ISSN: 2584-0355
DOI: doi.org/10.51219/MCCRJ/Kamrun-Nahar-Chowdhury/138

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https://urfpublishers.com/journal/case-reports

Vol: 2 & Iss: 4

Review

Evidence Based Chest Physiotherapy for Spinal Cord Injury (Tetraplegia)

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Citation: Chowdhury KN, Hossain MS. Evidence Based Chest Physiotherapy for Spinal Cord Injury (Tetraplegia). *Medi Clin Case Rep J* 2024;2(4):517-521. DOI: doi.org/10.51219/MCCRJ/Kamrun-Nahar-Chowdhury/138

Received: 22 September, 2024; **Accepted:** 16 October, 2024; **Published:** 18 October, 2024

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A B S T R A C T

Introduction: Tetraplegia is the condition which occurs because of the injury of the cervical spinal cord and respiratory problems are the one of the major problem. Chest physiotherapy may help this type of patient to lead a better life.

Methods: A narrative review. In this study RCT study was used to review the intervention.

Result: Several Randomized controlled trials has been found regarding chest physiotherapy for patients with Tetraplegia. The articles synopsis has been done based on PEDro score. The eligibility criteria was PEDro score 5-7; among five researches one research had score 7, other two had score 6 and two had score 5. The findings can be entitled as strong evidences. Among them one article has been originated form western settings.

Conclusion: Chest Physiotherapy interventions often designed in a mixed protocol to exercise the tetraplegia patients. The guideline of interventions should follow a respiratory assessment. The intensity of exercise prescription might also be customized according to race, physical condition and geographic and cultural context.

Keywords: Spinal cord injury; Respiratory distress; Breathing exercise.

Introduction

Spinal cord injury (SCI) is the injury to the spinal cord which occur disruption of the spinal colum or not with neurologic dysfunction[1]. Currently there is no way to repair the central nervous system (CNS) and restore function that's why Spinal cord injury (SCI) is one of the major medical problem[2]. Spinal cord injury is a major challenge for both the physician and the researcher that represents a great health and economic burden for patients and society. Spinal cord injuries are also measured complex clinical and functional dysfunctions, caused by damage to the spinal cord nerve tissue, usually through disturbing mechanisms, such as breaks or dislocation of vertebral bodies. These mechanisms invariably principal to wide-reaching and heterogeneous physiological changes, which include damage to neuromotor function - such as loss of motion due to complete limb paralysis, in addition to ineffective respiratory muscle strength for voluntary ventilation. The International Standards for Neurological and Functional Classification of Spinal Cord Injury define the level and the extent of the injury based on an examination of motor and sensory neurological function. tetraplegia (formerly called quadriplegia) - injury to the spinal cord in the cervical region with associated loss of muscle strength in all four extremities[3]. Tetraplegia results from acute cervical spinal cord trauma which is associated with insightful respiratory compromise. Injuries at or above the cord segments C3 to C5 involve the phrenic nerves and cause partial or complete bilateral hemidiaphragmatic paralysis[4]. There are some risk factors of spinal cord injury, traumatic cause is one of them[5]. Motor vehicle accident and fall from height, fall from tree and overload on the neck are also the risk factors of tetraplegia (Chen et al., 2013). Falling from height and carrying heavy weight on the head are common cause of spinal cord injury in Bangladesh. 43% SCI is caused by falling from height in Bangladesh and other country like India Thailand and Neigeria are 55%, ,43%, 48%[6]. In individuals with cervical lesions below C4, the motor innervation of the diaphragm and the sternocleidomastoid muscle will be intact, so one can breathe independently. This induces another, most likely less breathing pattern in individuals with complete as well as incomplete lesions[7]. The high frequency of respiratory complications in patients with spinal cord lesions, especially those with tetraplegia clearly contributes to their morbidity and mortality rates. The most important pulmonary function change is a nonparenchymatous pulmonary restriction remaining to weakness or paralysis of respiratory muscles[8]. Respiratory complications are a leading cause of morbidity and mortality in people with spinal cord injury (SCI) and are more noticeable in individuals with higher level and complete injuries. A major contributor to respiratory illness in individuals with SCI is secretion retention, particularly among individuals with cervical lesions[9].

High quadriplegics, defined as those with complete injuries above the C3 level, suffer from loss of diaphragmatic motion due to paralysis of primary inspiratory and expiratory muscles. Most such patients are permanently ventilator dependent. The impact of SCI on normal airway clearance can be exemplified by examining the sequence of a cough. After chest physiotherapy techniques of manual percussions and vibrations as well as postural drainage[10].

Body of Text

Randomized controlled trial was the study design. The aim of the study was to determine the effects of air stacking on pulmonary function and peak cough flow in patients with cervical spinal cord injury. Exclision criteria were intrinsic lung diseases, tracheostomy, medications. There were twenty six patients, experimental (n-14), control (n-12) group. Therapeutic exercises were performed by the two groups. Control group performed incentive spirometry twice a day with 20 repetitions, on the other hand experimental group performed 20 repetitions of AS twice a day. The two groups taught for 5 days a week, for 6 weeks. Forced vital capacity and peak cough flow were assessed during the study. Forced vital capacity increased significantly in the experimental group and in control group it also increased but not that much. Peak cough flow increased in the experimental group. Experimental group found higher PCF values because AS training for 6 weeks improved inspiratory capacity more effectively than IS. The patient suffering from a complete lesion at any level of the cervical cord (tetraplegia) suffer from many pulmonary difficulties. The respiratory insufficiency in tetraplegia is secondary to paralysis of the intercostal and abdominal muscles[11].

For the respiratory management the patient with SCI has focused on ventilation-independent breathing and the prevention of respiratory complications which is consisted of secretion retention, atelectasis and lower respiratory tract infection. In this study the aim was to evaluate the effects of Resistive inspiratory muscle training were compared with usual care. It was a single blinded Randomized controlled trial. Inclusion criteria were: Patient with SCI admitted for initial inpatient rehabilitation; motor level T12 or higher; American Spinal Injury Association Impairment Scale (AIS) grade A, B, C or D; ranging from 18 to 70 years old; and decreased lung capacity. Impaired pulmonary function was defined as forced expiratory volume in 1 second (FEV1) below 80% of the predicted value. And the exclision criteria were progressive diseases, a psychiatric condition that interfered with constructive participation, insufficient comprehension of the Dutch language, medical instability, ventilator dependency and the presence of tracheostomy. There were 40 SCI patients (15 with motor complete tetraplegia, 16 with incomplete tetraplegia, 8 with motor complete paraplegia and 1 with incomplete paraplegia) who had impaired pulmonary function and were admitted for initial inpatient rehabilitation Participants were assigned at random to either the control group or the RIMT group. Every participant got standard rehabilitation care. The intervention group's members also used a threshold trainer to do RIMT. The intervention were started 5 weeks after the start of active inpatient rehabilitation (defined as out of bed for at least 3 consecutive hours). All patients received usual care (including passive range of motion, muscle strength exercises and functional training) and 2 homogenous educational lessons on general aspects of respiratory function and respiratory complications. People assigned to the RIMT group trained 8 weeks with an IMT Threshold trainer. The proposed load at the start of the training was 60% of maximum inspiratory pressure (MIP) at baseline. Each training session involved of 7 sets of 2 minutes of breathing through the Threshold trainer followed by 1 minute of unresisted breathing. To get aware with the training, sets were increased from 3 to 7 in the first week. At each focus, one physical therapist employed at the SCI unit and instructed verbally and in writing was responsible for the execution of the protocol. Once a week, this therapist raised the threshold load after assessing the training. Other training sessions were planned as part of the overall rehabilitation program and supervised by an assistant. Furthermore, at the conclusion of the intervention period, a written questionnaire was used to subjectively evaluate the intervention. The therapist encouraged the members of the RIMT group to continue RIMT when the intervention time ended. Written questionnaires were used to retrospectively identify whether participants continued training at predetermined intervals: eight weeks following the intervention period and three, six, nine and twelve months following their release from inpatient rehabilitation[12].

The design of the study was randomized control trail and the aim of the study was to compare the effects of inspiratory resistance training (IRT) and isocapnic hyperpnea (IH) versus on respiratory function, voice and quality of life in patients with motor full tetraplegia, incentive spirometry (placebo) was used.

Respiratory problems are still the main cause of death in individuals with a spinal cord injury (SCI). Twenty-four individuals with traumatic motor complete (ASIA Impairment Scale [AIS] A) tetraplegia, between C5 and C8, 6 to 8 months post injury took part in this study. Participants were assigned randomly to one of three study groups: the first group received inspiratory resistance training (IRT), the second group underwent respiratory muscle endurance training using isocapnic hyperpnea (IH) and the third group received placebo training using incentive spirometry. All the patients completed 32 supervised training sessions (4 x 10 minutes per week) over 8 weeks. The group 1 (IRT group) used an electronic inspiratory threshold device with visual feedback of achieved resistance, called Respifit S. The patient had to inhale with maximal inspiratory power in each of the 90 repetitions. Inhalations with less than 80% of the individual maximal inspiratory power had to be repeated. The group 2 (IH group) used a device called Spirotiger. This device permits intensive hyperventilation as a result of partial re-breathing of ventilated air, held by visual and acoustic feedback of breathing volume and frequency. Patient had to hyperventilate for 10 minutes continuously at 40% to 50% of their individual maximal voluntary ventilation. The participants in Group 3, known as the placebo group, were instructed to engage in volume training using a Voldyne 5000 incentive spirometry device. Their task involved inhaling 16 times to reach total lung capacity, with 30 to 40 seconds of rest between each repetition. The researchers then calculated the differences between the values obtained before and after the training. A Friedman test was employed to compare the results of the inspiratory muscle training (IRT) or the inspiratory hold (IH) with those of the placebo group, with a significance level of $P < .05$[13].

Expiratory muscle force is reduced to less than 40 percent of it normal values which is causing a serious impairment on the patient's capacity to cough. In addition to this, vital capacity has been revealed to drop to levels less than 50 percent of its normal values. The study design was randomized controlled trial. Forty tetraplegia patients were present in the study and they were divided into control and experimental group. Around 40 percent of them spent most of the time in bed. They were put in supported sitting positions for only short periods. The other 60 percent spent part of the day in wheelchairs and the rest of the day in bed. At the begining, each patient was adapted with the experimental techniques so that learning would not produce spurious results. Vital capacity and maximum static respiratory pressures were measured in all patients in two study positions (supported sitting and supine position) during the training. The experimental group was gone through eight weeks of training. The training involved the use of the PFLEX muscle trainer which allowed the patient to expire against a set resistance. The resistive load at the start was adjusted to match 60 percent of the patient's highest expiratory mouth pressure. Each participant had to undergo training for 30 minutes daily, six days a week. The resistive load was raised every two weeks to maintain ideal loading during the training phase. The control group did conventional breathing exercises and assistance in coughing. Between two groups control group did not show any significant results, on the other hand, progressive resistive loading on accessory expiratory muscle showed a significant improvement[14].

The study design was randomized control trail. The aim of the study was to determine the effectiveness of neuromuscular electrical stimulation (NMES) on cough capacity and prevention of pulmonary complication in patients with acute cervical cord injury. There were twentysix tetraplegic patients who were divided into experimental group (n-13) and control group (n-13). In cervical spinal cord injuries most of the patients die because of different type of respiratory problems. These problems may be caused by loss of control of abdominal muscles, intercostal muscles and a partial or complete loss of diaphragmatic function. Different types of interventions are used to strengthen respiratory muscles, including abdominal weight training, incentive spirometry, face masks, positive pressure trainers and resistive inspiratory muscle training, have been used to improve the pulmonary function of tetraplegic patients. Clavicular portion of the pectoralis major is the key musckes for the active expiration in tetraplegia patients. So it is suggested to make a training programs to increase the strength and endurance of these muscles. Neuromuscular stimulation is used to strength the muscles, it uses a device that sends electrical impulses to nerves. This input causes muscles to contract. All patients had complete tetraplegia in this study. Control group patients went through conventional rehabilitation program for spinal cord injury, such as passive range of motion, mattress exercise, sitting balance or upper extremity functional training. Experimental group got conventional program plus NMES therapy. Electrodes were placed over the motor points of the clavicular portion of the bilateral pectoralis and abdominal muscles. One was applied on the abdominal wall near the umbilicus and then the electrode was moved to the other area near the umbilicus and if more prominent muscle contractions were noted with the same stimulation intensity, the stimulation intensity was decreased to the level that still could induce muscle contractions. The stimulation device administered symmetrical biphasic waveform stimulation at a rate of 30 Hz with a pulse width of 300 milliseconds. The rise time of the waveform was 0.5 seconds and the on/off time was configured at 4 seconds/4 seconds. The output from the stimulation device was current-regulated, ranging from 0 to 100 mA. The intensity of the stimulus was tailored to the patient's muscle contractions and was well-tolerated. Patients underwent NMES therapy for 30 minutes each day, 5 days a week, for 4 weeks. Data was assessed at 4 different time points (pre-therapy, post-therapy, 3-month and 6-month follow-up). Before and after the 4 weeks of therapy, a pulmonary function test was conducted to measure VC, FVC, FEV1, PEF, MIP and MEP. Significant improvements in VC, FVC, FEV1, PEF, MIP and MEP were observed in the NMES therapy group after 4 weeks of therapy, as well as during the 3-month and 6-month follow-up testing, with $p<0.05$ compared to the control group[15].

Guideline of Chest Physiotherapy for Tetraplegia patients

- Stage-I –Acute or medical stabilization
- Stage-II-Evaluation and Limited rehabilitation
- Stage-III-Full rehabilitation
- Stage-IV- Reintregation

Stage-I and Stage-II

Impairments

- Increased production of secretion
- Respiratory distress
- Decreased the strength of respiratory muscles,
- Shortness of breath
- Ineffective coughing

Treatment

Check Respiratory rate, Percussion & Postural drainage treatment Auscultate daily and Monitor sputum characteristics daily and practice deep breathing[16].

Percussion & Postural drainage treatment, Instruct and practice deep breathing exercises daily and Use incentive spirometer daily Provide P&PD as ordered[9].

Suction after P&PD, Assist with manual assisted coughing daily[17,18].

Air stacking exercise

Dose- 20 repetition twice a day, 5 days in a week[11].

Stage-III

Impairment

- Altered breathing pattern
- Decreased strength and endurance of diaphragmatic
- Decreased chest wall mobility
- Coughing problem

Treatment

Practice deep breathing exercises (including inflation hold and incentive spirometer)[16].

Perform diaphragmatic strengthening exercises

Dose-3 times daily per week[19].

Perform manual pectoral-chest stretching exercises

Dose-2 times daily per week[20].

Practice air-shift maneuvers

Dose -2 times daily per week

Resistive inspiratory muscle training

Dose- 7 sets ,2 minutes of breathing,3 times a week

Stage-IV

Impairment

Decreased inspiratory muscle strength

Decreased lung volume

Relaxation problem

Treatment

Patient and family direct or perform deep breathing,

Dose- Daily[21].

Diaphragmatic strengthening

Dose-3 times daily per week[19].

Manual chest stretching,

Dose-3 times daily per week[19].

Manual assisted coughing with abdominal binder[22].

Inspiratory resistance training for increase inspiratory muscle strength and lung volume

Dose- 4 training session, 10 minues per week[13].

Progressive resistive loading on accessory muscle

Dose- Half an hour each day, six days in a week[14].

Discussion

Spinal cord injury is one kind of severe injury. When the patients are affected into the four limbs, its called tetraplegia or quadriplegia. This type of patients suffer from many problems, among them respiratory distress is one of the major problem. Many patients have died because of involvement of phrenic nerve and who survive from this, they will live a pathetic life. The primary reasons for spinal cord injury in our nation are motor accidents, falls from heights and carrying heavy loads on the head. Respiratory distress, inactive coughing, shortness of breath, decrease respiratory muscle power are the common problems of the tetraplegia patient. Most of the patient have died in their house, only few get medical treatment. Rehabilitation program is very much beneficial for them but most of them do not get the treatment in our country. Chest physiotherapy is very much important for the tetraplegia patients. There are four stage of rehabilitation. In this stage they get different type of chest physiotherapy but we do not have any specific guideline in our Bangladesh. so it is very much difficult for us to treat the patient. In this assignment I tried to make a guidline for chest physiotherapy, by following some international guideline.

Conclusion

We conclude that a high percentage of those who are tetraplegic showed respiratory complications. Different types of chest physiotherapy helps them for betterment. Respiratory distress can cause death. Chest physiotherapy has the potential to lower the mortality rate. Resistive inspiratory muscle training has a significant short-term effect on inspiratory muscle function in people with SCI who have problem with pulmonary function. Air stacking exercise can also improve the pulmonary function. Only the expiratory muscles do not work, the accessory muscles also work. Progressive resistive loading on accessory expiratory muscles help to clear the bronchial secretion. Nerve stimulation applied to the chest and abdominal muscles could enhance cough capacity and lung function in individuals with tetraplegia due to spinal cord injury at the neck. This enhancement may be sustained for a period of 6 months and contribute to a reduction in pulmonary complications. Even with a relatively low training volume, high intensity inspiratory muscle training can enhance the strength of the breathing muscles in individuals with complete paralysis of both upper and lower limbs. For individuals with complete paralysis of both upper and lower limbs during the first year following the injury, inspiratory muscle training is more beneficial than intermittent hypoxic training.

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