SHORT-TERM BLOOD PRESSURE VARIABILITY AND ITS CORRELATIONS WITH THE LEVEL OF AMBULATORY SYSTOLIC BLOOD PRESSURE

Kanishcheva Olena
MD, Assistant professor
Internal Medicine Department
School of Medicine
V.N. Karazin Kharkiv National University

Bilchenko Oleksandr
PhD, Doctor of Medical Scvience, Professor
Head of the Department of Therapy #1
Educational and Scientific Institute of Postgraduate Education
Kharkiv National Medical University

Barabash Nadiya
PhD, Associate professor
Internal Medicine Department
School of Medicine
V.N. Karazin Kharkiv National University

Lebedynska Maryna
PhD, Associate professor
Department of Therapy #1
Educational and Scientific Institute of Postgraduate Education
Kharkiv National Medical University

A high level of systolic blood pressure (SBP) remains the main risk factor for mortality in the world [1]. SBP at least 140mmHg accounts for most of the mortality and disability burden (70%), and the largest number of SBP-related deaths per year are due to ischaemic heart disease (4.9 million), haemorrhagic stroke (2.0 million), and ischaemic stroke (1.5 million) [2]. In recent decades many studies have documented the relationship between the blood pressure variability (BPV), including short-term, and cardiovascular (CV) events and mortality, regardless of SBP level [3–5]. On the other hand, studies on short-term BPV demonstrated that patients with a higher SBP levels also have higher BPV values [6–8]. The level of SBP is considered one of the main determinants of increased BPV; however, it remains unclear whether excessive BPV is the cause of increased SBP and the hypertension (HT) development or a consequence of the mentioned conditions. Thus, the question of the relationship between SBP level and BPV remains not fully clarified.

The purpose of the current study was to evaluate the correlations among level of ambulatory SBP and short-term BPV in patients with HT.

Patients and methods. This is an open non-randomized cross-sectional cohort study of hypertensive outpatient referrals both Family and General Physicians to the Internal Medicine Department of V.N. Karazin Kharkiv University. 172 patients with HT older than 18 years old were enrolled to the study. The diagnosis of HT was made according to the 2018 ESC/ESH Guidelines for the management of HT [2]. All patients included to the study underwent ambulatory blood pressure monitoring (ABPM). The BP monitoring was carried out using the computer system "Cardiosens" (KhAI Medica, Ukraine) with an oscillometric method of blood pressure (BP) measurement in accordance with the Ambulatory Blood Pressure Monitoring International Recommendations [9]. The monitoring was performed in the conditions of a typical patient day, with the preservation of routine physical and psycho-emotional loads. The cuff was placed on the non-dominant hand. BP was measured with an interval of 15 minutes during the period of awake and 30 minutes during the sleep time. Periods of the day and night were defined based on the patient's diary.

The following BP parameters and their short-term variability were calculated: (1) standard deviations (SD) of all SBP and diastolic BP (DBP) readings during 24 hours, daytime, and nighttime periods; (2) 24-h SBP and DBP SDs were identified as weighted SD (SD_w) calculated as sum of daytime SD × number of diurnal hours and nighttime SD × number of nocturnal hours divided by 24 hours [10]; (3) coefficient of variation (CV), which were defined as the ratio between the SD and mean BP × 100 at the same periods; (4) blood pressure variability ratio (BPVR) for 24-hour, daytime, and nighttime equals to the ratio between SBP and DPB variability expressed as SD [12]; (5) average real variability (ARV) and (6) coefficient of successive variation (SV) calculated for 24-hour, daytime, and nighttime periods according to the previously published procedure [13].

Data analysis was carried out using STATISTICA version 10.0 and Microsoft Excel version 2010 software. Variables are expressed as M ± SD (Me [min-max]), where M is a mean value, SD is a standard deviation, Me is a median, min is a minimal value and max is a maximal value of a variable. To assess the normality of continuous variables Shapiro-Wilk`s statistics were used. Correlation among BP level and short-term BPV indices was evaluated using Spearman`s rank correlation analysis. Significance was set at $p < 0.05$.

Results and discussion. M ± Sd (Me [min-max]) of daily, daytime and nighttime SBP exceeded the recommended threshold values and were: 134 ± 15,4 (133 [11-190]) mm Hg,137 ± 15,9 (136 [104-193]) mm Hg and 125 ± 15,7 (124 [89-184]) mm Hg respectively. The results of the correlation analysis are presented in Table 1.

Table 1.

Correlations between indices of short-term blood pressure variability and 24-hour, daytime and nighttime ambulatory systolic blood pressure

BPV index	24-hour period		Daytime period		Nighttime period	
	r	p	r	p	r	p
	24-hour SBP					
SD_w SBP	0,37	< 0,001	-	-	-	-
SD_w DBP	0,33	< 0,001	-	-	-	-
SD SBP	0,40	< 0,001	0,33	< 0,001	0,25	0,001
SD DBP	0,34	< 0,001	0,26	0,001	0,33	< 0,001
CV SBP	-0,11	0,135	-0,13	0,078	-0,11	0,134
CV DBP	-0,03	0,704	-0,06	0,435	0,04	0,647
ARV SBP	0,35	< 0,001	0,30	< 0,001	0,25	0,001
ARV DBP	0,33	< 0,001	0,28	< 0,001	0,37	< 0,001
SV SBP	0,35	< 0,001	0,32	< 0,001	0,26	0,001
SV DBP	0,32	< 0,001	0,29	< 0,001	0,33	< 0,001
BPVR	-0,02	0,793	0,01	0,847	-0,16	0,041
	Daytime SBP					
SD_w SBP	0,38	< 0,001	-	-	-	-
SD_w DBP	0,35	< 0,001	-	-	-	-
SD SBP	0,47	< 0,001	0,35	< 0,001	0,23	0,002
SD DBP	0,41	< 0,001	0,29	< 0,001	0,32	< 0,001
CV SBP	-0,04	0,614	-0,12	0,105	-0,10	0,172
CV DBP	0,04	0,570	-0,04	0,578	0,06	0,436
ARV SBP	0,32	< 0,001	0,29	< 0,001	0,22	0,004
ARV DBP	0,33	< 0,001	0,28	< 0,001	0,35	< 0,001
SV SBP	0,34	< 0,001	0,31	< 0,001	0,23	0,003
SV DBP	0,33	< 0,001	0,30	< 0,001	0,32	< 0,001
BPVR	-0,04	0,636	-0,01	0,942	-0,17	0,023
	Nighttime SBP					
SD_w SBP	0,30	< 0,001	-	-	-	-
SD_w DBP	0,24	0,001	-	-	-	-
SD SBP	0,12	0,132	0,23	0,003	0,32	< 0,001
SD DBP	0,09	0,235	0,17	0,024	0,33	< 0,001
CV SBP	-0,35	< 0,001	-0,15	0,055	-0,09	0,231
CV DBP	-0,24	0,001	-0,08	0,294	-0,04	0,605
ARV SBP	0,36	< 0,001	0,29	< 0,001	0,33	< 0,001
ARV DBP	0,30	< 0,001	0,25	0,001	0,32	< 0,001
SV SBP	0,35	< 0,001	0,30	< 0,001	0,32	< 0,001
SV DBP	0,27	< 0,001	0,24	0,002	0,29	< 0,001
BPVR	0,01	0,876	0,03	0,669	-0,07	0,347

r - Spearman`s rank correlation coefficient

For most indices of SBP and DBP variability, a statistically significant direct relationship, mostly weak, with the level of 24-hour, daytime, and nighttime SBP was found. At the same time, the 24-hour BPV indices showed the closest relationship not with the 24-hour SBP level, as might be expected, but with daytime or nighttime, depending on the BPV index. For 24-hour SD and SDw indices of SBP and DBP, as well as for the 24-hour ARV and SV indices of DBP, the closest relationship was established with the level of daytime SBP. For the SD SBP and DBP indices it was of medium strength. At the same time, for the 24-hour ARV and SV SBP indices, the closest relationship was established with the level of nighttime SBP. The given facts testify to the greater informativeness of the indicated indices in determining the relationship between SBP and BPV. It is advisable to take the above into account when analyzing BPV according to one or another index, especially when looking for possible ways to normalize elevated BPV and correct antihypertensive therapy.

Daytime and nighttime SD SBP and SD DBP showed the closest relationship with the average level of SBP in the respective monitoring periods. At the same time, daytime and nighttime ARV and SV SBP and DBP, with the exception of nighttime SV SBP, had the closest relationship with the level of daytime SBP. Thus, it can be stated that the daytime BPV is determined by the nighttime SBP level, as well as the nighttime BPV - by the daytime SBP level. For most SBP and DBP CV indices, statistically significant relationships with the SBP level were not established, with the exception of daytime CV SBP and CV DBP, which demonstrated the presence of a weak statistically significant inverse correlation with the nighttime SBP level. Based on the above, it is possible to draw a conclusion about the relationship between the nocturnal SBP level and the 24-hour BPV, determined by the CV index.

No statistically significant correlations with the SBP level were established for 24-hour and daytime BPVR index during the main monitoring periods. The nighttime BPVR demonstrated a weak direct correlation with the 24-hour and daytime SBP level, which indicates a certain influence of the daytime SBP on the BPV determined by the BPVR index.

Based on the results, it can be stated that SD SBP and SD DAP indices have a closer relationship with the mean SBP level during corresponding period of monitoring. At the same time, 24-hour SD and SDw values of SBP and DBP are more influenced by the level of daytime SBP than the nighttime. The 24-hours values of ARV SBP and SV SBP indices are more dependent on the nighttime SBP level, and ARV DBP and SV DBP indices are more dependent on the daytime SBP level, as well as the nighttime BPVR. The absence of a statistically significant correlation between the majority of CV indices, BPVRs and the level of ambulatory SBP suggests that these indices reflect different pathogenetic links in the formation of BPV.

The results of current study showed that the level of SBP is a marker of BPV violation - both SBP and DBP, and the higher is the SBP level, the greater is the BPV. At the same time, the weak correlations among SBP level during the main monitoring periods and indices of short-term BPV indicates a relatively small influence of this parameter on BPV and presence of other, probably more important factors that cause BPV phenomenon and contribute to its increase in patients with HT.

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