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Commentary: Exploring the potential of mechanical insufflation–exsufflation

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Cough augmentation with mechanical insufflation–exsufflation (MI–E) has been described as a technique that facilitates airway secretion clearance in different neuromuscular disorders (NMD), thus avoiding hospitalisations, and preventing pneumonias and episodes of respiratory failure for patients with Duchenne muscular dystrophy [1, 2] spinal muscular atrophy [3], high spinal cord injury [4] and amyotrophic lateral sclerosis (ALS) [5]. Although there are a number of guidelines and consensus statements that emphasise its importance [6–9], MI–E is far from widely used [10, 11].

In the present issue of *Breathe*, M. Chatwin describes a very practical guide to the application and principal indications of MI–E for different settings that may encourage its use; however, some important considerations should be discussed to explore the full potential of this technique.

The importance of the use of manually assisted coughing for the optimisation of peak cough flows (PCF) has been demonstrated [12, 13] but it cannot be a comparable alternative to MI–E, rather an MI–E complement; so, except after a meal, applying MI–E with an abdominal thrust in conjunction with the exsufflations must be taken into consideration in order to optimise the technique [14].

Insufflation and exsufflation pressures

A normal cough expels a volume of air four times greater than a normal tidal volume. Therefore, provision of a normal tidal volume for NMD patients whose tidal volumes approach their vital capacities will not optimise their cough flows; this can never be accomplished for these patients by limiting insufflation and exsufflation pressures to 25 and -25 cmH_2O (2.4 and -2.4 kPa) [15].

For patients with NMD undergoing MI–E, barotrauma is rare. In >1,000 ventilator users, most of whom were dependent on MI–E with insufflation pressures of 40–60 cmH_2O (3.9–5.9 kPa) to spare them from upper respiratory tract infections (in some cases over a 52-year period), no pneumothoraces were ever found [16, 17].

The maximal effectiveness of MI–E at pressures of 40 to -40 cmH_2O (3.9 to -3.9 kPa) has been demonstrated in experimental models [15, 18] and both in adult [19] and paediatric populations [20]. Although MI–E pressures of 40 to -40 cmH_2O (3.9 to -3.9 kPa) are generally adequate for most patients, higher settings are often required when compliance decreases (by obesity or scoliosis) or resistance increases. In fact, SANCHO *et al*. [15], in a lung model, demonstrated the need for 70 to -70 cmH_2O (6.8 to -6.8 kPa) in order to achieve a clinically effective PCF of 2.67 L per s.

When using MI–E *via* small translaryngeal or tracheostomy tubes, higher pressures of 60–70 cmH_2O (5.9–6.8 kPa) is recommended to overcome the tube resistance, and cuffs should be inflated to prevent leaks. In this context, it has been demonstrated that MI–E *via* a tracheostomy tube is more effective in clearing secretions than conventional suctioning, and it is preferred by patients [21, 22].

Time settings

Although the machine can be managed automatically by programming the insufflation/exsufflation/pause times, the manual mode permits a better synchronisation and it is easier for patients to coordinate their insufflation and cough with the machine. This is especially true for infants with spinal muscular atrophy type 1, in whom the cycles should follow their rapid respiratory rate and chest movement [3]. Insufflation and exsufflation times should be adjusted to provide maximum chest expansion and lung emptying, respectively. If insufflation or exsufflation pressures and times are inadequate, the patient literally cannot breathe.

The application of MI–E

MI–E has been also described as a very efficient technique in the acute setting for NMD patients, in the treatment of respiratory failure due to upper respiratory tract infections [23], to avoid intubation [24], to facilitate extubation and decannulation and to prevent post-extubation failure [25–27]. However, the evidence supporting the role of this technique to facilitate extubation in difficult weaning patients is lacking. Our group has started to study how this technique can improve the efficacy of noninvasive ventilation in these patients, and the results so far are promising.

The application of MI–E in the post-operative phase has been also described both in initial and recent papers [28, 29]. In this context, as experience with MI–E increased, bronchoscopy was performed less frequently for the removal of bronchial secretions in our centre. For example, in an 18-year-old male with myotonic dystrophy who developed left lung atelectasis and respiratory failure after Nuss operation (for pectus excavatum), intensive MI–E avoided endotracheal intubation and bronchoscopy (figure 1).

Both in the acute and chronic setting, MI–E is labour intensive and often difficult for non-professional caregivers. However, it is next to impossible to manage advanced NMD patients without tracheostomy tubes, unless their families and care providers provide virtually all of their care during upper respiratory tract infection. It is inadequate for hospital staff to take full care of the hospitalised patient and instruct the family just before discharge, and then to expect another episode to be prevented. Whereas the family often has the time and motivation to use MI-E along with abdominal thrusts, sometimes every 15 min, and to use oximetry as feedback to maintain normal saturation (without supplemental oxygen) for the home or intensive care patient, one cannot expect the respiratory physiotherapy and nursing staff to do this.

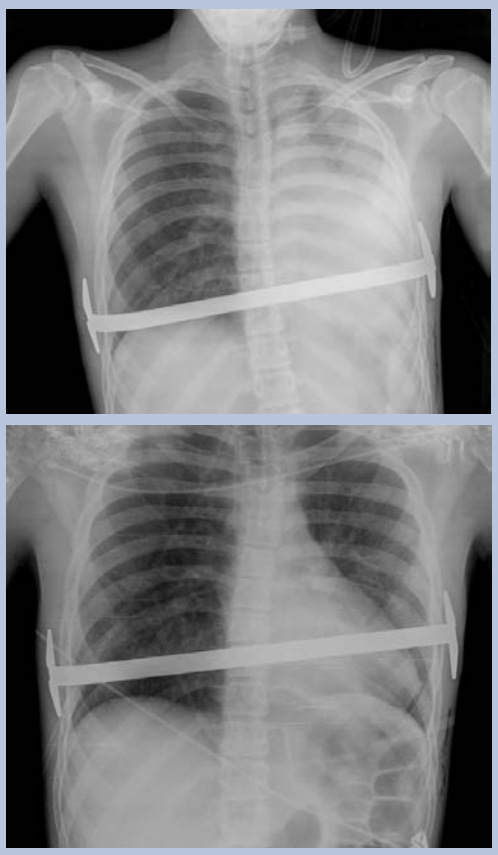

Figure 1
Eight sessions of MI-E applied to a patient with myotonic distrophy (following surgical procedure and general anaesthesia) reversed respiratory failure and atelectasis. Vital capacity, PCF and oxygen saturation improved with clearing of mucous plugs (vital capacity from 0.69 to 1.71 L, PCF from 175 to 350 L per min and oxygen saturation measured by pulse oximeter from 88 to 97%).

In NMD patients, MI–E failure only occurs in those who cannot cooperate (unless they have an endotracheal tube) or who have severe bulbar dysfunction [30]. In some bulbar ALS patients, MI–E can induce upper airway collapse, making the technique uncomfortable and ineffective [15]. In fact, the current authors have had two ALS patients (one with a floppy epiglottis and one with severe tongue weakness), in whom MI–E (and also nasal ventilation) caused stridor due to epiglottic prolapse and glossoptosis (figure 2). However, even in bulbar ALS it worthwhile attempting MI–E, since there are some patients that can improve PCF [31] and are able remove secretions during a chest infection [32].

According to the present authors' experience, MI–E can be very effective in NMD patients who are on continuous noninvasive ventilatory support for years despite no ventilator-free breathing ability, and it is possible to apply this technique proactively with oximetry feedback to

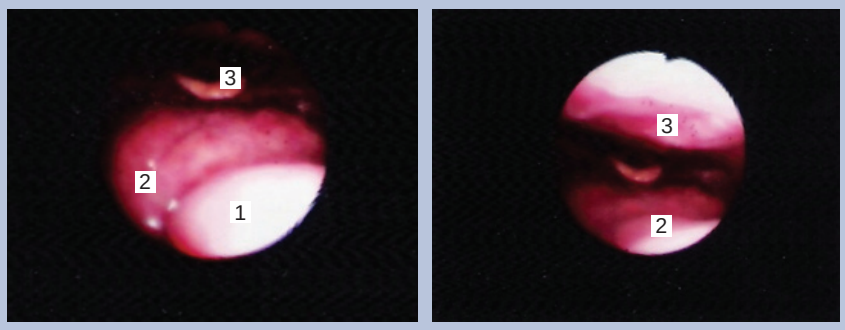

Figure 2
Nasopharyngoscopy: glossoptosis during positive pressure in a severe bulbar ALS patient with tongue weakness. 1: uvula; 2: tongue; 3: epiglottis.

avoid patients becoming hospitalised or developing pneumonia.

Conclusion

MI-E is very effective in the resolution of acute respiratory failure in NMD patients, but is rarely needed for stable patients with intact bulbar function who can air stack to maximum lung volumes [33] and close the glottis against high pressures with an abdominal thrust. However, even in stable patients it may be advisable to use it routinely, just to stay in practice so that the patient can apply it in an effective way during upper respiratory tract infections (as that is the time when the technique is most needed).

In conclusion, the use of MI–E can be time consuming but, without doubt, avoids hospital admissions and fibreoptic bronchoscopy for atelectasis, and reduces hospital stay, thus contributing to an improvement in patients' quality of life and a reduction of hospital costs. Further exploration of the use of this technique in the acute setting is thus warranted.

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