PEP therapy in secretion management

Positive expiratory pressure therapy is a useful and adaptable form of airway clearance therapy that can be used for individuals of all ages

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Airway clearance techniques (ACTs) are essential components of respiratory physiotherapy treatments for people who have excessive pulmonary secretions or who have difficulty clearing secretions. These techniques have been described in the literature for over a century, but positive expiratory pressure (PEP) therapy in its various forms, only began to appear in the literature after the Second World War, beginning with intermittent positive pressure breathing (IPPB). The use of IPPB specifically for secretion management by physiotherapists only emerged after a further two decades, but it is still used in many clinical settings today. The PEP mask, developed in Denmark in the late 1970s, was one of the earliest portable PEP secretion clearance devices which remains widely used in Scandinavia, Europe, and Canada.

The main aims of ACTs are to reduce mucus plugging, improve lung recruitment and gas exchange in patients with atelectasis and to improve cough efficacy in patients with a weak or ineffective cough due to pain, neurological deficits or fatigue. A successful airway clearance treatment may therefore result in removal of excess mucus, improvements in regional ventilation, reduction in atelectasis and a more effective cough. Patients who may benefit from ACTs include those with retained pulmonary secretions from acute or chronic causes, patients with reduced postoperative lung function from anaesthesia, fatigue and pain, or patients with neurological injuries or neuromuscular disease who may be unable to clear secretions due to weak muscles and an ineffective cough.

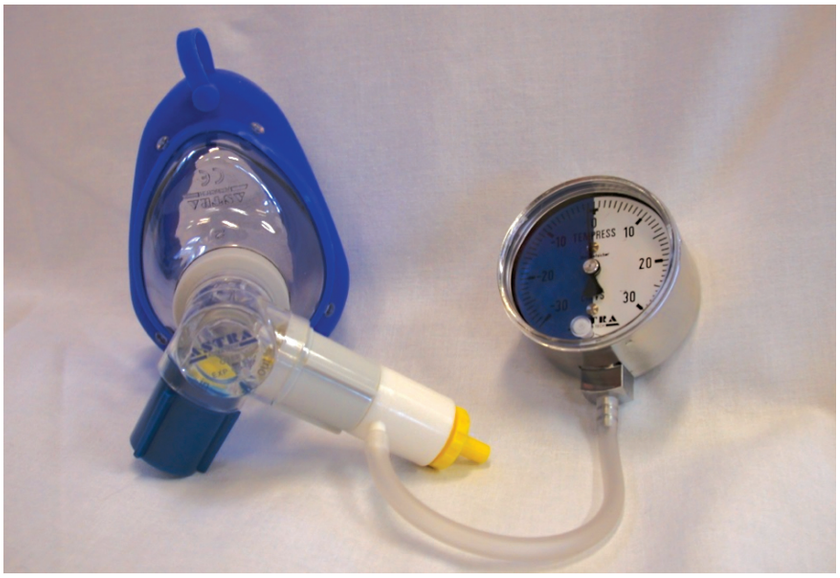

Fig. 1: PEP mask with manometer

Indications for use and types

The use of PEP within secretion management may be beneficial in a number of respects. PEP therapy involves the patient breathing out against a flow or threshold limited resistance, in order to produce positive airways pressure. PEP devices usually consist of a one-way valve allowing unrestricted (or supported) inspiration and a resistance to expiration either through a resistor valve or via an orifice, which may be varied depending on individual requirements. Most commercially available PEP devices incorporate flow resistance, with expiration occurring through a fixed (but interchangeable) orifice and the resultant positive pressure varying with the magnitude of expiratory airflow generated by the patient.

PEP is most commonly delivered

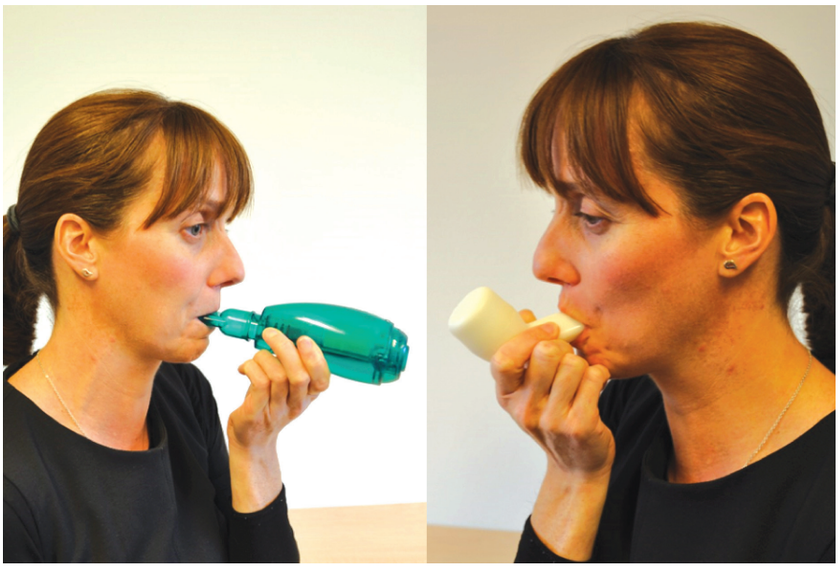

Fig. 2: Oscillating PEP devices, Acapella®on the left and Flutter® on the right

via a mouthpiece or a facemask with an attached PEP device. There are a wide variety of commercially available devices for the provision of PEP therapy. These include PEP devices both with and without an oscillatory airflow component. The PEP mask/mouthpiece delivers PEP only (Figure 1). There are also some combination devices, which deliver both PEP and airway oscillations during the expiratory phase of the breathing cycle. These oscillatory PEP devices include the Acapella®, RC Cornet®, Lung Flute®, Quake® and Flutter® (Figures 2 and 5). Many forms of PEP therapy are independent techniques that can provide effective secretion clearance while promoting treatment adherence, fostering patient independence and minimising physical discomfort.[1]

In addition, PEP therapy may be delivered via continuous positive airway pressure (CPAP), bi-level positive airways pressure (BiPAP), and intermittent positive pressure ventilation (IPPV) devices. There are also devices that combine elements of both positive and negative pressure throughout the breathing cycle with or without airway oscillations, such as intrapulmonary percussive ventilation (IPV).

When an individual breathes against the resistance through the PEP device, the increased pressure at the mouth is transmitted to the airways. This increased airways pressure holds the airways open during expiration, which is hypothesised to promote airflow through the peripheral airways and collateral channels of ventilation.[2] The increased expiratory airways pressure stabilises the airways by splinting them open during expiration, preventing premature airway closure and theoretically improving gas mixing, reducing gas trapping in the lung and facilitating airway clearance.[3,4] PEP therapy is also purported to promote movement of mucus towards the mouth by shifting the equal pressure point peripherally to maximise airflow behind the mucus. Utilising collateral ventilation channels in the lung theoretically does this and thus makes expiratory manoeuvres more effective.[5,6]

Because of these effects, the most common indications for PEP therapy use are retained secretions and atelectasis. It is recommended for use as a component of respiratory physiotherapy management for varying adult and paediatric patient groups including those with cystic fibrosis (CF),[4,5,7,8] acute and chronic respiratory disease,[1,9–11] for individuals with chronic obstructive pulmonary disease (COPD)[8] and in the postoperative setting.[12,13]

PEP therapy can be used in patients of all ages from infancy to older age.

" When an individual breathes against the resistance generated during PEP therapy, the increased pressure at the mouth is transmitted to the airways"

Fig. 3: Infant PEP mask

Infant PEP is usually delivered via an appropriately sized facemask, which is held in place over the infant's nose and mouth by the parent/carer and is usually performed in combination with some physical activity, for example sitting and bouncing on a gym ball (Figure 3). This is because infants are unable to change the size of their breath on command, and the additional activity will result in natural modulation of lung volumes. The mechanism of action of infant PEP is therefore different to that of PEP therapy for older children and adults. Infant PEP is primarily aimed at changing the ventilation distribution in infant's lungs whilst also creating the positive expiratory airways pressures to assist in splinting open the airways on expiration. These mechanisms facilitate changes in ventilation distribution and potentially clearance of secretions. The generation of specific airways pressures

Fig. 4: PEP mask for secretion management

is not the focus of treatment when using infant PEP as infants have poorly developed collateral ventilation. A pressure manometer is therefore not required in the infant PEP circuit.

For children under the age of four who no longer tolerate infant PEP but who are unable to progress to traditional PEP, "bubble PEP" can be a good alternative. Bubble PEP is a threshold resistor type of PEP in that the expiratory pressure remains constant once the tubing diameter is ≥8mm, independent of tube length.[14] It is a simple improvised device that can be constructed using easily accessible and low cost equipment in the home or hospital setting. It consists of a length of smooth bore rubber tubing and a plastic bottle (at least 1 litre in size) that is approximately half filled with water. The child blows through the tubing and this creates bubbles in the bottle. The height of water in the bottle (approximately 10cm above the bottom of the flexible tube) provides the threshold resistance to expiration and the bubbling effect produces an oscillatory effect in the airways. This is a fun way of engaging younger children in a secretion management technique which provides feedback and can be combined with more traditional airway clearance techniques such as the active cycle of breathing technique (ACBT).

PEP therapy via a mask or mouthpiece can be used for anyone over the age of about four years, as long they are able to follow instructions (Figure 4). PEP therapy requires an awareness of breath size as individuals are advised to inspire a volume of air that is slightly larger than a tidal volume breath at rest. An inspiratory hold just before breathing out is also recommended, to allow for the physiological mechanisms of pendelluft flow, interdependence and collateral ventilation to take place. During PEP therapy the individual is required to perform a controlled expiration against the resistance, aimed at maintaining expiratory pressures at the mouth between 10–20cm H_2O. Inserting a manometer into the circuit can provide both a useful monitor for the therapist and a very useful feedback mechanism for the individual. This form of therapy, involving slightly elevated tidal volume inspiration, and slightly active expiration against the resistance, is termed low-PEP.

Fig. 5: Oscillating PEP with RC-Cornet®

Another form of PEP, called high-PEP involves the use of high lung volumes and forced expiratory manoeuvres against the resistance that generate expiratory pressures greater than 20cm H_2O. The target pressures for high-PEP are calculated during spirometry, such that the target resistance would generate a pressure that allows the patient to produce a forced vital capacity (FVC) that is greater than the FVC produced without PEP.[3] High-PEP is not used as commonly in clinical practice as low-PEP.

PEP devices that contain an oscillatory component such as the Acapella®, RC Cornet®, Lung Flute®, Quake® and Flutter® are very useful in patients who have more tenacious secretions as the frequency of oscillations are hypothesised to loosen secretions and potentially reduce mucus viscoelasticity[15,16] (Figures 2 and 5). Oscillatory PEP (OPEP) devices are very commonly used in clinical practice and the generated oscillations are variable up to 30Hz (usually above 13Hz). Oscillation frequency is dependent on the type of device, the position of the device during use and the patient's individual ability. Oscillatory PEP devices are suitable for all age groups with the exception of infants and young toddlers.

PEP therapy is recommended for patients with an acute exacerbation of COPD (NICE guidelines for COPD, 2010), CF (UK Standards of care for CF) and non-CF bronchiectasis.[8,10] There are a substantial number of small or single treatment studies that suggest PEP therapy has largely equivalent benefits when compared with other chest physiotherapy techniques for secretion management.[6–9,11,15] Several systematic reviews have suggested there is no clear evidence that PEP therapy, with or without oscillation, is a more or less effective intervention overall than other forms of physiotherapy in a number of pathophysiological clinical circumstances. There is also no evidence to date that any one device is superior to another.[7,9,11,15,17]

A Canadian multicentre study

compared the use of high frequency chest wall oscillation (HFCWO) vest therapy to PEP therapy in 107 individuals with CF.[18] PEP therapy required a shorter treatment time and the group using PEP had significantly fewer pulmonary exacerbations (1.14 versus 2.0) and a significantly longer time to first pulmonary exacerbation (220 versus 115 days).

A randomised trial of patients who had undergone cardiac surgery, reported significantly increased oxygenation in those individuals who had PEP therapy in the first two postoperative days compared with control patients who only performed deep breaths.[13] Another randomised crossover trial in patients with non-cystic fibrosis bronchiectasis, found that regular chest physiotherapy using OPEP in non-CF bronchiectasis had small, but significant benefits compared with no regular chest physiotherapy, in terms of sputum volume, exercise capacity and quality of life.[10]

A Cochrane review investigating the immediate, short-term and long-term effects of ACTs for COPD included 28 studies in the review. In general, all ACTs were associated with a reduced need for ventilator assistance and reduced hospital length of stay in patients with an acute exacerbation of COPD (AECOPD). However, the magnitude of benefit from PEP-based ACTs appeared to be greater than for non-PEP ACTs.[17]

This was not corroborated in a recent multicentre randomised controlled trial in Australia by the same author. This trial compared usual care (including physical exercise), with or without additional PEP therapy on symptoms, quality of life and incidence of re-exacerbation in 92 patients with AECOPD and a productive cough. No significant differences were found between the control and intervention groups in any of the outcome measures, and the authors concluded that PEP therapy demonstrated negligible additional benefit on short-term (eight weeks) or long-term (six months) outcomes following discharge when used during AECOPD.[6]

Conclusion

PEP therapy is an effective and adaptable secretion management tool which can be used to counteract specific effects of atelectasis, air trapping and mucus plugging in individuals of all ages who require airway clearance treatment. There are a number of factors that need to be taken into account when considering using PEP therapy and these include the physiological indications, the age, cognitive ability and clinical status of the patient, the length of time the treatment is likely to be performed for and the patient's individual preference (if they have one). ACTs that apply PEP therapy to the airways have different physiological effects to those that do not use positive pressure and these novel mechanisms of augmenting lung volumes and prevention of early airway closure during expiration are important factors to be considered when deciding on the suitability of PEP therapy for an individual patient. ✦

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