REVIEW ARTICLE

Efficacy of physical therapy methods in airway clearance in patients with chronic obstructive pulmonary disease

A critical review

Roman Nowobilski[1,2], Tomasz Włoch[1,2], Maciej Płaszewski[3], Andrzej Szczeklik[1]

1 2nd Department of Medicine, Jagiellonian University Medical College, Kraków, Poland
2 Department of Rehabilitation, University School of Physical Education in Cracow, Kraków, Poland
3 Faculty of Physical Education in Biała Podlaska, Józef Piłsudski University of Physical Education in Warsaw, Warszawa, Poland

KEY WORDS

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ABSTRACT

Multiplicity and variety of chest physical therapy (CPT) methods for increasing bronchial clearance in patients with chronic obstructive pulmonary disease (COPD) require an assessment of validity and reliability of the available clinical evidence. The aim of the review was to evaluate publications on CPT in COPD patients and to establish the basis (objective criteria) on which given methods and techniques are recommended or refuted. Systematic reviews, narrative reviews, and clinical practice guidelines, published in English between January 1, 2000 and July 1, 2010, were identified from the PubMed/MEDLINE and Cochrane (DARE, CRD, The Cochrane Airways Review Group Register) databases. The PEDro and SIGN scales were used to assess the quality and grade of recommendations for selected papers. Generally, the papers that we identified were based on small studies, limited to short-term outcomes, mostly using crossover designs, and rarely including sham therapy. Recommendations from clinical guidelines were mainly grade C or D. Health-related quality-of-life analyses, including working and exercise capacity, are lacking. The evidence from the studies in patients with cystic fibrosis cannot be directly extrapolated to COPD subjects. Despite the lack of convincing evidence, clinical practice supports the value of CPT in COPD. However, when making a clinical decision, potential side effects should be considered.

Correspondence to:
Roman Nowobilski, MD, PhD, II Katedra Chorób Wewnętrznych, Uniwersytet Jagielloński, Collegium Medicum, ul. Skawińska 8, 31-066 Kraków, Poland, phone: +48-12-430-52-66, fax: +48-12-430-52-03, e-mail: nowobilski5@wp.pl
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Introduction Chronic obstructive pulmonary disease (COPD) is a progressive illness that requires life-long treatment. Its signs and symptoms are observed in about 10% of the general population over 40 years of age.[1] Pulmonary pathologies in COPD are characterized by partially reversible flow restriction in the airways.[2] The effect of the disease on a patient depends mainly on the severity of patophysiological changes, the intensity of symptoms (chronic cough, sputum production, resting dyspnea, and low working capacity), the presence of general, nonpulmonary pathologies (including body mass loss and dysfunction of the skeletal muscles, commonly associated with nutritional abnormalities) and comorbidities (osteoporosis, bone fractures, diabetes, chronic anemia, cardiovascular diseases, depression).[3-7]

Treatment intensity depends primarily on the severity of the disease and includes: cessation of smoking, drug therapy, chronic oxygen therapy, surgical treatment, and rehabilitation, including chest physical therapy (CPT).[1,4] Multiplicity and variety of manual[8-13] and mechanical[8,11,13-17] CPT treatments used for increasing bronchial clearance require an assessment of validity and reliability of the available evidence. The following questions arise: On what criteria given methods and techniques of CPT are recommended or refuted? Are the recommendations in the available clinical guidelines based on critical reviews or expert opinions? What about the recommendations that are based mainly on tradition, individual experience of physical therapists, and patients' preferences and are frequently not supported by reliable clinical evidence?

Selected physical therapy techniques **Manual interventions** Conventional chest physical therapy Conventional CPT comprises 5 separate elements introduced by the Cystic Fibrosis Foundation in 1997[18]: postural drainage (PD), percussion (P), vibration (V), deep breathing, and directed cough (DC). The term CPT is often more broadly used to describe airway clearance techniques and does not have to include all the above elements.[18] McCool et al.[19] limit CPT merely to PD, P, and V, while van der Schans[20] to DC or huff, PD, P, and/or shaking (S).

Postural drainage PD is based on a detailed anatomical topography of the bronchial tree. Such positioning allows the easiest outflow of mucus to the larger bronchus, located distally from individual segmental bronchi.

Percussion, vibration, and shaking These methods are based on the assumption that applying an external force to the chest wall to loosen the mucus facilitates airway mobilization and clearance. P involves rhythmical beating with properly shaped hands on the chest wall over specific regions of the lungs and removing the mucus. Manual V of the chest wall can be performed by placing both hands firmly on the chest wall over the treated region of the lungs and making fast pressing movements during expiration and loosening the hands during inspiration. S of the chest wall is performed by pressing the sides of the chest wall with flatly placed hands during expiration.

Positive expiratory pressure by pursed-lip breathing Pursed-lip breathing is used mainly in patients with emphysema (with diagnosed bronchial collapse). It helps the patient to generate higher pressure in the bronchial tree than in the surrounding alveoli. Such breathing prevents injured alveoli from collapsing, which might occur if no impeding pressure operated against the air trapped in the lung alveoli.

Forced expiratory technique Forced expiratory technique (FET) is performed by making 1 or 2 forced expirations beginning at middle lung volume and ceasing at low volume, with the subsequent period of relaxed, controlled diaphragm breathing. During the technique, the mucus is separated from the bronchial wall and moved to the upper airways where expectoration occurs. An additional technique is expiration with simultaneous generation of the "H" sound (so called huff). The aim of this method is to teach the patient to expectorate regardless of the position and without the assistance of a physical therapist.

Deep cough Deep cough, like autogenic drainage (AD), is aimed to move the sputum to the larger bronchus.

Autogenic drainage AD consists in breathing at different lung volumes and holding air for 3 seconds at the peak of each inspiration. Such breathing allows to move the sputum by inhaled air from the small to the medium bronchus, and from the medium to the large bronchus, and, finally, outside.

Directed cough The patient is instructed to maintain a sitting position with forward bending and to give a cough with appropriate force to deliver the retained sputum.

Manually assisted cough The technique is performed by pressing on the chest or epigastrium or both during expiration or cough. Costal-diaphragm facilitation and upper abdomen pressure techniques are distinguished.

Active cycle of breathing techniques Active cycle of breathing techniques (ACBT) is applied by performing given actions in the following order: controlled breathing (calm breathing), expansive thoracic exercises (deep breathing, with extended expiration), and FET.

Mechanical interventions Positive expiratory pressure: TheraPEP®, PEP-Mask Positive expiratory pressure (PEP) mask therapy uses anesthetic face masks with valves that enable the flow of exhaled air in one direction, with regulated, appropriate resistance during expiration. As a result, PEP is generated as in the pursed-lip breathing technique. Similarly, the TheraPEP® device uses PEP by utilizing a resistor of regulated resistance with a connector to attach it to a mouthpiece or face mask.

The PEP method, including pursed-lip breathing, PEP mask, or TheraPEP®, is used to facilitate the opening of the airways and loosening of the remaining (or "trapped") mucus in patients with COPD. Clinically, the PEP method has been also supplemented by varying airway pressure (by using such devices as Flutter®, RC-Cornet®, Acapella®).

Oscillating positive expiratory pressure, Flutter®, blow bottle Fluctuations of the air pressure, achieved by using the Flutter® device, produce turbulences inside the airways, which enables the mucus to separate from the airway walls, while the PEP helps increase the airway diameter.

High-frequency chest wall oscillation High-frequency chest wall oscillation (HFCWO) technique utilizes high-frequency oscillations of the chest, provoked by special mechanical devices (ThAIRapy Vest®, The VestTM® Airway Clearance System). The device consists of a pumped belt, attached to a generator of air pulses, which energetically pumps the belt in and out, pressing and loosening the chest wall, causing air movements in the lungs, and thus separating and moving bronchial secretion to the larger bronchus.

Intrapulmonary percussive ventilation Intrapulmonary percussive ventilation (IPPV) involves breathing with interrupted positive pressure in the airways. The method is used to remove the mucus from the bronchial tree in mechanically ventilated patients.

Search strategy Systematic reviews, narrative reviews, clinical practice guidelines, and, secondarily, primary studies analyzed in the selected reviews and guidelines, published in English between January 1, 2000 and July 1, 2010, were identified using the PubMed/MEDLINE and Cochrane databases (DARE, CRD, The Cochrane Airways Review Group Register). The following key words were used: COPD, postural drainage, chest physical therapy, chest percussion, forced expiratory technique, positive expiratory pressure, autogenic drainage, active cycle of breathing techniques, and high-frequency chest wall oscillation.

Findings From 15 retrieved studies, we included 7 systematic reviews on COPD for further analysis (none of them were based on a meta-analysis), 4 narrative reviews, and 4 clinical practice guidelines. Then, after a hand-search of the included studies, we decided to examine 65 clinical trials of various quality: 18 randomized controlled trials, 23 crossover studies, and 24 other clinical trials. Some of the studies were analyzed for their quality with the PEDro scale,[21,22] described in detail below. Moreover, we provided the grading of recommendations and/or level of evidence when describing the reviews and guidelines.[23]

Description of the reviews and analysis of selected primary studies In a systematic review from 2000, Jones et al.,[8] searched 3 databases (MEDLINE, EMBASE, CINAHL) for the studies on the effects of physical therapy in airway clearance, published between 1966 and 1999 (TABLE 1). Of the 99 initially identified studies, only 7 met the eligibility criteria and were included for further analysis. Their quality was low because of a small number of subjects (n = 6–35), heterogeneity of the groups (COPD, outpatients with stable chronic bronchitis [CB] and with exacerbation, brochiectases), and the outcomes determined from a single measure (e.g., sputum weight, radioaerosol clearance from the lungs, functional tests: vital capacity [VC], forced expiratory volume in 1 second [FEV_1], peak expiratory flow rate [PEFR], partial pressure of oxygen in arterial blood [PaO_2]). The effects of interventions on sputum weight and lung function were not clear and the results of the review inconclusive.

In a systematic review from 2001, Hess et al.[24] examined the data from 36 studies in patients with cystic fibrosis (CF) (CPT vs. control, PEP, CPT and exercise, FET, and cough, respectively; manual vs. mechanical P and V) (TABLE 1). The effect of CPT on sputum mass was evaluated in 12 studies. Generally, the studies were of short duration, the number of the examined patients was small, and crossover design was used only in 2 studies. Moreover, 6 meta-analyses included in the review did not concern COPD.

Due to lack of specific analyses in patients with COPD, we focused on selected studies on CF. Sutton et al.[25] examined the effect of vibratory-shaking on the bronchial radioactive aerosol clearance, indicating lack of significant benefits. Holody et al.[26] suggested the benefits of using mechanical V on PaO_2 in atelectasis or pneumonia, but the sample size was small (n = 10) and there was no comparison or control group. Only 1 study described long-term, 3-year effects of CPT in CF.[27] The following adverse effects were reported: hypoxemia,[28,29] increased oxygen consumption,[30-35] intracranial pressure,[36,37] and gastroesophageal reflux.[38-41]

AD and ACBT can be performed without any adjunctive equipment or additional assistance. Miller et al.[42] compared AD and ACBT in 18 patients with CF using crossover design. They showed that AD and ACBT are equally effective in mucus transport. In a crossover study, Giles et al.[43] found no significant differences between AD and ACBT in sputum clearance and pulmonary function. Temporary desaturation was observed during CPT, but not during AD. Savci et al.[44] assessed the effect of a long-term treatment in a prospective randomized trial and compared AD and ACBT over 20 days in 30 patients with stable COPD. Improvement in forced VC [FVC], FEV_1, PEFR, forced expiratory flow ($FEF_{25-75\%}$), PaO_2, oxygen saturation (SaO_2), chronic hypercapnia, exercise performance, and dyspnea intensity during exercise was observed in the AD group. Improvement in FVC, PEFR, PaO_2, and exercise performance was observed in the ACBT group. A significantly greater increase in PEFR, SaO_2, and in chronic hypercapnia was observed in the AD group in comparison with the ACBT group.

As indicated by Hess,[24] PEP therapy may be as effective as CPT. Studies on PEP have been conducted primarily in CF patients, and few studies on PEP in patients with CB or as a postoperative therapy are available. The role of PEP is known in CF but not in other patient groups. Generally, PEP has been observed to be more popular with patients than CPT, probably because it is simpler and takes less time.

A number of studies compared the Flutter® device with other techniques,[45-53] and the findings suggested similar effects of the compared therapies. One study[51] reported pneumothorax in association with the Flutter® device. Warwick et al.[54] reported an improvement in pulmonary function in CF during HFCWO therapy at 22 months. Arens et al.[55] conducted a randomized trial in 50 CF inpatients. A similar improvement in the clinical status and pulmonary function in patients receiving HFCC and conventional CPT was noted. HFCC might be a good alternative for hospitalized patients with CF.

In their narrative review, Henke et al.[56] presented clinical applications regarding airway secretion in COPD, with such key words as expectorants, surfactant, mucociliary clearance, cough, mucokinetic medications, and physical therapy. DC, FET, PD, CPT, clapping, V, HFCO, and breathing exercises were considered as standard CPT. Unlike CF, the efficacy of CPT in CB[57-60] and COPD[61,62] has been poorly studied.

Of note is the study by Wollmer et al.[60] who recommended considerable caution when using CPT with P and CPT with P and FET in bronchial hygiene. They indicated the effectiveness of the methods of evacuating "analogous to pounding on a ketchup bottle" (which we understand as V and S during expiration). There have been suggestions that ACBT is more effective than cough alone and DC, and might be as effective as PD, V and/or P, and coughing.[63]

A systematic review from 2006 by McCool et al.[19] contains graded recommendations for CPT in CF and also in COPD (**TABLE 1**). FET (huffing) should be taught in addition to other methods of sputum clearance. According to the authors, there is insufficient evidence to recommend PEP and oscillatory devices (Flutter®, intrapulmonary percussive ventilation [IPV], HFCWO) in patients with COPD.

In a systematic review from 2006, Holland et al.[64] suggested that techniques that assist the removal of mucus from the airways do not have a well-defined role in COPD management and are supported by limited and unclear evidence, owing to methodological limitations of the conducted studies and heterogeneity of COPD, especially in the case of long-term outcome analyses. However, the review supports the physiological rationale for airway clearance techniques (ACTs) in COPD, due to bronchiectasis, excessive mucus production, airflow obstruction, and decreased lung elastic recoil. For these reasons, the effect on lung volumes, expiratory flow, and dynamic airway compression ought to be considered when choosing an optimal ACT in COPD. To avoid airway collapse during forced expirations, they suggest PEP or AD in patients with reduced lung recoil pressure. Also, they recommend that patients accept ACTs as an important component of long-term treatment.

In 2007, Fink[65] published a narrative review comparing the effectiveness of FET, DC, and AD (**TABLE 1**). Of 18 studies included in the final analysis, only 3 small studies (a total of 46 patients) concerned COPD. We have already discussed reports by Bateman[66,67] and Savci[44] when analyzing the reviews by Jones et al.,[8] McCool et al.,[19] and Hess[24] (**TABLE 1**).

We considered 3 of 4 studies on COPD, analyzed in a narrative review from 2007 by van der Schans[68], i.e., Newton et al.,[69] May et al.,[58] and Oldenburg et al.[59] In a short-term study in 79 patients with COPD exacerbations, Newton et al.[69] compared the effects of conventional CPT and intermittent positive-pressure breathing (IPPB) on functional lung parameters and efficacy of airway mucus clearance. FEV_1, VC, and sputum volume were analyzed and no differences between the 2 techniques were found. The subjects were divided into 3 groups: men with PaO_2 >60 mmHg, men with PaO_2 <60 mmHg, and women. Patients in each group were randomly assigned to a control group treated pharmacologically and to 2 experimental groups receiving pharmacotherapy and CPT (group 1), or pharmacotherapy and IPPB (group 2). No significant differences in FEV_1 and VC between the CPT groups and the control groups were observed. Changes in PaO_2 were greater in the CPT subgroup in group 1 compared with the control group, and in the control group in group 2 as compared with the CPT subgroup. Mean sputum volume was only larger in the CPT subgroup in group 1 compared with the control group during the last 3 days of hospital stay. May et al.[58] compared the effectiveness of P, PD, V, and DC, analyzing peak expiratory flow, FVC, FEV_1, $FEF_{50\%}$, $FEF_{75\%}$, and sputum volume. A significant effect of the applied techniques (combination of forced expirations – DC or huff, PD, P, and/or S) on sputum volume was observed. Oldenburg et al.[59] showed certain differences between the applied methods (DC, exercise) in terms of mucus clearance, but the findings were not sufficiently reliable because of a very small study size (n = 8). Surprisingly, such correlation was not found in PD.

In a review from 2008, Hristara-Papadopoolou et al.[70] evaluated the effectiveness of current respiratory physical therapy devices, including PEP, HFCWO, oral high-frequency oscillation, IPV, incentive spirometry (IS), Flutter®, Acapella®, and RC-Cornet®. The authors compared the devices themselves and also made comparisons with both CPT and active techniques. Of the 63 retrieved short-term and 5 long-term studies, only 8 eligible studies were conducted in COPD patients, while 25 concerned CF and 1 primary cilliary dyskinesia. The most commonly used airway clearance techniques and devices were: PEP, HFCWO, IPV, IS, Flutter®, RC-Cornet®, and Acapella® (in 18, 11, 9, 3, 23, 3, and 1 study, respectively). PEP and Flutter® were observed to be more efficient in mucus evacuation, which was confirmed by pulmonary function tests, while HFCWO and IPV proved as effective as CPT. Only 1 study showed greater effectiveness of HFCWO in comparison with CPT. The authors concluded that Flutter® was the most popular device, an alternative for or supplement to standard CPT, but that it was not supported by evidence of adequate quality and reliability and there were no long-term studies of effects that would refer the findings to patients' quality of life.

Fagevik Olsén et al.[71] conducted a systematic review in 2009 to evaluate the effects of breathing exercises with PEP in comparison with other

TABLE 1 Characteristics of the analyzed studies

Author(s), year	Subjects	Type of study	Findings	Level of evidence[93]
Jones et al., 2000[8]	n = 126: COPD and/or bronchiectasis	SR; MEDLINE, EMBASE, CINAHL; initially 99 trials, finally 7 RCTs analyzed	significant effects of bronchopulmonary hygiene physical therapy on sputum production and radioaerosol clearance in 3 trials; no trials showed significant differences in the effects on pulmonary function between manual (PD, P, S, DC, and FET) vs. mechanical V	1+/1–
Hess, 2001[24]	n = 1656: 90 COPD (9–47), 546 CF, 216 CB (or bronchitis), 30 B, 26 mixed group (bronchitis, B, CF, asthma), 40 asthma, 387 RDS, 310 postoperative, 8 bronchiolitis	SR; MEDLINE (1966–2000) key words: chest physical therapy, chest physiotherapy, postural drainage, forced expiratory technique, autogenic drainage, high-frequency chest wall compression, flutter device and secretions, positive expiratory pressure and secretions, intrapulmonary percussion, mechanical in-exsufflation and secretions	no meta-analysis on CPT in COPD found; crossover and prospective RCTs included; intervention: P/PD vs. FET/PD, P vs. PD, V vs. positioning, PD/FET, fast/slow P vs. PD/FET, and PD during sleep, PD/ACB/cough, manual and mechanical P; outcome variables: sputum production, spirometry, SaO_2, PaO_2, arterial blood gases, radioactive aerosol, 6MWD, mucolytic use, antibiotic courses, pulmonary infections, acute exacerbations, atelectasis, dyspnea, length of hospital stay; conclusions: no satisfactory evidence for routine CPT in hospitalized patients; the effect of CPT on long-term outcomes and quality of life in patients with chronic diseases unknown; no evidence for benefit from P + V + PD vs. PD alone; AD is as effective as the ACBT in cleaning secretions and improving lung function; these techniques can be used in patients with stable COPD but the preferences of physical therapists and patients should be considered	1–
McCool et al., 2006[19]	n = 385: 16 probably COPD (2 groups, 10[66] and 6[67]), 241 CF, 28 CF + B, 23 B, and 93 CB and CHF for standard CPT n = 392: 14 with high sputum production due to COPD, CB and B,[73] 321 CF, 50 CB, and 17 B	SR and CPG; CPT, CPT + exercise, AD, PD, P, HFCWO, FET and DC vs. PEP, PEP + FET, HFCC, IPV MEDLINE (1960 to April 2004); search terms: chest physiotherapy, forced expiratory technique, positive expiratory pressure, high-frequency chest compression, insufflation, exsufflation	CPT and FET increase airway clearance as assessed by volume, weight, and viscosity of sputum and clearance of the radioaerosol from the lungs; long-term efficacy unknown; in COPD manually assisted cough alone or in combination with mechanical insufflation was detrimental and should not be used;[90] FET recommended, unlike PEP and oscillatory devices; CPT effectiveness in COPD assessed on extremely small groups;[66,67] Flutter® examined on a group of 14; No difference in sputum volume or FEV_1 compared with PD + P[73]	1– grade of recommendation for manually assisted cough in COPD: D (not recommended)
Fink, 2007[65]	n = 230: 46 (6–30 in single studies) COPD, 135 CF, 28 CF + B, 13 B, and 8 CB	NR; search strategy not known, except key words: forced expiratory technique, directed cough, autogenic drainage	FET, DC, and AD are of similar effectiveness as CPT in CF and COPD; they can be applied by a patient, with periodical control and evaluation; the improvement at least after 4 weeks	4
van der Schans, 2007[20]	n = 254: 132 COPD (8–79 in single studies), 112 CF, 10 mixed groups	NR; 4 studies on COPD (from 1978–1979) key words: chest physical therapy, pulmonary, mucus transport, sputum, cystic fibrosis, airway secretions, cough, huff, postural drainage, autogenic drainage	effectiveness of CPT + IPPB, P, PD, V, DC, exercise, and S assessed; COPD patients with exacerbation did not benefit from CPT; significant influence on sputum volume in a group with CPT (DC or huff, PD, P, and/or S)	4

Fagevik Olsén et al., 2009[71]	45 eligible, 11 selected for final analysis (7 of crossover design and 4 comparison studies); 5 COPD studies	SR; Cochrane Library (CENTRAL, DARE), PEDro, LILACS, MEDLINE/PubMed, CINAHL, AMED, EMBASE from 1970 (or from inception) to January 2008; RCTs compared Flutter® with: PD/P, expiration with the glottis open in a lateral position; PEP and FET vs. PD/FET; pursed-lip breathing vs. relaxation (music); PEP + assisted cough + NIPPV vs. assisted cough/NIPPV; blow bottle vs. CPAP; PEP/abdominal breathing, thoracic expansion, 2 "huffs" vs. FET/PD; PEP, huffs; cough vs. FET/PD/breath exercise/"huffs"/cough; PEP mask vs. placebo PEP mask and PEP mask vs. diaphragmatic breathing	outcome measures: FEV_1, FVC, PEFR, VC, TLC, RV, FRC, TV, $FEF_{25-75\%}$, DLCO, 6MWT, weaning time, mortality, feasibility of PEP, PaO_2, $PaCO_2$, $PtcO_2$, $PtcCO_2$, SpO_2, SaO_2, sputum volume and weight, sputum production (dry weight) mucociliary clearance, cough, cough difficulty score, days in hospital, dyspnea severity, exercise capacity, fever, acute exacerbation, use of medication; benefits of PEP found in isolated outcome measures in separate studies with a follow-up <1 month; contradictory effects during long-term follow-up; limited amount of trials with adequate quality; inconclusive data on the effect of PEP in COPD; several types of PEP techniques with varied intensity and duration of treatment and with different outcome measures and follow-up periods	1+/1–
Tang et al., 2010[13]	n = 473 with AECOPD, CPAP, BiPAP, and IPPV if they are part of physiotherapy treatment	SR; CINAHL, MEDLINE, Embase, Cochrane, Expanded Academic Index, Clinical Evidence, PEDro, PubMed, Web of Knowledge and Proquest (inception to September 2007) key words: acute exacerbation, COPD, chest physiotherapy interventions	PEP and IPPV can increase sputum expectoration in AECOPD; moderate evidence that CPT other than P are safe in COPD	1+/1–
Hill, 2010[85]	n =173; AECOPD	SR; MEDLINE (1950 to February 2009), CINAHL (inception to February 2009), EMBASE (1980–2009), PEDro,(inception to February 2009). and the Cochrane Library databases (inception to February 2009); PEDro scale for quality assessment key words: COPD, exacerbation, respiratory insufficiency, therapeutics, physiotherapy, respiratory therapy; outcome variables: resting lung function, sputum weight, volume or clearance of inhaled radiolabeled particles, gas exchange, symptoms, duration of NIPPV and hospitalization	1629 studies retrieved, 5 criteria met; mean PEDro score for RCTs: 5 (SD 4.4 ±1.1, range 3–6); analyzed interventions: breathing exercises, ACBT, FET, huffing, coughing maneuvers, PD, AD, P and/or V, PEP and oscillatory V, PD + P+ deep breathing + huffing vs. PD + deep breathing + huffing; outcomes in single qualified studies: FEV_1 decline after P on 2 consecutive days[60]; V in forward lean sitting + spontaneous coughing vs. positioning in forward lean sitting: increase of sputum volume within 1 hour[91]; increase in SpO_2 30 minutes after V in case of supplementary O_2 on 2 consecutive days[91]; nonoscillating PEP mask + assisted coughing, 2 minutes of undisturbed breathing vs. assisted coughing: increased sputum production during intervention and shorter time to wean from NIPPV[14]; optimal medical care + IPV vs. optimal medical care: shorter hospital stay in patients with IPV[92]	1+/1–

Abbreviations: 6MWD/T – six-minute walk distance/test, ACB – active cycle of breathing, ACBT – active cycle of breathing techniques, AD – autogenic drainage, AECOPD – acute exacerbation COPD, B – bronchiectasis, BiPAP – bi-level positive airway pressure, CB – chronic bronchitis, CF – cystic fibrosis, CHF – congestive heart failure, COPD – chronic obstructive pulmonary disease, CPAP – continuous positive airway pressure, CPG – clinical practice guidelines, CPT – chest physical therapy, DC – directed cough, DLCO – diffusion lung capacity for carbon monoxide, FEF – forced expiratory flow, FET – forced expiratory technique, FEV_1 – forced expiratory volume in 1 second, FRC – functional residual capacity, HFCC – high-frequency chest compression, HFCWO – high-frequency chest wall oscillation, IPPB – intermittent positive-pressure breathing, IPPV – intermittent positive pressure ventilation, IPV – intrapulmonary percussive ventilation, NIPPV – non-invasive positive pressure ventilation, NR – narrative review, P – percussion, $PaCO_2$ – partial pressure of carbon dioxide, PaO_2 – partial pressure of oxygen in arterial blood, PD – postural drainage, PEFR – peak expiratory flow rate, PEP – positive expiratory pressure, $PtcCO_2$ – transcutaneous partial pressure of carbon dioxide, $PtcO_2$ – transcutaneous oxygen tension measurements, RCT – randomized controlled trial, RDS – respiratory distress syndrome (postextubation), RV – residual volume, S – shaking, SaO_2 – arterial oxygen saturation, SpO_2 – pulse oximeter oxygen saturation, SR – systematic review, TLC – total lung capacity, TV – tidal volume, V – vibration, VC – vital capacity

ACTs or no treatment in COPD (TABLE 1). Short- and long-term outcomes were analyzed as follows: single treatment/direct effect (immediately/less than 1 hour), short-time follow-up (<1 week), 1 week to 6 months or long-term follow-up (6–12 months). The pursed-lip breathing technique significantly improved SaO_2 compared with the control group performing breathing while relaxing with music.[72] Two studies concerned Flutter® in 30-minute sessions with indefinite pressure[9] and pressure of 12 cm H_2O,[73] and the outcomes compared to PD, P,[9,74] and to ventilatory exercises in a lateral position.[9] The amount of produced sputum significantly increased in all 3 techniques, both directly and 1 hour after the interventions. FEV_1, SaO_2, sputum volume and weight, and subjective impressions did not differentiate Flutter® from the 2 other techniques. The PEP mask with resistance of 10 to 20 cm H_2O, combined with FET, was less effective in airway clearance than PD with FET,[74] but 9 of 14 patients preferred the PEP mask. Four short-term crossover trials (7–27 subjects) showed improvements between 1 hour and 6 days after treatment.[14,75-77] Only 1 study,[14] from 2002, was classified as representing adequate methodological quality. It showed sputum wet weight increase and decrease during non-IPPV in patients with the PEP mask, as compared with controls, but other authors[76] did not observe differences in daily bronchial secretion between patients treated with the PEP mask and FET combined with PD. PEP combined with FET increased diffusion capacity and improved 6-minute walk distance and cough efficiency compared with FET alone.[78] Christensen et al.[62] applied the PEP mask with expiratory pressure of 10 cm H_2O, 15 minutes, 3 times a day, for 6 months. Compared with placebo, no differences were found in pulmonary function, arterial blood gases, number of exacerbations, and hospital stay, but medication intake and sputum amount differed significantly. In another study,[79] the authors claimed that the PEP mask with individually adjusted expiratory pressure should be applied by patients themselves, twice a day, for 12 months. Positive effects of such training (increase in FEV_1, decrease in the number of exacerbations and drug intake, reduction in adverse symptoms) were observed compared with diaphragm ventilation alone. One study[78] described the effects of the TheraPEP® procedure, performed twice a day for 4 weeks. PEP combined with FET resulted in an increase in diffusion capacity and improved 6-minute walk distance and cough efficiency in comparison with the control group who received only FET.

Tang et al.[13] systematically reviewed 13 studies from 1964–2005, including 6 randomized trials[14,69,80-83] with no blinding of subjects and therapists, but with blinding of assessors in 1 trial.[84] Only 4 studies of satisfactory quality and reliability were included in quality assessment with the PEDro scale.[14,69,80,82] Basoglu et al.[80] compared incentive spirometry (5–10 breaths, every hour) with standard care. Dyspnea and quality of life were assessed using the visual analogue scale and St George's Respiratory questionnaire, respectively. A study from 1978[69] compared IPPV (applied 3 times a day for 10–15 minutes) with standard care. The start and endpoints were daily weight measurement, daily eating and sleep score, daily walking distance in 1 minute, arterial blood gases, FEV_1, and mean sputum volume. A randomized, comparative trial from 1967[82] compared combination therapy with standard care, but the authors do not provide details of the therapy. The outcome measures were: VC, expiratory reserve volume, functional residual capacity, peak expiratory flow, tidal volume, minute ventilation, ventilation-perfusion ratio, and mucus expectoration.

Hill et al.[85] evaluated the effectiveness and safety of ACTs during acute exacerbations of COPD (AECOPD) (TABLE 1). Randomized controlled or randomized crossover trials were included in their systematic review. Studies on non-IPPV and early rehabilitation were excluded. The main findings were as follows: ACTs did not improve measures of resting lung function or gas exchange; 5-minute continuous chest wall P reduced FEV_1; mechanical V and nonoscillating PEP mask increased mucus expectoration in patients with copious secretions; IPV and PEP mask therapy reduced the need for and duration of NIPPV, respectively, in patients with hypercapnic respiratory failure. The techniques were safe for patients during AECOPD, excluding continuous chest wall P. Airway positive pressure techniques may reduce hospital length of stay in AECOPD patients.

Clinical practice guidelines The American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR)[86] recommends (2004) use of ACTs in patients with major difficulties with mucus evacuation (TABLE 2). Instructions for airway clearance may include: cough techniques, PD, P (manual or mechanical, with a special vest), V, airway positive pressure,[87] PEP or Flutter® valves, AD. The AACVPR suggests that a patient's needs and therapist's expertise play an important role in individual care. Patients treated with bronchodilatators should be informed about the importance of drug intake before applying CP techniques. It is emphasized that patients should be trained in appropriate airway clearance techniques, including massage.

Recent guidelines (2009) of the British Thoracic Society and Association of Chartered Physiotherapists in Respiratory Care (BTS/ACPRC)[88] confirm our findings that there are more studies on the effectiveness of ACTs in CF than in COPD (TABLE 2). Most of the formulated guidelines are basically an extrapolation of the evidence from the studies in patients with CF. Furthermore, some techniques, applied separately, are also components of other procedures of airway clearance. For instance, the FET technique is part of the ACBT procedure. However, use of these techniques in accordance with PD is more effective than cough alone. According to the guidelines, dynamic airway compression, induced by FET, does not limit

TABLE 2 Clinical practice guidelines for airway clearance methods and techniques in chronic obstructive pulmonary disease

Guidelines, year	Recommended methods/techniques	Comments	Grade of recommendation[93]
ATS/ERS, 2006[89]	PD, P, FET, PEP mask, assisted cough	increased effectiveness of bronchial clearance; no evidence for lung function improvements; PEP mask and assisted cough more effective in exacerbation than assisted cough alone	A (doubtful – minimal criteria met – based on 1 SR)[8]
BTS/ACPRC, May 2009[88]	ACBT, FET, AD, PEP and oscillating PEP devices	ACBT and AD: significant improvements in pulmonary function (AD showed greater improvements in PEFR and $PaCO_2$, while ACBT in SaO_2), ABGs, work tolerance, and breathlessness; ACBT and AD equally effective in lung function improvements[24,94]	C: ACBT (with FET), AD, plain or oscillating PEP in stable COPD; D: supplementary PD only if it additionally facilitates clearance and has no negative effects; clinical practice suggestion: for COPD patients consider patient preferences[a]

a the authors graded the recommendations according to Brown et al.,[91] as we did for the ATS/ERS recommendations

Abbreviations: ABG – arterial blood gas, ATS/ERS – American Thoracic Society/European Respiratory Society, BTS/ACPRC – British Thoracic Society/Association of Chartered Physiotherapists in Respiratory Care, others – see TABLE 1

mucus clearance in COPD. PEP and oscillating PEP devices are as efficient in airway clearance as traditional CPT. The guidelines also underline patients' preferences in selecting the technique of airway clearance. PEP devices (with or without oscillation) are suggested as an effective alternative to PD and manual techniques. Little is known about the efficacy of airway clearance when traditional PD and manual techniques are supplemented by supportive techniques, such as FET or PEP. The guidelines indicate that the efficacy of PEP has not been compared with the efficacy of ACBT or PD in COPD.

The American Thoracic Society and European Respiratory Society (ATS/ERS)[89] suggest that a combination of PD, P, and forced exhalation improves airway clearance, but not lung function, in AECOPD. Supported cough and the PEP mask are more efficient than supported cough alone.

The Global Initiative for Obstructive Lung Disease (GOLD)[4] recommends techniques that facilitate evacuation of the mucus from the airways in AECOPD by evoking cough and forced expirations of low volume. Manual and mechanical P and PD may be beneficial in patients evacuating over 25 ml of sputum a day (difficult to determine as patients frequently swallow the sputum) or in patients with atelectasis.

CPT has been commonly used in patients with COPD. Various, even very renowned clinical centers apply physical therapy as an important treatment component, especially in hospitalized patients. A detailed analysis of the available evidence may suggest that recognition and, in some cases, recommendation of ACTs in COPD have been extrapolated from the findings concerning their efficacy and safety in patients with CF. Tradition, routine practice, as well as patients' preferences and expert opinions, which are not supported by reliable evidence, also play an important role. There are no clear guidelines as to when exactly CPT treatment should be administered in the course of COPD, which may raise doubts about its application. The above GOLD guidelines[4] recommend CPT treatment in COPD inpatients, as home-based therapy, and in patients recovering from AECOPD. Incorporation of PD, P, and FET is recommended in the ATS/ERS guidelines from 2006[89] for facilitating airway clearance in COPD patients with bronchiectasis. Furthermore, the guidelines suggest that the use of the PEP mask and assisted cough in patients with AECOPD is more efficient than assisted cough alone in airway clearance.

The BTS/ACPRC guidelines from 2009[88] recommend the following ACTs for patients with stable COPD: ACBT (including FET), AD, PEP, or oscillating PEP.

Conclusions Narrative reviews and a few systematic reviews have been published that raise concerns as to the lack of evidence to support the use of various secretion clearance techniques in COPD. The available studies have major methodological limitations. Most of the studies were small, used crossover designs, and only a few used sham therapy. Many studies were limited to short-term outcomes such as sputum clearance with a single treatment session. Moreover, some authors used single outcome measures. There are no health-related quality-of-life analyses, including working and exercise capacity, as well as hospital length of stay. The evidence from studies in patients with CF cannot be directly extrapolated to COPD subjects, but despite this, clinical practice does support the value of CPT in COPD. When deciding about the possible use of CPT, potential side effects should be considered. We believe that future research should also focus on more appropriate matching of physiological effects of individual ACTs to the pathophysiology of COPD, and additional research should be conducted on the quality of life. Also, dosage and treatment methodology should be standardized and best practice guidelines should be established.

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Ocena skuteczności metod fizjoterapii klatki piersiowej w oczyszczaniu dróg oddechowych u chorych na przewlekłą obturacyjną chorobę płuc

Przegląd krytyczny

Roman Nowobilski[1,2], Tomasz Włoch[1,2], Maciej Plaszewski[3], Andrzej Szczeklik[1]

1 II Katedra Chorób Wewnętrznych, Uniwersytet Jagielloński, Collegium Medicum, Kraków
2 Zakład Rehabilitacji w Chorobach Wewnętrznych, Katedra Rehabilitacji Klinicznej, Akademia Wychowania Fizycznego w Krakowie, Kraków
3 Zakład Fizjoterapii, Zamiejscowy Wydział Wychowania Fizycznego w Białej Podlaskiej, Akademia Wychowania Fizycznego Józefa Piłsudskiego w Warszawie, Warszawa

SŁOWA KLUCZOWE

fizjoterapia klatki piersiowej, przewlekła obturacyjna choroba płuc, techniki oczyszczania dróg oddechowych, wytyczne praktyki klinicznej, praktyka kliniczna oparta na faktach

STRESZCZENIE

Mnogość i różnorodność metod i technik fizjoterapii klatki piersiowej u pacjentów z przewlekłą obturacyjną chorobą płuc (POChP), stosowanych w celu toalety dróg oddechowych, wymaga oceny wiarygodności i rzetelności publikacji w tym zakresie. Celem pracy była ocena publikacji na temat metod i technik fizjoterapii klatki piersiowej i ustalenie kryteriów rekomendacji lub braku zaleceń stosowania danych metod i technik. Bazy danych PubMed/MEDLINE i Cochrane (DARE, CRD, The Cochrane Airways Review Group Register) przeszukano w celu znalezienia opublikowanych w języku angielskim od 1 stycznia 2000 r. do 1 lipca 2010 r. przeglądów systematycznych i opisowych oraz wytycznych praktyki klinicznej. W przypadku wybranych opracowań zastosowano skale PEDro i SIGN do oceny wiarygodności doniesień i siły zaleceń. Zidentyfikowane opracowania są zasadniczo oparte na badaniach małych grup, ograniczonych do wyników krótkoterminowych, w większości przeprowadzonych metodą grup naprzemiennych (*cross-over*), w których rzadko stosowano pozorowaną interwencję (*sham*). Wytyczne praktyki klinicznej zawierają w większości zalecenia stopnia C lub D. Brakuje analiz jakości życia związanej ze zdrowiem oraz dotyczących tolerancji wysiłku i aktywności fizycznej. Wyniki badań u pacjentów z mukowiscydozą nie mogą być bezpośrednio ekstrapolowane na chorych na POChP. Pomimo braku przekonujących dowodów w opublikowanych dotychczas wynikach badań, praktyka kliniczna potwierdza skuteczność fizjoterapii klatki piersiowej u chorych na POChP. Potencjalne działania niepożądane powinno się rozważać podczas podejmowania decyzji klinicznych.

Adres do korespondencji:
dr hab. Roman Nowobilski, II Katedra Chorób Wewnętrznych, Uniwersytet Jagielloński, Collegium Medicum, ul. Skawińska 8, 31-066 Kraków, tel.: 12-430-52-66, fax: 12-430-52-03, e-mail: nowobilski5@wp.pl
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