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Increased Level of Morning Surge in Blood Pressure in Normotensives: A Cross-Sectional Study from Pakistan

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ABSTRACT

Objective: To determine the mean morning surge (MS) in blood pressure, the frequency of increased morning surge in normotensive subjects, and to compare those with morning surge with those without MS.

Study Design: A cross-sectional, comparative study.

Place and Duration of Study: The Department of Medicine, The Aga Khan University Hospital, Karachi, from April 2011 to March 2012.

Methodology: Adult normotensive healthy volunteers aged 35 to 65 years were inducted. Their ambulatory blood pressure (ABP) was measured over a 24-hour period, using digital ambulatory blood pressure monitors. Morning surge was calculated as the average of four readings after waking minus the lowest three nocturnal readings. Increased morning surge was defined as > 11 mm Hg in systolic (SBP) or > 12 mm Hg in diastolic (DBP). Dipping was defined as > 10% dipping in blood pressure.

Results: Eighty-two healthy volunteers were recruited. Their mean age was 36.9 ± 1.2 years; 74.4 (61%) were men, and 58.5 (48%) woke up for morning prayers. Mean overall SBP was 113 ± 1.6 mm Hg, overall DBP was 73.9 ± 0.7 mm Hg, and overall heart rate was 75 (10) beats/minute. Mean morning surge was 17.6 ± 1.0 mm Hg in SBP and 16.0 ± 0.8 mm Hg in DBP. The frequency of increased morning surge was 66 (80.5%) in SBP, and 57 (69%) in DBP. On comparison of participants with normal morning surge and increased morning surge in SBP, there was a significant difference in non-dipping status (13.4% in normal vs. 18.3% in increased morning surge, $p = 0.001$).

Conclusion: Mean morning surge in SBP and DBP are relatively higher in this subset population in a tertiary care center in Pakistan. These values are higher than those reported in the literature.

Key Words: Blood pressure. Ambulatory blood pressure monitoring. Normotensives.

INTRODUCTION

Arterial blood pressure (BP) has a daily variation characterized by substantial reductions during sleep and a rapid rise upon awakening in normal and hypertensive subjects.¹ Excess sleep-trough morning surge in blood pressure is a strong predictor for future all-cause mortality and increased risk of cardiovascular outcomes.²

Higher morning BP surge (MBPS) might be an independent risk factor of atherosclerotic events beyond ambulatory and nocturnal BP falls.³ Adverse cardiovascular events such as myocardial infarction, stroke, arrhythmias, and sudden cardiac death are well known to follow a circadian pattern, peaking in the morning hours between 6 AM to 12 Noon.^{4,5} The most appropriate definition of morning surge in blood pressure is: BP 2 hours after rising, minus the average BP during sleep.⁶

Ethnic differences have been reported in the degree of morning surge in blood pressure.⁷ This holds true for South Asian population, who is also at higher risk of developing cardiovascular disease.⁸ Abrupt change in physical activity is not only a major determinant of the 2-peak diurnal variation of BP but also an important triggering factor for a cerebrovascular event.⁹ Hence, it was hypothesized that the South Asian population might have a higher mean morning surge in blood pressure than what is reported in the literature.

Therefore, this study was conducted to determine the mean morning surge in blood pressure and frequency of increased morning surge in normotensive subjects at a tertiary care center, and compare those with high morning surge with those having normal morning surge in blood pressure.

METHODOLOGY

This cross-sectional study was carried out on adult normotensive voluntary participants (employees) at the Aga Khan University (AKU), Karachi from April 2011 to March 2012. Adults aged 35 to 65 years who were normotensive (defined as systolic BP (SBP) < 120 mm Hg and diastolic BP (DBP) < 80 mm Hg on at least 2 separate occasions)¹⁰ and who were employed at AKU were included. Those who had known coronary artery disease (CAD), diagnosed with angina or myocardial

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Infarction, alcoholics, documented valvular heart diseases, cardiomyopathy, chronic renal failure [creatinine > 1.5], connective tissue disorder, and those with altered night-time sleep because of shift work were excluded. Ethical approval was taken from ethics review committee, Aga Khan University (ERC No.1315-Med ERC-09) and informed consent was taken from all participants.

The main outcome was morning surge in blood pressure defined as mean of BP during the first two hours after waking (eight BP readings), minus the mean BP during the night (as the average BP of three readings centred on the lowest nighttime reading).^{11,12} Independent variables were age, gender, morning prayers, current smoker, anti-depressant use, exercise in morning, caffeine use, non-dipping of blood pressure, and prehypertension. Morning prayers was defined as waking up from sleep and pleading fervently to God for something with intense yearning within an hour after waking up, which included a change in posture from lying to upright or sitting. Current smoker was defined as individuals who reported current smoking and having smoked at least 100 cigarettes or 'beddies' during their lifetime.¹³ Anti-depressant use was defined as being on it for at least a month. Caffeine use was defined as using 1 cup of coffee/tea at night within 2 hours before going to sleep.¹⁴ Pre-hypertension was defined as a 24-hour blood pressure mean between 120-139/80-90 mm Hg.¹⁵ Non-dipping was defined as < 10 % drop in night time blood pressure compared to morning blood pressure (awake BP-sleep BP)* 100/awake BP).¹⁵ Increased morning surge in blood pressure in normotensives was defined as increase in morning surge > 11 mm Hg in SBP and > 12 mm hg in DBP.¹⁶

ABP was measured with a noninvasive portable oscillometric (Space Labs Inc) device that utilized the Korotkoff sound technique. Patients were instructed to follow their usual daily activities but to stay still with the forearm extended during each ABP reading. The data on the ambulatory blood pressure monitor (ABPM) were transferred to a computer database, AccuTrack software, which was used to facilitate data summary.

A non-probability volunteer sampling method was used. The mean overall, night time, awake SBP and DBP readings, hypertension load, dipping characteristic, three night time readings centered around the lowest reading, and 4 readings after waking up were marked on the ABP print and entered and transformed into SPSS version 16 for the analysis. Morning surge was calculated after entry into SPSS by computing a formula (MSBP = average 4 readings after waking the lowest three night readings).

Distribution of the continuous variables was checked for normality by Shapiro-Wilk test. Those variables which had significance for the test of $p = < 0.05$, were not normally distributed. Results are presented as frequency

and percentages for qualitative variables and mean and standard deviation for quantitative variables (normally distributed). Independent sample t-test, chi-square test, and Fischer's exact test were used as appropriate.

RESULTS

A total of 100 participants initially agreed to participate via email response. Out of them, 90 (90%) participated and came for ambulatory blood pressure device application, 7 (7%) were on antihypertensives and therefore were ineligible. Data of one participant was not included as he was later on found to be on antihypertensive. Data was analyzed for 82 (82%) participants.

Mean age was 36.9 ±1.2 years and 61 (74.4%) were males. Forty-eight (58.5%) woke up for prayers during morning hours, 8 (9.8%) were current smokers, 4 (4.9%) were on anti-depressants, 7 (8.5%) took caffeine at night and only 8 (9.8%) exercised > 3 times/week.

Mean overall SBP was 113 ±1.6 mm Hg, wake up-SBP was 118.6 ±1.2 mm Hg and sleep-SBP was 103 ±1.0 mm Hg. Mean overall DBP was 73.9 ±0.7mm Hg, wake up-DBP was 77.4 ±0.7 mm Hg and sleep-DBP was 64.7 ±0.7mm Hg.

Mean morning surge was 17.6 ±1.0 mm Hg in SBP, and 16.0 ±0.8 mm Hg in DBP. The morning surge in heart rate was 16.1 ±1.1 beats/min. Overall frequency of increased morning surge was in SBP (n=80.5%, 66), and (n=69.5%, 57) in DBP. Non-dipping was present in 26 (31.7%) for SBP and in 17 (20.7%) for DBP.

On comparison of participants with normal and increased morning surge in SBP, there was significant difference in non-dipping status (13% in normal morning surge vs. 18.3% in increased morning surge, $p= 0.001$,

Table I: Comparison of characteristics among participants with normal and increased morning surge in SBP.

Characteristics	Normal morning surge SBP N (%) N=16	Increased morning surge SBP* N (%) N=66	p-value
Mean age in years ± SD	34± 9.3	37± 11	0.4
Male	11 (68.8)	50 (75.8)	0.3
Wake up for prayers	12 (75)	36 (54.5)	0.1
Current smoker	1 (6.3)	7 (10.6)	0.5
Use of caffeine	1 (6.3)	6 (9.1)	0.7
Exercise > 3 times a week	1 (6.3)	7 (10.6)	0.5
Overall SBP average mm Hg Mean ±SD	113.4 ±9.2	113.3 ±16	0.9
Wake up SBP average mm Hg Mean ±SD	115.2 ±9.0	119.6 ±11.0	0.1
Night time SBP average mm Hg Mean ± SD	107.7 ±10.8	103.1 ±9.3	0.09
Non-dipping in SBP***	11 (13.4)	15 (18.3)	0.001
Prehypertensives****	3 (18.8)	21 (31.8)	0.2

* > 11 mm Hg in SBP > 12 mm hg in DBP; ** average 4 readings after waking-lowest 3 night reading; *** < 10 % drop in night time blood pressure compared to morning blood pressure; ****24-hour blood pressure mean between 120-139/80-90 mm Hg.

Table I). Non-dipping status was 15.9% in normal morning surge in DBP and 15.9 % in increased morning surge in DBP group, $p=0.01$, Table II).

Table II: Comparison of characteristics between participants with normal and increased morning surge in DBP.

Characteristics	Normal morning surge SBP N (%) N=25	Increased morning surge SBP* N (%) N=57	p-value
Mean age in years \pm SD	36.8 \pm 10	36.7 \pm 11	0.9
Male	17 (68)	44 (77.2)	0.2
Wake up for prayers	17 (68)	31 (54.4)	0.1
Current smoker	3 (12)	5 (8.8)	0.4
Use of caffeine	3 (12)	4 (7)	0.3
Exercise > 3 times a week	1 (4)	7 (12.3)	0.2
Overall DBP Average mm Hg Mean (SD)	73 \pm 5.8	74.5 \pm 6.6	0.3
Wake up DBP Average mm Hg Mean (SD)	75.3 \pm 6.3	78.4 \pm 6.8	0.05
Night DBP Average mm Hg Mean (SD)	66.4 \pm 7.2	64.1 \pm 6.7	0.1
Non-dipping in DBP***	13 (15.9)	13 (15.9)	0.01
Prehypertensives****	6 (7.3)	18 (22)	0.3

* > 11 mm Hg in SBP > 12 mm Hg in DBP; ** Average 4 readings after waking-lowest 3 night reading; *** < 10 % drop in night time blood pressure compared to morning blood pressure; ****24-hour blood pressure mean between 120-139/80-90 mm Hg.

DISCUSSION

This study on normotensive healthy volunteers at tertiary care center showed that the mean morning surge in SBP was 18 mm Hg and mean morning surge in DBP was 16 mm Hg. The proportion of participants with increased morning surge was high so they were more likely to be pre-hypertensive. On comparing those with increased morning surge with those with normal morning surge, non-dippers were more prevalent in the group with increased morning surge in BP.

Estimates of the magnitude of the blood pressure surge on rising vary depending on technique and population. Some studies still use an isolated morning systolic blood pressure reading, a reflective of morning surge in blood pressure.¹⁷ However, numerous study use the definition of morning surge in blood pressure that we used. It is usually around 14 - 30 mm Hg systolic and 12 - 23 mm Hg diastolic in hypertensive patient.¹⁸ Morning surge in blood pressure has also been studied in normotensive Chinese population. The purpose of that study (n=67) was to test the hypothesis that ambulatory arterial stiffness index and other derivations of ambulatory BP, including pulse pressure, 24-hours BPV, dipping, and morning surge, would be correlated with the pressure response to common physiological stress maneuvers. The mean morning surge in SBP and DBP reported in that study was 11.4 mm Hg and 12.6 mmHg, respectively.¹⁹ Comparing to these values, the morning surge in normotensive Pakistani voluntary participants was much higher i.e.18 mm Hg in SBP and 16 mm in

DBP. Another study was done on Turkish population (n=79) to determine which abnormality in BP circadian rhythm [non-dipping status (NDS) or increased morning BP (MBP)] is more closely related to target organ damage in normotensives. The mean morning surge in SBP was 21 mmHg.²⁰ However, the study was restricted to those who came to cardiology clinic for checkup and might suffer from selection bias. Comparing morning surge in BP values in this study might be lower as our study comprised of healthy volunteer population. The reasons for relatively higher MSBP in this subsample of Pakistani population could be interlinked to mechanism of increased sympathetic stimulation, and obesity in relatively smaller height population.²¹ Secondly, South Asian population like Pakistan is at higher and earlier risk of cardiovascular disease secondary to several risk factors including central obesity.²² Thirdly, the higher morning surge in blood pressure may be linked to anxiety and sleep pattern in this population, given the law and order situation in Pakistan.²³

Both non-dipping status and increased MBP lead to an increase in left ventricular mass and urine albumin excretion independently.²⁰ In this study also the proportion of non-dipping is higher in patients who have increased morning surge in blood pressure, confirming what has been reported earlier. This indicates that morning surge in BP and non-dipping status in blood pressure might serve as an early detecting marker of developing hypertension and target organ damage. However, this requires further research.

The strength of this study is that it is one of the first studies to report morning blood pressure cutoffs in a subsample of normotensive population at tertiary care center. There are several limitations in this study, too. Firstly, the sample size is very small and cannot be generalised to entire population. There is no control group to compare morning surge from other population groups. The voluntary sampling technique might be biased. The sleeping time of the participants is based on their answers, which may have an element of recall bias. We also did not collect data for confounders for hypertension like diabetes mellitus.

CONCLUSION

Morning surge in SBP and DBP are relatively high, in this healthy volunteer subset of population. These values are higher than those reported in the literature. Normotensive healthy adults with increased morning surge have higher prevalence of non-dippers. Further, large scale studies are needed to define cutoffs in our population which may be predictive of worse cardiovascular outcomes.

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