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Maximum home systolic blood pressure is a useful indicator of arterial stiffness in patients with type 2 diabetes mellitus: Post hoc analysis of a cross-sectional multicenter study

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ABSTRACT

Aims: Maximum (max) home systolic blood pressure (HSBP) as well as mean HSBP or HSBP variability was reported to increase the predictive value of target organ damage. Yet, the association between max HSBP and target organ damage in patients with type 2 diabetes has never been reported. The aim of this study was to investigate the association between max HSBP and pulse wave velocity (PWV), a marker of arterial stiffness which in turn is a marker of target organ damage, in patients with type 2 diabetes.

Methods: We assessed the relationship of mean HSBP or max HSBP to PWV, and compared area under the receiver-operating characteristic curve (AUC) of mean HSBP or max HSBP for arterial stiffness in 758 patients with type 2 diabetes.

Results: In the univariate analyses, age, duration of diabetes mellitus, body mass index, mean clinic systolic blood pressure (SBP), mean HSBP and max HSBP were associated with PWV. Multivariate linear regression analyses indicated that mean morning SBP ($\beta = 0.156$, $P = 0.001$) or max morning SBP ($\beta = 0.146$, $P = 0.001$) were significantly associated with PWV. AUC (95% CI) for arterial stiffness, defined as PWV equal to or more than 1800 cm per second, in mean morning SBP and max morning SBP were 0.622 (0.582–0.662; $P < 0.001$) and 0.631 (0.591–0.670; $P < 0.001$), respectively.

Conclusions: Our findings implicate that max HSBP as well as mean HSBP was significantly associated with arterial stiffness in patients with type 2 diabetes.

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1. Introduction

Hypertension is a major risk factor for arterial stiffness leading to both the onset and progression of cardiovascular disease (CVD) in patients with diabetes. Studies have also demonstrated that type 2 diabetes is associated with increased arterial stiffness that may partly explain the increased CVD [1]. It has been shown that strict blood pressure control as well as blood glucose control decreases the incidence of CVD in patients with diabetes [2].

There has been accumulating evidence that HSBP predicts CVD better than clinic SBP [3–7]. In patients with diabetes, HSBP has been also reported to more accurately reflect target organ damage (TOD) than clinic SBP [8,9]. Not only mean HSBP but also variability in HSBP [10–14] plays an important part in the progression of TOD and in the triggering of vascular events. Moreover, in the recent study [15], max HSBP was reported to be better correlated with hypertensive TOD than the mean HSBP in untreated hypertensive patients. In routine clinical practice, it is very difficult for physicians to calculate mean HSBP or variability in HSBP from multiple self-measurement values for HSBP, on the other hand, max HSBP can be obtained at first glance.

Thus, if max HSBP can also provide the positive association with TOD as well as mean HSBP in patients with type 2 diabetes, it could become very useful values in routine clinical practice. Then, we aimed to assess, for the first time, the association between max HSBP and PWV, a marker of arterial stiffness which in turn is a marker of TOD, and compare max HSBP with mean HSBP in their correlations to arterial stiffness in patients with type 2 diabetes.

2. Materials and methods

2.1. Patients

Home blood pressure (HBP) measurements were performed in patients with type 2 diabetes who had regularly attended the diabetes outpatient clinic at Hospital of Kyoto Prefectural University of Medicine and the other four general hospitals, which had diabetes specialized outpatient clinic, more than 500 beds for hospitalization and about two thousands of outpatient per day. We consequentially recruited 1292 patients with type 2 diabetes who visited the facilities between March 2008 and October 2012. The winter season was not comprised in it to avoid the variation of BP caused by its coldness. There was no blood pressure (BP) level criterion for study inclusion.

We excluded patients who measure HBP less than 7 days either or both in the morning and in the evening ($n = 167$) and who had advanced renal dysfunction (serum creatinine equal to or more than 2.0 mg/dl; $n = 11$). Moreover, we excluded patients whose data of PWV were not available ($n = 356$) from the analyses. Finally, 758 patients comprised the study population (408 male, 350 female). The diagnosis of type 2 diabetes mellitus was based on the American Diabetes Association criteria [16].

2.2. Study design

This study was post hoc analysis of a cross-sectional multicenter study in patients with type 2 diabetes in general hospitals, which located in Kansai area in Japan.

First, we assessed the relationship of mean HBP or max HBP and major cardiovascular risk factors to PWV using a linear regression analysis. Second, we applied a multivariate linear regression analysis to evaluate independent determinants of PWV. Finally, we compared area under the receiver-operating characteristic (ROC) curve (AUC) of mean HSBP or max HSBP for arterial stiffness defined as PWV equal to or more than 1800 cm/s [17]. AUCs of the 2 ROC curves in morning and evening were compared using the algorithm developed by Metz et al. [18]. All procedures of the present study were approved by the local Research Ethics Committee and were conducted in accordance with the Declaration of Helsinki, and informed consent was obtained from all patients.

2.3. HBP measurement

Patients were instructed to perform triplicate morning and evening BP measurements for 14 consecutive days. Mean of three measurements in the morning or those in the evening for 14 consecutive days in each individual were taken as the mean HBP, and max HBP was defined as the highest of all readings in the morning or those in the evening for 14 consecutive days in each individual in this study. Morning measurements of BP were made within 1 h of awakening, before breakfast or taking any drugs, with the patient seated and rested for at least 5 min [19]. Evening measurements of BP were obtained in a homologous way just before going to bed. The cuff was directly placed around their non-dominant arm and the position of cuff was maintained at the level of the heart. HBP measurements were performed using an automatic device, HEM-70801C (Omron Healthcare Co. Ltd., Kyoto, Japan), which uses the cuff-oscillometric method to generate a digital display of heart rate and systolic/diastolic blood pressure value. HEM-70801C employs the identical components and BP determining algorithm to those of another device, HEM-705IT, which was previously validated and satisfied the criteria of the British Hypertension Society protocol [20]. CBP was taken as the mean of three readings by HEM-70801C, when we rented the device.

2.4. Data collection

Blood samples for biochemical measurements were collected in the morning. Hemoglobin A_{1C}, serum lipid profile (low-density lipoprotein cholesterol, triglycerides, and high-density lipoprotein cholesterol), and other biochemical data were determined by standard laboratory measurements. Hemoglobin A_{1C} was expressed as National Glycohemoglobin Standardization Program unit. Information including age, duration of diabetes, smoking and alcohol consumption status and antihypertensive medication were obtained at the time of the BP measurement. Retinopathy was assessed by chart review and was graded as follows: no diabetic retinopathy (NDR), simple diabetic retinopathy (SDR), and proliferative diabetic retinopathy (PDR). Nephropathy was