Physiotherapy with oscillating PEP systems (RC-Cornet®, VRP1®) in COPD

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Translation

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Introduction

Physiotherapy is an important supplement to drug therapy in COPD.

The aim of physiotherapeutic measures is to improve expectoration of bronchial mucus so as to reduce dyspnoea and prevent infections.

The techniques used include huffing, i.e. intentional coughing, deep breathing, positioning, chest wall vibration techniques, “tapping down” the thorax and the use of special aids such as a PEP mask or oscillating PEP systems such as the RC-Cornet® or the VRP1® (Flutter).

Other physiotherapeutic measures aim at prevention of airway collapse or air-trapping; these techniques are used when COPD is coupled with increasing pulmonary emphysema.

In this stage of disease, other techniques are also used to create a more favourable length-to-tension ratio in the inhalation musculature so as to reduce dyspnoea.

Effective techniques with this objective include muscle relaxation exercises [1-3], pursed lips breathing, which is nothing more than an expiratory PEP system (positive expiratory pressure of about 5 cm head of water) [4].

Gandevia demonstrated in cases of severe pulmonary emphysema that expiration volume is increased by 20% in relaxed expiration and pursed lips breathing [5].

On the basis of their experimental work, Tiep et al. [6] consider pursed lips breathing in severe COPD more effective than muscle relaxation training.

The efficacy of this airway technique – used spontaneously by most patients – is an established fact.

Direct mobilization of the bony thorax by physiotherapeutic or chiropractic means would be helpful in theory, but only one non-controlled study has demonstrated positive effects to date [7].

Other techniques aim at enhancing the strength and endurance of the respiratory musculature (inspiratory muscle training) [8].

A muscle becomes stronger in accordance with a more favourable length-to-tension ratio when it works with the same neural “input” over a greater length. The diaphragm can be stretched in this sense by a variety of methods:

1. By means of contraction of the abdominal muscles during expiration.
2. By assuming certain physical positions (in particular leaning forwards in the "coach driver" position, which increases intra-abdominal pressure).

The strength and endurance of inspiratory musculature can be trained using inspiratory muscle trainers such as the Threshold®. Many studies have shown that this can increase maximum inspiratory pressure [9], in turn reducing dyspnoea.

Oscillating PEP systems provide a "combination" of various physiotherapeutic approaches.

Oscillating PEP systems

Oscillating PEP systems generate, as the name says, a positive expiratory pressure during exhalation, which is transmitted further in the endobronchial direction. In contrast to the PEP mask or pursed lips breathing, this pressure is not constant, but rather oscillating, so that the expiratory airflow is also not constant, but rather interrupted – the so-called stop-and-go phenomenon. At the same time, strength is required for exhalation, causing the patient to contract the abdominal muscles, putting more tension on the diaphragm, further improving the degree of efficiency (see above) and reducing dyspnoea.

1 Dedicated to Prof. Dr. med. Heinrich Matthys on this 65th birthday.
There are currently 2 oscillating PEP systems available on the market. Both derive the energy required for oscillation and pressure alternation from the expiratory energy, so that they function without external energy sources. These are small, handy devices that COPD patients can carry with them (RC-Cornet®, VRP1® [Flutter]).

**RC-Cornet®**

The device comprises a mouthpiece with a central marking and a flattened inner ventilation tube as well as a curved section of rigid tube and a "silencer" (Fig. 1a).

The rigid tube kinks the ventilation tube at a certain point. When the patient blows into the RC-Cornet® and therefore into the ventilation tube, the air is compressed upstream from this kink until a critical pressure level is reached, which pushes the ventilation tube briefly upwards into the rigid tube, allowing the air to pass through, then recloses the airflow (Fig. 1b).

This generates pressure oscillations, the amplitude and frequency of which depend on the elasticity and dimensions of the ventilation tube.

In the starting position, the kink in the ventilation tube of the RC-Cornet® corresponds to the diameter of the tube. Rotating the mouthpiece, to which the ventilation tube is fastened, twists the inner tube. Inside the tube, it is now no longer the diameter that is kinked shut, but rather a diagonal (see Fig. 1c).

By this method, the pressure and amplitude can be varied with the RC-Cornet® by rotating the mouthpiece. By holding the mouthpiece and turning the Cor-net bend to the side, the patient can find the "tube position" that is best for him or her (see Fig. 2). The mouthpiece has graduation marks to enable the patient to find the desired setting without delay.
The generation of pressure in the RC-Cornet® is gravity-dependent, since the elasticity of the medical tube and the bend in the rigid tube determine the point at which the ventilation tube is kinked. The device can thus be used in all therapeutic positions.

VRP1® (Flutter)

The VRP1®, a physiotherapeutic device introduced in the early nineties, resembles a pea whistle (see Fig. 3).

During expiration, pressure builds up in the mouthpiece against a 28 g ball made of stainless material lying on top of a funnel. During exhalation, the pressure becomes so high that it pushes the ball up the funnel wall, so that air escapes and the mouthpiece pressure drops, whereupon the ball falls back into position, reclosing the funnel channel.

This is followed by renewed ball motion and thus to oscillations in pressure and airflow.

The pressure and airflow oscillations depend on the angle at which the device is held, since the ball falls back into the funnel due to the force of gravity. Thus
the pressure variations and absolute pressure at the mouth, as well as the oscillation frequency and breath flow, depend on the angle of the mouthpiece and the "blowing energy."

**Basic differences between the two devices:**

1. The RC-Cornet®, in contrast to the VRP1®, is independent of gravity and can be used as an oscillating PEP system in any therapeutic position.

2. With the RC-Cornet®, the entire expiration volume passes through the inner tube and is converted into pressure and flow oscillations; with the VRP1®, part of the expiratory air is exhaled as in a bypass, without generating flow and pressure oscillations.

3. With the VRP1®, a sinus oscillation with a predetermined frequency is generated by holding the device in a certain way, whereas with the RC-Cornet® a low-frequency basic oscillation that is generated depending on where the kink in the tube is, and a high auto-frequency of the inner ventilation tube (approx. 160 Hz) are superimposed to create a "frequency mix."

4. Depending on the setting of the RC-Cornet®, one obtains either a constant PEP with pressure variations amounting to about 30 to 50% of maximum pressure (setting 1 and initial position), whereas in position 4 – similarly to the VRP1® – the pressure varies between zero and maximum.

As seen in Fig. 4, positions 3 and 4 on the RC-Cornet® correspond approximately to the pressure variations of the VRP1®, but the pressure kinetics are different: In the VRP1® we have a sinus oscillation curve with even up and down variations in pressure and corresponding flow changes, whereas in the RC-Cornet® the pressure gradually builds up to maximum, then suddenly drops, then gradually climbs again. This unhurried pressure increase profile facilitates pressure buildup – and thus therapeutic efficacy – in very narrow bronchial segments with high time constants as well.

The sudden drop in pressure seen with the RC-Cornet® is followed by a fast airflow.

These basic differences (lack of dependence on device position, complete conversion of the entire expiratory volume into pressure and airflow in the RC-Cornet®,...
flow to close to normal FEV1. In such cases, the two systems are equally effective: These patients have sufficient expiratory volume to compensate the bypass effect in the VRP1®. Such patients also do not need to assume therapeutic positions that would lead to problems with the gravity aspect.

Up to an FEV1 of about 1.5 litres, the RC-Cornet® is superior to the VRP1® due to its more efficient conversion of expiratory air into oscillations, the rapid adjustment of pressure kinetics and the smaller amount of pressure required (oscillation begins at 8 cm H2O).

On the clinical efficacy of oscillating PEP systems

We investigated the efficacy and "tolerance" of the VRP1® in 1993 in an open, multi-centre study involving patients with chronic obstructive pulmonary disease and demonstrated that using the device three times a day for 5 minutes had significantly improved vital and forced vital capacity as well as peak flow after 14 days. In addition to this, the auscultation findings also improved greatly. The clinical symptoms cough, expectoration, dyspnoea, subjective well-being and performance capacity also showed positive influences [10]. Other authors described similarly positive effects of the VRP1® (Flutter) in COPD. In cystic fibrosis, Konstan et al [11] determined a fivefold increase in expectorated mucus volume under VRP1® therapy compared with coughing or slanted positioning. However, other authors were unable to confirm these differences in cystic fibrosis [12, 13].

This can be explained by the different stages of the disease as well as "accompanying circumstances" (infections, varying degrees of obstruction) in individual patients.

Mcllwaine et al [14] described significantly better courses and efficacy in cystic fibrosis with a PEP mask therapy as compared with VRP1® (Flutter), i.e. superiority of a constant PEP over a maximum-oscillation PEP.

We also investigated whether a continuous PEP system with low oscillation levels is more effective than a maximum-oscillation PEP system (see above) [15] in a randomized, prospective study involving 90 patients with chronic obstructive bronchitis and tracheobronchial instability.

We compared the RC-Cornet® in the initial position with the VRP1® (Flutter). In this study, a body plethysmographic examination was done on days 1, 4 and 7 as well as blood gas analysis before and after physiotherapy with the RC-Cornet® in the initial position or with the Flutter. Drug therapy was the same in the two groups.

On day 1, the RC-Cornet® group showed a significant decrease in hyperdistension (reduction of residual volume) compared with the VRP1® group at p <0.0082. In addition to this, hyperventilation due to the oscillating PEP system was significantly lower in the RC-Cornet® group than in the VRP1® group (p <0.004).

The symptoms charted by means of visual analogue scales (decrease in expectorated volume, ease of expectoration, improvement of well-being and general evaluation of treatment with the physiotherapy equipment) also showed significantly better results for the RC-Cornet® compared to the Flutter.

Dasgupta et al. [16] demonstrated that the pressure amplitude in oscillating PEP systems influences the change in mucus viscosity. They investigated the influence of the RC-Cornet® in vitro in the initial position (i.e. position with PEP and low-level pressure variation) compared to the same values for the VRP1®, i.e. a device with maximum pressure variations. After 30 minutes, the researchers determined that the threadability of the sputum was reduced in a more pronounced manner by therapy with the VRP1® than with the RC-Cornet® (5.6 ± 1.3 mm compared to 9.7 ± 1.1 mm).

In an in vitro comparison of the effect of the RC-Cornet® at settings 3-4, i.e. at maximum pressure variation, compared to the Flutter on bronchiectatic sputum cohesiveness based on the same throughput rate in the two devices, the RC-Cornet® reduced cohesiveness at p=0.006 more than the VRP1® at p=0.034 [17].

Feng et al. [18] determined similarly positive rheological effects with the RC-Cornet® at settings 3-4. In 50% of the bronchiectasis patients, these authors found a reduction of dyspnoea and a significant improvement in the pulmonary function parameters after 15 minutes of physiotherapy with the RC-Cornet®.

King et al. [19] demonstrated in a short-term study that, at settings 3-4 in the RC-Cornet®, i.e. the settings with the large pressure variations, the therapy has positive effects on the cohesiveness of the sputum in COPD patients; cohesiveness dropped at p <0.047 and 2 of the 10 patients under investigation reported an immediate improvement of dyspnoea.

Settings 3 and 4 with larger pressure variations are, as shown above, less effective in COPD than the initial position of the RC-Cornet® with the PEP and less pronounced pressure variations.

In a prospective, randomized crossover study involving patients with severe COPD with check-valves in their flow-volume curves and trapped air in their body plethysmograms, we investigated the extent to which inhalation of ipratropium bromide increases the bronchodilative effect of oscillating PEP expiration [20].

Following broncholysis with 2 strokes of salbutamol in the autohaler, specific conductance was determined before and after inhalation of ipratropium bromide with the jet atomizer "Pari-Boy."

In one group, an RC-Cornet® was inserted into the expiration arm of the atomizer in the initial position. A significant improvement of specific conductance at
p = 0.000001 was seen in the RC-Cornet® group compared to the inhalation only group.

Repeated measurements after 2 hours revealed that this rise was not only caused by improved deposition of the drug substance, but also by an additional physiotherapeutic effect [21].

Discussion

As was demonstrated by the above-mentioned studies, physiotherapy with oscillating PEP systems is an effective method in COPD, especially in cases involving bronchial system instability.

This is subjectively demonstrated by reduced dyspnoea, easier expectoration and enhanced well-being, but it can also be objectified in terms of pulmonary function parameters and rheological measurements of sputum cohesiveness.

App et al. [22] explain these effect in terms of a relaxation of the bronchial musculature and spasmolysis of the airways and as a stimulation of ciliary beat frequency and improvement of mucociliary clearance and reduction of the viscoelasticity of the bronchial mucus.

In our opinion, the following factors also contribute to the positive effects:

1. Pressure-related bronchial expansion involving a separation of the bronchial mucus from the bronchial walls.
2. Easing of expectoration due to intermittent respiratory flow acceleration ("stop-and-go" breathing).
3. Using the RC-Cornet® in the initial position, the continuous positive pressure with little variation results in a decrease in hyperdistension via collateral ventilation in compartments with large time constants and in bronchial opening and a resulting vis à tergo which moves the mucus in mini-dystelectatic compartments.
4.Expiration against resistance leads to contraction of the abdominal musculature, which tenses and arches the diaphragm, improves the length-to-tension ratio (see above), reduces dyspnoea and eases expectoration.
5. As demonstrated by Homma et al. [23], vibrations at the mouth reduce dyspnoea.

As the above report has shown, there are not only differences between constant PEP (e.g. PEP mask) and oscillating PEP systems in terms of efficacy in different pneumological clinical pictures, there are also differences between the two oscillating PEP systems (RC-Cornet® and VRP1® Flutter) (see above).

Significant differences between these two oscillating PEP systems are seen in COPD beginning at a forced vital capacity level below 1.5 l/s.

Therapy with oscillating PEP systems is a valuable therapeutic tool in advanced COPD, both as a supplementary treatment to drug therapy and in inhalative therapy, due to its general availability, easy carrying characteristics and low price.

Summary

Oscillating PEP systems integrate many different physiotherapeutic approaches.

In view of the differing physical principles of the RC-Cornet® and VRP1®, differentiated use of these systems is discussed on the basis of the differing pressure and airflow kinetics in COPD, bronchiectasis and cystic fibrosis and confirmed by clinical and in vitro studies.

With the RC-Cornet® it is possible to change from a continuous PEP with a very low level of pressure variation to maximum pressure variation, as with the VRP1®, by rotating the mouthpiece.

Significant differences between these two oscillating PEP systems are seen in COPD beginning at a forced vital capacity level below 1.5 l/s.
References


