Positive Expiratory Pressure Physiotherapy for Airway Clearance in People With Cystic Fibrosis: A Cochrane Review Summary With Commentary

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Background

Cystic fibrosis (CF) is an inherited disorder that involves several organs; however, 85% of mortality from this disorder is related directly to lung disease. CF results in an overproduction of thick, tenacious secretions that obstruct airways, making them prone to infection. The trapped airway secretions are a suitable media for bacterial growth because of the sugar content, high humidity, and warm environment. The infected secretions often lead to inflammation of the airways and atelectasis. Trapped secretions can lead to occluded distal airways that may act as a ball-valve mechanism producing hyperinflation of the lung. The associated air trapping results in ventilation-perfusion mismatching by increasing the dead-space-to-tidal-volume ratio

Techniques used to augment airway clearance traditionally have included percussion, vibration, and postural drainage (PVPD), also referred to as chest physiotherapy (CPT), followed by a series of both forced exhalations and coughing. CPT is a time-consuming process and can also be uncomfortable for the patient who is receiving the therapy.[1] CPT requires assistance either from another practitioner or a family member, which can have an effect on the adherence to prescribed therapy.[2] Alternative techniques have been described that are more patient-initiated including thoracic oscillating devices such as the vest or positive expiratory pressure (PEP) therapy. PEP can be provided either with a face mask or by using a mouthpiece.

PEP involves exhaling against a spring-loaded valve or through a flow resistor.[1-4] The expiratory impedance generates back pressure that has been hypothesized to stent open flaccid airways, thus delaying dynamic airway collapse.[3,4] With the airway supported against premature closure, secretion clearance is enhanced by 2 mechanisms: improved aeration resulting from a more complete exhalation and an increase in flow distal to the mucus. With the resulting back pressure created during this procedure, there is a temporary increase in functional residual capacity (FRC) and tidal volume (V_T).

PEP is intended to be a self-administered treatment using various interfaces such as a face mask or a mouthpiece with nose clips, creating a closed system. As the patient exhales, the goal is to achieve a level of positive pressure between 10–20 cm H_2O for a period of 12–15 breaths. The interface is then removed from the patient, who is then encouraged to follow through with a series of forceful exhalations or huffing in order to aid secretion clearance. Another variation in PEP technique consists of forcefully exhaling against the resistor, creating high expiratory pressures ranging from 40–100 cm H_2O (Hi-PEP). This forceful exhalation often stimulates a cough through the mask.

The purpose of this commentary is to discuss the published Cochrane Review "Positive Expiratory Pressure Physiotherapy for Airway Clearance in People with Cystic Fibrosis"[2] from a respiratory care perspective, produced under supervision of Cochrane Cystic Fibrosis and Genetics Disorders Group. Cochrane Corner is produced in agreement with RESPIRATORY CARE by Cochrane Rehabilitation.

What is the Aim of This Cochrane Review?

The aim of this Cochrane Review was to determine the effect of PEP on the clearance of airway secretions compared to other airway clearance techniques in people with CF and to test the following hypotheses:

1. PEP improves outcomes for people with CF more than other airway clearance techniques
2. PEP is more acceptable to people with CF than other airway clearance techniques.[3]

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What Was Studied in the Cochrane Review?

Subjects of all ages ranging from infants < 4 months of age to adult with a diagnosis of CF regardless of disease severity were included. CF subjects post lung transplant were excluded from analysis in this review.

Two differing levels of PEP were included for consideration within this review. For most of the studies included, expiratory pressures between 10–20 cm H_2O for 12–15 breaths were the preferred method. Alternatively, expiratory pressures as high as 40–100 cm H_2O were used by Oberwaldner in one study of 20 subjects referred to as "Hi-PEP."[2]

This review included randomized controlled studies of both parallel and crossover design as well as prospective observational. Studies included both individual and cluster grouping. Due to the nature of the interventions being evaluated, blinding was not possible.

The primary outcomes were changes in FEV_1, number of respiratory exacerbations between baseline and post intervention, and direct measures of mucus clearance rate as assessed by radioactive tracer. There were 14 other secondary outcomes: amount of expectorated secretions, FVC, forced expiratory flow 25%-75%, total lung capacity, residual volume, FRC, exercise tolerance, well-being, blood oxygen levels, lung clearance index, ventilation scanning, cost of intervention, adherence to treatment, and adverse events.

Up to Dateness of the Cochrane Review?

This review included studies published up to February 2019.

What Are the Main Results of the Cochrane Review?

The authors of this review identified 116 citations representing 70 studies. A total of 28 studies met the inclusion criteria set involving 788 participants. Twenty-one were published as full articles, whereas 7 were published in abstract form only. The age of participants ranged from infants at 4 months of age through adult. Two of the 28 studies had a matched-gender ratio, whereas the other 26 studies had more male than female participants. The duration of the treatment varied ranging from a single treatment to 1 y. Twenty-six of the studies reported the impact on FEV_1. One of the 2 studies that did not report FEV_1 reported FEV 0.75, and the other study was in infants. One study (19 participants) measured FVC after a single treatment with either PEP or PVPD. Five studies (151 participants) measured FVC after a series of treatments over 7 d.

The review shows that:

- Comparison: PEP versus PVPD among the 5 relevant studies. There was significant advantage in the PEP group compared with PVPD in the change in FEV_1 from baseline with a mean difference (MD) 8.26 (95% CI 0.76–15.76) (one study with 106 participants); however, other studies (4) found no significant difference between groups (low certainty evidence).
- FEV_1 improved by a mean of 5.98% of predicted for the PEP group, whereas the PVPD group deteriorated by 2.28% (MD 8.26 [95% CI 0.76–15.76]) (1 study with 40 participants).
- No significant difference in the rate of decline in FEV_1 was reported for adults in a 2-y study (MD −0.65 [95% CI −3.25 to 1.95]) (1 study with 66 participants).
- No significant difference in number of exacerbations between groups (one study with 66 participants).

Comparison: PEP Versus Oscillating PEP

- No significant difference regarding change in FEV_1 from baseline was noted between groups (7 studies with 247 participants) (moderate quality evidence).
- A mean hospitalization per participant rate of 0.3 in the PEP group and 0.7 hospitalizations per participant in the flutter group (MD −0.40 [95% CI −0.92 to 0.12]) (1 study with 52 participants).

Comparison: PEP Versus HFCWC

- No significant difference regarding change in FEV_1 from baseline was noted between groups (4 studies with 174 participants) (low certainty evidence).
- A parallel study with 106 participants compared PEP to high-frequency chest-wall compressions (HFCWC) and found 60% (26) in the PEP group had a total of 49 exacerbations, whereas 83% (40) of subjects receiving HFCWC had 96 exacerbations in the HFCWC limb (95% CI 0.55−0.95) (high certainty evidence).
- Comparing PEP to HFCWC, change in FEV_1 over 1 y was not significantly different between the 2 groups (MD −3.59 [95% CI −9.29 to 2.11]) (one study with 107 participants) (low certainty evidence).

Comparison: PEP Versus BPAP

- No significant difference in FEV_1 was demonstrated (2 studies with 52 participants) (low certainty evidence).

- One study comprising 32 participants in a 3-month trial showed no significant differences in FEV_1 when using either PEP or bi-level positive airway pressure (low quality evidence).
- When a variety of other airway clearance techniques were compared against PEP, 3 studies totaling 56 participants were unable to show a significant improvement in FEV_1. The studies ranged from one week to at least a month.

What Did the Authors Conclude?

Even though there was variable quality of evidence ranging from studies conducted over a few days to randomized controlled trials, the evidence described in this updated Cochrane Review suggests that all techniques and devices described may have a place in the treatment of CF symptoms. There was some evidence to recommend PEP as a more acceptable intervention compared with CPT. The studies suggesting that PEP is preferential over other techniques generally came from lower-quality studies with smaller sample sizes.

What Are the Implications of the Cochrane Evidence for Respiratory Care Practice?

Airway clearance is vital to the practice of respiratory care. Maintaining patency of the bronchi and distal airways improves gas exchange and can decrease opportunities for infection and inflammation of the lung. Various techniques have been developed to achieve this goal, but some require specialized equipment, assistance from another person and can impart discomfort to the participant. This review explored the efficacy of a specific type of treatment, PEP, compared with other therapies.

The authors of this review's primary focus, FEV_1, number of exacerbations, and secretion clearance, all strive for the same goal, to improve pulmonary mechanisms in order to prevent comorbidities forming. The FEV_1 and secretion clearance rate measure cough effectiveness. Being able to generate and sustain sufficient flow in order to mobilize secretions was the primary focus for the included studies. The number of exacerbations over a fixed period of time reflects the effectiveness of the therapy or group of therapies to prevent the need for increased care. Hospitalization has a monetary cost and a cost on the patient's personal quality of life.

Although describing a different population than examined here, in a study by Osadniket al,[3] when comparing PEP therapy to the usual care for a group of 98 subjects with COPD, the authors found no significant variation between the 2 groups except for a reported improvement in shortness of breath in the PEP group during the 6-month follow-up. This is consistent with the findings of the authors of this review. However, the authors did not identify a decrease in the rate of hospitalization between the 2 groups. This is likely due to the nature of COPD, where the benefit of PEP disappears once the back pressure discontinues and dynamic airway collapse is more common.

Many of the studies included within this review are in abstract form only, which presents some difficulty in assessing the effect of each intervention. The severity of illness of the subjects was not considered in any of the included reports within this review. Disease severity, PEP device and method, as well as pharmacologic treatments are factors that could be matched in larger and longer-term studies. This gap reinforces the need identified by the review's authors for more robust research within this population.

PEP therapy either using oscillating PEP, Hi-PEP, or standard PEP is a therapy; and due to the diversity of symptoms of CF and other pulmonary diseases, it is a tool that can be used by the practitioner. Perhaps if it is alternated with other therapies this would not pose as much of a burden on the patient, and continued use might have prolonged effects.

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