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REVIEW

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Airway clearance techniques – a proposed classification based on definitions?

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ABSTRACT

Introduction: Airway clearance techniques (ACT) are a longstanding modality of treatment in many chronic respiratory diseases. Their aims are to counteract airway obstruction by mobilizing airway secretions and/or by limiting the airway collapse.

Areas covered: This review first outlines the physiological mechanisms underlying ACT. In a second part, it categorizes the ACT into seven distinct groups. These groups include both instrumental and non-instrumental ACT. Strategies such as physical activity and upper airway clearance techniques are also considered as ACT due to their complementary roles in mobilizing airway secretions.

Expert opinion: The lack of standardized definitions for airway clearance techniques (ACT) leads to significant differences in the clinical practice and effects because the variability in physiological mechanisms. Studies show that both manual and instrumental ACT are influenced by therapist-dependent factors such as applied force, duration of the application, and patient positioning. To ensure reproducibility and effective teaching, a single, physiologically grounded description of ACT is urgently needed.

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Airway clearance technique; sputum; physiology; description; chest physiotherapy

1. Introduction

Airway clearance techniques (ACT) are components of treatment in many patients with respiratory disease, particularly in those suffering from chronic and suppurative respiratory diseases such as cystic fibrosis, bronchiectasis, or chronic obstructive pulmonary disease (COPD). In these conditions, mucus stasis contributes significantly to airway obstruction, recurrent infections, progressive lung damage and a lung function decline. These complications not only exacerbate the clinical course of the disease but also lead to a substantial reduction in patients' quality of life.

Various modalities are encompassed in ACT, all are designed to mobilize and remove secretions from the airways, thereby breaking the vicious circle of hypersecretion, inflammation, and lung damage. Modalities of ACT include both manual maneuvers and instrumental techniques. Despite numerous studies and their widespread use, the clinical efficacy of ACT remains controversial. This is largely due to the variability in reported outcomes across different patient populations and disease severities, which makes comparisons difficult and limits the ability to draw general conclusions. Furthermore, variability in how ACT are applied by different healthcare professionals is also considerable.

This document explores the physiological rationale behind ACT and their practical implementation in a first part. The second part of this paper proposes a classification of airway clearance techniques, derived from their functional and operational characteristics, resulting in seven distinct categories (Figure 1) aiming to clarify the mechanisms underlying each of these techniques. These groups include upper airway clearance techniques and physical activities sometimes considered as adjunctive strategies. By consolidating the descriptions of ACT, we aim to support healthcare professionals in delivering evidence-based ACT and to understand the terminology used in the scientific literature.

2. Physiological mechanisms

The objective of ACT is to achieve optimal gas–liquid (air-mucus) interaction during expiration in order to mobilize bronchial secretions from the peripheral lungs toward the mouth. By modulating lung volumes and airflow rates, the physiotherapist aims to generate a linear airflow velocity high enough to produce an effective shearing force on the mucus obstructing the bronchial lumen. The relative effectiveness of ACT is influenced by factors such as the geometry of the bronchi and the physical properties of the mucus, which itself has a threshold effect below which it cannot be mobilized [1,2]. This threshold effect means that the elasticity and viscosity of the mucus must be neither too high nor too low to be mobilized. This leads to modulation of the driving pressure

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Article highlights

- Airway clearance techniques are a cornerstone in the management of chronic respiratory diseases, aiming to improve mucociliary clearance to prevent airway obstruction and mucus stasis.
- This paper describes seven categories encompassing all airway clearance techniques, including both manual and instrumental techniques, as well as complementary approaches such as physical activity and upper airway clearance.
- Physiological principles are used to describe each airway clearance techniques.
- A better understanding of the functioning of airway clearance techniques is a key factor to personalize the optimal approaches.

(the difference between alveolar pressure and atmospheric pressure) by increasing intrapleural pressure, which is generated by the action of the expiratory muscles, with or without assistance from the physiotherapist's hands or devices.

During expiration, intrabronchial pressure gradually decreases from the alveoli toward the mouth. If the intrapleural pressure outside the bronchus is sufficiently high, there is a point in the bronchial tree where it equals the intrabronchial pressure, known as the equal pressure point. It is important to note that this point is virtual, as it continuously shifts toward the lung periphery during expiration. Downstream from this virtual point (i.e. toward the mouth), it is thus assumed that intrabronchial pressure becomes lower than intrapleural pressure, resulting in compression – known as dynamic airway compression [3] (Figure 2(A)). This physiological principle is utilized in ACT and explains their functioning. This dynamic compression increases resistance and limits peak expiratory flow but locally and temporarily increases airflow velocity and turbulence (Figure 2(B)). By using ACT, the goal for the physiotherapist is to move the equal pressure point closer to the secretions to enhance the force exerted by the air on the mucus, which is proportional to the ratio of airflow velocity to bronchial diameter [1]. However, the greater the flow, the higher the linear velocity. One might try to maximize alveolar pressure by increasing the patient's expiratory effort and/or manual pressure, but this simultaneously increases intrapleural pressure. As a result, dynamic compression extends toward the alveoli, reducing the maximum achievable flow. In situations where pulmonary elastic recoil is reduced (e.g. pulmonary immaturity, emphysema), bronchial collapse may occur, resulting in no flow or velocity [4]. In addition to preventing kinetic energy transfer, the patient's efforts are not rewarded.

The challenge of ACT is to generate a localized flow capable of mobilizing secretions during expiration without causing airway closure, which is already present due to respiratory impairment and even worsens during forced expiration. This challenge is more complicated when the rheological properties of mucus are altered [5,6]. Indeed, its properties – particularly elasticity and viscosity – modify the mucus behavior. When the elasticity and/or viscosity are increased, the mucociliary clearance is slowed down. The minimum kinetic energy required to mobilize the mucus then increases, but with the constraint of the limited maximum achievable flow.

3. Categories of ACT based on the physiological components

All the ACT will be described hereunder (Figure 1). Even if the ACT are usually adapted in the daily practice depending on the condition of the patient and the patient itself, it is important to highlight their main components. These definitions highlight the authors recommendation based on the descriptions found in the literature and adapted to the actual knowledge.

3.1. Non-instrumental expiratory airway clearance techniques

3.1.1. Definitions and principles

These are techniques in which the expiratory phase plays a predominant role in airway clearance and do not require the use of any instrument. However, their effectiveness depends also on the quality of the inspiratory phases. A deep inspiration maximizes the traction force exerted by alveolar expansion on the surrounding lung tissue, thereby stimulating the re-expansion of collapsed ventilatory units [7]. A tele-inspiratory pause, the duration of which may vary is suggested in many techniques to reduce ventilation heterogeneity between lung compartments with different time constants (ventilatory asynchrony), which result from variations in airway resistance and lung compliance [8]. This strategy facilitates the entry of air into poorly ventilated lung units [5] by promoting collateral ventilation [9], which is then expelled in the following expiration, carrying airway secretions toward larger airways.

3.1.2. Active cycle of breathing technique (ACBT)

This consists of repeating a cycle of three consecutive phases [10]: a breathing control phase with relaxed, tidal breathing (1), a thoracic expansion phase with deep inspirations followed by an open-glottis tele-inspiratory pause (2), and one or more Forced Expiration Techniques (Figure 3(A)). These are the main components of this technique. No manual pressure is required during this technique. The flexibility of the regimen (the number of deep breaths, the number of huffs, and the length of the periods of breathing control) and order of the components varies with the patients' condition and should be adapted to suit the individual (Figure 3(A)). Each component plays a key role in the clearance of secretions. A longer period of breathing control is generally required in the presence of wheeze, shortness of breath, irritable cough, or anxiety.

3.1.3. Autogenic drainage

This technique involves 'sighing' expirations with an open glottis and it is performed at different level of lung volumes (Figure 3(B)). Classically, it is described in three stages: Stage 1 – low lung volume breaths (in the expiratory reserve volume) to mobilize secretions from the peripheral airways; Stage 2 – medium lung volume breaths (around the FRC) to collect mucus from the intermediate airways; Stage 3 – large-volume breaths (in the inspiratory reserve volume) to facilitate expectoration from the central airways. In practice, the transition between lung volumes is progressive, with breaths performed at gradually increasing volumes to move secretions

Figure 1. Diagram of the different Airway Clearance Techniques (ACT) by categories. Each color represents a category of ACT.

from the peripheral to the proximal airways. The breathing in the different volume is controlled by the patient alone or with the aid of the physiotherapist who use thoraco-abdominal pressure to guide the patient into each breathing phase. The inspirations are followed by an open-glottis tele-inspiratory pause. To avoid ineffective efforts, coughing is minimized during the mucus migration process [11].

Assisted Autogenic Drainage is used when the patient cannot actively participate, such as in infants. In this case, the physiotherapist's hands restrict the thorax inflation during inspirations and guide the child's rib cage motion during expirations at different lung volumes without increasing driving pressure [12]. No tele-inspiratory pause is used in this adaptation.

3.1.4. Increased expiratory flow

This involves an active, activo-passive, or passive increase in expiratory flow, initiated at varying lung volumes (Figure 3(C)), with the goal of mobilizing and evacuating tracheobronchial secretions. When expiration is passive, the physiotherapist applies manual pressure to the thorax, with variable speed, force, and duration depending on the objective [13]. The Forced Expiration Technique is the equivalent of rapid Increase of Expiratory Flow (known as rapid AFE in French). These are controlled accelerations of exhaled air, performed with an open glottis starting from different level of lung volumes and continuing down to residual volume [13,14].

3.1.5. Prolonged and slow expiration

This technique is intended for young infant and young children. The physiotherapist applies slow manual pressure simultaneously on the thorax and abdomen from functional residual capacity (FRC) and mobilizes the expiratory reserve volume to achieve optimal deflation. It is often combined with induced coughing. Due to the high respiratory rate in infants, thoracoabdominal pressure is divided over two or three consecutive expiratory phases to avoid bronchial collapse [15] (Figure 3D).

3.1.6. Total slow expiration with open glottis in lateral decubitus (ELTGOL)

This technique aims to locally optimize pulmonary compliance by using gravity's effects on lung tissue and

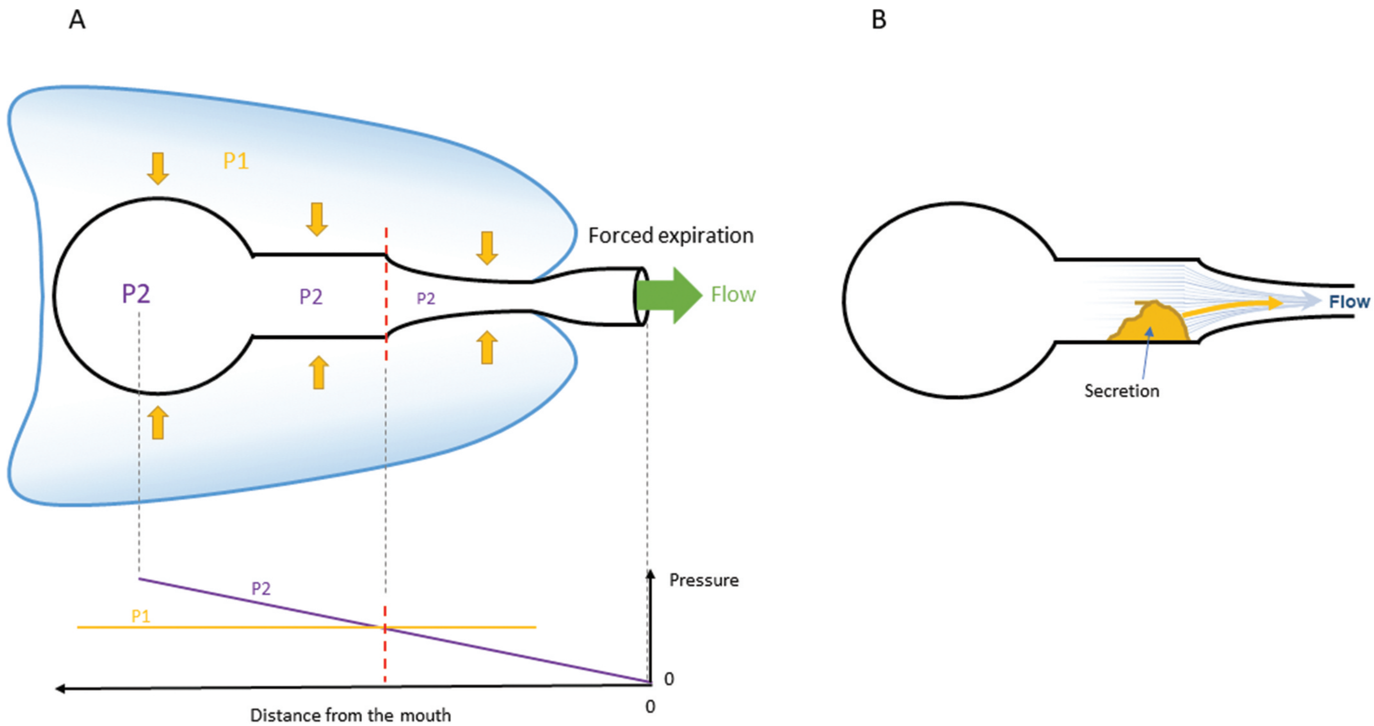

Figure 2. Physiological explanation of the dynamic airway compression with the corresponding pressure (A) and the related flow change in the airway of a single compartment lung (B). P1 and P2 correspond to the intrapleural pressure and intrabronchial pressure, respectively. The red dotted line corresponds to the virtual position of the equal pressure point. When the glottis is opened, the pressure is zero at the mouth. In the lower A part, the related evolution of P1 and P2 at the different level of the respiratory tract.

diaphragm position. The patient is positioned on the side, with the targeted lung in the dependent position, where deflation and ventilation are maximized. This technique can be used from ages 10–12, as younger children's lung volumes tend to redistribute preferentially to the supralateral lung [16,17].

The technique can be performed independently by the patient, without external resistance or physiotherapist assistance. Instructions focus on engaging the abdominal muscles and maintaining an open glottis during exhalation. Participants are guided to inhale normally and then to exhale slowly up to the end of the expiratory reserve volume.

When the physiotherapist is active, this maneuver replicates the previous description but included manual assistance. During exhalation, the physiotherapist positioned behind the subject, applies coordinated thoracoabdominal pressure to enhance lung deflation. The cephalic hand is positioned on the rib cage of the left lung to guide and support thoracic movement, while the caudal hand is placed over the umbilical region to gently press and tilt the abdominal contents upward, thereby assisting diaphragmatic ascent and promoting lung deflation.

3.1.7. *Effectiveness of the techniques*

These techniques were mainly investigated in patients with COPD and bronchiolitis. All the comparisons with a control group are highlighted in supplemental data (Table 1). The results are heterogeneous, and it is difficult to be totally convinced about their effectiveness.

3.2. *Cough assistance techniques*

3.2.1. *Definitions and principles*

Coughing is spontaneous or provoked. It is a defense mechanism against the inhalation of foreign bodies and consists of three successive phases (Figure 4(A)): inspiration to reach a sufficient pre-cough volume (Phase 1), glottis closure with contraction of expiratory muscles (intercostal and abdominal muscles) to increase the pressure into the lungs (Phase 2), and expulsion by sudden glottis opening while maintaining expiratory muscles contraction (Phase 3). Only the phases 1 and 3 can be substituted.

All cough assistance techniques aim to increase as much as possible peak cough flow [18,19] (Figure 4(B)) and are selected based on the patient's values. An effective cough is defined as having peak cough flow or peak expiratory flow values above 270–300 L/min. A threshold of 160 or 180 L/min is generally cited for initiating mechanical cough assistance in the literature [18–21].

3.2.2. *Inspiratory assistance*

The general principle is to cumulate or stack several successive inspiratory volumes without permitting expiration between them to increase the pre-cough volume. The air may be inhaled spontaneously by the patient (glossopharyngeal breathing), delivered by a caregiver using a resuscitation bag, or insufflated by a mechanical noninvasive ventilator (air stacking). Patient cooperation and good glottic function are necessary to retain the cumulated inspired air volume before the next inhalation. The aim is to improve the phase 1 of the cough (Figure 4(A)).

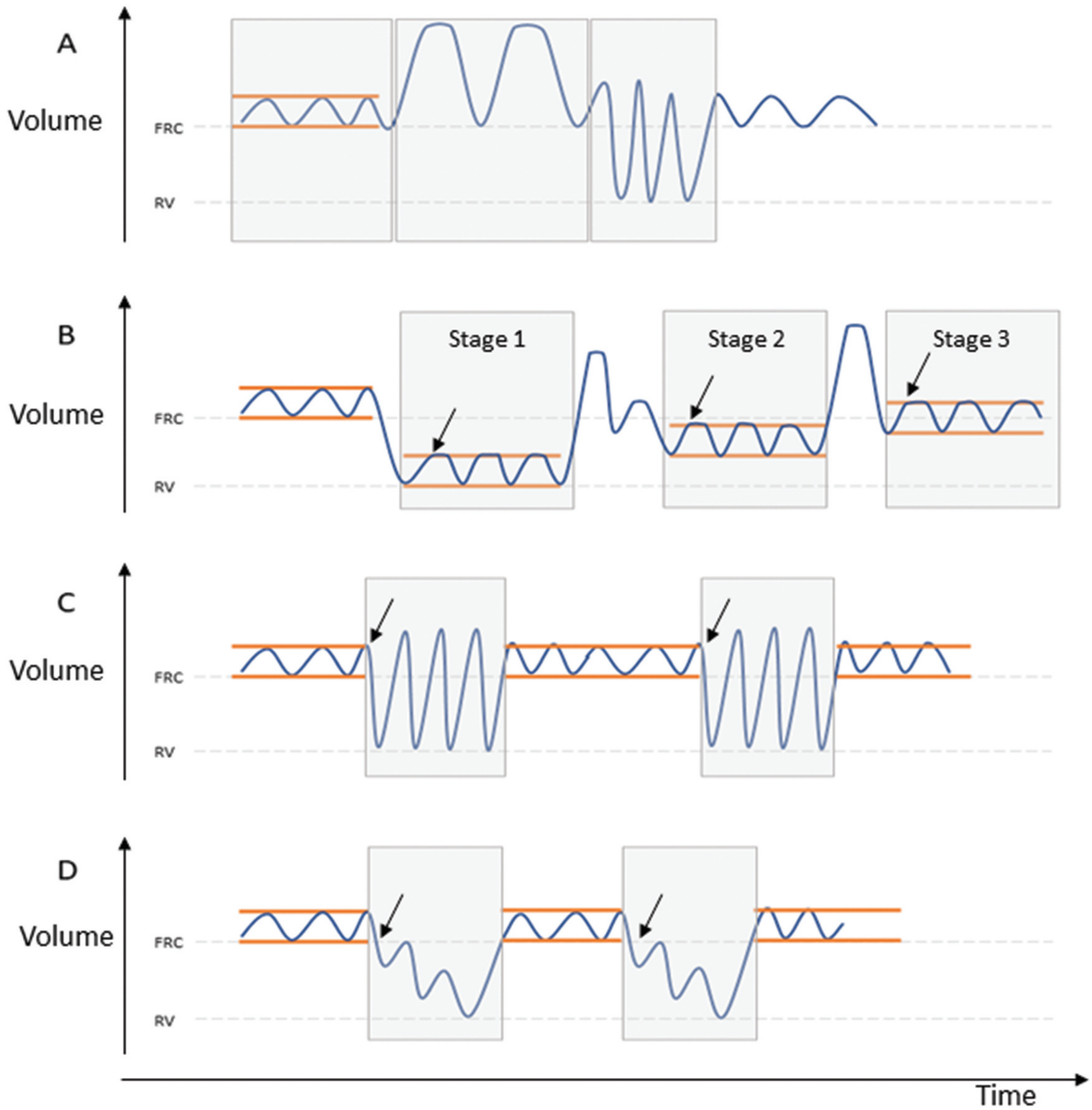

Figure 3. Illustration of the pattern of breathing on the volume–time curve associated to the Non-Instrumental Expiratory Airway Clearance Techniques. A: Active Cycle of Breathing Technique – B: Autogenic drainage – C: Increased expiratory flow – D: Prolonged and slow expiration. The gray zones correspond to the different cycles of the Airway Clearance Techniques. The orange lines correspond to the cycles of breathing with a tidal volume. Arrows show the beginning of the pressure.

3.2.3. Expiratory assistance

The assistance during expiration can be manual or mechanical and substitutes to phase 3 of the cough (Figure 4A). Manual expiratory assistance involves increasing intra-abdominal and intrathoracic pressure during the expiratory phase of a cough by applying rapid manual compression to the abdomen and/or thorax [22,23]. This technique requires patient cooperation and optimal caregiver-patient coordination. The compression has to be simultaneous to the expiratory movement of the rib cage. For the mechanical expiratory assistance, exsufflations are produced by instantly mechanically generated negative pressure. The exsufflations can be imposed or superposed to expirations of the patient.

3.2.4. Combination of inspiratory and expiratory assistance

This combination of inspiratory and expiratory assistance may involve manual or mechanical assistance [22,24–26] and replaces or completes phases 1 and 2 of the cough (Figure 4(A)).

Mechanical in-exsufflation combines inspiratory and expiratory assistance in a unique device generating a positive pressure that creates an optimal pre-cough volume, and immediately followed by a negative pressure that induces a rapid exsufflation. Various devices are available on the market. Pressure settings are adjusted according to the patient's needs and condition. The cycle of the combination is triggered either manually or automatically.

3.2.5. Effectiveness of the techniques

These techniques were frequently found in randomized controlled trials in patients with neuromuscular diseases. The supplementary data (Table 2) summarize the results from all these trials. All these techniques offer a way to improve the cough efficiency in these patients and they demonstrated to increase the peak cough flow.

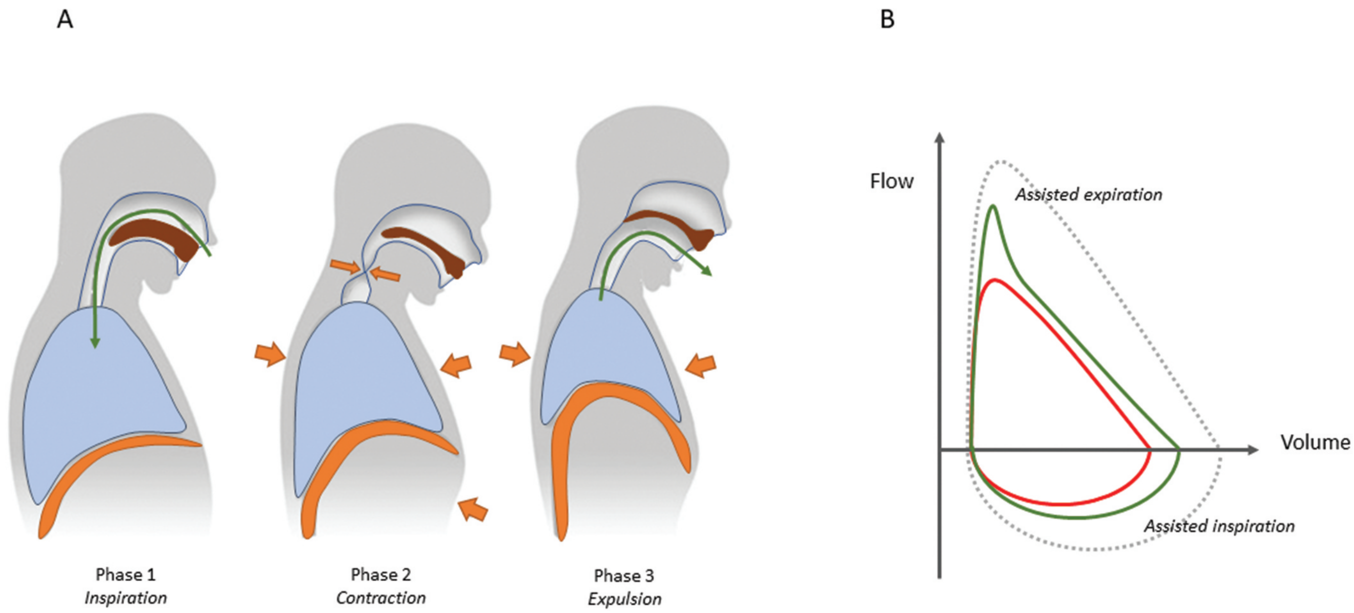

Figure 4. Cough sequence with the three phases (A) and changes on the flow–volume curve with the different ACTs assisting the cough (B) The red curve illustrates a typical restrictive flow–volume curve with a reduced peak flow compared to the normal curve (dotted gray curve). Improvement of the cough is illustrated by the green curve.

Table 1. Non-instrumental expiratory airway clearance techniques (NIE-ACT).

Reference	Population	Design	N	Technique(s)	Comparator(s)	Outcomes	Key finding
Basri et al. 2017 [52]	COPD	RCT	60	ACBT	/	VAS, SpO2, PEFR	ACBT improved 3times more PEFR, SaO2 and on VAS than the control group
Martins et al. 2012 [53]	COPD	RCTc	12	ELTGOL	/	Radioaerosol clearance	ELTGOL increased peripheral airway clearance independent lung
Shen et al. 2021 [54]	COPD	RCT	100	ACBT	/	Sputum, Sputum viscosity, LF, QoL, cost-effectiveness	ACBT results in increased sputum volume and LF but not viscosity, QoL or cost-effectiveness
Kodric et al. 2009 [55]	AECOPD during hospitalization	RCT	59	ELTGOL	/	Sputum, Length of stay, exacerbation, Dyspnea, QoL	ELTGOL failed to show an advantage during exacerbation of COPD
Hristara-Papadopoulou and Tsanakas 2007 [56]	Pediatric	RCT	35	ACBT, Percussion/ Vibration	ACBT, Control	Sputum	ACBT does not increase the quantity of sputum
Corten et al. 2018 [40]	Pneumonia	RCT	29	AD	/	Length of stay, Hospitalization, SpO2,	AD was safe but did not change the outcomes
Rochat et al. 2012 [57]	Bronchiolitis	RCT	99	PSET	/	Clinical state, and clinical (feeding, vomiting and Quality of sleep) and respiratory change	Passive expiratory manoeuver di dnot show effectiveness in infants hospital-ised for bronchiolitis.
Conesa-Segura et al. 2019 [58]	Bronchiolitis	RCT	80	PSET	/	Clinical state, SpO2	A prolonged slow expiration physiotherapy reduces Bronchiolitis Severity and does not change O 2 saturation. From this group, Infants stay less days in hospital and no adverse events were detected
Gomes et al. 2012 [59]	Bronchiolitis	RCT	30	PSET (G1) cCPT (G2)	Suction	Clinical state, SpO2, Length of stay	Both CPT decreased the severity but no difference between the three groups
Postiaux et al. 2011 [60]	Bronchiolitis	RCT	20	Neb 3%NaCl +PSET	Neb 3%NaCl	Clinical state	PSET showed short-term benefits to some respiratory symptoms
Guimaraes et al. 2012 [61]	NCFB	RCTc	10	ELTGOL (G1) OPEP (Flutter) (G2)	/	Sputum, LF	ELTGOL and OPEP reduce lung hyperinflation, but only ELTGOL increases the removal of lung secretions
Santos et al. 2020 [62]	NCFB	RCTc	34	PEP (Bubble) (G1) ACBT (G2)	/	Sputum, SpO2, Fatigue, Dyspnea	Sputum wet weight is significantly greater with PEP and ACBT than control. It is greater with PEP than ACBT at 60-min-post

Abbreviations: NIE-ACT: non-instrumental expiratory airway clearance techniques; ACBT: active cycle of breathing technique; AD: autogenic drainage; ELTGOL/PSE: expiration lente totale glotte ouverte/prolonged slow expiration; AFE: increased expiratory flow (augmentation du flux expiratoire); FET: forced expiratory technique (huff); PD: postural drainage; CF: cystic fibrosis; COPD: chronic obstructive pulmonary disease; NCFB: non-cystic fibrosis bronchiectasis; FVC: forced vital capacity; 6MWT: 6-minute walk test; SpO2: oxygen saturation; SGRQ: St George's Respiratory Questionnaire; RCT(c): Randomized clinical trial (crossover); QoL: quality of life; LF: Lung function; PEP/OPEP: positive expiratory pressure/oscillatory positive expiratory pressure; CPT: chest physiotherapy.

3.3. Inspiratory techniques

3.3.1. Definitions and principles

These techniques aim to improve the inspiration designed to optimize lung recruitment. They reach a maximal and localized alveolar expansion and the resulting surrounding traction on lung tissue. The re-expansion of collapsed ventilatory units is the main objective [7]. There are two main inspiratory techniques.

3.3.2. Controlled inspiratory flow exercise

It is a slow inspiratory airway clearance technique described for treating deep lung ventilation disorders such after a thoracic or abdominal surgery. The patient is positioned in lateral decubitus, and the goal is to re-expand the supra-lateral lung region (non-dependent lung) through slow, deep inspirations up to the maximal lung volume, followed by tele-inspiratory pauses [27]. It can be combined with incentive spirometry in clinical practice, which is not considered an airway clearance technique on its own.

3.3.3. Resistive inspiratory maneuver

Adapted from techniques used in inspiratory muscle training, the patient performs successive inspirations against a resistance generated by a device. The resistance is set by the physiotherapist for the session, based on the patient's maximal inspiratory pressure. For each session, the patient performs 6 series of 6 repetitions. The principle is to mobilize peripheral secretions by increasing the recruitment of obstructed lung regions. Few protocols are available in the literature [28,29].

3.3.4. Effectiveness of the techniques

To date, these techniques have not been assessed in randomized controlled trials, making it impossible to provide definitive statements about their efficacy as independent ACT.

3.4. Intrathoracic instrumental techniques

3.4.1. Definitions and principles

Intrathoracic Instrumental Techniques are airway clearance or ventilatory-support methods that use mechanical devices to generate pressure and/or flow oscillations within the thorax. These techniques act directly on the intrapulmonary airways and lung parenchyma to delay the onset of expiratory flow limitation (Figure 5(A)), modify the rheological properties of the secretions, improve ventilation distribution, recruit alveoli, and/or mobilize airway secretions. They achieve this by delivering positive pressure, negative pressure, or high-frequency flow pulses via a mouthpiece, mask, or tracheostomy, thereby producing mechanical effects directly inside the lung instead of applying compression externally on the chest wall.

3.4.2. Intrapulmonary percussive ventilation

Intrapulmonary Percussive Ventilation is a technique that delivers small bursts (percussions) of pressurized gas into the airways at a high frequency of 80 to 650 cycles per minute, usually through a mouthpiece, mask, or tracheostomy. Thus,

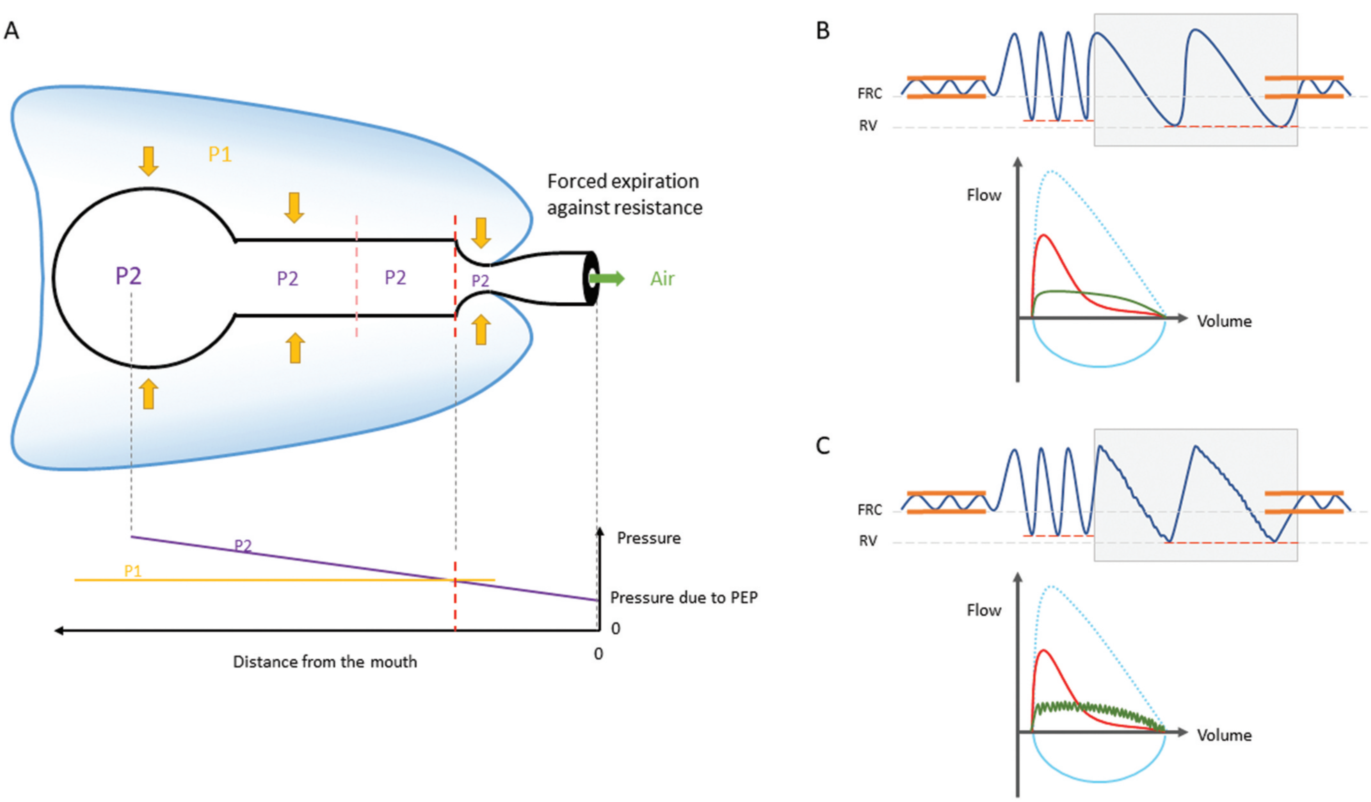

Figure 5. Effect on the dynamic airway compression of a positive expiratory pressure at the mouth with the resulting position change of the equal pressure point (A) and modification of the volume-time (upper) and flow-volume curves (lower) with PEP (B) or OPEP devices (C) Dotted red lines highlight the improvement of the recruitment. Red curves correspond to the expiration with airway obstruction. Green curves illustrate the benefit of the positive pressure on the flow–volume curve.

a pressure is generated in the airways, ranging from 5 to 35 cm H_2O. The airway walls vibrate due to the superimposed percussions [30].

3.4.3. Positive expiratory pressure devices

These devices generate continuous (Figure 5(B)) or oscillating positive expiratory pressure (Figure 5(C)) (PEP or OPEP) by a resistance during active expiration [31–33], slowing expiration and then improving the flow waveforms. Device settings allow adjustment of the resistance and frequency of the oscillation which modify the flow waveforms. Some devices are gravity-dependent which means the body position or device orientation modify either the settings or the therapeutic effect. In these cases, the optimal oscillations depend on the correct angle of the mechanism.

The PEP devices generate either low (10–20 cmH_2O) or high (40–100 cmH_2O) pressures depending on the fixed resistance and the expiratory flow (Figure 6). The standard protocol involves 10 to 15 breathing cycles through the device followed by 2 to 3 forced expirations out of the device. This cycle can be repeated as needed. The devices can be gravity-dependent and the use has to be adapted depending on that.

3.4.4. Temporary positive expiratory pressure

The Temporary Positive Expiratory Pressure, called T-PEP, involves applying an expiratory pressure of less than 1 cm H_2O only at the beginning of the expiratory phase. This pressure is generated by a pulsatile flow of approximately 42 Hz.

3.4.5. Intermittent intrapulmonary deflations

The aim of this technique is to delay the onset of expiratory flow limitation. After a slow inspiration, the patient activates intermittent intrapulmonary deflations using a remote control during oral expiration. Intermittent negative pressures are generated and interrupted at a frequency of 12 Hz during the expiratory phase, producing low-frequency vibrations mimicking a suction. The depression intensity is adjusted and corresponds to the volume of air removed with each suction cycle, which can range from 25 to 40 mL. At a fixed operating frequency of 12 Hz (reduced to 6 Hz at the end of the program), this corresponds to an expiratory flow of approximately 300–500 mL per second. This rapid air capture produces a succession of localized negative pressure pulses within the bronchial tree, with the amplitude of these depressions increasing progressively as the device continues to extract intrapulmonary air during expiration.

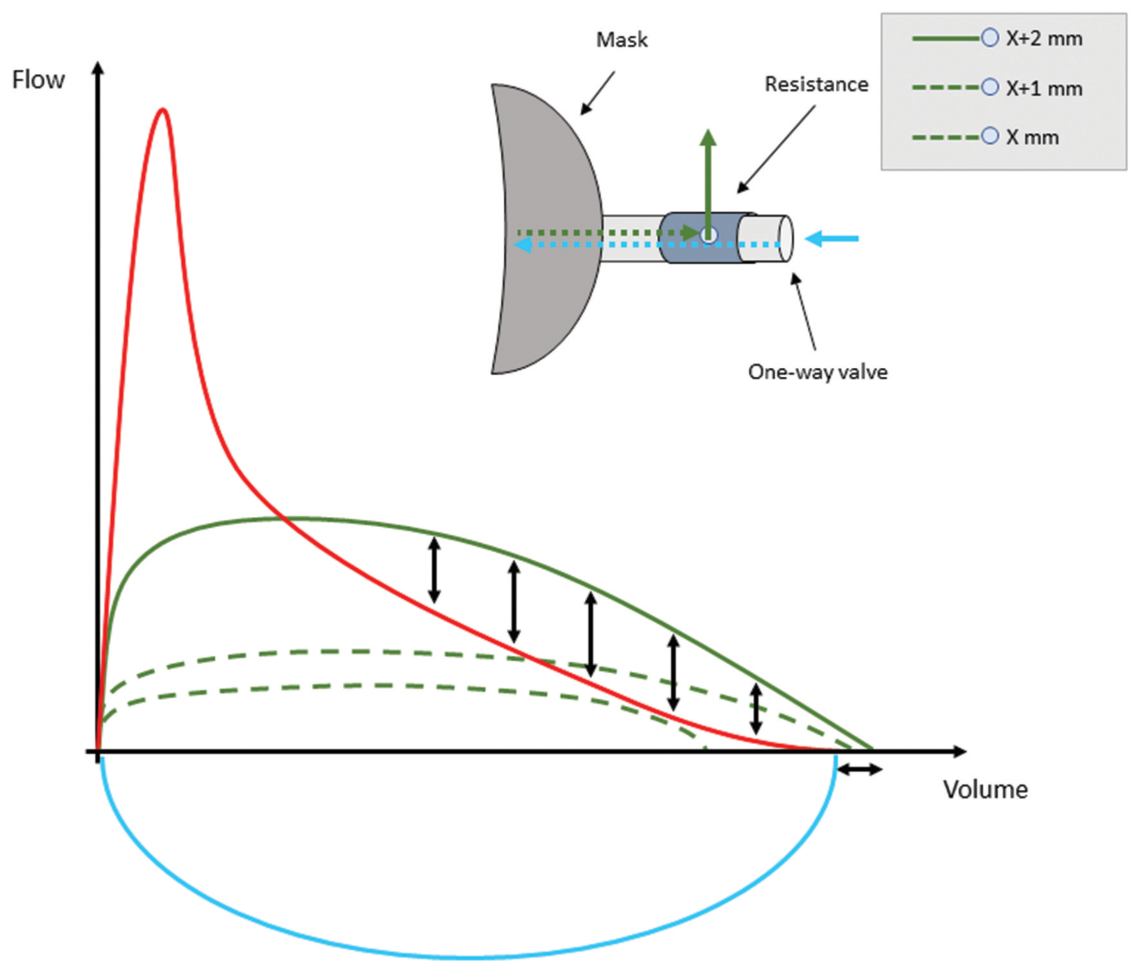

Figure 6. Effect of different resistances on the flow–volume curve. The different green curves correspond to different level of resistance and it permit to highlight the most optimal resistance (X +2 mm) based on the curve producing the highest flow in the left part of the curve.

Table 2. Intrathoracic instrumental techniques.

Reference	Population	Design	N	Technique(s)	Comparator(s)	Outcomes	Key finding
Guimaraes et al. 2012 [61]	NCFB	RCTc	10	ELTGOL (G1) OPEP (Flutter)(G2)	/	Sputum, LF	ELTGOL and OPEP reduce lung hyperinflation, but only ELTGOL increases the removal of lung secretions
Santos et al. 2020 [62]	NCFB	RCTc	34	PEP (Bubble) (G1) ACBT (G2)	/	Sputum, SpO2, Fatigue, Dyspnea	Sputum wet weight is significantly greater with PEP and ACBT than control. It is greater with PEP than ACBT at 60-min-post
Van Ginderdeuren et al. 2008 [63]	CF	RCTc	20	IPV + AD	AD	Sputum, SpO2, HR, Dyspnea	IPV does not improve sputum or other outcomes
Osadnik et al. 2014 [64]	AECOPD	RCT	92	PEP	/	Sputum, Dyspnea, QoL, LF, 6MWT	PEP therapy during AECOPD does not improve important short-term or long-term outcomes.
Dwyer et al. 2019 [65]	CF	RCTc	14	PEP +cough (G1) Treadmill (G2)	/	Radioaerosol clearance, SpO2, HR	PEP and cough is more effective on lung mucus clearance than treadmill and control
Mortensen et al. 1991 [66]	CF	RCTc	30	PEP + cough (G1) PD + cough (G2)	/	Radioaerosol clearance, Sputum, SpO2, HR, LF	PD or PEP when combined with FET has similar effects on short-term whole lung and regional tracheobronchial clearance
Darbee et al. 2004 [67]	CF	RCTc	5	Low-PEP (G1) High-PEP (G2)	/	Inert gaz, Sputum, LF, SpO2	Low- and High-PEP improve gas mixing and increase lung function, sputum, and SpO2
Braggion et al. 1995 [68]	AE-CF	RCTc	16	PEP (G1) HFCC (G2) PD (G3)	/	Sputum, FVC, Radioaerosol clearance, Exacerbations	Sputum is greater for all CPT regimens than for control without differences between them. No effect on lung function was observed
San Miguel-Pagola et al. 2020 [69]	CF	RCTc	22	OPEP + DA + Neb HS	DA + Neb HS	Sputum, Cough, and LF	OPEP increases immediate sputum expectoration and improves sputum symptoms
Svenningsen et al. 2016 [70]	COPD	RCTc	27	OPEP	/	Sputum, QoL, LF, MRI, 6MWT	OPEP improves FVC, QoL, 6MWT and sputum in sputum producers but not in non-producers.
Mascardi et al. 2016 [71]	AECOPD	RCT	99	T-PEP	/	Exacerbations, LF, blood gases, dyspnea, and health status	Patients treated with T-PEP have less exacerbations. T-PEP improves LF, dyspnea, and health status.
Christensen and Dahl 1991 [72]	COPD	RCT	28	PEP + Neb terbutaline	Neb terbutaline	Sputum, Dyspnea, Cough, PEF	PEP enhances bronchodilation, cough, and difficulty in expectoration
Ozden and Parlar Kilic 2023 [73]	COPD	RCT	105	PEP (G1) Reading (G2)	/	Fatigue, Dyspnea, LF, and SpO2	PEP improves LF
Xu et al. 2023 [74]	COPD	RCT	25	PEP	sham	6MWT, Dyspnea, Fatigue	6MWT, dyspnea and fatigue improve with PEP
Tambascio et al. 2017 [75]	NCFB	RCTc	17	OPEP (Flutter)	sham	Mucociliary transport, microbiology, inflammation	OPEP improve mucus transport by coughing and contribute to the reduction of the total number of inflammatory cells of the respiratory secretions
Figueiredo et al. 2012 [49]	NCFB	RCTc	8	OPEP (Flutter)	sham	Sputum, IOS	OPEP improves secretion removal
Murray et al. 2009 [50]	CF, NCFB	RCTc	20	OPEP (Acapella)	/	Sputum, Cough, LF, QoL, Exacerbations, 6MWT	OPEP improves cough severity, QoL, 6MWT, and removal of secretions but has no effect on sputum microbiology, LF, or exacerbation
de Souza Simoni et al. 2019 [48]	NCFB	RCTc	20	OPEP (Flutter) (G1) Compression (G2)	/	Sputum, Dyspnea, IOS	OPEP is effective for the removal of secretions and in decreasing total and peripheral respiratory system resistance. Thoracic compression has comparable positive effects on the peripheral resistance.
Su et al. 2007 [76]	COPD	RCT	32	PEP + FET	FET	LF, SpO2, 6MWT	PEP as an adjunct to FET enhanced DLCO and 6MWD, and reduced cough difficulty only in COPD patients with mucus hypersecretion.
Osadnik et al. 2014 [64]	AECOPD	RCT	92	PEP	/	Sputum, Dyspnea, QoL, LF, 6MWT	PEP therapy during AECOPD do not improve important short-term or long-term outcomes.

Abbreviations: ACT: airway clearance technique; ACBT: active cycle of breathing technique; CF: cystic fibrosis; COPD: chronic obstructive pulmonary disease; CPT: chest physiotherapy; NCFB: non-cystic fibrosis bronchiectasis; NIV: noninvasive ventilation; OPEP: oscillatory positive expiratory pressure; PD: postural drainage; PEF: peak expiratory flow; PEP: positive expiratory pressure; QoL: quality of life; SpO2: arterial oxygen saturation; WSW: wet sputum weight; ELTGOL/PSE: expiration lente totale glotte ouverte/prolonged slow expiration; RCT: Randomized clinical trial; 6MWT: 6-minute walk test; QoL: quality of life; HR: heart rate; LF: lung function.

3.4.6. Effectiveness of the techniques

The techniques using continuous or oscillating positive expiratory pressures were the most frequently assessed in randomized controlled trials. Some of them used interesting physiological outcomes (Table 3). The data are sufficiently convincing to conclude on the effectiveness of these techniques in patients with secretions, mainly in stable state. Indeed, the removal of secretions evidently improved with the use of oscillating positive expiratory pressure.

3.5. Extrathoracic instrumental techniques

3.5.1. Definitions and principles

Extrathoracic Instrumental Techniques are instrumental ACT in which the primary mechanical action is applied outside the thorax, typically on the chest wall, to influence intrathoracic pressures and expiratory flow, thereby enhancing secretion mobilization and/or improving ventilation. The mechanical effect is generated externally rather than by pressurizing or oscillating the air within the lungs, distinguishing them from intrathoracic techniques.

3.5.2. High-frequency chest wall oscillation

High-Frequency Chest Wall Oscillation (HFCWO) is the only extrathoracic instrumental technique. This ACT uses an inflatable vest connected to an air-pulse generator to deliver rapid compressions to the chest wall by successive inflation and deflation of the vest. These compressions are applied at adjustable frequencies, typically between 5 and 25 Hz, and generate oscillatory changes in intrathoracic pressure and airflow. Unlike manual chest physiotherapy, HFCWO provides a reproducible and sustained external mechanical stimulus and does not require patient – therapist synchronization with breathing cycles.

3.5.3. Effectiveness of the techniques

The results of the literature based on the randomized controlled trials are not sufficient to conclude on the effectiveness of these techniques (Table 4).

3.6. Physical activity

3.6.1. Definitions, principles, and effectiveness

Several studies suggested that physical activity may induce changes in respiratory dynamics that could contribute to or even replace traditional bronchial clearance techniques. Physical activity modulate airflow similarly to bronchial drainage and affect the mechanical properties of mucus. Depending on the clinical context, it can be used as a standalone drainage technique or, more commonly, as a complement to ACT. Modalities include continuous (e.g. cycling, treadmill walking) and intermittent exercises (e.g. interval training, trampoline). Some studies combine interval training with huffing or OPEP during the rest period. Despite the limited number of randomized controlled trials assessing physical activity as an ACT (Table 5), the available results provide a strong rationale for future studies.

3.7. Upper airway clearance techniques

3.7.1. Definition and principles

Upper airway clearance encompasses two main groups of techniques aimed at restoring the patency of the upper airways. These methods rely on physical mechanisms that use either the force of a liquid or the force of air to dislodge, mobilize, and remove secretions or obstructions from the upper airway.

3.7.2. Nasal irrigation

The modalities of nasal irrigation involve propelling a certain amount of liquid into the sino-nasal cavities. Techniques vary in patient positioning, volume and type of liquid, pressure applied, and interface [34]. The basic principle is rinsing the sino-nasal cavities with an isotonic or hypertonic saline solution.

3.7.3. Retrograde rhinopharyngeal clearance

Performed in infants or young children, this technique involves a forced nasal inspiration to rinse the nasal cavities and nasopharynx. After instillation of a solution and a prolonged expiration, the child's mouth is briefly closed to induce a strong nasal inspiration. These techniques can be used alongside nasal irrigation.

3.7.4. Effectiveness of the techniques

The effectiveness of these techniques has primarily been investigated in children. Although numerous other studies have focused on their underlying mechanisms (Table 6). The heterogeneity of protocols significantly hampers the comparability of results. Beside this, the healthcare workers usually include these techniques in the routine for the patients with nasal secretions.

4. Conclusion

Many ACTs exist. They represent an important part of the management in patients with chronic respiratory diseases when mucus stasis and/or impaired mucociliary clearance are present. Their physiological mechanism is frequently not yet entirely understood by the scientific community. By categorizing and describing the wide range of available techniques, this paper intends to help healthcare workers in personalizing the choice of the ACT depending on the clinical condition, the situation of the day, and on the patient. Guidelines were recently published about these techniques [35] and the strongest recommendations were:

Regular long-term use of Non-Instrumental Expiratory Airway Clearance Techniques is recommended to increase expectoration and to reduce cough severity. It is recommended to take into account the patient preference in order to promote adherence.

Table 3. Cough assistance techniques.

Reference	Population	Design	N	Technique(s)	Comparator(s)	Outcomes	Key finding
Kim et al. 2016 [26]	Neuromuscular disease (mixed)	RCTc	40	MAC after MIC; MI-E; MI-E+MAC	Unassisted cough	PCF	All improved PCF; MI-E+MAC yielded highest PCF (combination superior to single techniques).
Brito et al. 2009 [77]	DMD on nocturnal NIV; FVC < 60%	Pre – post with randomized order of techniques	28	Air-stacking; compression thrust; combined	Unassisted cough	PCF; impact of kypho-scoliosis	Combined air-stacking+compression > either alone; benefits independent of kypho-scoliosis.
Trebbia et al. 2005 [78]	Neuromuscular disease	Determinants study (n = 155) + intervention subset (n = 10)	155/10	Insufflation (air-stacking); MAC; MI-E	Unassisted cough	MIC; PCF; contribution of VC/MEP/ERV	MIC was strongest determinant of PCF; MI and MAC both increased VC and PCF; MI+MAC > either alone.
Lacombe et al. 2014 [79]	Neuromuscular disorders	RCTc (3 techniques)	18	IPPB+MAC; MI-E; MI-E+MAC	Within-subject comparison	PCF	IPPB+MAC produced highest PCF; MI-E+MAC did not exceed MI-E alone in those already achieving high PCF.
Hov et al. 2024 [80]	Children with neurodisability using MI-E	Multicentre RCTc of MI-E strategies (A/B/C)	74	MI-E with symmetrical high pressures (A), asymmetrical (B), individualized/ optimized (C)	Within-subject A vs B vs C	PCF during MI-E; comfort/safety	A yielded highest PCF but lowest comfort; B/C improved comfort with acceptable PCF; strong inter-individual variability.
Chatwin et al. 2003 [81]	Neuromuscular disease (adults/ children)	Physiological RCTc	22	MI-E vs chest physiotherapy vs NIV-assisted cough	Within-subject	PCF; acceptability	MI-E increased PCF more than other comparators with comparable acceptability.
Toussaint et al. 2016 [82]	Adults with DMD on NIV	RCT (single-session)	52 (27 ventilator; 25 bag)	Air-stacking via ventilator vs via resuscitator bag	Between techniques	MIC; assisted PCF (CPFAS)	Bag- vs ventilator-based air-stacking achieved similar CPF; very low baseline PCF rarely reached 160 L/min with air-stacking alone.

Abbreviations: DMD = Duchenne Muscular Dystrophy; GPB = Glossopharyngeal Breathing; IPPB = Intermittent Positive Pressure Breathing; IVC = Inspiratory Vital Capacity; MAC = Manually Assisted Cough; MIC = Maximum Insufflation Capacity; MI-E = Mechanical Insufflation – Exsufflation; NIV = Non-Invasive Ventilation; PCF/PCEF = (Peak) Cough Expiratory Flow; PEF = Peak Expiratory Flow; RMW = Respiratory Muscle Weakness; SMA = Spinal Muscular Atrophy; VC = Vital Capacity; RCT: Randomized clinical trial; RCT(c): Randomized clinical trial (crossover).

Table 4. Thoracic oscillation techniques (HFCWO).

Reference	Population	Design	N	Technique(s)	Comparator(s)	Outcomes	Key finding
Mahajan et al. 2011 [83]	Adults hospitalized for acute asthma/ COPD	RCT	52	4 sessions during admission	Sham-HFCWO	Dyspnea response after serial sessions; safety	Greater dyspnea improvement vs sham; other clinical endpoints similar; safe.
Nicolini et al. 2018 [84]	Adults with COPD (clinical program)	RCT (HFCWO vs alternative CPT)	60	Vest-based HFCWO (clinical routine)	Alternative CPT (e.g. IPV)	Acceptability, symptom change, selected clinical outcomes	Similar comfort/satisfaction versus comparator; supportive safety data.
Lange et al. 2006 [85]	ALS	RCT (12 weeks)	46	HFCWO at home	Usual care	FVC, tolerance	No superiority on primary spirometric endpoints; acceptable adherence and safety.

Abbreviations: HFCWO/HFCC/HFCWC: High-Frequency Chest Wall Oscillation/Compression; COPD: Chronic Obstructive Pulmonary Disease; CPT/PD: (Conventional) Chest Physiotherapy/Postural Drainage; ALS: Amyotrophic Lateral Sclerosis; FVC : Forced vital capacity; RCT(c): Randomized clinical trial (crossover).

Table 5. Physical activity.

Reference	Population	Design	N	Technique(s)	Comparator(s)	Outcomes	Key finding
Dwyer et al. 2017 [86]	Adults with clinically stable cystic fibrosis; outpatient lab setting.	RCTc	24	Single session of moderate-intensity treadmill exercise; single session of Flutter OPEP; or seated rest (randomized order).	Flutter OPEP and Rest (within-subject).	Sputum mechanical impedance (G*, G′, G″), sputum solids (%), PEF:PIF ratio (airflow bias), cough counts, perceived ease of expectoration.	treadmill exercise and Flutter® therapy were equally effective in augmenting mucus clearance mechanisms in adults with CF
Dwyer et al. 2019 [65]	Adults with cystic fibrosis; hospital outpatient research visits.	RCTc	14	20-min treadmill exercise at moderate intensity; 20-min PEP therapy (PEP +FET); 20-min seated rest.	PEP therapy and Rest (within-subject).	Whole-lung and regional mucociliary clearance over 90 min; cough counts; symptoms.	90-min clearance was ~3% higher after exercise than rest and ~7% lower after exercise than after PEP; i.e. exercise produced clearance between rest and PEP without clear superiority.
Dwyer et al. 2011 [87]	Adults with cystic fibrosis; laboratory sessions.	RCTc	14	Single session of moderate-intensity treadmill exercise vs seated rest (and other ACT in separate comparisons).	Rest (and other ACT in separate arms).	Respiratory flow pattern (PEF, PIF, PEF:PIF), sputum mechanical impedance (G*, G′, G″), ease of expectoration.	Exercise increased peak expiratory flow without increasing inspiratory flow (favorable airflow bias) and reduced sputum mechanical impedance; perceived ease of expectoration improved.

Abbreviations: CF = cystic fibrosis; PEP = positive expiratory pressure; OPEP = oscillatory positive expiratory pressure; FET = forced expiratory technique; PEF = peak expiratory flow; PIF = peak inspiratory flow; Vcap = pulmonary capillary blood volume; G′/G″/G* = elastic/viscous/complex moduli (sputum rheology); RCT(c): Randomized clinical trial (crossover).

Devices generating oscillating positive expiratory pressures must be used to improve secretion clearance in stable patients with COPD or bronchiectasis.

In neuromuscular diseases, manual expiratory assistance, inspiratory assistance, or the combination of the two techniques must be used to increase the peak cough flow.

In-exsufflation must be used to increase the peak cough flow when efficacy of the manual techniques is insufficient in patients with neuromuscular diseases

High-frequency chest wall oscillations must not be used to improve secretion clearance in patients with CF (adult and children) during exacerbation

Further researches are still necessary but they should use standardized protocols of ACT to improve the number of strong recommendations and the global level of these recommendations.

5. Expert opinion

ACTs appeared a long time ago. In 1959, the first paper referring '*one of the more important introductions into the treatment*' focused on cystic fibrosis [36]. Mechanical percussions were included among these techniques [37]. Soon after, physiological studies were published to verify the clinical results [38]. Over the time, many techniques emerged.

The definition and standardization of a maneuver is important to maintain its validity and to ensure its reproducibility in the time and between physiotherapists. Such a definition of airway clearance techniques is sometimes missing. Indeed, similar techniques are often described differently by various authors in the literature, which may affect their clinical efficacy. Moreover, the lack of definition reduces the comparison of the studies based on similar airway clearance techniques if they are not similarly performed.

This element is essential because their efficacy is related to the optimal use of the techniques which are based on physiological responses. As illustration, two very interesting papers about the assisted autogenic drainage described differently this technique. Indeed, Lievens et al. performed assisted autogenic drainage '*in supine position*' [39] and Corten et al. mentioned to place the child '*in a sitting position on the physiotherapist's lap*' [40]. Independently on the effect of the manual maneuvers, only these positions do not have the same physiological effect in children because of the induced

Table 6. Upper airway clearance techniques (UACT): summary of clinical studies.

Reference	Population	Design	N	Technique(s)	Comparator(s)	Outcomes	Key finding
Alexandrino et al. 2019 [88]	Parallel-group randomized study; immediate pre – post assessment	RCT. Infants/ young children with upper-airway obstruction (outpatient)	44	Rhinopharyngeal clearance protocol (retrograde nasal-pharyngeal clearance with saline; physiotherapist-delivered)	No airway clearance intervention (control)	Nasal auscultation classification (obstructed vs unobstructed), middle-ear peak pressure and tympanic compliance; baseline vs immediately post intervention	Higher frequency of unobstructed nasal sound in intervention group immediately after the protocol; middle-ear peak pressure improved post-intervention; tympanic compliance unchanged
Pinto et al. 2021 [89]	Randomized controlled trial (ambulatory setting)	RCT. Children < 2 years with mild-to-moderate bronchiolitis; outpatient follow-up (≈45 analyzed)	45	Modern chest physiotherapy session including prolonged slow expiration, rhinopharyngeal clearance, and provoked cough	No chest physiotherapy (usual care)	Respiratory status over ~15 days; clinic re-assessments	Significant improvement in overall respiratory status in the intervention group vs control at follow-up
Schreiber et al. 2016 [90]	Single-blind, multicentre randomized controlled trial (three-arm)	RCT. Infants ≤1 year with bronchiolitis and SpO_2 88–94% (n = 133)	133	Single nasal irrigation with 1 mL per nostril of 0.9% (isotonic) or 3% (hypertonic) saline via syringe	Standard care (no irrigation)	SpO_2 and WARM respiratory distress score at 5, 15, 20 and 50 min	Isotonic irrigation increased SpO_2 within 5 min and at all time points vs standard care; hypertonic improved SpO_2 only by 50 min; no change in WARM score
Wang et al. 2009 [91]	Randomized controlled trial	RCT. Children with acute sinusitis	69	Daily isotonic nasal irrigation (large-volume, low-pressure) + usual care	Usual care alone (no irrigation)	Pediatric Rhinoconjunctivitis Quality of Life Questionnaire (PRQLQ), nasal peak expiratory flow (PEFR); short-term follow-up	Greater improvement in PRQLQ and nasal PEFR with irrigation; benefits pronounced in children with atopy
Tugrul et al. 2014 [92]	Randomized parallel-group trial	Adults with chronic nasal symptoms/ rhinitis	91	Large-volume, low-pressure isotonic nasal saline irrigation plus intranasal fluticasone furoate (2 weeks)	Standard therapy without irrigation	SNOT-22 and NOSE scores at 2 weeks	Significantly larger improvements in SNOT-22 and NOSE with irrigation+steroid vs standard therapy
Slapak et al. 2008 [93]	Randomized controlled trial (children with URTI); treatment and prevention phases	RCT. Children with common cold/flu; follow-up into prevention phase	390	Isotonic seawater – processed saline spray (fine vs medium jet); regular nasal wash regimen	Observation/no irrigation; crossover of subgroups for prevention	Symptom resolution, medication use, complications, school absence; later URTI episodes	Children in the saline group showed faster resolution of some nasal symptoms during acute illness and less frequent reappearance of rhinitis subsequently
Alexandrino et al. 2017 [94]	Randomized controlled trial (primary care)	RCT. Children with mild acute rhinosinusitis and allergic rhinitis	138	Isotonic saline irrigation as add-on to standard therapy	Standard therapy without irrigation	SNOT-22 and NOSE scores; caregiver-reported improvement; medication use; short-term follow-up	Greater improvement in symptom scores and caregiver-reported improvement with irrigation; some reduction in medication needs

Abbreviations: WARM = wheeze, air-exchange, respiratory rate, muscle use score; PRQLQ = Pediatric Rhinoconjunctivitis Quality of Life Questionnaire; PEFR = peak expiratory flow rate; SNOT-20/22 = Sino-Nasal Outcome Test (20- or 22-item); NOSE = Nasal Obstruction Symptom Evaluation; VAS = visual analogue scale; URTI = upper respiratory tract infection; RCT = randomized controlled trial RCT: Randomized clinical trial.

changes in the diaphragm course, lung expansion, and ventilation distribution. To standardize the abdominal stabilization, Franco et al. included an abdominal belt during assisted autogenic drainage to provide stability to the abdominal muscles and the zone of apposition of the diaphragm [41]. This illustrates the need of understanding the physiological mechanism of each airway clearance technique, to be used in the research field and in the clinical practice.

This point is important because, even when a clear definition is available, the practice of ACT has been demonstrated to be physiotherapists-dependent [42–44]. For example, a study showed that ACT involving the manual application of forces and oscillations to the chest wall of children were influenced by the physiotherapist [42]. Considerable variability was observed in the magnitude of applied force, number and frequency of oscillations, and duration of force application between physiotherapists. However, physiotherapists demonstrated to have fine control over the application of forces during manual ACT with a good intra-physiotherapist reliability even if the force and duration of the application differed depending on the patients [44]. The instrumental techniques are also subject to inter-patients' variability which must be addressed through appropriated teaching and training to reduce this variability [45].

Another reason for the urgent need to define the ACT is the diffusion of the knowledges by helping the teacher of ACT. With the growing status of social network and accessibility to the information, variability in teaching of ACT increases because the wide diffusion of potential mistakes [46]. The misinformation related to technical medical teaching was previously associated to social network because the involvement of non-specialists even if this form of teaching can be successfully integrated in the medical education [47].

The future of the airway clearance techniques which are frequently discussed due to the lack of evidences depends on uniformity in the practice and in the trials. Indeed, the self-adaptation of techniques by authors as explained before will introduce bias in the results of the future studies which could decrease the level of evidence of the true technique.

With the growing use of artificial intelligence, it is also important to collect the description of the ACT in one paper. It could contribute to vehiculate a uniform information for the students, the teachers, and the professionals.

Beyond the problematic of definitions, the multitude of techniques also raises the issue of choosing the most appropriate one for the therapist, depending on the patient's clinical situation. Indeed, each patient – and even each clinical situation for the same patient – requires adapting the choice of the most suitable technique. To facilitate this decision-making in the context of secretion management and airway clearance techniques, the authors suggest taking into account two physiological aspects: the presence and properties of secretions.

If the presence of secretions is confirmed through auditory detection, auscultation, or manual stimulation techniques performed by a qualified physiotherapist (noting that none of the methods is foolproof), the use of an airway clearance technique should be taken into account. In this case, the site of secretions become essential for the optimal choice. A technique that modulates slow expiratory airflow at the mouth should be favored for peripheral site in the lungs due to the physiological response in the peripheral airways. Indeed, in this context, a maximal flow can be expected in the peripheral parts of the bronchial tree and then mobilize the secretions in this area. Conversely, faster expirations will be more appropriate for proximal secretions because they improve the flow in the proximal airways.

The properties of the secretions are a key factor in the decision. If they are viscous, the use of techniques generating oscillation of the airflow would be useful. Indeed, as demonstrated in the literature, an OPEP device (Oscillating Positive Expiratory Pressure) should be included in the management of diseases with hypersecretions such as bronchiectasis, cystic fibrosis … Many studies demonstrated that the use of OPEP the increase of the amount of sputum following [48–51].

A technique that generates positive expiratory pressure should be used when dynamic airway compression leads to locally insufficient expiratory flow, preventing effective secretion mobilization – whether through spontaneous breathing, coughing, or other airway clearance techniques. This excessive bronchial obstruction, which impairs secretion mobilization during expiration, is often detectable by ear or through the therapist's hands.

In conclusion, while ideal research should evidently adhere to established methodological guidelines, it must also recognize the physiotherapy session as a dynamic process involving a rigorous and qualitative assessment followed by the optimal selection of airway clearance techniques (ACT). The goal of a physiotherapy session is not to repeatedly apply a single ACT, but rather to identify and implement the most appropriate technique – or combination of techniques – based on the patient's clinical condition, as assessed by the physiotherapist during each session. No single ACT is universally suitable for all patients or for every session in the same patient. The perfect approach would be a personalized ACT. Designing a study that reflects this 'real-life' approach would be innovative, even if it introduces heterogeneity across sessions. Nevertheless, it could provide valuable insight into the impact of a skilled physiotherapist on secretion management.

The future of airway clearance techniques now relies less on the emergence of new maneuvers than on the clarification, standardization, and personalization of existing ones. Advances in physiological understanding, combined with standardized descriptions and emerging digital and artificial intelligence tools, may support more reproducible practice, improved training, and better-designed clinical studies.

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