IJPMR 13, April 2002; 28-34

Pulmonary Functions and Effect of Incentive Spirometry During Acute and Post Acute Period in Tetraplegia

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Abstract

A prospective study was undertaken to evaluate if incentive spirometry can improve peak inspiratory mouth pressure (PIMP), peak expiratory mouth pressure (PEMP), and cough peak expiratory flow rate (CPEFR) in traumatic tetraplegia. Fifty patients who were seen within 7 days from the date of trauma were randomly selected for treatment (25 patients) and control (25 patients) group. The patient under treatment group received incentive spirometry training for 15 minutes per day, 7 days a week for six months.PEMP & PIMP were measured using an indigenously designed modified sphygmomanometer. CPEFR was measured using CPEFR meter. Measurements were taken on initial examination (basal value) and after the end of each week for 4 weeks, after 3 months and after 6 months & statistical test of significance were performed.Higher values of PEMP, PIMP, CPEFR were observed in both the groups. But in treatment group the improvement was significant to highly significant statistically.To conclude,incentive spirometry can improve PEMP, PIMP and CPEFR by increasing strength of innervated muscles and thus can improve cough capability, inspiratory capacity, endurance and perceived dyspnea, and can help in decreasing pulmonary complications.

Key Words : Tetraplegia, Pulmonary Function, Incentive Spirometry

Introduction

Pulmonary complications present a major threat in patients suffering from cervical spine injury[1], as it results in paralysis of intercoastal muscles leading to change in rib cage compliance and detrimental effect on diaphragmatic function causing it to operate from disadvantaged position[2]. Even in low cervical cord lesions normal function of fully innervated diaphragm is impaired due to paralysis of abdominal muscles[3].

Inspiratory and expiratory muscle dysfunction can be demonstrated by a marked reduction in static inspiratory and expiratory mouth pressure, and cough peak expiratory flow rate. It results in difficulty to cough out phlegm and increased risk of pulmonary complications[4]. It is therefore evident that tetraplegic patients require a comprehensive pulmonary rehabilitation with patient's involvement to improve; it's respiratory capacity.

A study was conducted in fifty patients of cervical spine injury to assess the respiratory muscle strength and to evaluate the effect of training on respiratory muscle strength and cough efficacy following exercise with incentive spirometer.

Material and Methods

Fifty consecutive cases of traumatic cervical spine injury with quadriplegia admitted in the

Department of Physical Medicine & Rehabilitation, S M S Hospital, Jaipur, from December 1996 to December 1998 were included in this study. Patients who had incomplete lesion, ASIA Grade C, D or E, tracheostomy, chest injuries, spasticity and those who reported after more than seven days from the date of trauma were excluded from the study. In all patients' peak inspiratory and expiratory mouth pressure were assessed by using a modified sphygmomanometer with a connecting tube and a mouthpiece. A bore was made at the upper end of the mercury gauze / column. The tube was connected to the lower end of sphygmomanometer for recording peak expiratory mouth pressure obtained by forceful expiration of air and rise of mercury column.Where as the tube was connected to the upper end for recording peak inspiratory mouth pressure by forceful inspiration / sucking and thereby rise of mercury column. The pressure generated was noted in millimeter of mercury (mm Hg).

Peak inspiratory and peak expiratory mouth pressure were selected because in contrast to lung volumes measurment and dynamic tests such as maximum breathing capacity, which many intrapulmonary diseases may alter. Determination of the maximal pressures is a specific method for estimating respiratory muscle strength[5,6].

Peak expiratory flow rate during cough was measured in litres per minute (lt / min) by vitalograph (Holland, lat no. 43000). It records peak expiratory flow values between 50 and 800 litres per minute and can read to an accuracy of approximately 10 litres per minute, cough peak expiratory flow rate was used to evaluate coughing and expiratory capabilities as it correlates well with peak expiratory flow rate, maximal breathing capacity test and with maximal rate of airflow of a recording pneumotachograph[7,8]. The testing procedure of rapid and deep expiration as did for cough peak expiratory flow rate gives a mirror view of expiratory efficacy as well as ventilatory capabilities. And the most important advantage of the peak flow rate is that it is a physiological measure and a convenient means of following cough response in patients with an ineffective cough due to neurological disorders.

Air life air incentive spirometer from Baxter (Lat No. 001900) was used for training of inspiratory group of muscles. It is attached with a calibrated dial , which can be rotated to increase or decrease the resistance of flow by increasing the minimal air flow allowances in ml/sec. The spirometer had setting range from 210 ml/sec to 1400 mL/sec.

These fifty patients were divided into two equal groups matching in age and sex. Control group was left alone without any intervention. Treatment group were assigned incentive spirometer exercises 15 minutes per day and seven days a week.

Initially cough peak expiratory flow rate was measured by forceful cough on "Vitalograph", whereas peak inspiratory mouth pressure and peak expiratory mouth pressure was measured by modified sphygmomanometer, in all patients who were on cervical traction with crutchfield tong in supine position. Cough peak expiratory flow rate was measured by forceful cough on "Vitalograph", whereas peak inspiratory mouth pressure and peak expiratory mouth pressure was measured by modified sphygmomanometer. Three repetitions were done after giving at lease ten seconds and up to one minutes of rest between the measurements depending on patient's ability and comfort for each measure and the mean was computed for each subject.

Peak inspiratory and expiratory mouth pressure and cough peak expiratory flow rate was measured before the beginning of protocol and at the conclusion of each week up to four weeks. Patients were then discharged with instructions to continue inspiratory muscle training protocol by incentive spirometer and were called for follow up, at three months and six months from the date of initial trauma.

Observation and Statistics

All cases ranged from 28 to 54 years were included in the study within seven days from the date of trauma.

Out of 25 patients in treatment group one was female (4%) and rest were male (96%). Two patients (8%) discontinued from the study as they did not come for follow up and 2 (8%) expired during study. So 21 patients (84%) were included for statistical analysis.

Out of 25 patients in control group one was female (4%) and rest (96%) was male. One patient (4%) expired during study, one (4%) had to be shifted to intensive care unit thus could not continue the protocol and one (4%) patient developed spasticity. So, 22 (88%) were included for statistical analysis.

The cough peak expiratory flow rate, peak inspiratory mouth pressure & peak expiratory mouth pressure showed improvement from the basal value, which was recorded at the time of admission.

On comparing the mean of peak inspiratory and expiratory mouth pressure at different points of time for all the patients in treatment and control group, improvement was seen in all the three measures but higher values were observed in treatment group. In peak inspiratory mouth pressure, improvement was found in both the groups but higher values were observed in treatment group (Table 1). The mean for change from basal value was calculated and test of statistical significance was applied significant to highly significant improvement of peak inspiratory mouth pressure was seen in treatment group (Table 2). In peak expiratory mouth pressure, higher values were observed in both the groups (Table 3) but on comparing the mean for change from basal value a statistically non-significant improvement was found (Table 4).

Similarly a improvement was seen in cough

Table 1 : Comparative values of mean standard deviation (SD) in peak inspiratory mouth pressure at different points of time in treatment and control group

	Mean ± SD (mm Hg)	
	Control	*Treatment*
Basal Value	9 ± 4.74	12.28 ± 5.93
After 1st week	9.54 ± 4.22	13.90 ± 4.60
After 2nd week	11.54 ± 2.00	15.62 ± 3.36
After 3rd week	14.36 ± 2.74	17.71 ± 3.28
After 4th week	15 ± 2.39	21.52 ± 2.46
After 3 months	19 ±2.15	29.80 ± 6.29
After 6 months	21.45 ± 2.64	32.38 ± 5.81

Table 2 : Comparative values of mean change standard deviation (SD) in peak inspiratory mouth pressure from basal value to measurements at different points of time in treatment and control group; & its significance.

	Mean change ± SD (mm Hg)		*P value*	*Significance*
	Control	*Treatment*		
After 1st week	0.54 ± 2.06	1.62 ± 2.42	> .05	Not Significant
After 2nd week	2.54 ± 3.76	3.34 ± 3.30	> .05	Not Significant
After 3rd week	5.36 ± 3.87	5.43 ± 3.75	> .05	Not Significant
After 4th week	6 ± 4.99	9.24 ± 5.81	< .05	Significant
After 3 months	10 ± 4.78	17.52 ± 9.16	< .01	Significant
After 6 months	12.45 ± 4.78	20.01 ± 8.35	< .001	Highly Significant

Table 3 : Comparative values of mean standard deviation (SD) in peak expiratory mouth pressure at different points of time in treatment and control group.

	Mean ± SD (mm Hg)	
	Control	*Treatment*
Basal Value	6.18 ± 4.30	7.52 ± 3.46
After 1st week	6.54 ± 4.14	8.19 ± 2.89
After 2nd week	9.73 ± 1.38	12.67 ±1.98
After 3rd week	11.91 ± 1.53	17.23 ± 2.65
After 4th week	16.36 ± 1.87	19.90 ± 3.46
After 3 months	19.45 ± 2.84	22.95 ± 2.59
After 6 months	21.54 ±2.76	24.09 ±2.64

Table 4 : Comparative values of mean change standard deviation (SD) in peak expiratory mouth pressure from basal value to measurements at different points of time in treatment and control group; & its significance

	Mean change ± SD (mm Hg)		*P value*	*Significance*
	Control	*Treatment*		
	Control	Treatment		
After 1st week	0.36 ± 2.10	0.67 ± 2.31	> .05	Not Significant
After 2nd week	3.73 ± 3.56	5.15 ± 2.49	> .05	Not Significant
After 3rd week	5.73 ± 3.40	9.71 ± 3.65	< .001	Significant
After 4th week	10.18 ± 3.76	12.38 ±5.04	> .05	Not Significant
After 3 months	13.27 ± 4.16	15.43 ± 3.85	> .05	Not Significant
After 6 months	15.36 ±4.38	16.57 ± 3.80	> .05	Not Significant

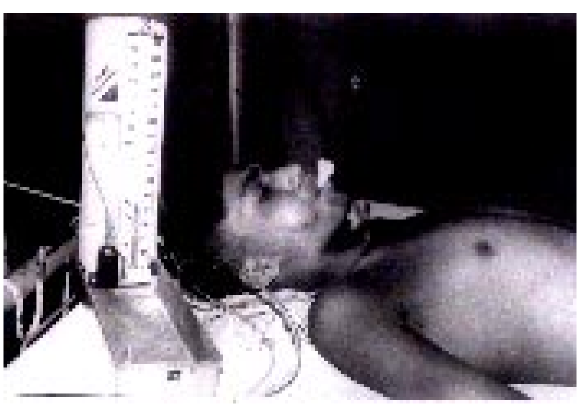
Table 5 : Comparative values of mean standard deviation (SD) in cough peak expiratory flow rate at different points of time in treatment and control group

	Mean ± SD (mm Hg)	
	Control	*Treatment*
Basal Value	42.27 ± 36.05	68.09 ± 41.36
After 1st week	45 ± 34.87	70.95 ± 42.30
After 2nd week	65.19 ± 17.50	92.38 ± 29.42
After 3rd week	75.45 ± 12.33	122.96 ± 16.66
After 4th week	93.18 ± 12.57	130.95 ± 14.44
After 3 months	108.18 ± 13.36	141.90 ± 15.00
After 6 months	125.45 ± 11.17	162.85 ± 23.33

Table 6 : Comparative values of mean change standard deviation (SD) in cough peak expiratory flow rate from basal value to measurements at different points of time in treatment and control group; & its significance.

	Mean change ± SD (mm Hg)		*P value*	*Significance*
	Control	*Treatment*		
After 1st week	2.73 ± 13.86	2.86 ± 6.44	>.05	Not Significant
After 2nd week	22.73 ± 26.56	24.29 ± 23.14	>.05	Not Significant
After 3rd week	33.18 ± 27.15	54.77 ± 38.16	<. 05	Significant
After 4th week	50.91 ± 30.69	62.86 ± 41.25	>.05	Not Significant
After 3 months	65.91 ± 32.75	73.81 ± 41.53	>.05	Not Significant
After 6 months	83.18 ± 33.45	94.76 ± 44.90	>.05	Not Significant

Fig.1 Measuring PEMP with modified sphygmomanometer.



peak expiratory flow rate in treatment and control group (Table 5), but on comparing mean change observed in cough peak expiratory flow rate from basal value a non-significant improvement was found (Table 6).

Discussion

The pulmonary functions of fifty tetraplegic subjects were evaluated by peak inspiratory mouthpressure, peak expiratory mouth pressure and cough peak expiratory flow rate with an aim to determine whether incentive spirometry can improve the respiratory capabilities & cough efficacy.

Incentive spirometry was used as a mode of training in patients with tetraplegia in treatment group and the device selected was such that it provided resistance to the airflow and patient could adjust their inspiratory pressure load or resistance by adjusting it's airflow allowance.

During initial acute & post acute period low columns of peak expiratory & inspiratory mouth pressure were observed because during this period respiratory muscles are paralyzed and there is instability of the chest wall along with rib cage abdominal paradox[9]. Expiratory muscle strength is decreased more severely than inspiratory strength and the expiratory muscle weakness causes a decrease in the effectiveness of cough as reflected by low cough peak expiratory flow rate.

Improvement was observed in all the three measures in comparison to basal value in both the group of patients but it was higher in those who were on incentive spirometry. The general improvement in both the groups can be considered related to, change from muscle flaccidity associated with the initial phase of spinal shock to trained accessory muscle status and slowly developing hypertonicity of the paralyzed intercostals and abdominal muscles[10].

On comparing the two groups, significant to highly significant improvement in peak inspiratory mouth pressure in tetraplegics was observed in those who were on incentive spirometry.

Tetraplegics are predisposed to chronic alveolar hypotension, which is due to increased work required to overcome the extra pulmonary resistances. Early fatigue in these patients leads to respiratory acidosis, which can be assessed by associated signs and symptoms[11]. Though inspiratory muscles are trained with each breath as it is a active process and slowly it improves but incentive spirometery trains the innervated respiratory muscles by providing strengthening of these muscles and thereby increase peak inspiratory mouth pressure which results in improved dyspnea, increase in both strength and endurance[12,13,] protection against fatigue and reduced metabolic cost of breathing[14].

Awareness of phlegm or wheeze, ineffective cough and resulting chronic retention of secretion are the root cause of various pulmonary complications in tetraplegics. The reasons are both loss of expiratory muscles strength as well as decreased vital capacity due to loss of inspiratory muscles and in spinal injured population expiratory muscle strength is often decreased more severely than inspiratory strength. Expiratory muscle weakness causes a decrease in the effectiveness of cough due to impairment in cough induced dynamic compression, leading to a reduction in the velocity of air flow as seen by the low values of cough peak expiratory flow rate. An improvement of peak expiratory mouth pressure and cough peak expiratory flow rate was observed in both the groups. The increase in expiratory flow rate is related to vital capacity and in a tetraplegic patient vital capacity increases with time from an approximate doubling of vital capacity three months after injury to 60% of predicted by fifth month 10. This improvement is due to change from muscle flaccidity of initial phase to increasing tone of paralyzed intercostals and abdominal muscles with time[15]. In treatment group still higher values can be attributed to increased inspiratory capacity and vital capacity due to incentive spirometry exercise, because to achieve an effective cough the patient must reach the largest lung volume possible prior to initiation of cough 16 but it was non significant because specific training of expiratory muscles was not undertaken and without expiratory muscles it is impossible to generate high intrathoracic pressure to accelarate air flow.

Incentive spirometry can thus be used in tetraplegics during acute and post acute period as a preventive measure to reduce pulmonary complications most of which are due to decreased inspiratory capacity and chronic retention of secretions due to decreased expiratory pressure and flow. It also improves neuromuscular coordination, so patients can consciously breathe deeper and slower. When exerting them it may also decrease the fear of dyspnea and can thus put them in a position to attempt a higher level of activity.

Acknowledgement : We are thankful to Dr. Virendra Singh, Consultant, Pulmonary Medicine, SMS Hospital, Jaipur for providing us Modified Sphygmomanometer.

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