Effect of positive expiratory pressure mask physiotherapy (PEP) versus forced expiration technique (FET/PD) on regional lung clearance in chronic bronchitics

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ABSTRACT: On theoretical grounds it is assumed that positive expiratory pressure mask physiotherapy (PEP) as a means of promoting mucus clearance is especially effective in the more distal airways. In a randomized cross-over trial including a control measurement the effect of PEP and of the forced expiration technique combined with postural drainage (FET/PD) on regional lung clearance was evaluated in seven patients with chronic bronchitis and abundant sputum production (mean 32 g·day⁻¹). PEP consisted of positive expiratory pressure mask breathing interspersed with breathing exercises, forced expiration manoeuvres (huffing) and, if necessary, coughing. FET consisted of breathing exercises, huffing and also, if necessary, coughing. FET was combined with PD. Following inhalation of a radio-aerosol regional lung clearance was estimated by means of gamma camera imaging.

The results after PEP appeared to be not significantly different from control. The mean clearance in all three lung zones (peripheral, intermediate and inner) was largest after FET/PD as compared with PEP and control. Statistical significance (p<0.02) was reached only for clearance in the inner region.

It is concluded that PEP has no demonstrable effect on regional lung clearance in these patients.


It has been reported by Falk et al. [1] that positive expiratory pressure mask physiotherapy (PEP), which is performed in a sitting position only, is better accepted than other forms of chest physical therapy, which do include postural drainage. Most patients find it easier, less time consuming and more convenient because they can use it whenever necessary.

PEP is thought to achieve its effect on mucus mobilization by increasing collateral ventilation [2], thereby opening up airways occluded by secretions and also by preventing airway collapse during expiration in obstructive lung disease [3]. It is assumed, therefore, that the effect of PEP on the mobilization of secretions in the peripheral airways is more pronounced than, for instance, the effect of coughing and possibly also of the forced expiration technique (FET) [1]. There exists no study in which the effect of positive expiratory pressure in vivo on clearance in separate regions of the lungs has been evaluated.

The aim of this study was to assess by means of an objective radio-aerosol technique the effect of PEP on regional lung clearance in patients with chronic bronchitis, as compared with FET, which included postural drainage (FET/PD).

Methods

Patients

Seven patients (6 males, 1 female) with chronic bronchitis according to the MRC criteria [4] took part in the study. Their mean age was 62 yrs (range 48–73 yrs). The mean forced expiratory volume in one second (FEV₁) was 56 (sd±21) % predicted, the mean forced vital capacity (FVC) 75 (sd±29) % predicted, and the mean FEV₁/VC% 64 (sd±22) % predicted. The mean sputum production was 32 (range 16–58) g·day⁻¹.
Study design

In order to standardize the treatment as much as possible only two experienced physiotherapists participated in the study. PEP included positive expiratory pressure mask (Astra-Meditec, The Netherlands) breathing for 2 min at a level of 10–15 cm H₂O sitting with the elbows resting on a table, followed by a few cycles of abdominal breathing, after which the patient performed two huffs (maximal forced expirations from mid-lung volume). Mobilized secretions reaching the central airways were cleared by coughing. This procedure was performed five times resulting in a total duration of about 20 min.

FET/PD was applied according to standard procedures [5] and was combined with postural drainage. This consisted of six positions of which four lying on a tilted bed (15° head down) and two in the sitting position (leaning 45° forward and 30° backward, respectively). In every position the patient was instructed to start with diaphragmatic breathing. When the patients had relaxed sufficiently this was followed by thoracic expansion exercises and again diaphragmatic breathing. Then followed two huffs with chest compression alternated with relaxed diaphragmatic breathing. If necessary, the patient did cough. The duration of a FET-session was about 30 min.

Both PEP and FET/PD were performed without aid. During the control measurement the patient had no physiotherapy and coughed only spontaneously. In each patient the three measurements (PEP, FET/PD and control) were performed in a randomized order on separate days with at least two days in between.

Medication was continued unaltered during the study. The clinical condition of the patient had to be stable for at least six weeks prior to and during the study period. The patients were informed about the design and the aims of the study. Written informed consent was obtained. The study was approved by the Medical Ethics Committee of the hospital.

Test parameters

The effect of either treatment was assessed by measuring the clearance of an inhaled radio-aerosol. The aerosol consisted of monodisperse 5 μm ⁰⁰Kr-labelled polystyrene particles [6] and was inhaled under standardized conditions.

Regional lung clearance was calculated by means of gamma camera imaging as described by AGNEW et al. [7] with the exception of the correction for alveolar deposition. A posterior 40,000 count image was recorded directly before and after each therapy session. Each subject also had a 200,000 count posterior ventilation study using radioactive krypton (⁰⁰Kr). The gamma camera images were recorded in 64x64 format with a MDS computer system (MDS-A², Medtronic Medical Data Systems, Ann Arbor, Michigan, USA). By means of the contours of the ⁰⁰Kr image a 5x8 matrix was fitted on each lung. Thereby the lungs were divided into inner, intermediate and peripheral zones (fig. 1).

Regional clearance after physiotherapy, and in the control run after a similar time lapse, was expressed as percentage of the count rate in a particular zone before the treatment plus the cumulative loss of count rate from more peripheral zone(s) [7].

To estimate the deposition pattern of the radio-aerosol both 24 h retention and penetration index were calculated. Twenty four hour retention of the radio-aerosol was determined as described by PAVIA et al. [8]. For this the radioactivity in the thorax was measured by means of two horizontally opposed scintillation detectors, one was positioned in front and the other behind the seated patient. Measurements were made directly after and at 24 h after inhalation of the radio-aerosol. Furthermore, using the gamma camera data, the penetration index (PI) of the radio-aerosol was calculated as described by AGNEW et al. [9]. The Wilcoxon test for paired data was used to evaluate the significance of any differences observed.

Results

No significant difference was found between the values for 24 h retention in the three measurements. The mean values were 31 (so±20)% after PEP, 28 (so±14)% after FET/PD and 34 (so±19)% in the control run. The relatively high so is a consequence of the large inter-subject variability. Neither was there a significant difference between the PI values. The mean values were 0.51 (so±0.24) for PEP, 0.46 (so±0.23) for FET/PD and 0.55 (so±0.23) in the control run. The results of the calculated regional lung clearance are shown in figure 2. The mean clearance in all three lung zones was largest after FET/PD as compared with PEP and control. Statistical significance (p<0.02) was reached only for clearance in the inner region after FET/PD as compared with both PEP and control.
Correction. As shown in figure 2, the mean clearance in the inner region was largest after FET/PD. After PEP/PD appeared to have a significant effect on clearance in central airways.

Discussion

In this type of study comparison of the individual results is allowed only if there is little variation in aerosol deposition in each patient. Therefore, a monodisperse aerosol was used. The inhalation procedure was standardized. The values of 24 h retention, which is considered an estimate of aerosol deposition in the non-ciliated regions in the lungs, showed no consistent difference between the three runs (PEP, FET/PD and control). Nor did the results of the calculated PI, which is another estimate of aerosol deposition.

In the calculation of the regional lung clearance no correction has been made for alveolar deposition as described by Agnew et al. [7]. As a consequence thereof regional clearance is probably underestimated. This holds particularly true for the peripheral region because deposition in alveoli compared with deposition in conducting airways is largest in this region. This correction has not been made because gamma camera images at 6 h after inhalation of the radio-aerosol have not been recorded. These are necessary to calculate the estimate of alveolar deposition. In our experience the amount of radioactivity present in the lungs at 6 h after inhalation is so little, that gamma camera images show rather poor statistics. Furthermore, this was a crossover study with small intra-subject variability of the deposition, so that there was no strong need for such a correction. As shown in figure 2, the mean clearance in every lung region (inner, intermediate and peripheral) is largest after FET/PD. Significance is reached only in the inner region. In every single patient clearance in the inner region was largest after FET/PD. After PEP

there is no significant effect at all. These results are in agreement with those reported by Hofmeyr et al. [10]. The effects of PEP and FET/PD on tracheobronchial clearance as we have reported earlier do support the findings in the present study [11]. Both PEP and FET/PD in this study included huffing interspersed with diaphragmatic breathing. Because PEP is ineffective, as shown in this study, probably the most effective components of FET/PD are postural drainage and/or the thoracic expansion exercises.

Postural drainage alone has been shown to be effective in mobilizing secretions [12, 13]. The additional effect of expansion exercises remains to be elucidated. In conclusion, the results of this study indicate that PEP has no effect on regional lung clearance. In contrast, FET/PD appeared to have a significant effect on clearance in central airways.

References

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RÉSUMÉ: L'on suppose sur des bases théoriques, que la physiothérapie avec masque à pression positive expiratoire en vue de faciliter la clairance du mucus, est particulièrement efficace dans les voies aériennes plus périphériques. Au cours d'un essai randomisé avec permutation croisée, nous avons évalué, chez 7 patients atteints de bronchite chronique avec production abondante d'expectoration (32 g par jour en moyenne), l'effet de la PEP et de la technique d'expiration forcée combinée au drainage postural (FET/PD) sur la clairance régionale pulmonaire. PEP a consisté en une respiration au moyen d'un masque à pression positive expiratoire alternant avec des exercices respiratoires, des manœuvres d'expiration forcée (huffing) et, en cas de nécessité, la toux. FET a consisté en des exercices de respiration, du "huffing", et également, en cas de nécessité, la toux. FET a été combiné avec PD. Après inhalation d'un radio-aérosol, la clearance pulmonaire régionale a été estimée au moyen d'une gamma-caméra. Les résultats obtenus après PEP ne sont pas significativement différents du contrôle. La clearance moyenne dans les trois zones pulmonaires (périphérique, intermédiaire et centrale), s'avère la plus importante après FET/PD, par comparaison avec PEP et contrôle. La signification statistique (p<0.02) n'est obtenue que pour la clearance de la région centrale.

Nous concluons que PEP n'a pas d'effet démontrable sur la clearance pulmonaire régionale dans ce type de patients. *Eur Respir J.*, 1990, 4, 651–654.