Comparison between active cycles of breathing with postural drainage versus conventional chest physiotherapy in subjects with bronchiectasis

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KEYWORDS
Bronchiectasis; Postural drainage; Active cycle of breathing; Conventional physical therapy; Airway clearance

Abstract Introduction: Bronchiectasis is a chronic debilitating condition with abnormal permanent dilatation of the airways causing impaired mucus clearance, despite regular chest physiotherapy being mainstay of management for bronchiectasis, there is little evidence supporting regular chest physiotherapy in bronchiectasis which aims to mobilize secretions and facilitate effective expectoration, providing control of cough and improving airway clearance. The objective of this study was to compare between the efficacy of 2 techniques of chest physiotherapy ACBT with postural drainage and conventional chest physical therapy as a method of airway clearance in adults with productive bronchiectasis.

Methods: The study included 30 subjects, 20 males and 10 females; all having bronchiectasis, the study was carried out on October 6 at the University Hospital. The participating subjects underwent conventional chest physical therapy or ACBT following postural drainage as the airway clearance technique in random order on 14 successive days with twice daily frequency.

Results: There was a significant difference regarding mMRC before and after both ACBT and conventional physiotherapy, there was a significant improvement regarding FVC and MMEF after ACBT while there was a significant improvement of FEV1 and MMEF after conventional physiotherapy. As regards arterial blood gas data comparison, there were significant improvements regarding PaCO2, PaO2 and PAO2 while there was no significant difference as regards P (A-a) O2 gradient after both types of physiotherapy techniques. Comparison between the 2 groups regarding mMRC dyspnea score, spirometry, arterial blood gas data, Leicester cough questionnaire (LCQ) and sputum wet volume before starting physiotherapy shows no significant difference while there were significant differences in advance to post ACBT physiotherapy sessions as regards PaO2, P (A-a) O2 gradient, LCQ (physical domain score and total score) and sputum wet volume.

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Introduction

Bronchiectasis is a chronic debilitating condition, with abnormal long-lasting dilatation of the airways causing compromised mucus clearance, chronic bacterial infection and persistent bronchial inflammation. Subjects suffer from daily cough, extra sputum production and frequent exacerbations [1]. They may also report breathlessness, wheeze and fatigue. Such incapacitating symptoms impact on subjects’ health-related quality of life (HRQoL) [2].

Away from any sensible suspicion, one of the greatest accomplishments of medicine in the treatment of bronchiectasis is physiotherapy, where it effectively reduces its morbidity and mortality especially during repeated infective exacerbation [3]. Physiotherapy aims to loosen secretions and facilitate efficient expectoration, through control of cough and enhancing airway clearance. Therefore it is broadly advocated as a pillar of management of bronchiectasis.

Despite little evidence supporting the routine use of regular chest physiotherapy in bronchiectasis it provided significant profits compared with no chest physiotherapy [4].

Previous small studies in bronchiectasis have compared various techniques, some realized small alterations being achieved by many methods of chest physiotherapy as regards improvement in functional capacity and HRQoL [5,6]. More studies are needed to explore prospective benefits on other outcome measures in order to determine a method to be superior; however, patient preference was subjective besides the related effects on lung function during the exacerbations [1].

The aim of this study is to compare the efficacy of twice daily physiotherapy using active cycles of the breathing method with postural drainage (ACBT-PD) against conventional chest physiotherapy in bronchiectasis subjects not previously practicing regular chest physiotherapy.

Methods

Subjects

The study was conducted on 30 subjects, recruited from the inpatient department of October 6 University Hospital, complaining of infective exacerbation of bronchiectasis which was defined as a clinical deterioration with all of the following: increasing cough, increasing sputum volume and worsening sputum purulence [7].

The subjects were randomly assigned to receive either active cycle breathing technique physiotherapy with postural drainage or the conventional chest physiotherapy technique and accordingly they were divided into 2 groups; group (1): included 15 subjects who underwent the active cycle breathing physiotherapy technique with postural drainage; 10 males and 5 females, their mean age was (53.73 ± 14.78 years); and group (2): included 15 subjects who underwent the conventional chest physiotherapy technique; 10 males and 5 females, their mean age was (49.40 ± 15.43 years). The study was approved by the review board of pulmonary medicine department of the Ain Shams University and signed informed consents were obtained from all subjects. All subjects were subjected to the following on admission: medical history including a history of smoking, Leicester Cough Questionnaire (LCQ) and modified medical research council (mMRC) dyspnea scale (filled by the attendant physician), clinical examination including anthropometric measurements (weight, height and calculated body mass index [BMI]), sputum collection daily with monitoring of amount (in mL) and type, sputum examination including (Gram stain, Zeihl Nelsen stain, culture and sensitivity) high resolution chest computerized tomography with contrast, electrocardiogram, liver and renal function tests, spirometry, arterial blood gas analysis, calculated PAO2 (using alveolar gas equation) and P(A-a)O2 gradient.

Exclusion criteria

Participants were excluded if they have:

(1) Smoking history or physician diagnosis of COPD [8].
(2) A clinical diagnosis of asthma [9].
(3) Interstitial lung disease (clinical/radiological diagnosis); pneumonia (clinical/radiological diagnosis); acute or chronic other comorbid disease (clinical/laboratory diagnosis).
(4) Respiratory failure.
(5) Hemothysis.
(6) Inability to perform the physiotherapy techniques.
(7) Corticosteroid intake during the previous 4 weeks.

All subjects received standard medical treatment in the form of: empirical antibiotics, inhaled bronchodilator (β2-agonist and/or anticholinergic), mucolytic. The antibiotic regimen was modified later on (if needed) according to the results of the sputum culture and sensitivity.

Cough specific health-related quality of life (HRQoL)

HRQoL was measured using the Leicester Cough Questionnaire (LCQ) which measures the physical, psychological and social impact of chronic cough [10]. It consists of 19 items with responses based on a 7-point scale and has been validated in subjects with bronchiectasis. A higher score indicates less impact on HRQoL [11].

mMRC dyspnea scale

A scoring method was used which uses a simple grading system to assess a patient’s level of dyspnea. It is composed of 5 grades (0–4) with higher scores indicating more dyspnea severity [12].
CT Imaging

A helical CT scanner (Hi Speed Advantage; GE Medical Systems, DX/i) was used for conventional contiguous scanning with a slice thickness of 10 mm to screen for chest abnormalities, followed by HRCT scanning at full inspiration (at total lung capacity (TLC) level) with 1-mm collimation of 120 kVp, 200 mA, pitch 1.0.

Spirometry

Spirometry was done using Spirometrics, ENC Flowmate according to the American Thoracic Society/European Respiratory Society standards in all subjects [13].

Arterial blood gas analysis

Arterial blood sample withdrawn from the radial artery using a 23 gauge heparinized syringe was sent to the laboratory for analysis using BAYER RAPIDLAB 248 blood gas analyzer.

Alveolar gas equation

PAO\textsubscript{2} = (FiO\textsubscript{2} * (Patmos – PH\textsubscript{2}O)) – (PaCO\textsubscript{2}/RQ).

The FiO\textsubscript{2} is the fraction of inspired oxygen (expressed as a decimal).

- Patmos is the ambient atmospheric pressure, which is 760 mmHg at sea level.
- PH\textsubscript{2}O is vapor pressure of water at 37 °C and is equal to 47 mmHg (760–47 mmHg).
- RQ is the respiratory quotient or respiratory coefficient (the ratio of CO\textsubscript{2} eliminated divided by the O\textsubscript{2} consumed), and its value is typically 0.8.

The alveolar gas equation is most commonly used in the calculation of the Alveolar – arterial oxygen gradient: A-a gradient = PA\textsubscript{a}O\textsubscript{2} – PaO\textsubscript{2} [14].

Sputum collection

Any sputum produced during and following either treatment was collected into the same plastic beaker (labeled mL scale) and the volume was measured.

Intervention

Group (1)

Active cycle breathing chest physiotherapy technique with postural drainage. It consists of 3 steps: subjects were sitting comfortably in a standard chair.

1. Breathing control: subject breathes at a normal rate and depth using the lower chest.
2. By resting one hand on the epigastrium allowing the subject to breath in slowly and deeply using the lower chest (Pause) then breathe out fully but not forcefully. Repeated 2 to 3 times. Return to breathing control.
3. Sputum removal: subject takes a slightly bigger than normal breath in, making the subject to open the mouth and keep it O shaped. Breathing out more forcefully by contracting the abdominal muscles while keeping the mouth and throat open. It should sound like a forced sigh as HUFFING.

Return to breathing control till the patient is ready to begin another cycle. The patient is advised to start coughing any sputum if necessary [15,16]. Each standardized ACBT cycle lasted around 2 min and was repeated for 15–20 min with postural drainage/gravity assisted drainage i.e. the use of specific positioning in which gravity enhances mucus transport from distal bronchi. Repeated twice daily with a minimum 6 h duration [17].

Group (2)

Conventional chest physiotherapy technique. The use of gravity assisted position combined with diaphragmatic breathing exercises with percussion. This technique is done for 15–20 min twice daily [18].

Antibiotic therapy

All subjects completed 14 days of antibiotic therapy and doses used were as recommended for bronchiectasis/cystic fibrosis in the British National Formula [19].

Side-effects

No adverse side-effects were reported and no changes to treatment regimens occurred. All subjects successfully completed 14 days of treatment.

Data analysis

Data variables of the 2 groups were compared by independent sample T-test. Comparison within a group before and after the intervention was done using the paired t-test. Analysis was performed using statistical software (SPSS version 17; SPSS, Inc., Chicago, IL). Data are presented as mean ± SD, \( p < 0.05 \) was considered significant.

Results

The study included 30 subjects, 20 males (66.7%) and 10 females (33.3%); all having bronchiectasis diagnosed clinically and radiologically. Their mean age was 51.56 ± 15 years. The participating subjects were randomly assigned to chest physiotherapy either ACBT-PD (included 15 subjects) or conventional physiotherapy (included 15 subjects). The characteristic data of both groups are presented in Table 1.

Comparison between both groups regarding age and anthropometric data measures using independent sample t-test. There were no significant difference, the results are shown in Fig. 1.

Comparison as regards mMRC dyspnea score before and after ACBT-PD using the paired t-test. There were no significant difference, the results are shown in Fig. 2. Comparison as regards mMRC dyspnea score before
and after conventional physiotherapy using the paired $t$-test. There was a significant difference ($t = 5.245$, $p = 0.000$).

These results are shown in Fig. 3.

Spirometry data were compared within group (1) before and after ACBT-PD using paired $t$-test showed that there were significant differences regarding FVC ($t = 4.812$, $p = 0.000$) and MMEF ($t = 2.229$, $p = 0.043$); there were no significant differences as regards FEV1 ($t = 0.907$, $p = 0.380$) and FEV1/FVC ratio ($t = 1.613$, $p = 0.129$). These results are shown in Fig. 4. Also spirometry data were compared before and after conventional physiotherapy within group (2) using the paired $t$-test; there were significant differences regarding FEV1 ($t = -2.219$, $p = 0.044$) and MMEF ($t = -4.532$, $p = 0.000$); there were no significant differences as regards FVC ($t = -0.386$, $p = 0.705$) and FEV1/FVC ratio ($t = -1.758$, $p = 0.101$). The results are shown in Fig. 5.

As regards arterial blood gas data comparison before and after ACBT-PD using paired $t$-test. There were significant differences.
differences regarding PaCO₂ (t = 6.775, p = 0.000), PaO₂ (t = −12.548, p = 0.000) and PAO₂ (t = −6.775, p = 0.000); there was no significant difference as regards P (A-a) O₂ (t = 1.104, p = 0.288). These results are shown in Fig. 6. Comparison as regards arterial blood gas data before and after conventional physiotherapy using paired t-test. There were no significant differences as regards PaO₂ (t = −0.907, p = 0.380) and FEV1/FVC ratio (t = 1.613, p = 0.129).

**Discussion**

Although bronchiectasis doesn’t have actual prevalence in many countries, it remains a cause of excessive morbidity [20]. In the current situation of limited health resources of the developing countries, it is important to provide interventions which not only contribute to improved HRQoL, but positively influence on disease progression and prognosis especially during the exacerbations which worsen lung functions on the reasoning of the copious secretions and the low cough flow during sickness.

This study assisted in the choice of technique of physiotherapy for the treatment of subjects with bronchiectasis in clinical practice.
The study included 30 subjects, 20 males and 10 females; all having bronchiectasis with a heterogeneous clinical profile, secondary to the multiple etiologies from which it may originate, diagnosed clinically and radiologically, they were all in acute infective exacerbation. Subjects that were admitted to the inpatient department received their optimum medical treatment and were randomly assigned to chest physiotherapy set as 15–20 min twice daily ACBT-PD (included 15 subjects) or conventional physiotherapy (included 15 subjects). This study selected a twice daily physiotherapy regimen following previous studies assessing different physiotherapy techniques for bronchiectasis have achieved compliance with this frequency [6,21].

The results of this study revealed no significant differences between the 2 groups regarding all anthropometric data. There were also no significant differences between the 2 groups before physiotherapy regarding clinical (modified MRC dyspnea score), spirometry, arterial blood gas data, Leisester cough questionnaire (including its 3 domains and the total score) and sputum wet volume.

As regards the statistical analysis of the data after ACBT-PD and conventional physiotherapy there was a significant improvement in MMRC dyspnea score in both groups without significant difference between them.

Regarding spirometry data of the subjects included in this study there was a significant improvement in some spirometry data in both groups, including a significant improvement of airway obstruction and small airway affection, which had been achieved due to the 14 day duration of regular treatment. This was in contrary to other studies with a more brief treatment duration where there was no significant improvement in any of spirometry data [22].

This study demonstrated statistical differences regarding FVC and MMEF (percentage predicted) of the subject group (1) who had undergone ACBT-PD where this technique clears and mobilizes excess pulmonary secretions from the small airways at the periphery thus an alternation of thoracic expansion with controlling breathing followed by the forced expiratory technique i.e. forced expiration with an opened glottis associated with gravity assisted postural drainage gave a superiority

**Figure 6** Comparison as regards arterial blood gas data before and after ACBT using the paired t-test. There was significant difference regarding PaCO₂ (t = 6.775, p = 0.000), PaO₂ (t = −12.548, p = 0.000) and PAO₂ (t = −6.775, p = 0.000); there was no significant difference as regards P (A-a) O₂ (t = 1.104, p = 0.288).

**Figure 7** Comparison as regards arterial blood gas data before and after conventional physiotherapy using the paired t-test. There was significant difference regarding PaCO₂ (t = 3.696, p = 0.002), PaO₂ (t = −10.490, p = 0.000) and PAO₂ (t = −3.696, p = 0.002); there was no significant difference as regards P (A-a) O₂ (t = 0.332, p = 0.745).
Table 2  Comparison between both groups before physiotherapy.

<table>
<thead>
<tr>
<th></th>
<th>ACBT</th>
<th>Conventional</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>mMRC</td>
<td>2.93 ± 0.96</td>
<td>2.87 ± 1.73</td>
<td>0.131</td>
<td>0.897</td>
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<tr>
<td>FVC</td>
<td>70.69 ± 22.52</td>
<td>70.85 ± 30.26</td>
<td>−0.017</td>
<td>0.986</td>
</tr>
<tr>
<td>FEV1</td>
<td>57.19 ± 13.81</td>
<td>54.09 ± 20.46</td>
<td>0.486</td>
<td>0.630</td>
</tr>
<tr>
<td>FEV1/FVC ratio</td>
<td>84.25 ± 17.23</td>
<td>74.29 ± 18.66</td>
<td>1.520</td>
<td>0.140</td>
</tr>
<tr>
<td>MMEF</td>
<td>31.64 ± 14.11</td>
<td>32.26 ± 17.93</td>
<td>−0.105</td>
<td>0.917</td>
</tr>
<tr>
<td>PCO2</td>
<td>52.56 ± 6.25</td>
<td>55.91 ± 8.21</td>
<td>−1.258</td>
<td>0.219</td>
</tr>
<tr>
<td>PaO2</td>
<td>73.0 ± 13.22</td>
<td>60.67 ± 16.71</td>
<td>2.242</td>
<td>0.330</td>
</tr>
<tr>
<td>PAO2</td>
<td>84.03 ± 7.81</td>
<td>79.82 ± 10.27</td>
<td>1.258</td>
<td>0.219</td>
</tr>
<tr>
<td>P(A-a)O2 gradient</td>
<td>11.02 ± 7.91</td>
<td>19.17 ± 9.11</td>
<td>−2.614</td>
<td>0.140</td>
</tr>
<tr>
<td>LCQ Physical</td>
<td>4 ± 2</td>
<td>3.7 ± 1.9</td>
<td>0.435</td>
<td>0.122</td>
</tr>
<tr>
<td></td>
<td>Psychological 3 ± 1.3</td>
<td>3 ± 1.4</td>
<td>0.337</td>
<td>0.216</td>
</tr>
<tr>
<td></td>
<td>Social      3 ± 1.2</td>
<td>3 ± 1</td>
<td>0.326</td>
<td>0.084</td>
</tr>
<tr>
<td></td>
<td>Total       10 ± 1.4</td>
<td>9 ± 1.7</td>
<td>0.514</td>
<td>0.115</td>
</tr>
<tr>
<td>Sputum wet volume (ml)</td>
<td>43 ± 9.02</td>
<td>43.67 ± 9.16</td>
<td>−0.201</td>
<td>0.842</td>
</tr>
</tbody>
</table>

There were no significant differences between the 2 groups before physiotherapy regarding clinical (modified MMRC dyspnea score), spirometry, arterial blood gas data, Leicester cough questionnaire (LCQ) (including its 3 domains and the total score) and sputum wet volume.

Table 3  Comparison between both groups after physiotherapy.

<table>
<thead>
<tr>
<th></th>
<th>ACBT</th>
<th>Conventional</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>mMRC</td>
<td>1.60 ± 0.91</td>
<td>2.00 ± 1.46</td>
<td>−0.899</td>
<td>0.376</td>
</tr>
<tr>
<td>FVC</td>
<td>73.97 ± 23.46</td>
<td>71.93 ± 31.66</td>
<td>0.200</td>
<td>0.843</td>
</tr>
<tr>
<td>FEV1</td>
<td>57.68 ± 13.97</td>
<td>56.71 ± 20.69</td>
<td>0.150</td>
<td>0.882</td>
</tr>
<tr>
<td>FEV1/FVC ratio</td>
<td>81.70 ± 15.6</td>
<td>77.82 ± 18.08</td>
<td>0.630</td>
<td>0.534</td>
</tr>
<tr>
<td>MMEF</td>
<td>36.67 ± 12.83</td>
<td>38.92 ± 18.52</td>
<td>−0.387</td>
<td>0.701</td>
</tr>
<tr>
<td>PCO2</td>
<td>47.02 ± 6.71</td>
<td>49.66 ± 9.37</td>
<td>−0.887</td>
<td>0.382</td>
</tr>
<tr>
<td>PaO2</td>
<td>80.86 ± 13.02</td>
<td>69.13 ± 17.02</td>
<td>2.119</td>
<td>0.043*</td>
</tr>
<tr>
<td>PAO2</td>
<td>90.96 ± 8.39</td>
<td>87.66 ± 11.71</td>
<td>0.887</td>
<td>0.382</td>
</tr>
<tr>
<td>P(A-a)O2 gradient</td>
<td>10.1 ± 7.33</td>
<td>18.52 ± 10.00</td>
<td>−2.652</td>
<td>0.014*</td>
</tr>
<tr>
<td>LCQ Physical</td>
<td>6 ± 3.2</td>
<td>4 ± 2.9</td>
<td>0.118</td>
<td>0.023*</td>
</tr>
<tr>
<td></td>
<td>Psychological 5 ± 2</td>
<td>5 ± 2.2</td>
<td>0.232</td>
<td>0.121</td>
</tr>
<tr>
<td></td>
<td>Social      3 ± 2.9</td>
<td>3 ± 1.8</td>
<td>0.341</td>
<td>0.316</td>
</tr>
<tr>
<td></td>
<td>Total       14 ± 3</td>
<td>12 ± 4.2</td>
<td>0.642</td>
<td>0.019*</td>
</tr>
<tr>
<td>Sputum wet volume (ml)</td>
<td>14.67 ± 3.99</td>
<td>19 ± 5.73</td>
<td>−2.402</td>
<td>0.023*</td>
</tr>
</tbody>
</table>

There were no significant differences between the 2 groups after physiotherapy regarding clinical (modified MMRC dyspnea score), spirometry and arterial blood gas data except for PaO2, P (A-a) O2 gradient, Leicester cough questionnaire (LCQ) (physical domain score and total score) and sputum wet volume.

* Significant.

Figure 8  Comparison regarding sputum wet volume before and after each type of physiotherapy (i.e. ACBT and conventional) using the paired t-test. There was significant improvement in sputum wet volume after both types of physiotherapy ($t = 19.75, p = 0.000$) and ($t = 13.22, p = 0.000$) respectively.
of significant difference of the amount of sputum expectorated per day with respect to the amount of sputum in group (2) leading to improvement of alveolar ventilation and optimizing ventilation perfusion matching, which increase alveolar oxygen tension and finally improves tissue oxygenation. These results reason the significant difference regarding \( \text{PaO}_2 \) and \( \text{P (A-a)} \) \( \text{O}_2 \) gradient in advance to the subjects of the group that had undergone ACBT-PD, while insignificant improvement of FEV1 would have been noted as a result of middle and large airway obstruction due to the forced expiratory maneuver in ACBT.

Regarding group (2) subjects who underwent conventional physiotherapy their spirometry data developed significant differences in FEV1 and MMEF (percentage predicted) where the manual percussion of the chest wall with the strategic positioning of the subjects for mucus drainage was associated with diaphragmatic breathing and coughing thus giving priority to improvement of airway obstruction from the mucus plug and significant improvement of the amount of sputum of the subjects, but with less respiratory muscle training.

Previous studies nullified statistical improvement in spirometry data to both techniques and this could be due to the difference in the study designs and methodologies [22].

In this study sputum volume is measured by a simple non-invasive method to measure the effectiveness of airway clearance, subjects were accustomed to expectorate sputum and discouraged from swallowing it. The results of this study demonstrated a significant difference of the amount of sputum per day only after both techniques of ACBT-PD and conventional physiotherapy.

As regards comparison of arterial blood gas data after both ACBT-PD and conventional physiotherapy, there were significant differences regarding \( \text{PaO}_2 \), and \( \text{P (A-a)} \) \( \text{O}_2 \) gradient.

Despite this study investigating the difference in the efficacy of both types of regular chest physiotherapy techniques in aiding airway clearance and improvement in spirometry data, it also reflected one of the major goals of the management of bronchiectasis: an improvement in HRQoL. Specifically, it assessed the impact of the predominant symptom of bronchiectasis, cough severity by the Leicester cough questionnaire which was developed and validated to determine the impact of cough severity on quality of life [11]. It proved a statistical significant difference as regards the physical domain score and the total score giving advance to the ACBT-PD.

In conclusion, this study found that regular chest physiotherapy in bronchiectasis has significant benefits in both the compared chest physiotherapy techniques. ACBT-PD achieved a superior improvement in airway clearance reflected by the amount of sputum per day, better arterial blood oxygenation due to increased \( \text{PaO}_2 \), and minimization of \( \text{P (A-a)} \) \( \text{O}_2 \) gradient and improved the impact of cough severity on quality of life signaled by the significant progression of the physical domain score and the total score of the Leicester cough questionnaire, which determines one of the major goals in the management of bronchiectasis.

Further studies are needed to specifically address different comparisons between various chest physiotherapy techniques with optimal frequency and duration and above all the tailored technique for each patient with bronchiectasis to explore potential benefits on other outcome measures.

Conflict of interest

There is no conflict of interest.

References


