The Usage of High-Frequency Chest Compression
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**Mechanism of Action**
High-frequency chest compression (HFCC) devices have a complex mechanism of action that has not been fully elucidated. One prevailing theory hypothesizes that these devices affect air movement via the pendelluft mechanism, or the movement of gas out of and into other airspaces. Pendelluft will increase recirculation of air, and ultimately increase alveolar ventilation to closed or under-ventilated lung units, resulting in improved gas mixture and homogenization of expiratory gas concentration from neighboring lung units with differing time constants. In addition, evidence suggests that differential airflow velocities cause shearing of mucous with dislodging of adherent mucous and cephalad flow (Hansen 1994). The vibratory effect of HFCC therapy may also cause a reduction in mucous viscosity (Majaesic 1996).

High-frequency chest compression (HFCC) devices deliver high oscillation frequencies, which may lead to small airway closure and deterioration of gas exchange, particularly for patients with expiratory flow limitation, and, therefore, may result in desaturation during therapy. Functional residual capacity (FRC), or end expiratory lung volume (EELV) may be decreased during high-frequency chest wall therapy because of positive pressure applied across the chest wall (Jones 1995). HFCC devices come in multiple forms.

**Research Supporting Utility**

**Cystic Fibrosis**
In pediatric patients with cystic fibrosis, use of HFCC device therapy is approaching standard of care in the United States, particularly in the outpatient setting. It is one option for airways clearance, shown to be effective but not superior to other alternatives, including positive expiratory pressure therapy. Studies indicate the HFCC device is well tolerated and associated with better compliance (Yuan 2010) compared to standard chest physiotherapy. HFCC has been shown to be as effective as conventional chest physiotherapy with relation to clinical status, pulmonary function, and secretion clearance in pulmonary exacerbations (Arens 1994, Burnett 1993).

**Respiratory disease related to neurologic disease**

**Cerebral Palsy**
Studies in this field are small, and more research is indicated in this significant population. One study in pediatric cerebral palsy patients (n=6) indicated that high-frequency chest wall devices may result in fewer pneumonias, respiratory-related hospitalizations, and increased effective suctioning interventions (Plioplys 2010). Another study of 13 subjects compared outcomes in the year before and after initiation of the HFCC device, and showed a significant reduction in hospitalizations and ER visits (Overgaard 2005). In a randomized controlled trial with 23 subjects on HFCC vest, Yuan (2010) found a trend toward fewer hospitalizations and decreased antibiotic use.

**Neuromuscular Disease**
Data in this disease group is similarly limited in patient number and study duration, however HFCC has been well tolerated without major adverse events in at least one short-term safety study (Castagnino 1996). A recent study of 22 patients lasting 2 years compared outcomes in the year prior to and following initiation of HFCC vest. A significant reduction in hospitalization rates was found: 45% of
patients hospitalized before initiation of therapy compared to 36% in the first year after and 13% after the second year (Fitzgerald 2014). Although the sample size is modest, the large effect size suggests that usage of HFCC in this group may decrease hospital burden.

**Non Cystic Fibrosis Bronchiectasis**

The HFCC device has been commonly used in patients with bronchiectasis, but with limited data to objectively confirm clinical effectiveness.

**Device Specifics**

Age indication for usage is not clearly established (with some usage reported as early as age 2). The equipment consists of an air pulse generator attached to tubing with an adjustable jacket. The jacket is generally applied at approximately 110% of the chest wall circumference. The device can be set at variable frequencies and pressure settings specific to each device. The device delivers compressive pulses to the chest wall to produce airflow through an oscillatory effect in the airway. Given the significant differences in frequency and pressure amplitudes across the different devices, it is advised to monitor clinical effect and tolerance of individual patients.

The original devices utilized square waveform physiology. These have been replaced largely by sine waveform technology followed by triangle waveform technology. A study by Milli et al. (2004) suggests pressure waveforms produced by the vest are demonstrable at the level of the mouth, and there is potentially improved sputum production in patients using the triangle waveform. However, optimal frequencies for each waveform, disease, and patient have not been clearly identified. Adjustments in device inflation pressure and frequency of compressions can produce differences in the volume of air displaced and flow of air. High-frequency chest wall devices are best tolerated by patients who are able to generate their own endogenous cough.

**Device Time Cost**

Time cost for the therapy includes 20 minutes for initial setup and 20-30 minutes for treatments. In general, documentation of usage of device by patient is required by durable medical equipment companies for ongoing providing of equipment.

**Summary**

In general, the HFCC device is well tolerated and safe in adult and pediatric patients. Adherence rates are generally high when compared to other airway clearance regimens. Strength of data to support effectiveness is variable according to disease process.

HFCC device therapy has approached “standard of care” status for the cystic fibrosis population, particularly in the US, and is particularly efficacious in those with endogenous cough. Outside of cystic fibrosis, the data are relatively sparse, yet some studies are suggesting decreased respiratory-related hospitalization rates in patients with respiratory manifestations of neurologic disease. Literature available largely includes single-center studies involving fewer than 30 patients and without an independent matched control group. HFCC device use is common in pediatric patients, yet studies to date are only suggestive of a modest benefit to those who are experiencing frequent acute exacerbations of their chronic disease. As this therapy is being used widely and at great expense, it is imperative that research into its clinical effectiveness be supported, with particular attention being paid to impact on disease progression, quality of life, cost effectiveness, and rates of hospitalization.

**Indications**
HFCC therapy is indicated in patients with cystic fibrosis as part of an airways clearance regimen. HFCC therapy may be indicated in patients with cerebral palsy (particularly those with inability to clear secretions) and neuromuscular disease specifically if the goal of therapy is to reduce respiratory hospitalizations and ER visits. HFCC therapy may be indicated in primary ciliary dyskinesia and other types of non-CF bronchiectasis.

Contraindications
Relative contraindications to vest therapy include chest wall pain/wounds, instability of spine, elevated intracranial pressure, bronchospasm, massive hemoptysis, thrombocytopenia, lung contusion, and pneumothorax.

Future Research Needs
Studies to evaluate:
  a) Long term outcomes in the chronically ill, namely neuromuscular weakness, cerebral palsy with and without cognitive impairment, and non-cystic fibrosis bronchiectasis
  b) Decreasing need for hospitalization by improving patient compliance with use of the device and improving lung function in outpatient cohorts
  c) Any studies, including case series, studying the effect of HFCC on PCD given widespread usage

References:


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