Cold Pressor Test Explores Increase in Sympathetic Activity in Term of Predominance Activation of Alpha-over Beta-Adrenoceptors in Healthy Individuals

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Abstract

Background: Cold pressor test (CPT) is introduced to assess the cardiovascular responses in healthy subjects and several disorders.

Objectives: This study is aimed to explore the involvement of sympathetic discharge in stimulating the beta-adrenoceptor as well as the alpha-adrenoceptor during CPT.

Materials and methods: This study was conducted in Department of Physiology, College of medicine, Al-Mustansiriya University in Baghdad, Iraq from February to June 2010. A total number of 31 participants, their ages ranged 18-24 years were included in the study. Each participant was subjected to 1- minute cold pressor test. The blood pressure and pulse rate were recorded before, at the end of one minute of cold pressor test, and three minutes after the test. The mean arterial blood pressure (diastolic blood pressure + 1/3(systolic-diastolic) as an indication of perfusion pressure and pulse pressure (systolic-diastolic) were calculated.

Results: Both systolic and diastolic blood pressures were significantly increased during testing and returned to the basal level after five minutes of testing. The mean arterial blood pressure was significantly increased during testing by (17.6%) of the basal level. Pulse pressure was significantly reduced during testing to reach (-11.8%) of the basal level. The significant increase in pulse rate during testing was less pronounced than blood pressure.

Conclusions: sympathetic activity in terms of activation of alpha and beta-adrenoceptors in cardiac and vascular smooth muscles is responsible for the significant changes in blood pressure during CPT and hyper-reactors as well as those with high pressure rate product required follow-up.

Key words: cold pressor test, Sympathetic nervous system

Introduction

Several tests were introduced to assess the cardiovascular responses in healthy individuals and patients. Cold pressor test (CPT) is introduced in 1948 to assess the systolic and diastolic blood pressures, heart rate and pressure rate product. In healthy individuals, CPT is reliable for systolic blood pressure. Large intra-individual heart rate and diastolic blood pressure were found [1] and large variability was also found when the test was repeated on different days [1]. There is evidence that the response of arterial blood pressure and heart rate in CPT was greater when another test simultaneously introduced like isometric extension knee test. Additional effect of cold immersion of hand during isometric knee extension may be due to vasoconstriction effect in the contralateral unstressed limb [2]. Fast Fourier Transform algorithm based on a 256 point time series was used to estimate the amplitude spectra of the heart rate and blood pressure rhythmicity at the low frequency and it showed the CPT increases low frequency alteration of systolic blood pressure fluctuation which reflects an increase in sympathetic vasomotor control [3]. The sympathetic discharge during CPT is related to the health status of the individual. During CPT, both adrenaline and noradrenaline in healthy subjects is increased while in diabetic patients only noradrenaline is increased because the resting adrenaline concentrations are related insulin secretion [4]. The vasoconstriction during CPT in the upper extremity contralateral to the cold immersion, detected by skin surface temperature gradient and laser Doppler flowmetry, is mediated via alpha adrenoceptor in the peripheral blood vessels. This study is aimed to explore the involvement of sympathetic discharge in stimulating the beta-adrenoceptor as well as the alpha-adrenoceptor during CPT.

Materials and methods

This study was conducted in Department of Physiology, College of medicine, Al-Mustansiriya University in Baghdad, Iraq from February to June 2010. This study was approved by the local scientific committee in the medical college and a verbal consent form was obtained from each participant prior to study. Random samples of medical students were allocated to enroll in the study. A total number of 31 participants, their ages ranged 18-24 years were included in the study. Each participant was subjected to cold pressor test by immersing the right hand (up to the wrist) in ice-cold water (0ºC) for one minute. The blood pressure and pulse rate were recorded before, at the end of one minute of cold pressor test, and three minutes after the test by using of Medical Rossmax Blood Pressure Monitor MG 150F. The mean arterial blood pressure (diastolic blood pressure + 1/3(systolic-diastolic) as an indication of perfusion pressure and pulse pressure (systolic-diastolic) were calculated. The pressure rate product as a measure of cardiac work is calculated by multiplying heart

rate and systolic blood pressure. Individuals who are responded to the cold pressor test by increasing systolic blood pressure more than 15 mmHg are considered as hyper-reactors. The anthropometric measurements including weight (kg), height (m) were taken and the body mass index was calculated using Qutelet's equation (weight (kg) / height (m^2). Moreover the body water and muscle percentages of each participant were obtained using Diagnostic Scale, Beurer GmbH, Germany.

Statistical analysis

The results are presented as absolute number, percentages and whenever possible as mean ± SD. The data were analyzed using paired and unpaired, two tailed Student's "t" test taking $p \leq 0.05$.

Results:

Table 1 shows the characteristics of the study. The height and weight of male participants were significantly higher than corresponding female gender (Table 1). Although the body mass index of males was higher than female but it did not reach the level of significance. The water and fat percentages were comparable in males and females and there were insignificant differences between them. The muscle mass of male participants was significantly higher than female (Table 1). Table 2 shows the hemodynamic changes in term of changes in blood pressure and pulse rate during testing the participants by cold pressor test. Both systolic and diastolic blood pressures were significantly increased during testing and returned to the basal level after five minutes of testing. The mean arterial blood pressure was significantly increased during testing by (17.6%) of the basal level. Pulse pressure was significantly reduced during testing to reach (-11.8%) of the basal level (Table 2). The significant increase in pulse rate during testing was less pronounced than blood pressure. All the hemodynamic changes returned to the basal levels after five minutes.

Table 1. The characteristics of the study

	Male	Female	Total
Gender	21	10	31
Age (year)	20.1±1.73	19.7±1.83	19.96±1.74
Weight (m)	76.48±15.63*	59.4±11.45	70.96±16.37
Height (m)	1.732±0.054**	1.576±0.032	1.682±8.86
Body mass index (kg/m^2)	25.438±4.936	23.815±3.899	24.914±4.626
Body water (%)	53.85±5.128	51.91±2.868	53.22±4.566
Body fat (%)	26.4±7.134	29.2±4.055	7.31±6.372
Muscle mass (%)	43.35±4.965*	36.28±2.379	41.07±5.426

The results are expressed as mean ± SD. * $p<0.001$, ** $p < 0.01$ compared with female gender.

Table 2. The effect of 1 minute cold exposure of hand on the blood pressure (mmHg) and heart rate (beat/min).

	Cold pressor test		
	Before	During	After
Systolic BP	117.83±7.633	134.87±7.783*	117±9.825
Diastolic BP	71.29±4.634	85.96±4.686*	71.32±5.787
Mean arterial BP	86.79±5.296	102.11±5.426*	86.53±13.425
Pulse pressure	46.54±5.058	41.07±4.875*	45.67±6.703
Pulse rate	82.74±12.94	88.32±15.561**	79.54±6.554

The results are expressed as mean ± SD and analyzed by paired "t" test. * $p<0.001$, ** $p < 0.05$ compared with data before cold pressor test.

Discussion:

The results reported in this study showed significant elevation of systolic and diastolic blood pressures which reflected on the mean arterial and pulse pressure. The significant increase in the mean arterial blood pressure indicated the involvement of central endogenous sympathetic activity as well as the sympathetic activation in the skeletal muscle

vasculature [6]. The changes in heart rate are less than that observed with mean arterial blood pressure indicating the superimposed effect of noradrenaline upon adrenaline. It is well known that adrenaline activates beta-1 adrenoceptors in heart producing increase heart rate as well as it activates alpha-1 adrenoceptors in blood vessels producing vasoconstriction while noradrenaline activates only alpha-1 adrenoceptors in blood vessels. Cui et al [7] demonstrated that CPT for 3 minutes produced significant increase in muscle sympathetic activity and mean arterial blood pressure but it did not show any significant changes in heart rate. Moreover, Wang et al reported the involvement of renin-angiotensin system in blood pressure responses to CPT and this explained the pronounced effect of cold on the blood pressure compared to its effect on heart rate [8]. Also it is reported that sodium sensitivity was also more common in individuals with higher responses to a cold pressor test i.e. those people are liable to have high blood pressure in the future [9]. This study highlighted another two important findings: first the presence of high percent of blood pressure hyper-reactor individuals (i.e. the increase in systolic blood pressure exceeds 15 mmHg) which amounted 35.% (11 out of 31) [10], and the second the significant high cardiac work (i.e. systolic pressure rate product) which amounted 9313.2±1791.4 before CPT compared with 11305.3±1991.9 ($p < 0.001$) during CPT which indicated the role of cardiac beta-1 adrenoceptor activation and it gives information that people will be at cardiovascular risk in the future [11]. It concludes that sympathetic activity in terms of activation of alpha and beta-adrenoceptors in cardiac and vascular smooth muscles is responsible for the significant changes in blood pressure during CPT and hyper-reactors as well as those with high pressure rate product required follow-up.

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