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Influence of Cervical Collar on Vertebral Artery Blood Flow

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Abstract

Objective: *This study was carried to determine the effect of hard cervical collar placement on vertebral artery (VA) lumen diameter (LD) and blood flow velocity parameters.*

Methods: *In a sample of fifteen patients with cervical discogenic radiculopathy, color-coded duplex Doppler diagnostic ultrasound was used to collect data on LD, peak systolic velocity (PSV), and end diastolic velocity (EDV) at the vertebral artery foraminal segment (V2) before and after wearing hard cervical collar for four weeks. Pair-wise mean differences between measurements were analyzed using paired t-tests with alpha set at 0.05.*

Results: *There were no significant differences in LD and blood flow velocity parameters before and after wearing of hard collar for four weeks.*

Conclusion: *In patients with cervical discogenic radiculopathy, vertebral artery LD , PSV and EDV was affected after wearing rigid cervical collars for four weeks, however theses changes were non significant.*

Keywords: *Cervical spine, Color-coded duplex Doppler diagnostic ultrasound imaging, Blood flow velocity, Lumen Diameter, vertebral artery.*

Introduction

Short-term use of cervical immobilization by a cervical collar may reduce acute attacks of cervical pain secondary to radiculopathy[1],[2],[3],[4] .Immobilization of the neck with a cervical collar may decrease inflammation and irritated nerve root and may also limit muscle spasm [4].

Hard cervical collar has an important role in the successful management of cervical spine syndromes [5]. It was found that wearing cervical collar decreases pain in 76% of patients with neck pain[1]. Neck immobilization offered by wearing hard cervical collar decreases foraminal root compression and inflammation, which lead to greater reduction of radiating pain compared with neck disability and cervical pain [1],[6].

Although short-term wear of collars is of vital importance, prolonged wearing should be avoided [3].Cervical collars may lead to a number of complications such as pressure ulcers, respiratory compromise and increased intracranial pressure[7],[8].

Vertebrobasilar insufficiency (VBI) refers to the temporary or permanent reduction or stoppage of blood supply to the hindbrain through vertebral arteries (VA) and the basilar artery[9],[10] . Cervical spine has an intimate relationship to the VA [10]. Doppler ultrasound appears to be the most commonly used technique due to its feasibility and cost-effectiveness for patients and health professional[11],[12] [13],[14]. The duplex Doppler ultrasound measure blood flows accurately, allowing for measuring the blood flow velocity at different points within the examined artery. Compared to the gold standard of angiography, color-coded duplex Doppler US has demonstrated 90% sensitivity, 100% specificity, 100% positive predictive value, and 95% negative predictive value for detection of disease at any point in the vertebrobasilar circulation [12],[13].

Changes in blood flow velocity can be used to reflect changes with the blood flow volume [15], which is the main factor influencing brain perfusion[16][17] .This is based upon the fact that pulsatility index of the VA and its internal diameter do not change during normal laminar blood flow; therefore blood flow velocity and blood flow volume will change proportionally. Thus, measuring changes in blood flow velocity, associated with neck movements, is considered a valuable detector of relative blood flow volume changes[17].

Using rigid cervical collar may affect adversely vertebral artery blood flow, which will affect the patient quality of life and may limit his/her performance of activities of daily living. The study reported here was designed to investigate the impact of rigid cervical collar on vertebral artery blood flow using duplex ultrasound as most published articles on cervical spine syndromes have addressed the impact of wearing cervical collar on neck veins only. It was hoped that such information could be used to enhance clinical utility and safety of cervical collars and guide physicians, physiotherapists and orthotics when recommending cervical collar for patients suffering from cervical pain.

SUBJECTS AND METHODS

Patients

Fifteen patients from both sexes (male and female) were diagnosed as having cervical discogenic radiculopathy participated in this study, and were selected from Kasr AL-Ainy hospital, outpatient clinics (neurology and physical therapy). They were diagnosed on the basis of a medical review and an objective examination by the same neurologist and physical therapist. Diagnosis was confirmed by plain x-ray and magnetic resonance imaging (MRI) on cervical spine. All of the participants had both neck pains and also evidence of cervical radiculopathy (manifested by sensory, motor and reflex changes). All of the participants were suffering from acute, non traumatic cervical pain and were receiving the same symptomatic medical treatment. None of the chosen patients wore a cervical collar before this study. Exclusion criteria included conditions associated with a sensation of dizziness during cervical movement such as vestibular involvement or visual disturbances, previous history of vertebrobasilar insufficiency (VBI) and Carotid artery insufficiency.

Instrumentations and Materials

In this study, a Colour pulsed doppler ultrasonographic apparatus (Phillips HDI 5000) with real-time imaging by a linear 10 MHz transducer at Cairo University, Neurosonology Unit (CUNU) at Kasr Al –Ainy hospital, Neurology department was used. Hard collar made up of high density polythene sheet specially designed with two pieces height adjustment to maintain desired flexion or extension. Velcro closures are used for easy application, removal and adjustment

Study protocol

Vertebral artery (VA) measurements before and after wearing a cervical collar for four weeks were obtained. VA lumen diameter (LD) was measured in millimeters (mm) and blood flow velocity in centimeters per second (cm/s). The vertebral artery was identified by anterior approach, sagittal view with the patient lying supine with extended neck. Examination started by a B- mode longitudinal scanning of the extracranial vertebral arteries (V2 segment) begun with the right side. The vertebral segments were seen between the shadowing of the cervical transverse processes. Diameter of the VA was measured using average of three segments. Measured blood flow velocity parameters were obtained at initial ventricular contraction yielding the peak systolic velocity (PSV) and at the end of ventricular contraction yielding the end diastolic velocity (EDV). These measurements quantify maximum (PSV) and minimum flow velocity (EDV). The peak systolic velocity (PSV), and end diastolic velocity (EDV) were obtained in each examined artery. All testing was done by a single qualified ultrasonographer in the examination of extracranial vessels. All measurements of VA blood flow velocity and LD were performed at the V2 segment of the VA, specifically on the intertransverse portion of the artery at the C5–C6 level. A second measurement at the same site was taken after wearing the rigid cervical collar for a period of four weeks.

Ethical consideration

This study was approved by the Institutional Review Board of the faculty of physical therapy, Cairo University. All patients were informed about the purpose, tools, procedures, and duration of the study and signed a written consent.

Statistical analysis

Paired t test was conducted for comparing peak systolic velocity, end diastolic velocity, and lumen diameter between pre and post treatment conditions. The level of significance for all statistical tests was set at $p < 0.05$. All statistical analysis was conducted through SPSS (statistical package for social sciences, version 19).

Results

Subject characteristics:

Fifteen subjects (11 female, 4 male) (3 Lt. side & 12 Rt. Side Radiculopathy) participated in the study. Table 1 showed the mean ± SD age, weight, and height of the study group.

Table (1): *Mean age, weight, and height of the study group*:

	Study group	Female	Male
	$\bar{X}$ ±SD	$\bar{X}$ ±SD	$\bar{X}$ ±SD
Age (years)	40.2±3.54	40.81±3.94	38.5±1.29
Weight (kg)	85.66±9.85	86±9.6	84.75±11.98
Height (cm)	163.66±6.59	162.54±6.45	166.7± 6.84

$\bar{X}$, Mean; SD, standard deviation.

Comparison between pre and post treatment conditions:

The PSV, EDV, and LD consecutively of the right vertebral artery increased post treatment by 7.66, 15.8, and 3.33%. However, there was no significant difference in PSV, EDV, and LD between pre and post treatment conditions (p > 0.05). (table 2, figure 1-2).

The PSV, EDV, and LD of the left vertebral artery increased post treatment by 2.33, 0.89, and 0.3%. There was no significant difference in PSV, EDV, and LD between pre and post treatment conditions (p > 0.05). (table 2, figure 1-2).

Table (2): *Mean PSV, EDV, and LD of the right and left vertebral arties pre and post treatment of the study group:*

	Pre treatment	Post treatment				
	$\bar{X}$ ±SD	$\bar{X}$ ±SD	MD	% of change	t- value	p- value
RT vertebral artery						
PSV (cm/sec)	42.94 ± 8.63	46.23 ± 9.03	-3.29	7.66	-1.59	0.13*
EDV(cm/sec)	14.05 ± 2.49	16.27 ± 4.95	-2.22	15.8	-1.91	0.07*
LD (mm)	0.3 ± 0.04	0.31 ± 0.04	-0.01	3.33	-1.97	0.06*
LT vertebral artery						
PSV (cm/sec)	44.84 ± 8.51	45.84 ± 6.74	-1	2.23	-0.45	0.65*
EDV(cm/sec)	15.62 ± 3.99	15.76 ± 3.21	-0.14	0.89	-0.12	0.9*
LD (mm)	0.325 ± 0.02	0.326 ± 0.02	-0.001	0.3	-0.28	0.77*

$\bar{X}$, Mean; SD, standard deviation; t-value, paired t value; p-value, level of significance;* Non significant; PSV, peak systolic velocity; EDV, end diastolic velocity; LD, lumen diameter.

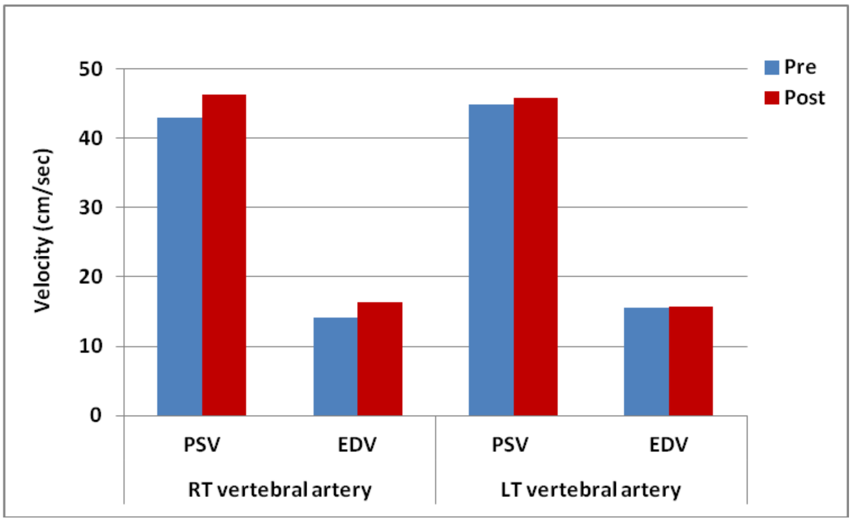

Figure (1): mean PSV and EDV of the right and left vertebral artery pre and post collar wearing.

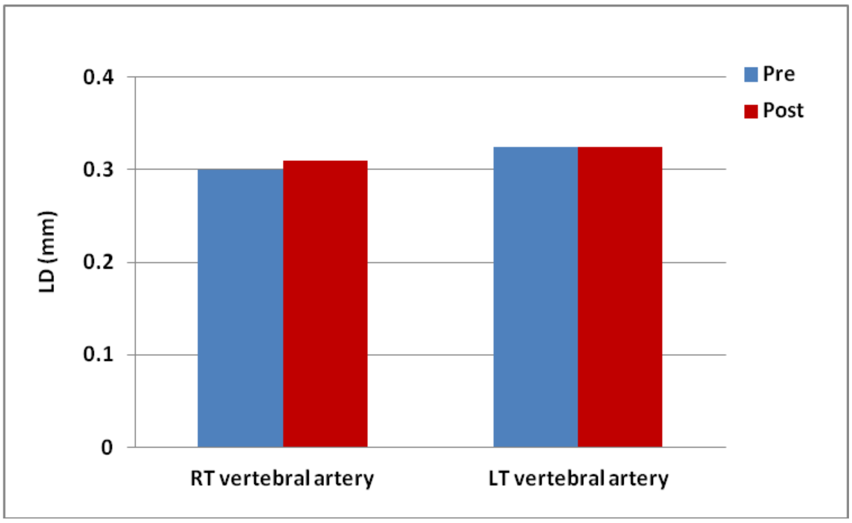

Figure (2): mean LD of the right and left vertebral artery pre and post collar wearing

Discussion

Literature review revealed no previous studies examined the effect of rigid cervical collar placement on vertebral artery blood flow in patients with cervical discogenic radiculopathy. The results of this study suggest that rigid cervical collar placement do not appear to pose a risk to blood flow to the hindbrain through vertebral arteries. Blood flow in the vertebral arteries varied but was not significantly changed by placement of rigid cervical collar.

The results showed no significant differences in blood flow measurements including PSV and EDV for either of the vertebral arteries (right vertebral artery, *P0.13, 0.7*; left vertebral artery, *P0.65, 0.9*). This study showed that blood flow of both vertebral arteries was not negatively affected by wearing of rigid cervical collar. LD also remained fairly constant suggesting that rigid cervical collar was not affecting it. However, affection in both EDV and LD was more in the right side than that of left side suggesting that affected side of radiculopathy was more susceptible for affection than that of other side. This study could not identify exactly what caused change in the vertebral artery blood flow but compression on neck veins and arteries is an expected explanation.

Change in blood flow velocity at and/or immediately beyond the point of constriction of a vessel was explained by Bernoulli principle. Its increasing reflect stretching or compression of the vessel. At this point, there is a reduction in the diameter of the vessel, which causes an increase in flow velocity. Also, Poiseuille's Law states that flow is proportional to the fourth power of the radius of the vessel [15]. It has been suggested that stretching and pressure on a muscular artery like the VA can lead to vasospasm, causing a reduction of blood flow and VBI [19].

Results of this study agree with those of Kuhnigk et al who did not find a significant change in ICP in 18 severely head injured patients following collar application. They decided that the risk of increasing ICP in a head injured patient was low [20]. A number of studies have detected a tourniquet effect of rigid cervical collar on neck veins, with an influence on intracranial pressure [21], [22].This has been supported by research postulating that ICP increases when a cervical collar is applied, and then gradually decreases on removal [23].

Stone et al were the first to evaluate the influence of wearing a cervical collar on the dimensions of the internal jugular veins in healthy volunteers, using ultrasound examination They recorded an increase in cross sectional area following wearing of cervical collar, supporting the hypothesis that collars create compression on neck veins causing venous obstruction that might cause an increased

ICP, but this could not be ascertained as the measurement of ICP is invasive, and therefore not applicable for volunteer studies [24].

Ferguson and colleagues suggested that compression and distortion of neck veins caused by wearing rigid cervical collars might affect venous drainage from the head. They recorded interface pressures of around 10 mmHg underneath six types of collar [21].

Hunt et al [25] investigated the impact of wearing cervical collars on patients with a traumatic brain injury. Results showed that ICP increased when collars wore. There were no other associated changes in cardiorespiratory parameters; accordingly, compression on neck veins was considered to be the casual factor of the observed effect. They suggested that the impact of wearing cervical collars will be more prominent in those with a greater risk of neurological deterioration.

These findings were confirmed by Mobbs et al [26] who concluded that obstruction of venous drainage and the potential for the collar to precipitate a painful stimulus may both affect ICP. However, they were unable to define the exact cause for the recorded increase in ICP.

Limitations

The type of collar used may influence the change in VA, and it is possible that a different type of rigid cervical collar could also result in a different effect on vertebral artery blood flow parameters. There were no measurements of subject's blood pressures or other markers of intravascular volume. Additionally, measurements were taken after cervical collar application for four weeks. It is possible that the changes in vertebral artery measurements may equilibrate with time.

Conclusion

In patients with cervical discogenic radiculopathy, vertebral artery LD , PSV and EDV was affected negatively after wearing rigid cervical collars for four weeks, however theses changes were non significant. Ultrasonographic examination of vertebral artery may be required before recommending hard cervical collar for those patients.

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