean, with the accepted normal range between 10% and 20%.[6] Dips that less than 10% are described as non dipper, those in excess of 20% are known as extreme dipper and Bp rise at night as reverse dipper.[7]

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The non-dipping phenotype has been shown to be an independent risk factor for CV events in hypertensive patients and in other populations.[3] Non-dipping and Reverse dipping is also associated with metabolic abnormalities,[5] end organ damage and new-onset diabetes(8).[8] Furthermore, studies have suggested that nocturnal BP levels, accompanied by a non-dipping pattern, are better at predicting CV events, CV mortality and total mortality than office BP.[9]

Blood pressure (BP) normally follows a circadian pattern characterized by a decline of ≥ 10% in mean BP levels from day to night (dipping). This results from exogenous patterns of activity, stress and posture during the 24h, as well as endogenous circadian rhythms in autonomic nervous and endocrine systems.[10] Any alterations in these intrinsic circadian rhythms can result in the absence of the nocturnal BP decline (non-dipping). This altered pattern is commonly seen in patients with essential hypertension, several forms of secondary hypertension and disorders of the autonomic nervous system. The clinical relevance of this phenomenon lies in the fact that non-dipping has been associated with increased frequency of hypertensive target organ damage (brain, heart and kidney), as well as cerebrovascular and cardiovascular events in hypertensive patients.[11]

Materials and Methods

A single centre descriptive cross-sectional study was done to assess the prevalence of patterns of Nocturnal dipping using 24 hour ABPM. The 24 hour holter monitoring of 66 patients were included from November 2025 to February 2026. Each patient was provide with an informed consent and the study was approved by Institutional Review Committee (IRC), BPKIHS, Dharan (Ref No 231/082-083).

Inclusion Criteria: Patients aged > 18 years who consent to participate in the study,Patients undergoing ABPM for suspected HTN, cardiovascular risk assessment or other medical indications.

Exclusion Criteria: Patients with acute medical conditions (eg. Infections, ACS, stroke) that may influence BP, Individuals with irregular sleep patterns, Patients with secondary HTN and Pregnant women.

The sampling method done in this study was convinence sampling. sample size was estimated using following formula: n=Z2Pq/d2, where, n= sample size, Z=95%, CI value of 1.96, P= prevalence, q=1-P, d= precision (5%). Multiple studies found out the prevalence of reverse dipper to be approximately 22%.

With a 95% confidence interval and allowing 10% maximum error:

Z = 1.96,p = 22% (0.22),q = 1-p (1 - 0.22= 0.78),d = 10% (0.05)

n=((1.96)^2×0.22×0.78)/[0.1]^2 = 66

Twenty-four hours Ambulatory Blood Pressure measure (TONOPORT V) was measured using a validated device by oscillometer technique. ABP cuff was wrapped around the patient's arm which was connected to a recorder worn by a patient using a belt around the waist. Patients were instructed to stop moving, not to exert, not to talk and to keep arm still at the level of the heart as cuff would inflate and deflate to record blood pressure. The monitor was programmed to record BP at 30 minutes and 60 minutes' intervals during day and night respectively. The night time was set in accordance with the sleep on and sleep off pattern of the patient commonly between 10 pm to 6 am. Measurements on recorder was downloaded in a computer and analyzed with CARDIOSOFT program and blood pressure was categorized into 24-hour, daytime and nighttime mean. Participants were be included in the analyses if they had at least 70% of expected readings and twenty measurements during the day and at least seven readings during the night, following ESH recommendations.6 ABP monitoring will be done for 24 hours among the patients who had hypertension. The reports were reviewed by the cardiologists (authors). The ABPM monitoring reports were evaluated for the nocturnal dipping pattern. Classification of hypertension was done as per 2018 ESC/ESH (European Society of Cardiology/ European Society of Hypertension) guideline for the management of Hypertension.[12]

All the data were analyzed using SPSS, Version 16 (SPSS Inc., Chicago IL). The prevalence of these abnormalities were expressed in terms of absolute numbers and percentage. The association between age and risk factors with nocturnal dipping patterns were done by Chi-square statistical analysis.

Results

1. Age and gender

Out of 66 patients, 41 were male patients and 25 were female. The mean age of the patients was 51.07± 7.59 years. Most of the patients were between the age group 40-59 years.

Table 1: Age category

Age group	Frequency	Percent
<40	3	4.5%
40-49	26	39.4%
50-59	28	42.4%
≥60	9	13.65
Total	66	100%

Table 2: Sex Category

Sex category	Frequency	Percentage
Male	41	62.12%
Female	25	37.87%
Total	66	100%

2. Risk factors

Among risk factors , most common was Hypertension in 45.4%, followed by Diabetes Mellitus in 40.9% and smoking in 33.3%.

Table 2: Risk factors

Risk factors	Frequency	Percentage
DM II	27	40.9%
HTN	30	45.4%
Smoking	22	33.3%

3. Mean 24 hour blood pressure

The mean 24 hour systolic blood pressure was 124.79 ± 9.30 mmHg and mean 24 hour diastolic blood pressure was 124.79 ±9.30 mmHg. Similarly mean night time systolic BP was 116.39 ±11.42 mmHg and mean night time diastolic BP was 71.94 ±7.7 mmHg

Table 4: Mean 24 hour blood pressure

Variable	Mean ±SD
Mean 24 hour Systolic BP	124.79 ±9.30 mmHg
Mean 24 hour Diastolic BP	78.03 ±11.93 mmHg
Mean Day time Systolic BP	128.25 ±10.44 mmHg
Mean Day time Diastolic BP	82.42 ±9.14 mmHg
Mean Night time Systolic BP	116.39 ±11.42 mmHg
Mean Night time Diastolic BP	71.94 ±7.7 mmHg

4.Nocturnal dipping patterns

Most of the patients belonged to Reverse dipper (39.4%), followed by Non dipper 36.4%. Normal dipping was present in 19.7% of the patients whereas extreme dipper was present in 4.5% of the patients.

Table 5: Nocturnal dipping patterns

Dipping Patterns	Frequency	Percentage
Normal Dipper	13	19.7%
Non Dipper	24	36.4%
Extreme Dipper	3	4.5%
Reverse Dipper	26	39.4%
Total	66	100%

5. Association of age group with nocturnal dipping patterns

Reverse dipping pattern was seen most commonly in age group 40-59 years old. But there was no any statistical significance (p value= 0.216)

Table 6: Age wise dipping patterns among patients

Age group	Normal dipper, n(%)	Non-dipper, n(%)	Extreme dipper, n(%)	Reverse dipper, n(%)	p-value
<40	1 (33.3)	1 (33.3)	1 (33.3)	0 (0.0)	0.216
40-49	6 (23.1)	7 (26.9)	1 (3.8)	12 (46.2)	
50-59	5 (17.9)	10 (35.7)	1 (3.6)	12 (42.9)	
≥60	1 (11.1)	6 (66.7)	0 (0.0)	2 (22.2)	

6. Association between risk factors and nocturnal dipping patterns

Although most of the Diabetes Mellitus patients belonged to non dipper and Reverse dipper, it was not statistically significant (p value = 0.39). Most of the hypertensive patients belongd to non dipper and reverse dipper category but it was not statistically significant (p value = 0.36). Similarly most of the Smoker belonged to non dipper and rec=verse dipper, it was also not statistically significant (p = 0.24).

Table 7: Association between risk factors and dipping patterns

S.N.	Variables	Normal dipper, n(%)	Non-dipper, n(%)	Extreme dipper, n(%)	Reverse dipper, n(%)	Total, n(%)	P-value
1	Diabetes Mellitus	5 (18.5)	13 (48.1)	1 (3.7)	8 (29.6)	27 (40.9)	0.39
2	Hypertension	5 (16.7)	12 (40.0)	0 (0.0)	13 (43.3)	30 (45.4)	0.36
3	Smoking	2 (9.1)	10 (45.5)	2 (9.1)	8 (36.4)	22 (33.3)	0.24

Discussion

This study was done to evaluate the patterns of nocturnal blood pressure dipping in patients undergoing ABPM at BPKIHS. A total of 66 patients underwent ABPM during the 3 months duration and were included in the study with mean age of 51.07 ±7.59 years with majority of patients between 41-59 years. Male patients constituted 62.1%, indicating male predominance in this study.

In this study Reverse dipping was the most common nocturnal Blood pressure pattern (39.4%), followed by Non dipping in 36.4%. Similarly, normal dipping was seen in only 19.7% of the patients and extreme dipping in 4.5%. It was similar to a study done by Afsar and colleagues in which they reported prevalence of Reverse dipping reverse dipping to be high i.e in 36% of the patients.[13] These findings suggest that abnormal nocturnal blood patterns are highly prevalent among patients undergoing ABPM. Reverse dipping and non dipping patterns have been associated with increased cardiovascular mortality in a clinical cohort study done by Bae keun kim in 401 patients wherehe frequency of CV mortality was 14.0% in Reverse dipppers and 5.8% in others highlighting the importance of identifying these patterns in clinical practice.[14] These patterns are often associated with sympathetic overactivity, endothelial dysfunction and impaired autonimic regulation, al of which contribute to increased cardiovascular risk.

In this study, Reverse dipping was particularly common in age group 41-59 years, whereas non dipping was more frequent in individuals aged ≥60 years. However the association between age group and dipping patern was not statistically significant (p=0.216). This may be due to relatively small sample size and uneven distribution of participants across age groups.

Regarding cardiovascular risk factors, HTN was present in 45.4% of patients, DM in 40.9% and smoking in 33.33%. Although abnormal dipping patterns appeared more frequently among individuals with these risk factors, the association were not statistically significant (DM II p=0.39, HTN p=0.36,smoking p=0.24). This lack of statistical significance could be due to limited sample size.

The mean 24 hour Systolic and Diastolic blood pressure were 124.79 ±9.30 mmHg and 78.03 ±11.93 mmHg respectively. As expected night time blood pressure values were lower than day time values, reflecting the physiological circadian rhythm of blood pressure. However, the high precalence of non-dipping and reverse-dipping patterns indicate disruption of normal nocturnal pressure regulation in a significant proportion of patients.

The findings of this study highlight the clinical importance of ABPM in detecting abnormal nocturnal blood pressure patterns that may

not be estimated during routine blood pressure measurement. Identification of these patterns can help guide more individualized management strategies and improve cardiovascular risk stratification.

Conclusion

Reverse dipping and non-dipping patterns were highly prevalent among patients undergoing Ambulatory Blood Pressure measurement in our study patients. Furthur large studies are required to better understand the determinants and clinical implication of nocturnal blood pressure patterns in the Nepalese population.

Limitations

The present study has certain limitations. The sample size was relatively small and the study was conducted in a single tertiary centre, which may limit the generalizability of the findings. Similarly the potential determinants of nocturnal blood pressure variation such as sleep disorders, medication timing and autonomic dysfunction were not evaluated.

Conflicts of Interest: The authors declare no conflict of interest.

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