SCRIPTA MEDICA (BRNO) – 73 (1): 25–30, *January 2000*

SHORT-TERM VARIABILITY OF BLOOD PRESSURE AND BAROREFLEX SENSITIVITY IN ESSENTIAL HYPERTENSION

FIŠER B.[1], SIEGELOVÁ J.[2], PLACHETA Z.[2], DUŠEK J.[2]

[1] Department of Physiology, Faculty of Medicine, Masaryk University, Brno
[2] Department of Functional Diagnostics and Rehabilitation, Faculty of Medicine, Masaryk University, Brno

A b s t r a c t

The aim of the study was to measure short-term blood pressure variability and baroreflex sensitivity (BRS) in patients with essential hypertension and in healthy young subjects with low values of baroreflex sensitivity without high blood pressure. Blood pressure was noninvasively monitored beat-by-beat (Finapres Ohmeda). The results confirmed the former finding that blood pressure variability was lower in subjects with high BRS and vice versa. On the other hand in hypertensive subjects, blood pressure variability was low despite both low heart rate variability and low BRS. It is concluded that, in patients with essential hypertension, the low variability of blood pressure at 0.05 Hz corresponded to the normal blood pressure component of the baroreflex and the increased blood pressure variability at 0.1 Hz reflected an impaired heart rate component of the baroreflex.

K e y w o r d s

baroreflex sensitivity, short-term variability of blood pressure

INTRODUCTION

Baroreflex heart rate sensitivity (ms/mmHg, BRS) is low in patients with essential hypertension. This fact has been demonstrated by the phenylephrine method (*1*) and the spectral method (*2,3*). The mean BRS value in hypertensives is about one half of that in normotensive subjects. Because of a large variance of individual values in these two groups, there are many normotensives who have a lower BRS value than the mean value in hypertensive subjects and vice versa.

On the other hand, a gain in the blood pressure component of the baroreflex is normal in essential hypertension (*4*). This is a finding different from that in patients with heart rate failure where both the heart rate component and the blood pressure component are decreased (*5*).

The aim of the present study was to compare BRS in patients with essential hypertension and in healthy, normotensive, young subjects who had low BRS values. There is an important question whether young normotensives with low BRS can be at risk for the development of hypertension later in their lives and an answer to it can contribute to the understanding of the problem of hypertension.

The estimation of the baroreflex blood pressure component in the present study was based on the evaluation of short-time blood pressure variability. It has been demonstrated that this variability is decreased in subjects with high BRS (*6*) because of the baroreflex homeostatic function in damping blood pressure oscillations.

MATERIALS AND METHODS

Blood pressure was recorded in finger arteries by Peňáz's non-invasive, volume-clamp method (*7*) for 5 min (Finapres, Ohmeda) during metronome-controlled breathing (0.33 Hz) in a group of non-treated subjects (n=10; age, 99±11 years/mean±SD) with essential hypertension (systolic/diastolic blood pressure, 155±23/99±12 mmHg). The diagnosis of essential hypertension (EH) was established by detecting elevated blood pressure (more than 140/90mmHg) on the basis of sphygmomanometer measurements on three different occasions within one month. The possibility that patients had secondary causes of hypertension was excluded by clinical examination. The other control groups consisted of subjects selected from group of controls. BRS (ms/mmHg) was determined by a spectral analysis of spontaneous fluctuation in systolic blood pressure and cardiac intervals. The results were compared with those of a group of healthy, young subjects (n=10) who had low BRS (<6ms/mmHg, LBRS) and with those of a group of subjects (n=10) with high BRS (>25 ms/mmHg, HBRS). The two control groups, selected from a population of 100 healthy, young adults (age 20-22 years), comprised subjects with the lowest and the highest baroreflex sensitivity, respectively.

The method of BRS determination is described elsewhere (*8*). At least 30 min before the test, the subjects had been resting and adjusting to the environment (room temperature, 20°C). Meanwhile, a plethysmographic transducer, Finapres Ohmeda, was applied. Blood pressure was monitored at rest for 10 min. A 3-minute record made at the end of the resting period was taken for further analysis. Each subject was then instructed to breathe synchronously with a metronome at 0.33 Hz for 5 min. The last 3 minutes were recorded and analysed. The two records, one made during spontaneous and the other during metronome-controlled breathing, were evaluated by means of power spectral analysis. From the noninvasive, continuous blood pressure records, beat-to-beat values of systolic and diastolic blood pressure and pulse intervals were derived and analysed. The values of all three circulatory variables were linearly interpolated at 2 Hz to ensure equidistant sampling in each time series. The baseline linear trend was removed from all signals. Power spectral densities and cross-spectral densities were calculated from auto- and cross-correlation functions using Hanning's spectral window. The value of cross-spectral power density of pulse intervals and systolic blood pressure fluctuation [ms*mmHg] was divided by the value of power spectral density of systolic blood pressure fluctuation [mmHg*mmHg] at 0.1 Hz. The obtained value, modulus, was considered to be the measure of BRS [ms/mmHg]. The coherence at 0.1 Hz, i. e., the degree of linear coupling between systolic pressure and pulse interval fluctuation, was calculated from the records of both spontaneous and metronome-controlled breathing.

The study was approved by the Ethics Committee of Masaryk University in Brno and all subjects gave their written informed consent.

RESULTS

The variation in systolic blood pressure at 0.05 Hz (mean±SD) was 44.1±35.3 $mmHg^2/Hz$ in HBRS and 194.1±141.2 $mmHg^2/Hz$ in LBRS subjects.

The results confirmed the former finding that blood pressure variability was low in subjects with high BRS and blood pressure variability was high in subjects with low BRS. In the patients with essential hypertension, however, blood

pressure variability was low despite both low heart rate variability and low BRS. Variation in systolic blood pressure at 0.05 Hz was 61.8±26.5 $mmHg^2/Hz$ (EH versus LBRS: $P<0.05$, Wilcoxon). At 0.1 Hz, variation in systolic blood pressure was higher in EH patients than in LBRS and HBRS subjects (EH, 52.9±26.5 $mmHg^2/Hz$; HBRS, 17.6±15.9 $mmHg^2/Hz$; LBRS, 35.3±13.2 $mmHg^2/Hz$; EH versus HBRS, $P<0.05$).

The low variation of blood pressure at 0.05 Hz corresponds to the normal blood pressure component of baroreflex in patients with essential hypertension. The increased blood pressure variation at 0.1 Hz in this group of patients reflects the impaired heart rate component of baroreflex.

DISCUSSION

The difference in power spectra density of cardiovascular variables between the normotensive subjects and the patients with essential hypertension indicates that, in each group, low BRS was caused by a different mechanism. The low BRS in healthy subjects can be due to low baroreceptor sensitivity because both baroreflex components, i.e., blood pressure component and heart rate pressure component, are attenuated. This resembles the situation in patients with heart failure, where low baroreceptor sensitivity was proved. In animal experiments was found that a high level of aldosteron, which stimulates Na/K-ATPase, decreases the sensitivity of baroreceptors. This state can be reversed by digoxin, a potent Na/K-ATPase inhibitor (*9*). The results of previous study in humans, which used various methods to assess the relationship between baroreflex sensitivity and blood pressure components (*10, 11*) are in agreement with our findings.

In patients with essential hypertension the situation is different. In mild and moderate hypertension, the resetting of baroreceptors is responsible for a shift from the set-point to a higher level of blood pressure, but the slopes of the blood pressure-cardiac interval curve, which corresponds to BRS, and of the blood pressure-muscle sympathetic activity curve remain unchanged (*12*). In severe hypertension, the set-point further moves to higher values of blood pressure but a decrease in curve slope takes place (*13*). This, however, was not the case in our hypertensive subjects. It is most probable that the high sympathetic activity observed in essential hypertension accompanied by low parasympathetic activity is responsible for a decrease in BRS at intact baroreceptor sensitivity (*14*).

It is necessary to realise that, in hypertensives, the magnitude of fluctuation in blood pressure can be different and this fact can weaken our findings concerning the normal baroreceptor sensitivity in essential hypertension. On the other hand, the results of experiments with vasoactive drugs support these results (*12*).

The problem whether the low BRS is involved in the development of hypertensive disease, left ventricular hypertrophy and arterial smooth muscle hypertrophy and whether it further increases a risk of cardiovascular disease and

to what extent - these are questions which warrant further research (*12,14,15*). Only a prospective study of a large number of subjects can provide an answer. The spectral method of BRS determination is non-invasive and, in our modification with a controlled rate of respiration, would be suitable for such investigation.

Fišer B., Siegelová J., Placheta Z., Dušek J.

KRÁTKODOBÁ VARIABILITA KREVNÍHO TLAKU A BAROREFLEXNÍ SENZITIVITA U ESENCIÁLNÍ HYPERTENZE

S o u h r n

Cílem studie bylo měření krátkodobé variability krevního tlaku a baroreflexní senzitivity (BRS) u pacientů s esenciální hypertenzí a u mladých zdravých osob s nízkými hodnotami baroreflexní senzitivity bez vysokého krevního tlaku. Krevní tlak byl neinvazivně monitorován tep po tepu (Finapres, Ohmeda). Výsledky potvrdily dřívější zjištění, že variabilita krevního tlaku je nižší u osob s vysokou BRS a naopak. Na druhé straně variabilita krevního tlaku u hypertoniků byla nízká navzdory nízké variabilitě srdeční frekvence i nízké BRS. Z toho vyplývá, že nízká variabilita krevního tlaku při 0.05 Hz odpovídá normální tlakové komponentě BRS u pacientů s esenciální hypertenzí. Zvýšená variabilita krevního tlaku při 0.1 Hz v této skupině pacientů svědčí o porušené komponentě srdeční frekvence baroreflexu.

Acknowledgements

This study was supported by grant no. 4313-3 from the Grant Agency of the Ministry of Health of the Czech Republic.

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