Effect of respiratory muscles training in weaning of mechanically ventilated COPD patients

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Abstract Background: Inspiratory muscle weakness is common in patients receiving mechanical ventilation, especially COPD patients with prolonged duration of mechanical ventilation. Inspiratory muscle training could limit or reverse these unhelpful sequelae and facilitate more rapid and successful weaning.

Objective: Assessment of the effect of respiratory muscle training in weaning of mechanically ventilated COPD patients admitted in respiratory ICU in the Abbassia chest hospital.

Patients and methods: The study was conducted on 40 COPD patients admitted to the respiratory intensive care unit in the Abbassia chest hospital in the period between October-2011 and March-2013. All patients were diagnosed as having acute exacerbation of COPD with acute respiratory failure necessitating mechanical ventilatory support and difficult weaning; patients were subdivided into 2 groups: GROUP (A): (20 patients) include patients who received respiratory muscle training and GROUP (B): (20 patients) include patients who did not receive inspiratory muscle training.

Results: There was a significant difference between the 2 groups as regards the primary outcomes including weaning success rate, duration of mechanical ventilation, length of stay in ICU, length of stay in hospital. Also there was a significant improvement of secondary outcomes in group (A) including PO2, O2 saturation, TV, RR, MIP over the 5 days of IMT; while there was a significant difference between the 2 groups regarding the above secondary outcomes in favor to group (A).

Conclusion: Inspiratory muscle training increases muscle strength and endurance as well as it assists in weaning from mechanical ventilation in COPD patients with difficult weaning.

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Introduction

In intensive care, weaning is the term used for the process of withdrawal of mechanical ventilation to enable spontaneous breathing to be re-established. Inspiratory muscle weakness and reconditioning are common in patients receiving...
mechanical ventilation, especially that of prolonged duration and chronic obstructive pulmonary disease (COPD) patients. Inspiratory muscle training could limit or reverse these unhelpful sequelae and facilitate more rapid and successful weaning [1].

Failure to wean from mechanical ventilation is a significant clinical and economic problem; weaning failure resulting in prolonged ventilation is detrimental to the individual as it is associated with increased risk of respiratory muscle weakness, critical illness myopathy, nosocomial infection and airway trauma. Prolonged mechanical ventilation is also associated with an increase in mortality, morbidity and intensive care unit (ICU) length of stay, as well as reduced functional status and quality of life. In addition prolonged mechanical ventilation is expensive, consuming a large fraction of hospital resources, with a healthcare burden that may continue after hospital discharge [2]. Weakness or fatigue of the diaphragm and accessory muscles of inspiration is widely recognized as a cause of failure to wean from mechanical ventilation. Fatigue may be due to excessive load on the inspiratory muscles, which may result from increased airway resistance and/or reduced lung compliance. A reduction in the capacity of the respiratory muscle pump may also occur due to phrenic nerve injury, corticosteroids, endocrine or nutritional factors. There is increasing evidence to show mechanical ventilation itself may adversely affect the diaphragm’s structure and function, which has been termed ventilator-induced diaphragmatic dysfunction. The combination of positive pressure ventilation and positive end-expiratory pressure may unload the diaphragm therefore subjecting it to changes in myofibril length, which may account for its rapid atrophy. In addition, patients who undergo prolonged periods of ventilation demonstrate a decrease in respiratory muscle endurance and are at risk of respiratory muscle fatigue [3].

Patient and methods

This study was conducted on 40 COPD patients admitted to the respiratory intensive care unit in the Abbassia chest hospital in the period between October-2011 and March-2013. All patients were diagnosed (by clinical and arterial blood gas findings) as having acute exacerbation of COPD with acute respiratory failure (ARF) necessitating mechanical ventilatory support and difficult weaning.

Difficult weaning is defined as: The need for more than three spontaneous breathing trials or more than one week to achieve successful weaning [2].

The patients were subdivided into 2 groups:

Group (A): (20 patients) Include patients who received inspiratory muscle training.

Group (B): (20 patients) Include patients who did not receive inspiratory muscle training.

The patients were connected to a mechanical ventilator.

Two types of ventilators will be used:

1- Servo 1 maquet model no 6449701 Sweden used in the Abbassia chest hospital respiratory ICU.
2- Servo 300 model no 30207 Sweden used in the Abbassia chest hospital respiratory ICU with all varieties of modalities and data auto-analysis.

Study design

Patients were subjected to the following: full history taking from the patient or his relatives, general and local chest examination, laboratory investigations in the form of: arterial blood gases (using BAYER RAPIDLAB 248 blood gas analyzer), serum electrolytes, liver and kidney functions, blood glucose, complete blood picture, ECG, chest radiography (Anteroposterior view).

All patients enrolled in the study received standard medical treatment in the form of: antibiotics: parenteral, broad-spectrum, empirical then guided by sputum culture and sensitivity, bronchodilators in the form of intravenous theophylline infusion, inhaled b2-agonists, inhaled ipratropium bromide (dosage of them titrated according to body weight), corticosteroids (intravenous then shifted to oral), expectorants, propylactic anticoagulant, oral sulfadiazine, physiotherapy (chest percussion). All patients underwent continuous cardiac and arterial oxygen saturation monitoring.

Ventilator setup

Both groups were trained and weaned on pressure support mode, with FiO2 0.4 and positive end expiratory pressure (PEEP) was titrated to 5 cm H2O [4].

Inclusion criteria

Criteria of a weanable patient: (1) Criteria of weaning from mechanical ventilation: Respiratory rate less than 38 breaths/min., tidal volume 4-6 ml/kg., minute ventilation 10–15 L/min., maximal inspiratory pressure –15 to –30 cm H2O, rapid shallow breathing index (RSBI) 60–105, PaO2/FiO2 ratio > 150–200, improving or normal appearing chest radiogram, hemodynamic stability without need for vasoactive drugs, consciousness and normal orientation (Glasgow coma score > 11), ability to initiate spontaneous breaths, PH > 7.25, arterial oxygen saturation > 90% [5]; (2) patient is afebrile; (3) minimal secretions; (4) within normal lab investigations [6].

Patients were subdivided into 2 groups:

Group (A): (20 patients) Include patients who were received respiratory muscle training.

1. Pressure support ventilation was titrated at a level sufficient to achieve a respiratory rate of 20–30 breath/min and tidal volume 4–6 ml/kg.
2. Pressure support was reduced by 2 cm H2O every hour to reach pressure support 8 cm H2O.
3. Two exercise sessions were performed, at 9 AM and 5 PM.
4. Training will be based on decreasing the trigger sensitivity gradually in order to increase muscle endurance.
5. The trigger sensitivity was adjusted to 20% of the first recorded MIP at the start of training (In the first session), inspiratory muscle training (IMT) was limited to 5 min; afterwards the duration was increased by 5 min at every session until it reached 30 min. If a patient tolerated 30 min of IMT, The next session would be performed with increasing trigger sensitivity by 10% of the initial MIP.
Weaning of mechanically ventilated COPD patients

Patients who could not tolerate IMT with 20% of MIP for 5 min were trained with 10% of MIP [7].

IMT sessions stopped after 5 days and trial of weaning was done.

The inspiratory muscle training session was stopped if the patient had any of the following signs: Respiratory frequency of more than 38 breaths per minute, Arterial oxygen saturation below 90%, Tidal volume less than 4–6 ml/kg. Systolic blood pressure above 180 mm Hg or below 90 mm Hg. Paradoxical breathing. Heart rate more than 120/min [8].

**Group (B):** (20 patients) include patients who did not receive inspiratory muscle training.

1. Patients were weaned in pressure support mode.
2. Pressure support ventilation was titrated at a level sufficient to achieve a respiratory rate of 20–30 breath/min and tidal volume 4–6 ml/kg.
3. Pressure support was reduced by 2 cm H2O every hour to reach pressure support 8 cm H2O.
4. When the patients tolerated pressure support 8 cm H2O for 1 h the patient was extubated.

ABG assessments were done to detect early signs of weaning failure. Pressure support ventilation is terminated if the patient successfully tolerates at the end of weaning or starts showing signs and symptoms of failing (respiratory rate > 35 for > 5 min, SaO2 < 90% for > 30 s, 20% increase or decrease in heart rate for > 5 min, Systolic blood pressure SBP > 180 or SBP < 90 for 1 min with repeated measurements, Agitation, Anxiety, Or diaphoresis as a change from the baseline) [8].

When extubation was carried out, the trial of weaning was considered successful after 48 h.

When decompensation of ABGs occurred as well as appearance of signs of respiratory muscle fatigue within 48 h, the weaning trial was considered as a failed trial and the patient was returned to controlled ventilation.

**Definitions of weaning success and failure**

Several studies define weaning success as the ability of a patient to sustain spontaneous ventilation without the need of intubation for at least 48 h [9].

In most studies, weaning failure is defined as either the failure of SBT or the need for re-intubation within 48 h following extubation [10].

**Data analysis**

Data were statistically analyzed using Statistical package for Social Science (SPSS version 15.0.1). Parametric data were expressed as range, mean and standard deviation (±SD). Non-parametric data were expressed as frequency and percentage. Paired t-test was used to assess the statistical significance of the difference between two means of one quantitative variable measured twice for the same study group. Independent sample t-test was used to assess the statistical significance of the difference between two means of one quantitative variable of two groups. ANOVA test was used to assess the statistical significance of the difference between more than two study group means and Post Hoc test along with Tukey’s method was used for comparisons of all possible pairs of group means.

**Results**

This study was conducted on 40 COPD patients presented with ARF necessitating mechanical ventilation. Patients were classified into 2 equal groups; group (A) included 20 patients (16 males and 4 females) whose mean age was 61.07 ± 12.40 and they were trained by increasing trigger sensitivity method, and group (B) included 20 patients (17 males and 3 females) and their mean age was 64.33 ± 8.29 for whom weaning process was carried out by the PSV method. Comparison between the 2 groups regarding age and sex showed insignificant results (p > 0.05).

**Primary outcome measures**

Comparisons were done between both groups using independent sample t-test regarding primary outcome measures including: weaning outcome, duration of mechanical ventilation, duration of hospital stay and duration of stay in ICU. All comparisons revealed significant differences between the 2 groups. These are summarized in Figs. 1–4.

**Secondary outcome measures**

Comparisons between both groups regarding the secondary outcome measures including: arterial blood gas parameters, lung mechanics parameters were done using independent sample t-test and revealed non-significant differences. These comparisons are illustrated in Tables 1 and 2.

**Group (A):** The mean change of arterial blood gas parameters (PH, PO2, oxygen saturation) and lung mechanic data values (respiratory rate, tidal volume, maximum inspiratory pressure) were studied in group (A), using ANOVA test followed by Post Hoc test with Tukey’s method, over the time of the training sessions. The study showed a significant improvement of the above parameters over the training session period. These are presented in Figs. 5–9.

**Group (B):** As regards the arterial blood gas parameters in group B; before weaning the mean PH was 7.4 ± 0.03, mean PO2 was 60.65 ± 1.9 and the mean O2 Sat was 90.8% ± 2.5.
While after weaning PH was 7.29 ± 0.05, mean PO2 was 62.55 ± 14.7 and the mean O2 Sat was 89.3 ± 4.6. Comparisons between the above pairs of means before and after weaning using the paired *t*-test were done and revealed no significant results (Figs. 10–12).

As regards lung mechanics, before weaning the mean TV was 282.3 ± 90.08 ml, the mean RR was 26.1 ± 10.2 b/min and the mean MIP was 14.6 ± 5.8 cm/H2O, while after weaning the mean TV was 279 ± 70.14 ml, the mean RR was

Table 1  Comparison between group A and B at the beginning of training in group A and weaning in group B as regards ABG.

<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH</td>
<td>7.38 ± 0.04</td>
<td>7.4 ± 0.03</td>
<td>1.8</td>
<td>0.8</td>
</tr>
<tr>
<td>PO2</td>
<td>58.4 ± 4.01</td>
<td>60.65 ± 1.9</td>
<td>5</td>
<td>0.6</td>
</tr>
<tr>
<td>O2 SAT</td>
<td>89.35 ± 1.8</td>
<td>90.8 ± 2.5</td>
<td>14.9</td>
<td>0.3</td>
</tr>
</tbody>
</table>

The differences between both groups were insignificant.

Table 2  Comparison between group A and B at the beginning of training in group A and weaning in group B as regards lung mechanics.

<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV</td>
<td>307 ± 39.88</td>
<td>282.3 ± 90.08</td>
<td>1.1</td>
<td>0.2</td>
</tr>
<tr>
<td>RR</td>
<td>26.3 ± 1.9</td>
<td>26.1 ± 10.2</td>
<td>0.08</td>
<td>0.9</td>
</tr>
<tr>
<td>MIP</td>
<td>15.2 ± 2.41</td>
<td>14.6 ± 5.8</td>
<td>0.4</td>
<td>0.6</td>
</tr>
</tbody>
</table>

The differences between both groups were insignificant.

Figure 2  There was a significant difference between both groups regarding the mean duration of mechanical ventilation.

Figure 3  There was a significant difference between both groups regarding the mean hospital stay duration.

Figure 4  A significant difference between group A and B as regards the duration of ICU stay (*p* = 0.0001).

Figure 5  Mean PO2 changes through the respiratory muscle training sessions, there was significant improvement in PaO2 over training sessions (from 58.4 ± 4.01 to 72.3 ± 12.7) (*F* = 9.8, *p* = 0.000).

Figure 6  Mean O2 saturation changes through the respiratory muscle training sessions, there was highly significant improvement in O2 saturation over training sessions (from 89.35 ± 1.8% to 93.35 ± 4.19%) (*F* = 6.07, *p* = 0.000).
26.7 ± 10.7 b/min and the mean MIP was 13.9 ± 5.6 cm/H₂O. Comparisons between the above pairs of means before and after weaning using the paired t-test were done and there was a significant decrease in MIP after weaning from 14.6 ± 5.8 to 13.9 ± 5.6 cm/H₂O. This is summarized in Fig. 13. While there were no significant differences regarding RR and TV.

Comparisons between both groups regarding the arterial blood gases and lung mechanics parameters at the end of weaning (before extubation) were done using independent sample t-test. There were significant differences in favor to group (A) in all the above mentioned parameters except for PH. These results are summarized in Table 3 and illustrated in Figs. 14–18.
Chronic obstructive pulmonary disease (COPD) is a major public health problem. It is projected to rank five in 2020 as a worldwide burden of disease [11].

If ventilatory demand of COPD patients exceeds work output of the respiratory muscles, acute respiratory failure (ARF) follows. For these patients, admission to an intensive care unit (ICU) is common, 26–74% of them receive mechanical ventilatory support, and average hospital and ICU stays are long and expensive. In studies restricted to patients with COPD and acute respiratory failure, about 10% were at high risk for mechanical ventilation (MV) >21 days, and failure in weaning ranged from 55% to 78%. The association between abnormal lung mechanics, in particular auto-positive end-expiratory pressure (auto-PEEP), lung resistances, and reduced pressure-generating capacity of the inspiratory muscles because of pulmonary hyperinflation are the major reasons for prolonged mechanical ventilation (PMV) in patients with COPD [12].

There is increasing evidence to show mechanical ventilation itself may adversely affect the diaphragm’s structure and function, which has been termed ventilator-induced diaphragmatic dysfunction. The combination of positive pressure ventilation and positive end-expiratory pressure (auto-PEEP), lung resistances, and reduced pressure-generating capacity of the inspiratory muscles because of pulmonary hyperinflation are the major reasons for prolonged mechanical ventilation (PMV) in patients with COPD [12].

There is increasing evidence to show mechanical ventilation itself may adversely affect the diaphragm’s structure and function, which has been termed ventilator-induced diaphragmatic dysfunction. The combination of positive pressure ventilation and positive end-expiratory pressure may unload the diaphragm therefore subjecting it to changes in myofibre length, which may account for its rapid atrophy. In addition, patients who undergo prolonged periods of ventilation demonstrate a decrease in respiratory muscle endurance and are at risk of respiratory muscle fatigue [13].

Inspiratory muscle training (IMT) is a technique that targets the muscles of inspiration-namely the diaphragm and accessory inspiratory muscles-with the aim of increasing inspiratory muscle strength and endurance [14].

### Table 3  Comparison between group A and B at the end (before extubation).

<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH</td>
<td>7.27 ± 0.01</td>
<td>7.29 ± 0.05</td>
<td>5.3</td>
<td>0.1</td>
</tr>
<tr>
<td>PO₂</td>
<td>72.3 ± 12.7</td>
<td>62.55 ± 14.7</td>
<td>2.2</td>
<td>0.03</td>
</tr>
<tr>
<td>O₂ SAT</td>
<td>93.35 ± 4.19</td>
<td>89.3 ± 4.6</td>
<td>2.9</td>
<td>0.006</td>
</tr>
<tr>
<td>TV</td>
<td>357 ± 55.26</td>
<td>279 ± 70.14</td>
<td>3.05</td>
<td>0.004</td>
</tr>
<tr>
<td>RR</td>
<td>18.65 ± 4.04</td>
<td>26.7 ± 10.7</td>
<td>3.14</td>
<td>0.003</td>
</tr>
<tr>
<td>MIP</td>
<td>24.45 ± 3.97</td>
<td>13.9 ± 5.6</td>
<td>6.87</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

A significant difference (in favor Group A) between two groups as regard PO₂, O₂ saturation, TV, RR and MIP after weaning.

### Discussion

Chronic obstructive pulmonary disease (COPD) is a major public health problem. It is projected to rank five in 2020 as a worldwide burden of disease [11].

If ventilatory demand of COPD patients exceeds work output of the respiratory muscles, acute respiratory failure (ARF) follows. For these patients, admission to an intensive care unit (ICU) is common, 26–74% of them receive mechanical ventilatory support, and average hospital and ICU stays are long and expensive. In studies restricted to patients with COPD and acute respiratory failure, about 10% were at high risk for mechanical ventilation (MV) >21 days, and failure in weaning ranged from 55% to 78%. The association between abnormal lung mechanics, in particular auto-positive end-expiratory pressure (auto-PEEP), lung resistances, and reduced pressure-generating capacity of the inspiratory muscles because of pulmonary hyperinflation are the major reasons for prolonged mechanical ventilation (PMV) in patients with COPD [12].

There is increasing evidence to show mechanical ventilation itself may adversely affect the diaphragm’s structure and function, which has been termed ventilator-induced diaphragmatic dysfunction. The combination of positive pressure ventilation and positive end-expiratory pressure may unload the diaphragm therefore subjecting it to changes in myofibre length, which may account for its rapid atrophy. In addition, patients who undergo prolonged periods of ventilation demonstrate a decrease in respiratory muscle endurance and are at risk of respiratory muscle fatigue [13].

Inspiratory muscle training (IMT) is a technique that targets the muscles of inspiration-namely the diaphragm and accessory inspiratory muscles-with the aim of increasing inspiratory muscle strength and endurance [14].
In ventilated patients, IMT can be undertaken in several ways: isocapnic/normocapnic hyperpnoea training, resistive flow training, threshold pressure training, or adjustment of the ventilator to provide a training load for the inspiratory muscles. To provide resistance and hence a pressure load to the inspiratory muscles. By progressively adjusting the pressure trigger sensitivity, the inspiratory load can be gradually increased. This is typically based on a percentage of the maximal inspiratory pressure (MIP). One aspect of the invention relates to inspiratory muscle strength training provided by a mechanical ventilator that includes an inhalation assembly that imposes negative pressure (relative to set or baseline pressure) during inspiration so that the patient is required to generate and sustain a set number of breaths at a predetermined inspiratory training pressure for the entirety of each inspiratory act, thus providing a strength training stimulus to the inspiratory muscles. As defined, “negative pressure” and “predetermined inspiratory training pressure” are pressures that are below or less than the set pressure or baseline pressure of the ventilator. For example, if a patient’s baseline or set pressure on a ventilator is 10 cm H₂O end expiratory pressure (PEEP), an initial exemplary inspiratory training pressure may be 5 cm H₂O, or −5 cm H₂O (note all of the exemplary pressure values are below the baseline pressure of 10 cm H₂O). Inspiratory muscles respond to training in the same way as other skeletal muscles in regard to the principles of overload, specificity and reversibility [14]. In most studies, weaning failure is defined as either the failure of SBT or the need for reintubation within 48 h following extubation [2].

Difficult weaning is defined as: the need for more than three spontaneous breathing trials or more than 1 week to achieve successful weaning [2].

In the current study, the 1st group (A) of (20) COPD patients difficult to wean due to respiratory muscle weakness and MIP below −20 cm H₂O were selected for training by adjustment of ventilator sensitivity method while the 2nd group (B) of (20) COPD patients difficult to wean due to respiratory muscle weakness and MIP below −20 were also selected to be weaned by the (PSV) mode.

All patients of the two groups were complaining of acute respiratory failure secondary to acute exacerbation of COPD and mechanically ventilated with difficult weaning because of respiratory muscle weakness.

Regarding the age and sex there were no statistically significant difference between the two groups regarding age and sex. This is in contrast to what was concluded by Zilberberg and Epstein (1998) and Vieira et al. (2008) that age had an important effect on the outcome of mechanically ventilated patients [15,16]. However, this matches with that reported by Gursel (2005) that age had no effect in a mixed ICU population [12]. This is probably, because the severity of the underlying disease and general condition of the patient are much more determinant factors of weaning outcome than age and sex.

The primary outcome measures were studied in all patients which included; the success rate among groups, duration of mechanical ventilation, the duration of stay in hospital and the duration of stay in ICU.

As regards the success rate in group A successful weaning was carried out in 18 patients of group A (90%), while group B was 11 patients (55%). Failure of weaning was carried out in 2 patients of the group A (10%), in 9 patients of the group B (45%), the difference was statistically highly significant and showing significant increase in success rate among group A.

This result coincides with the observations of Martin and his colleagues, 2002 that 9 of 10 patients were successfully weaned from MV. Highly significant success rate was found in the IMT group [17].

Also these results coincide with observations of Martin and his coworkers, 2011 that Twenty five of 35 patients from the IMT group were weaned, and sixteen of 34 from the control group \( p = 0.039 \) [18].

Weaning failure resulting in prolonged ventilation is detrimental to the individual as it is associated with increased risk of respiratory muscle weakness [19].

The mean duration of mechanical ventilation in group A before successful weaning was 11.67 days ± 1.95 while in cases with group B 14.12 days ± 1.73. This is highly significant and indicates that IMT shortens the duration of stay in mechanical ventilation.

The duration of stay in hospital in group A is 13.77 ± 1.9 days while in group B 18.2 ± 1.3 days also the duration of stay in ICU in group A is 12.6 days ± 1.6 while in group B 17.1 days ± 1.29. This is highly significant and indicates that IMT shortens the duration of long stay in the hospital and ICU.

These results coincide with observations of Cader and his coworkers (2010) who used pressure threshold device with the training group. The control group received no training of the respiratory muscles. The effect of IMT on the weaning process was to reduce this period by 1.7 days [20].

This is consistent with the results of Epstein et al. (2009) who showed that extubation failure was associated with prolonged duration of MV and hospital length of stay [21].

Prolonged ventilation was associated with an increase in mortality, morbidity and ICU length of stay, as well as reduced functional status and quality of life [19].

Factors that may have been involved in shortening the duration of mechanical ventilation and consequently the duration of stay in ICU include the avoidance of sedation, elimination of extra work of breathing imported by the endotracheal tube, the lower rate of ventilator associated pneumonia and earlier removal from ventilation [22].

In summary, the above data show that the primary outcome data were all statistically significant in favor of the IMT group and also were matching with result of previous studies done on the same parameters.

The secondary outcome data were studied which included the follow up of the changes of means of the following parameters in IMT group over five training sessions and PSV as a mode of weaning.

These changes between two groups were blood gases results (PH, PaO₂, O₂ saturation) and respiratory mechanics (MIP, TV, and respiratory rate).

No significant difference between the two groups as regards blood gas parameters and ventilator parameters (RR, MIP and TV) was measured before starting training in group A and weaning in group B.

Regarding blood gases and lung mechanics before and in the end of training in group A there were significant differences between blood gas parameters and ventilator parameters (RR,
MIP and TV) which shows very significant improvement in PaO$_2$, O$_2$ saturation, TV, RR and MIP.

When the change of mean respiratory rate over the training sessions is studied, it was found that was a very high statistically significant decrease in RR over training from 26.3 ± 1.9 b/min before training to 18.65 ± 4.04 b/min and this may be due to the more accommodation of the patient to training. Increase of respiratory muscle strength due to increase in MIP from 15.2 ± 2.41 cm H$_2$O before training to 24.45 ± 3.97 cm H$_2$O in the end of training sessions.

These results coincide with observations of Sprague and his colleagues (2003), that MIP increased from a mean of 22.5 to 54.0 cm H$_2$O, for a 140% gain in pressure [23].

Regarding blood gases in the group (B) there were no significant changes in blood gas parameters before and after weaning while there were significant deteriorations in MIP after weaning.

These results coincide with observations of Chang and colleagues (2005) that prolonged MV results in increased fatigability of inspiratory muscles following successful weaning from MV. Given that post weaning outcomes are often poor for patients undergoing prolonged MV, evaluation of IMT as a method to ameliorate residual weakness, and thus accelerate rehabilitation, appears warranted [13].

The observation of MacIntyre [6] shows that because of the hazards associated with continuation of MV, ventilator management should be aimed at getting the patient off ventilatory support as rapidly as possible. Delayed discontinuation of mechanical ventilatory support exposes patients to unnecesary risks of infection, sedation needs, airway trauma, and costs. The discontinuation process must be performed with proper caution and monitoring, conversely aggressive weaning can result in premature discontinuation which is related to an increase in mortality due to severe clinical problems, such as loss of airway protection, cardiovascular stress, suboptimal gas exchange, and muscle overload and fatigue [6].

It is clear, from this study that there were significant differences between blood gas parameters and ventilator parameters (RR TV, MIP) between group A and group B (in favor group A).

These results coincide with observations of Cader et al. (2010) that MIP in the IMT group was increased from 15.1 to 25.0 cm H$_2$O while by conventional methods from 15.3 to 17.6 cm H$_2$O, a significant increase in IMT group by 26.3 ± 2.41 cm H$_2$O before training to 24.45 ± 3.97 cm H$_2$O in the end of training sessions.

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It is clear from this study that IMT improves inspiratory muscle strength, reduces inspiratory muscle fatigability and dyspnoea and improves quality of life and functional measures in this population. Furthermore, it proves that IMT lowers rate of reintubation and short post-ICU length of hospital stay in COPD mechanically ventilated patients [24].

Conflict of interest

The authors have no conflict of interest to declare.

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quality of life outcomes of patients requiring more than 14 days of ventilation, Crit. Care Med. 31 (5) (2003) 1373–1381.


