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Benefit of Selective Inspiratory Muscles Training on Respiratory Failure Patients

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ABSTRACT

The purpose of this research was to detect the effect of training of inspiratory muscle on respiratory failure patients. ***Method:*** *Thirty patients with respiratory failure were selected from Cairo university hospital (critical care department). These patients were divided equally into two groups, study Group A and control Group B. Each patient of Group A received inspiratory muscles training using threshold inspiratory muscle trainer (IMT), while patients of Group B received only chest physiotherapy. Oxygen level and respiratory muscles strength for each group were measured. Result revealed significant improvement in both groups, improvement was higher in Group A more than Group B regarding oxygen level and respiratory muscles strength.* ***Conclusion:*** *Training of respiratory muscles using threshold inspiratory muscle trainer could be a useful in improving oxygen level and respiratory muscles power in patients with respiratory failure, this study revealed that, respiratory muscles training could be a helpful tool to improve oxygen level and inspiratory muscle strength for respiratory failure patients.*

Keywords: Respiratory failure, Respiratory muscles training, Traditional chest physiotherapy

INTRODUCTION

Inspiratory muscles training on respiratory failure has received much attention in recent years due to its imbalance between the respiratory muscles endurance and the overload on them is an important reason of failure of weaning from mechanical ventilation (MV) [1,2]. The rate of failure after a spontaneous breathing trial (SBT) is recorded in the literature ranged from 20% to 43%, the results depend on the studied population and the criteria used to identify failure in weaning from (MV) [3-5]. Meanwhile, weaning failure from mechanical ventilation leading to increase the morbidity and mortality, and the stay period in the intensive care unit (ICU) [6-10].

The study conducted on 126 patients under Mechanical ventilation was found that, only 9% of discharge (N=70) were able to independently perform ADL, while 65% were completely dependent on others [10]. Despite that, inspiratory muscle training (IMT), aims to increase the strength of the inspiratory muscles, for patients with history of weaning failure [8,11].

Also, there were two devices for inspiratory muscles trainer IMT, namely: pressure (dividing line/point where something begins or changes) devices and (not going in a straight line) resistors. So, pressure (dividing line/point where something begins or changes) devices differ from (not going in a straight line) resistors because the load (forced (on people)/caused an inconvenient situation) on the breathing and lung related system is independent from the inspiratory flow created by the patient. The (not going in a straight line) resistors are devices that have smaller holes through which the patient breathes [12,13]. Consequently, the inspiratory load (forced (on people)/caused an inconvenient situation) on the patient's breathing and lung related system during IMT with (not going in a straight line) resistors depends on the inspiratory flow created by the patient. So, it differs/changes according to the breathing pattern adopted by the patient. This makes (not going in a straight line) resistors a less advantage-giving option for IMT [14,15]. In this study pressure (dividing line/point where something begins or changes) devices was used.

MATERIALS AND METHODS

The current research involved a randomized study that was possibly (in the future) managed and did/done on 30 mechanically ventilated patients admitted to the critical care department of Cairo university hospital. Thirty Patients were divided into two groups: A and B, 15 patients for each group. Group A received chest physiotherapy, Group B received inspiratory muscle training. Also, only patients included in this study were told they had a disease named breathing and lung related failure and because of this mechanically ventilated for at least 7 days, and should be extremely stable during the study period, conscious and respond to verbal command. Therefore, the patients should be accepting, stable and can tolerate unplanned (and sudden) breathing trial, with this setting FiO_2 0.4 or less, PEEP less than 5 Cm H_2O, SpO_2 more than 90%. The study leaves out/keeps outpatients with unstable hemodynamics, unstable nerve-based problems, lack of attention and cooperation, flail chest and skipping of any sessions for any cause.

Procedures

For each subjects the following measures were recorded before and after treatment, blood gases (O_2%, PaO_2, and calculating PaO_2/FiO_2), muscle power (NIP) negative inspiratory pressure were recorder through ventilator reading and sputum amount.

Chest physiotherapy

Traditional chest physiotherapy in the form of percussion, vibrations, suction and breathing exercises and general exercises for upper and lower limb were applied three times per day for all patients for one week.

Procedure for inspiratory muscles training

A threshold device was used because it provides resistance to inspiration using a flow-independent one-way valve, generating a linear pressure load. During expiration, there is no resistance because the one direction valve opens, while during inspiration the valve closes, providing resistance to inspiration. Thus, the amount of resistance can be changed by increasing the compression on a spring mechanism in the device [16].

Procedure for inspiratory muscle training

Starting intensity was 30% of NIP of each patient recorded by ventilator reading then raise the load on IMT trainer by 1-2 Cm H_2O every time. Whereas, training consists of 5 to 6 sets of repetitions through the trainer. This training was repeated 6 times in each set, training was completed for a total of 18 to 30 times per session for about 10 minutes. IMT sets were conducted 2 times per day for about one week for each subject.

Assessment of the results

Assessment of variables was done before and after sets for both groups, the variables were: oxygenation (O_2 %, PaO_2, and calculating PaO_2/FiO_2) inspiratory muscle power (negative inspiratory pressure) (NIP) and sputum amount after suction in ml. All analysis was performed by using SPSS for Windows 16.0; paired t-test was carried out to detect the significance of the measurements pre- and post-study in both groups, with p-value of less than 0.05.

RESULTS

Date obtained in previous studies using study groups A and B; composed of 30 patients,15 patients for each group, their ages from 50 to 60 years its mean of 49.67 ± 4.28 years for Group A, a mean of 45.80 ± 5.62 years for Group B. There is no significant difference between both groups regarding to age with p=0.097.

Pre- and post-O_2% between groups A and B

The outcome of this study revealed no significant difference when comparing the pre-treatment mean values of the study groups in O_2% (p=0.217), but post treatment was greatly improved in the values of O_2% in both study groups (p=0.0001), improvement percent was 0.93% for Group A, and increased to 2.05% for Group B due to using respiratory muscles training to traditional chest physiotherapy see (Table 1).

Table 1 Mean pre- and post-O_2 percentage between groups A and B

Variables	O_2%			
	Pre-treatment	**Post-treatment**	**(p-value) Within groups**	**(%) of improvement**
Group A	95.70 ± 0.67	96.59 ± 0.70	0.0001	0.93%
Group B	96.03 ± 0.76	98.00 ± 0.75	0.0001	2.05%
F-value	1.28	1.15	-	-
(p-value) among groups	0.217	0.0001	-	-
Significance (p<0.05)	NS	S	-	-

Pre- and Post-PaO2 value between groups A and B

The outcome of this study revealed no significant difference when comparing the pre-treatment mean values of the study groups regarding to PO_2 (p=0.99), but post treatment there was big improvement in the values of PO_2 in both study groups A and B (p=0.0001), improvement percent was 4.11% for Group A, and increased to 22.91% for Group B due to using respiratory muscles training, as shown in Table 2.

Table 2 Mean pre- and post-PO_2 between groups A and B

Variables	PO_2			
	Pre-treatment	**Post-treatment**	**(p-value) Within groups**	**(%) of improvement**
Group A	136.20 ± 10.39	141.80 ± 10.10	0.0001	4.11%
Group B	136.20 ± 12.26	167.40 ± 6.34	0.0001	22.91%
F-value	1.39	2.53	-	-
(P-value) between groups	0.99	0.0001	-	-
Significance (P<0.05)	NS	S	-	-

Pre- and Post-PaO_2/FiO_2 ratio between groups A and B

The findings of this research showed no difference when comparing the pre-treatment values of both groups regarding to PaO_2/FiO_2 (p=0.948), but post treatment there was high improvement in the mean values of PaO_2/FiO_2 in both groups A and B (p=0.0001), improvement percent was 4.1% for Group A, then increased to 22.67% for Group B due to using respiratory muscles training, as shown in Table 3.

Table 3 Mean pre- and post- PaO_2/FiO_2 within and among groups A and B

Variables	PaO_2/FiO_2			
	Pre-treatment	**Post-treatment**	**(p-value) Within groups**	**(%) of improvement**
Group A	340.50 ± 25.98	354.50 ± 25.25	0.0001	4.11%
Group B	341.17 ± 29.74	418.50 ± 15.86	0.0001	22.67%
F-value	1.31	2.5	-	-
(p-value) between groups	0.948	0.0001	-	-
Significance (P<0.05)	NS	S	-	-

Pre- and Post-NIP value between groups A and B

The results of this study showed no difference when comparing the pre-treatment values of the study groups regarding to NIP (p=0.44), but post treatment there was significant improvement in the mean values of NIP in both groups A and B (p=0.0001), improvement percent was 6.44% for Group A, and increased to 33.86% for Group C due to using respiratory muscles training as shown in Table 4.

Table 4 Mean pre- and post- NIP between groups A and B

Variables	NIP			
	Pre-treatment	**Post-treatment**	**(p-value) Within groups**	**(%) of improvement**
Group A	15.53 ± 3.33	16.53 ± 2.97	0.0001	6.44%
Group B	16.33 ± 2.19	21.87 ± 3.11	0.0001	33.86%
F-value	2.313	1.097	-	-
(p-value) between groups	0.444	0.0001	-	-
Significance (p<0.05)	NS	S	-	-

Pre- and post-sputum amount between groups A and B

The outcome of this study revealed that there was significant increase in the mean values of Sputum clearance amount in both groups A and B (p=0.0001), this improvement was higher in Group B more than A, as shown in Table 5.

Table 5 Mean sputum amount value among groups A and B

Variables	Sputum amount
Group A	13.27 ± 3.19
Group B	27.33 ± 6.55
F-value	14.06
Level of significance (p-value)	0.0001
Significance (p<0.05)	S

DISCUSSION

Last work has documented the effectiveness of patients who undergo long time of ventilation showed a decrease the power of respiratory muscle and increase the risk of respiratory muscle fatigue. inspiratory muscle training (IMT) is a technique that targets the respiratory muscles (diaphragm and accessory inspiratory muscles) with the aim to increase inspiratory muscle strength [17].

IMT can be done in several ways:

1. Isocapnic/normocapnic hyperpnoea training
2. Resistive flow training
3. Threshold pressure training
4. Alternatively, adjustment of the ventilator to provide a training load for the inspiratory muscles [18].

Improving the strength and endurance of the inspiratory muscles may therefore decrease ventilator dependence over time and enhance the spontaneous breathing. Reducing ventilation time may help to decrease the incidence of ventilator-associated complications and may reduce ICU and hospital length of stay [19].

Inspiratory muscle strength training (IMT) can be done with resistance or pressure threshold devices. The resistance-training devices typically consist of breathing through a series of adjustable orifices providing flow-dependent resistances that decrease as airflow decreases. Moreover, pressure threshold devices provide a sustained pressure challenge throughout the entire inspiration that is independent of airflow. Therefore, when inspiring through a pressure-threshold device the individual must generate a minimum inspiratory muscle force to overcome a threshold load by generating an inspiratory pressure sufficient to open the spring-loaded valve and must sustain that pressure level throughout the inspiration. Thus, the inspiratory pressure load provided by a pressure-threshold device does not modify airflow mechanics. Therefore, pressure-threshold training provides a quantified pressure challenge to the inspiratory muscles that is independent of airflow [20].

The present investigation was designed to study the benefit of selective inspiratory muscles training on respiratory failure patients with the hypothesis that may be no effect of physiotherapy modalities on oxygenation, respiratory muscle strength and sputum clearance amount for respiratory failure patients. The results in the present investigation revealed statistically significant improvement in both study groups in oxygenation parameters (O_2%, PaO_2, and PaO_2/FiO_2), respiratory muscles strength parameters (NIP) and sputum clearance amount, this improvement significantly increased when we added inspiratory muscles training to traditional chest physiotherapy.

Regarding to the effect of traditional chest physiotherapy

Few studies have reported the effects of physiotherapeutic modalities for mechanical ventilation patients, Hodgson, et al. [21]. stated that when they used chest physiotherapy on 18 mechanically ventilated patients, the results showed a high improvement O_2 saturation in 90% of these patients, the same of our study revealed that physiotherapy interventions improved oxygen saturation of both study groups, improvement is more in Group B more than Group A because of adding more modalities in Group B (inspiratory muscles training in addition to traditional chest physiotherapy).

The study done by Maa, et al. [22] revealed that the potential benefits of physiotherapy in a group of intubated patients, had statistically significant improvement in respiratory system capacity and improvement of PaO_2/FiO_2 compared to the control groups. These results emphasized our result that showed the improvement in PaO_2/FiO_2 of both groups, in contrast to the above mentioned positive findings, the study done by Paratz [23], established that when chest physiotherapy was performed to seven ventilated patients with septic and cardiogenic shock, oxygenation was recorded, the results showed were no significant changes in oxygenation parameters. This may be due to the hemodynamic instability of these cases. In our study the careful selection of patients and exclusion of unstable one excluded such effects on oxygenation parameters.

Regarding to the effect of inspiratory muscle strength (IMT)

In our study, there was significant improvement in the mean values of inspiratory muscle strength (NIP) in study Group B more than A (p=0.0001), the percent improvement was 6.44% for Group A, then increased to 33.86.11% for group B due to adding inspiratory muscles training, these results go in hand with the study done by Martin, et al. [24], they test whether inspiratory muscle strength training (IMT) would improve weaning outcome in failure to wean (FTW) patients. IMT was performed with a threshold inspiratory device, the results showed a higher percent of improvement of respiratory muscles strength and weaning time in IMT patients than of control group.

In another study, Bassett, et al. [25] described the use of specific inspiratory muscle training to improve weaning from mechanical ventilation in patients who had failed conventional weaning. Therefore, a program of daily inspiratory muscle training was initiated. The mean training threshold increased and the periods of unassisted breathing achieved increased. Also, the mechanical ventilation was no longer required.

On the other hand, Ntoumenopoulos, et al. [26] the study was done on mechanical ventilation patients that received standard nursing care and chest physiotherapy, or standard nursing care alone. The outcome measurements included blood gas analysis, the incidence of nosocomial pneumonia, the number of days when ventilation was provided and the length of stay in the ICU. No statistical differences were found between the groups in the length of time when mechanical ventilation was provided, the length of stay in the ICU (mean 7.4-day physiotherapy group, 6.8-day control group) or the mortality rate in the ICU (for both groups). This differs from this study findings mostly due to that the patients of these studies were subjected to traditional chest physiotherapy treatment, so improvement done to both groups but higher and significant in the study group.

CONCLUSION

IMT, especially when performed using pressure threshold devices, the results in increased inspiratory muscle strength (NIP) and improve oxygenation (O_2%, PaO_2, and PaO_2/FiO_2) and is, therefore, a treatment option with the potential to reduce ventilator weaning time and increase the success rate of mechanical ventilation withdrawal.

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