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COMMENT

Nocturnal hypoxia and the difference in morning and evening blood pressure measured at home

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Globally, recent hypertension management guidelines have pointed out the importance of out-of-office blood pressure (BP), measured by home BP and 24-h ambulatory BP, for hypertension management [1]. These validated approaches are able to identify hypertension phenotypes such as white coat hypertension and masked hypertension. The prognostic value of home BP measurement (HBPM) is superior to that of office BP measurement and appears to be better than that of daytime systolic BP (SBP) and daytime diastolic BP (DBP) obtained from 24-h ambulatory BP measurement (ABPM) [2]. In addition, HBPM is more practical in clinical practice than ABPM, particularly among those who are on antihypertensive medication. Home BP monitoring consists of performing morning and evening BP measurements twice on each occasion, with a minimum of 3 days and a preferred period of 7 days [3]. Previous studies revealed that higher levels of HBPM were associated with an increased risk of cardiovascular disease (CVD), both in general and hypertensive populations [1]. Morning minus evening home BP (MEdif), calculated as the difference in the home morning BP and the evening BP, was significantly associated with a greater risk of CVD [4].

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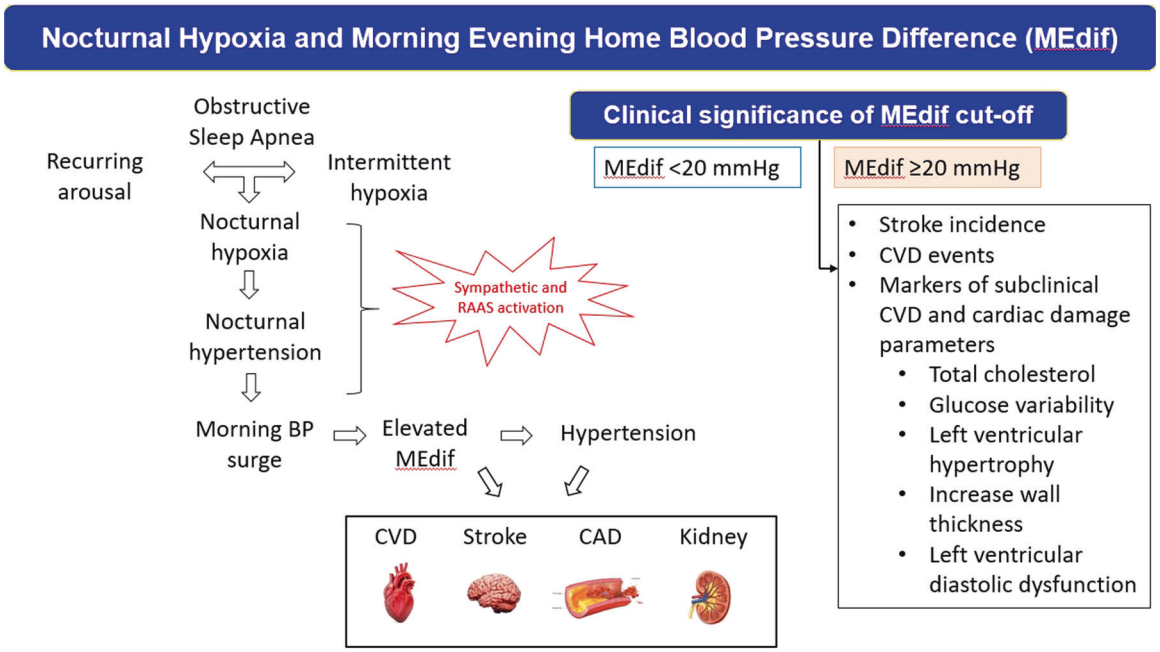
The present study by Hoshide et al. demonstrates that lower oxygen saturation (SpO_2) during the nighttime was associated with higher MEdif (≥20 mm Hg), independent of cardiovascular risk factors, among the outpatient population with at least one cardiovascular risk [5]. Nocturnal hypoxia, characterized by severe oxygen desaturation, which is commonly observed in patients with obstructive sleep apnea, was associated with a hypoxia-peak SBP and nocturnal SBP surge [6] and consequently may lead to increased morning BP [7]. Sympathetic excitation may explain the association of nocturnal hypoxia with increased MEdif. Nocturnal hypoxia causes the activation of sympathetic activity through chemoreflex stimulation during apneic episodes [8]. Sympathetic activation could cause an acute transient BP elevation, and this repeated brief surge of sympathetic activity during sleep and increase in nocturnal BP may eventually occur during the daytime, leading to the elevation of morning BP. Additionally, the magnitude of BP elevation during sleep is dependent on oxygen desaturation and specific sleep stages [6]. This chemoreflex-mediated hypoxic stimulation of sympathetic activity declines progressively during the deeper stage of nonrapid eye movement [6]. Moreover, a association of nocturnal BP with morning hypertension has been observed among hypertensive patients [7]. Figure 1 shows a schematic diagram of the possible relationship between nocturnal hypoxia and MEdif.

Hoshide et al. also found that only the lowest SpO_2, but not the mean SpO_2 and oxygen desaturation index, was significantly associated with MEdif ≥20 mm Hg [5]. A prior study also found that the lowest SpO_2 was inversely associated with the hypoxia-peak SBP, nocturnal BP surge and maximum value of BP surge [6]. Generally, morning BP is likely to be higher than evening BP in Japanese individuals. The morning hours are crucial period due to the major changes in physiological mechanisms that occur during arousal. Many of the mechanisms have a direct impact on the cardiovascular system and BP. Morning home SBP was



MEdif= morning and evening home BP difference; BP= blood pressure; CVD= cardiovascular disease; CAD= coronary artery disease; RAAS= renin-angiotensin-aldosterone system.

Fig. 1 Schematic diagram of the proposed relationship between nocturnal hypoxia and morning evening home BP difference (MEdif)

significantly associated with the risk of stroke and coronary artery disease [9]. Hoshide et al. also previously reported that morning home SBP ≥ 135 mm Hg was associated with a higher risk of stroke than morning home SBP < 135 mm Hg [10]. From the morning and evening BP measurements, Kario et al. defined abnormal MEdif based on a cutoff value of highest quartile of morning and evening SBP differences. The group with an MEdif of ≥20 mm Hg had higher stroke incidence and CVD events compared to the group with an MEdif <20 mm Hg [4, 11]. Similar to nocturnal hypoxia, MEdif was also significantly associated with markers of subclinical CVD and cardiac damage parameters such as total cholesterol levels [12], night glucose variability [13], left ventricular hypertrophy, relative wall thickness and left ventricular diastolic dysfunction [14, 15] among hypertensive patients. Available evidence has shown that the cutoff value of 20 mm Hg is a potential threshold for clinical MEdif. However, the hypertension status and control could affect the variability of MEdif [16].

Hoshide et al. also found that the association between the lowest SpO_2 during the nighttime and MEdif was unchanged even after the exclusion of those who were taking antihypertensive medication [5]. The findings further emphasized the independent association of nocturnal hypoxia and MEdif regardless of antihypertensive medication status. The Japan Morning Surge-Home Blood Pressure (J-HOP) study provides an excellent opportunity to understand the prognostic value of home BP from a nationwide population that involves a large number of participants with CVD risk factors. Moreover, the application of the validated devices and standardized HBPM schedules in this study provide strong scientific evidence for hypertension research. Identifying patients with high MEdif in the clinic and community and then planning appropriate treatment strategies might be beneficial to reduce the risk of nocturnal hypoxia. On the other hand, treating patients with sleep disorders might also improve BP prognosis. The causal relationship between nocturnal hypoxia and MEdif is still unknown. Even so, the present study demonstrated a significant association between nocturnal hypoxia and MEdif. Hence, a longitudinal study examining the association between nocturnal hypoxia and MEdif is needed to identify the cause-and-effect relationship.

Compliance with ethical standards

Conflict of interest The authors declare no competing interests.

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References

1. Kario K, Shimbo D, Hoshide S, Wang J-G, Asayama K, Ohkubo T, et al. Emergence of home blood pressure-guided management of hypertension based on global evidence. Hypertension. 2019;74:229–36.
2. Fagard R, Van Den Broeke C, De Cort P. Prognostic significance of blood pressure measured in the office, at home and during

ambulatory monitoring in older patients in general practice. J Hum Hypertens. 2005;19:801–7.
3. Muntner P, Shimbo D, Carey RM, Charleston JB, Gaillard T, Misra S, et al. Measurement of blood pressure in humans: a scientific statement from the American Heart Association. Hypertension. 2019;73:e35–e66.
4. Narita K, Hoshide S, Kario K. Difference between morning and evening home blood pressure and cardiovascular events: the J-HOP Study (Japan Morning Surge-Home Blood Pressure). Hypertens Res. 2021;44:1597–605.
5. Hoshide S, Kubota K, Kario K. Difference between morning and evening blood pressure at home and nocturnal hypoxia in the general practitioner-based J-HOP study. Hypertens Res. 2022. https://doi.org/10.1038/s41440-022-01054-4
6. Sasaki N, Nagai M, Mizuno H, Kuwabara M, Hoshide S, Kario K. Associations between characteristics of obstructive sleep apnea and nocturnal blood pressure surge. Hypertension. 2018;72:1133–40.
7. Li X, Li J, Liu K, Gong S, Shi R, Pan P, et al. Association between sleep disorders and morning blood pressure in hypertensive patients. Clin Exp Hypertens. 2018;40:337–43.
8. Grassi G, Seravalle G, Mancia G. Sympathetic activation in cardiovascular disease: evidence, clinical impact and therapeutic implications. Eur J Clin Investig. 2015;45:1367–75.
9. Kario K, Saito I, Kushiro T, Teramukai S, Tomono Y, Okuda Y, et al. Morning home blood pressure is a strong predictor of coronary artery disease: the HONEST study. J Am Coll Cardiol. 2016;67:1519–27.
10. Hoshide S, Yano Y, Haimoto H, Yamagiwa K, Uchiba K, Nagasaka S, et al. Morning and evening home blood pressure and risks of incident stroke and coronary artery disease in the Japanese general practice population: the Japan Morning Surge-Home Blood Pressure Study. Hypertension. 2016;68:54–61.
11. Kario K, Ishikawa J, Pickering TG, Hoshide S, Eguchi K, Morinari M, et al. Morning hypertension: the strongest independent risk factor for stroke in elderly hypertensive patients. Hypertens Res. 2006;29:581–7.
12. Aparicio LS, Barochiner J, Cuffaro PE, Alfie J, Rada MA, Morales MS, et al. Determinants of the morning-evening home blood pressure difference in treated hypertensives: the HIBA-Home Study. Int J Hypertens. 2014;2014:569259.
13. Shimizu T, Uzui H, Sato Y, Miyoshi M, Shiomi Y, Hasegawa K, et al. Association between changes in the systolic blood pressure from evening to the next morning and night glucose variability in heart disease patients. Internal Med. 2021;60:3543–49.
14. Shibuya Y, Ikeda T, Gomi T. Morning rise of blood pressure assessed by home blood pressure monitoring is associated with left ventricular hypertrophy in hypertensive patients receiving long-term antihypertensive medication. Hypertens Res. 2007; 30:903–11.
15. Matsui Y, Eguchi K, Shibasaki S, Shimizu M, Ishikawa J, Shimada K, et al. Association between the morning–evening difference in home blood pressure and cardiac damage in untreated hypertensive patients. J Hypertens. 2009;27:712–20.
16. Kawabe H, Saito I, Saruta T. Status of home blood pressure measured in morning and evening: evaluation in normotensives and hypertensives in Japanese urban population. Hypertens Res. 2005;28:491–8.