

# High-Frequency Chest Compression: A Practical Therapy for Patients with Bronchiectasis

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Retained airway secretions, chronic infection and mucus impaction are the main factors leading to respiratory failure in bronchiectasis. Uncleared mucus is strongly correlated to episodes of acute illness and progressive, often sharp declines in FEV1. Assistive airway clearance therapy (ACT) is an intuitive intervention for patients with impaired clearance mechanisms and is recognized as standard of care for the management of bronchiectasis. Although a variety of ACT modalities are available, many are unsuitable for patients with certain functional or comorbid conditions or with severely diminished lung capacity. High-frequency chest compression (HFCC) is the only therapy able to provide consistent effective clearance for bronchiectasis patients regardless of individual limitations and treatment obstacles. HFCC is recommended in the medical literature for patients with bronchiectasis of all etiologies.

Bronchiectasis is a serious and growing public health concern.<sup>1,2</sup> Prevalence is high in developing countries, owing largely to lower rates of childhood immunization, inadequately treated respiratory infections and other factors associated with poverty.<sup>3-5</sup> In contrast, bronchiectasis in industrialized countries has long been regarded as a relatively rare condition.<sup>6</sup> That impression is changing rapidly. Improved imaging techniques, especially high-resolution computed tomography (HRCT), are yielding a growing number of positive diagnoses.<sup>7,8</sup> It is now possible to detect bronchiectasis early, to recognize clinical manifestations and to correlate clinical features with structural abnormalities in the airways.<sup>9</sup>

## **PATHOPHYSIOLOGY**

*Bronchiectasis may be induced by an infectious insult in any patient with defective host defense mechanisms, diminished mucociliary clearance function and obstructed airways.*<sup>5</sup>

Bronchiectasis is not a disease per se. It is best described as a syndrome characterized by irreversible airway dilation and thickening of the bronchial wall arising as a consequence of chronic bacterial/mycobacterial colonization, viral or fungal infection and severe inflammation.<sup>10-13</sup> Symptoms include chronic cough, daily production of large volumes of viscid,

purulent sputum, declining pulmonary function with commensurate dyspnea and general debility. Progression is marked by increasingly frequent, severe respiratory exacerbations, gross lung tissue damage, mucus plugging and respiratory failure. Regardless of the underlying cause, the common denominator in bronchiectasis is the breakdown of the lung defense system - especially airway clearance mechanisms.

## **Final common pathway**

Bronchiectasis is the final common pathway of a diverse array of respiratory and systemic diseases.<sup>10-13, 14-16</sup> The condition is nearly universal among adult cystic fibrosis (CF) patients.<sup>17,18</sup> As survival into early middle age is now common, the absolute number of such patients has risen significantly. Increased use of high resolution computed tomography (HRCT) has led to identification of CF in patients previously missed; adults now make up nearly seven percent of new CF diagnoses.<sup>19</sup> Other disorders associated with bronchiectasis include congenital diseases, most notably dyskinetic ciliary syndromes, primary and acquired immunodeficiency states, inhalation/aspiration injuries, and numerous rheumatic and inflammatory conditions.<sup>10-14,20</sup> Increasingly, bronchiectasis is emerging as a complication of solid organ and bone marrow transplantation.<sup>21</sup>

## **PREVALENCE**

The actual prevalence of bronchiectasis in the United States is difficult to estimate. Because bronchiectasis is a complication of an antecedent condition, it is rarely cited as a primary diagnosis.<sup>6,7</sup> As an example, although bronchiectasis is clinically demonstrable in about 90% of adults with CF, that information is not easily retrieved from medical records.<sup>7</sup>

## **Non-CF bronchiectasis (NCFB)**

The most recent assessment of the prevalence and economic burden of non-cystic fibrosis bronchiectasis (NCFB) was published in 2005 by Weycker et al.<sup>8</sup> In a retrospective cohort study, data were extracted from a health care claims database incorporating more than 30 U.S. insurance plans encompassing 5.6 million covered lives. Author's found:

- Diagnoses of NCFB: 1,424
- Overall prevalence : 52.3 per 100,000 adults
- Mean age at diagnosis: 61 years
- Gender: 68% female; prevalence higher among women

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at all ages

- Prevalence increased with age
  - Age 18-34: 4.2/100,000
  - Age > 75: 271.8/100,000

Extrapolating from the current U.S. population, an estimated 110,000 Americans over the age of 18 yr may be assumed to have NCFB. To some extent, this number is corroborated by the rank of bronchiectasis as a leading indication for surgical lobectomy or lung transplantation.<sup>22-24</sup>

### Economic burden

*Costs related to severe respiratory illnesses consume a major and rapidly growing proportion of health care resources and expenditures.*<sup>25</sup>

The overall economic burden of advanced lung disease is rising rapidly. Where data exist, it is apparent that costs related to the morbidity and mortality of these illnesses are substantial. As aging populations with significant chronic lung disease grow, their healthcare expenses rise disproportionately. When matched for age, sex, geographic region, and several selected comorbidities, patients with NCFB used significantly more medical resources than their cohorts. Treatment costs for NCFB are currently estimated at \$630 million annually in the United States alone.<sup>8</sup>

Data from a 2005 study show that persons with NCFB, compared with non NCFB cohorts, averaged...

- 2.0 additional days in hospital (1.7-2.3)
- 6.1 additional outpatient encounters
- 27.2 (25.0-29.1) more days of antibiotic therapy
- Total excess medical care expenditures: \$5681 (\$4862-\$6593)

Contemporaneous United Kingdom statistics for bronchiectasis-related hospitalizations are consistent with US figures:<sup>26</sup>

- 7,605 Emergency room visits [0.06% of total for all causes] for 2002-2003
  - 78% required admission
  - 54% required emergency admission
  - 61% of admission were for women; 39% for men
  - Mean length of stay (LOS) per episode: 10.5 days
  - Median LOS: 8 days
  - Mean age of patients hospitalized for bronchiectasis: 60 years
  - Bronchiectasis hospitalizations for 15-59 year olds: 37%
  - Bronchiectasis hospitalizations for people > 75 years: 22%
  - Single day hospitalizations: 16%
  - Hospital bed days for bronchiectasis: 0.09% (48, 984).

Mortality rates after first ICU admission for bronchiectasis are high. In the first study of its kind, a retrospective analysis (1990-2000) of patient outcomes for first admissions to the ICU for respiratory failure secondary to bilateral bronchiectasis showed in-hospital deaths at 19% and one-year mortality rates of 40%.<sup>27</sup>

## TREATMENT

### Surgery

Diffuse bronchiectatic lung disease develops rapidly in patients with recurrent infection and ineffective secretion clearance mechanisms. Although a complete surgical cure is rarely possible, some patients may be helped by removal of the most

septic lung regions.<sup>28-30</sup> The goal is to reduce acute infective episodes, to diminish production of purulent, tenacious secretions and to remove airways prone to uncontrolled hemorrhage. Post-surgical lifetime therapy is necessary to maintain the health of less involved lung regions. Follow-up studies of surgically treated bronchiectasis patients show mixed outcomes: Mortality reported in case series papers range from 0% to more than 8%; complication rates vary between 9.4% and 23%.<sup>30</sup> Complications include empyema, hemorrhage, prolonged air leak. As a consequence of persistent obstructive atelectasis or suppuration, expansion in remaining lung tissue may be poor.<sup>29</sup> For appropriate patients, surgery for bronchiectasis may be a good choice. In follow-up studies, the majority showed marked improvement of symptoms; fewer than 10% were unimproved or worsened.<sup>30</sup> However, most bronchiectasis patients are not suitable candidates for surgery and must rely upon medical treatment.

### Medical treatment

*"With its tenacious sputum and defects in clearance of mucous, good bronchial hygiene is paramount in the treatment of bronchiectasis..."*<sup>36</sup>

Medical treatment for bronchiectasis is focused upon controlling infection and inflammation and managing secretions.<sup>10,11,31-33</sup> Besides cystic fibrosis and dyskinetic ciliary disorders, bronchiectasis is the prototypical indication for interventions to enhance mobilization and removal of secretions.<sup>10,34,35</sup> With disease progression, radiological studies show the presence of large volumes of viscid mucus and multiple mucus plugs.<sup>9,12</sup> Significant quantities of mucus are also seen in diseased distal pulmonary passages.<sup>9,12</sup> Retained secretions are both necessary and sufficient to drive the bronchiectatic process. Accordingly, standard care includes combination therapy with mucolytic and mucokinetic agents, bronchodilators and antiinflammatory therapy and, most critically, some form of physical/mechanical airway clearance therapy (ACT).<sup>10, 11, 13, 31, 34-36</sup>

### Airway Clearance Therapy

*"Airway clearance techniques are indicated for specific diseases that have known clearance abnormalities...including cystic fibrosis, dyskinetic cilia syndromes, and bronchiectasis from any cause."*<sup>37</sup>

The goal of ACT is to avoid retention of pathogen-laden mucus and thus control the cycle of recurrent infection leading to progressive pulmonary deterioration.<sup>35,37-39</sup> Efficient removal of pooled respiratory secretions, combined with antibiotics and other drugs, can moderate episodes of acute illness and delay progressive deterioration. Pulmonologists that treat NCFB patients routinely prescribe ACT as an essential component of the care plan.<sup>10,11,13,31</sup> Mobilization of secretions can be accomplished by a variety of techniques and devices. However, finding a suitable ACT for bronchiectasis patients is often a challenge because physical and disease-related factors can diminish or negate therapeutic benefits.

### Chest physiotherapy

*Chest physiotherapy (CPT) aka percussion and postural drainage (P&PD), can be used effectively in some patients with bronchiectasis. Although studies in patients with NCFB are sparse, available data show enhanced mucus mobilization when CPT is used compliantly three to four times daily.*<sup>40,41</sup>

Although, under ideal conditions, CPT can work well, the method is not suitable for most patients with NCFB. For CPT to be useful in the management of bronchiectasis, a competent, reliable, physically able caregiver must administer manual or mechanical percussion of the chest wall for 3-5 minutes on each of 9-12 thoracic regions, pausing to strategically position the patient to permit mucus drainage, coughing and breathing techniques. CPT is *unrealistic* for patients without a dedicated caregiver. It is *inappropriate* for those physically unable to assume and tolerate required postures or with contraindications such as gastroesophageal reflux. And CPT is ineffective for those with cognitive or emotional barriers that preclude daily therapy. For the majority of patients living with NCFB in the twenty-first century, CPT is neither a practical nor wise choice for secretion management.

#### Alternatives to CPT

Some bronchiectasis patients have been shown to benefit from ACTs including choreographed breathing maneuvers (active cycle of breathing exercises) and a variety of devices that require active effort, mastery of technique and/or physical agility. Examples include oral high-frequency (OHF) devices and positive end-expiratory pressure (PEP) masks.<sup>42</sup> Other patients with advanced disease and/or a variety of comorbidities may not have the physical stamina or lung capacity to benefit from techniques that depend on forced expiration. For patients unable to use such ACTs effectively, high-frequency chest compression (HFCC) therapy offers an ideal solution.

#### High-frequency chest compression

HFCC therapy is an FDA-approved airway clearance technology used widely for nearly two decades.<sup>43</sup> Basic research studies demonstrate several synergistic physiological effects that enhance mucus mobilization and clearance.<sup>43,44</sup> Dozens of clinical trials demonstrate the safety and efficacy of HFCC in a broad range of patient populations.<sup>43,44</sup> The therapy has been used successfully by more than 70,000 patients with impaired airway clearance arising from an array of acute and chronic conditions that compromise mucociliary clearance. In numerous published studies, investigational endpoints include the comparative volume of expectorated secretions, changes in pulmonary function scores, quality of life gains and reductions in healthcare utilization. HFCC is the only ACT shown to sustain or improve pulmonary function.<sup>45</sup>

HFCC therapy is administered by means of an air pulse generator attached by two lengths of tubing to an adjustable, inflatable jacket/vest garment fitted over the users' thorax. The jacket component of the device transmits compressive forces to the chest wall to produce increased airflow and oscillatory effects within the airways, thus enhancing mucus mobilization and clearance. The therapy is technique-independent and requires no active effort from the user.<sup>43</sup>

Tolerance barriers and risk for gastroesophageal reflux are eliminated because, unlike CPT, the therapy does not require Trendelenberg positioning. During HFCC, all segments of the lung are treated simultaneously. Most aerosolized medications may be administered during therapy, thus reducing time and burden of treatment.<sup>43</sup> Because HFCC is automated, treatments are consistent and reliable. Adherence to daily airway clearance therapy has been shown to modify the progression of pulmonary deterioration in patients with impaired secretion clearance function.<sup>44,45</sup> In bronchiectasis, long-term use of HFCC

may prove to be the most cost-effective component of care. The human and economic benefits are even greater if mechanical ventilation, lung reductions surgery and lung transplantation can be avoided.<sup>46-49</sup>

#### SUMMARY

Bronchiectasis patients with uncontrolled disease require frequent hospitalization for treatment of severe respiratory exacerbations. They experience accelerating declines in lung function, progressive lung damage and eventual respiratory failure. Extended survival and improved general health for patients with severe septic respiratory disease is predicated upon daily clearance of airway mucus. HFCC is an evidence-based therapy that meets or exceeds standard of care criteria. Physicians' preference for HFCC is clear; they prescribe it for the majority of their CF patients as well as thousands of patients with non-CF bronchiectasis. Patient acceptance and satisfaction is demonstrated by superior adherence to therapy. Improved patient outcomes support cost-effectiveness. HFCC may be relied upon to meet the intensive lifetime therapy needs of patients NCFB.

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