

AIRWAY CLEARANCE

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- ✓ The mucociliary transport system is impaired in bronchiectasis

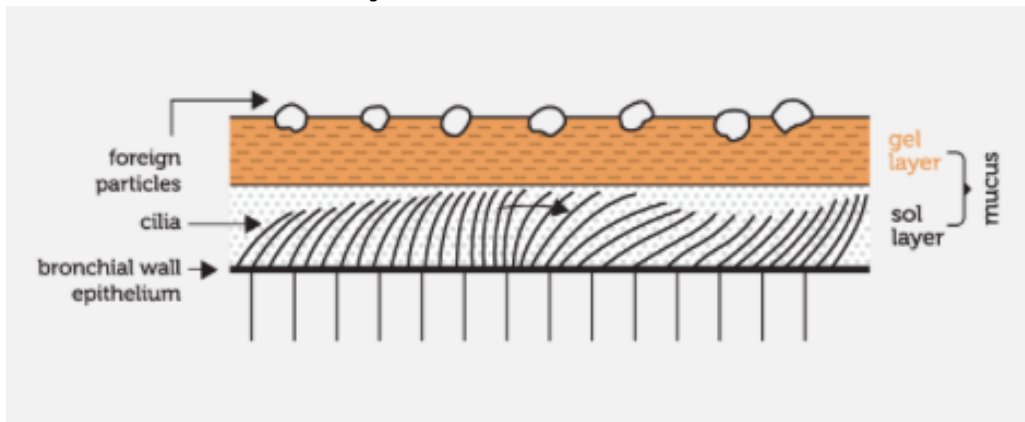
Patients must do Airway Clearance because:

- ✓ It improves removal of sputum
- ✓ Is recommended by International Guidelines
- ✓ The mucociliary transport system is impaired in bronchiectasis
- ✓ Physiologically, airway clearance is more effective than coughing

Sputum is not mucus

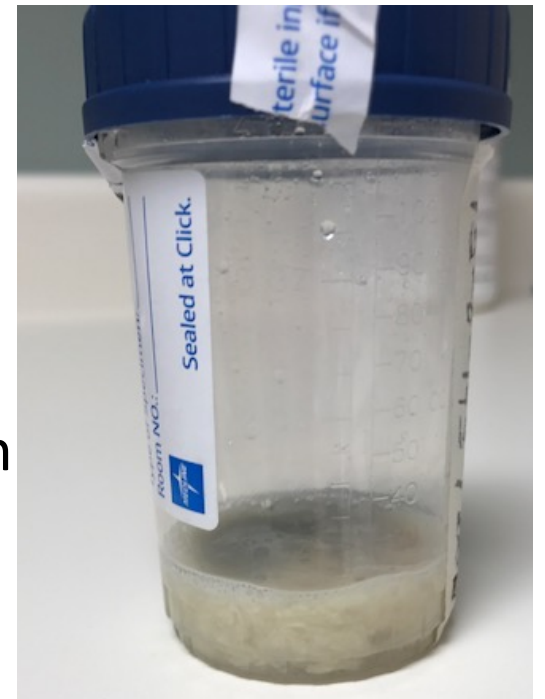
Mucus

- Mucin Glycoproteins
- Antimicrobial and anti-inflammatory properties
- Cleared by cilia



Sputum

- Large polymers that include:
 - DNA
 - Filamentous actin
 - Proteoglycans
 - Bacteria
 - Inflammatory cells
 - Impairs cilia motion



Airway Clearance is recommended by International Guidelines



British Thoracic Society
Pasteur MC, et al.
Thorax 2010;65
(Suppl 1):i1–58.



Thoracic Society of
Australia and New
Zealand
Chang AB, et al. Med
J Aust. 2015;202:21–
3.



European
Respiratory Society
Polverino E, et al. Eur
Respir J 2017; 50:
1700629



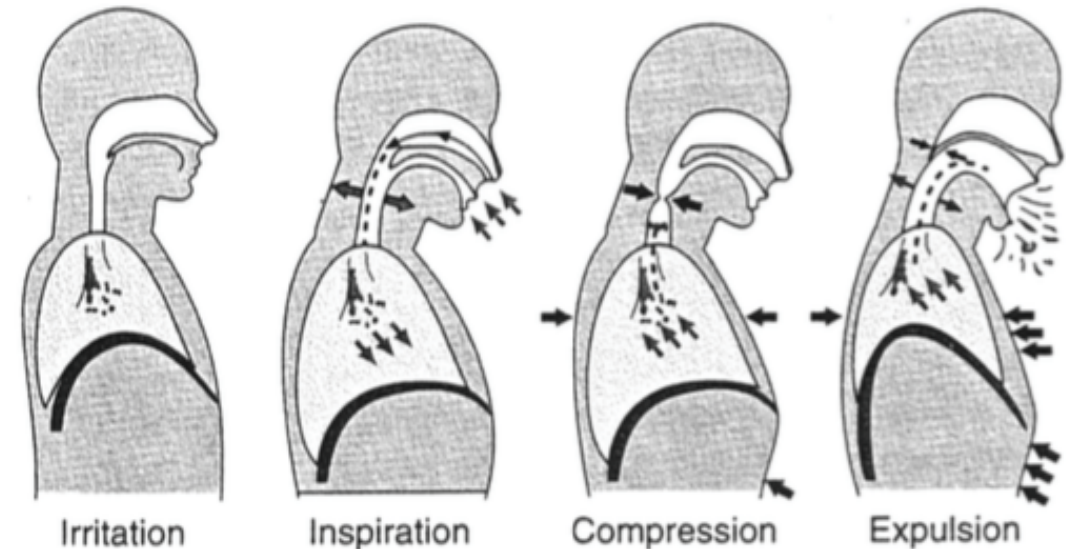
American Thoracic
Society
McShane, PJ et al.
2013; 188; 647
**(NOT OFFICIAL
GUIDELINE)**

Airway
Clearance
and Exercise



Normal Cough

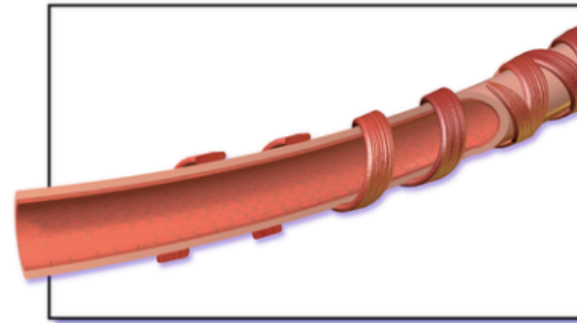
- Clears secretions to the 7th or 8th generation
- Deep inspiration --> closure of the glottis:
 - Up to 300mmHg intra-thoracic pressure --> dynamic airway compression shear force detaching mucus from the airway wall
 - High explosive, turbulent expiratory flow rate (~500L/min)



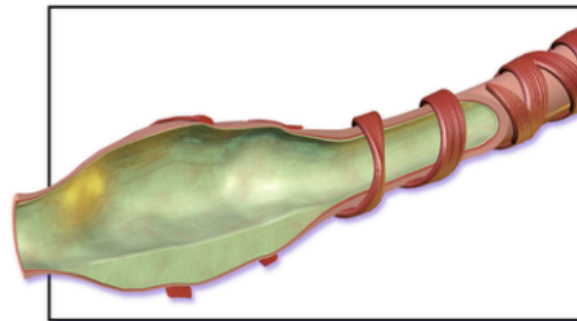
Coughing is not enough in bronchiectasis

- Bronchial wall instability and “floppy” airways close prematurely
 - ***Expiratory flow is reduced thereby limiting the effectiveness of the cough***

Normal Airway



Airway with Bronchiectasis



Airway Clearance Techniques

- ✓ Allow air to move behind obstruction and ventilate distal regions
- ✓ Modulate expiratory airflow in a way to propel secretions proximally up the airways

Modes of Airway Clearance

to be CUSTOMIZED to patient preference and success

Breathing Techniques

Active Cycle of Breathing

Autogenic Drainage

Huff

Postural Positioning

Devices

Positive Expiratory Pressure (PEP) Mask

Positive Expiratory Pressure (PEP) with Oscillation

High Frequency Chest Wall Oscillation (HFCWO) "Vest"

Nebulized Solutions

Hypertonic saline (7%, 3%)

Albuterol

Acetylcysteine

Assistance

Percussion

Postural Positioning

Active Cycle of Breathing Technique





www.bronchiectasis.com.au

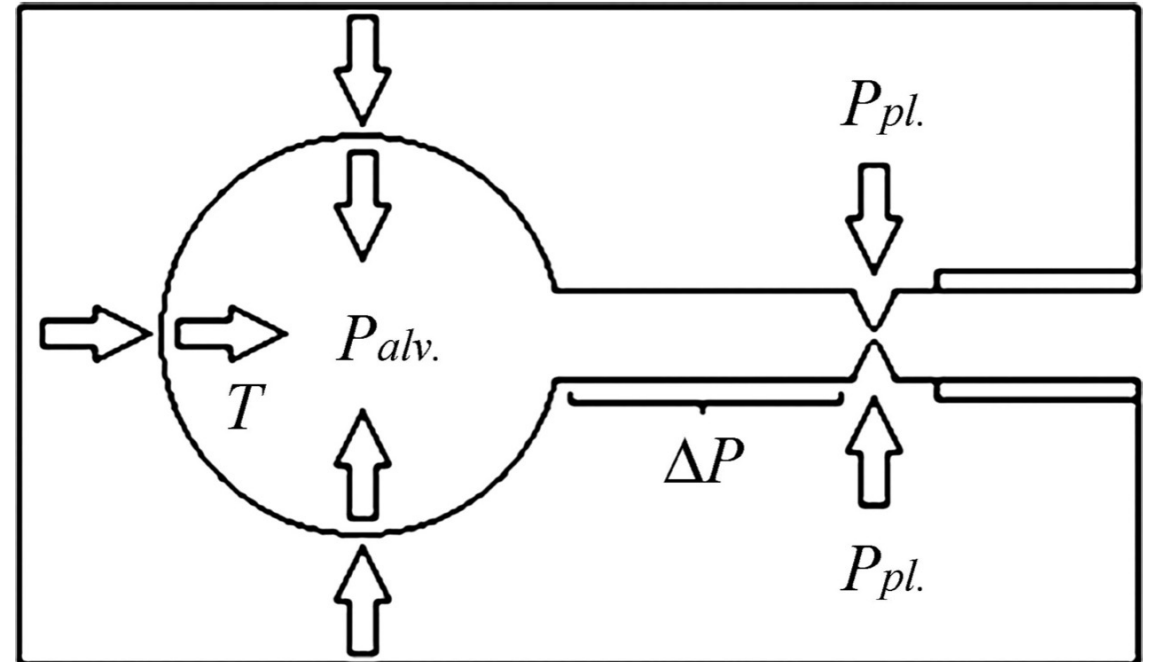


Bronchiectasis
Toolbox

www.bronchiectasis.com.au

Huff

- Accelerates expiratory airflow creating high linear velocities which
 - ***Increases airway surface liquid***
 - ***Shears mucus from the airway wall****
- At low lung volumes, Equal Pressure Point (EPP) shifts to the periphery

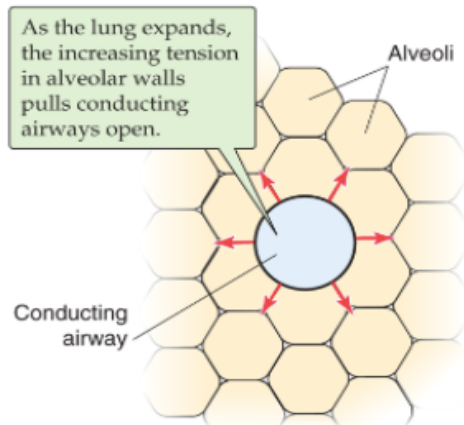


At EPP dynamic compression of the airways creates increase of linear velocity of expiratory airflow which helps to propel secretions proximally

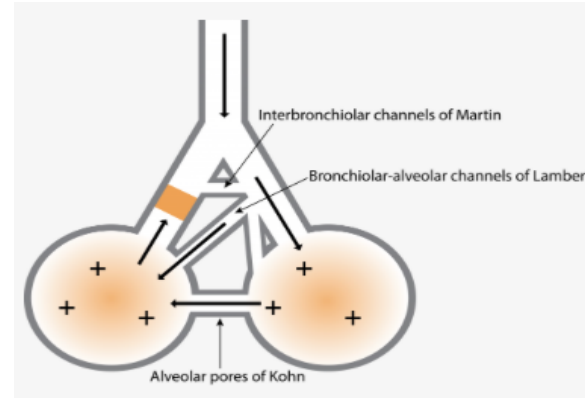
*Depends on mucus depth and viscoelastic properties

Physiologic Basis for Active Cycle of Breathing

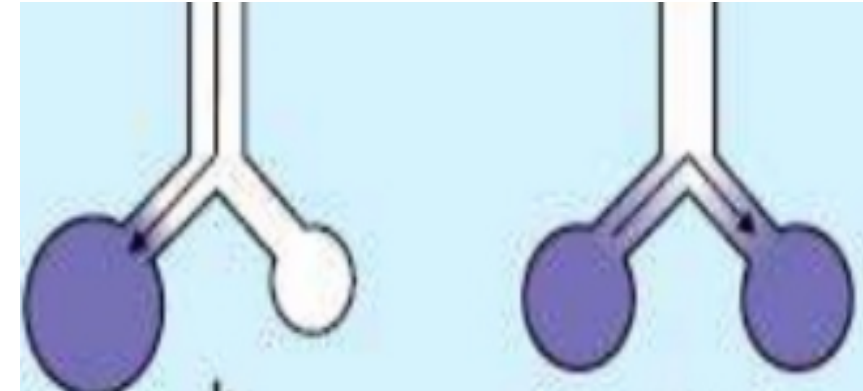
Thoracic Expansion and Breath Hold improves ventilation



Interdependence



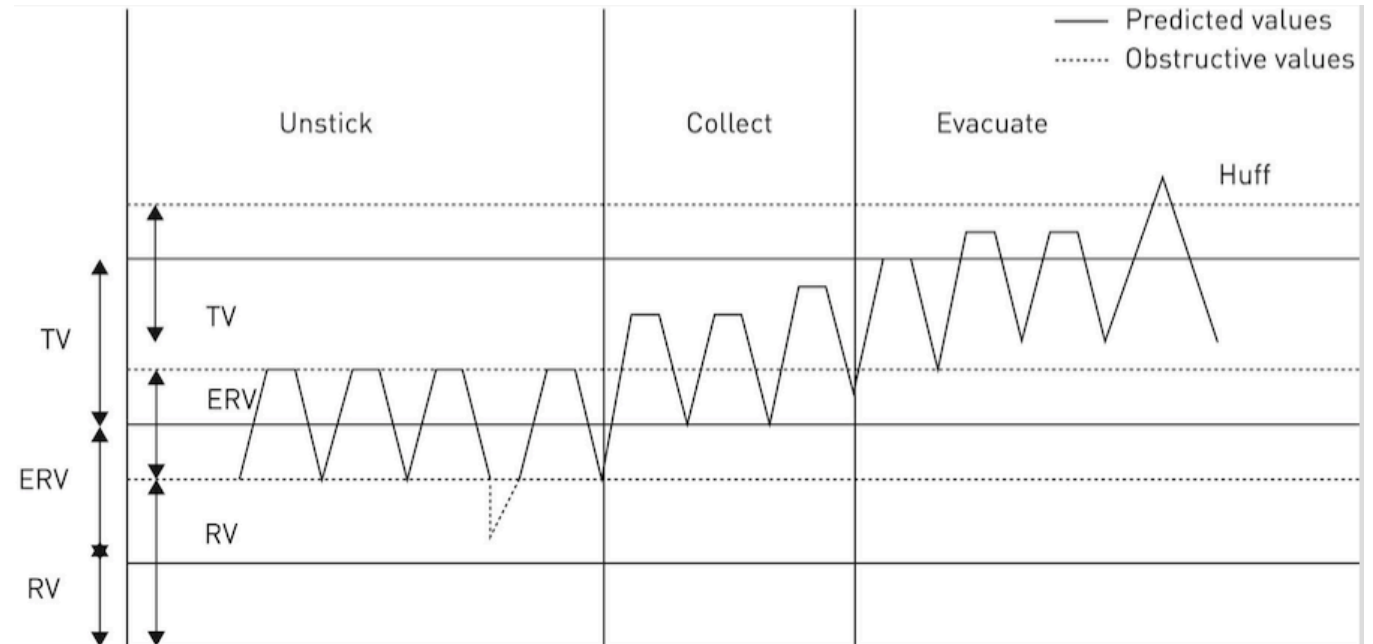
Collateral Ventilation



Pendelluft Flow

Autogenic Drainage

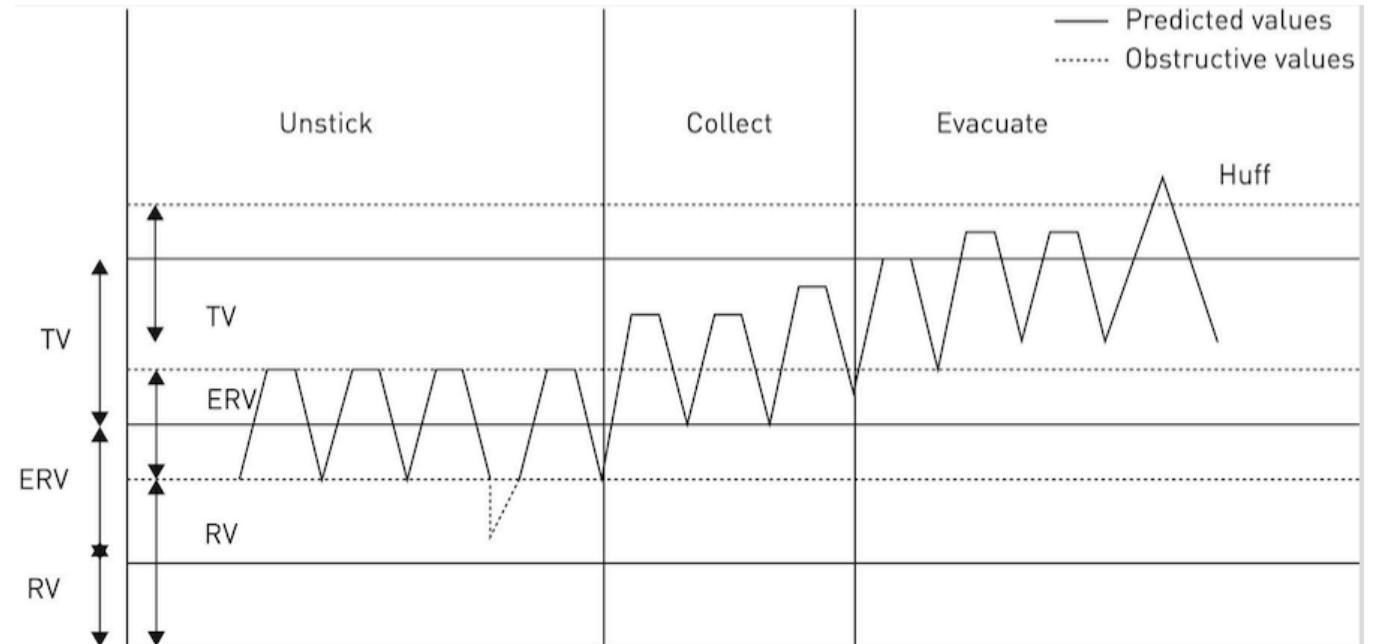
- Uses controlled breathing in 3 stages
- Different lung volumes to loosen, mobilize, and move secretions to the central airways
- Performed with open glottis
- Typically in seated position



Bronchiectasis Toolbox: www.bronchiectasis.com.au

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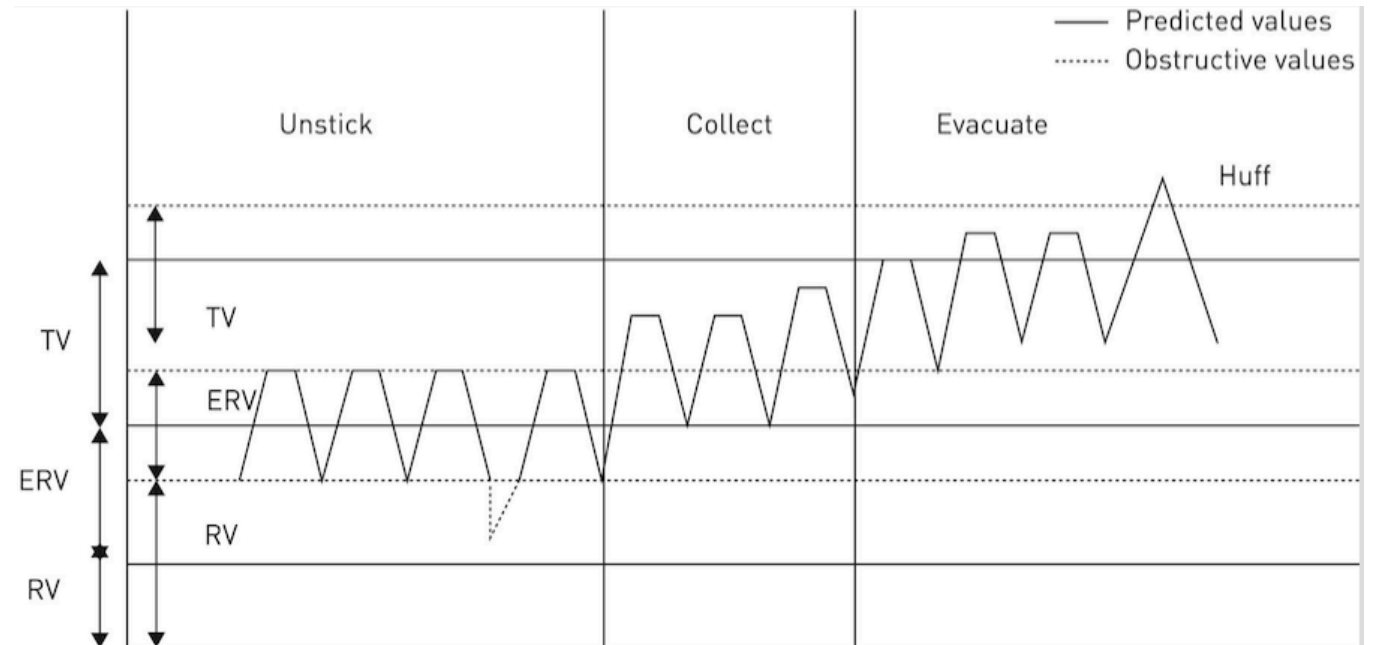


Bronchiectasis Toolbox: www.bronchiectasis.com.au

✓ **Ventilates obstructed regions of the lung**

Autogenic Drainage

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Bronchiectasis Toolbox: www.bronchiectasis.com.au

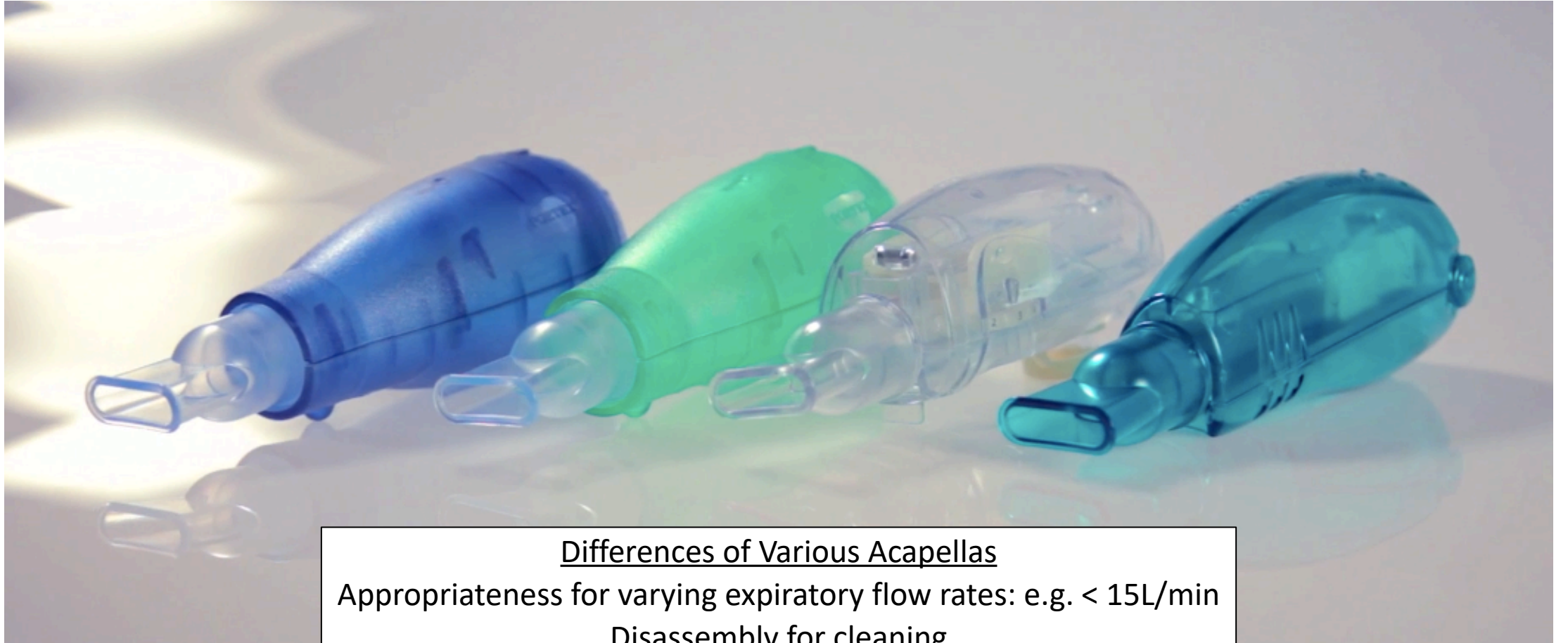
- ✓ **Ventilates obstructed regions of the lung**
- ✓ **Avoids dynamic compression of airways by modulation of expiratory airflow**

Positive expiratory pressure (PEP) with Oscillation

Acapella Devices



Acapella Devices



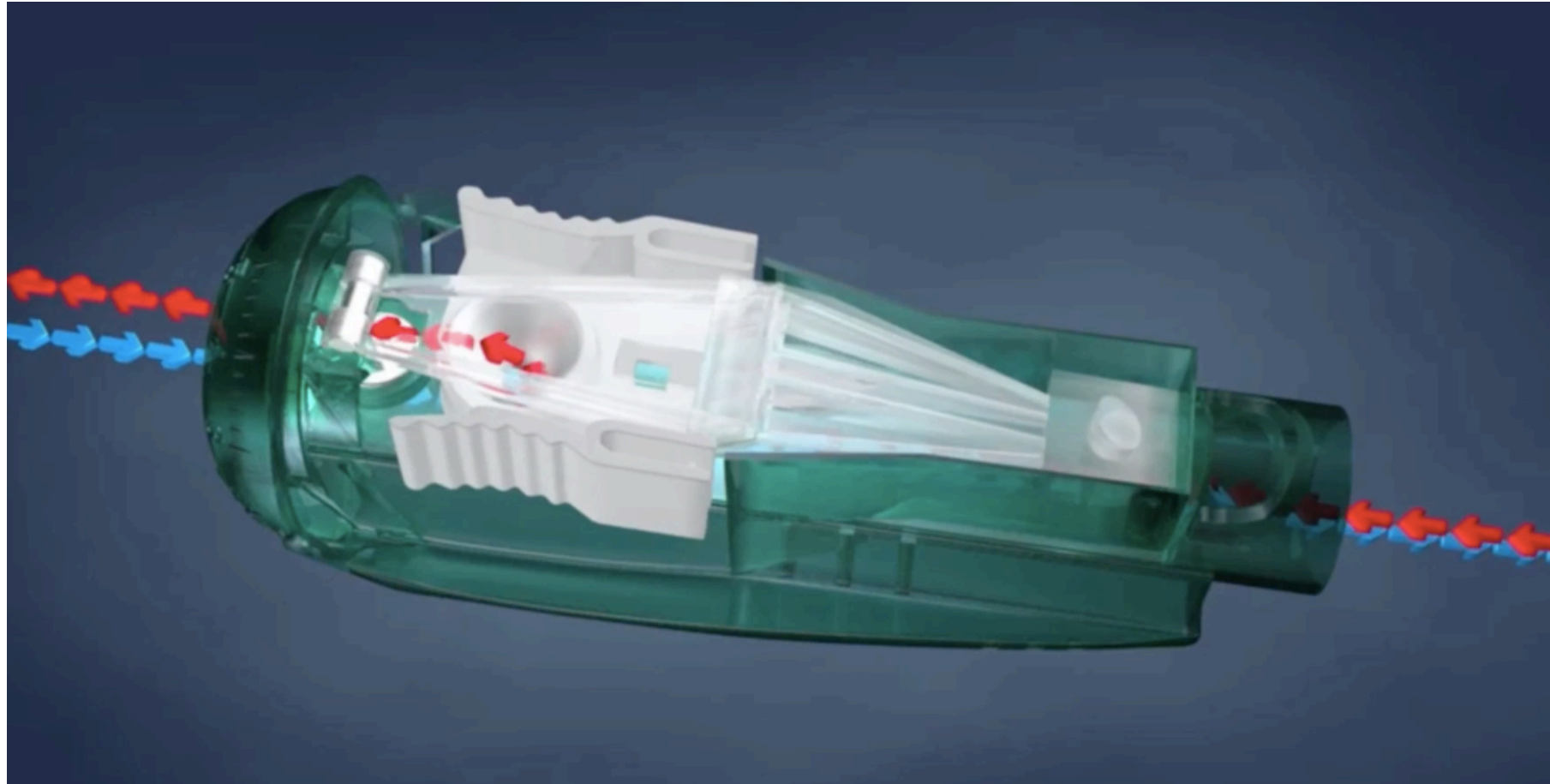
Differences of Various Acapellas

Appropriateness for varying expiratory flow rates: e.g. $< 15\text{L}/\text{min}$

Disassembly for cleaning

Built in nebulizer port

Counter weighted plug and magnet creates airflow oscillations with patient breaths



Flutter Valve



Aerobika



Oscillating with Positive Expiratory Pressure

Oscillation

- Frequencies of 5-17 Hz improve tracheal mucus clearance
 - Flutter: 15-29 Hz
 - Acapella: 13-30Hz

Positive Pressure

- Flutter: 5-19 cmH₂O
- Acapella: 6-21 cmH₂O

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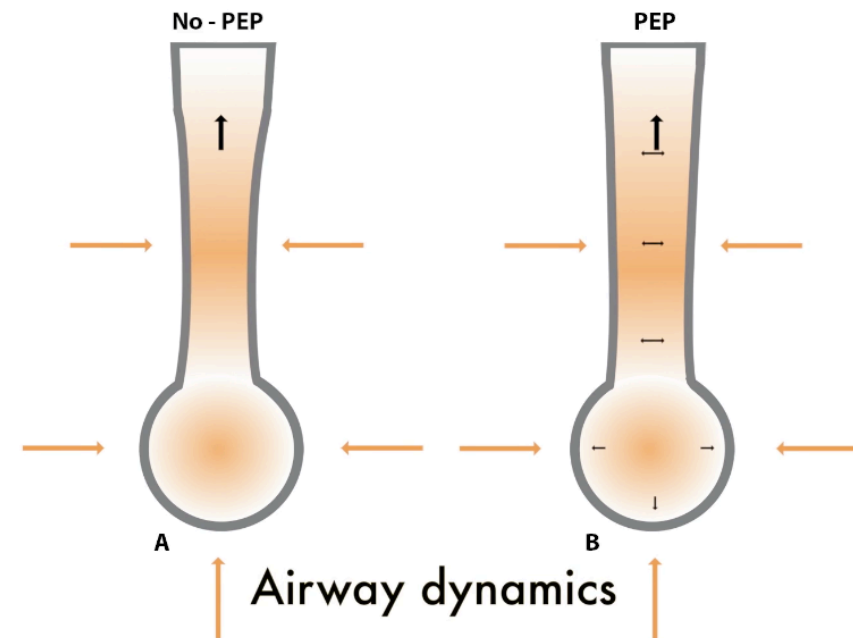
Note: In healthy lungs, cilia beat at a mean frequency of 11-13 Hz

Oscillating with Positive Expiratory Pressure

Oscillation

- Improves mucus rheological properties
 - Reduces mucus rigidity (sum of viscosity and elasticity)
 - Reduces Spinnability (thread forming capacity of mucus)
 - Improves Cough Clearance index (higher index = easier to clear)

Positive Expiratory Pressure



PEP / Oscillating Devices

- Inexpensive (relatively)
- Easy to use
- Minimal space
- Portable

High-frequency chest wall oscillation (HFCWO)



High-frequency chest wall oscillation (HFCWO)

Benefits

- Alters rheological properties of mucus
- Creates an expiratory flow bias that shears mucus from the airway walls
- Enhances ciliary beat frequency
- Creates PEFR average 120 L/min^{-1} sufficient to overcome mucus adhesion

High-frequency chest wall oscillation (HFCWO)

Benefits

- Alters rheological properties of mucus
- Creates an expiratory flow bias that clears mucus from the airway walls
- Enhances ciliary beat frequency
- Creates PEFR $< 120 \text{ L/min}^{-1}$ – sufficient to overcome mucus adhesion

Concerns

- Provides no means of ventilating behind obstructive airways
- Does **not** provide PEP
 - End expiratory volume has been reported to decrease by 10-50% during compression

Manual Percussion



Postural Positioning



Postural Positioning



Personalizing airway clearance strategies

- **No one ACT has been found to be more effective than another**
- One size fits all approach may not address specific patient needs
- Take into account:
 - Patient's disease state
 - Preference
 - Motivation
 - Maturity

Nebulized Agents

Hypertonic Saline

- ***Nicolson et al. Resp Med 2012; 106: 106: 661-667***
- Blinded, prospective, randomized, 12-month study
- 6% hypertonic saline vs. 0.9% saline Q12hrs.
- QOL increased in both groups (SGRQ and LCQ)
- **Sputum bacterial load decreased:**
 - 55% of hypertonic saline group had positive cultures at the start of therapy
 - 15% of hypertonic saline group had positive cultures at the end of the study

Hypertonic Saline

- *Nicolson et al. Resp Med 2012; 106: 106: 661-667*

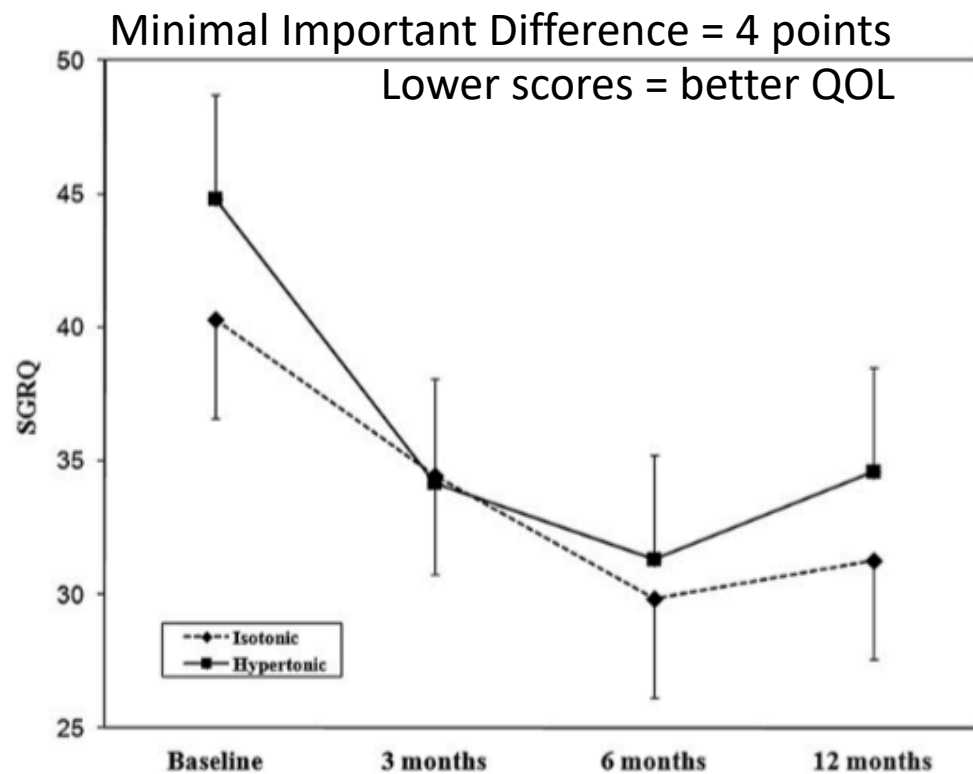


Figure 2 SGRQ Totals. No significant difference between groups at any time point.

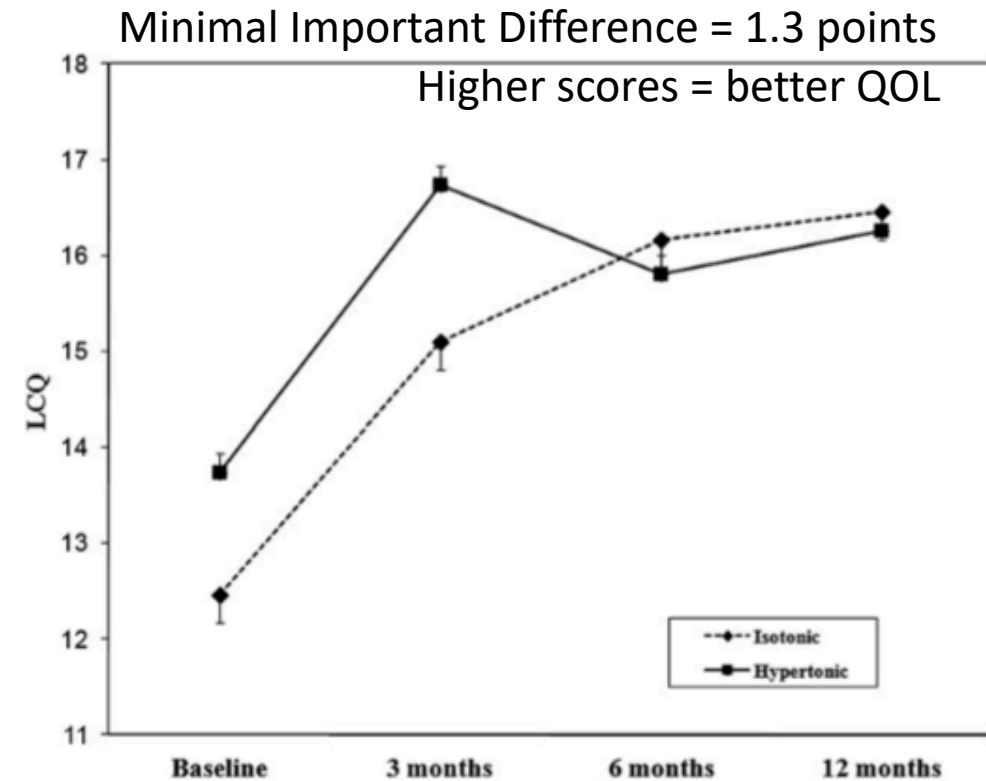


Figure 3 LCQ Totals. No significant difference between groups at any time point.

Hypertonic Saline

Hypertonic saline
can cause **chest
tightness and wheezing**

....therefore, some patients may benefit from
inhaled albuterol ***prior*** to hypertonic saline

Long-term benefits of airway clearance in bronchiectasis: a randomised placebo-controlled trial

Gerard Muñoz^{1,2}, Javier de Gracia^{3,4,5}, Maria Buxó⁶, Antonio Alvarez^{3,4} and Montserrat Vendrell^{1,3}

- Slow expiration with the glottis opened in the lateral posture (ELTGOL)
 - Randomized, placebo-controlled trial over 1-year period
 - ✓ Improved sputum removal
 - ✓ Reduced exacerbations
 - ✓ Improved quality of life

Conclusion

- Patients should do airway clearance because:
 - ✓ Coughing is not adequate or a complete airway clearance
 - ✓ Airway clearance enhances ventilation and improves quality of life
 - ✓ Airway clearance should be customized to the patient