

## Conventional physiotherapy and forced expiration manoeuvres have similar effects on tracheobronchial clearance

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*Conventional physiotherapy and forced expiration manoeuvres have similar effects on tracheobronchial clearance. M. van Hengstum, J. Festen, C. Beurskens, M. Hankel, F. Beekman, F. Corstens.*

**ABSTRACT:** This study compared the effect of two forms of chest physiotherapy. In the "conventional" form of physiotherapy, postural drainage was combined with percussion and directed coughing. The other, relatively new form of physiotherapy, was the forced expiration technique, i.e. huffing combined with postural drainage, breathing exercises and, if necessary, coughing. Eight patients (six with cystic fibrosis, two with agammaglobulinaemia) took part in the study. No difference was found in tracheobronchial clearance, regional lung clearance, sputum production or lung function between the two forms of treatment. The forced expiration technique can be performed without an assistant. Therefore, it is concluded that in general the forced expiration technique is preferable.

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Several techniques of chest physiotherapy have been developed in order to improve mucus mobilization in patients with retention of bronchial secretions.

Two frequently used regimens are conventional physiotherapy (CONV) and the relatively new forced expiration technique in combination with postural drainage (FET). CONV usually implies the combination of percussion and/or vibration with postural drainage and directed coughing. FET consists of huffing and breathing exercises combined with postural drainage and can be performed without an assistant.

By means of various non-invasive techniques using radionuclides, the effect of components of these regimens on mucus clearance have been evaluated separately and in combination with each other [1-8]. In contrast with the study by OLDENBURG *et al.* [1], other studies have shown that postural drainage enhances tracheobronchial clearance [2-4]. Percussion and vibration have appeared to be relatively ineffective [5-6] and do not seem to add to the effectiveness of the combination of coughing, breathing exercises and postural drainage [7]. FET, even without postural drainage, enhances tracheobronchial clearance [8].

To our knowledge, no study has compared the effectiveness of conventional physiotherapy with that of the FET, both including postural drainage, using the objective *in vivo* assessment of tracheobronchial clearance by means of a radio-aerosol technique. The aim of this study was to compare the effect on tracheobronchial clearance and regional lung clearance of conventional physiotherapy with that of the forced expiration technique.

## Methods

### Patients

Six patients with cystic fibrosis and two with agammaglobulinaemia took part in the study. Their mean age was 23 yrs (range 15-27 yrs). The mean forced expiratory volume in one second ( $FEV_1$ ) was 65 ( $SD \pm 29$ )% predicted. The mean vital capacity (VC) was 80 ( $SD \pm 19$ )% predicted. The mean sputum production was 53 g per day.

### Study design

In order to standardize the treatment as much as possible only two experienced physiotherapists participated. The duration of a CONV- or FET-session was 30 min.

Both regimens included postural drainage consisting of six positions, four lying on a tilted bed (15° head down) and two seated (leaning 45° forward and 30° backwards, respectively). During CONV, in each position, percussion was applied for 4 min followed by a few deep breaths and directed coughing. FET was applied according to standard procedures [9]. During FET, in every postural drainage position, the patients were instructed to start with diaphragmatic breathing. When the patient had relaxed sufficiently this was followed by thoracic expansion exercises and again diaphragmatic breathing. Then followed two huffs (maximal forced expirations from mid-lung volume) with chest compression alternated with relaxed diaphragmatic breathing. If necessary the patients

coughed. FET was performed without aid. The protocols of CONV and FET were similar to the regimens in clinical practice. There was a four-day treatment period in a randomized order for both CONV and FET. The first three days were used for daily instruction and treatment of the patients. On the fourth day the effect of the respective treatments was assessed. Medication was continued unaltered during the study. The clinical condition of the patients 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

Tracheobronchial clearance was measured using a radio-aerosol technique [10]. A monodispersed  $5 \mu\text{m}$   $^{99\text{m}}\text{Tc}$ -labelled polystyrene particle aerosol was inhaled under standardized conditions.

The radioactivity in the thorax was measured by means of two horizontally opposed scintillation detectors. One detector was placed in front of the seated subject and centred at the sternum, and the other behind the subject and centred at the spinal column. Measurements were started directly after inhalation and repeated at regular intervals, *i.e.* approximately every 20 min up to 2.5h after physiotherapy was started and once more at 24h after inhalation. As described by PAVIA *et al.* [11], the sum of the radioactivity count rates of the two detectors was corrected for background activity, isotope decay and 24h retention. The latter is considered to be an estimate of the aerosol deposition in the non-ciliated regions of the lung. The corrected count rate was expressed as a percentage of the count rate assessed immediately before the start of the physiotherapy. These percentages were plotted against time after the start of the physiotherapy, thus resulting in tracheobronchial clearance curves. The mean of the eight individual clearance curves obtained during either CONV or FET was calculated using the values actually measured at 20 min intervals. In the case of different intervals interpolations were made.

Regional lung clearance was estimated by means of gamma-camera imaging as described by AGNEW *et al.* [12] with the exception of 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 ( $^{81\text{m}}\text{Kr}$ ). The gamma-camera images were recorded in 64x64 format with a MDS computer system (MDS-A<sup>2</sup>, Medtronic Medical Data Systems, Ann Arbor, Michigan, USA).

By means of the contours of the  $^{81\text{m}}\text{Kr}$  image a 5x8 matrix was fitted on each lung. The lungs were thereby divided into inner, intermediate and peripheral zones (fig. 1). Regional clearance after physiotherapy was expressed as a percentage of the count rate in a particular zone before the treatment plus the cumulative loss of count

rate from more peripheral zone(s).

Sputum was collected during the physiotherapy session and during the 24h following the radio-aerosol inhalation. Sputum wet weight was recorded. In addition sputum was dried for 72h at 50°C to determine sputum dry weight.

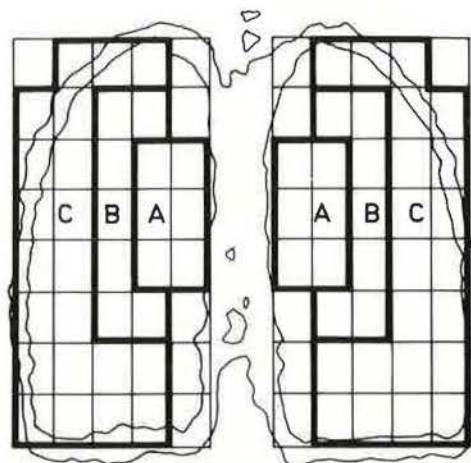


Fig. 1. - 5x8 matrix fitted to the 15 and 30% contours of the  $^{81\text{m}}\text{Kr}$  ventilation image. A: inner zone; B: intermediate zone; C: peripheral zone.

Flow volume curves were measured just before radio-aerosol inhalation and at about 90 min after physiotherapy.

The Wilcoxon test for paired data was used to evaluate the significance of any differences observed.

#### Results

No significant difference between 24h retention after CONV and after FET was found. The mean 24 h retention was 42 (SD±12)% and 38 (SD±15)%, respectively.

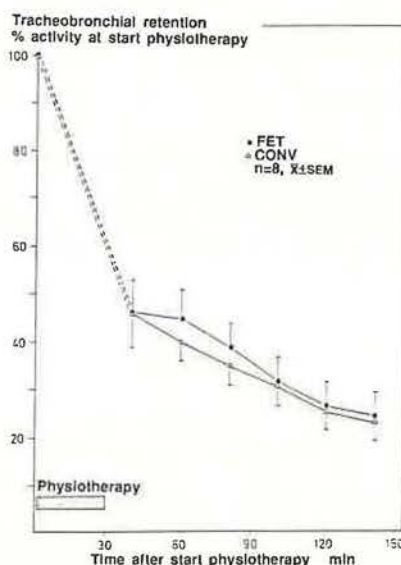


Fig. 2. - Mean tracheobronchial clearance curves.

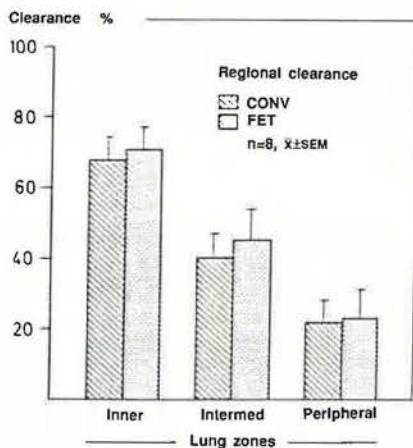


Fig. 3. — Mean clearance from the peripheral, intermediate and inner zone after FET and CONV.

The mean curves of the tracheobronchial clearance obtained during CONV and FET are presented in figure 2. At every interval there appeared to be no significant difference between the two curves.

The results of the measurement of regional lung clearance are shown in figure 3. Again no significant differences were found between CONV and FET.

The mean sputum production during the treatment was 754 mg ( $SD \pm 780$ ) dry weight for CONV and 780 mg ( $SD \pm 733$ ) dry weight for FET. The mean 24h sputum production was 51 g ( $SD \pm 52$ ) wet weight for CONV and 55 g ( $SD \pm 58$ ) wet weight for FET.

The mean values for  $FEV_1$  and forced vital capacity (FVC) before and after CONV and FET, respectively, are listed in table 1. There was no change in lung function after physiotherapy nor were there significant differences between CONV and FET.

Table 1. — Lung function data ( $n=8$ ).

	before CONV	after CONV	before FET	after FET
Mean $FEV_1$ l	2.3	2.4	2.3	2.3
Mean FVC l	3.5	3.7	3.7	3.7

There appeared to be no correlation between the amount of 24h sputum production and the effect of either treatment on tracheobronchial clearance or regional lung clearance, nor between the degree of airway obstruction and clearance.

### Discussion

BATEMAN *et al.* [13] described the effectiveness of the combination of percussion, vibration and postural drainage compared to control. SUTTON *et al.* [8] demonstrated the effect of FET alone and combined with postural drainage compared to control [9]. The radio-aerosol technique, which has been used to measure tracheobronchial clearance in both these studies, is identical to the technique used in our study. Since the efficacy of both

CONV and FET had been proven in the two studies mentioned above, no control measurement was included in our study.

The design of the study and the protocols of the two treatments were such, that the common practice of the patients requiring daily chest physiotherapy was mimicked as closely as possible. The results of this study are therefore, directly applicable to the treatment of these patients. However, the design of the study, *i.e.* three days with optimal chest physiotherapy whilst effects were evaluated on the fourth day, may have had a negative effect on the discriminative power of the study.

In our study no significant difference was found between the two treatments, which both included postural drainage. Therefore, the question arises whether the addition of other techniques (percussion, FET) substantially increases the effect of postural drainage. In several studies [5–7] no additional effect of percussion has been shown. Furthermore, chest physiotherapy consisting of postural drainage in several positions during one session, including percussion, has been shown to produce a fall in oxygen saturation [14]. A more recent study [15] showed a fall in oxygen saturation particularly related to chest percussion. The forced expiration technique appeared to increase the efficacy of postural drainage [8]. After proper instruction and training practically every patient can perform the forced expiration technique without assistance. Patients, who require regular physiotherapy, therefore become more independent. It is important to prevent physiotherapist dependency in these patients. Independence also reduces expense related to treatment by a physiotherapist. Despite this and the fact that the value of percussion and vibration still remains to be proven, many doctors and physiotherapists, as well as patients, seem to be reluctant to switch from conventional physiotherapy to the forced expiration technique.

On the basis of the results of this study it can be concluded that the forced expiration technique, including postural drainage, is as effective as conventional physiotherapy. In view of the considerations mentioned above the forced expiration technique is preferable, especially for long-term treatment.

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RÉSUMÉ: Cette étude compare les effets de deux formes de physiothérapie thoracique. Dans la forme "conventionnelle", on a combiné le drainage postural avec la percussion et la toux dirigée. L'autre forme, relativement nouvelle, de physiothérapie, consiste en une technique d'expiration forcée, avec halètement, drainage postural, exercices respiratoires, et toux en cas de nécessité. 8 patients ont participé à l'étude (6 cas de fibrose kystique, 2 cas d'agammaglobulinémie). On n'a pas trouvé de différence entre les deux techniques en ce qui concerne la clearance trachéo-bronchique, la clearance pulmonaire régionale, la production d'expectorations, ou les épreuves fonctionnelles pulmonaires. La technique d'expiration forcée peut être réalisée sans assistance. C'est la raison pour laquelle on conclut qu'en général il y a lieu de préférer cette dernière technique.