

Editorial Comment

Assessment of Nocturnal Blood Pressure by Home Blood Pressure Monitoring

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(*Hypertens Res* 2007; 30: 661–662)

Key Words: nocturnal blood pressure, home blood pressure monitoring, dipping status

Among blood pressure measurements obtained by ambulatory blood pressure monitoring (ABPM), nocturnal blood pressure has been reported to have greater prognostic significance than daytime blood pressure or 24-h blood pressure (1, 2). Blunted nocturnal blood pressure dipping (as seen in non-dippers or risers) has also been shown to be a risk factor for hypertensive target organ damage (3), cardiovascular events (4), and stroke events (5). We reported that patients with exaggerated nocturnal blood pressure fall (extreme-dippers) (5) or with exaggerated morning blood pressure surge (6) had a higher risk for stroke events. These ABPM data revealed the benefits of measuring nocturnal blood pressure, both in patients with high and those with extremely low nocturnal blood pressure. However, Verdecchia *et al.* (7) reported that nocturnal blood pressure was not a good predictor of cardiovascular outcome in subjects with perceived sleep deprivation, which is quite relevant to ABPM, since the frequent blood pressure measurements required by this method often lead to sleep disturbance. In contrast, home blood pressure seems to be less likely to cause sleep deprivation, and can be repeated for days or even weeks. Therefore, nocturnal blood pressure assessed by a self-measurement device at home could be a possible alternative to that assessed by ABPM.

Hosohata *et al.* (8) developed a self-measurement blood pressure device for use during sleep, and reported that 66.5% of subjects had sleep disturbance when using this device. In the subjects who reported sleep disturbance, the reproducibility of nocturnal blood pressure by the self-measurement device was lower than in those without sleep disturbance. Additionally, the reproducibility of nocturnal blood pressure level by the self-measurement device was lower than that by

ABPM in previous reports (9–12). Although the number of measurements per night is substantially reduced by the use of a self-measurement device, the results of this study might indicate that the improvement is not sufficient to reduce sleep disturbance. Hosohata's data (8) raise the question of how many nights of self-measurement of nocturnal blood pressure, and how many measurements per night, are needed to increase the reproducibility without decreasing the subjects' compliance with the home blood pressure measurement.

What time of night should we assess nocturnal blood pressure using self-measurement devices? Hosohata *et al.* (8) measured nocturnal blood pressure once at 2:00 AM, because this was the point when subjects tended to have their lowest blood pressure in their previous study (13). The nocturnal blood pressure level at 2:00 AM is affected by the time of going to sleep, because the bedtimes differ among the subjects, and thus the amount of time spent sleeping before the 2:00 AM measurement also differs. Thus a single measurement of blood pressure at a fixed time may not detect the nadir of nighttime blood pressure during sleep.

Nocturnal blood pressure at 2:00 AM may underestimate the nocturnal blood pressure in subjects with various conditions, including sleep apnea syndrome (14), diabetes (15), and decreased renal function (16). The oxygen desaturation in sleep apnea syndrome, and the salt retention in renal dysfunction may affect the nocturnal blood pressure level differently at different times of night. For example, in subjects with sleep apnea syndrome, it has been reported that nocturnal desaturation frequently occurs during the rapid eye movement (REM) stage of sleep (17), and apnea is worse during the last third of the night (18).

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Received June 18, 2007.

One possible alternative to measuring nocturnal blood pressure at 2:00 AM is evaluation of morning blood pressure surge using a self-measurement device. We can evaluate morning hypertension using conventional self-measurement blood pressure devices; however, there are two subtypes of morning hypertension, *i.e.*, nocturnal hypertension (as seen in non-dippers or risers) and morning blood pressure surge (19). Unfortunately, we cannot distinguish between these two diurnal blood pressure changes using conventional self-measurement blood pressure devices.

The improvement of methodological problems would lessen the frequency of sleep disturbance, and may increase the reproducibility. Recently, we have developed a nocturnal hypoxia-triggered blood pressure measurement system to detect sleep apnea-specific blood pressure surges during sleep (20). Applying this system to home blood pressure monitoring may avoid unnecessary blood pressure measurements which could lead to a reduction in sleep quality. Further studies will be needed to confirm the efficacy of this device, as well as to clarify the prognostic significance of morning blood pressure surge, nocturnal blood pressure level, and dipping status as assessed by a self-measurement device at home.

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