Is mechanical insufflation exsufflation (M-IE) useful in children with neuromuscular disease?

Cross Canada Rounds – ProCon debate January 2017
Dr K Keown Respiratory Fellow
BC Children’s Hospital
Structure of presentation

• Clinical problem
• Cough physiology
• How M-IE works
• Evaluation of evidence
  • Physiology of M-IE mechanism
  • Use in acute illness
  • Long term use
• Are there alternatives??
• Summary
Introduction: The clinical problem

• Respiratory complications are primary cause of morbidity and mortality in NMD

• Progressive weakness

• Weakness causes
  • Chronic hypoventilation
  • Reduced cough effectiveness
Cough in neuro-muscular weakness

Impairment at one or more phase

Result = retention of pulmonary secretions

Impaired secretion clearance compounds issue

Global Physiology and Pathophysiology of Cough : ACCP Evidence-Based Clinical Practice Guidelines

M-IE/Cough assist machine/’Coughhalator’

• 1952 - used in poliomyelitis
• Not used for 40 years
• Early 90s - regained popularity
• Delivers pre-set positive pressure during inspiration (insufflation), then abrupt change to negative pressure
• Rapid exsufflation causes increased expiratory flow and secretion clearance
Evidence
Evaluation of evidence for M-IE

1. Physiological mechanism of action: safety/harm

2. Usefulness in acute illness

3. Long term effects
Physiological effects of M-IE

Physiological Effects of Exsufflation with Negative Pressure (E.W.N.P.)
Beck, Scarrone. 1953

• Studied in respect to cardiovascular function, diaphragmatic motion, and intragastric pressure.

• Significant changes in arterial blood pressure during exsufflation

• Marked changes in the electrical axis of the heart
Insufflation – physiological effects

• **High intra-thoracic pressures**
  - abdominal distention, GOR, cardiovascular effects, pneumothorax (Homnick 2007)
  - Two cases of pneumothorax described in adult patients following use of MI-E (Suri 2008)

• **Barotrauma / volutrauma**
  • High TV implicated in ventilator-induced lung injury (Albuali 2007)
  • TV not measured during mechanical insufflation
  • Increased chest wall compliance in NMD = greater risk high inspiratory pressures
Repeated I/E - Physiological effects

• **Atelectatrauma**
  • Ventilator-induced lung injury associated with repeated alveolar collapse and re-expansion (*Saharan 2010*)
  • Lung-protective ventilation strategies: limiting TVs and preventing derecruitment by loss of PEEP or wide swings in pressure (*Saharan 2010*)

• Mechanism of MI-E contradicts these established lung-protective strategies
Forced deflation – physiological effects

• **Airway collapse** – Motoyama, 1986 + Hammer and Newth, 1996
  • demonstrated with flow volume loops that infant airways more collapsible with technique

• **Hypocapnia** - Infant lung function testing*
  • Repeated manoeuvres may result in hypocapnia, affecting vascular and broncho-motor tone
  • High positive pressures may impede venous return to the right heart
  • Invasive nature of technique precludes its use in routine setting

20 volunteers – video recorded flexible transnasal fiber-optic laryngoscopy while performing MI-E

- Erratic laryngeal movements
- Greater narrowing of TVFs and hypopharyngeal constriction with higher negative pressures

Evidence: M-IE in acute illness

1. **Chatwin 2009.** MI-E reduces treatment time compared with conventional physiotherapy (30min vs 47, p=0.03)
   - Crossover, 8 patients NMW using NIV

   *Chatwin M, Simonds AK. The addition of mechanical insufflation/exsufflation shortens airway-clearance sessions in neuromuscular patients with chest infection. Respir Care 2009;54:1473e9.

2. **Vianello 2005.** Treatment failure (need for tracheostomy or intubation) lower in the group treated with MI-E vs standard physio (2/11 vs 10/16, p<0.05)
   - Major study design flaws (small study numbers, historical controls, different group numbers, no matching etc etc)
   - No significant difference in other outcomes – duration of stay, NIV, duration of mechanical ventilation

Evidence: M-IE in acute illness

   - prospective study, 29 subjects (COPD and NMD)
   - PCF significantly elevated (greater than M-IE) with MAC


4. Fauroux 2008. Significant increase in CPF at 40 cm H2O
   Physiological measurements of 17 children with NMD pre and post MIE
   The MI-E had no significant effect on VC or minute ventilation after each series of six applications

Evidence: regular long term use of M-IE

1. Reducing frequency of respiratory illnesses
   - No RCTs showing that MIE is more effective than other forms of physiotherapy in reducing frequency of respiratory illness

2. Improvement in quality of life or survival
   - No long term trials showing that MIE improves survival or quality of life in adults or children with NMD
Reported long term outcomes with regular M-IE

1. Phillips 2015. Fewer admissions and hospitalised days for respiratory infections (p=0.11)
   - Series of 6 patients. Retrospective. Comparing pre and post introduction of M-IE status
   - Excluding #1 No difference in admission number (14 vs 13)
   - No difference in antibiotic use (39 vs 41)


2. Stehling 2014. M-IE use improves vital capacity (non-sig)
   Retrospective data analysis 21 patients (16.1 ± 6.5 years) with NMD using nocturnal NIV. Unclear if benefit from Insufflation vs exsufflation. Unclear when NIV introduced

   Stehling et al. Mechanical insufflation/exsufflation improves vital capacity in neuromuscular disorders. December 3, 2014
Evaluation of evidence for M-IE

1. Physiology of mechanism ? safety ? potential harm

2. Acute context

3. Long term effects: lung function/quality of life/survival
Mechanical insufflation-exsufflation for people with neuromuscular disorders (Review)

Morrow B, Zampoli M, van Aswegen H, Argent A
Cochrane review 2013

- To determine the efficacy and safety of MI-E in people with NMDs
- All studies were short-term (<2 days)
- None reporting mortality, morbidity, quality of life, serious adverse events or any of the other prespecified outcome

Cochrane review - Authors’ conclusions

1. Existing studies do not clearly show that MI-E improves cough expiratory flow more than other cough augmentation techniques.
2. Important short and long-term outcomes not addressed
3. There is insufficient evidence for or against the use of MIE in NMD
4. RCTs are needed to test the safety and efficacy of MI-E.
Are there evidence based alternatives to M-IE?
Forty eligible ALS patients
Randomized to (twice daily)
1. breath-stacking using a lung volume recruitment bag ($n = 21$) or
2. MI-E ($n = 19$)
followed up at three-monthly intervals for at least 12 months or until death
Rafiq 2015. Improved survival Breathstacking vs M-IE

Kaplan-Meier survival curves.
(a) Overall study.
(b) Patients with moderately impaired bulbar function.
(c) Patients with severely impaired bulbar function.

Survival days severe bulbar impairment: 229 vs 138 (p=0.07)
Improved QOL (SQUALI >75% 280d vs 205d)

Breathstacking – does the evidence stack up?

- **Toussaint 2009.** Breath stacking, MAC and breathstacking+MAC all significantly improved Peak cough flow
  - Cough augmentation techniques in 179 clinically stable patients with NMD
  - breath-stacking plus MAC greatest effect PCF (P < .001)

Breathstacking – does the evidence stack up?

• **Improves atelectasis and maintains compliance** \( (p = 0.03) \)
  

• **Increased Vt + minute ventilation** \( (P < 0.05) \)
  

• **Significant increase in peak cough flows** \( (p < 0.05)(P < 0.001) \)
  
  *Maximum Insufflation Capacity*\(^*\) Seong-Woong Kang; and John R. Bach, CHEST 2000; 118:61–65

Lung Volume Recruitment Slows Pulmonary Function Decline in DMD

- Retrospective cohort study of FVC trajectory in adults with DMD pre & post LVR
- 22pts, FVC, 21.8±16.9 % pred
- 86% using NIV

FVC Rate of decline:
Pre-LVR = - 4.7 % predicted/yr
Post-LVR = - 0.5 % predicted/yr
(p < 0.001)
# Devices for LVR/Breathstacking

<table>
<thead>
<tr>
<th>Self-inflating AMBU-bag with one-way valve</th>
<th>Inexsufflator (M-IE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct feedback given to provider → comfortable volume delivered</td>
<td>Mechanically provides positive pressure breaths (at unknown volumes) followed by rapid negative pressure which generates a cough</td>
</tr>
<tr>
<td>May need abdominal thrust to generate cough</td>
<td></td>
</tr>
<tr>
<td>Readily available</td>
<td>Not covered by all provincial insurance plans (support in Ont., Que., BC)</td>
</tr>
<tr>
<td>Inexpensive ($30-70)</td>
<td>Expensive (~ $4500-6000)</td>
</tr>
<tr>
<td>Portable</td>
<td>Cumbersome, less portable</td>
</tr>
</tbody>
</table>
Seear et al (not yet published)

• Crossover of 3 physio techniques in 40 stable NMD
  • intra-pulmonary percussive ventilation (IPV)
  • mechanical insufflation-exsufflation (MI-E)
  • BiPAP-assisted maximal inspiration (BAMI)

• M-IE produced no significant improvements in FVC or PEF and some children got worse

• M-IE was treatment least preferred technique
Summary

• >60 years old – no long term studies assessing safety or long term effects

• Non-physiological mechanism of action and potential lung damage – no studies directly assessing physiological effects of M-IE (in adults or children)

• No convincing evidence of superiority over other cough augmentation techniques

• Cheaper, evidence based, effective treatments have been demonstrated to reduce morbidity, slow decline in FVC and improve outcomes in NMD