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EFFECT OF RESPIRATORY STRENGTHENING EXERCISE ON ARTERIAL BLOOD GASES IN POST-CERVICAL SPINAL CORD INJURY PATIENTS

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ABSTRACT

Background: Respiratory dysfunction remains a leading cause of morbidity and mortality after cervical spinal cord injury (SCI). **Objectives:** To determine the effect of respiratory strengthening exercise on arterial blood gases in post-operative cervical spinal cord injury patients. **Methods:** Forty-four patients of both sexes post-operative cervical SCI, C3, 4, 5. They were selected from inpatient department Kasr Al-aini hospital, Cairo University. All patients were carefully examined and referred by their (neurosurgeon). All patients were randomly assigned into groups, group A included 21 patients trained by (power breath plus traditional chest physiotherapy as diaphragmatic breathing exercise, costal breathing exercise (localized breathing), suction, percussion and vibration, for 2 weeks for 2 weeks, 3 times / day. Group B included 23 patients, who received traditional chest physiotherapy only for 2 weeks, 3 times / day. Arterial blood gases were assessed pre- and post-intervention. **Results:** There were significant differences between the two groups at the end of the study. Significant improvement of pH, PO_2, PCO_2, and HCO_3 were observed in group A ($p<0.05$), While there was non-significant changes in group B ($p>0.05$) after the 2-week intervention. **Conclusions:** Respiratory strengthening exercise has positive effects on arterial blood gases in post-operative cervical spinal cord injury patients.

KEYWORDS: SCI, Strengthening exercise, arterial blood gases.

INTRODUCTION

Spinal injury with cord damage (SCI) has a profound effect on the mechanics of respiration and on respiratory function particularly in cervical cord injuries.[1] A global-incident rate (2007) is estimated at 23 thoracic spinal cord injury cases per million (179 312 cases per annum). East -Africa (21 per million).[2] Early mobilization of patients with high thoracic and cervical cord injuries especially during the stage of spinal shock is likely to cause further reduction in vital capacity added morbidity.[3]

Respiratory dysfunction remains a leading cause of morbidity and mortality after spinal cord injury (SCI). The pathophysiology of respiratory dysfunction in SCI is multifactorial, resulting from diaphragmatic weakness, accessory muscle weakness, impaired cough, decreased surfactant production, and unopposed vagal tone leading to increased secretions and bronchospasm. The greatest determinant of respiratory failure after acute SCI is the level and completeness of injury relative to the phrenic nucleus at C3-C5.[4]

Indeed, diaphragmatic function is responsible for 65% of an individual's forced vital capacity .While there have been promising results with phrenic nerve and diaphragm motor-point stimulation, mechanical ventilation remains the mainstay of management for patients with respiratory failure after SCI. At the time of discharge from acute hospitalization, greater than 70% of patients with complete cervical SCI at C5 and above have historically been shown to require ongoing mechanical ventilation. Unfortunately, mechanical ventilation is one of the most costly consequences of cervical SCI due to the associated infectious risks, social isolation, financial and caregiver burdens. Diaphragmatic breathing technique is the pattern of breathing utilizing the diaphragm which is the chief inspiratory muscle. Diaphragmatic breathing increases relaxation, lymphatic flow & efficiency of gas exchange, most important to maintain proper health of tissues & muscles. Breathing has substantial effect on parameters of basal lung function.[4]

Arterial blood gases are measured to determine the amount of oxygen dissolved in the blood (PO2) the percentage of hemoglobin saturated with oxygen (SaO2). The amount of carbon dioxide dissolved in the blood (PCO2). And the amount of acid in the blood PH. The oxygen measure may be used to determine whether a patient needs oxygen therapy. The carbon dioxide measure gives some idea of lung function and is especially important to know when starting oxygen therapy.[5]

Patients can sometimes be liberated from mechanical ventilation by phrenic-nerve pacing and pacing of the external intercostal muscles. also methods for secretion clearance include chest physical therapy, spontaneous cough, suctioning, cough assistance by forced compression of the abdomen (“quad cough”), and mechanical insufflation-exsufflation.[6-8]

Power breathe is one of the existing linear load resistor models on the market, which generates resistance via a spring-loaded system or an electronic valve. The basic difference between this tool and the others is its ability to offer the largest load during the therapy, and to adapt inspiratory resistance to the pressure x lung volume curve. which could generate load stabilization along the breath, by providing a feeling of comfort to the patient.[9]

Spinal cord injury (SCI) is among the most catastrophic injuries that a person can experience. The personal and social effect of a significant SCI is profound because it confers lifelong disability on persons who are typically young adults. Fifty-four percent of all SCIs occur in individuals between 16 and 30 yr of age, with 75% of injuries occurring in those≤45 yr old.[10] Around 40% of spinal cord injuries occur in the cervical spine, a trend that is steadily increasing, with respiratory causes being responsible for death in over 20% of individuals. Loss of lung volumes and relative hypoxemia contribute to global hypoxaemia, exacerbating cord ischemia in the acute period.[11]

Data on the prevalence of the effect of power breath on ABG in patients undergoing cervical neurosurgery is important for gauging demand for health care and social support and how to deal with medical consequences in patients with respiratory acidosis or alkalosis and to determine the effect of power breath comparing to the traditional respiratory muscles training. It was hypothesized that there would be no effect of respiratory strengthening exercise on ABG in patients post cervical spinal cord injury. The Purpose of the study was to determine the effect of respiratory strengthening exercise on arterial blood gases in post-operative cervical spinal cord injury patients.

MATERIALS AND METHODS

Subjects

Sixty patients of both sexes post-operative cervical SCI, C3, 4, 5. They were selected from inpatient department, Kasr Al-aini hospital, Cairo University. All patients were carefully examined and referred by their (neurosurgeon). The purpose, nature and potential risks of the study were explained to all patients. The patients were asked to sign a consent form. Inclusion criteria were, 1) patients following cervical SCI, 2) age from 30 to 50, and 3) both sexes were included. The patients were excluded if they have the following criteria; 1) asthma patients who have low symptom perception and suffer from frequent, severe exacerbations or with an abnormally low perception of dyspnea[12], 2) ruptured ear-drum or any other condition of the ear, 3) marked elevated left ventricular end-diastolic volume and pressure, and 4) worsening heart failure signs and symptoms after RMT / IMT . All Patients were randomly divided into 2 equal groups; group A included 30 patients trained by (power breath plus traditional chest physiotherapy as diaphragmatic breathing exercise, costal breathing exercise (localized breathing), suction, percussion and vibration, for 2 weeks for 2 weeks, 3 times / day and group B included 30 patients, who received traditional chest physiotherapy only for 2 weeks, 3 times / day.

Evaluation

Arterial blood can be obtained by direct arterial puncture most usually at the wrist (radial artery). Alternatives to the radial artery include the femoral and brachial artery - both of which are usually used in emergency settings. The dorsalis pedis artery and ulnar artery may also be used. It is important to ensure good collateral circulation, as there is a theoretical risk of thrombus occlusion. If multiple samples are required then an indwelling arterial cannula can be placed. If the radial artery is to be used, Allen’s test was performed to confirm collateral blood flow to the hand.

An arterial blood sample (2 to 3 ml) was drawn a small bore needle attached to a (3-5 ml) plastic air tight syringe. The syringe was pre-packed and contained a small amount of heparin to prevent coagulation by drawing a small amount of heparin and squirting it out again. The sample was placed in acid-base analyzer device measures the pH, partial pressure of arterial oxygen (PO2), and partial pressure of arterial carbon dioxide (PCO2).

Treatment

Powers breathe plus use a variable load calibrated spring, calibrated to your chosen Resistance. It can be adjusted from the lowest load setting (17cmH2O) when training began and increased as the patient breathing muscles adapt and become stronger (maximum load setting 274cmH2O).

Each patient was asked to do all breathing exercises sitting down, the first few days of practice. Use a comfortable chair, preferably straight-back so that the spine is nice and straight at all times during the exercise. The feet should be flat on the floor, hands resting in lap or on knees. Head straight, facing frontally. Clothes should be loose (or none) and all belts, buttons or zippers about the abdomen should be loosened for maximum comfort and abdominal expansion.

Each patient was asked to fix gaze on a point straight ahead. This is an important step to begin with because it helps to concentrate on the breath without distraction.

Later when do the breathing randomly throughout the day while walking etc., this step may of course be eliminated.

Traditional chest physiotherapy as diaphragmatic breathing exercise, costal breathing exercise (localized breathing), basal breathing suction, percussion and vibration, for 2 weeks for 2 weeks, 3 times / day.

RESULTS

From the 60 patients who included in this study, 44 completed the program of the study regularly, 21 patients (13 males and 8 females) from group A and 23 patients (12 males and 11 females) from the group B. Nine patients who were assigned to group A did not complete the exercise program because of health issues (5) and discharge (3) and death (1). Regarding group B, seven patients did not complete the study program, health issues (4), discharge (2) and death (1), their data were not accounted statistically.

Demographic data (Age, weight, and height) showed non-significant differences between the two groups as presented in Table 1. Also clinical characteristics (PH, PO2, PCO2, and HCO3) showed non-significant differences between the two groups at the initial evaluation before starting the study program (Table 1).

Table 1: Baseline and clinical characteristics before intervention in the two groups

Arterial blood gases	Group A (n=21)	Group B (n=23)	*P*-value
Age (years)	41.83 ± 7.4	41.32 ± 7.2	0.818
Weight (Kg)	95.72 ± 11.3	96.12 ± 11.5	0.908
Height (cm)	167 ± 6.3	166 ± 5.8	0.586
pH (%)	7.23 ± 0.41	7.29 ± 0.38	0.625
PO2 (mmHg)	74.64 ± 15.4	73.61±16.2	0.831
PCO2 (mmHg)	43.66 ± 9.6	43.06 ± 8.8	0.829
HCO3 (Eq/litre)	30.24 ± 7.4	31.07 ± 7.6	0.722

Data is presented as mean ± standard deviation; Significance level at p<0.05; pH, blood acidity; PO2, Partial pressure of oxygen in arterial blood; PCO2, Partial pressure of carbon dioxide in arterial blood; HCO3, Arterial blood bicarbonate.

At the end of the study after two weeks, there was significant improvement in group A in all measures (p<0.05) while group B showed slight changes with non-significant difference between pre and post- intervention (p>0.05) as presented in Table 2.

Table 2: Statistical analysis of mean differences in two groups pre- and post- intervention.

Variables	Group A (n=21)			Group B (n=23)		
	Pre-	Post-	P-value	Pre-	Post-	P-value
pH (%)	7.23 ± 0.41	7.42±0.22	0.041	7.29 ± 0.38	7.35±0.31	0.561
PO2 (mmHg)	74.64 ± 15.4	85.78 ± 9.8	0.008	73.61±16.2	76.13±15.5	0.0613
PCO2 (mmHg)	43.66 ± 9.6	34.7 ± 5.3	0.006	43.06 ± 8.8	41.62 ±7.4	0.5512
HCO3 (Eq/litre)	30.24 ± 7.4	24.82 ± 5.2	0.009	31.07 ± 7.6	28.75 ± 6.9	0.284

Data is presented as mean ± standard deviation; Significance at P≤0.05; pH, blood acidity; PO2, Partial pressure of oxygen in arterial blood; PCO2, Partial pressure of carbon dioxide in arterial blood; HCO3, Arterial blood bicarbonate.

Comparing the post-intervention mean values of the arterial blood gases indicates significant differences (p<0.05) between the two groups in favor of group A as presented in Table 3.

Table 3: Statistical Analysis of Mean Differences Between The Two Groups Post-Intervention.

Variables	Group A (n=21)	Group B (n=23)	P-value
pH (%)	7.42±0.22	7.35±0.31	0.039
PO2 (mmHg)	85.78 ± 9.8	76.13±15.5	0.018
PCO2 (mmHg)	34.7 ± 5.3	41.62 ±7.4	0.001
HCO3 (Eq/litre)	24.82 ± 5.2	28.75 ± 6.9	0.041

Data is presented as mean ± standard deviation; Significance at P≤0.05; pH, blood acidity; PO2, Partial pressure of oxygen in arterial blood; PCO2, Partial pressure of carbon dioxide in arterial blood; HCO3, Arterial blood bicarbonate.

DISCUSSION

The present study was designed to study the effect of respiratory strengthening exercise (power breathing exercise for 2 weeks, 3 times / day) on arterial blood gases in post-operative cervical spinal cord injury patients (pH, PO_2, PCO_2, and HCO_3). With the hypothesis that there is no effect of respiratory strengthening exercise on arterial blood gases in patients post cervical spinal cord injury.

Arterial blood gases (pH, PO_2, PCO_2, and HCO_3) were recorded in the two groups at two intervals; the starting of the experiment (pre) and at the end of the two weeks (post- program). The results of the present study showed that arterial blood gases and dyspnea index score were improved at the end of the study program in group A ($p<0.05$), while the improvement in group B was statistically non-significant ($p>0.05$). The comparison between group A and group B showed extreme significant differences in all measures in favor to group A ($p<0.05$).

Our results coincided with results of Golder et al. who studied respiratory motor recovery after unilateral spinal cord injury: eliminating crossed phrenic activity decreases tidal volume and increases contralateral respiratory motor output.[12] They found that mean value of PCO2 significantly decreased, while the mean value of PO2 significantly increased in rate underwent hemisecting at C2 level who received respiratory muscle training.[13]

Also, Gregoretti et al. studied physiologic comparison between conventional mechanical ventilation and trans-tracheal open ventilation in acute traumatic quadriplegic and they demonstrated significant reduction of PaCO2 in patients with acute quadriplegic injury after ventilatory training.[14] In addition, previous study concluded that resisted exercise resulted in a significant improvement in pulmonary functions in elderly patients with chronic obstructive pulmonary disease.[15]

Moreover, Wanke et al. endorsed our results when they studied the effect of inspiratory muscle training in patients with Duchene muscular dystrophy found an increase of PaO2 and decrease in PaCO2 after inspiratory muscle training in patients.[16]

In agreement with our study, Lin et al. found that Abdominal weight and inspiratory resistance have beneficial effects on inspiratory muscle functions during maximal voluntary breathing in chronic tetraplegic patients.[17] As well, Abdelkader examined the impact of respiratory muscle training on blood gases and pulmonary function among thirty six patients with complete spinal cord injury at level from C5 to C8, and concluded that resistive respiratory muscle training improves blood gases and pulmonary function suggesting this intervention as an efficacious therapy for patients with cervical spinal cord injury.[18]

CONCLUSION

Respiratory strengthening exercise has positive effects on arterial blood gases in post-operative cervical spinal cord injury patients.

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