Airway Clearance Techniques in Non-CF Bronchiectasis.

Maggie McIlwaine MCSP
Clinical Instructor, School of Rehabilitation Medicine,
University of British Columbia
Cardiorespiratory Specialist Physiotherapist,
BC Children’s Hospital
Vancouver, BC, Canada.
Financial Interest Disclosure
(over the past 24 months)

Maggie McIlwaine

<table>
<thead>
<tr>
<th>Company</th>
<th>Speaker</th>
<th>Advisory</th>
<th>Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novartis</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Forest Laboratory</td>
<td>✓</td>
<td></td>
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</tr>
</tbody>
</table>
Objectives:

- At the end of this session, participants will be able to:
  - Understand the rationale for performing an airway clearance technique in non-CF bronchiectasis.
  - Describe the ACTs of Active Cycle of Breathing technique, Autogenic Drainage, Positive Expiratory Pressure, Oscillating Positive pressure, and High Frequency Chest Wall Oscillation and their use in Non-CF bronchiectasis.
  - Be able to synthesize the evidence for the use of ACTs and exercise in the treatment of Non-CF bronchiectasis.
<table>
<thead>
<tr>
<th>AETIOLOGY</th>
<th>INCIDENCE</th>
<th>SUPPORTING DIAGNOSTIC FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post infectious (e.g. pneumonia, pertussis, <em>Mycobacterium tuberculosis</em>, <em>Nontuberculous mycobacteria</em>)</td>
<td>29–42%</td>
<td>• History or radiological evidence of previous infection</td>
</tr>
<tr>
<td>Connective tissue disease (commonly rheumatoid arthritis; also systemic sclerosis, systemic lupus erythematosus, relapsing polyarthritis, ankylosing spondylitis)</td>
<td>3–6%</td>
<td>• History or clinical signs of connective tissue disease ± vasculitis • Positive findings on autoimmune screen (e.g. rheumatoid factor, anti-nuclear antibodies, antineutrophil cytoplasmic antibodies)</td>
</tr>
<tr>
<td>Allergic bronchopulmonary aspergillosis</td>
<td>1–8%</td>
<td>• History of asthma • Peripheral eosinophilia • ↑Total serum immunoglobulin (Ig) E • ↑Specific IgE and IgG to <em>Aspergillus fumigatus</em> • Positive skin test reactivity to <em>Aspergillus fumigatus</em> • Central bronchiectasis on CT chest scan</td>
</tr>
<tr>
<td>Immunodeficiency (typically common variable immunodeficiency, X-linked agammaglobulinaemia, IgA deficiency)</td>
<td>1–8%</td>
<td>• Variable deficiencies possible [IgG (including IgG subclasses), IgA, IgM] • In IgG subclass 2 deficiency, history of recurrent infections with gram++ve encapsulated organisms • Low baseline specific antibody levels against tetanus toxoid and the polysaccharide capsules of <em>Streptococcus pneumoniae</em> and <em>Haemophilus influenzae</em> type B</td>
</tr>
<tr>
<td>Cystic fibrosis</td>
<td>1–4%</td>
<td>• Symptoms of malabsorption, male infertility • Upper lobe bronchiectasis on CT chest scan • Persistent culture of <em>Staphylococcus aureus</em> in sputum • Positive cytogenetics for cystic fibrosis transmembrane regulator receptor mutations • Positive sweat test</td>
</tr>
<tr>
<td>Ciliary defect (e.g. primary ciliary dyskinesia)</td>
<td>1–10%</td>
<td>• History of chronic upper respiratory tract problems, otitis media, male infertility • Positive saccharin taste test (saccharin not tasted after 60 minutes) • Abnormal ciliary beat pattern ± frequency on nasal brushings</td>
</tr>
<tr>
<td>Inflammatory bowel disease (ulcerative colitis, Crohn’s disease)</td>
<td>1–3%</td>
<td>• History or clinical signs • Positive pathological features on colonoscopy</td>
</tr>
<tr>
<td>Aspiration/inhalation of foreign body</td>
<td>1–4%</td>
<td>• History of aspiration • Localised (single lobe) bronchiectasis • Positive findings at bronchoscopy</td>
</tr>
<tr>
<td>Idiopathic</td>
<td>26–53%</td>
<td>• Above causes excluded</td>
</tr>
</tbody>
</table>
## Symptoms and signs of bronchiectasis

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Signs</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Chronic cough</td>
<td>• Crackles</td>
</tr>
<tr>
<td>• Sputum production (or a history of recurrent/persistent <em>moist</em> cough in small children too young to expectorate)</td>
<td>• Wheeze</td>
</tr>
<tr>
<td>• Wheeze</td>
<td>• Dullness to percussion</td>
</tr>
<tr>
<td>• Chest pain</td>
<td>• Coarse breath sounds</td>
</tr>
<tr>
<td>• Haemoptysis</td>
<td>• Clubbing</td>
</tr>
<tr>
<td>• Dyspnoea</td>
<td>• Chest wall deformity</td>
</tr>
<tr>
<td>• Failure to thrive</td>
<td>• Cyanosis</td>
</tr>
<tr>
<td></td>
<td>• No signs</td>
</tr>
<tr>
<td>Characteristic</td>
<td>Disease severity</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td></td>
<td>Mild</td>
</tr>
<tr>
<td><strong>Sputum colour</strong></td>
<td>Mucoid</td>
</tr>
<tr>
<td><strong>24 hr sputum volume</strong></td>
<td>&lt;5 ml</td>
</tr>
<tr>
<td><strong>Exacerbation frequency</strong></td>
<td>≤3 per annum</td>
</tr>
<tr>
<td><strong>Exacerbation severity</strong></td>
<td>Oral antibiotics</td>
</tr>
<tr>
<td><strong>Sputum bacteriology</strong></td>
<td>Not chronically infected</td>
</tr>
<tr>
<td><strong>Affected lobes on CT</strong></td>
<td>One lobe</td>
</tr>
<tr>
<td><strong>Degree of bronchial dilatation</strong></td>
<td>Tubular dilatation</td>
</tr>
</tbody>
</table>
FIGURE 2 The vicious cycle in bronchiectasis.\textsuperscript{17}

Morbidity in bronchiectasis is often quantified in terms of frequency of infective exacerbations as this perhaps has greatest impact both socioeconomically and individually on patients’ health-related quality of life. US data for 1993–2006 found the average annual prevalence of hospitalisation due to bronchiectasis to be 16.5 per 100,000 population.\textsuperscript{13} UK hospital admission data for 2007–08 found bronchiectasis to be the primary diagnosis in one in 1,800 hospitalisations and bronchiectasis-related deaths in England and Wales have shown a rise in absolute numbers of deaths per year from 797 in 2001 to 908 in 2007, an increase in mortality of 3% per annum.\textsuperscript{11}
Mucociliary Clearance

- Normal cilia

Mucus
Cilia
Epithelium
Viral Infection

- Reduction in ciliary beat frequency
- Increased dyskinetic beat pattern
Overview of a comprehensive approach to bronchiectasis management.

BRONCHIECTASIS CONFIRMED BY HRCT

CLINICAL HISTORY AND LABORATORY EVALUATION TO IDENTIFY ETIOLOGY

TREAT UNDERLYING CAUSE
- eg, AAT Replacement
- IgG Replacement

INITIATE AIRWAY CLEARANCE
1. Nebulized Agent
2. Chest Physiotherapy
3. Postural Positioning

SPUTUM CULTURE

EXERCISE PROGRAM OR PULMONARY REHABILITATION

CONSIDER MACROLIDE THERAPY IF PATIENT EXPERIENCES FREQUENT EXACERBATIONS

NORMAL FLORA
- Observe

NON-PSEUDOMONAS
- Antibiotic targeted toward specific bacteria and local sensitivity patterns*

PSEUDOMONAS

NTM
- Monitor future cultures for NTM
- If > 2 positive cultures consider treatment according to ATS/IDSA guidelines
- Avoid macrolide monotherapy

Goals of therapy

- Reduce symptoms
- Improve quality of life
- Prevent exacerbations
- Aiding expectoration of secretions
- Improving efficiency of ventilation
- Mobilizing and improving or maintaining exercise tolerance
- Improving knowledge and understanding, and reducing breathlessness and thoracic pain.
British Thoracic Society guidelines management of non-CF Bronchiectasis.

SUMMARY OF RECOMMENDATIONS

All patients with bronchiectasis who have a chronic productive cough and/or evidence of mucus plugging on HRCT scanning should be taught airway clearance by a physiotherapist experienced in these techniques (D).

The duration and frequency of the airway clearance technique should be specific to the needs of the individual. Generally it should be performed for 20 – 30 minutes once or twice daily (D).

Pulmonary rehabilitation should be offered to individuals who have breathlessness affecting their activities of daily living (B).
Cochrane Review
Airway clearance Techniques for bronchiectasis.

Lee AL, Burge A, Holland AE.
Cochrane library 2013
Summary of Cochrane Review

**Objective:** To determine the effects of ACTs versus no ACTs in non-CF bronchiectasis.

**Results:** Included 5 randomised controlled studies: Compared ACT to no treatment.

- ACTs did not show any difference in the rate of **pulmonary exacerbations**.

- **Volume of sputum** produced was significantly higher with an ACT than no treatment.

- ACTs resulted in a decrease in **FRC level** in patients with hyperinflation.

- **Health-related quality of life** demonstrated significant improvement over 3 months with an ACT.
AIRWAY CLEARANCE TECHNIQUES

Cough & Huffing
Postural Drainage and percussion/vibrations
Active Cycle of Breathing (ACBT)
Autogenic Drainage (AD)
Positive Expiratory Pressure (PEP)
Oscillating PEP
High Frequency Chest Wall Oscillation (HFCWO)
Need to look at the strength of the evidence to support the use of individual airway clearance techniques.

Not all are equally as effective!
Table 3.7 Suggested Clinical Pathway for airway clearance studies⁵.

New airway clearance technique

- Proof of Concept study
  - Yes
  - No → Discard technique

Phase II study Designs Pilot studies to assess safety and efficacy

- Single centre
  - Short-term
    - Randomised or cross-over CF in-patients with PE → No Discard technique
    - YES

  - Single centre
    - Short-term
      - Randomised or cross-over Stable Paediatric CF patients → No Discard technique
      - YES

  - Single centre
    - Short-term
      - Randomised or cross-over Stable adult CF patients → No Discard technique
      - YES

Phase III study Designs

- Multi-centre
  - Long-term
    - Randomised or cross-over Stable Paediatric and adult CF patients → No Discard
    - YES

Follow-up studies

- Single system study
- Patient preference study
- Cost-effectiveness study
French Technique

German AD

Key:
- BC: Breathing control
- TEE: Thoric expansion exercise
- FET: Forced expiration technique

Chest Vest
Air-Pulse Generator
Full Vest
22mm Mouthpiece
Soft Touch, Rotating Handle

Key:
- BC: Breathing control
- TEE: Thoric expansion exercise
- FET: Forced expiration technique
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Phase II study Designs Pilot studies to assess safety and efficacy

Single centre

Single centre

Single centre

Short-term

Short-term

Short-term

Randomised or cross-over

Randomised or cross-over

Randomised or cross-over

CF in-patients with PE

Stable Paediatric CF patients

Stable adult CF patients

→ No Discard technique

→ No Discard technique

→ No Discard technique

YES

YES

YES

Phase III study Designs

Multi-centre

Long-term

Randomised or cross-over

Stable Paediatric and adult CF patients

→ No Discard

YES

Follow-up studies

Single system study

Patient preference study

Cost-effectiveness study
Aerobika – Proof of Concept study
Hyperpolarized $^3$He Magnetic Resonance Imaging following Positive expiratory pressure treatment in COPD

- 4 week cross-over study with 17 COPD patients
- 14 completed study, results presented are from 2 patients, Only one patient had a clear improvement

CONCLUSIONS
- Dyspnea score improved in patients after OPEP use
- Sub-group with imaging improvement after OPEP use, also showed improved ease in bringing up sputum and improved gas distribution

Results presented at ATS 2013
Noticeable Improvement:

- Reduced Dyspnea
- Increase in gas distribution to previously unventilated areas (circled areas)
- Decreased hyperinflation of the lungs (gas trapping)
Table 3.7 Suggested Clinical Pathway for airway clearance studies.

New airway clearance technique

Proof of Concept study

Yes  No → Discard technique

Phase II study Designs Pilot studies to assess safety and efficacy

Single centre  Single centre  Single centre
Short-term Short-term Short-term
Randomised or cross-over Randomised or cross-over Randomised or cross-over
CF in-patients with PE Stable Paediatric CF Stable adult CF patients

→ No Discard technique  → No Discard technique  → No Discard technique

YES  YES  YES

Phase III study Designs

Multi-centre
Long-term
Randomised or cross-over
Stable Paediatric and adult CF patients

→ No Discard

YES

Follow-up studies

Single system study  Patient preference study  Cost-effectiveness study
The Devices

The Vest™

SmartVest®

InCourage™
<table>
<thead>
<tr>
<th>Author</th>
<th>Date</th>
<th>Length Of Study</th>
<th>No of Patients</th>
<th>Comparison</th>
<th>Outcome Measures</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warwick</td>
<td>1991</td>
<td>22 months</td>
<td>16 Patients</td>
<td>Retrospective study Pts doing PD&amp;P, then changed to vest, compared PFTs while doing PD&amp;P to vest</td>
<td>PFTS</td>
<td>Small numbers, SI improvement in PFTS after commencing vest. Pts had not been monitored while doing PD&amp;P, but encouraged to use the vest</td>
</tr>
<tr>
<td>Arens</td>
<td>1994</td>
<td>2 weeks</td>
<td>50 adults</td>
<td>PD&amp;P V vest</td>
<td>Sputum PFTS</td>
<td>No difference, Short duration</td>
</tr>
<tr>
<td>Braggion</td>
<td>1995</td>
<td>2 days</td>
<td>16 Patients</td>
<td>PD&amp;P V PEP V Vest V control</td>
<td>Sputum Tolerance</td>
<td>Too small No’s, Short duration</td>
</tr>
<tr>
<td>Kluft</td>
<td>1996</td>
<td>4 days</td>
<td>29 patients</td>
<td>PD&amp;P v vest</td>
<td>Sputum</td>
<td>No difference in sputum. (unreliable)</td>
</tr>
<tr>
<td>Oermann</td>
<td>2001</td>
<td>4 weeks</td>
<td>29 patients</td>
<td>PD&amp;P V Vest V Flutter</td>
<td>PFTS</td>
<td>No difference, Short duration</td>
</tr>
<tr>
<td>Varekojis</td>
<td>2003</td>
<td>2 days</td>
<td>24 patients</td>
<td>PD&amp;P V Vest V Intrapulmonary percussive ventilation</td>
<td>sputum</td>
<td>No difference, unreliable, short duration</td>
</tr>
<tr>
<td>Phillips</td>
<td>2004</td>
<td>2 days</td>
<td>10 Patients</td>
<td>Vest v active cycle of breathing</td>
<td>Sputum PFTS</td>
<td>Vest less effective, short duration.</td>
</tr>
</tbody>
</table>
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Proof of Concept study

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Phase II study Designs Pilot studies to assess safety and efficacy

Single centre
Short-term
Randomised or cross-over CF in-patients with PE

→ No Discard technique

YES

→ No Discard technique

→ No Discard technique

Phase III study Designs

Multi-centre
Long-term
Randomised or cross-over
Stable Paediatric and adult CF patients

→ No Discard

YES

Follow-up studies

Single system study  Patient preference study  Cost-effectiveness study
Multi-centre randomised controlled trial

- 107 subjects were enrolled in the study from 12 CF Centres across Canada
- 51 were randomized to PEP and 56 to HFCWO
- Analysis is based on intention to treat of 43 subjects in PEP group and 48 subjects in HFCWO group
- Primary outcome – Pulmonary exacerbations.
# Respiratory Exacerbations over the one year study period

<table>
<thead>
<tr>
<th></th>
<th>PEP</th>
<th>HFCWO</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of respiratory exacerbations requiring antibiotics.</td>
<td>49 Mean 1.14 (0.79-1.49)</td>
<td>96 Mean 2.0 (1.55-2.45)</td>
<td>P= 0.007*</td>
</tr>
<tr>
<td>Number of respiratory exacerbations requiring IV antibiotics</td>
<td>6 Mean 0.14 (0.11-0.44)</td>
<td>19 Mean 0.40 (0.20-0.27)</td>
<td>P=0.24</td>
</tr>
<tr>
<td>Mean length in days of IV antibiotics per treatment</td>
<td>14.2±3.65</td>
<td>13.3±7.2</td>
<td>P=0.57</td>
</tr>
<tr>
<td>Number of exacerbations requiring oral/inhaled antibiotics</td>
<td>43 Mean 1.0</td>
<td>78 Mean 1.62</td>
<td>P=0.025*</td>
</tr>
</tbody>
</table>

(Mean ± SD; 95% CI)
Kaplan-Meier Plot of Time to First Exacerbation

Exacerbation-free Survival (%)

Days

$T_{1/2}^{PEP} = 220$ days

$T_{1/2}^{HFCWO} = 115$ days

$P = 0.02$
3 Year study comparing Airway Clearance Techniques

Results:

- Enrollment goals not met.
- Study stopped early at 1.3 years due to high dropout rate especially in PD&P and Flutter.
- No sig diff in annual rate of decline in FEV1, but FEF25-75 declined sig faster (P=0.02) with Vest compared to Flutter or PD&P.
- Treatment satisfaction was greater with Vest compared to PD&P
- There was no sig diff in Health Related Quality of Life.

Sontag et al. Peds Pulmonol 2010;45:291-300
Conclusions

- Use only evidence based ACTs with Phase III studies
- Don’t assume all techniques are equally effective
- Consider the underlying pathology
- Adapt the techniques to suite the individual patient’s needs.
Ways of working with Oscillating PEP

- **Physiological principles**

  The Acapella maintains a raised FRC level during use, the flutter lowers the FRC level.

  - mobilize secretions up airways by huffing, PEF v PIF exceeds 1:1. With Flutter PEF exceeds the PIF. Acapella needs to be combined with huffing.

  - Can use Acapella, but not Flutter in various positions to enhance ventilation to a specific region of the lung.

  - Oscillation has been shown to decrease the visco-elastic properties of mucus.

  - Oscillation may assist in rehydrating ASL by inhibiting Na absorption.
SUMMARY OF RECOMMENDATIONS

All patients with bronchiectasis who have a chronic productive cough and/or evidence of mucus plugging on HRCT scanning should be taught airway clearance by a physiotherapist experienced in these techniques (D). The duration and frequency of the airway clearance technique should be specific to the needs of the individual. Generally it should be performed for 20 – 30 minutes once or twice daily (D).

Pulmonary rehabilitation should be offered to individuals who have breathlessness affecting their activities of daily living (B).
Airway clearance techniques and exercise recommendations

*The Active Cycle of Breathing Techniques (ACBT) in PD positions (A)

*Oscillatory PEP (Acapella) and FET in PD positions (A)

Autogenic Drainage (D)

Positive expiratory Pressure (D)

Pulmonary rehabilitation (B).

* Based on two studies of single treatments cross-over study by Patterson 2004 and 2005.
Acapella versus usual airway clearance technique

20 patients with acute exacerbation of bronchiectasis

Compared Acapella to usual ACT (ACBT = 9, PEP =1), over 10 – 14 days

Results: Mean volume of sputum produced with Acapella was greater than with usual ACT but non-significant

Conclusion: Acapella is an acceptable alternative to usual ACT

Patterson, Chronic Resp Dis 2007.
ACBT versus Flutter versus ACBT in PD positions

Cross-over study in patients with bronchiectasis, single treatment.

Compared ACBT to Flutter to ACBT in PD positions.

**Results:** Mean volume of sputum produced with ACBT in PD positions was sig greater than with ACBT or Flutter in sitting.

**BUT:** Patients found ACBT in PD positions the least tolerated and caused the most discomfort.

**Conclusion:** ACBT can be used in PD positions if tolerated and adherence is not impaired.

Eaton. Chronic Resp Dis 2007;4:23-30..
Airway clearance improves quality of life in people with bronchiectasis

- 20 adults with bronchiectasis, randomised cross-over design, 3 months intervention vs 3 months no treatment

- **Intervention** – Acapella BID

- **Outcome** – Leicester Cough Questionnaire (LCQ)

- **Results:**
  - LCQ sig improvement p=0.002
  - SGRQ – sig improvement p=0.005
  - 24 hour sputum p= 0.02
  - Shuttle test – sig improvement p=0.001

Regular ACT improves disease related QOL and exercise capacity.

Murray MP Eur Respir J. 2009;34:1086-92
First question? Did gravity influence the movement of secretions of did changes in regional ventilation influence secretion clearance?

Would have been good to know which lobes of the lung were affected by bronchiectasis.
Mechanism of postural drainage

- Influence of gravity to move secretions
- Or
- Influence of ventilation due to changes in positioning.
- Lannefors using a radioactive tracer, found that patients mobilized more secretions from the dependant lung that the uppermost lung when performing postural drainage and percussion.

Effects of gravity in different positions

- on regional FRC and
- on regional ventilation

Adult

Child

schematic drawing courtesy Louise Lannefors
Table showing optimal positioning for increasing ventilation to obstructed regions of the lung.

<table>
<thead>
<tr>
<th>Position</th>
<th>Upright</th>
<th>Sidelying</th>
<th>Supine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secretion in Upper lobes</td>
<td>No</td>
<td>2(^{nd}) choice</td>
<td>1st choice</td>
</tr>
<tr>
<td>Secretions middle section both lungs</td>
<td>1(^{st}) choice</td>
<td>May use alternate sidelying</td>
<td>2(^{nd}) choice</td>
</tr>
<tr>
<td>Secretions in Right lung</td>
<td>No</td>
<td>Adults, place in right sidelying. Children in left sidelying</td>
<td>No</td>
</tr>
<tr>
<td>Secretions in Left lung</td>
<td>No</td>
<td>Adults place in left sidelying Children in right sidelying</td>
<td>No</td>
</tr>
<tr>
<td>Secretions lower lobes</td>
<td>1(^{st}) choice</td>
<td>May use alternate sidelying</td>
<td>No</td>
</tr>
</tbody>
</table>
What is the role of exercise in Bronchiectasis.

- Limited evidence

- Some evidence that pulmonary rehab and inspiratory muscle strength increase exercise endurance.

- No evidence on the affect exercise on airway clearance
Pulmonary Rehabilitation

8 week study with 32 bronchiectatic patients.

**Treatment:** Pulmonary rehab program, V pulmonary rehab + inspiratory muscle trainer, V Control.

**Results:** PR and PR + IMT resulted in sig increase in incremental shuttle walking test and endurance exercise capacity.

3 months late, exercise capacity was maintained in the PR + IMT group only.
Pulmonary rehabilitation and airway clearance

- Randomised study over 8 weeks with 30 Bronchiectasis patients.

**Treatments:** Acapella (but only $\frac{1}{2}$ RX)+ PR X3 weekly

Acapella only (again $\frac{1}{2}$ RX).

**Results:** Acapella + PR increased walking distance both measured by incremental shuttle test and endurance walking test. $P=0.04$ and $p=0.003$ respectively). No difference in Lung function.

**Conclusion:** The use of PR in addition to airway clearance lead to an increase in exercise capacity.

ROLE OF EXERCISE AS AN ACT

Cochrane review – J. Bradley 2005. No evidence to support or refute the substitution of AC sessions with physical training. Thus exercise usually thought of as an adjunct to ACT.

Based on studies, as exercise increases the velocity of inspiratory and expiratory airflow, it improving mucus transport.
During normal breathing, the resistance through the collateral ventilation channels is high and thus no air passes through. Could reinflate excised dogs lungs using collateral ventilation. Anderson 1979.
Two-phase gas liquid flow mechanism

- Peak expiratory flow rate (PEFR)
- Peak inspiratory flow rate (PIFR)
- PEFR needs to be >30-60l/m
  
  PEF/PIF needs to be > 1.1 to achieve expiratory airflow.

J. Appl Physiology 1987;959-974
Ventilation in side lying

**CHILD**

- VENT: 45%
- Ventilation: 55%

**ADULT**

- VENT: 45%
- Ventilation: 47%
Perfusion in side lying

**CHILD**

**ADULT**
The frequency of oscillation and positive pressures of Flutter, Acapella and Aerobika

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Frequency Hz</th>
<th>Pressure H2O</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Flutter</td>
<td>11.3± (7.5 – 13.7)</td>
<td>18 -35 cms H2O</td>
</tr>
<tr>
<td>*Acapella</td>
<td>13.5±1.7 (10.0 – 18.3)</td>
<td>10-25 cms H2O</td>
</tr>
<tr>
<td>¶Aerobika</td>
<td>7-15</td>
<td>7-17 cms H2O</td>
</tr>
</tbody>
</table>

*Data are presented as means ±SD of means of each subject McCarren and Alison 2006
¶ Data from manufacturer of Aerobika
GRAVITY ASSISTED

EXPIRATORY
AIRFLOW

VENTILATION

Oscillation
FORCED EXPIRATIONS ARE PROBABLY THE MOST EFFECTIVE COMPONENT OF AIRWAY CLEARANCE

van der Schans 1997
Effects of physiotherapy interventions and a cough on peak exp flow rates

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Subject n</th>
<th>PEFR L/s ±</th>
<th>PIFR L/s ±</th>
<th>PEFR/PIFR Ratio</th>
<th>Frequency ±</th>
</tr>
</thead>
<tbody>
<tr>
<td>Huff</td>
<td>17</td>
<td>5.04±2.03</td>
<td>2.08±1.42</td>
<td>2.80</td>
<td></td>
</tr>
<tr>
<td>Cough</td>
<td>17</td>
<td>4.67±1.91</td>
<td>1.68±0.74</td>
<td>3.07</td>
<td></td>
</tr>
<tr>
<td>Vibration</td>
<td>17</td>
<td>1.58±0.73</td>
<td>1.06±0.27</td>
<td>1.51</td>
<td>8.4±0.4</td>
</tr>
<tr>
<td>Flutter</td>
<td>17</td>
<td>1.13±0.30</td>
<td>1.05±0.27</td>
<td>1.15</td>
<td>11.3±1.5</td>
</tr>
<tr>
<td>Percussion</td>
<td>18</td>
<td>0.83±0.14</td>
<td>0.84±0.10</td>
<td>0.99</td>
<td>7.3±0.3</td>
</tr>
<tr>
<td>Acapella</td>
<td>18</td>
<td>0.59±0.08</td>
<td>0.98±0.27</td>
<td>0.64</td>
<td>13.5±1.7</td>
</tr>
<tr>
<td>PEP</td>
<td>18</td>
<td>0.44±0.15</td>
<td>0.96±0.2</td>
<td>0.47</td>
<td></td>
</tr>
</tbody>
</table>
Autogenic Drainage

- Is based on adjusting one’s breathing level and flow rate. The aim is to create a homogenous and synchronous expiratory airflow with an optimal shear effect over the largest possible area of the lungs, especially in the obstructed regions.
BREATHING IN AUTOGENIC DRAINAGE

UNSTICK

COLLECT

EVACUATE

TV

ERV

PRED

RV

HUFF

COPD

PRED VAL
Breathing against an expiratory resistor
Maintains positive pressure within airways 10 – 20cms H$_2$O
Increases FRC, opens up obstructed regions
Combined with huffing to mobilize secretions
Dwyer found PEP sig↑MCC
PEP – low pressure: obstructed hyper-secretion patients

Airway clearance alternative PEP used in a pulmonary obstructed patients with hypersecretion problems

TLC

Slightly active TV breathing towards an expiratory resistor

FET at different lung volumes

Cough

Opening volume

Closing volume

Healthy = predicted volumes

Obstructed, hyperinflated
When using PEP for airway clearance, it should always be combined with a manoeuvre to increase expiratory flow rates such as huffing and breathing control