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COMMENT

Effective out-of-office BP monitoring to detect masked hypertension: perspectives for wearable BP monitoring

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Comment regarding "The prevalence of masked hypertension and masked uncontrolled hypertension in relation to overweight and obesity in a China nationwide registry" Xia et al. *Hypertens Res 2022*.

Masked hypertension is defined as a condition in which an individual's office blood pressure (BP) is in the normal range yet his or her out-of-office BP is elevated in the hypertension range. Masked morning hypertension, masked daytime hypertension, and masked nocturnal hypertension are three typical types of masked hypertension, classified according to the time-window of BP elevation, i.e., morning, daytime, and nighttime [1]. Ambulatory BP monitoring (ABPM) and home BP monitoring (HBPM) have been commonly used to monitor out-of-office BP, and wearable BP monitoring (WBPM) has recently become an option [2, 3] (Fig. 1).

ABPM is performed with short (15- to 60-min) measurement intervals over a 24-h period, and ABPM has the ability to detect morning, daytime, and nocturnal hypertension in a single 24-h measurement [4]. HBPM is usually measured on only two occasions per day (in the morning and evening), which is the home BP measurement schedule recommended by guidelines for hypertension management. However, HBPM is also suitable for assessing an individual's day-by-day BP variability over time. A nocturnal HBPM device that uses a timer function to monitor BP during sleep can measure nighttime BP repeatedly for multiple nights [5].

WBPM can monitor an individual's BP values during daily activity at any time and in essentially any place, depending on the wearer's decision; it is also suitable to monitor BP at a worksite or under stressful conditions [6, 7]. The accuracy of BP values measured by a wristwatch-type WBPM device that uses an oscillometric method (HeartGuide, Omron Healthcare, Kyoto) has been confirmed in both laboratory and daily ambulatory settings [2, 8]. Notably, WBPM devices that use cuffless BP monitoring techniques are not recommended for clinical evaluation or the management of hypertension at this time [9], and the availability of validated and recommended WBPM devices is limited. As described above, there are various methods to monitor out-of-office BP, and each method has different features (Fig. 1). It is thus important to know which BP monitoring method is most appropriate and effective for each individual to detect masked hypertension.

The present study by Xia et al. demonstrated that among patients under treatment for hypertension, overweight and obesity were significantly associated with a higher prevalence of masked hypertension [10]; this finding indicates that office BP measurements might both overestimate the effect of antihypertension treatment and underestimate the masked cardiovascular risks in treated hypertensive patients with obesity. Based on a previous observation that obese patients have higher nighttime BP than normal weight patients [11], Xia et al. speculated that poor nighttime BP control was a major driving factor of the high prevalence of masked uncontrolled hypertension in treated patients with overweight/obesity. Another interesting finding described by Xia et al. is that the significant association between overweight/obesity and masked hypertension was observed only in treated hypertension patients (odds ratio 1.45 vs. normal weight) and not in untreated patients.

As described in their study's Discussion, the discrepancy in data between the patients with and without treatment may be partly explained by the insufficient antihypertensive effect of short-acting drugs. However, masked daytime hypertension was also more frequently identified in the

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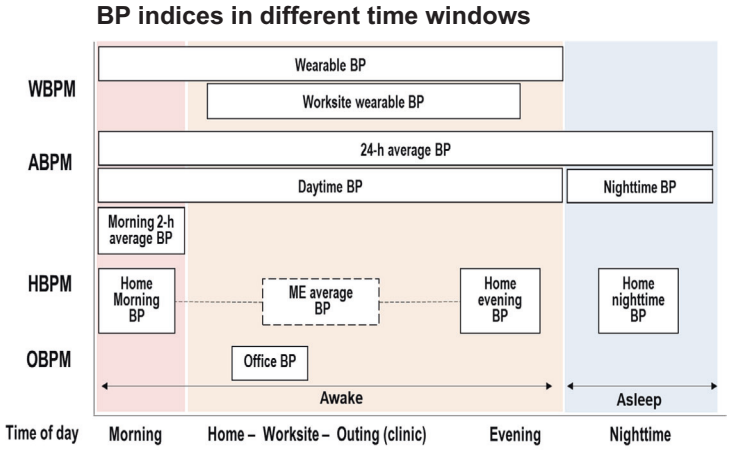

	Measurement period and frequency	BP variability (BPV)
WBPM	• Several days to months • Any time you want, as often as you want	• Acute BPV • (by physical or psychological stress) • Day-by-day BPV
ABPM	• Over 24 hours • 15 to 30-min intervals	• Acute BPV (between intervals) • Diurnal BPV (nighttime dipping, morning surge)
HBPM	• Several days to months • Several occasions per day	• Diurnal BPM (morning–evening difference) • Day-by-day BPV • Seasonal BPV
OBPM	• Every clinical visits • Once in a few months	• Visit to visit BPV • Seasonal BPV

Fig. 1 Office BP and out-of-office BP monitoring: the features of each BP monitoring method and BP index. Figure: BP indices in different time windows measured by each BP monitoring method. *Table:* BP measurement method, measurement frequency, and capacity for measuring BP variability for each BP monitoring method. ABPM: ambulatory blood pressure monitoring, BP: blood pressure, BPV: blood pressure variability, HBPM: home blood pressure monitoring, ME morning−evening, OBPM office blood pressure monitoring, WBPM wearable blood pressure monitoring

treated patients with overweight/obesity than in those with normal weight (odds ratio 1.40); thus, this explanation does not explain all of their results. We suggest that further research is necessary to interpret these results. Given the findings of the Xia et al. study and previous investigations, we propose that it would be advisable to monitor the out-of-office BP of treated hypertensive patients with obesity, especially by monitoring their nighttime BP.

Another unique observation in the Xia et al. study is the masked hypertension data detected by ABPM and those detected by HBPM. The observation that the prevalence of masked hypertension was higher in treated patients with overweight/obesity than in those with normal weight was more significant when the patients' out-of-office BP was assessed by ABPM (vs. HBPM). This result supports the hypothesis that nighttime BP monitoring is particularly important for obese patients.

In our HI–JAMP study in which ABPM and HBPM were performed with the same device in treated hypertensive patients, the prevalence of patients with uncontrolled BP in the morning hours was relatively high [12, 13]. Contrary to the results reported by Xia et al., the prevalence of masked hypertension detected by HBPM was higher than that detected by ABPM (25.0% vs. 19.8%) [13]. Our patients were older than those in the Xia et al. study (average age: 69.2 vs. 54.9 years), and all of our patients were taking antihypertensive medications [13]. In patients taking a once-daily morning dose of an antihypertensive drug, a morning BP value measured immediately prior to the next dose may result in a "blind spot" regarding BP-lowering effects.

In a European study including treated and untreated participants (average age 57.1 years; 49% treated) assessed with ABPM and HBPM, masked hypertension detected only by ABPM was much more common in the younger participants, and masked hypertension detected only by HBPM was much more common in the older (>65 years) participants [14]. The daytime ambulatory BP values of the older patients were lower than their home BP values, which may be explained in part by the sedentary lifestyles of older individuals. Based on these results, we recommend that an assessment of a patient's BP control status focusing on his or her BP values in the morning hours be conducted (i.e., home morning BP and ambulatory morning 2-h average BP), especially for hypertensive patients and older patients under treatment for hypertension.

We have demonstrated a significant elevation in BP measured at a worksite: in a study of working individuals with hypertension whose BP was measured by a validated oscillometric WBPM device for 5.5 ± 1.2 days, the subjects' average worksite systolic BP (SBP) was higher than their morning home SBP (133.4 ± 12.7 mmHg vs. 128.5 ± 13.8 mmHg) [3]. In addition, the peak value of worksite SBP was significantly associated with the left ventricular mass index. These results indicated that, for working adults, the assessment of daytime BP during working hours by a WBPM device or an ABPM device is also important for the management of hypertension.

Office BP is measured under static conditions and is less impacted by some lifestyle- and environmental-related factors, although in some cases, the white coat effect can cause an increase in office-measured blood pressure. Conversely, out-of-office BP is vulnerable to various lifestyle- and environmental-related factors. Knowledge of the characteristics of individual patients who are likely to have each masked hypertension phenotype will contribute to the selection of the most effective out-of-office BP monitoring method, resulting in better hypertension management. As noted in the study limitations described by Xia et al., differing results might be obtained in other populations of different ethnicities or those living in different regions. Further efforts are necessary to reveal effective out-of-office BP monitoring for individuals of various ethnicities and lifestyles.

Compliance with ethical standards

Conflict of interest K.K. has received research grants from Omron Healthcare and A&D Co. The other authors have no conflicts of interest to declare.

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