Original Research Article

Valsalva ratio: Assessment of autonomic modulation in patients of cervical spondylosis

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International Archives of Integrated Medicine, Vol. 3, Issue 6, June, 2016.

Available online at http://iaimjournal.com/
ISSN: 2394-0026 (P) **ISSN: 2394-0034 (O)**
Received on: 21-05-2016 **Accepted on:** 30-05-2016
Source of support: Nil **Conflict of interest:** None declared.
How to cite this article: Singh M, Khurana I, Kundu ZS, Kaushik NK. Valsalva ratio: Assessment of autonomic modulation in patients of cervical spondylosis. IAIM, 2016; 3(6): 107-112.

Abstract

Background: Cervical spondylosis is a common progressive degenerative disorder of the human spine often caused by the natural aging process. Osteophytic formations contribute to biomechanical changes that result in neural and vascular compression. The spinal compression of the obliquely passing cervical nerve roots can result in possible autonomic imbalance in the body. Valsalva maneuver is a simple, non-invasive and cost effective means to assess the autonomic activity. The results are appreciably reproducible if done properly under standardized conditions. Valsalva ratio is an important index of the baroreflex-mediated bradycardia and gives a fair idea about the parasympathetic tone.

Aim: The aim of our study was to assess the level of autonomic activity by studying the valsalva ratio in patients with cervical spondylosis and to compare it with healthy controls.

Materials and methods: This prospective random case control study was conducted at Pt. B. D. Sharma PGIMS, Rohtak. The study sample comprised of 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).

Results: In our study, valsalva ratio was found to be significantly low ($p<0.01$) in patients of cervical spondylosis as compared to healthy individuals.

Conclusion: Altered parasympathetic tone can predispose the patients to hemodynamic instability leading to adverse cardiovascular implications in the long run.

Key words

Autonomic activity, Cervical spondylosis, Valsalva ratio.

Introduction

Cervical spondylosis is a broad term which describes the age related chronic disc degeneration. Etiological factors are usually multi-factorial, including poor posture, anxiety, depression, neck strain and sporting or occupational activities. Aging is the major risk factor that contributes to the onset of cervical spondylosis [1, 2]. The degenerative changes start in the inter vertebral disc with osteophyte formation leading to physiological degenerative cascade that contributes to biomechanical changes that result in neural and vascular compression [3, 4]. The activity and relative balance between sympathetic and parasympathetic nervous system is regulated by afferent inputs directed primarily to brain. Dysfunction of the ANS may result from diseases that affect either central nervous system (CNS) or peripheral autonomic nervous system [5, 6]. The tests for assessment of Autonomic nervous system (ANS) are based on evaluation of the cardiovascular reflexes triggered by performing specific provocative manuevers. Changes in heart rate during valsalva maneuver reflect the parasympathetic modulation. It is one of the most informative study methods employed to evaluate the integrity of cardiac autonomic function based on heart rate responses associated with the arterial pressure stabilizing baroreflex mechanism [7].

Aim and objectives

To assess the level of autonomic activity in patients of CS by studying the effect of valsalva maneuver on the heart rate and calculating the valsalva ratio.

Materials and methods

This prospective random case control study was conducted in the Department of Physiology in collaboration with Department of Orthopedics, Pt. B. D. Sharma PGIMS, Rohtak in patients with cervical spondylosis and normal healthy subjects. The study sample comprised of 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 study groups. This study was approved by the institutional ethical 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 whole procedure. The tests were conducted during working hours (9 am – 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-AP and Lateral view) were included in the study.

Exclusion criteria

The patients with acute onset of symptoms likely due to prolapsed inter vertebral disc, history of smoking, any chronic drug intake in recent past which may alter the autonomic functions, history of any neck surgery and/or cervical spine injury, any infection, inflammation or malignancy or co-morbid systemic disease like diabetes and hypertension were excluded from the study.

Valsalva maneuver was performed by using an aneroid sphygmomanometer connected with a mouthpiece through a tube was used. The length of the pressure tubing was appropriate (35-40 cm) to keep an eye on the meter reading while blowing through it. The subjects were trained properly before performing the test. They were instructed to blow into mouthpiece so that pressure of about 40 mm Hg was maintained for 15 seconds. Care was taken that the glottis remained closed and the subject was not merely blowing with his /her cheeks. Then the subject was asked to release the pressure. HRV were recorded before (5min), during (15 sec) and after the procedure (5 min) using Power lab 26T Polyrite. The mean resting heart rates and the R-R intervals during and after the strain period were recorded. The lower limit of normality of valsalva ratio was taken to be at 1.5.

Statistical analysis

Statistical analysis was done by student t-test using SPSS software version 20. Significance of result was predicted on the basis of p value (significance level < 0.05).

Results

Basal heart rate and R-R intervals

Basal heart rate and R-R intervals were compared between normal healthy subjects (group I) and patients of cervical spondylosis (group II) as per **Table - 1**.

The basal heart rate and minimum R -R interval were slightly higher in group II as compared to group I. Maximum and mean R-R interval were lower in group II, but the difference was statistically insignificant.

Heart Rate, R-R intervals and Valsalva ratio during Valsalva maneuver

The values of heart rate and various R-R intervals (maximum, minimum and mean) during valsalva maneuver of group I and group II are depicted in **Table – 2**.

The above table compared the heart rate, R-R intervals and valsalva ratio of group I and group II during valsalva maneuver. Minimum R-R interval was significantly increased (p <0.05) and valsalva ratio was significantly low (p <0.01) in group II. The mean heart rate, maximum and mean R-R intervals were comparable in both groups.

Heart rate and R-R intervals during valsalva recovery

Table - 3 showed statistically significant increase in the minimum R-R (706.10 ± 58.30, p <0.05) interval in group II. The difference between mean heart rate, maximum R-R interval and mean R-R interval in both the groups was not statistically significant.

Valsalva ratio

Valsalva ratio in group I and group II was as per **Table - 4**.

Table – 1: Basal heart rate and R-R intervals in group I and group II.

Parameter	Group I (Mean ± SD)	Group II (Mean ± SD)	p value
Mean HR (beats/min)	77.73 ± 7.62	78.33 ± 7.98	0.652
Max R-R interval (ms)	893.28 ± 74.80	875.84 ± 79.77	0.404
Min R-R interval (ms)	667 ± 57.87	676.38 ± 67.88	0.583
Mean R-R interval (ms)	780.20 ± 75.40	769. 87 ± 75.16	0.307

Discussion

Cervical spondylosis is a common progressive degenerative disease affecting the cervical spine caused by natural aging process. It is characterized by compression of spinal nerves due to degenerative changes like osteophytes, bony spurs and obliteration of disc spaces between the cervical vertebrae leading to nerve impingement. This neural compression can lead to multitude of symptoms, most common being axial neck pain and cervical radiculopathy [1, 3].

Autonomic nervous system plays a major role in determining heart rate, stroke volume and peripheral vascular resistance to meet the appropriate requirement of the body. Numerous studies have demonstrated the increased sympathetic and decreased parasympathetic nervous system activity hikes the risk of ventricular tachycardia, ventricular fibrillation and sudden cardiac death. Very few studies have been done to assess the effect of this neural compression on autonomic functioning of the body and any possible relation of autonomic imbalance and the symptomatology in cervical spondylosis [8].

Table – 2: Heart rate, R-R intervals and Valsalva ratio during Valsalva maneuver.

Parameter	**Group I (Mean ± SD)**	**Group II (Mean ± SD)**	**p value**
Mean HR (beats/min)	82.32 ± 8.14	82.32 ± 8.54	0.999
Max R-R interval (ms)	847.24 ± 103.21	800.24 ± 164.66	0.200
Min R-R interval (ms)	659.61 ± 67.32	673.85 ± 77.52	***0.026**
Mean R-R interval (ms)	735.84 ± 73.89	736.49 ± 76.40	0.974

* Statistical significance (p<0.05)

Table – 3: Heart rate and R-R intervals in group I and group II during Valsalva recovery.

Parameter	**Group I (Mean ±SD)**	**Group II (Mean ±SD)**	**p value**
Mean HR (beats/min)	77.23 ± 7.44	76.15 ± 7.70	0.609
Max R-R interval (ms)	880.46 ± 87.25	901.66 ± 78.90	0.372
Min R-R interval (ms)	669.43 ± 69.56	706.10 ± 58.30	***0.047**
Mean R-R interval (ms)	783.13 ± 77.08	795.07 ± 76.10	0.576

*statistical significance (p<0.05)

Heart rate responses to the Valsalva-Weber maneuver are the result of reflex mechanisms, predominantly of baroreceptor origin, which involve principally the parasympathetic autonomic nervous system but also the sympathetic division. Cardiopulmonary and chemoreceptor reflexes appear to be also involved to a lesser extent, interacting with the baroreflex. The phase III to IV progressive bradycardia that follows the liberation of straining is thought to be due to parasympathetic activation alone, because of the very rapid functional action of this autonomic division or possibly combined with some sympathetic inhibition. The mechanism of the tachycardia during the maneuver remains controversial, with some authors suggesting exclusive slow enhancement of the sympathetic activity, others crediting it to exclusive rapid depression of parasympathetic outflow, and still others attributing it to combined synergistic opposing autonomic effects [9-12]. Valsalva ratio is the most important index of the baroreflex-mediated bradycardia and is calculated as the ratio of the highest heart rate during expiration and the lowest heart rate during the first 20 s after the expiratory strain. It is derived from the longest RR interval in phase IV divided by the shortest RR interval in phase II.

$$\text{Valsalva ratio} = \frac{\text{Maximum R-R interval after the strain}}{\text{Shortest R-R interval during the strain}}$$

Table – 4: Valsalva ratio in group I and group II.

Parameter	**GroupI (Mean ± SD)**	**GroupII (Mean±SD)**	**p value**
Valsalva ratio	1.33	**1.22**	****0.003**

**highly significant (p<0.01)

Its value below 1.21 is considered abnormal and it reflects the parasympathetic activity [13].

Fernando L, et al. revealed in their study that when performed carefully and evaluated correctly, the Valsalva maneuver is a helpful tool in the assessment of cardiovascular autonomic function. Low and coworkers established the age and gender specific normative data. A ratio below 1.10 is abnormal. According to some authors even a ratio below 1.2 is considered abnormal. Based on large number of studies, lower limit of normality for valsalva ratio has been set 1.50 [14-15].

The quantification of heart rate or heart interval variations associated with the Valsalva-Weber maneuver has been used as a sensitive, reliable, reproducible, and very simple method for characterizing the suddenly acting cardiac autonomic modulation. This approach has helped to characterize particularly the parasympathetic nervous function in healthy subjects and patients with different clinical conditions [15].

Verrier RL, et al. reviewed the recent paper by the Heart Rate Working Group comprised of European and U.S. investigators which states that heart rate is a pivotal variable that is precisely regulated in health but disrupted in disease. Heart rate is mainly indicative of the actions of the sinoatrial node and not directly related to the conducting system or the ventricular myocardium.

An enhanced adrenergic activity is arrhythmogenic and efferent vagal tone is cardioprotective by opposing its action. Elevated heart rate catalyzes the atherosclerotic processes and are associated with arterial stiffness and turbulent flow in cerebral and coronary circulations. In recent years there has been strong interest in lowered resting heart rate as and its cardioprotective role to reduce cardiovascular risk and mortality [16].

PK Jones et al in their study emphasized the role of valsalva ratio in identifying parasympathetic dysfunction as a cause of syncope in many clinical disorders [17].

Conclusion

In our study the cases of CS had a significant low value of valsalva ratio (1.22, $p < 0.01$). Valsalva ratio is an indicator of the vagal tone and it was found to be below the normative values, thus suggesting a lower parasympathetic tone in cases of CS than normal individuals.

Decreased parasympathetic tone is detrimental to cardiovascular health of an individual as reported by numerous recent studies [18-20]. Increased vagal tone is cardioprotective as there is decreased sensitivity of beta receptors. Thus, an increased parasympathetic modulation induces electrical stability while a high sympathetic activity increases the vulnerability of the heart and cardiovascular events. Moreover, these subtle autonomic disruptions occur much before the appearance of symptoms of the disease itself and can be helpful as an adjunct to diagnostic tests, prognostic follow-up and drug prescriptions. Autonomic function testing can therefore prove to be a valuable tool in aiding the clinicians to timely diagnose and stratify the cervical spondylosis patients according to cardiovascular risks, if any and give timely adjunctive management, thereby preventing significant morbidity.

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