Mechanical Insufflation – Exsufflation for airway secretion clearance and lung expansion therapy

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Objectives
- Understand the indications for Airway Clearance Therapy (ACT)
- Identify appropriate airway clearance therapies based upon the patient's condition and need for loosening vs cough clearance.
- Understand the indications, contraindications and cautions for the use of mechanical insufflation-exsufflation (MI-E)
- Identify the advantages of using a noninvasive MI-E device over invasive airway clearance (suction)
- Identify the new functions available with the CoughAssist T70

Living in the age of Social Media is great!

Normal Airway Clearance

Natural airway clearance includes three essential components:

A. Mucus traps impurities
B. Cilia beat carry mucus to large airways
C. A strong cough clears mobilized secretions

In most individuals, these three components work in harmony to keep our airways clear.
Factors that affect mucociliary clearance

- Airflow
- Hypersecretion
- Viscelasticity of mucus
- Shear forces
- Airway aperture
- Ciliary beat strength and frequency

Indications for Airway Clearance Therapy (AARC Clinical Practice Guideline)

- Difficulty with secretion clearance
- Sputum production > 30 ml/day
- Artificial airway in place
- Atelectasis from mucus plugging
- Diseases/conditions: CF, DMD, Bronchiectasis, Pneumonia
- Foreign body in airway

Inadequate Airway Clearance

Problems may occur with diseases or conditions characterized by:

- Excessive production of thick mucus
  - Cystic fibrosis
  - Bronchiectasis
  - Chronic obstructive pulmonary disease (COPD)
- Inability to mobilize secretions (mucociliary disorders)
  - Primary ciliary dyskinesia
  - Lung transplantation
- Neuromuscular deficits
  - Cerebral palsy
  - Duchenne muscular dystrophy
  - ALS or higher spinal cord injuries

Indications for MI-E therapy

- Patients with an ineffective cough due to neuromuscular disorders
- Patients with paralysis of the respiratory muscles such as a high spinal cord injury
- Patients that have an ineffective cough due to respiratory fatigue associated with intrinsic lung disease
- In the acute and chronic care setting—neuromuscular disease patients in respiratory failure
  - Avoid intubation
  - Facilitate extubation and decannulation
  - Prevent post-extubation failure

Patient conditions

- Patients with neuromuscular diseases and spinal injuries
  - Muscular dystrophy (Duchenne)
  - Myasthenia gravis
  - Poliomyelitis
  - Spinal cord injury
  - Amyotrophic lateral sclerosis (ALS)
  - Bronchiectasis
  - Spinal muscular atrophy (SMA)

- See AARC Clinical Practice Guidelines for nonpharmacological Airway Clearance Therapy

Contraindications to MI-E

- Bullous emphysema
- Pneumothorax or pneumomediastinum
- Recent barotrauma

General information:
Patients need to be cooperative unless they have an artificial airway
AARC Clinical Practice Guideline
Nonpharmacologic Airway Clearance Therapies

For adult and pediatric patients with neuromuscular disease, respiratory muscle weakness, or impaired cough, 1) cough assist techniques should be used in patients with neuromuscular disease, particularly when peak cough flow is < 270 L/min.

CoughAssist mechanical insufflation-exsufflation is intended for use on adult or pediatric patients unable to cough or clear secretions effectively.

PCF < 160 LPM (Bach JR et al., Chest 1996)

Indications for use – Peak Cough Flowrate

Complications of retained secretions

Atelectasis
Increased work of breathing
Hypoxemia
Infection
Lung Damage

Desirable components of an ideal AC Therapy

- Addresses the patient's primary need (loosening, cough clearance or both)
- Easy to teach/learn
- Portable, Cost effective, evidence based
- Time Efficient
- Adaptable to changing severity of patients medical condition
- Provides information on adherence, efficacy and optimization of settings
- The one that the patient will use!
**Loosening vs Cough Clearance**

- Oscillation devices
- Positive expiratory pressure
- Secretion clearance
- Mucociliary clearance
- High-frequency chest-wall compression
- Cough clearance
- Cough mobilization
- Suctioning

**Chest PT** (PD&P, BD, Time for your beating etc.)

- Mucus loosening

**Airway Clearance Techniques**

**Mucus Loosening**

- Oscillatory PEP examples

**Coughing Techniques – Deep Cough and Huff Cough**

  (National Jewish Hospital website)

  - **Deep Cough**: Start by taking a deep breath, held the breath for 2-3 seconds. Use your stomach muscles to forcefully expel the air. Avoid a hacking cough or merely clearing the throat. A deep cough is less tiring and more effective in clearing mucus out of the lungs.

  - **Huff Cough**: Huff coughing or huffing, is an alternative to deep coughing if you have trouble clearing your mucus. Take a breath that is slightly deeper than normal. Use your stomach muscles to make a series of three rapid exhalations with the airway open, making a "ha, ha, ha” sound. Follow this by controlled diaphragmatic breathing and a deep cough if you feel mucus moving.

**Manually-assisted cough – Cough Clearance**

- Performed by a caregiver
- Various positions and techniques

**Breathing Techniques**

- Breathing Techniques:
  - Active Cycle Breathing
  - Autogenic Drainage
  - Used by Physiotherapists in Canada and Europe, some CF Centers teach.
  - Can be difficult to learn and teach
**Suctioning (Cough clearance)**

- Invasive procedure
- Misses left main stem bronchus 90% of the time
- Tracheal trauma, suctioning induced hypoxemia, hypertension, cardiac arrhythmias and raised intracranial pressure have all been associated with suctioning
- Patients have reported that suctioning can be a painful and anxiety-provoking procedure

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**Issues with invasive airway suction**

J.R. Bach, MD

- Because invasive airway suctioning misses the left mainstem bronchus over 90% of the time and for patients with ventilatory pump failure over 83% of pneumonias are in the left lung.
- To permit definitive noninvasive ventilatory support because tracheotomy tubes cause 89% of the mortality for tracheostomy ventilation users.

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**Airway Clearance Devices**

- HFCWO/HFCC vest therapy
  - Loosening

**Metaneb and IPV - Loosening effect**

Oscillatory airflow with a nebulizer also

**Other device approaches**

- Frencurier uses acoustics to create vibrations (from Canada)

Hayek Chest Shell – claims to provide ventilation, HFCWO and a cough effect.
Mechanism of Action – Cough Clearance

- The mechanical insufflator-exsufflator assists patients in clearing retained secretions by applying a positive pressure to the airway, then rapidly shifting to a negative pressure.
- This rapid shift in pressure produces a high expiratory flow rate from the lungs.

Introduction

- The treatment can be delivered via facemask, mouthpiece or endotracheal or tracheostomy tube.
- It is effective for both invasive and non-invasively ventilated patients.
- Intended for use by adult and pediatric populations.

Settings

- **Trigger type**: Cough-Trak, Auto or Manual. Cough-Trak lets the patient trigger with spontaneous breaths.
- **Insufflation Pressure**: Start with low for initial instruction (10 to 15 cmH2O). Increase to tolerance and effect. Usually you will need at least 35 to 50 cm H2O. Higher pressures may be necessary with a trach tube.
- **Exsufflation Pressure**: Start with low for initial instruction (10 to 15 cmH2O) and work up. Set for tolerance and effect. Usually same as Insufflation Pressure.
- **Pause time**: Time between cough cycles. Do not need to set if using Cough-Trak.

History of MI - E

...Since 1954 to 2010

- The co-flator
- The “Tin Can” Insufflator-Exsufflator
- The Cough Assist
- The In-Exsufflator

Secretion removal techniques and devices

- MI-E: The legacy CoughAssist CA 3000 and the current CoughAssist T70.
Cough-Trak trigger

Cough-Trak ON
Inhale + Exhale + Pause = Cycle
Repeat cycle 4-6 times
Rest 20-30 seconds
Repeat sequence 4-6 times

Suggested CoughAssist T70 MI-E treatment

Patient triggering
Pause time varies from one cycle to another

Cough-Trak Off

Timing triggering

Is my patient compliant?
Is my patient triggering? 1 year compliance data and pattern of usage (coughs per day)

How does patient’s ability to cough progress?
1 year long-term trends (average peak cough flow and Vti)
Daily trends (flow, pressure, Vti, oximetry)

Benefits of Insufflation

Enhancing Therapy with the Oscillations

Clinical aim:
Oscillations help releasing mucus from the bronchial walls, increasing mobilization and improving bronchial drainage

How:
No helping respiratory airflows in the lung

Settings:
- The oscillations can be applied to the
  inhale, exhale, or both phases
- Frequency: 1-20 Hz
- Amplitude: 1-10 cmH2O
- Note: In Advanced Auto mode, when oscillations are enabled in the inhale phase, it also applies to the posttherapy breaths

New features with expanded applications

Oxydog: The discreet mobile oxygen concentrator

Downloads

To get the values
More than a year of statistics Summary Settings and prescription history

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Is my patient compliant?
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Primary recommendations
Do what is comfortable for patient; there is no additional contraindication!

Fewer sensation:
High frequency and small amplitude

Primary recommendations
Do what is comfortable for patient; there is no additional contraindication!

Stronger sensation:
Small frequency and high amplitude

Suggestion 1:
Start at a high frequency (e.g., 20 Hz) and low amplitude (e.g., 1-2 cmH2O) and adjust the settings until comfortable for patient

Suggestion 2:
Use it with your normal coughing session!

Expanding therapy options with Advanced Auto Mode

Clinical Aim:
To adapt to the evolution of the airway clearance practices and expand therapeutic options to help clinicians better treat their patients

How:
• By integrating some successive insufflations to help with lung volume recruitment prior to the cough therapy
• By automating the number of cycles being delivered so the caregiver just has to press the ON/OFF button to start/stop the therapy
• By allowing the therapy to end on an insufflation (positive pressure) as opposed to an exsufflation (negative pressure)

Settings:

Advanced Auto Mode – Example

Advanced Auto Mode – Which benefits

• Patients with hyper reactive airways and prone to develop bronchospasm during the MI-E therapy can benefit from the pre-therapy breaths with low insufflation volume prior to the cough cycles.

• Patients who can stack several insufflations promoting lung volume recruitment (to maximize their insufflation volume) prior to exsufflation, to help maximizing their peak cough flow outcome.

• Patients predisposing to the development of persistent atelectasis can benefit from the pre-therapy breaths with insufflation volume followed by breath hold to simulate the lung/thoracic/chest expansion therapy.

• Patients needing secretion mobilization from the peripheral airways can benefit from the pre-therapy breaths with varying insufflation volumes to simulate alternative Airway Clearance Techniques.
A few studies

- Respiratory Failure in ALS – CHEST July 7 2018

CoughAssist MI-E strategy: ventilator-dependent spinal cord injured patients

- Protocol established to include
  - Patient identification
  - Treatment plans
  - Treatment procedures

- Results
  - Low incidence of atelectasis
  - Increased functional residual capacity
  - VAP rate <1%
  - 97% weaning rate (excluding cervical injuries above C-4)
  - Successful decannulation rate
  - Patient preference for CoughAssist MI-E over suctioning


Effects of MI-E in preventing respiratory failure after extubation

- Objective
  - To assess the efficacy of MI-E as part of a protocol for patients who develop respiratory failure after extubation

- Method
  - Randomized control trial
  - 75 patients from a 12-bed ICU
  - Neuromuscular patients excluded
  - On vent for more than 48 hrs.
  - Successfully tolerated spontaneous breathing trial
  - Randomized into two groups
    - Control group – conventional extubation protocol
    - Study group – CoughAssist protocol


Results

- Study group has significantly lower re-intubation rates and lower time under mechanical ventilation (MV)
- Mean ICU stay post-extubation was significantly lower in study group

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<thead>
<tr>
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<th>Control group</th>
<th>Study group</th>
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<tbody>
<tr>
<td>NIV application</td>
<td>20 (50%)</td>
<td>14 (40%)</td>
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<tr>
<td>Total period of MV (days)</td>
<td>17.8 ± 6.4</td>
<td>11.7 ± 3.5</td>
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<tr>
<td>Total ICU length of stay</td>
<td>19.3 ± 8.1</td>
<td>16.9 ± 11.1</td>
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<tr>
<td>Post-extubation ICU length of stay</td>
<td>9.8 ± 6.7</td>
<td>3.1 ± 2.5</td>
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Conclusion

- Inclusion of MI-E in post-extubation failure may reduce re-intubation rates with consequent reduction in post-extubation ICU stay
- Technique improves the efficacy of NIV in this population
Mechanical In-Exsufflation–Expiratory Flows as Indication for Tracheostomy Tube Decannulation: Case Studies – Am Journal of PM&R July 9, 2018
Bach, John R., MD; Giménez, Gloria C., BA; Chiou, Michael, MD

- MI-E expiratory flows correlate with upper airway patency. Patients dependent on NIV with severe SMA type 1, now over 20 years old, have used MIE effectively along with NIV to avoid trachectomy indefinitely.
- While MIE-EF can decrease in ALS to necessitate tracheotomy, they can increase over time and remain effective in all SMA types.
- Two cases demonstrate an association between increasing MIE-EF and ultimately successful decannulation of a NIV dependent patient with SMA type 2 and a patient with obesity hypoventilation syndrome. Only when MIE-EF increased to exceed 200 L/m did the decannulations succeed. Definitive noninvasive management (CNVS) of these patients may only be possible when MIE is effective and the greater the MIE-EF, the greater its effectiveness. Thus, increasing MIE-EF can signal resolution of upper airway obstruction sufficiently to permit decannulation whether a patient is ventilator dependent or not.

Summary
- Used via facemask, mouthpiece, endotracheal or trach tube with pediatric and adult patients
- Maximal effectiveness at pressures of 40 to -40 cm H2O
- Increase peak cough expiratory flows more than 80%1
- Recommended use to reduce recurrent respiratory infections in patients with respiratory weakness from neuromuscular disease2
- Patients prefer MI-E to suctioning for comfort and effectiveness2
- Addition of oscillatory airflow adds loosening therapy to the Cough Clearance therapy.
- Addition of Advanced Auto mode adds lung expansion/airway recruitment

2Boitano, Louie, Mgmt of Airway clearance in NMD. Respiratory Care, August 2006.

Bonus CEU opportunity. CoughAssist webinar by Dr. John Bach. Free CEU.

Dr. John Bach – On the CoughAssist

https://www.youtube.com/watch?v=mOYP6HmsBaw&list=PL2K_6mTqNQTpvkAVsTuiwbKU-HMxRsYnay