Effect of Physical Therapy Program for Cervical Spondylosis on Maximum Voluntary Ventilation and Diaphragmatic Motor Nerve Conduction

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ABSTRACT

Purpose of the study: The aim of this study was to determine the effect of physical therapy program, including hot packs, intermittent cervical traction and isometric neck exercises on maximum voluntary ventilation and phrenic nerve conduction which is the sole motor supply for the diaphragm. Subjects: Fifteen patients, their age ranged from 40 to 55 years with a mean of 47.6 ± 5.1 years suffering from multiple cervical spondylotic radiculopathy involving C3, C4 and C5.Methods: They received 12 sessions of physical therapy program in the form of intermittent cervical traction, hot packs and isometric neck exercises. Maximum voluntary ventilation (MVV) and phrenic nerve conduction studies were tested before and after treatment. Results: The results of this study showed considerable relief of patients' symptoms including occipital headache, neck and shoulder pain, tingling sensation and referred pain to arms .There were significant improvement in MVV and phrenic nerve amplitude but there were no significant differences in phrenic nerve latency and duration. It was concluded that, the improvement of diaphragmatic function tested in MVV was due to improvement of phrenic nerve function which occurred as a result of the mechanical effect of intermittent cervical traction.
Key words: *Cervical Spondylosis – Diaphragmatic Motor Nerve Conduction –Maximum Voluntary Ventilation.*

INTRODUCTION

Cervical spondylotic myelopathy is a common disease caused by chronic segmental compression of the spinal cord[17]. The "respiratory center consists of several groups of neurons located bilaterally in the brain stem[13,26]. Respiratory dysfunction may occur as a result of lesions in the upper cervical spinal cord, disturbing the descending pathways subserving automatic and volitional ventilatory control. The most anterior part of lateral column of cervical spinal cord is critical for maintance of automatic respiratory activity in humans[9]. Despite the fact that the columns of the nuclei of the phrenic nerve are located between the 3rd and the 5th cervical nerve segments, phrenic nerve paresis is not usually clinically significant[16]. Fregni et al.,[6] demonstrated cases of cervical spondylotic myleopathy with bilateral phrenic nerve paresis in whom magnetic resonance imaging and surgical findings confirmed intrinsic cord disease as being the cause of the syndrome. This finding suggests that one pathophysiology of the clinical phrenic nerve paresis may be segmental damage to the anterior horns caused by cervical spondylosis.

Acute traumatic lesions of the spinal cord, particularly at high cervical levels, are well known to affect respiratory control[9]. However, the effect of long-standing lesions such as cervical degenerative disease on respiratory function has received scant attention. Some clinical studies investigated the effect of chronic lesions of the cervical spine on respiratory function by examining the changes in respiratory function after laminoplasty[15,18,23,28].

In previous study, it was found an improvement of pulmonary functions in patients with chronic cervical spondylosis after application of physical therapy program[7]. In the current study, an attempt was conducted to verify this finding and investigate the underlying mechanism. So the current study was designed to determine the effect of physical therapy program of 12 sessions including intermittent cervical traction, hot packs and isometric exercises of neck muscles, on maximum voluntary ventilation and phrenic nerve conduction study.

SUBJECTS MATERIALS AND METHODS

Subjects

This clinical study was conducted on 15 male patients suffering from chronic multiple cervical spondylotic radiculopathy involving C3, C4 and C5 levels. The study was performed at El-Harm Medical Insurance Center. The age of the participant was ranged from 40 to 55 years with a mean of 47.6 ± 5.1 years, their weight ranged from 65 to 90 kg, with a mean of 76.9 ± 7.6 kg, and their height ranged from 1.65 to 1.88 m. with mean value of 1.77 ± 0.08 m. All patients were non-smokers, they were not suffering from diabetes or hypertension and they were chest and cardiac free. The patients were examined carefully by a neurologist, they suffered from variable symptoms such as occipital headache, tingling sensation, referred pain to neck, shoulders and arms, decreased muscle stretch reflex, and motor weakness. The neurological status at pre-study were recorded according to the Neurosurgical Cervical Spine Scale (NCSS)[11]. All patients were received non-steroid anti-inflammatory and muscle relaxant medications, which continued throughout the entire course of the study.

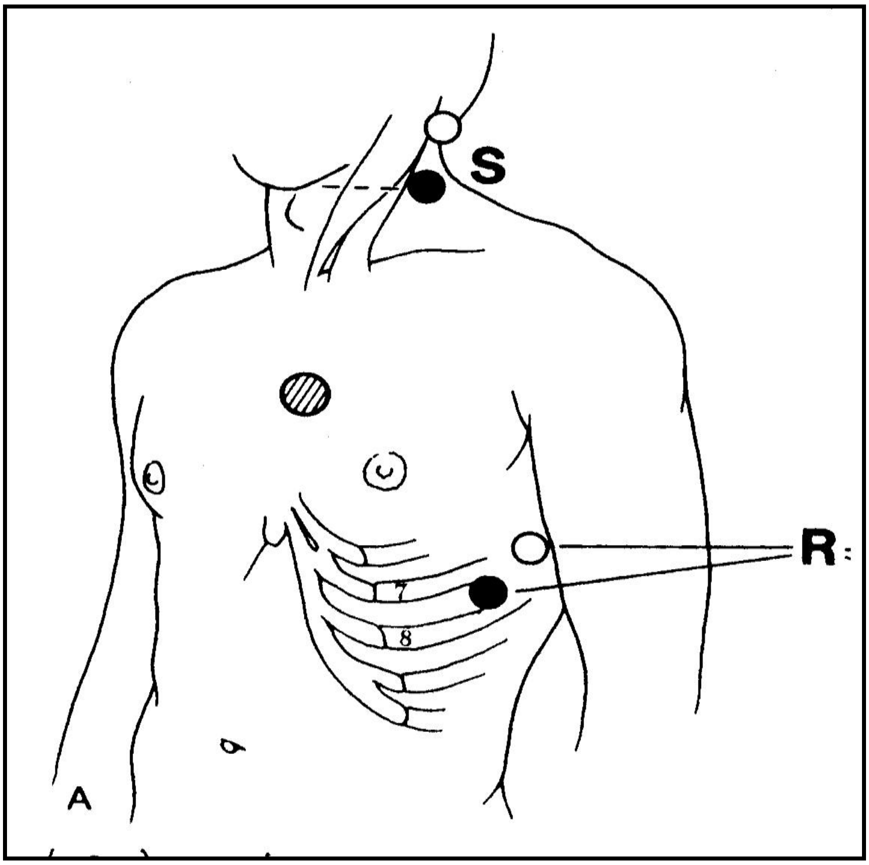
Methods

After all subjects were chosen carefully according to the specific criteria, the procedure was started in the following steps, which were explained for each subject before participation. Maximum voluntary ventilation (MVV) and phrenic nerve conduction studies were obtained from all patient before receiving their treatment program, as a base line result. Then, all patients received 12 sessions, day after day, in the form of hot packs, intermittent cervical traction and therapeutic neck exercises beside their medical treatment.

Evaluation Procedure

I- Phrenic nerve conduction study:

Electromyogram appliance, model; (4-Channel Reprter equipment-Esaote Biomedica) was used in nerve conduction studies of phrenic nerve. The patient was in supine position. Surface electrodes for both stimulating and recording were used. The phrenic nerve was stimulated along the posterior border of the sternocleidomastoid muscle at the mid portion of that muscle, on a line with the upper border of the thyroid cartilage. While the diaphragmatic compound muscle action potential was recorded with an active surface electrode placed in the midline over the inferior part of the sternum, 5 cm above the xiphoid. The reference electrode was placed 16cm inferiorly laterally on the lower costal margin. The ground electrode was placed on the sternum, midway between the stimulating and recording electrodes[14,19]. The wave of phrenic nerve evoked responses were analyzed for; (1) latency in millisecond, (2) amplitude in microvolt, (3) duration of the evoked response, and (4) side-to-side difference. These measurements were analyzed during rest, inspiration and expiration, Fig. (1).



S: stimulating electrode R: reference electrode

Fig.(1): Newsome-Davis's method (19).

II- MVV measurement:

A hand-held computerized spirometer, (Discovery Spirometer) was used to test the maximum voluntary ventilation, from setting position, with supported trunk. Placed a nose clips around the nose to prevent air from pacing through nose. The subject put the mouth-piece firmly into his mouth and breathed few times before started the examination procedure then he was instructed to breathe as deeply and rapidly as possible for 15 seconds. The volume expired was extrapolated to yield the flow rate in liters per minute. The subject performed 3 trials successively and the mean taken and recorded[8].

Treatment Procedures

Then the subjects started the physical therapy program which consisted of: hot packs, intermittent cervical traction and isometric exercises of neck muscles.

(1) Hot Packs:

The heated pack was placed in a bath towel and was applied to the patient's neck while he was in setting position. The temperature of the pack should not exceed 44°C, or according to patient's tolerance, duration of application was 20 minutes[12].

(2) Cervical intermittent traction:

After the muscles of the neck became heated and relaxed, the traction was applied; using a computerized traction appliance, model: (Huntleigh Akron) to apply an intermittent traction for the cervical region. The subject was positioned in a relaxed supine position with a small pillow under his knees to relax his back muscles. The neck was placed in 20° – 25° degrees of flexion measured by a goniometre and maintained by a small pillow, the traction force was 15 to 20 Kg according to patient's tolerance, the duration of traction was 15 minutes divided into 50 seconds hold and 10 seconds relax. The subject wore the head halter, one arm under his chin and the other one under his occiput. The traction force was increased gradually till 15kg. to avoid pain sensation. Any discomfort felt by the patient during traction, such as neck pain, referred pain, tingling sensation in shoulders or arms, or occipital headache, traction was stopped immediately and repeated again after some rest. At the end of the traction time, the subject was allowed to sit few minutes before standing up to avoid orthostatic hypotension[1].

(3) Isometric exercises of neck muscles:

Isometric exercises were performed to improve the neck muscles strength after being stretched by traction. These exercises were applied from the first session and continued till the end of the program (the details presented in reference "2".

Statistical Analysis

The collected data were introduced to the computer to be analyzed. These data were described in form of the mean and standard deviation for all the measured values of all patients. The mean values of obtained pre-and post-treatment were compared using the paired "t" test. The Pearson's correlation coefficient was used to compare among the values of MVV and the values of phrenic nerve conduction studies of both sides that were obtained pre-and post-treatment. For all the statistical test done, the threshold of significance was fixed at 0.05 (P-value). A P-value > 0.05 indicates non significant result. A P-value ≤ 0.05 indicates significant result. The smaller the P-value obtained, the more significant is the result.

RESULTS

I- Comparison between the pre-and post-treatment values of the right phrenic nerve:

The following results were obtained from 15 patients with cervical spondylosis. Before and after 12 sessions of physical therapy program; including hot pack, intermittent cervical traction and neck exercise. The mean values of NCSS were 8.75 ± 1.14 and 11.25 ± 0.75 before and after treatment respectively. As shown in table (1), the measurement of the mean of the latency of the right phrenic nerve in milliseconds at rest showed statistical insignificant difference between the pre-and post-treatment values; it was 8.09 ± 1.5 and after treatment, it became 8.44 ± 2.07, P > 0.05. The mean of latency during inspiration changed from 9.96 ± 2.35 before treatment into 9.43 ± 2.47 after treatment which is statistically non-significant as P > 0.05. On measuring the latency during expiration, one could notice that, the change in mean values from 9.61 ± 2.19 before treatment into 8.67 ± 1.93 after treatment with P value > 0.05 which is also statistically non significant.

Table (1): Shows the differences between the pre and post-treatment values of the latency in melliseconds of the right phrenic nerve during rest, inspiration and expiration.

Item	Pre	Post	MD	"t" value	P value	Significance
	Mean ± SD	Mean ± SD				
Rest	8.09±1.5	8.44±2.07	-0.35	0.91	0.377	NS
Inspiration	9.96±2.35	9.43±2.47	0.53	0.664	0.517	NS
Expiration	9.61±2.19	8.67±1.93	0.94	1.35	0.198	NS

SD: Standard Deviation MD: Means Difference "t" value: Paired t value P value: Probability value
NS: Non-significant- P value > 0.05

As shown in table (2), the measurement of the mean of amplitude of the right phrenic nerve in microvolt at rest showed statistical significant difference between the pre-and post-treatment values; it was 278.33 ± 225.68 and after treatment, it became 560.2 ± 433.46, P < 0.05. The mean of amplitude during inspiration changed from 321.44 ± 400.74 before treatment into 497.04 ± 360.99 after treatment which is statistically non-significant as P > 0.05. On measuring the amplitude during expiration, one could notice that, the change in mean values from 362.05 ± 320.39 before treatment into 1041.27 ± 1268.09 after treatment with P value > 0.05 which is also statistically non significant.

Table (2): Shows the differences between the pre and post-treatment values of the amplitude in microvolts of the right phrenic nerve during rest, inspiration and expiration.

Item	Pre	Post	MD	"t" value	P value	Significance
	Mean ± SD	Mean ± SD				
Rest	278.33±225.68	560.2±433.46	-281.87	2.33	0.035	S
Inspiration	321.44±400.74	497.04±360.99	-175.6	1.73	0.106	NS
Expiration	362.05±320.39	1041.27±1268.09	-679.21	2.05	0.06	NS

SD: Standard Deviation MD: Means Difference "t" value: Paired t value P value: Probability value
NS: Non-significant-P value > 0.05 S: Significant P value ≤ 0.05

As shown in table (3), the measurement of the mean of the duration of the right phrenic nerve in milliseconds at rest showed statistical insignificant difference between the pre-and post-treatment values; it was 5.41 ± 2.32 and after treatment it became 6.21 ± 2.11, P > 0.05. The mean of duration during inspiration changed from 6.43 ± 3.4 before treatment into 7.12 ± 4.54 after treatment which is statistically non-significant as P > 0.05. On measuring the duration during expiration, one could notice that, the change in mean values from 7.38 ± 3.01 before treatment into 9.18 ± 4.96 after treatment with P value > 0.05 which is also statistically non significant.

Table (3): Shows the differences between the pre and post-treatment values of the duration in milliseconds of the right phrenic nerve during rest, inspiration and expiration.

Item	Pre	Post	MD	"t" value	P value	Significance
	Mean ± SD	Mean ± SD				
Rest	5.41±2.32	6.21±2.11	-0.80	0.88	0.393	NS
Inspiration	6.43±3.4	7.12±4.54	-0.69	0.49	0.631	NS
Expiration	7.38±3.01	9.18±4.96	-1.8	1.22	0.234	NS

SD: Standard Deviation MD: Means Difference "t" value: Paired t value P value: Probability value
NS: Non-significant-P value > 0.05

II- Comparison between the pre-and post-treatment values of the left phrenic nerve:

As shown in table (4), the measurement of the mean of the latency of the left phrenic nerve in milliseconds at rest shown statistical insignificant difference between the pre-and post-treatment values; it was 8.77 ± 2.22 and after treatment, it became 8.75 ± 2.05, P > 0.05. the mean of latency during inspiration changed from 9.29 ± 1.83 before treatment into 8.44 ± 1.83 after treatment which is statistically non-significant as P > 0.05. On measuring the latency during expiration, one could notice that, the change in mean values from 7.79 ± 1.01 before treatment into 8.2 ± 1.17 after treatment with P value > 0.05 which is also statistically non significant.

Table (4): Shows the differences between the pre and post-treatment values of the latency in milliseconds of the left phrenic nerve during rest, inspiration and expiration.

Item	**Pre**	**Post**	**MD**	**"t" value**	**P value**	**Significance**
	Mean ± **SD**	Mean ± **SD**				
Rest	8.77±2.22	8.75±2.05	0.02	0.12	0.91	NS
Inspiration	9.29±1.83	8.44±1.83	0.86	1.63	0.125	NS
Expiration	7.79±1.01	8.2±1.17	-0.41	1.44	0.171	NS

SD: Standard Deviation MD: Means Difference "t" value: Paired t value P value: Probability value
NS: Non-significant-P value > 0.05

As shown in table (5), the measurement of the mean of amplitude of the left phrenic nerve in microvolts at rest showed statistical insignificant difference between the pre-and post-treatment values; it was 276.2 ± 291.14 and after treatment, it became 1734.2 ± 3707.8, (P > 0.05). The mean of amplitude during inspiration changed from 363.13 ± 325.54 before treatment into 852.4 ± 649.37 after treatment which is statistically highly significant as P < 0.05. On measuring the amplitude during expiration, one could notice that, the change in mean values from 393.27 ± 360.51 before treatment into 622.4 ± 363.44 after treatment with P value < 0.05 which is statistically significant.

Table (5): Shows the differences between the pre and post-treatment values of the amplitude in microvolts of the left phrenic nerve during rest, inspiration and expiration.

Item	**Pre**	**Post**	**MD**	**"t" value**	**P value**	**Significance**
	Mean ± **SD**	Mean ± **SD**				
Rest	276.2±291.14	1734.2±3707.8	1458	1.5	0.156	NS
Inspiration	363.13±325.54	852.4±649.37	489.27	3.28	0.005	HS
Expiration	393.27±360.51	622.4±363.44	229.13	2.89	0.012	S

SD: Standard Deviation MD: Means Difference "t" value: Paired t value P value: Probability value
NS: Non-significant-P value > 0.05 S: Significant-P value ≤ 0.05 HS: Highly significant-P value < 0.005

As shown in table (6), the measurement of the mean of the duration of the left phrenic nerve in milliseconds at rest showed statistical insignificant difference between the pre-and post-treatment values; it was 7.64 ± 3.25 before treatment and after treatment it was 8.55±3.78. At inspiration the values changed from 7.67 ± 3.56 before treatment into 16.22 ± 25.87 which is statistically non-significant as P > 0.05. At expiration, there was change in mean values from 7.17 ± 2.4 before treatment into 8.12 ± 2.83 after treatment with P value > 0.05 which is also statistically non significant.

Table (6): Shows the differences between the pre and post-treatment values of the duration in milliseconds of the left phrenic nerve during rest, inspiration and expiration.

Item	Pre	Post	MD	"t" value	P value	Significance
	Mean ± SD	Mean ± SD				
Rest	7.64±3.25	8.55±3.78	0.91	0.65	0.524	NS
Inspiration	7.67±3.56	16.22±25.87	8.55	1.35	0.198	NS
Expiration	7.17±2.4	8.12±2.83	0.95	1.08	0.299	NS

SD: Standard Deviation MD: Means Difference "t" value: Paired t value P value: Probability value
NS: Non-significant-P value > 0.05

III- Comparison between the pre-and post-treatment measurement of spirometry:

As shown in fig (2), the measurement of the mean of maximum voluntary ventilation changed from 97.53 ± 19.36 l/min before treatment into 115.41 ± 26.85 l/min after treatment which is statistically highly significant as P < 0.05.

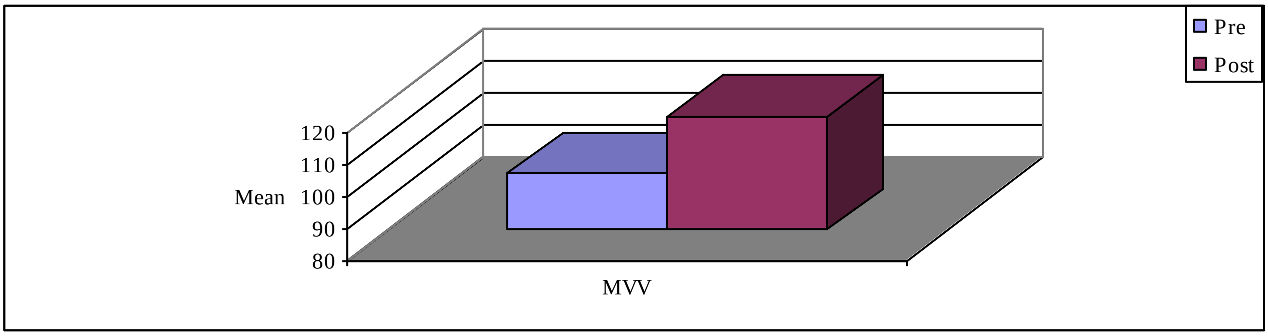


Fig. (2): Shows the differences between the pre-and post-treatment mean values of the maximum voluntary ventilation (MVV).

IV- Correlation coefficient between right and left phrenic nerves' amplitudes and spirometeric measurement:

As shown in table (7), fig. (3), the correlation coefficient between the pre-treatment amplitudes of the right phrenic nerve during inspiration and the pre-treatment values of maximum voluntary ventilation MVV was (r = 0.777) which means a highly significant positive correlation as P value < 0.001 and it was of direct proportional nature. It also noticed that, the correlation coefficient (r = 0.889) between the post-treatment amplitudes of the right phrenic nerve during inspiration and the post-treatment values of MVV, i.e., there was a highly significant positive correlation (P value < 0.0001) and of direct proportional nature. One could notice that correlation coefficient between the pre-treatment amplitudes of left phrenic nerve during inspiration and MVV was (r = 0.257) which means a nonsignificant positive correlation as P > 0.05. But, it was noticed that the correlation coefficient between the post-treatment amplitudes of left phrenic nerve during inspiration and MVV was (r = 0.725) which means that there was a highly significant positive correlation as P < 0.002 and of direct proportional nature.

Table (7): Shows the correlation coefficient between the amplitude and MVV in both right and left phrenic nerves during inspiration.

Nerve	Related variables	Correlation coefficient "r"	P value	Significance
Right phrenic	Pre value of MVV & amplitude	0.777	0.001	HS
	Post values of MVV & amplitude	0.889	< 0.0001	HS
Left phrenic	Pre value of MVV & amplitude	0.257	0.356	NS
	Post values of MVV & amplitude	0.725	0.002	HS

P value: Probability value NS: Non-significant-P value > 0.05 MVV: Maximum Voluntary Ventilation
HS: Highly Significant-P Value < 0.05

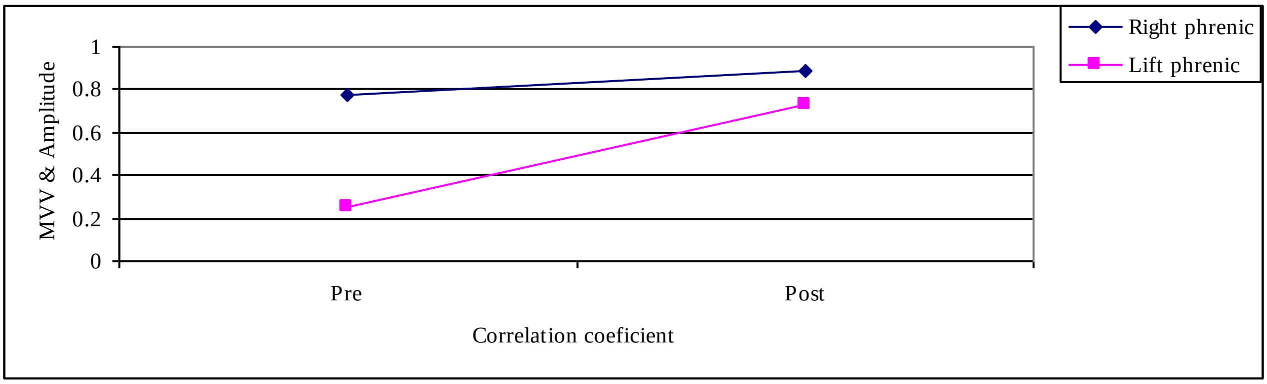


Fig.(3): Shows the correlation coefficient between the amplitude and MVV in both right and left phrenic nerve during inspiration.

DISCUSSION

Perusal of extant literature revealed extensive description of cervical spondylotic myelopathy (CSM) symptoms, but none had previously reported an associated neuromuscular weakness of the diaphragm. Magnetic resonance imaging analyses indicated that the existing degree of upper cervical cord compression, when reinforced by the additional posterior and anterior pressures consequent to cervical spinal extension and flexion, could readily account for the functional impairment of phrenic nerve neuron cells and/or their efferent fibers[20,23].

In this study, twelve sessions of physical therapy program including hot packs, intermittent cervical traction and isometric neck exercises were applied to fifteen patients, suffering from chronic multiple cervical spondylosis including C3 to C5 with complains of occipital headache, neck and shoulder pain, and referred pain to either upper limbs. The maximum voluntary ventilation (MVV) and phrenic nerve conduction studies were tested before and after treatment program which lasted for four weeks.

The results of this study showed considerable relief of patients' symptoms including occipital headache, neck and shoulder pain, tingling sensation and referred pain to arms. This may be attributed to the effect of applied program. This was in agreement with studies which described the use of intermittent cervical traction in four patients with cervical radiculopathy and large-volume herniated discs. Complete resolution of symptoms for each patient occurred within three weeks. They concluded that cervical spine traction could be considered as a therapy of choice for cervical radiculopathy[4].

Concerning the most important active ventilatory function test, the maximum voluntary ventilation (MVV), which measures the ability of the subject to breath in and out rapidly and deeply as much as possible usually for about 15 seconds. This test depends mainly on the strength and endurance of diaphragmatic muscle as well as the volume of air respired in each cycle. Also, maximum voluntary ventilation provides a most useful measure for monitoring ventilatory impairment, than other pulmonary function parameters; in patients with cervical myelopathy[18]. This was supported by studies which stated that one of the earliest indications of diaphragmatic muscle weakness is a reduced maximal voluntary ventilation[5]. The results of this study showed highly significant difference between the pre-and post-treatment values of MVV, with a percentage of improvement about 18.33%, which revealed an improvement in diaphragmatic function after completing 12 sessions of intermittent cervical traction. This result is in agreement with studies which stated that there was an improvement of pulmonary functions, including MVV, in 35 patients with chronic cervical spondylosis after application of 12 sessions of physical therapy program including intermittent cervical traction, short wave diathermy and neck muscle exercises and this improvement was attributed to the effect of cervical traction in reducing the vertebral compression at the C3, C4 and C5 levels on the roots of phrenic nerve resulting in the improvement of the diaphragmatic function which was associated with pulmonary functions improvement[7].

Phrenic nerve conduction studies were conducted in this study to show, in an objective way, any differences in the phrenic nerve parameters after application of the physical therapy treatment. Also, they were used to confirm objectively any changes that occurred in data obtained by spirometry. This concept supported by studies which stated that phrenic nerve conduction studies would assess the diaphragmatic muscle function in a more objective manner than usage of spirometry, in which, the subject was required to volitionally perform difficult breathing maneuvers in order to obtain reliable data[3].

Three parameters including "latency, amplitude and duration" were tested in phrenic nerve conduction studies for both right and left phrenic nerves of the same patient before and after the physical therapy program. The latency is identified as the time from the stimulus to the initial compound muscle potential (CMAP) deflection from base line. Latency represents three separate processes: (1) the nerve conduction time from the stimulus site to the neuromuscular junction (NMJ), (2) the time delay across the NMJ, and (3) the depolarization time across the muscle. The CMAP amplitude is most commonly measured from baseline to the negative peak. CAMP amplitude reflects the number of muscle fibers that ultimately fire. Low CMAP amplitudes most often result from loss of axons (as in a typical axonal neuropathy).The CMAP duration is measured from the initial deflection from baseline to the first baseline crossing. Duration is primarily a measure of synchrony (i.e., the extent to which each of the individual muscle fibers fire at the same time). Duration characteristically increases in conditions that result in slowing of some motor fibers but not others (e.g., in a demyelinating lesion)[21].

The results of this study showed no significant differences between pre-and post-treatment latencies and duration of both right and left phrenic nerves, but on analyzing the results of amplitudes, it showed a significant difference "statistically" between the pre-and-post-treatment means amplitudes of both right phrenic nerve during rest and left phrenic nerve during inspiration and expiration. But, the pre-and-post-treatment means of amplitude of right phrenic nerve during inspiration and expiration and the pre-and-post-treatment means of amplitude of left phrenic nerve during rest were obviously improved numerically but not statistically, this could be attributed to the small number of the sample of this study and to its heterogeneous obtained data.

It was noticed that the amplitude was affected, which indicated axonal lesion of the phrenic nerve root due to compressive lesion resulted from cervical spondylotic radiculopathy. This opinion was potentiated by studies which stated that reduced amplitude with normal distal latency and conduction velocity is the primary abnormality associated with axonal lesions provided the largest and fastest conducting axons remain intact. Mild slowing of conduction velocity and distal latency may occur if the largest and fastest conducting axons are lost[21].

The improvement of amplitudes of both phrenic nerves could be attributed to the effect of intermittent cervical traction which caused decompression of the phrenic nerve roots with subsequent improvement of phrenic nerve function. This opinion was supported by studies which stated that traction decreases the pressure on the nerve and increases the blood circulation to the nerve, reduces edema and allows the nerve to return to normal function[22]. It was assumed that applied program in the current study resulted in decompression of the phrenic nerve, similarly to cervical laminoplasty. The effect of cervical spondylosis on respiratory function in 12 patients over 65 years of age who underwent expansive laminoplasty was studied. Functional and neurological status were assessed. To assess the effect of laminoplasty on respiratory function in patients with cervical spondylosis, lung volumes including vital capacity, tidal volume, inspiratory reserve volume, expiratory reserve volume, inspiratory capacity, and forced expiratory volume were measured by spirometer before surgery and 6 months after surgery. All patients showed functional and neurological improvement after surgery, lung volumes showed significant improvement compared to before surgery. This study revealed that laminoplasty improved respiratory function in patients over 65 years of age with cervical spondylotic myelopathy. Lung volume measurement may be one method of estimating spinal cord function after a surgical procedures which is easy and universally accepted[28]. Moreover another study was conducted to clarify the characteristics of respiratory dysfunction associated with chronic-onset cervical myelopathy. Eighty-four consecutive patients without history of respiratory disease who underwent surgery of cervical myelopathy were studied. The control group consisted of 84 age-matched patients with lumbar degenerative disease. Parameters of spirometry, arterial blood gas, height of the diaphragm, and the score for neurologic impairment were analyzed before and after surgery. They found that percent VC (%VC) was significantly lower in the study group than in the control group. In patients with cranial (upper) cord lesions and multilevel cord lesions, %VC had not decreased before surgery, and no further improvement was obtained. They concluded that, in patients with chronic-onset cervical myelopathy, %VC also correlates with the preoperative neurologic score and improves with surgical treatment in patients with more cranial cord lesions. They also reported that respiratory dysfunction should be taken into consideration as a part of neurologic impairment in chronic-onset cervical myelopathy[10]. Roth et al[24]; concluded that spinal cord injury (SCI) causes restrictive ventilatory changes, with reductions in vital capacity, functional residual capacity, and expiratory reserve volume. He found an excellent correlation between vital capacity and nearly all of the other pulmonary function tests but not with maximum positive expiratory pressure not with maximum negative inspiratory pressure, in 52 patients with recent acute traumatic SCI. Latter a study was conducted to evaluate the respiratory function of patient with chronic cervical spondylotic myelopathy, in this study, spirometric parameters were measured in 94 patients with C5 before they underwent expansive laminoplasy. These measurements were compared with those obtained in age-and sex-matched control group. Patients were also subdivided into two groups: those with spinal compressive lesions above or below the C3-C4 disc level were compared in terms of respiratory function. The vital capacity values measured in patients with CCS were significantly lower than those in the control group. In patients, whom spinal cord compression was present above C3-C4, vital capacity values were lower than in patients in whom the compression level was below C3-C4. Peak expiratory flow rate was significantly decreased. So, they concluded that expiratory flow may be impaired or incomplete in patients with CCS and underlying sub clinical respiratory dysfunction appears to be associated with CCS[27].

In this study, there was a trial to compare between pre-values of the amplitudes of right phrenic nerve and those of the left phrenic nerve, in order to, make one side serve as a normal control for the other side but, the results of comparison were insignificant. This was attributed to bilateral phrenic nerve lesion. Even in unilateral phrenic nerve lesion, after following very detailed studies, have made the observation that side-to-side correlations for both amplitude and waveform were poor. As a result, they considered the uninvolved side to be unreliable standard for comparison when assessing for unilateral phrenic nerve lesion[25].

While the correlation between mean values of right and left phrenic nerves' amplitudes and mean values of MVV during inspiration was highly significant. Improvement of MVV was attributed to improvement of the diaphragmatic strength and endurance resulted from improvement of the right and left phrenic nerves' amplitudes.

Finally, it is obvious from the previously mentioned findings that, in case of chronic multiple cervical spondylotic radiculopathy, application of intermittent cervical traction causes improvement of diaphragmatic motor nerve amplitude with subsequent improvement of diaphragmatic muscle function (tested by MVV). The finding of the present clinical study must be minded during pulmonary rehabilitation of patients with cervical spondylosis, also in patients who subjected to open heart surgery, where the function of phrenic nerve was in danger.

Conclusion

It was concluded that respiratory dysfunction should be taken into consideration as a part of neurological impairment in chronic- onset cervical spondylosis. Successful physical therapy program (hot packs, intermittent cervical traction and neck exercise) resulted in improved the amplitude of phrenic nerve conduction, which in turn, improve the diaphragmatic function represented by maximum voluntary ventilation. So maximum voluntary ventilation provides a useful measure for monitoring ventilatory impairment in patients with cervical spondylosis.

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الملخص العربى

تأثير برنامج العلاج الطبيعى لمرضى خشونة الرقبة المزمن على أقصى معدل لتهوية الرئتين وعلى توصيل العصب الحركى للحجاب الحاجز

الغرض من هذا البحث كان التعرف على أثر برنامج العلاج الطبيعى على أقصى معدل لتهوية الرئتين وتوصيل العصب الحركي للحجاب الحاجز. اشتلمت الدراسة على خمسة عشر مريض يعانون من خشونة مزمنة بالرقبة مشتملة على الفقرات العنقية الثالثة والرابعة والخامسة. تلقي المرضى اثنى عشر جلسة علاج طبيعي في شكل شد رقبة متقطع وكمادات ساخنة وتمرينات رقبة. تم قياس أقصى معدل لتهوية الرئتين قبل وبعد البرنامج العلاجي وتم أيضاً دراسة العصب الحركي للحجاب الحاجز. وقد أظهرت النتائج عدم حدوث تغير في زمن توصيل العصب ولكن حدث تحسن في حجم التهوية القصوى الإرادية وفي قوة توصيل العصب الحركي للحجاب الحاجز ويعزي هذا التحسن لتأثير الشد المتقطع للرقبة ، حيث تسبب الشد المتقطع للرقبة لتقليل الضغط على العصب وتحسين الدورة الدموية للعصب مما أدى إلى تحسن وظيفة العصب والذي أدى بدوره لتحسن وظيفة عضلة الحجاب الحاجز وقد تسبب هذا التحسن في تحسن حجم التهوية القصوى الإرادية. يستخلص من هذه الدراسة أن خشونة الرقبة المشتملة على الفقرات العنقية الثالثة والرابعة والخامسة تؤثر على وظيفة عضلة الحجاب الحاجز نتيجة لانضغاط العصب الحركي للحجاب الحاجز وهذا التأثر في الوظيفة يمكن أن يتم اختباره بواسطة دراسة العصب الحركي للحجاب الحاجز وقياس أقصى معدل لتهوية الرئتين. ويستخرج أيضاً أن هذا التأثر في وظيفة الحجاب الحاجز يمكن معالجته باستخدام جهاز شد الرقبة المتقطع والذي يؤدي إلى تخفيف الضغط على العصب وتحسين وظيفته وبالتالي تحسين وظيفة الحجاب الحاجز.

الكلمات الدالة: خشونة الرقبة – توصيل العصب الحركي- معدلات تهوية الرئتين.