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High-Frequency Chest Wall Oscillation Successful in Controlling Refractory Asthma

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Abstract

Introduction—High-frequency chest wall oscillation (HFCWO) has been traditionally implemented for airway secretion clearance in conditions such as cystic fibrosis (CF) and bronchiectasis. There have been few reports of its use in refractory asthma.

Case report—A 36-year-old, non-smoker male presented with a lifelong history of poorly controlled asthma. Despite multiple controller medications, he reported daily chest congestion, copious phlegm, and frequent exacerbations. Imaging, blood work, and bronchoscopy ruled out atypical infections, immunodeficiency, CF, and other chronic conditions. Pulmonary function tests supported a diagnosis of asthma.

Results—We initiated HFCWO therapy twice daily in addition to standard inhaled pharmacological therapy. After 2 months, the patient noted resolution of respiratory symptoms as well as improvement in lung function. He remained symptom-free at his 2-year follow-up.

Conclusion—High-frequency chest oscillation may be useful in phenotypes of asthma characterized by prominent mucus hypersecretion.

Keywords

asthma; clearance; HFCWO; hypersecretion; mechanical; mucus; vest

INTRODUCTION

Severe persistent asthma, characterized by respiratory symptoms limiting physical activity, frequent exacerbations, and persistent airflow obstruction, affects 5–10% of asthma patients (¹). To date, asthma strategies have mainly targeted bronchoconstriction and inflammation. In contrast, control of airway mucus hypersecretion has received less attention. Mucus plugging contributes to the pathophysiology of asthma, further narrowing airways and exacerbating chronic airflow limitation, and is a consistent feature of fatal asthma in adults and children (^{2, 3}). Therefore, targeting mucociliary dysfunction with pharmacotherapy or

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DECLARATION OF INTEREST

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facilitating mucus clearance with mechanical approaches may be an important component of effective asthma treatment. In this case report, we describe the use of a mechanical approach to mucus clearance with high-frequency chest wall oscillation (HFCWO) in a patient with refractory asthma.

CASE REPORT

A 36-year-old man presented with a life-long history of poorly controlled asthma. He described episodes of wheezing and chest tightness that began in childhood and continued into adulthood, daily cough with copious clear phlegm, and 1–2 nocturnal awakenings each month. Chronic symptoms were punctuated by frequent episodes of worsening congestion, wheeze, chest tightness, and drops in peak flow from 400 to 300 L/min, especially in cold weather. These episodes required multiple courses of systemic corticosteroids and antibiotics with only partial relief. He denied fevers, chills, hemoptysis, and sinus symptoms. He did not report significant environmental exposures (including tobacco smoke), eczema, or gastro-esophageal reflux disease (GERD). Symptoms were unrelenting despite long-term therapy with controller medications, including a variety of high-dose inhaled corticosteroids, leukotriene-receptor antagonists, anti-cholinergics, and a trial of theophylline. Physical examination revealed a 167.5-cm, 72-kg male with a 97% oxyhemoglobin saturation on room air. He had no oropharyngeal lesions or nasal polyps. Chest examination revealed clear lungs bilaterally without crackles, rhonchi, or wheezes. His cardiac examination was unremarkable. Examination of the vocal cords under direct visualization showed no paradoxical motion. Blood work revealed a WBC count of 5.3 K with 2% eosinophils. Serum immunoglobulins (IgG, IgA, and IgM) were within normal limits. Serum IgE was 133 IU/mL and sweat chloride level was normal at 15 mEq/L. A complete serum hypersensitivity panel, including precipitating antibodies to *Aspergillus fumigatus*, was negative. Microbiologic testing of expectorated sputum showed normal respiratory flora and a bronchoalveolar lavage (BAL) culture specimen did not grow pathologic organisms, including acid-fast bacilli; cell count of the BAL was not available. Pulmonary function tests showed a forced expiratory volume in 1 second (FEV₁)/forced vital capacity (FVC) of 45%, FEV₁ of 1.64 L (55%), FVC of 3.63 L (83%), and a residual volume (RV)/total lung capacity (TLC) of 41%, confirming obstruction in the absence of provocative or bronchodilator testing. A computed tomography (CT) scan of the chest performed with contrast revealed hyperinflation, but no parenchymal or airway abnormalities (Figure 1). Based on this workup, he was deemed to have asthma characterized by significant mucus dysfunction.

RESULTS

As conventional pharmacologic management for asthma had been unsuccessful for this patient, we initiated a trial of HFCWO (Figure 2). The HCFWO regimen consisted of twice daily, 20-minute sessions at a frequency of 14 Hz and pressure setting of 4 (The Vest® System; Hill-Rom, St. Paul, MN, USA). The patient reported immediate improvement in mobilization of mucus with each cough. After several weeks, all sputum expectoration ceased, and his cough and congestion resolved. He no longer required regular use of a rescue inhaler. He continued to have symptom-free days for several months, with no further need

for antibiotics or corticosteroids. His FEV₁ improved to 2.22 L (60%) without significant change in FVC (3.8), FEV₁/FVC increased to 58% predicted, and his RV/TLC decreased to 33% after 3 months. After a prolonged asymptomatic period, the patient then discontinued HFCWO. His cough and sputum expectoration recurred after only 5 days. We re-initiated treatment, and his symptoms once again subsided. Follow-up at 2 years, with self-reported regular use of HFCWO, demonstrated continued asthma control without daily symptoms or frequent exacerbations.

DISCUSSION

This case typifies severe asthma, refractory to medical therapies directed against airway inflammation and bronchoconstriction. A prominent feature of this patient's asthma was excessive mucus production, which prompted us to consider HFCWO. His remarkable subjective and objective improvement on HFCWO, previously tolerated in patients with asthma exacerbations⁽⁴⁾, demonstrates that management of his airways secretions was integral to achieve asthma control.

Several phenotypes of severe asthma are recognized, including more severe variants that are characterized by excessive sputum production⁽⁵⁾. In normal airways, mucus is essential for trapping allergens and irritants, which are then swept out of the lungs by beating cilia and the cough reflex⁽²⁾. In asthmatic airways, increased mucus secretion or its impaired clearance can not only be an indicator of an uncontrolled underlying process⁽⁵⁾, but also promote infection, injury, and inflammation⁽²⁾. Thus, airway clearance such as HFCWO may prove useful in arresting the cycle of mucus, airway inflammation, plugging, and injury caused by mucus dysfunction. Furthermore, successful clearance of mucus may improve aerosol delivery to distal airways.

Few studies have rigorously examined the utility of HCFWO or other mechanical methods of mucus clearance in asthma management. Mahajan et al. reported that HCFWO use resulted in subjective improvements in dyspnea after patients with asthma or chronic obstructive pulmonary disease (COPD) were admitted to the hospital⁽⁶⁾, and a single case report described clinical improvement with the use of HCFWO in a patient with asthma admitted for acute mucous plugging following an acute toxic inhalation⁽⁷⁾. Our report is, to our knowledge, the first published account of the benefit of HCFWO for asthma in the outpatient setting. In contrast, studies of other modalities of mechanical clearance have not shown consistent results. While a randomized placebo controlled trial of chest physiotherapy in thirty-eight children shortly after admission to the hospital for severe asthma did not alter lung function compared to placebo, a small subset of these children did demonstrate significant improvements in lung function suggesting that the benefit may be limited to certain types of asthma⁽⁸⁾. Another strategy, positive end-expiratory pressure device, was studied in 54 adults with asthma and found to improve lung function, but only after β_2 -agonist nebulization therapy⁽⁹⁾. As studies have been small, inconclusive, and heterogeneous, a Cochrane review of randomized trials examining the utility of various manual therapies in asthma concluded that evidence was insufficient to support their use, emphasizing the need for more work in this area⁽¹⁰⁾. Therefore, recommendations regarding the use of any of these modalities (including HFCWO) will require larger

randomized controlled trials that assess benefit in patients with asthma where mucous dysfunction is a prominent feature.

CONCLUSION

HFCWO may be a useful drug-sparing treatment modality for patients with difficult-to-control asthma characterized by excessive mucus production.

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FIGURE 1.

A representative section of the patient's thoracic CT, which revealed hyperinflation, but no bronchiectasis, infiltrate, or effusion.

FIGURE 2.

High-frequency chest wall oscillator, pictured here on a model. An inflatable garment is worn across the chest and is connected to a generator that rapidly fills and deflates the garment, allowing compression and release of the chest wall. This high-frequency process dislodges mucus from the bronchial walls and moves secretions up into the central airways to be cleared. Photo by Christian Merlo.