Blood Pressure Morning Surge and Hostility
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This study examined the effects of hostility on blood pressure (BP) during the early morning hours before awakening and several hours afterward. Our objective was to determine whether the pattern of BP change and the slope of the morning BP surge were related to hostility. The subjects were 32 patients with a history of Stage 1 hypertension. The morning surge in BP was derived from ambulatory BP monitoring of sleeping and waking hours, which were averaged per subject and centered around the wake-up hour. The periods used were 3 h before and 3 h after awakening. Only systolic blood pressure (SBP) is being reported on in this paper as this is the primary measure found relevant to the morning surge phenomenon. Hostility was assessed by the Buss-Durkee Hostility Inventory (total score). The results revealed significant differences between low and high hostility subjects for overall levels of sleep SBP: 120 ± 11.4 mm Hg for low hostility and 131.3 ± 14.9 mm Hg for high hostility subjects \( (P = .02) \). Low hostility subjects showed a steep rise in SBP from sleeping to waking while high hostility subjects had almost reached their post-sleep level of SBP in the hours immediately before waking up \( (P = .03) \). These data indicate that individual differences in hostility are related to different patterns of BP during sleep and the early morning hours, a period of the day that has been associated with an increased risk of cardiovascular incidents. The data also suggest the need for further study of the significance of hostility and other personality traits and the relationship of these traits to the mechanisms of the morning surge and the risk of cardiovascular events. Am J Hypertens 1998;11:245–250 © 1998 American Journal of Hypertension, Ltd.

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It is well known that blood pressure shows a biphasic circadian rhythm with higher values during wakefulness and lower values during sleep. It has also been recognized that blood pressure rises rapidly in the morning, the so-called morning surge, and that this rise has been associated with increased risk of cardiovascular events such as stroke\(^1\) and myocardial infarction.\(^2\) The biphasic circadian rhythm of blood pressure and morning surge is believed to be influenced by intrinsic and extrinsic factors; however, the majority of findings are supportive of the predominance of activity and other extrinsic factors.\(^3\) The morning rise in blood pressure was shown to be related to both the time of awakening\(^4\) and the time of getting up.\(^5\) A recent study by Suzuki et al\(^6\) described two types of

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morning surge, one that occurs immediately after waking up and one that begins gradually during sleep. The mechanisms of the morning surge and the influence of intrinsic factors, therefore, remain to be determined.

A number of studies have reported a relationship between hypertension and hostility or suppressed aggression. Some studies focused on hostility as a predictor of hypertension development and response to antihypertensive medications, whereas others reported on hostility and the prediction of coronary heart disease. Recently, there have also been reports on blood pressure patterns and hostility in hypertensive subjects and in paramedics without hypertension. In the former study, those subjects who scored high on the Buss Durkee Hostility Inventory tended to be consistently high in blood pressure, whether in the clinic, at home, or in 24-h ambulatory blood pressure recordings, whereas low hostility subjects also had high blood pressures in the clinic, but were lower in the other measurements. In the latter study, subjects scoring high on a scale of cynical hostility had significantly higher levels of ambulatory blood pressure both during waking and sleeping periods. In a study of college students, a comparable result was obtained for black but not white subjects. However, no information is currently available on the role of hostility and other personality factors related to changes in blood pressure occurring around the waking hours or in the morning surge in blood pressure.

The present study examined the effects of hostility on blood pressure during the early morning hours before awakening and several hours afterward. Our objective was to determine whether the pattern of blood pressure change and the slope of the morning blood pressure surge were related to hostility. The trait of anxiety was also examined to see whether the results were unique to hostility or related to a more general factor of negative affective personality traits.

**METHODS**

**Subjects** The subjects were 32 patients, 14 women and 18 men between the ages of 35 and 65 (mean age = 50.2 ± 8.7 years) with a history of Stage 1 hypertension, who were being evaluated for a study of the combined effects of blood pressure medication and behavioral treatment. The study was approved by the University of California at Los Angeles Human Subjects Protection Committee, and all subjects gave their informed consent. At intake all subjects underwent a complete physical examination including fundoscopy, 12-lead electrocardiography, urinalysis, hematology, and serum chemistry. Individuals with secondary hypertension, hypertension complications, or history of any major medical or psychiatric disorder were excluded from the study. All inclusion and other study criteria are described elsewhere. Individuals who were already being treated with various antihypertensive medications were slowly withdrawn from their previous medications over a period of 3 to 6 weeks. To proceed with the study, the subjects’ mean unmedicated clinic diastolic blood pressure (DBP) had to be between 95 and 110 mm Hg, measured on three weekly clinic visits over a period of 2 to 4 weeks. After the measurements and evaluations were made all the subjects were given antihypertensive medication.

**Blood Pressure** Ambulatory blood pressure was obtained when subjects had discontinued all medications. Only systolic blood pressure (SBP) will be reported on in this paper, as this is the primary measure found in previous research to be relevant to the morning surge phenomenon. The recording was made at 30-min intervals during the 24-h period using a battery-operated Accutracker II (Suntech Medical Instruments, Raleigh, NC). Previous research has established the validity and reliability of this clinical device, and the criteria for recording and for elimination of artifacts in these patients have been reported elsewhere. The recording was made during a weekday in the subject’s usual everyday setting. Subjects were asked to carry on with their regular daily activities, but to avoid strenuous exercise.

The morning surge in blood pressure was derived from the sleeping and waking periods, which were determined separately for each subject and based on diary information provided by the subject. We started with the time of awakening for each subject and took the three subsequent waking hours and the three preceding sleeping hours. All recordings occurring within each of these hours were averaged per subject. The morning surge was calculated from the six hourly BP values for each subject using the linear regression equation: \( y = mx + b \), where \( m \) is a slope and \( b \) is an intercept. In addition, the pre- and the postawakening hours were averaged into single sleeping and waking means for the three sleeping and the three waking hours. Overall waking and sleeping means for each subject were also computed from the 24-h BP recording.

Clinical BP values were obtained while the subjects were unmedicated. They were based on the mean of three weekly visits, three readings per visit, following standard clinical measurement guidelines. The nurse practitioner doing the evaluation was blinded to the subject’s scores on the personality scales. The ambulatory recording was made shortly after the third visit.

**Psychologic Assessment** All subjects took a computer-administered battery of psychologic tests. The Buss-Durkee Hostility Inventory (BDHI) is a true-false 75-item questionnaire designed to provide a total hostility score and scores on eight separate dimensions of
The total score was used in the analysis as a more stable and reliable measure of hostility than any single dimension. The Taylor Manifest Anxiety Scale (TMAS) is a questionnaire designed to measure anxiety. Each scale was dichotomized to give low and high scoring subgroups. Taking into account characteristics of the distribution of values resulted in 15 low hostility and 17 high hostility subjects (high scores were 22 or greater). The mean scores on the BDHI were 14.0 \pm 4.8 and 29.2 \pm 6.1, respectively, \( P, .001 \). The low and high hostility groups, respectively, did not differ significantly in gender composition (7 women and 8 men versus 7 women and 10 men), age (50 v 50 years), body mass index (bmi) (25.7 v 25.1 kg/m\(^2\)), years of hypertension (6.1 v 9.9 years), or clinic BP (144/96 v 147/98 mm Hg). The TMAS scores were divided into 15 low and 17 high anxiety subjects (high scores were 6 or greater). The mean scores for the two groups were 2.4 \pm 1.5 and 8.8 \pm 2.4, respectively, \( P < .001 \). The low and high anxiety groups, respectively, did not differ in gender composition (7 women and 8 men versus 7 women and 10 men), age (51 v 49 years), bmi (25.2 v 25.5 kg/m\(^2\)), years of hypertension (7.9 v 8.3 years), or clinic BP (146/97 v 146/98 mm Hg). Neither the time of awakening nor the total amount of sleep differed between the low and high hostility or low and high anxiety subgroups. The hostility and anxiety scales were slightly correlated (\( r = 0.35, P < .05 \)).

**Data Analysis** Statistical analysis was done using independent \( t \) tests comparing high and low subgroups on the two personality scales for the dependent variables—overall waking and sleeping SBP, sleeping SBP for the 3 h preceding awakening, waking SBP for the 3 h after awakening, change in SBP from sleeping to waking (hours 3 to 4), and other selected differences. Although the subgroups did not differ on gender, age, bmi, or years of hypertension, additional analyses of covariance were done to control for these variables. None of the effects reported were significantly changed, and the adjusted values were only slightly different from the unadjusted values. The latter are reported in the Results section. The \( P = .05 \) level was used to determine statistical significance.

**RESULTS**

**Effects of Hostility** Significant differences between low and high hostility subjects were obtained for overall levels of sleeping SBP but not for waking SBP (low hostility, 120.2 \pm 11.4 mm Hg; high hostility, 131.3 \pm 14.9 mm Hg; \( P = .03 \)). High hostility subjects also had a higher SBP during the sleeping portion of the 6-h morning surge (\( P = .03 \)) (see Figure 1). Mean SBP for the 3 waking hours of the surge data did not differ as a function of hostility.

The slope calculated for the entire 6-h period did not differ as a function of hostility (low hostility, 6.6 mm Hg/h; high hostility, 4.9 mm Hg/h). Figure 1 shows...
the hourly SBP values for each group. The discontinuity in the values over time, especially in the low hostility subjects, suggests that the simple overall slope calculation may have limited value in representing the pattern of change during the 6 h of sleeping and waking. As can be seen, the curves differ mainly in the steep rise in SBP in the low hostility subjects from sleeping to waking (hours 3 to 4), which was larger than the change shown for high hostility subjects (P = .03). In contrast, the high hostility subjects had almost reached their post-sleep level of SBP in the hour immediately before getting up (hour 2 to 3).

Effects of Anxiety Low and high anxiety subjects did not differ in overall levels of BP during waking or sleeping periods (Figure 1). Nor did they differ for the sleeping or waking portions of the 6-h morning surge data. The overall slope was higher in the high than in the low anxiety group (7.0 ± 3.1 mm Hg/h for high anxiety subjects compared to 4.3 ± 2.5 mm Hg/h for low anxiety subjects, P = .01). Discontinuities in the pattern of means over the 6 h were apparent, as with hostility (Figure 1). Although the change from the sleeping to the waking portion of the hourly values was greater in high compared to low anxiety subjects, the difference between the groups was not significant. The high anxiety group tended to show a large increase in SBP from hours 2 to 3, comparable to what was observed in high hostility subjects.

DISCUSSION

This study demonstrated that low and high hostility scored subjects have different patterns of blood pressure during the hours of sleep immediately preceding awakening and the early morning hours after waking, i.e., during the morning surge. High hostility subjects had higher blood pressures during the 3 h before to getting up and the slopes of their blood pressure appeared steeper during the sleeping portion, before getting up, compared to low hostility subjects. Previous work has demonstrated that high hostility is correlated with higher levels of blood pressure during sleep in several different populations that have been studied. However, specific information regarding blood pressure in the hours immediately before and after awakening and their correlation with the level of hostility has not been previously reported. It is not known why individuals with higher hostility levels showed a gradual increase during the prewaking sleep hours. One reason could be that their sleep may not be sound and that it may be disturbed by “angry” thoughts or dreams, which may increase their blood pressure as they approach the time to wake up. Emotional states of anger, depression, and anxiety have been associated with difficulty in falling asleep and with poor quality of sleep as well as somatic tension before sleep. Negative moods have also been associated with a reduction in sleep time and with higher ambulatory blood pressure, particularly during sleep. The results were not related to differences in total amount of sleep or time of awakening, which did not differ as a function of hostility scores. Further research is needed on the relation between hostility and sleep patterns in hypertensive patients and the role it may play in maintaining high levels of blood pressure in some patients. It is not known whether individual differences in hostility are related to differences in the frequency and duration of REM (rapid eye movement) sleep. This information would be particularly important because REM sleep has been associated with myocardial ischemia.21

The relationship shown in this hypertensive sample for hostility was not shown for anxiety. Although the role of hostility in hypertension is more clearly established, other affective traits may add to the processes that establish and maintain high levels of blood pressure, including anxiety. One way of interpreting the present findings is that hostility appears to be more significant than anxiety as an emotional factor affecting blood pressure. In the present study, anxiety was not associated with significant differences in blood pressure during either sleeping or waking periods. Subjects scoring low in hostility showed a large increase in blood pressure from just before waking to waking, reflecting in part their relatively low stable blood pressure during sleep. One particular concern about this information is whether this subgroup is more vulnerable to cardiovascular events, such as heart attack or stroke, as some studies have shown greater risk for cardiovascular events with greater variability of blood pressure. Conceivably, the low hostility subgroup may be at greater risk. This would also mean that low hostility individuals with a similar profile to our subjects may be more amenable to treatment with drugs that reduce such variability, that is, drugs that will maintain low levels of blood pressure more consistently, such as the slow-release type.

Similar patterns to our low and high hostility subjects have been described by Suzuki et al. They described two patterns of morning blood pressure rise in their hypertensive subjects. A steep rise in blood pressure immediately after awakening was found to be more common in older subjects, whereas the morning surge developing gradually during sleep was more common in younger hypertensive subjects.

Previous work by Pickering and James has described some differences in diurnal rhythm of blood pressure, namely, the “dippers” and “nondippers.” The “nondippers,” in whom the normal nocturnal fall of blood pressure was diminished, were found to have more target organ damage, such as left ventricular hypertrophy, than the “dippers.” They also specu-
lated that the pattern of blood pressure, in addition to the level of blood pressure, is probably prognostically important, although there have been no outcome studies to prove this hypothesis. In the present study, high hostility subjects had significantly higher levels of blood pressure than low hostility subjects during sleep in general as well as during the 3 h before getting up.

In conclusion, it appears that the subgroup of individuals who score high on a scale measuring the personality trait of hostility have a different pattern of blood change during sleep and the early morning hours compared to individuals who score low on this trait. The pattern of high-scoring individuals is such that sleeping blood pressure tends to be higher during sleep in general and during the early morning hours, and it tends to rise immediately before awakening. Paralleling the results of previous studies, the high hostility subjects may also be characterized as “nondippers.” They show a gradual rise in blood pressure during the sleeping hours that continues into the waking hours. A similar pattern of blood pressure has been observed in young individuals with hypertension unrelated to hostility. Although age and hostility were not related in our sample, others have found hostility to be age-dependent.

The blood pressure pattern similar to the one of our high hostility subjects has previously been postulated to be associated with more target organ damage, such as left ventricular hypertrophy, and it has been speculated that those individuals may be more prone to heart attacks. In contrast, the blood pressure pattern of low hostility subjects was shown to be a large increase in blood pressure occurring after awakening, therefore exhibiting a steeper blood pressure slope during that transition. This type of blood pressure pattern has previously been described as a characteristic of “dippers” and older individuals. It has been speculated that individuals with such patterns may be more prone to cerebrovascular accidents, which may result from the greater blood pressure variability.

Finally, we note limitations of the use of the slope in the analysis of the overall pattern of change in blood pressure over the hours preceding and succeeding the time of awakening and getting up. The changes in blood pressure did not follow a uniform course and discontinuities were observed in the graphs that varied in the different subgroups of subjects. These observations lead us to conclude that closer examination of the patterns of blood pressure may be fruitful in future research on the morning surge and its implications for cardiovascular disorders.

In summary, this preliminary study has shown that hostility is associated with different blood pressure patterns during the early morning hours, the period of the day that has been associated with an increased risk for cardiovascular incidents. Close examination of these patterns appears to provide potentially significant diagnostic information beyond that provided by calculations of the overall slope. Further studies are necessary to shed more light on hostility and other emotional response dispositions of the individual and how they are related to the risk of cardiovascular events and the mechanisms of the morning surge in blood pressure.

REFERENCES


