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Original Article

The connections among resting heart rate, ambulatory blood pressure and left ventricular hypertrophy in elderly hypertensive patients

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Abstract: Objects: To investigate the connections among resting heart rate, ambulatory blood pressure and left ventricular hypertrophy in elderly hypertensive patients. Methods: 103 elderly hypertensive patients were chosen and divided into three groups according to the resting heart rate (RHR): RHR1 group: <70/min (n = 28); RHR2 group: 70/min ≤ RHR <80/min (n = 42), RHR3 group: RHR ≥80 times (n = 33) three groups. Clinical examinations including the resting ECG, echocardiography, ambulatory blood pressure, fasting plasma glucose (FPG), serum total cholesterol (TC), triglyceride (TG), low density lipoprotein (LDL-C), high density lipoprotein (HDL-C), uric acid (UA), serum creatinine (Cr), body mass index (BMI) were done for all the patients in three groups. Results: (1) We found that the levels of FBG, TC, TG, LDL-C, HDL-C, UA, Cr, BMI of patients in RHR3 group were significantly higher than those of both RHR1 and RHR2 groups (P<0.05). (2) In the ambulatory blood pressure examination among three groups, we found the 24 h SBP, dSBP, nSBP, 24 h PP, dPP, nPP of RHR3 group were significantly higher than those of RHR1 and RHR2 groups (*P*<0.01 or *P*<0.05). (3) There were significant differences in all groups on LVMI, LVPW, IVST, LVDD and LVEF (*P*<0.01 or *P*<0.05). (4) The levels of FPG, TC, LDL-C, LVEDD, LVMI, 24 h SBP, dSBP, nSBP, 24 h PP, dPP and nPP were positive correlated to RHR, However, the levels of HDL-C and LVEF were negative correlated to RHR. Conclusion: RHR changes was closely related with SBP, PP, glycolipid metabolic abnormalities and left ventricular hypertrophy, therefore control of the heart rate and glycolipid metabolism should be paid attention to as well as the control of blood pressure.

Keywords: Elderly patients with essential hypertension, resting heart rate (RHR), dynamic blood pressure parameters, left ventricular hypertrophy

Introduction

In recent years, resting heart rate (RHR) on the prognosis of hypertension patients was focused, studies showed the increased RHR would lead to the increases of cardiovascular events in hypertension patients. RHR is an independent risk factor for hypertension death [1]. With the acceleration of population aging, elderly hypertensive becomes a major public health problem all over the world. Hypertension is the most common disease in the aged, the hypertensive in elderly patients had a high risk of left ventricular hypertrophy, left ventricular hypertrophy is the key to the development of heart failure, myocardial infarction, malignant arrhythmias and sudden cardiac death. Currently the studies on the correlation between resting heart rate (RHR) and target organ damage were rare in elderly hypertension (EH) patient. Our study was designed to investigate the connections among resting heart rate, ambulatory blood pressure and left ventricular hypertrophy in elderly hypertensive patients.

Material and methods

Object selection

103 patients (53 males and 50 females) with hypertension aged 60-80 (average 68.01± 5.31) were chosen from hospitalized patients in department of Cardiology at the first affiliated hospital of Liaoning Medical university from 2011.1 to 2012.1. All these patients were not receiving antihypertensive medications or receiving antihypertensive medications but withdrawal for more than 14 d themselves. The

Table 1. General clinical data comparison between 3 groups

Project	RHR1 group (32 n)	RHR2 group (38 n)	RHR3 group (33 n)
Age (year)	69.59±5.76	67.39±5.69	68.01±5.31
His/hers (n)	17/15	20/18	17/16
Smoke [n (%)]	17 (53.13)	18 (47.37)	18 (54.55)
hypertension duration (year)	17.13±3.78	12.53±4.06	14.09±3.73
BMI (kg/m^2)	21.62±2.79	23.84±3.18^{b}	26.90±3.81^{b,d}
FPG (mmol/L)	4.82±0.93	5.75±0.62^{b}	6.76±1.01^{b,d}
TC (mmol/L)	4.33±0.93	5.01±0.77^{b}	5.88±1.01^{b,d}
TG (mmol/L)	1.06±0.44	1.36±0.55^{a}	1.66±0.14^{b,c}
HDL-C (mmol/L)	1.06±0.13	0.98±0.12^{b}	0.93±0.11^{b,c}
LDL-C (mmol/L)	3.24±0.67	3.80±0.66^{b}	4.90±0.95^{b,d}
UA (μmol/L)	380.56±14.59	386.00±10.22^{a}	399.55±13.85^{b,d}
Cr (μmol/L)	59.47±7.63	72.21±9.29^{b}	86.18±18.53^{b,d}

Note: Compared to RHR1 group, $^{a}P<0.05$, $^{b}P<0.01$; Compared to RHR2 group, $^{c}P<0.05$, $^{d}P<0.01$.

Table 2. Echocardiography parameters comparison between 3 groups ($\bar{x}\pm s$)

Indices	RHR1 group (32 n)	RHR2 group (38 n)	RHR3 group (33 n)
LVEDD (mm)	48.66±2.56	51.78±2.36^{b}	52.95±2.52^{b,c}
IVST (mm)	11.03±0.78	12.24±1.53^{a}	13.21±1.41^{b,c}
LVPWT (mm)	10.38±1.07	11.24±1.29^{b}	12.85±1.48^{b,d}
LVMI (g/m^2)	113.16±5.92	116.68±7.89^{a}	122.39±7.55^{b,d}
LVEF (%)	65.59±4.26	63.03±4.16^{a}	57.85±5.45^{b,d}

Note: Compared to RHR1 group, $^{a}P<0.05$, $^{b}P<0.01$; Compared to RHR2 group, $^{c}P<0.05$, $^{d}P<0.01$.

Judgment of hypertension was according to the "Chinese elderly hypertensive Prevention Guide 2010". Disease history such as age, height, weight, smoking history, duration of hypertension, family history and so on were detailed inquired and recorded. Exclude: ① acute coronary syndrome or previous history of acute coronary syndrome. ② non-coronary heart disease and peripheral vascular malformations and other diseases at large. ③ chronic heart failure (NYHA grade III to IV). ④ serious arrhythmias such as sinus disease, atrial fibrillation, atrioventricular block (II-III), frequent premature ventricular contractions and so on. ⑤ secondary hypertension, diabetes. ⑥ acute and chronic liver disease. ⑦ tumor or severe infection. ⑧ kidney disease (serum creatinine >178 umol/L) ⑨ diseases which effect heart rate such as hyperthyroidism and anemia. ⑩ took drugs which affect heart rate such as β-blockers.

Methods

Blood pressure measurement: Calibrated mercury sphygmomanometer was used. Patients should have five minutes rest before had blood pressure measured. Blood pressure was measured for 3 times at right arm brachial artery. Took the first Korotkoff sound as the systolic blood pressure and took the fifth sound as the diastolic blood pressure. The patients should have 2 min rest between two tests, and the average was record.

The definition and measurement of the resting heart rate (RHR): RHR is the number of beats per minute while the patients were at awake, active, quiet state. All selected objects were given an ECG examination using the Japanese Fukuda ECG FCP-7402 twelve 4800 ECG machine ECG tracings, select II lead, recording 20 cardiac cycle, and calculate the average RR interval and the calculate resting heart rate at 9-10 in the morning in a quiet examination room after 5 min supine rest.

Biochemical tests: After fasted for 12 hours, all the selected objects took the biochemical tests, taken 2 ml blood from left cubital vein. Fasting plasma glucose (FPG), total cholesterol (TC), triglyceride (TG), high density lipoprotein cholesterol (HDL-C) and low density lipoprotein cholesterol (LDL-C), serum creatinine (Cr), uric acid (UA) were measured using automatic biochemical analyzer.

Table 3. Ambulatory blood pressure parameters comparison between 3 groups (x±s, mmHg)

Group	n	TSBP	dSBP	dDBP	nSBP	nDBP	TPP	dPP	nPP
RHR1	32	161.88±7.12	164.69±6.07	91.00±4.36	156.91±5.09	82.25±2.96	69.25±4.73	71.84±4.74	72.19±4.30
RHR2	38	165.34±6.33[a]	168.11±6.88[a]	92.45±3.88	160.32±5.35[a]	83.79±3.08	72.39±3.95[a]	3.95±5.06[a]	74.79±5.35[a]
RHR3	33	73.21±5.88[b,d]	176.39±7.77[b,d]	93.09±4.82	167.58±8.84[b,d]	84.18±3.93	75.82±3.37[b,c]	79.82±5.22[b,d]	80.45±4.49[b,d]

Note: Compared to RHR1 group, [a]$P<0.05$, [b]$P<0.01$; Compared to RHR2 group, [c]$P<0.05$, [d]$P<0.01$.

Ambulatory blood pressure measurement: Ambulatory blood pressure was measured using noninvasive portable ambulatory blood pressure monitoring (Beijing, China). The detector subjects on 2.5 cm up at the elbow on the left upper arm, kept an appropriate tightness that can be inserted into the two fingers. Took blood pressure measurement every 30 minutes from 8:00 to 22:00 and every 60 minutes from 22:00 to 8:00 at the next day. The time for the blood pressure was from 8:00 to 8:00 at the next day. Patients were without their daily activities limited, but avoid strenuous exercise, agitation, anxiety, while excluding persons with poor nighttime sleep. The number of effective blood pressure monitoring should reach 90% the number of theoretical times. The missing dates were re-measured next day. Effective systolic blood pressure was 70-260 mmHg, effective diastolic blood pressure was 40-150 mmHg, PP was 20-110 mmHg. TSBP, TDBP, TPP, dSBP, dDBP, dPP, nSBP, nDBP, nPP, SBPL and DBPL were recorded and analyzed.

Echocardiography examination: Philips IE-33 color Doppler ultrasonic diagnostic apparatus was used, the probe frequency was 2.2-4.0 MHZ. LVEDD, LVESD, IVST, LVPWT were measured. We calculated LVM and LVMI using the Devereux Formula. LVM (g) = 0.8 × 1.04 [(IVST + LVEDD + LVPWT) 3-LVEDD] 3 + 0.6 g; LVMI: = VM/body surface area (BSA) g/m^2, body surface area (BSA) = 0.0061 × height (cm) + 0.0128 × weight (kg) - 0.1529. Took the LVMI>125 g/m^2 (male) and LVMI>120 g/m^2 (female) [1] as left ventricular hypertrophy diagnostic criteria.

Grouping

103 elderly hypertensive patients were chosen and divided into three groups according to the resting heart rate (RHR): RHR1 groups: <70/min (n = 28); RHR2 group: 70/min ≤ RHR <80/min (n = 42), RHR3 group: RHR ≥ 80 times (n = 33) three groups.

Statistical analysis

All data were expressed as the mean ± S and statistically analyzed using SPSS 17.0. Differences between the groups were assessed using the one-way analysis of variance (ANOVA). Spearman's rho tests were used to detect relationships among different indices. $P<0.05$ was considered to indicate significant differences.

Results

Differences on general information in three groups

As shown in **Table 1**, the patient's age, gender, smoking and non-smoking ratio, duration of hypertension among the three groups were not statistically significant ($P>0.05$). However, there were statistically significant in three groups on BMI, FPG, TC, TG, HDL-C, LDL-C, UA, Cr.

*Differences on echocardiography examination (**Table 2**)*

As shown in **Table 2**, compared to RHR1 group, the indices including LVEDD, IVST, LVPWT, LVMI, and LVEF were higher significantly in RHR3 group and RHR2 group ($P<0.05$ or $P<0.01$).

*Differences on ambulatory blood pressure measurement (**Table 3**)*

The dates of RHR3 were higher than those of RHR1 and RHR2. And RHR2 were higher than those of RHR1. There were statistically significant between RHR3 and RHR1 as well as RHR2 on 24 h SBP, dSBP, nSBP, 24 h PP, dPP, nPP. There was no statistically significant among RHR1, RHR2 and RHR3 on 24 h SDP, dSDP, nSDP.

Statistical correlation

There were positive correlations between RHR and FPG, LDL-C, TC. However there was a negative correlation between RHR and HDL-C. There were positive correlations between RHR and 24

Table 4. Correlation analysis among the included parameters

Parameters	RHR	
	r	P
FPG	0.245	0.012
LDL-C	0.323	0.041
TC	0.225	0.033
HDL-C	-0.201	0.044
24 h SBP	0.157	0.019
dSBP	0.374	0.017
nSBP	0.241	0.042
24 h PP	0.197	0.031
dPP	0.410	0.004
nPP	0.312	0.009
LVEDD	0.152	0.014
LVMI	0.144	0.034
LVEF	-0.147	0.044

Table 5. The relation between RHR and other parameters in multivariable linear regression model

	Beta	SE	P
24 h SBP	6.54	1.24	0.011
dSBP	4.23	2.41	0.014
nSBP	5.41	2.11	0.024
24 h PP	2.45	0.78	0.005
dPP	2.78	1.78	0.014
nPP	4.89	2.14	0.018
LVEDD	2.55	0.98	0.001

h SBP, dSBP, nSBP, 24 h PP, dPP, nPP. There were positive correlations between RHR and LVEDD, LVMI. There was a negative correlation between RHR and LVEF (**Table 4**).

Multivariable analyses

After adjustment of confounders such as HDL-C, FPG, LDL-C, TC, 24 h SBP, dSBP, nSBP, 24 h PP, dPP, nPP, LVEDD, LVMI and LVEF, we found 24 h SBP, dSBP, nSBP, 24 h PP, dPP, nPP, and LVEDD were correlated with RHR (**Table 5**).

Discussion

Resting heart rate is a mark for hemodynamic and autonomic nervous system status, the increase of heart rate is an independent risk factor of the occurrence of cardiovascular disease [2-4]. Especially in the early stage of hypertensive, their heart rate often increased by 10%-15%, the faster resting heart rate is often associated with high blood pressure. Elevated catecholamine directly causes the increase of RHR, and the increase of catecholamine stands for the sympathetic activation. RHR is a reliable indicator of the over-activity of sympathetic system [5-7]. In several experimental animal models of hypertension and clinical double-blind clinical trials, excessive activation of the sympathetic nervous system promoted the formation of high blood pressure and the development of target organ damage, and there were positive correlations among them both in the early and late hypertension [8-11].

Studies showed that the increase of heart rate was closely related to obesity, elevated blood pressure, glucose and lipid metabolism and other cardiovascular risk factors, and the incidence of cardiovascular events and death rate increased [12, 13]. Our study showed that there were statistically significant among these three groups on FPG, TC, TG, LDL-C ($P<0.05$ or $P<0.01$) and increased following the increase of RHR. There were statistically significant on HDL-C among the three groups ($P<0.05$ or $P<0.01$) and it decreased following the increase of RHR. RHR and lipid metabolism are closely related, and this result is consistent with previous research [14]. The average systolic blood pressure and pulse parameters in RHR3 group were significantly higher than those in RHR1 group and RHR2 group, these results showed that RHR was closely related to systolic blood pressure and pulse parameters of elderly EH patients. RHR increase may be due to sympathetic nerve-adrenal system activity, the sympathetic impulse output was enhanced, adrenal catecholamine secretion increased, myocardial contractility enhanced, resulting the systolic blood pressure and pulse pressure increased. Excessive activation of the sympathetic nervous system is a feature of patients with hypertension, its severity was directly proportional to the sympathetic activation degree, heart rate also be important to left ventricular hypertrophy [15]. Our results showed there were positive correlations between RHR and LVEDD, LVMI, while there was a negative correlation between LVEF and RHR, these show RHR is closed related to the left ventricular hypertrophy. Long-term systemic small artery lumen narrowing causes peripheral vascular resis-

tance increase was mainly due to left ventricular hypertrophy in hypertensive patients. Left ventricular hypertrophy is easily caused a higher incidence of cardiovascular disease and mortality, severer left ventricular hypertrophy caused higher RHR, the faster RHR reduces coronary vasodilator reserve and coronary blood flow increases, and increased the percentage of hypertensive left ventricular hypertrophy [16]. In summary, heart rate speed could reflect the sympathetic activity. Excessive sympathetic activation is characteristic of EH, and its activation is parallel with elevated blood pressure. Excessive activation of the sympathetic nervous system could cause severe organ damage. Faster heart rate basis may be an independent risk factor that cause target organ damage in elderly patients with hypertension.

RHR increase can promote hypertensive disease in elderly and it is a risk factor for hypertension. The increase of RHR promote lipid metabolism and left ventricular hypertrophy in some extent, and impacts the cardiovascular events. Numerous clinical trials confirmed the application β-blockers and calcium blockers can reduce blood pressure, but if the application of these drugs can effectively slow down the patient's resting heart rate, thus further delaying lipid disorders, the degree of left ventricular hypertrophy and improve the prognosis of hypertension is another direction for future research [17].

Disclosure of conflict of interest

None.

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