ORIGINAL ARTICLE

The efficacy of incentive spirometry in patients with COPD

OZEN KACMAZ BASOGLU, ALEV ATASEVER AND FEZA BACAKOGLU

Department of Chest Diseases, Ege University Faculty of Medicine, Izmir, Turkey

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Objective: Although incentive spirometry (IS) is frequently used to prevent postoperative pulmonary complications, its efficacy in patients with COPD has not been documented. The aim of this study was to evaluate the effects of IS on pulmonary function tests, arterial blood gases, dyspnoea and health-related quality of life in patients hospitalized for COPD.

Methodology: A total of 27 consecutive patients (mean age, 68.4 ± 7.9 years; 26 males) admitted for COPD exacerbations were recruited for the study. In total, 15 (IS treatment group) used IS for 2 months, together with medical treatment. The remaining 12 (medical treatment group) were given only medical treatment. Pulmonary function and blood gases were measured. Assessment of dyspnoea by visual analogue scale (VAS) and quality of life using the St. George’s Respiratory Questionnaire (SGRQ) were performed at admission and after 2 months of treatment.

Results: The activity, impact and total scores for the SGRQ improved (all P ≤ 0.0001), PaCO₂ values decreased (P = 0.02), PaO₂ and PAO₂ values increased (P = 0.02 and P = 0.01, respectively) in the IS treatment group. However, there were no significant differences between the measurements made pretreatment and after 2 months of medical therapy in the medical treatment group, with regards to pulmonary function, blood gases, SGRQ scores and VAS.

Conclusion: The use of IS appears to improve arterial blood gases and health-related quality of life in patients with COPD exacerbations, although it does not alter pulmonary function parameters.

Key words: arterial blood gases, chronic obstructive pulmonary disease, health-related quality of life, incentive spirometry, pulmonary function test.

INTRODUCTION

The incentive spirometer is a device that encourages patients with visual and other positive feedback, to maximally inflate their lungs and sustain that inflation. It is a common mode of postoperative respiratory therapy and involves deep breathing facilitated by a simple mechanical device. Maximal lung inflation is thought to open collapsed alveoli and thereby prevent and resolve atelectasis. Incentive spirometry (IS) is the treatment technique which utilizes the incentive spirometer for respiratory therapy.1–6 The use of the incentive spirometer is recommended for COPD patients postoperatively.7 However, its efficacy in COPD patients, independent of surgery, is unknown.

Lung hyperinflation increases dead space ventilation and energy consumption during hyperpnoea, leading to decreased ventilatory reserve and lower oxygenation in COPD patients. Incentive spirometry is widely used postoperatively in the belief that intermittent ventilation restores alveolar aeration and improves oxygenation. It was hypothesized that the use of IS in patients with COPD may improve oxygenation, lung function and quality of life.

The aims of this study were to evaluate the effect of IS on arterial blood gases (ABG), pulmonary function tests (PFT), and on health-related quality of life in COPD patients hospitalized for an acute exacerbation, and then at follow up to 2 months later. Besides, patients who received both medical therapy and used an incentive spirometer were compared with patients who received medical treatment alone.
METHODS

The study was a prospective randomized trial in patients with COPD. The criteria specified by the Global Initiative for Chronic Obstructive Pulmonary Disease were used to define and classify COPD patients. All patients were over 40 years of age and were ex-smokers with a smoking history of at least 20 pack-years. Patients with a history of asthma, allergic rhinitis or atopy were excluded. The study population consisted of 32 consecutively selected patients who were hospitalized for an acute exacerbation of COPD. A computer random generator was used to assign each patient to one of the two groups: incentive spirometry plus medical treatment (IS treatment group) or only medical treatment (medical treatment group). Therefore, the study and control groups were not matched.

A total of 16 patients were allocated to the IS treatment group. They were asked to undertake IS and were also given medications for COPD: bronchodilators via nebuliser (salbutamol, ipratropium bromide), theophylline, antibiotics if there was acute bacterial exacerbation, systemic corticosteroids (40 mg/day) if there were no contraindications, and only bronchodilators on discharge. The remaining 16 patients (medical treatment group) received only medical treatment as described above. This was not a placebo-controlled study as it was not possible to find a similar device that could be used as placebo. The patients stayed approximately 10 days (range, 7–15 days) in hospital. The criteria for discharge and medical treatment at home and in the hospital were the same for both groups.

The patients were evaluated on five occasions. The first visit was on admission to the hospital: a full history was taken and previous medical problems, medications, smoking history and comorbid diseases were recorded. After a physical examination, a chest X-ray was obtained. PFTs were performed with a water-sealed spirometer (Sensor Medics 2400, USA). ABG samples were obtained by percutaneous arterial puncture of the femoral artery, while breathing room air and at rest, and were analysed on a gas analyser (Ciba Corning 238 pH–Blood gas analyser, UK). Visual analogue scale (VAS) was used to assess perception of dyspnoea and a Turkish version of the St. George’s Respiratory Questionnaire (SGRQ) was used in the evaluation of health-related quality of life. All baseline measurements of ABG, pulmonary function, dyspnoea and SGRQ were performed immediately after hospitalization and before treatment. As the duration of hospital stay was short, patients were not re-evaluated at discharge. The next three visits were performed via telephone calls every 2 weeks, and the compliance of the patients with IS and medical treatment was questioned. Clinical evaluation, ABG, PFT, VAS and SGRQ were all repeated at the hospital on the fifth visit, which was 2 months after the first admission. The effects of IS on arterial blood gases, pulmonary function, perception of dyspnoea and quality of life were assessed by comparing the pre- and post-treatment results for the IS treatment group and the medical treatment group. The local ethics committee approved the study and all subjects gave informed consent.

Incentive spirometry

The patients performed IS using a flow-oriented incentive spirometer (Tri-Ball, Ref 259–12 000, Leventon SA, Spain), which had three chambers, 600, 900 and 1200 mL/s and a mouthpiece (Fig. 1). They were initially instructed on the use of IS by one of the research doctors. After a quiet expiration, they were encouraged to take slow maximal inspirations through the mouthpiece of the device and to hold each breath for as long as possible. Corresponding to the inspiratory flow, the balls were lifted and kept suspended by the sustained inspiratory flow. The balls served as visible feedback of the inspiratory flow. The patients were encouraged to take slow maximal inspirations through the mouthpiece of the device and to hold each breath for as long as possible. Corresponding to the inspiratory flow, the balls were lifted and kept suspended by the sustained inspiratory flow. The balls served as visible feedback of the inspiratory flow. The patients were encouraged to use the device for 5–10 breaths per session, at a minimum, every hour while awake. The administration of IS was started on the first day of hospitalization and was continued at home for 2 months. The compliance of the patients was assessed by telephone contact every 2 weeks. One of the family members was also asked to check that IS was being used.

Visual analogue scale

The perception of dyspnoea was evaluated using a VAS consisting of a horizontally marked scale from 0 to 10, with 10 representing the presence of the most severe breathlessness and 0 representing the absence of breathlessness.
St George’s Respiratory Questionnaire

Health-related quality of life was assessed using the Turkish version of the SGRQ. This is a specific respiratory instrument developed for patients with COPD. Its validity, reproducibility and response to change over time have been demonstrated. It has three components: symptoms, activity and impact. The responses to the items can be aggregated into an overall score and three subscores for symptoms, activity and impact in the range 0–100%. Higher scores indicate a poorer quality of life.

Statistical analysis

Student’s t-test was used to analyse parametric measures. For analysis of categorical variables, the χ² test, Fisher’s exact test or the Mann–Whitney U-test were used. A P-value <0.05 was considered significant for all statistical analyses.

RESULTS

Although 32 patients with COPD were recruited for the study, one patient in the IS treatment group and four patients in the medical treatment group were excluded as they developed a second new acute exacerbation of their disease prior to the end of the study period. The remaining 27 patients (mean age, 68.4 ± 7.9 years; 26 males) completed the study. The characteristics of the patients are shown in Table 1. A total of 12 patients (44.4%) had a coexisting disease and some had more than one. However, they were all clinically stable and under medical treatment for these concomitant diseases. There were no significant differences in terms of gender, duration and severity of COPD, presence of comorbidity, PFT parameters and PaO₂ measurements between the two patient groups. Dyspnoea (assessed by VAS), total and component SGRQ scores and previous use of systemic corticosteroids or bronchodilators also demonstrated no significant differences between the two groups at admission. The patients in the medical treatment group were somewhat older and smoked more cigarettes than those in the IS treatment group (P = 0.02 and P = 0.03, respectively), and the mean PaCO₂ was higher in the IS treatment group (P = 0.03).

When all the pretreatment measurements for the IS treatment group were compared to the post-treatment measurements, there were no significant differences for PFT, D(A-a)O₂, VAS and SGRQ symptoms scores. However, at the end of 2 months the PaCO₂ had decreased from 51.5 ± 14.3 to 42.9 ± 7.5 mmHg (P = 0.02), the PaO₂ had increased from 56.4 ± 15.0 to 68.7 ± 16.3 mmHg (P = 0.02) and PaO₂ had improved from 85.3 ± 17.9 to 96.1 ± 9.4 mmHg (P = 0.01). Furthermore, the activity, impact and total SGRQ scores were improved by the use of incentive spirometry (P ≤ 0.0001 for all; Table 2). In contrast, for the medical treatment group, PFT, ABG, VAS and the SGRQ scores showed no significant difference between the pre- and post-treatment assessments (Table 2).

DISCUSSION

COPD is characterized by impaired lung function, hyperinflation, dead space ventilation and increased energy consumption that lead to reduced ventilatory capacity and are associated with shortness of breath and limitation of daily activities. Since medications do not relieve all COPD symptoms nor cure the illness, pulmonary rehabilitation has been employed to improve performance of daily activities and quality of life. In this study, the effects of IS on arterial blood gases, pulmonary function and health-related quality of life in COPD patients presenting with an acute exacerbation were evaluated. Use of IS for 2 months together with medical treatment improved arterial blood gases and health-related quality of life, although pulmonary function parameters remained unchanged.

Pulmonary complications are a major cause of morbidity and mortality following upper abdominal operations. Of the many approaches for dealing with this, IS has become the most common modality used, despite the conclusions of a systematic review that there is no evidence to support the use of IS for decreasing the incidence of postoperative pulmonary complications following cardiac or upper abdominal surgery. However, in a meta-analysis evaluating the efficacy of IS, deep breathing and intermittent positive pressure breathing in the prevention of postoperative pulmonary complications, IS and deep breathing exercises have been found to be more effective. Although the use of IS has been assessed postoperatively in COPD patients, its efficacy in COPD independent of surgery has not been investigated properly.
Table 2  Comparison of pre- and post-treatment measurements in the incentive spirometry treatment group and the medical treatment group

<table>
<thead>
<tr>
<th>Parameters</th>
<th>IS treatment group (n = 15)</th>
<th>Medical treatment group (n = 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretreatment</td>
<td>Post-treatment</td>
</tr>
<tr>
<td>Visual analogue scale</td>
<td>8.3 ± 1.2</td>
<td>7.7 ± 1.4</td>
</tr>
<tr>
<td>SGRQ*</td>
<td></td>
<td></td>
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<tr>
<td>Symptoms</td>
<td>70.6 ± 15.8</td>
<td>69.9 ± 14.7</td>
</tr>
<tr>
<td>Activity</td>
<td>83.0 ± 15.6</td>
<td>46.9 ± 23.7*</td>
</tr>
<tr>
<td>Impact</td>
<td>60.4 ± 17.4</td>
<td>33.9 ± 17.4*</td>
</tr>
<tr>
<td>Total</td>
<td>69.1 ± 14.2</td>
<td>44.4 ± 15.0*</td>
</tr>
<tr>
<td>FEV1 (L)</td>
<td>1.02 ± 0.36</td>
<td>1.09 ± 0.35</td>
</tr>
<tr>
<td>FEV1, % predicted</td>
<td>37.9 ± 11.2</td>
<td>41.6 ± 13.3</td>
</tr>
<tr>
<td>FVC (L)</td>
<td>2.03 ± 0.45</td>
<td>2.25 ± 0.44</td>
</tr>
<tr>
<td>FVC, % predicted</td>
<td>55.1 ± 10.8</td>
<td>59.9 ± 14.0</td>
</tr>
<tr>
<td>FEV1/FVC, %</td>
<td>52.0 ± 11.9</td>
<td>49.0 ± 12.8</td>
</tr>
<tr>
<td>PaO2 (mmHg)</td>
<td>56.4 ± 15.0</td>
<td>68.7 ± 16.3**</td>
</tr>
<tr>
<td>PaCO2 (mmHg)</td>
<td>51.5 ± 14.3</td>
<td>42.9 ± 7.5**</td>
</tr>
<tr>
<td>PAO2 (mmHg)</td>
<td>85.3 ± 17.9</td>
<td>96.1 ± 9.4***</td>
</tr>
<tr>
<td>D(A-a)O2 (mmHg)</td>
<td>28.9 ± 16.5</td>
<td>27.3 ± 10.9</td>
</tr>
</tbody>
</table>

1Values are expressed as mean ± SD.
2Higher SGRQ scores indicate a poorer quality of life.
3P < 0.0001, **P = 0.02, ***P = 0.01.
4IS, incentive spirometry; SGRQ, St. George's Respiratory Questionnaire.

The effects of IS as an inspiratory muscle training device was evaluated in the present study. IS is designed to mimic natural sighing or yawning by encouraging the patient to take long, slow, deep breaths and it can be used for inspiratory muscle training. The use of IS increases transpulmonary pressure, inspiratory volumes and inspiratory muscle performance. Scherer et al.11 studied the effects of respiratory muscle training using a portable device for 8 weeks in COPD patients, while the control group performed breathing exercises using IS. They showed that breathing exercises improved the maximum inspiratory pressure (Pmax) and dyspnoea in the incentive spirometry group as a result of an improvement in their inspiratory muscle performance. Although it can be argued that these changes were due to a placebo effect or based on motivation, the fact that Pmax and threshold loading, but not maximum expiratory pressure (Pmax) or respiratory muscle endurance, improved suggests that a mild training effect occurred.

Igarashi et al.12 assessed the effects of IS on pulmonary function and ABG in healthy adults of advanced age and in COPD patients. Both the control subjects and COPD patients showed a significant decrease in alveolar-arterial oxygen gradient and increases in pulmonary function parameters and PaO2 values. In the present study, it was also able to be demonstrated that PaCO2 values decreased, while PaO2 and PAO2 values increased after the use of IS, but this improvement in arterial blood gases did not correlate with pulmonary function test parameters. However, there was no increase in pulmonary function nor in ABG in COPD patients treated with medication alone. Although alveolar-arterial oxygen gradient decreased non-significantly in both groups, there was a significant increase in PAO2 in the IS treatment group. It was concluded that IS improved inspiratory muscle performance and this led to an increase in minute ventilation and as a result, an increase in PAO2.

The goals of pulmonary rehabilitation programmes are mainly to improve the quality of life of the patients, rather than functional parameters. It has been shown that pulmonary rehabilitation, with and without additional inspiratory muscle training, can improve quality of life in patients with COPD.14-17 An improvement in inspiratory muscle strength and endurance might reduce symptoms and improve functional capacity in patients with severe COPD, even if airway obstruction does not improve. Inspiratory muscle training is recommended for COPD patients,18 and in a recent meta-analysis,19 inspiratory muscle training alone significantly improved inspiratory muscle strength and endurance, whereas the sensation of dyspnoea decreased significantly in patients with COPD. In the present study, health-related quality of life improved in the IS group, while the medical treatment group showed no significant change after 2 months of treatment. Tiwary et al.20 reported a remarkable improvement in subjective feeling of well-being and breathlessness with the use of incentive spirometry in COPD patients. These subjective findings reflect an improvement in quality of life as reported in this study.

There were some limitations to the present study. The number of subjects studied was small, the two groups were not matched in terms of age, smoking history or baseline PaCO2 levels, and some patients were treated with corticosteroids. It may have been better to have performed this study in stable COPD patients and this will be done so in the future. In most studies inspiratory muscle training has been per-
formed using resistive breathing or threshold loading. Unfortunately, the facilities were not available for the authors to do this.

An incentive spirometer is a simple device that can easily be used at the bedside for inspiratory muscle training. It was concluded that the use of IS improves arterial blood gases and health-related quality of life in patients hospitalized for acute exacerbations of COPD, without altering pulmonary function parameters. Further prospective studies are needed to evaluate the use of IS and to compare it with other respiratory therapies, both in stable COPD patients and in those with acute exacerbations of COPD.

REFERENCES


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