Evaluation of Physiological Cardiovascular Reactivity to Cold Pressor Stress Test

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ABSTRACT :

Background: Cardiovascular hyperactivity is a possible predictor for future development of hypertension. Cold stressor can help identify young healthy individuals who are at risk of developing hypertension in future. Instituting life style modifications in such at-risk individuals could help prevent hypertension related mortality and morbidity in later years.

Method: In this study, 72 voluntary subjects in the age group of 19 to 25 years were selected. Using a standard mercury sphygmomanometer, mean of three pre-procedure blood pressure recordings was designated as the basal blood pressure. This was followed by application of a cold pressor and blood pressure readings were obtained at 1 minute and 5 minutes. Heart rate (HR), systolic blood pressure (SBP) and diastolic blood pressure (DBP) were tabulated and statistical inferences were drawn.

Results: Our data revealed sharp increase from pre-stressor to 1 minute post-stressor HR, SBP and DBP. From 1 minute post-stressor to 5 minutes post-stressor time, there was a sharp decrease in HR, SBP and DBP, but the values were significantly higher than the pre-immersion control values ($p<0.05$).

Conclusion: Cold stressor test can easily identify apparently healthy individuals with cardiovascular hyperactivity. This information can be used to identify population at risk and design strategy to prevent hypertension and its related complications in later years

Keywords: Hypertension, cold stressor, cold pressor.

INTRODUCTION:

Hypertension has since long been considered as a major risk factor towards development of cardiovascular and cerebrovascular morbidity and mortality (1-3). Cardiovascular hyperactivity to stressful phenomena has been hypothesized as a possible predictor for development of hypertension in the future. The cold pressor test, which quantifies cardiovascular response to a cold stressor, has been used to identify apparently healthy normotensive subjects who are at risk of developing hypertension (4-6). This test, originally described by Hines and Brown (7) identified striking variation in blood pressure of subjects when an extremity was immersed in ice cold water. Using cold pressor test would thus help in early identification of at risk population groups and would allow for instituting timely remedial measures to prevent hypertension and its related complications in later years.

The study aims to evaluate the base line values and cold pressor test values in apparently normal healthy subjects for determining changes in the systolic blood pressure, diastolic blood pressure and heart rate upon exposure to a cold stressor.

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MATERIALS AND METHODS

The study sample comprised of 72 voluntary subjects in the age group of 19 to 25 years, most of whom were college going students. The procedure was explained to the subjects in detail and subsequently their verbal consent was obtained. A standard questionnaire was used to collect information regarding personal and family medical history and lifestyle deviations like cigarette smoking and alcohol consumption. The subjects were advised to avoid cigarette smoking and intake of tea and coffee at least three days before the examination. None of our subjects had history of alcohol intake. The excluding criteria were history of cardiovascular or renal disease, neurological dysfunction, hypertension, sweating disorder, cold intolerance and any systemic disease.

On the day of examination, the subjects were advised to have a light breakfast. Upon reporting for examination, the subjects were asked to lie supine in a quiet room and were made to relax physically and mentally for at least twenty minutes. Using a standard mercury sphygmomanometer, three blood pressure recordings were obtained at 10-minute intervals. The mean of these measurements was designated as the basal blood pressure.

The subject was next asked to immerse one hand up to just above the wrist in a bucket containing ice cold water which was kept at a temperature of 3 to 4 0C. After keeping the hand immersed for one minute, blood pressure readings were taken in the opposite arm at 1 minute and 5 minutes.

The heart rate (HR), systolic blood pressure (SBP) and diastolic blood pressure (DBP) were tabulate and statistical inferences were drawn.

RESULTS:

All the 72 subjects included in the study sample exhibited a very characteristic response to the cold pressor. As depicted in Table 1, the mean pre-immersion HR was 86.29 ± 3.53; at 1 minute post-immersion it rose to 101.95 ± 3.85 ($p < 0.001$) and at 5 minutes it was recorded at a mean value of 91.94 ± 3.24 ($p < 0.001$). The pre-immersion SBP was recorded at a mean value of 123.31 ± 5.37; after immersion at 1 minute it rose to a mean of 137.83 ± 5.57($p < 0.001$) and at 5 minutes the mean value recorded was 128.54 ± 4.68 ($p < 0.001$). Similarly, the pre-immersion DBP was recorded at a mean value of 79.29 ± 2.77; after immersion at 1 minute it rose to a mean of 91.48 ± 3.38 ($p < 0.001$), and at 5 minutes the mean value recorded was 82.64 ± 4.09 ($p < 0.001$).

Variable	Pre-immersion (mean ± S.D)	Post-immersion 1 minute (mean ± S.D)	Post-immersion 5 minutes (mean ± S.D)	Pre vs. 1 minute (mean difference)	Pre vs. 5 minute (mean difference)
HR	86.29 ± 3.53	101.95 ± 3.85	91.94 ± 3.24	15.66 ($p< 0.001$)	5.64 ($p< 0.001$)
SBP	123.31 ± 5.37	137.83 ± 5.57	128.54 ± 4.68	14.52 ($p< 0.001$)	5.23 ($p< 0.001$)
DBP	79.29 ± 2.77	91.48 ± 3.38	82.64 ± 4.09	12.18 ($p< 0.001$)	3.35 ($p< 0.001$)

Line diagrams were plotted (Fig1: a,b,c) depicting pre-procedure data with post-stressor data

obtained at 1 and 5 minutes in terms of HR, SBP and DBP; these reveal a sharp increase from pre-immersion to 1 minute post immersion HR, SBP and DBP. From 1 minute post immersion to 5 minutes post immersion time, there was a sharp decrease in HR, SBP and DBP, but significantly higher than the pre-immersion control values ($p<0.05$).

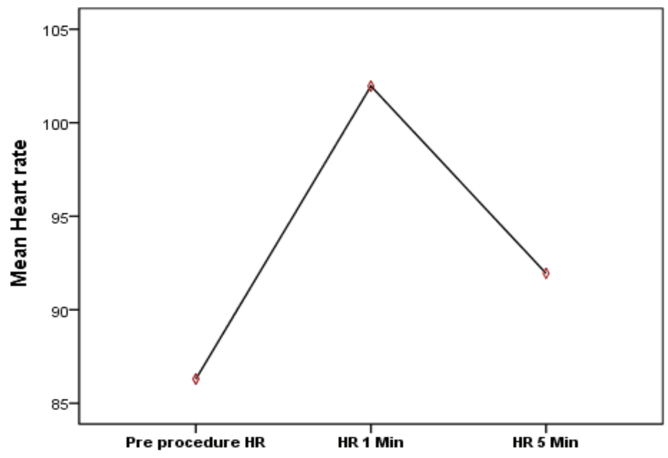

Fig1a: Line diagram plot depicting changes in mean heart rate pre- and post- stressor.

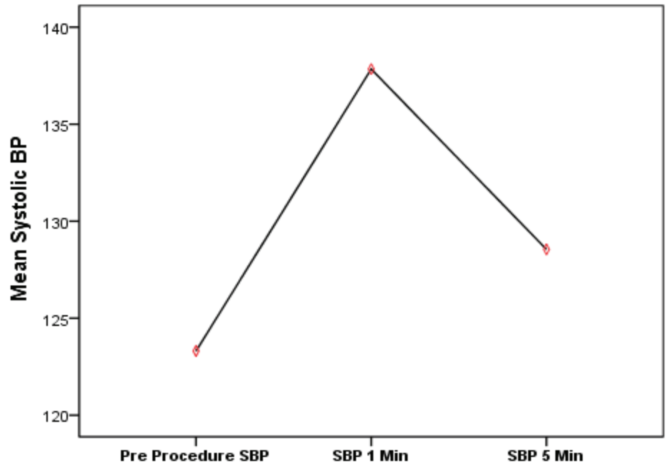

Fig1b: Line diagram plot depicting changes in mean systolic BP pre- and post- stressor.

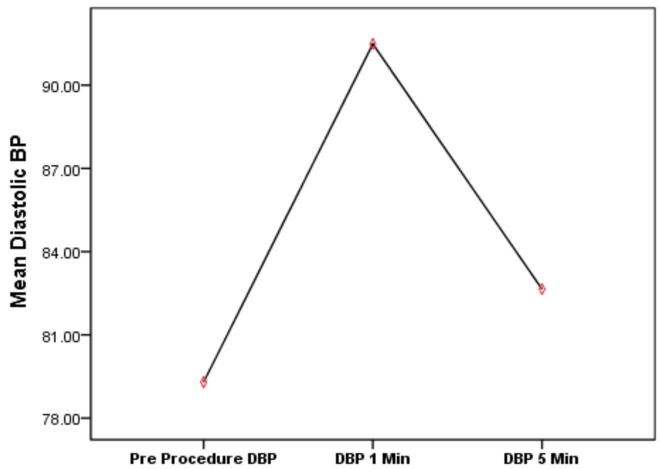

Fig1c: Line diagram plot depicting changes in mean diastolic BP pre- and post- stressor.

DISCUSSION:

A variety of stressor methods have been described to study the cardiovascular reactivity including infliction of pain, exposure to bright light, application of low intensity electric shocks and exposure to loud noise; however these ran into disrepute as results were not reproducible [8].

Cold pressor test attempts to assess the physiological response of a person to environmental stimuli in terms of cardiovascular reactivity [4]. This assumes significance by way of prospective cohort studies having implicated exaggerated cold pressor responses to possible development of hypertension with advancing age [9,10]. It thus follows that likely identification of subjects with probable risk for developing hypertension in future would allow early intervention by way of instituting life style modifications and close monitoring of blood pressures aiming at annulling time bound associated mortality and morbidity.

Cold pressor test allows identification of individuals with exaggerated response of the autonomic nervous system to a cold stressor [11, 12]. The postulated underlying mechanism being abnormal sympathetic stimulation which acts as a trophic factor for vascular hypertrophy [13,14] and consequent development of hypertension. It has been found that there is a weak link between perception of pain secondary to application of a cold pressor and concomitant rise in blood pressure; the postulated mechanism put forth holds pain responsible for resetting the baroreflex causing stimulation of muscular sympathetic activity [15]. In normal subjects, the physiological reactions to the application of cold pressor have been described as an elevation in SBP and DBP, increase in heart rate, rise in vascular resistance and increase in muscular sympathetic activity; these changes being mediated by stimulation of autonomic neural pathways [16]. Moreover, cardiovascular autonomic neuropathy is an independent risk factor for sudden cardiac death; it thus follows that timely identification and management of autonomic neuropathy would preserve life and its quality [17]. Cold immersion test is an outdoor day time procedure which can conveniently be used to assess autonomic functions in patients and healthy subjects [17].

However, establishing the physiological responses of circulatory hemodynamics to cold stressor is mandatory to build confidence in execution of such investigations. In the index study, we assessed cardiovascular response to cold stressor over time and compared it with the pre-immersion values. We noted a significant upsurge in the values of HR, SBP and DBP within 1 minute of applying cold stressor. Equally interesting was a sharp decline in HR, SBP and DBP at 5-minutes post-stressor; however these values continued to be significantly high when compared to pre-immersion data. Our results were in agreement with those obtained by other workers [17,18].

There are four basic underlying assumptions of cold pressor test which include: that the individual response to cold stimulation is constant to a degree suitable for use as a clinical tool (± 10 mm Hg); that in a normal person without any cardiac disorder the rapid increase in blood pressure is due to increase in peripheral resistance and vasoconstriction; that cold pressor test is basically an indicator of vasoconstrictor response; that elevation of DBP in response to a stressor is a more reliable indicator when compared to an elevated SBP; and finally that the cold pressor test is an index of vascular reactivity [8].

We made subjects to immerse the hand up to just above the wrist in a bucket containing ice cold water kept at a temperature of 3 to 4 0C. Many workers have described different levels of immersion of hands into cold water such as up to the level of wrist, metacarpo-phalyngeal region, fingers and face, but the obtained cardiovascular responses did not show any significant variation [19]. Sensitive to the fact that Kashmir is climatically a cold alpine zone, we performed the study during milder late spring and early autumn time; this was done to annul the effects of climatic extremes on our results, since it has been reported that adaptation of subjects to a cold pressor was better in colder climates than in warm regions [20].

The largest study for evaluating long-term reproducibility of cardiovascular response to a cold stressor was conducted by Zhao and colleagues [4] amongst 568 subjects; they established that blood pressure response to cold pressor test is a reproducible index rather than a random phenomenon.

Our study establishes the upsurge in HR, SBP and DBP within 1 minute of applying cold stressor, followed by a sharp fall in HR, SBP and DBP at 5-minutes post-stressor; the data at 5-minutes however being significantly higher than that obtained in the pre-stressor stage. Long term application of this methodology may help in early identification of population at risk of developing hypertension in later years and would aid in designing a strategy to prevent hypertension and its related complications in later years.

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