

Barriers to Effective Airway Clearance

I. Introduction

Barriers exist for all prescribed treatments regardless of diagnosis. To assure positive health outcomes, these barriers must be assessed prior to the initiation of a specific therapy to avoid progression of disease, development of complications, lack of compliance, the need for more aggressive, costly treatments and reduced quality of life.

The following discussion addresses expected outcomes or goals of an effective airway clearance therapy and the barriers that often exist for patients to achieve the desired clinical results.

II. Goals/Expected Outcomes of Airway Clearance Therapy (ACT)

The following outcomes should be realized from the consistent use of an effective ACT:

- Clear secretions
- Preserve lung function
- Reduce infectious exacerbations
- Reduce dependence on antibiotic therapy and other medications
- Reduce the need for hospitalizations and auxiliary medical services
- Delay disease progression
- Reduce the burden of care
- Enhance quality of life
- Promote long-term cost effectiveness

If these therapy goals are not being met, physicians and other health care professionals involved in the care of a patient suffering from retained secretions will re-assess the prescribed ACT for barriers that may limit its effectiveness.

III. Barriers to Effective ACT

Specific contraindications exist for chest physiotherapy (CPT). These are documented in the American Association of Respiratory Care Guidelines: Postural Drainage Therapy. They include:

- Elevated intracranial pressure
- Aged, confused or anxious patients who do not tolerate position changes
- Spinal injury or rib fracture
- Uncontrolled hypertension
- Distended abdomen
- Uncontrolled airway/risk for aspiration
- Bronchospasm

Several sources site specific barriers and limitations of CPT:

CPT is an airway clearance technique that combines manual or mechanical percussion of the chest wall by a caregiver, strategic positioning of the patient for mucus drainage, and cough and breathing techniques. Typically, a treatment session consists of manual percussion for 3-5 minutes on each of nine specific thoracic regions while assuming appropriate drainage postures. Although CPT is established in the peer-reviewed literature as an effective method for mobilizing mucus,¹ its benefits are compromised by a number of intrinsic and extrinsic factors.^{2,3,4,5}

Intrinsic limitations:

- CPT is most effective with mental and physical cooperation from the patient... *it cannot be administered efficiently to patients who are totally immobile, technology-dependent, and/or cognitively compromised*⁶
- CPT requires physical tolerance...*contraindications arising from anatomical deformity, transient hypoxemia associated with postural drainage, predisposition to gastroesophageal reflux, inability to perform breathing techniques, etc., preclude the use of CPT*⁷
- CPT requires rigorous treatment adherence...CPT has the lowest adherence rate of any aspect of bronchial hygiene care^{8,9,10,11}

Extrinsic limitations:

- CPT is technique-dependent...*effective treatment depends upon the skill and dedication of a trained caregiver*¹²
- CPT is labor-intensive...*caregivers must possess the physical strength and endurance both to administer effective chest percussions and to position patients on a slant board to facilitate gravitational movement and expectoration of mucus*¹³
- CPT is also time-consuming...*typical treatment sessions last 30-45 minutes and may be required three or more times daily*¹⁴
- CPT is costly. *Hourly rates for skilled therapists may be prohibitive*

Barriers exist for other types of therapies as well.

Mechanical insufflation-exsufflation

Mechanical in-exsufflation is a cough-assist modality. Treatment is delivered by a device (Emerson™ In-Exsufflator) that applies a positive pressure breath (insufflation) followed by negative pressure (exsufflation) for the purpose of stimulating a secretion-clearing cough. The device is intended to aid individuals whose cough function is ineffective.¹⁵ The technique requires use of a facemask, mouthpiece, or an adaptor applied to an endotracheal or tracheostomy tube. Positive pressure is delivered gradually to the airway; then shifted rapidly to a negative pressure. A cough is thus

stimulated, mobilizing secretions to permit clearance by expectoration or suctioning.¹⁶ Although the mechanical in-exsufflator is used by some patients with neuromuscular or neuromotor conditions as part of their respiratory care regimens, evidence of its effectiveness is limited to anecdotal, non-randomized case series reports.^{17, 18}

Many neuromuscular disease, paralyzed and/or technology dependent patients cannot use mechanical insufflation-exsufflation effectively because it requires:

- Caregiver skill and availability
- Adequate cognitive function
 - Ability and motivation to concentrate
 - Ability to cooperate
- At least minimal bulbar muscle function¹⁹

In-exsufflation is not a complete airway clearance method. It may be suitable for patients in whom weak cough function is the sole impediment to normal secretion clearance.²⁰ Most quadriplegic/SCI patients suffer also from acquired impairment of MCC function as a result of ventilator dependence and/or lung tissue damage secondary to recurrent respiratory exacerbations.²¹

Intrapulmonary percussive ventilation (IPV)

Intrapulmonary percussive ventilation (IPV) involves the use of a pneumatic device called the Percussionaire[®] to deliver minibursts of positive pressure to the airways via a mouthpiece. It is designed to treat patchy atelectasis while mobilizing and clearing secretions. High frequency puffs of air are believed to open atelectatic alveoli and deliver air behind mucus plugs, helping to dislodge them. Use of the device may also enhance delivery of aerosolized medications to the airways.²²

During inspiration, the patient or caregiver depresses a button that triggers delivery of up to 300 bursts of air per minute. The button is released during expiration. Sudden release of the button can create a cough-like expiration. A treatment time of twenty minutes is recommended.²³

Effective use of IPV requires:

- Caregiver skill and availability
- Adequate cognitive function
 - Ability and motivation to concentrate
 - Ability to master breathing techniques
- Specific physical attributes
 - Adequate motor control; unsuitable for spastic individuals
 - No incompatible facial deformities
 - Ability to tolerate; the manufacturer lists sore ribs, fatigue, stress and irritation as potential side effects.²⁴

IPV may be inadequate to effect tracheobronchial clearance of thick or tenacious secretions.²⁵

PEP

Positive Expiratory Pressure (PEP) is an airway clearance technique administered with a mechanically applied pressure device. The patient breathes through a flow resistor held in place by a tight-fitting mask, exhaling against a valve, which creates a back pressure in the lungs. The patient then performs the huff cough. If done properly and the pressure generated is sufficient, lung volumes are improved and the cough becomes more productive, enhancing clearance of secretions.²⁶

PEP can be an effective airway clearance method when used properly by patients sufficiently healthy to manage the rather strenuous, choreographed breathing techniques. Effective use of PEP is extremely patient-dependent, and lapses in procedure or compliance diminishes or negates the value of PEP therapy.²⁷

PEP cannot be used by patients who are physically unable to generate the considerable expiratory force it requires. Such patients include those with significant neuromuscular weakness or general infirmity, impaired cough function, spastic disorders, quadriplegia or high-level spinal cord injury, tracheostomy or dependence on mechanical ventilation.²⁸

PEP therapy requires:

- Caregiver skill and availability
- Adequate cognitive function
 - Ability and motivation to concentrate
 - Ability to master breathing techniques
- Specific physical attributes
 - Adequate motor control; unsuitable for spastic individuals
 - No incompatible facial deformities

Effective PEP therapy relies heavily upon patient compliance. Pneumothorax is a recognized potential complication of this technique.²⁹

Flutter® Valve

The Flutter® valve is a hand-held mucus clearance device designed to combine positive expiratory pressure (PEP) with high frequency airway oscillations at the airway opening. The device resembles a pipe with an inner cone leading to a loosely supported steel ball covered by a perforated cap. Exhalation through the Flutter® device is thought to create oscillations at the airway opening, which cause transient increases in airflow. The weight of the steel ball housed within the device provides intermittent PEP mechanisms, which, together with the airway oscillations, vibrate the airway walls. As a result,

secretions are loosened, expiratory flow rates accelerated, and mucus is advanced to central airways.³⁰

To use the device, the patient exhales through the Flutter® valve while using controlled breathing techniques, thus building pressure in the airways and in the passageway beneath the enclosed steel ball until the ball begins to move and some air escapes. When the technique is performed correctly, the ball oscillates rapidly, opening and closing gas pathways, thus producing vibrations, which resonate throughout the tracheobronchial tree. The position or angle of the device determines the intensity of airway vibration. Cough techniques are used to expectorate mucus from the central airways.³¹

The Flutter® valve may be an effective airway clearance modality for persons who have appropriate physical, cognitive, and behavioral characteristics. It is unsuitable for patients who are physically or cognitively unable perform the technique correctly, including those with neuromuscular weakness or general infirmity, impaired cough function, spastic disorders, quadriplegia or high-level spinal cord injury, tracheostomy or dependence on mechanical ventilation.³²

Flutter® therapy requires:

- Adequate cognitive function
 - Ability and motivation to concentrate
 - Ability to master breathing techniques
- Adequate motor control
 - Ability to assume correct posture
 - Ability to hold device at a correct angle
 - Ability to form seal with lips
 - Ability to generate adequate expiratory force

Barriers to different types of therapy are present as a result of specific disease characteristics or complications, concomitant therapies, cognitive ability, age, and patient and/or caregiver disabilities.

Barrier	Related Diagnosis/es
Susceptibility to gastro-esophageal reflux, risk for aspiration	CF, primary ciliary dyskinesia, cerebral palsy, spinal cord injury, neuromuscular disorder, trachesotomy
Technology dependence (multiple IV access, ventilator dependence, gastrostomy tube insertion, etc.)	Varies
Anatomical abnormalities (severe kyphoscoliosis preventing proper positioning, facial deformities preventing proper mouth seal for certain therapies, etc.)	Muscular dystrophies, cerebral palsy
Inability to generate sufficient expiratory force due to restrictive lung disease and/or reduced lung volumes	Neuromuscular disorder, COPD, ALS, SMA, asthma, CF, bronchiectasis
Spasticity or motor control dysfunction	Cerebral palsy, quadriplegia
Cognitive impairment	Mental retardation, developmental delay, down syndrome, cerebral palsy
Patient age	
Caregiver issues (physical, mental and/or emotional disabilities)	Carpal tunnel syndrome, shoulder or wrist injuries, arthritis
Patient resistance to dependence	Age dependent, puberty
Poor adherence to therapy	Varies

The Vest™ system provides a safe, effective alternative to technique and caregiver dependent forms of ACT. It is not position dependent, requires no postural drainage and treats all lobes of the lung simultaneously. This therapy thereby reduces the risk for gastroesophageal reflux, aspiration and postural-related hypoxemia. In a recent study, users of The Vest™ system reported the highest levels of overall satisfaction and adherence when compared to CPT and the Flutter® valve.³³ Users of The Vest™ system also reported significantly fewer missed therapies. Finally, because The Vest™ system provides an independent form of therapy, minimal caregiver assistance is required.

Absolute contraindications for The Vest™ system include:

- Head and/or neck injury that has not yet been stabilized
- Active hemorrhage with hemodynamic instability

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