Effect of Pulmonary Rehabilitation on Ventilatory Function after Posterior Surgical Correction of Idiopathic Adolescent Scoliosis

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ABSTRACT

Background: *Posterior surgical correction of idiopathic adolescent scoliosis results in a significant reduction of ventilatory functions which can be improved by organized pulmonary rehabilitation program.* ***Purpose of the study:*** *It was conducted to determine the effect of pulmonary rehabilitation program on ventilatory functions after posterior surgical correction of idiopathic adolescent scoliosis.* ***Methods:*** *Seventy patients underwent posterior spinal correction including both sexes with mean age 15±2 years, mean height 150±7 cm, and mean weight 60±5 kg. They presented with idiopathic scoliosis for 6-12 months with mean Cobb's angle 60±10 degrees. They were divided into two groups. Both groups received instructions for the right way of breathing, positioning, and proper activity of daily living after one week postoperatively, then the studied group received pulmonary rehabilitation program in a form of breathing exercise and incentive spirometer for one month followed by treadmill, cycle ergometer and abdominal weights till six months after operation.* ***Results:*** *showed significant improvement after pulmonary rehabilitation training program for three months and increase gradually till six months.* ***Conclusion:*** *Pulmonary rehabilitation program is effective in improving ventilatory function after posterior surgical correction of idiopathic adolescent scoliosis.*

INTRODUCTION

Scoliosis is defined as a complex three dimensional malalignment of the vertebral column in which there is lateral curvature of the spine in the coronal plane associated with flattening of the contour in the saggital plane and rotation of the vertebrae around their longitudinal axis[9].

The most common symptom of adolescent idiopathic scoliosis (AIS) is difficulty of breathing especially during effort. On the other hand, the common signs on physical examination include; trunk asymmetry, abnormal increase or decrease of lordosis or kyphosis, unequal shoulder heights, increased space between elbow and trunk due to trunk deviation, prominence of the hip, pelvis or breast and discrepancy of lower limbs length[4].

Posterior surgical spinal correction for idiopathic scoliosis is suggested when curve magnitude is 40º or more in either the previously untreated patient or in one who fails brace treatment. The goals of surgery were mentioned by Peer[8], as to prevent spinal deformity progression or correction of deformity.

In evaluation of ventilatory functions, such as FVC, FEV_1 and TLC after surgical arthrodesis of primary thoracic and double primary thoracic – lumber types. At three months post operatively, posterior spinal fusion showed significant improvement in ventilatory functions. At two years postoperatively, patients showed more improvement[10].

Jone et al.,[3] defined pulmonary rehabilitation as an art of medical practice. A multi-discrepancy program is formulated through accurate diagnosis, emotional support and education aiming to return the patient to the highest possible functional capacity allowed by his pulmonary handicap and overall life situation. The objectives of pulmonary rehabilitation are to control and alleviates as much as the symptoms and pathophysiological complications of respiratory impairment and to teach the patient how to achieve optimal capability for carrying out his or her activities of daily living.

The physiological and psychological outcomes of pulmonary rehabilitation program for patients of respiratory disorders including restrictive and obstructive pulmonary disease were gathered by Ong et al.,[7]. The maximal oxygen uptake and work rate improved significantly by 132 ml/kg/min. and 10.7 watt respectively. Six minute walking test improved by a mean 67.3 meter. The dyspnea scores decreased by 1.2%. From the psychological point of view, the total scores of the questionnaire increased by a mean of 21.7 points at the end of the program. The improvement still continued with 17 patients through six months after the program.

This study was conducted to determine the effect of pulmonary rehabilitation program on ventilatory functions after posterior surgical correction of idiopathic adolescent scoliosis.

SUBJECTS, MATERIAL AND METHODS

Subjects

Seventy patients underwent posterior spinal surgical correction including both sexes with mean age 15±2 years, mean height 150±7 cm, and mean weight 60±5 kg. They presented with idiopathic scoliosis for 6-12 months with mean Cobb's angle 60±10 degrees. Before participation, all were examined clinically to exclude any cardiopulmonary disorders which may affect ventilatory functions. All of them did not receive any physical therapy program prior to operation or participation in the study. All participants were randomly divided into two groups (35 patients) as a studied group and (35 patients) as a control group.

Materials

For evaluation

- Stress X- Ray (Dur 511): for measuring the degree of Cobb's angle and detection of the site of curvature.
- Spirometer (Medicor): to determine ventilatory capacity.
- Seca apparatus: for measuring anthropometric measures weight and height.

For treatment

- Incentive spirometer (Spiro ball):It is used for respiratory muscle training.
- Abdominal weights: used for diaphragmmatic resistive breathing exercise.
- Trademill (Tunturi J 880): used for lower limb exercise.
- Cycle ergometer: (Monark 881). It is used for upper limb exercise.

Procedure

All the students signed firstly the medical consent form and they then undertook the following evaluation including interview, questions about the past history like progression of the curve, onset of pain, any respiratory symptoms like dyspnea, special habits of the students as swimming or basketball, pattern of his breathing (shallow or rapid, abdominal or costal) then explanation about the program was demonstrated for each one. The degree of scoliosis has been measured by antero-posterior view of the

whole spine from standing using Cobb's method.

Both groups received instructions for the right way of breathing, positioning, and proper activity of daily living after one week postoperatively, then the studied group received pulmonary rehabilitation program in a form of breathing exercise and incentive spirometer for one month followed by treadmill, cycle ergometer and abdominal weights till six months after operation.

For evaluation

- Ventilatory function test: It was done by explaining for each patient the test procedure. Then ask the patient to take deep inspiration to fill their chest with air as much as they could. Then they were asked to exhale forcefully and rapidly as much as possible in the mouth piece of the apparatus and then the values printed on a tape. The patients were tested from sitting position. The data were obtained after three successive trials of the test. The student then asked to perform ten successive breathing for measuring MVV.
- Stress X-Ray: It was done from standing position by taking A-P and lateral views for whole spine to measure the degree of curvature through Cobb's angle. A perpendicular line was drawn from the upper margin of the vertebrae which inclines most toward the concavity while the other line is drawn from the inferior border of the lower vertebrae with greatest angulations towards the concavity. The angle between these transecting lines was measured and recorded. Patients with angle more than 40^{o}were included in this study.
- Measuring anthropometric measures (weight and height scale). Students stand on the apparatus in erect position, the height is recorded from vertical scale. Weight is recorded from horizontal scale.

For treatment

- Incentive spirometer (Spiro-ball): It consists of three plastic tubes with graduated scale which containing a marker moving on it (up and down). This scale expresses the amount of air inspired through the mouth piece connected with it.
- Abdominal weights: To increase the diaphragmatic strength by using sand bags connected with adhesive straps to be applied firmly; their weights were graduated from half to three kilograms according to the patient's ability.
- Treadmill (Tunturi J 880): It is a revolving plateform connected with two rectangular stainless arms for hand grip, in one of them; there is a monitor for measuring speed and time.
- Cycle ergometer (Monark 881): It is a metal device consisting of rounded stainless part connected with stainless arm for hand grip. The rounded part has a valve for increasing or decreasing the resistance according to the patient's ability.

The program was done three days per week till the end of six months after operation, ventilatory function test was repeated at the end of the training period.

Statistical Analysis

Descriptive statistical analysis (mean ±SD), t-test was done to compare between two means. The threshold of significance was $P<0.05$.

RESULTS

The results of this study showed the following data including vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), maximum voluntary ventilation (MVV) immediately post operative till six months post operative. The

postoperative values after one week before application of pulmonary rehabilitation program were: The mean value of vital capacity was 52.30 ±31.27 percentages; the mean value of FVC was 38.39±24.08 percentage, the mean value of FEV_1 percentage was 31.97±20.78, the mean value of MVV (L/min) was 46.42±26.81 percentage for both groups. After three months, the studied group showed VC (80±30.54) percentage, FVC (74.2±29.64) percentage, FEV_1 (62.4±27.24) percentage, and MVV (78.6±38.06) L/min. with P value < 0.0001. The mean value for the control group after three months include VC (59±31.69) percentage, FVC (52.3±26.65) percentage, FEV_1 (43.9±25.46) percentage, MVV (61.08±28.18) percentage L/min. The mean values of these parameters after six months of training in the study group were VC (100.4±22.97) percentage, FVC (95.5±25.02), FEV_1 (48.6±25.61), and MVV (95.2±30.06) L/min (P<0.0001) while in the control group were 78.6±32.93 percentage, 70.8±27.66 percentage, 56.9±23.45 percentage and 74.7±31.22 percentage respectively. The results showed significant improvement at six months of training P<0.0001. Table (1) and Figure (1-2).

Table (1): Mean values of VC, FVC, FEV_1 and MVV (%) one week post operative, three months post operative and six months post operative regarding studied and control groups.

Items	Postoperative one week	Three months		Six months	
		Study	Control	Study	Control
VC%	52.38±31.27	80±30.54	59.6±31.69	100.4±22.97	78.6±32.93
FVC%	38.39±24.08	74.2±29.64	52.3±26.65	95.5±25.02	70.8±27.66
FEV_1%	31.97±20.78	62.4±27.24	43.9±25.46	48.6±25.61	56.9±23.45
MVV%	46.42±26.81	78.6±38.06	61.08±28.18	95.2±30.06	74.7±31.22

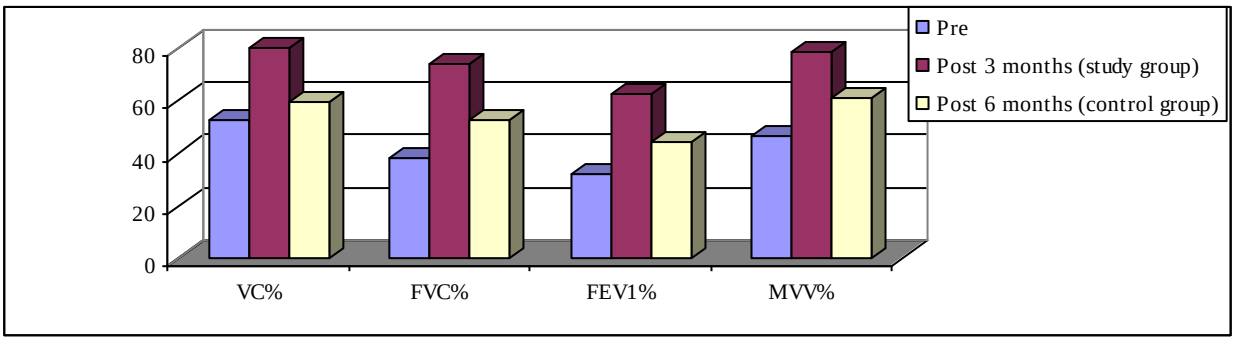

Fig. (1): Illustrates the mean values of VC, FVC, FEV_1 and MVV (%) pre treatment and three months post treatment for studied and control groups.

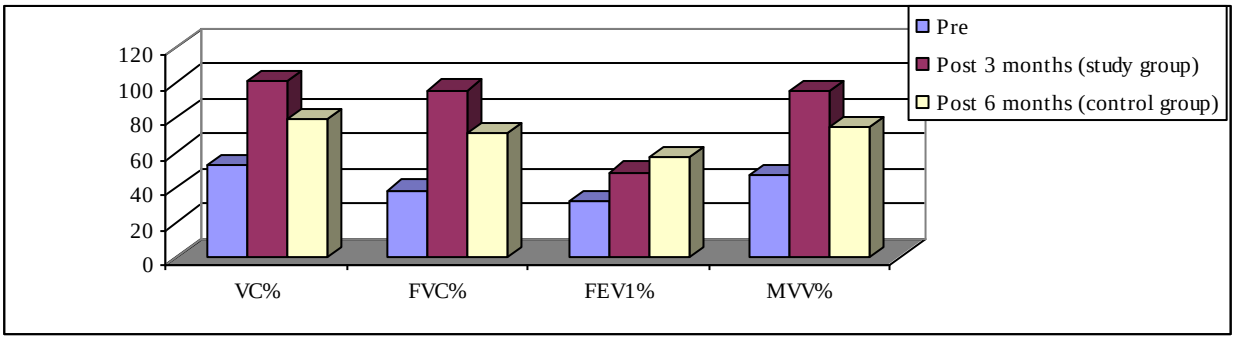

Fig. (2): Illustrates the mean values of VC, FVC, FEV_1 and MVV (%) pre treatment and six months post treatment for studied and control groups.

DISCUSSION

This study was conducted to investigate the changes of ventilatory functions after six months of pulmonary rehabilitation for patients had posterior surgical correction of adolescent idiopathic scoliosis.

The study was conducted in the physical therapy department of the students with idiopathic scoliosis (56 females and 14 males) selected randomly from the Spinal Clinic. All of them complained of idiopathic scoliosis from 6-12 months and their Cobb's angle mean was 60±5 degrees.

From the statistical study of the collected data of the present sample, it was found that girls were more liable to be affected by scoliosis than boys. The affected girls constitute 80% while the boys were about 20% of the total sample. This can be related to the nature of muscle weakness and reduced endurance in females as well as their specific posture, habits and activities. Also it may be related to hormonal changes which are documented previously by Michel et al.,[6] but without interpretation or clear explanation. On analyzing the statistical data of the studied and control groups showed many observations different explanations regarding all parameters.

On comparing the MVV for both the studied and control groups, results showed the maximum improvement after six months. This proved the importance of duration of the program to give a maximum response. A short duration program (4-8) weeks may not be sufficient to cause permanent effects on ventilatory functions. So, follow up and home program must be continued up to complete one year postoperative i.e. the longer the duration of the program, the more the response. This was proved by Inoue et al.,[2] through gaining 10% improvement in VC after six weeks of pulmonary rehabilitation program as regards to time of application. While, authors considered FEV_1 which is a time – volume relationship measured from total FVC is the most significant parameter showing improvement[11].

The high improvement of FEV_1 47.7% considered as the same results gained by Yues et al.,[12]. That FEV_1 showed improvement by 70% after comprehensive pulmonary rehabilitation program for two months in treatment of chronic respiratory diseased patients. The difference in training program time may be due to the difference in the nature of the patient's complaining between reduction in ventilatory function only without any surgical interference in Yues's[12] study and going through operation in this study with the expected ventilatory function postoperatively.

In the studied group, MVV showed gradual improvement throughout the total duration of the program. Attribution of the ventilatory function improvement after the rehabilitation program can be based on mechanical bases. As the improvement in VC was mainly due to increase in thoracic cage parameters, vertical, lateral and anteroposterior. While the improvement in FVC mainly indicated an increase in the respiratory muscle mechanical efficiency to generate power and to inspire more deeply, this is also noticed in the results of MVV and FEV_1. Another scientific explanation including the relation between VC, FVC and Cobb's angle is associated with an increase of vital capacity. This was proved by Hamed and Salem[1].

Maximum voluntary ventilation depends on the ability of respiratory muscles to contract and relax rapidly and deeply related to their strength and endurance. It was found to be decreased by 34% in the studied group. This reduction may be due to several factors as: weakness of respiratory muscles, the effect of incisions on intercostal muscles or the patient's fear with their inability to take deep and rapid breathing.

Keith and Ronald[5] mentioned that, there was an acute decrease of respiratory system compliance by about 20%-40%. This started in the operating room immediately after surgery. They found that FVC and total lung capacity remained 40%-60% less than the preoperative values up to several weeks postoperatively. Hence, patients with FVC less than 40% of predicted values should be referred to pulmonologist and anesthesiologist before surgery to avoid the permanent postoperative FVC reduction.

Conclusion

Surgical correction of idiopathic adolescent scoliosis reduces ventilatory function by approximately 50% immediately postoperatively, the function may be improved gradually but still below normal values. The close relationship between posture deformity, lung function, and surgical correction must be considered to avoid pulmonary complications. The changes of intercostal muscle function, fixation of the spine and alteration of breathing pattern all have a strong connection to pulmonary function. The pulmonary rehabilitation program should start as early as possible and lasts for long time at least one year. It should include preventive measures, followed by endurance program saving curative time and enhancing the patient to return as early as possible to be normal.

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الملخص العربي

تأثير برنامج التأهيل الرئوي على وظائف الرئة بعد عمليات إصلاح الانحناء الجانبي للعمود الفقري لدى المراهقين

أكد كثير من العلماء على التأثير السلبي المباشر للجراحة على وظائف التنفس والذ ي يسبب عادة انخفاض حاد ف ي وظائف التنفس يتبعه تحسن تدريجي في خلال سنة من الجراحة . أجريت هذه الدراسة على سبعين طالبا و طالبه تم اختيارهم عشوائيا من عياد ة العمود الفقري بمستشفى الطلبة للتامين الصحي بالقاهرة . تم عمل القياسات المطلوبة (الطول والوزن ، قياس نسبه الانحناء ، مقاييس مقننه لقياس وظائف التنفس قبل العمليات الجراحية وبعدها بأسبوع ثم بعد ثلاثة وستة اشهر) . تم عمل برنامج تأهيلي للجهاز الدوري والتنفسي مقنن بعد إجراء العمليات بأسبوع واستمر لمدة ستة اشهر . أوضحت النتائج وجود تحسن ذات دلاله إحصائية بعد ثلاثة اشهر من البرنامج ، ازداد هذا التحسن تدريجيا حتى ستة اشهر ولذلك أوصت الدراسة باستمرار البرنامج التأهيلي لمدة عام كامل .