Physiological Evidence for the Efficacy of Short Term Positive Expiratory Pressure Training in COPD Patients

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ABSTRACT

Background: *Patients with chronic obstructive pulmonary disease (COPD) have chronic airflow limitation leading to increase the resistance to airflow and gas trapping which results in ventilation/perfusion mismatch and hypoxemia.* ***Purpose of the Study:*** *To investigate the effect of short term positive expiratory pressure (PEP) breathing on arterial partial pressure of oxygen (P_aO_2) and arterial partial pressure of carbon dioxide (P_aCO_2) in patients with moderate COPD.* ***Subjects and Methods:*** *Forty patients with moderate COPD from both genders (30 males and 10 females) were recruited to participate in the study. They were divided into study and control groups each comprised 20 patients. The study group have received training with threshold PEP device twice daily for two weeks with 10-20 cmH_2O pressure and both groups continued their medications throughout the study period. Arterial P_aO_2 and P_aCO_2 were measured before beginning and after finishing the program in both groups.* ***Results:*** *Improvement of arterial P_aO_2 and P_aCO_2 were observed in the study group at the end of the study (P-value < 0.05) with no change in the control group (P-value > 0.05). On comparing the mean values of arterial P_aO_2 and P_aCO_2 between both groups a statistical significant difference was observed (P-value < 0.05) at the end of the study in favor of the study group with 8.05% and 0.36% increase in P_aO_2 and 6.65% and 0.35% decrease in P_aCO_2 in study and control group respectively.* ***Conclusion:*** *Short term PEP breathing training in patients with COPD improves the arterial P_aO_2 and P_aCO_2 and helps in controlling the hypoxemia.*
Key words: *Chronic obstructive pulmonary disease; Positive expiratory pressure; arterial blood gases.*

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a major and increasing global health problem and among the top-ten leading causes of mortality worldwide[2]. It has multiple components including pulmonary inflammation, airway remodeling and mucociliary dysfunction; which caused by mucus hyper secretion combined with decreased mucus transport[13]. Accumulation of secretions leads to airway inflammation predisposing to airway narrowing that increases the airflow resistance and gas trapping. This results in ventilation/perfusion mismatch[5], which is followed by development of hypoxemia[14].

In addition, patients with COPD usually have dynamic pulmonary hyperinflation due to expiratory airflow limitation, air trapping and auto positive end-expiratory pressure leading to increase of the total lung capacity and functional residual capacity above their normal levels[15]. With dynamic hyperinflation, the respiratory muscles are recruited to increase intra thoracic pressure in an effort to maintain comparable inspiratory and expiratory volumes leading to increased work of breathing and worsening of hypoxemia[3] leading to exercise intolerance, limited physical activity and poor quality of life[8].

A variety of interventions are used to enhance airway clearance with the goal of improving lung mechanics and gas exchange[7]. Positive expiratory pressure (PEP) therapy was developed in the 1970s and has been introduced as an alternative to conventional physiotherapy in an effort to provide effective secretion clearance[6]. PEP breathing can mobilize secretions, help in the management of post-operative atelectasis, and enhance the benefits of aerosol bronchodilator delivery[10].

The aim of this study was to investigate the effect of short term PEP breathing training on arterial blood gases (partial pressure of oxygen (P_aO_2) and partial pressure of carbon dioxide (P_aCO_2) in patients with moderate chronic obstructive pulmonary disease.

MATERIALS AND METHODS

Subjects

Forty COPD patients of both genders (30 males and 10 females) participated in the study who were diagnosed to have stable moderate COPD ($FEV_1/FVC< 70\%$ and $50\% \leq FEV_1 < 80\%$ predicted according to Global Initiative Obstructive Lung Disease (GOLD) guidelines[9]. Their ages ranged from 40-60 years. There were no statistical significance differences between the patients in both groups regarding the mean of age, weight and the height (P-value > 0.05) as shown in (Table 1).

Table (1): Demographic data of patients in both groups.

	Study Group	Control Group	t-value	P-value
	Mean ± SD	Mean ± SD		
M/F (number)	17/3	13/7		
Age (yrs)	52.52 ± 4.12	52.73 ± 3.49	0.16	0.86
Weight (Kg)	77.64 ± 7.58	76.4 ± 5.22	0.55	0.58
Height (cm)	165.44 ± 6.9	163.93 ± 7.08	0.66	0.51

SD: standard deviation, M: male, F: female, Yrs: years, Kg: kilogram, cm: centimeter

They were selected from the outpatient clinic of the Abasseya Chest Hospital. All patients were medically and clinically stable and had good mentality to follow the instructions while patient who was medically unstable or obese was excluded from the study. The purpose, nature and potential risks of the study were explained to all subjects and a written informed consent was assigned prior to participation. The patients were randomly assigned to two groups of equal number; the study and the control group (each 20 patients). All patients in both groups continued their medications throughout the study period while those only in the study group received training with the threshold positive expiratory pressure device twice daily, three times per week for two weeks.

Evaluation procedure

Assessment of lung function was performed for all patients participated in the study using electronic spirometer (VIASYS Healthcare micro, England) prior to starting the program to ensure that the selected patients were met the inclusion criteria. Evaluation of arterial blood gases (P_aO_2 and P_aCO_2) level through analysis of a blood sample taken from either the radial artery in the wrist or the brachial artery in the arm by acid-base analyzer (SIEMENS 284) was performed for all patients in both groups before beginning the study and after finishing the training program for the patients in the study group and for the patients in the control group another measure was done after two weeks.

Training by threshold positive expiratory pressure device for the study group

The patients in the study group received training by threshold positive expiratory pressure device. The device consists of a mouthpiece, a one-way valve, to which expiratory resistances is attached and a manometer between the valve and the resistance, to monitor the actual value of pressure. The training was performed while the patient in the upright sitting position while holding the mouthpiece tightly between the lips and wearing a nasal clip. The expiratory resistor was adjusted to 10-20 cm H_2O. Then the patient was asked to breathe in using the diaphragm to the vital capacity and to hold the breathe for 3 seconds and to gently exhale, maintaining a prescribed pressure of 10-20 cmH_2O trying to maintain the exhalation time approximately three times longer than inhalation. The patient performed eight to ten PEP breaths, and then they were encouraged to cough as much as necessary to clear secretions. These steps were repeated for twenty minutes twice daily, three times per week for two weeks[5,6].The practical part of this research has been done during the months of July and august 2012.

Statistical Analysis

Statistics were analyzed using SPSS software package. Results are shown as the mean ± SD. Both t-tests were used to assess significance of differences within each group and between the two groups. Significance was accepted as P-value ≤ 0.05.

RESULTS

Statistical analysis of the pre and post treatment measurements of P_aO_2 showed statistical significant difference in the study group with P-value < 0.05 and the percentage of improvement (increase) was 8.05%. On the other hand the P_aO_2 showed no statistical significant differences between pre and post treatment measurement in the control group (P-value > 0.05) as the percentage of improvement (increase) was 0.36% as shown in (Table 2) and (Figure 1).

Table (2): Comparison of PaO2 and PaCO2 between the study and the control group pre and post the treatment.

	P_aO_2		P_aCO_2	
	Mean ± SD		Mean ± SD	
	Pre	Post	Pre	Post
Study group	66.06 ± 1.93	71.38 ± 1.94	39.22 ± 1.31	36.61 ± 1.3
Control group	64.96 ± 2.35	65.21 ± 2.27	39.02 ± 1.51	38.88 ± 1.4
t- value	1.59	9.11	0.44	5.16
P-value	0.11	0.0001*	0.65	0.0001*

SD: standard deviation, pre: pretreatment, post: post treatment, * : significant

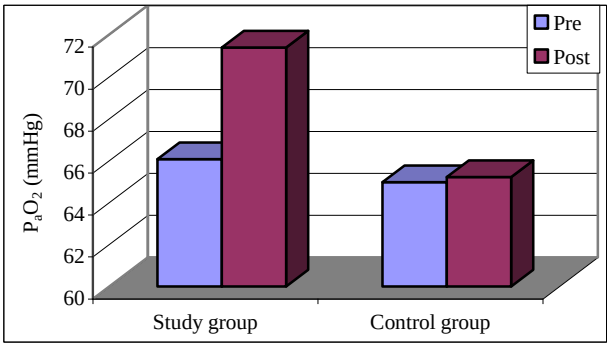

Fig. (1): The mean values of PaO2 in both groups before and after the program.

Regarding the P_aCO_2, there was a statistical significant difference between pre and post treatment measurements (P-value < 0.05) as the percentage of improvement (decrease) was 6.65% in the study group compared to 0.35% of improvement (decrease) within the control group (P-value > 0.05) as shown in (Table 2) and (Figure 2).

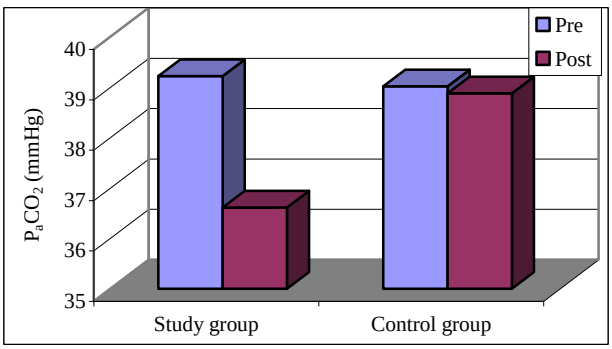

Fig. (2): Comparison between the mean values of PaCO2 in both groups before and after the program.

On comparing all measurements between both groups as shown in (Table II) there were no statistical significant differences between both groups before starting the treatment regarding the means of P_aO_2 and P_aCO_2 (P-value > 0.05) which changed into statistical significant differences (P-value < 0.05) at the end of the study in favor of the study group.

DISCUSSION

This study focuses on investigating the effects of short term PEP breathing training on P_aO_2 and P_aCO_2 in patients with COPD and the results indicated that this form of intervention resulted in improvement of the P_aO_2 and P_aCO_2 which suggests that PEP breathing can be used to control the hypoxemia and the hypercapnia associated with those patients.

In patients with COPD, airflow limitation, caused by obstruction of the airways, and emphysematous alveolar destruction leads to remodeling of the gas exchange zone with extensive loss of alveolar surface area and pulmonary capillaries that leads to ventilation/perfusion mismatch, which remains the most important cause of arterial hypoxemia with or without arterial hypercapnia[11], that worsens as the disease progresses[1].

Positive expiratory pressure (PEP) breathing is a form of chest physiotherapy in which the patient expires against a resistance. There are two different methods to apply PEP: threshold resistor devices and flow resistor devices. In flow resistor devices, the magnitude of the expiratory pressure is determined by the airflow and by the applied outflow resistor. While in pressure-threshold devices, the patient has to establish an airway pressure higher than the preset pressure before expiration occurs to open the valve and maintain a minimum pressure to keep the valve open through the entire exhalation[10,12].

In agreement with the results of the current study PEP breathing in patients with cystic fibrosis improved the process of ventilation distribution and gas exchange as during PEP breathing, the closed airways are opened, more residual volume was exhaled allowing a larger inspired volume of gas entered the lung which improve the gas exchange[4,5].

PEP breathing is somewhat similar to pursed-lips breathing in that a resistance to expiration is applied at the mouth during expiration which results in increased pressure at the mouth that is transmitted to the airways and acts to hold the airways open during expiration. The increased airway pressure during expiration is thought to prevent premature airway closure and thus reduce gas trapping in the lungs[5].

The purpose of PEP therapy is to increase the transpulmonary pressure gradient and improve pulmonary expansion, which consequently improves oxygenation[10]. PEP therapy allows increased amounts of air to enter through collateral channels, facilitating reinflation of collapsed alveoli[13] and preventing airway collapse during expiration[7]. It can also reduce the dynamic hyperinflation through prolonging the expiratory time and decreasing the respiratory rate thereby reducing airway closure[8]. PEP therapy is also beneficial in reducing the respiratory work as it is associated with increase in lung volume and removal of pulmonary secretions due to the improvement of lung collateral ventilation and a reduction in air trapping[10].

Most previous studies investigated the effects of PEP therapy on mucus clearance and found that the administration of PEP can improve mucus clearance by either increasing gas pressure behind secretions through collateral ventilation or by preventing airway collapse during expiration[7], and a recommendation was made by adding the PEP device to the routine care of the patients with chronic respiratory diseases as PEP device may give independence to patients, as it can be carried out without an assistant and is easy and convenient in use[6].

Conclusion and Recommendation

Short term PEP therapy in patients with moderate COPD have a favorable effects on P_aO_2 and P_aCO_2 which could be attributed to opening of the closed airway allowing the trapped air to be exhaled during the longer time of expiration which leads to inspiration of larger volume of gas into the lung and consequently improved the process of gas exchange. Therefore, it is recommended for COPD patients to use PEP device to control their hypoxemia.

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الملخص العربي

الدليل الفسيولوجي على فعالية التدريب قصير المدى باستخدام الضغط الزفيري الإيجابي في مرضى السدة الرئوية المزمنة

خلفية : يعانى مرضى السدة الرئوية المزمنة من صعوبة مزمنة في تدفق الهواء مما يؤدي إلى زيادة المقاومة لتدفق الهواء واحتباسه والذي ينتج عنه عدم توافق في نسبة التهوية والتروية ونقص الأكسجين ف ي الدم . **الهدف من البحث :** هو دراسة تأثير التدريب قصير المدى باستخدام جهاز الضغط الزفيري الإيجابي على الضغط الجزيئي الشرياني للأكسجين وثاني أكسيد الكربون في المرضى الذين يعانون من مرض السدة الرئوية المزمنة المتوسط الشدة . **خطوات البحث :** تم اختيار أربعين مريضا بالسدة الرئوية المزمنة متوسطة الشدة من الجنسين (30 من الذكور و 10 من الإناث) للمشاركة في الدراسة والذين تم تقسيمهم إلى مجموعتين متساويتين في العدد : المجموعة التجريبية والتي تلقت التدريب باستخدام جهاز الضغط الزفيري الإيجابي مرتين يوميا لمدة أسبوعين بضغط يتراوح من 10-20 سنتيمتر ضغط ماء بينما استمرت المجموعة التجريبية والضابطة في تناول العلاج الدوائي طوال فترة الدراسة . تم قياس الضغط الجزيئي الشرياني للأكسجين وثاني أكسيد الكربون قبل بداية وبعد الانتهاء من البرنامج في كلا المجموعتين . **النتائج :** أظهرت النتائج حدوث تحسن ملحوظ في قياسات الضغط الجزيئي الشرياني للأكسجين وثاني أكسيد الكربون في المجموعة التجريبية مع عدم حدوث تغيير في هذه القياسات في المجموعة الضابطة عند نهاية الدراسة . وعند مقارنة قياسات الضغط الجزيئي الشرياني للأكسجين وثاني أكسيد الكربون بين المجموعتين لوحظ وجود فروقات ذات دلالة إحصائية في نهاية الدراسة لصالح المجموعة التجريبية . **الاستنتاج :** التدريب قصير المدى باستخدام جهاز الضغط الزفير ي الإيجابي يحسن من قياسات الضغط الجزيئي الشرياني للأكسجين وثاني أكسيد الكربون ويساعد في السيطرة على نقص الأكسجين في الدم .
الكلمات الدالة : مرض السدة الرئوية المزمنة، الضغط الزفيري الإيجابي، غازات الدم .