Section 5: Airway clearance

Sherri Lynne Katz & on behalf of the CTS Pediatric Home Ventilation Guidelines Panel

To cite this article: Sherri Lynne Katz & on behalf of the CTS Pediatric Home Ventilation Guidelines Panel (2018) Section 5: Airway clearance, Canadian Journal of Respiratory, Critical Care, and Sleep Medicine, 2:sup1, 32-40, DOI: 10.1080/24745332.2018.1494979

To link to this article: https://doi.org/10.1080/24745332.2018.1494979

Published online: 23 Oct 2018.

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Introduction

Airway patency is required in order to maintain adequate ventilation. Inhaled material impacted in the peripheral airways is moved out to the larger airways and hence to the oropharynx by mucociliary clearance. If this mechanism is inadequate to clear entrapped material from the larger airways, then coughing is utilized to achieve adequate airway clearance. An adequate cough requires (1) a deep inspiration; (2) forced expiration against a closed glottis; and (3) subsequent opening of the glottis, producing sufficient velocity of expiratory flow to shear mucoid material attached to the airway walls into the air stream.\(^1,2\) Coughing therefore requires the ability to achieve adequate inspiration (needing sufficient inspiratory muscle strength), the ability to close the glottis and reasonable expiratory muscle strength for forced expiration. Patients with respiratory muscle weakness that is severe enough to require ventilatory support are unlikely to have adequate cough clearance. This is further compromised in patients receiving invasive ventilation by the presence of the tracheostomy interfering with glottic closure.\(^3\)

Recurrent atelectasis and pneumonia are therefore frequent complications in these patients.\(^4-6\) Additionally, decreased range of motion of the chest wall due to weakened inspiratory muscles may result in reduced chest wall compliance, with decreased lung volumes also leading to micro-atelectasis and reduction in elastic properties of lung tissues, further compromising the ability to cough.\(^7\)

Supportive airway clearance techniques\(^8\) have been developed to assist with removal of secretions from the lungs and airways\(^9-11\) and should therefore be considered in these patients. Noninvasive airway clearance strategies aim to (1) increase inspired lung volume to reach maximum insufflation capacity (MIC), through Lung Volume Recruitment (LVR) or “breath-stacking”; (2) increase expiratory force in the expulsive phase of cough with manually assisted coughing by applying abdominal pressure; and/or (3) acceleration of expiratory airflow through application of positive and negative airway pressures with mechanical in-exsufflation (MI-E). Physiotherapy techniques assist with mobilization of secretions from the distal airways and agents that alter viscosity of secretions may aid with airway clearance. Finally, in individuals with tracheostomies, suctioning is often also applied to clear secretions from the large airways.

These approaches have been applied in individuals with neuromuscular disease and spinal cord injury who have impaired cough. They have not been studied in individuals without evidence of impaired cough efficacy. Recommendations are, therefore, based upon observational studies and professional consensus in these patient populations.

Literature review: Methodology

Searches were conducted looking for publications on (1) glossoharyngeal breathing, lung volume recruitment and airway clearance in respiratory muscle weakness and/or neuromuscular disease; (2) physiotherapy techniques (including positive end expiratory pressure, percussion, active cycle of breathing, high frequency chest wall oscillation and intra-pulmonary percussive ventilation in individuals with respiratory muscle weakness and/or neuromuscular disease; and (3) airway clearance in tracheostomized individuals. We aimed at identifying all studies published in English and French. We searched Cochrane and MEDLINE databases (1966–August 24, 2015). As well, we hand-searched reference lists from identified publications in order to add any missed studies. We also searched the web sites of large associations of physicians and health professionals in the field of respiratory medicine, intensive care, nursing and respiratory therapy for reviews, consensus statements and clinical practice guidelines. We obtained the full publication of all relevant studies identified.

Results

We retrieved 218 English-language publications that were relevant to our inclusion criteria and dealt with home mechanical ventilation in children. Editorials and opinions, general reviews, publications with clinical practice guidelines and publications on the type of equipment used for airway clearance were eliminated. Publications dealing solely with adult populations were eliminated as well. We were then left with 15 publications dealing specifically with cohorts including children with respiratory muscle weakness and/or neuromuscular disease, and/or on home mechanical ventilation (HMV) (including the search terms home care services, hospital-based, long-term care, outpatients, palliative care, chronic)
which dealt with airway clearance (insufflation, inspiratory positive pressure ventilation (IPPV), manual or mechanical insufflation, in-exsufflation, lung volume recruitment) (Table 1). These studies largely describe experiences at single institutions, in case series, where airway clearance was part of a treatment plan which also included ventilatory support. An additional three studies were found which examined physiotherapy techniques in this population, including positive expiratory pressure, active cycle of breathing, high-frequency chest wall oscillation (HFCWO), percussion, intrapulmonary percussive ventilation (IPPV). These consisted of 2 case reports and 1 randomized controlled trial. There were no systematic reviews of either airway clearance or physiotherapy in children. There is only one pediatric study reporting on LVR.12

**Airway clearance in individuals at risk of or requiring noninvasive ventilation**

**Lung volume recruitment**

Lung volume recruitment (LVR) is the most commonly employed technique to assist with cough and airway clearance in individuals with respiratory muscle weakness. It is a means of stacking breaths to achieve maximal lung insufflation capacity, expand the chest wall and fill the lungs. Insufflation may also help to maintain chest wall range of motion and lung compliance.9 By increasing lung volume, LVR has also been shown to improve cough efficacy. LVR was shown to increase peak cough flows (PCF), a measure of cough capacity achieved by having an individual cough as forcefully as possible into a peak flow meter) above those achieved by maximal unassisted coughs or coughs assisted by conventional physiotherapy or noninvasive ventilation.5 Intermittent positive pressure-assisted hyperinsufflation, a manual insufflation technique that assists patients with inflating the lungs above what they would be able to do without assistance, has specifically been shown to improve PCF in pediatric neuromuscular disorders in children as young as 6 years.12 Most studies performed to date have incorporated LVR as an integral part of an overall approach to care, making it difficult to assess its impact alone on clinical course.13 LVR may be applied in individuals at risk of requiring or already receiving noninvasive ventilation to increase lung volumes above spontaneous vital capacity and may manually or mechanically assist cough, using techniques of:

1. **Glossopharyngeal breathing** (air stacking or “frog breathing”14 which requires no equipment but is a difficult technique to master. It involves taking a breath and holding it, followed by 15–20 gulps of air while the soft palate seals off the nasopharynx.15
2. **Manual Insufflation** with a self-inflating resuscitation bag and patient interface with a one-way valve. This technique has been used in adults with neuromuscular disease and is described in detail at [http://www.irrd.ca/education](http://www.irrd.ca/education). The equipment is readily available and inexpensive, lightweight, relatively small, requires no external power and is easily portable. Users can also provide direct feedback to caregivers so inflation occurs to an adequate, but comfortable volume,8 to assist a subsequent cough maneuver.9,16–18 It may be accompanied by **manually assisted cough**, during which an abdominal thrust is applied during expiration.

3. **Mechanical In-exsufflation** using the Respironics In-exsufflator provides mechanically assisted cough ([http://www.coughassist.com](http://www.coughassist.com)), by delivering positive pressure breaths, usually followed by a rapid negative pressure to mimic a cough.3,5,19 It is, however, relatively expensive, cumbersome, requires external power and is less easily portable.

**Literature review**

**Manual insufflation**

Manual insufflation with a bag and mask containing a one-way valve or glossopharyngeal breathing technique has also been shown to significantly increase PCF as compared to unassisted cough, to a level comparable to that obtainable with an MI-E.14,16,20–22 The PCF achievable in adults with manual LVR technique is 1.8 times greater than with an unassisted cough.16,23

**Mechanical in-exsufflation (MI-E)**

One case series, which studied mainly adults, demonstrated an improvement in MIC (the maximum volume of air that can be held in the lungs with a closed glottis after breath-stacking), despite a decrease in vital capacity, over 0.5–24 years of follow up in 282 patients with neuromuscular disease.24 Integrating the MI-E into an overall plan of care has also been successful in some case series in avoiding hospitalization, pneumonias, episodes of respiratory failure and tracheotomy.25–28 A similar protocol using noninvasive positive pressure ventilation (NIV) and LVR has been used in a prospective cohort study to avoid intubation and death in episodes of acute respiratory failure in 79.2% of adults with neuromuscular disease, and in a series of children under 3 years of age with Spinal Muscular Atrophy type 1.29,30 It is difficult to determine, however, whether the improved outcomes in these studies were due to NIV or the MI-E.

A single cohort study of adults and children using manual insufflation twice daily (as per self-report) demonstrated improvement in MIC and PCF over time.7 In a largely pediatric population, there has only been 1 retrospective review of long-term regular (once a day to every 4 hours) use of MI-E in 62 individuals with neuromuscular disease and impaired cough (age range 3 months to 28.6 years). The treatment modality was used for a median duration of 13.4 months.31 Six percent of participants experienced an improvement in chronic atelectasis and 8% noted a reduction in frequency of pneumonias, although the number of acute lower respiratory tract infections was too small to permit meaningful comparison with a pretreatment period. In an analysis of a patient registry for Spinal Muscular Atrophy Type I, the use of an
MI-E device had a significant independent impact in reducing death.32

LVR maneuvers (manual and mechanical) have been performed for more than 650 patient-years and hundreds of applications without dangerous side effects.23,33 Excellent tolerance (≥90%) of LVR has been reported in children.9,31,34 LVR may cause chest discomfort due to stretching of muscles of the chest wall. There are case reports of nausea and abdominal distension, pneumothorax or pneumomediastinum35 in adults and premature ventricular contractions (in an adolescent with DMD and cardiomyopathy).9

Optimal pressure settings for manual and mechanical insufflation are not known and range in the literature from 15 to 45 cm H2O.36 Higher pressures (40 cm H2O) can increase vital capacity greatly in children.34 Pressures need to be individually determined and titrated. Furthermore, pressures may require readjustment during periods of infection, when respiratory compliance may be diminished. Also there may be physiologic limits, outside of which MI-E has been recommended.37

Additional therapies

The use of chest physiotherapy techniques, including HFCW0 and IPPV, are controversial and not fully established in individuals with respiratory muscle weakness.8,11,38–43 IPPV can improve clinical and radiographic evidence of atelectasis/consolidation in some children (case series).43 A single, short, randomized cross-over study showed preliminary benefit (i.e., increased weight of mucus collected) from IPPV, when added to manually assisted cough with forced expiratory technique, in tracheostomized, hospitalized DMD patients with mucus hypersecretion.42 Two case reports exist of use of HFCW0 in children with neuromuscular disease, indicating some clinical benefit in ventilation and atelectasis.44,45 A single pediatric randomized controlled trial in 23 children with neuromuscular disease or cerebral palsy compared HFCW0 to standard physiotherapy techniques used three times day over a mean follow up of five months. Safety, tolerability and increased compliance were seen in those using HFCW0, although no differences between groups was seen in hospitalizations, antibiotic use or nocturnal oxygenation.46 The only other study of HFCW0 (uncontrolled) was conducted in adults with impaired cough, in which oxygen saturation improved and patients reported satisfaction with the therapy.47,48

Similarly, agents that alter viscosity of secretions have not been well-studied in children with impaired cough. These therapies have been used for airway clearance in children with cystic fibrosis, who have normal cough capacity but copious, thick airway secretions.8 On a case-by-case basis, in those with atelectasis, this treatment may be considered.8

A discussion of the management of sialorrhea is beyond the scope of these guidelines but it is important to attempt to minimize sialorrhea in conjunction with using airway clearance techniques.

Finally, management of associated comorbidities of the underlying condition that contribute to impaired airway clearance needs to be addressed. Obesity can reduce chest wall compliance and malnutrition decreases muscle mass, both of which further compromise cough effectiveness.8 Aspiration of oral secretions and/or food, as well as gastroesophageal reflux, can also contribute to an increased volume of secretions for the individual to handle.8

Clinical approach to airway clearance

Optimal frequency of usage of LVR and MI-E is not known, although it has been shown that during the first 24–36 hours of illness, individuals with weak respiratory muscles experience a decline in forced vital capacity of 13–29%, as well as maximal inspiratory and expiratory pressures.49 Airway clearance techniques are therefore critical at these times to prevent morbidity and mortality.

Furthermore, the patient populations that will benefit most from these interventions have not been clearly determined. Lung and chest wall compliance, as well as bulbar function, determine the degree to which LVR can be performed.13,50 It is, therefore, more likely that LVR will be most beneficial in those with a compliant chest wall and lungs, and preserved bulbar function. In addition, cooperation of the patient is required for successful application of these techniques, especially MI-E, in order that airway patency is maintained during the expiratory phase.51 Appropriate patient selection is therefore critical. These techniques may be most applicable to patients with neuromuscular or chest wall disease and are less likely to be beneficial in those with obstructive airway diseases.3

LVR has been recommended by Bach and Finder as the “standard of care” for neuromuscular patients.3,11,13,25,26,52–54 American Thoracic Society guidelines from 2004 have suggested its implementation when baseline cough peak flow is <270 L/minute,11 maximum expiratory pressure <60 cm H2O,11 or baseline forced vital capacity <40% predicted, in children and teens with neuromuscular disease.54 Other guidelines for the management of Duchenne muscular dystrophy advocate for use of manual and mechanically assisted cough techniques during times of established infections.44 Volume recruitment/deep lung inflation devices are listed as “necessary equipment” and “critical therapy.”54 Manual or mechanically assisted coughing is recommended when patients experience hypoxemia and hypoventilation in the context of a respiratory infection, retained respiratory secretions, infections and/or atelectasis, as well as postoperatively if PCF is <270 L/minute or baseline MEP is <60 cm H2O.56 They further suggest the use of insufflation (manual or mechanical) when FVC <40% predicted and the use of MI-E when:

1. respiratory infection is present and baseline PCF <270 L/minute (in older teen and adult patients);
2. baseline PCF <160 L/minute or MEP <40 cmH2O; or
3. baseline FVC <40% predicted (or <1.25 L) in older teen and adult patients.54

It should be noted, however, that PCF in younger children varies and that values below 270 L/minute can be normal in boys younger than 11 years and girls younger than
<table>
<thead>
<tr>
<th>Author (Year)</th>
<th>Study type</th>
<th>Patient number and condition</th>
<th>Lung volume/flow</th>
<th>Ventilator support</th>
<th>Survival</th>
<th>Respiratory findings</th>
<th>Hospitalization/Respiratory exacerbations</th>
<th>Quality of life</th>
<th>Patient satisfaction</th>
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<tbody>
<tr>
<td>Ottonello (2011)</td>
<td>Retrospective chart review</td>
<td>16 with Spinal Muscular atrophy Type 1 under 3 years of age</td>
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<td>Protocol of “high span” bi-level positive airway pressure and mechanical airway clearance reduced episodes of respiratory failure and hospitalization for children under 3 years of age, compared to historical controls (0.15 hospitalizations/year vs. 0.88–7.6 episodes/year)</td>
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<td>Gomez-Merino (2002)</td>
<td>Retrospective review</td>
<td>125 with Duchenne muscular dystrophy (included some children 14.9 years and older [&lt; 34 years])</td>
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<td>5 patients decannulated and weaned to noninvasive ventilation for 1.6 1.6 years</td>
<td>51 full-time NIV users had prolonged survival for 6.3 4.6 years</td>
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<td>Bach (2008)</td>
<td>Case series</td>
<td>282 neuromuscular patients with VC &lt;70% predicted (included some children)</td>
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<td>In 46/78 patients with multiple measurements, MIC and passive lung insufflation capacity increased (462 260 and 365 289 mL) despite a decrease of VC of 209 97 mL</td>
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<td>Tzeng (2000)</td>
<td>Observational study</td>
<td>94 individuals with neuromuscular disease, comparing 45 patients pre-protocol (of whom 45 had previous episodes of respiratory failure) vs. post-protocol</td>
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<td>For the 10 patients who never used any ventilation, hospitalizations/year decreased from 1.4 0.84 to 0.03 0.11 (p = 0.003). Significant differences also seen in noninvasive ventilator users in hospitalizations and days in hospital.</td>
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<td>Miske (2004)</td>
<td>Retrospective review</td>
<td>62 pediatric neuromuscular patients with impaired cough (MEP &lt;60 cm H₂O)</td>
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<td>Need for “mini-tracheostomy” or endotracheal intubation was lower in MI-E group than in the controls (2/11 vs. 10/16 cases, p = 0.047). No differences in the number needing noninvasive ventilation or time on mechanical ventilation</td>
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<td>Vanello (2005)</td>
<td>Observational study with historical controls</td>
<td>11 neuromuscular patients with respiratory tract infections in ICU (included 2 children) vs. 16 historical controls (included 2 children)</td>
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<td>Chatwin (2003)&lt;sup&gt;5&lt;/sup&gt;</td>
<td>Cross-sectional</td>
<td>22 patients with neuromuscular disease (including 8 children age 10–16 years) and 19 age-matched controls</td>
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<td>Greatest increase in PCF seen with MI-E (235 111 vs. 169 90 (unassisted))</td>
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<td>Chatwin (2009)&lt;sup&gt;73&lt;/sup&gt;</td>
<td>Randomized cross-over study</td>
<td>8 patients (age range 4–44 years) with sputum retention</td>
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<td>Treatment time shorter with in-exsufflation (30 min vs. 47 min, p = 0.03).</td>
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<td>Kang (2000)&lt;sup&gt;7&lt;/sup&gt;</td>
<td>Observational cohort</td>
<td>43 patients with neuromuscular conditions (including 3 patients with SMA) (age 11.2–40 years)</td>
<td>MIC increased from 1402 μL to 1711 μL (p &lt; 0.001) in 30/43 patients. Those with increased MIC also increased assisted PCF from 3.7 1.4 to 4.3 1.6 L/s (p &lt; 0.05) despite decreasing VC and unassisted PCF</td>
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<td>Oskoui (2007)&lt;sup&gt;12&lt;/sup&gt;</td>
<td>Retrospective analysis of patient registry</td>
<td>Spinal Muscular Atrophy Type 1 (N = 143)</td>
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<td>Controlling for demographic and clinical care variables, MI-E showed a significant effect in reducing risk of death</td>
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<td>McKim (2012)&lt;sup&gt;74&lt;/sup&gt;</td>
<td>Retrospective cohort study</td>
<td>Duchenne muscular dystrophy (N = 22)</td>
<td>Annual decline of FVC was 4.7 percent-predicted a year before LVR and 0.5 percent-predicted a year after LVR initiation. (Difference = 4.2 percent-predicted a year (95% confidence interval, 3.5–4.9; P &lt; .000).</td>
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<td>Bach (1995)&lt;sup&gt;75&lt;/sup&gt;</td>
<td>Cohort study with historical comparison</td>
<td>Spinal Muscular Atrophy, receiving ventilation (N = 10)</td>
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<td>Significantly higher incidence of respiratory hospitalizations and pneumonias prior to introduction of IPPV, compared to after IPPV introduction</td>
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<td>De Troyer (1981)&lt;sup&gt;76&lt;/sup&gt;</td>
<td>Cross-sectional study</td>
<td>Adolescents and adults with generalized neuromuscular disorders (N = 10)</td>
<td>No difference in functional residual capacity, and static pulmonary compliance</td>
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<tr>
<td>Dohna-Schwake, (2006)&lt;sup&gt;12&lt;/sup&gt;</td>
<td>Cross-sectional</td>
<td>Various neuromuscular disorders (age 12.6–3.6 years, range 6–20 years) with PCF &lt; 160 L/min and/or history of chest infections (N = 29)</td>
<td>Augmentation of lung volumes: 69% increase in FVC, 75% increase in PCF</td>
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9 years old. PCF thresholds cannot therefore be applied to younger children. A retrospective study of older children with neuromuscular disease (age 12.7 to 3.7 years) found that thresholds of inspired vital capacity (IVC) < 1.1 L and PCF < 160 L/minute were useful to discriminate between individuals with and without previous severe chest infections, a finding previously demonstrated in adult patients. Pediatric thresholds of PCF are therefore still not well-defined.

The use of LVR has been recommended by some in patients with neuromuscular disease and impaired cough, not only during times of infection or exacerbation, but also regularly once or twice daily, to ensure familiarity with the technique. The paucity of long-term clinical studies to demonstrate efficacy of LVR, however, and the lack of controlled trials evaluating the impact of its routine use have left several groups worldwide calling for further prospective, controlled studies. It remains, however, an additional tool that may assist with respiratory health maintenance, in individuals with impaired cough efficacy and/or reduced vital capacity.

**Airway clearance techniques for children ventilated via tracheostomy**

Cough functionality is further impaired in children with neuromuscular weakness who also have a tracheostomy, which bypasses the glottis. Presence of an endotracheal or tracheostomy tube also impairs mucociliary clearance and may increase risk of infection. Suctioning via catheter is effective at removing secretions from the large airways in individuals with artificial airways. This practice is largely guided by clinical experience, rather than rigorous clinical studies, which are lacking to inform this practice. However, techniques to mobilize secretions from the peripheral airways are still needed. Suctioning is not a benign intervention and deep suctioning has been associated with airway trauma, alveolar collapse and hypoxemia. Shallow, minimally invasive suctioning, to the tip of the tracheostomy tube, is preferred. The recommended suctioning technique includes use of a “premeasured” catheter with side holes close to the distal end (0.5 cm or less) of the catheter tube, inserted to a premeasured depth so that the most distal side holes just exit the tip of the tracheostomy tube. It is recommended that the largest size catheter that fits inside the tracheostomy be used and that a rapid technique, completed in less than 5 seconds, be employed. Deeper suctioning may occasionally be necessary, for example, in the presence of a mucus plug below the level of the tracheostomy tube.

Clean, rather than sterile, technique is recommended for suctioning in home care. Sterile conditions are required in hospital where multiple caregivers are involved and the environmental bacteria are more frequent.

Additional adjunctive treatments to enhance airway clearance in this population include increasing patient mobility and repositioning, which may aid in moving secretions, and the use of heated humidity, which thins secretions, rendering them easier to mobilize. The use of heat/moisture exchangers (HME) is generally not as effective as heated humidity and is associated with increased dead space, minute ventilation, work of breathing, hypercapnia and respiratory rate. HMEs are useful adjuncts to provide humidity for a mobile patient when leaving the home. It is important to note that using an HME during periods of sleep is not recommended. In addition, HMEs need to be used cautiously in children with smaller caliber tracheostomy tubes, given the increased risk of tracheostomy tube blockage. Tracheostomized patients also require adequate fluid intake to avoid dehydration, which can result in inspissated secretions.

A number of clinicians have used the MI-E device in critical care patients with tracheostomies, with anecdotal benefit. This has also not been rigorously studied. It is most effectively used in this context with auffed tracheostomy or endotracheal tube, in order to minimize air leak. It is most effective when employed in conjunction with suctioning, so that secretions mobilized into the proximal airways during in-exsufflation can be removed with the suction catheter.

**Conclusion**

Manual and mechanical in-exsufflation can be used for airway clearance and have been shown in observational and cohort studies to have benefits in individuals with impaired cough. Given the lack of pediatric literature and/or randomized controlled trials, the optimal role and applications of this therapy needs further study, particularly in invasively ventilated patients. Similarly, additional airway clearance modalities, including IPPV and HFCWO, are not well-studied, but may be beneficial in select patients. Suctioning remains the standard of care for airway clearance in tracheostomized individuals.

**Research questions**

1. Does regular LVR use slow the decline in lung function, decrease respiratory infections and/or improve survival or quality of life in children with impaired cough?
2. What is the optimal timing for initiation and frequency of use of LVR techniques in children with impaired cough?
3. Does the use of LVR techniques during respiratory infections and/or atelectasis hasten recovery?
4. What are the optimal pressure settings for manual insufflation and MI-E in children?
5. What is the efficacy of IPPV (intrapulmonary percussive ventilation) and HFCWO in children with impaired cough?
6. Are LVR, IPPV and HFCWO effective airway clearance modalities in invasively ventilated children?

**Recommendations for airway clearance in children using long-term mechanical ventilation at home**

**Patients using NIV**

1. Airway clearance techniques should be taught to children and caregivers as a preventative strategy in those with evidence of impaired cough, especially if they have had...
episodes of deterioration with respiratory infections. (Grade 1C)

2. In the absence of contraindications, manual and/or mechanical lung volume recruitment techniques should be introduced for children with impaired cough (defined by clinical assessment and/or MEP < 60 cm H2O and/or PCF in children ≥ 12 years < 270 L/min and/or FVC < 40% predicted). (Grade 2C)

3. Mechanical lung volume recruitment techniques (i.e., mechanical in-exsufflation) should be considered in very weak children, those with loss of bulbar function and those who cannot cooperate with manual lung volume recruitment techniques or in whom the methods are not effective. (Grade 1C)

4. High Frequency Chest Wall Oscillation (HFCWO) and Intra-Pulmonary Percussive Ventilation (IPPV) could be considered for patients with impaired cough with atelectasis/consolidation, despite use of other airway clearance techniques. (Consensus)

Patients ventilated via tracheostomy

1. Minimally invasive rather than deep suctioning is recommended when possible. (Grade 2B)

2. Heated humidity is recommended over heat-humidity exchangers. (Grade 1A)

3. Clean, as opposed to sterile, conditions are adequate for home secretion clearance and suctioning. (Grade 2C)

6. High Frequency Chest Wall Oscillation (HFCWO) and Intra-Pulmonary Percussive Ventilation (IPPV) could be considered for patients with impaired cough with atelectasis/consolidation, despite use of other airway clearance techniques. (Consensus)

7. Mechanical lung volume recruitment (i.e., mechanical in-exsufflation) should be available in the acute-care setting in all hospitals that treat children using HMV with the purpose of preventing deterioration. (Grade 2C)

References


