

High-Frequency Chest-Wall Compression During the 48 Hours Following Thoracic Surgery

James S Allan MD FAARC, Julie M Garrity BSN, and Dean M Donahue MD

BACKGROUND: Postoperative pneumonia continues to be a leading cause of mortality and morbidity after thoracic surgery. High-frequency chest-wall compression (HFCWC) is an established therapeutic adjunct for patients with chronic pulmonary disorders that impair bronchopulmonary secretion clearance. We studied the feasibility of applying HFCWC following thoracic surgery. **METHODS:** Twenty-five consecutive adult patients who underwent a variety of thoracic operations received at least one HFCWC treatment in the first 2 postoperative days, along with routine postoperative care. HFCWC was applied at 12 Hz, for 10 min. Routine hemodynamic and pulse oximetry data were collected before, during, and after HFCWC. We also collected qualitative data on patient tolerance and preference for HFCWC versus percussive chest physiotherapy. **RESULTS:** No major adverse events were encountered. Hemodynamic and pulse oximetry values remained stable before, during, and after HFCWC. Eighty-four percent of the subjects reported little or no discomfort during therapy, and the subjects who expressed a preference preferred HFCWC to conventional chest physiotherapy by more than two to one. **CONCLUSIONS:** HFCWC is a safe, well-tolerated adjunct after thoracic surgery. The observation of hemodynamic stability is especially important, considering that the patients were studied in the early postoperative period, during epidural analgesia. *Key words:* postoperative pneumonia, thoracic surgery, high frequency chest wall compression, HFCWC. [Respir Care 2009;54(3):340–343. © 2009 Daedalus Enterprises]

Introduction

Postoperative pneumonia resulting in respiratory failure continues to be a leading cause of mortality, morbidity, and prolonged hospital stay after thoracic surgery.¹ A patient's ability to clear pulmonary secretions following thoracic surgery is a key determinant of the success or failure of the patient's postoperative course. Retained secretions increase intrapulmonary shunt, decrease lung capacity, cause hypoxemia, increase the work of breathing, and are the substrate for nosocomial pneumonia.²

Over the past half century, chest physiotherapy, which consists of manual percussion and vibration of the chest,

has been used to facilitate the clearance of postoperative pulmonary secretions.³ Several recent controlled clinical trials (and a large body of anecdotal experience) have demonstrated benefit from manual chest physiotherapy,^{4,5} but the potential for discomfort and iatrogenic complications from chest physiotherapy is also well described.⁶ Unfortunately, conventional chest physiotherapy is highly operator-dependent,⁷ so its efficacy is quite variable. Moreover, it is labor-intensive, costly, and can be quite painful,

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especially when applied over a healing thoracotomy, which usually is the area most in need of treatment.

High-frequency chest-wall compression (HFCWC) applies rapid but gentle external compressions to the thorax to generate air flow velocities that facilitate bronchopulmonary secretion clearance.⁸ HFCWC is typically delivered in a timed, standardized fashion, with a vest attached to an air-pulse generator. For over 10 years HFCWC has been an established therapy in the management of non-

James S Allan MD FAARC, Julie M Garrity BSN, and Dean M Donahue MD are affiliated with the Division of Thoracic Surgery, Department of Surgery, Massachusetts General Hospital, Boston, Massachusetts.

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Correspondence: James S Allan MD FAARC, Division of Thoracic Surgery, Massachusetts General Hospital, 55 Fruit Street, Blake 1570, Boston MA 02114.

Table 1. Surgical Procedures (*n* = 25)

Description	No.
Lobectomy	6
Wedge resection	5
Esophagogastrectomy (Ivor-Lewis)	4
Sleeve lobectomy	2
Wedge and chest-wall resections	1
Pulmonary decortication	1
Belsey hiatal hernia repair	1
Pleurodesis with pleural biopsies*	1
Rib resections	1
Segmentectomy	1
Lung biopsy*	1
Bullectomy	1

* Minimally invasive, video-assisted

surgical patients who have impaired bronchial secretion clearance, including individuals with neuromuscular disorders,⁹⁻¹² chronic obstructive pulmonary disease,^{13,14} and cystic fibrosis.¹⁵⁻¹⁸ HFCWC has also shown promise in optimizing pulmonary function and enhancing the organ-procurement rate in potential lung-transplant donors.^{19,20} Finally, HFCWC is well tolerated by and potentially beneficial for critically ill patients.²¹ Based on that clinical experience, we hypothesized that HFCWC could provide well-tolerated, effective, standardized, and low-cost pulmonary toilet after thoracic surgery.

Methods

Twenty-five consecutive patients (age range 47–83 y), who underwent a variety of elective thoracic operations, received at least one HFCWC treatment (in addition to routine postoperative care) during postoperative day 1 or 2 (Table 1). HFCWC was applied with The Vest (Hill-Rom, St Paul, Minnesota), which consists of an air-pulse generator and a single-patient-use chest wrap, which was applied snugly over the patient’s gown. The principal determinant of the tightness of the vest was the static pressure setting of the air-pulse generator, which was 5. The air-pulse generator was set at 12 Hz, which is a commonly used frequency and appears to maximize air flow and the volume of air displaced.^{22,23} HFCWC was applied for 10 min, which is the typical duration of manual percussive chest physiotherapy in this patient population. Blood pressure was continuously monitored via radial-artery catheter. Heart rate was monitored via electrocardiography. Hemoglobin oxygen saturation was measured via digital pulse oximetry. Data were collected during the 10 min prior to HFCWC, the HFCWC period, and the 10 min after HFCWC. During the post-HFCWC period we also collected

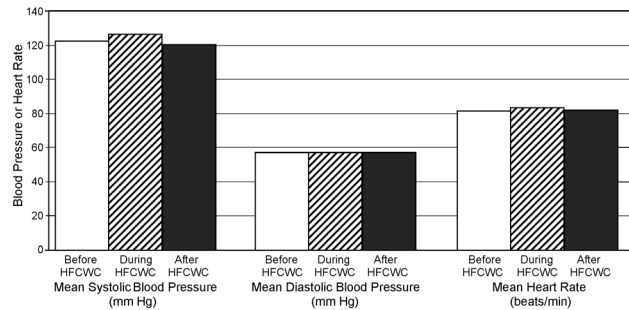


Fig. 1. Blood pressure and heart rate before, during, and after high-frequency chest-wall compression (HFCWC).

qualitative data regarding patient tolerance of and preference for HFCWC versus percussive chest physiotherapy.

Hemodynamic and oximetry values were compared with a heteroscedastic 2-tailed Student’s *t* test. Differences were considered significant when *P* < 0.05.

In addition to the HFCWC described above, all patients received our standard postoperative respiratory care, which includes the nurse’s encouragement of deep breathing, incentive spirometry every 2 hours while awake, and ambulation at least 3 times a day, beginning on the morning following surgery. Also, percussive chest physiotherapy (focused on the operation site) was administered on a protocol-driven basis by respiratory therapists, who see the patient immediately after surgery. These routine physiotherapies are applied to all our thoracic surgery patients to prevent secretion retention, atelectasis, and pneumonia. The fraction of inspired oxygen (F_{IO₂}) was titrated to keep arterial oxygen saturation ≥ 92%. Most patients were on supplemental oxygen at 2 L/min via nasal cannula, and in no case did supplemental oxygen exceed 4 L/min via nasal cannula, or F_{IO₂} 0.40 via air-entrainment mask.

This investigation was conducted in accordance with our institution’s policies and requirements for the protection of human research subjects, and all subjects gave informed consent.

Results

No major adverse events (unfavorable alterations in hemodynamics or oxygenation, cardiac arrhythmia, wound dehiscence, wound infection, tube dislodgement, or other medical conditions that resulted in the need for unanticipated medical intervention) were encountered during or after HFCWC. Before, during, and after HFCWC there were no significant changes in mean systolic blood pressure (122 ± 24 mm Hg vs 126 ± 22 mm Hg vs 121 ± 18 mm Hg), mean diastolic blood pressure (57 ± 7 mm Hg vs 57 ± 8 mm Hg vs 57 ± 7 mm Hg), heart rate (82 ± 13 beats/min vs 83 ± 13 beats/min vs 82 ± 13 beats/min), respectively (Fig. 1), or hemoglobin

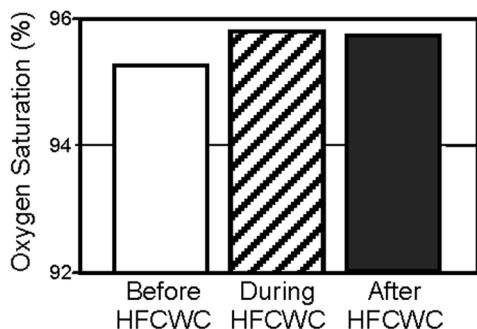


Fig. 2. Hemoglobin oxygen saturation before, during, and after high-frequency chest-wall compression (HFCWC).

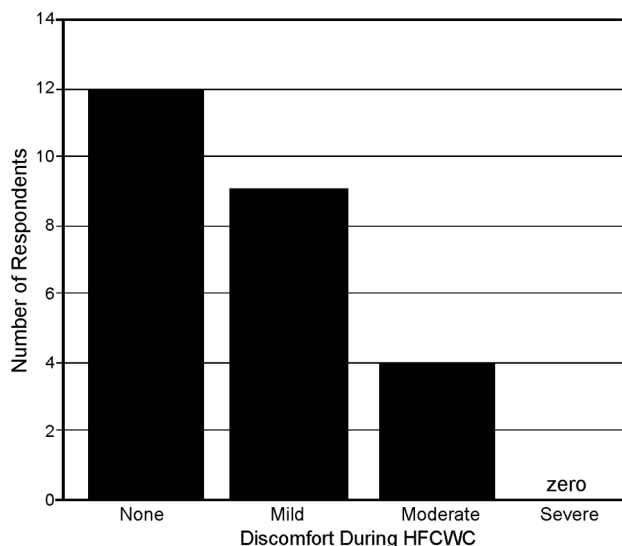


Fig. 3. Patient-reported discomfort during high-frequency chest-wall compression (HFCWC).

oxygen saturation ($95 \pm 2\%$ vs $96 \pm 2\%$ vs $96 \pm 2\%$) (Fig. 2).

Eighty-four percent of the subjects reported little or no discomfort during HFCWC (Fig. 3). HFCWC was preferred to conventional chest physiotherapy by more than two to one among the subjects who expressed a preference (Fig. 4). There were no significant demographic differences between the subjects who expressed a preference for HFCWC or conventional chest physiotherapy.

Discussion

First and foremost, the present data confirm that HFCWC can be safely applied in the first 48 postoperative hours in typical thoracic surgery patients. Our study population included patients who underwent pulmonary and esophageal operations, with minimally invasive techniques and with major thoracotomy. During HFCWC we observed no hemodynamic lability (see Fig. 1), despite using HF-

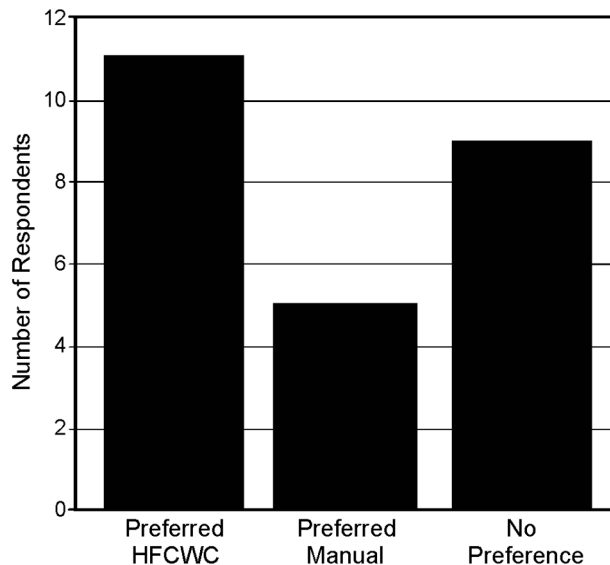


Fig. 4. Patient-reported preference for high-frequency chest-wall compression (HFCWC) or conventional manual percussive chest physiotherapy.

CWC during the early postoperative period, when these patients are typically mildly hypovolemic and receiving thoracic epidural analgesia. Additionally, oxygen saturation was unchanged during HFCWC (see Fig. 2), without increasing the F_{IO_2} , which suggests that the mild chest-wall restriction imposed by the HFCWC vest is not sufficient to cause clinically important respiratory embarrassment.

Second, our subjects had a high degree of acceptance of HFCWC, most of them had little or no discomfort during HFCWC (see Fig. 3), and the subjects who expressed a preference preferred it to conventional chest physiotherapy by more than two to one (see Fig. 4). This high acceptance most likely relates to the fact that the oscillatory impulses from the vest are non-focally distributed across the thorax, in contrast to the focal impacts of manual percussion.

Limitations

Because this study was designed solely to assess the feasibility of HFCWC after thoracic surgery, routine airway clearance measures (including manual percussive chest physiotherapy) were not replaced by HFCWC. To determine whether HFCWC could replace manual chest physiotherapy (and other routine postoperative pulmonary care measures) a much larger randomized study would be needed. We also did not include an untreated control group, because this study was designed solely to determine the feasibility of HFCWC during the 2 days after thoracic surgery. Nonetheless, it is our clinical judgment that HF-

CWC is an excellent alternative to the labor-intensive practice of conventional percussive chest physiotherapy, and offers greater patient acceptance and standardization of therapy after thoracic surgery.

Conclusion

HFCWC is a safe, well-tolerated secretion-clearance adjunct in the first 2 days after thoracic surgery.

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