

Original Article

Link of sympathetic activity with cardiovascular risk in patients of cervical spondylosis

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Abstract

Background and Aim: Spinal cord compression as observed in cervical spondylosis patients may result in focal autonomic deficit affecting various organ systems. Hence, in the present study we aim to assess the level of sympathetic activity in patients with cervical spondylosis using cold pressor test.

Methods: Cold pressor test was recorded in two groups comprising of thirty patients with cervical spondylosis and thirty healthy age and sex matched controls. Basal blood pressure (BP) was recorded in all the subjects. The BP values immediately after removal of hand from cold water and then after 5 minutes were also observed. Rate pressure product (RPP), a marker cardiovascular risk was calculated.

Results: The patients with cervical spondylosis during the recovery period showed a sustained rise in BP and RPP. A rise of more than 20/10 mm of Hg, or a failure of BP to return to basal levels after 5 minutes has a positive predictive value.

Conclusion: The patients with cervical spondylosis have higher sympathetic tone due to cervical compression.

Key words: Autonomic response, blood pressure, cervical spondylosis, rate pressure product, sympathetic activity

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INTRODUCTION

Cervical spondylosis is a broad term that describes the age-related chronic disc degeneration. The degenerative changes start in the intervertebral disc with osteophyte formation and lead to physiological degenerative cascade leading to biomechanical changes that result in neural and vascular compression. Toussiro *et al.* demonstrated the changes in autonomic functions in patients of ankylosing spondylosis that may be due to the involvement of cervical spine (CS), responsible for spinal cord compression.^[1-3]

Autonomic nervous system influences the functions of nearly all organ systems and is responsible for maintaining homeostasis through a complex integration of autonomic and somatic sensory information and descending influences from higher centers. The

activity and relative balance between sympathetic and parasympathetic nervous system is regulated by afferent inputs directed primarily to brain.^[4,5] Cold pressor test (CPT) measures the function of sympathetic neural control of the cardiovascular (CV) system. In CPT, heart rate increases which indicates that the cardiac sympathetic nervous system activation and rise of blood pressure are due to a widespread vasopressor reaction initiated through a neurogenic reflex arc.^[6]

CPT can be used as an adjunct for assessing the level of sympathetic activity and any possible CV risk in chronic diseases such as cervical spondylosis. Therefore, in the

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present study, we aimed to assess sympathetic activity (assessed by means of CPT) with possible CV risk (increased rate pressure product [RPP]) in patients with cervical spondylosis.

MATERIALS AND METHODS

This prospective case-control study was conducted in the Department of Physiology in collaboration with the Department of Orthopaedics, PGIMS, Rohtak, in patients with cervical spondylosis and normal healthy subjects. The study sample comprised Group I consisting of thirty randomly selected age- and sex-matched healthy controls and Group II of thirty patients diagnosed with cervical spondylosis (age group 30–60 years of either sex). Written informed consent was taken from all the participants included in both the groups. This study was approved by the Institutional Ethics Committee. The whole procedure was explained in detail to each subject in his/her own language to allay any fear or apprehension. Consent was taken from every individual to undergo the whole procedure. The tests were conducted during working hours (9 am to 1 pm) to avoid diurnal variation. All the subjects were tested under similar laboratory conditions and allowed to acclimatize themselves to the experimental and environmental conditions.

Inclusion criteria

The patients with history of symptoms of cervical spondylosis for at least 6 months, restriction of neck movements, impaired dermatomal sensations, and reflexes (triceps, biceps, and supinator jerks), radiating pain, and radiologically diagnosed cases of CS (plain X-ray-anteroposterior and lateral view) were included in the study.

Exclusion criteria

The patients with acute onset of symptoms likely due to prolapsed intervertebral disc, history of smoking, any chronic drug intake in recent past, which may alter the autonomic functions, history of any neck surgery and/or CS injury, any infection, inflammation, or malignancy or comorbid systemic disease such as diabetes and hypertension were excluded from the study.

The basal recording of blood pressure was taken by tying the sphygmomanometer cuff on the right arm. Mean arterial pressure (MAP) and RPP^[7] were also calculated. Then, the subject's left hand up to wrist was immersed into ice cold water (8°C) for 2 min, and blood pressure and heart rate were recorded immediately after the removal of the hand from ice cold water and then after 5 min.^[6] Recordings of Group I (controls) were compared with Group II (patients with cervical spondylosis) by applying Student's *t*-test using IBM SPSS statistics version 20

(SPSS software Inc, Chicago, United states). Significance of result was predicted based on the *P* value with significance set at <0.05.

RESULTS

The basal blood pressure (systolic blood pressure [SBP], diastolic blood pressure [DBP], and MAP), mean heart rate, and RPP did not show any statistically significant difference between Group I (controls) and Group II (cases) [Table 1]. Table 2 demonstrates that the brisk elevation in the mean heart rates, SBP, DBP, MAP, and RPP in both the groups, as an immediate response to cold stimulus. However, this rise was not found to be significantly different between Group I and Group II as compared in Table 2.

Table 3 depicts the response to CPT after 5 min of the recovery period. In Group II, RPP significantly increased in Group II compared to Group I subjects. Though the mean heart rates, SBP, DBP, and MAP remained high in Group II compared to group, it was not found to be statistically significant.

DISCUSSION

Degenerative cervical spondylosis has received insufficient attention of clinicians and researchers, in contrast to degenerative lumbar spondylosis. In fact, degenerative cervical spondylosis may be more common than previously thought.^[8,9] Disorders of autonomic regulation are described in multiple and diverse diseases that directly afflict the nervous system as well as other organs, where they trigger or enhance pathological symptoms.^[10]

Under stressful conditions, either physical or psychological, there is activation of sympathetic nervous system. The cold pressor response gives a painful stimulus and is used to study the autonomic response and assess CV

Table 1: Basal blood pressure in controls and cervical spondylosis patients

Parameter (mmHg)	Group I (n=30)	Group II (n=30)	Mean percentage difference	<i>P</i>
Mean heart rate (bpm)	77.73±7.62	78.33±7.98	0.77	0.767
SBP (mmHg)	119.92±10.5	117.59±11.94	1.94	0.425
DBP (mmHg)	77.77±8.95	78.97±9.72	1.54	0.621
MAP (mmHg)	90.41±10.35	91.74±9.90	1.47	0.613
RPP (mmHg/min)	93.21±10.35	92.10±10.35	0.92	0.655

The values are expressed as mean±SD. Statistical analysis was done by Student's *t*-test. The *P*<0.05 was statistically considered significant. SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MAP: Mean arterial pressure, RPP: Rate pressure product, SD: Standard deviation, Group I: Controls; Group 2: Cervical spondylosis

Table 2: Cold pressor test (immediate response) in controls and cervical spondylosis patients

Parameter (mmHg)	Group I (n=30)	Percentage change from basal	Group II (n=30)	Percentage change from basal	P
Mean heart rate (bpm)	80.45±7.59	+3.5	80.76±8.94	+3.08	0.885
SBP (mmHg)	130.4±9.29	+8.73	125.38±14.82	+6.63	0.121
DBP (mmHg)	87.28±8.22	+12.22	86±9.08	+8.96	0.569
MAP (mmHg)	101.54±8.42	+12.31	99.24±11.37	+8.16	0.376
RPP (mmHg/min)	104.90±8.44	+12.54	101.25±11.88	+9.94	0.175

The values are expressed as mean±SD. Statistical analysis was done by Student's *t*-test. The *P*<0.05 was statistically considered significant. SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MAP: Mean arterial pressure, RPP: Rate pressure product, SD: Standard deviation, Group I: Controls; Group 2: Cervical spondylosis

Table 3: Cold pressor test (after 5 min) in controls and cervical spondylosis patients

Parameter (mmHg)	Group I (n=30)	Percentage change from basal	Group II (n=30)	Percentage change from basal	P
Mean heart rate (bpm)	76.96±7.17	-0.99	80.24±8.15	+2.44	0.103
SBP (mmHg)	120.64±10.42	+0.06	124.82±13.53	+6.15	0.185
DBP (mmHg)	78.32±7.99	+0.70	80.90±7.79	+2.44	0.210
MAP (mmHg)	92.43±9.99	+2.23	95.54±9.28	+4.14	0.216
RPP (mmHg/min)	92.84±8.79	-0.39	100.16±10.84	+9.40	0.006

The values are expressed as mean±SD. Statistical analysis was done by Student's *t*-test. The *P*<0.05 was statistically considered significant. SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MAP: Mean arterial pressure, RPP: Rate pressure product, SD: Standard deviation, Group I: Controls; Group 2: Cervical spondylosis

reactivity. It has been implicated in the etiology and development of both hypertension and CV disease.^[6] Heightened sympathetic activation has been shown to be a critical mediator linking the psychological stress of CV regulation to serious and often fatal CV outcomes.^[11]

In our study, the basal blood pressure, mean resting heart rate, and RPP of both the study groups were comparable. Immediately after exposure to cold stimuli, both the control and cases showed a brisk response and elevation of blood pressure and RPP. Although the RPP in patients of cervical spondylosis showed statistically significant low rise in response to cold stimulus, during the recovery period, the patients with cervical spondylosis showed a sustained rise in the heart rate, SBP, and RPP. The significant increase in RPP reflects a sympathetic overdrive in these patients. Sustained rise in the peripheral vascular resistance during later stage leads to rise in the DBP and the MAP in these patients.^[12] Moreover, heightened RPP following cardiac sympathetic stimulation promotes aggravated ischemic episodes.^[13]

As reported by White, myocardial oxygen demand is correlated with RPP. Whenever RPP is high, when myocardial oxygen demand is compromised, leading to adverse CV events such as myocardial ischemia, infarction, and sudden death.^[7] An increased RPP is detrimental to CV health and predisposes a patient to myocardial ischemia, infarction, and sudden cardiac death in any chronic pathology which is stressful to the body. An increase in blood pressure may be due to an increased cardiac output during the initial period of the test, whereas

an increase in the muscle sympathetic activity elevates peripheral resistance and pulse pressure mainly at the end of the test. The heart rate response to this test is less well-defined, with a high inter-individual variability.^[6,14,15]

Verrier and Tan reviewed the recent paper by the Heart Rate Working Group comprised the European and USA investigators which state that heart rate is a pivotal variable that is precisely regulated in health but disrupted in disease. An enhanced adrenergic activity is arrhythmogenic, and increased efferent vagal tone is cardioprotective by opposing its action. Elevated heart rate catalyzes the atherosclerotic processes and is associated with arterial stiffness and turbulent flow in cerebral and coronary circulations.^[16]

Power spectral studies have correlated high sympathetic tone with increase in the low-frequency band (LF) in the heart rate variability (HRV) analysis.^[17] Rise in the LF values has also been reported to present with parallel increase in the RPP. Ruoru *et al.* did a retrospective study on the HRV in patients with cervical spondylosis and deduced that it is one of the significant factors influencing the HRV. Cervical spondylosis was found to be positively correlated with LF.^[18] Pal *et al.* have studied that soothing music and exercises lead to decrease in LF and RPP values and improve the CV status of the individuals.^[19]

As reported by Bleasdale-Barr and Mathias, the symptoms of paracervical neck pain and dizziness as in cases of cervical spondylosis might be due to underperfusion of the tonically-active cervical muscles. The underlying reason might be that the blood pressure changes are

not capable of rapid adjustments in these cases. The attributed symptoms such as neck pain in sub-occipital and paracervical region could be due to a possible autonomic derangement that occur along with symptoms of visual disturbance, dizziness, and fainting episodes.^[20] Moreover, there is a possibility of exacerbation of the symptoms in patients of cervical spondylosis, which needs to be investigated.

Thus to summarize, there is a definitive autonomic imbalance in patients of cervical spondylosis with deficient adaptability to stress. The RPP, marker of CV stress, was more in recovery phase of CPT indicating that the delayed CV autonomic response was abnormal and could be detrimental to the cardiac function in chronic cases of cervical spondylosis. This can lead to exacerbation of their other autonomic symptoms such as heart rate and blood pressure changes associated with neck pain and increased CV risk.

Limitations of the study

As CPT is a highly subjective test and results may vary according to the environmental conditions, emotional state, levels of disease process, and individual tolerance of the subjects. Therefore, larger study groups and standardized conditions are needed to make these results more reproducible.

CONCLUSION

The findings of our study suggest that in patients with cervical spondylosis though the immediate response to CPT was not as brisk as in the controls, the sympathetic vasoconstriction persisted in the recovery period leading to deranged autonomic control. RPP was more in the recovery period, indicating delayed impact of increased CV stress. These patients show a relatively higher sympathetic tone in the late phase of cold pressor stress, as compared to control group, which may be due to the chronicity of the disease process. Autonomic function testing could, therefore, prove to be a valuable tool in detecting late-response CV risks in cervical spondylosis patients and thereby preventing significant CV morbidity.^[21,22]

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Conflicts of interest

There are no conflicts of interest.

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