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Current status and future of mechanical cough support

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Mechanical insufflation-exsufflation (MI-E) is an established component of respiratory care in individuals with neuromuscular disease who present with ineffective cough and secretion retention. Considering recent developments and the growing emphasis on evidence-based personalization of therapy, this editorial highlights key considerations regarding titration and individual adaptation of MI-E. Additionally, attention is drawn to the lack of consistency in terminology across MI-E device manufacturers, which may lead to confusion in both clinical practice and training. Bench testing and experimental models are also discussed as tools to advance understanding of device performance; however, the need for standardized test conditions is evident to ensure comparability and clinical relevance across different systems.

In the era of personalized medicine, MI-E should not be applied as a standardized, one-size-fits-all therapy. Rather, it should be titrated and adapted to everyone, reflecting the unique interplay of respiratory mechanics, bulbar function, disease progression, and patient experience. MI-E therapy aims to support effective cough by simulating the physiological phases of increasing inspiratory volume and enhancing the expiratory flow and velocity, that remove the secretions in the central airways. This requires selecting initial settings based on clinical presentation and adjusting them over time. Our clinical practice and previous work have shown that a stepwise, patient-centred titration approach enhances both tolerance and efficacy [1–6]

The MI-E titration begins with introduction and familiarization—using low pressures and gradually adding components (exsufflation, pause, adjustment of insufflation rise-time and triggering, and adding oscillation if preferred), while closely observing chest wall movement, upper airway behaviour, and patient-reported comfort—with settings individually adapted over time. In patients with bulbar involvement, abrupt or high pressures can provoke laryngeal closure, impeding lung inflation[1,2,5]. Strategies such as prolonged rise-time and insufflation time, asymmetric pressure settings, or using fewer cycles can mitigate this risk [3,5] . Further, monitoring provides key clinical feedback of leakage, patient effort and treatment compliance. Tools like flow-and pressure waveforms, cough peak flow (CPF), and qualitative feedback guide ongoing adjustments. Note that CPF alone may not reflect effective airway clearance, especially with upper airway closure or bulbar dysfunction. In such cases, inspiratory volume, laryngeal auscultation, visualisation via with transnasal fiberoptic laryngoscopy or diagnostic ultrasound offer additional insight [7]. Regular reassessment is essential, especially for patients with rapidly progressing neuromuscular disease, where settings that once worked may become inadequate [1,3]. We propose that MI-E titration should be structured yet flexible, incorporating clinical algorithms (see Figure 1) and standard terminology. A unified nomenclature

across devices is warranted to facilitate clearer communication and training, ultimately improving outcomes.

Despite the need for a personalised medicine approach for the delivery of MI-E, we believe that manufacturers have a responsibility to add evidence-based features to MI-E devices. In recent years we have seen the addition of oscillations with MI-E to mimic intrapulmonary percussive ventilation (IPV). However, IPV therapy is often delivered for over 15 minutes to move secretions from the peripheral airway to the central airways. MI-E therapy is often for less than one minute and aims only to mobilise secretions from the central airways. It is hardly surprising that Sancho and co-workers have shown no benefit in patients with ALS [8,9]. Positive airway pressure during the pause phase has been used to aid re-recruitment after exsufflation, though no studies have confirmed its benefit with MI-E. One study applying a recruitment manoeuvre after high-frequency chest wall oscillation in critically ill patients showed no effect [10]. Manufactures add these features to devices to give a unique selling point. Then these often-redundant features are added to by health care organisations to a tender, meaning that other manufacturers add these features to their device in order for their device to be considered for reimbursement. This can lead to confusion and sub optimal treatment for patients. Another confusion that can occur is that manufactures call the same parameter with a different term (see Figure 2, where highlighted in bold the different terminology used for same features). In addition, different definitions are used for the rise time and trigger, some with a number whilst others use a word to describe. To ensure a truly personalized approach, it makes sense for things to be consistently named. This aids education around devices and prevents barriers to use.

Although there is significantly less experience compared to the field of non-invasive ventilation—where the performance of different devices has been extensively evaluated in terms of trigger sensitivity, pressurization capabilities, and propensity for asynchronies [11,12] —studies are beginning to emerge on the behavior of various devices in bench test environments.

Frigerio et al [13] demonstrated significant differences across four devices when tested under identical settings in a bench model. The presence of leaks and changes in lung mechanics were found to influence the externally measured peak flow values. In another recent study, Martínez-Alejos et al. reported a systematic underestimation of peak flow values in a bench test model [14].

However, one of the fundamental aspects of a bench test is its ability to faithfully replicate what would occur in a clinical setting. In the specific case of MI-E, the clinical model involves several upper airway structures (velopharynx, oropharynx, glottis, etc.), whose behavior—under substantially higher absolute pressure values than those typically applied during non-invasive ventilation—may elicit different responses in healthy individuals compared to patients with neuromuscular disease.

Finally, the effects of synchronization with the patient's spontaneous cough have not yet been studied in vitro.

In this regard, Andersen et al [15] demonstrated in healthy volunteers that expiratory resistance to negative pressure exceeds inspiratory resistance, resulting in less negative pressures in the lower airways than those programmed on the device. Understanding the behavior of the upper airway in response to the delivery of such pressure magnitudes is also essential for tailoring cough assistance parameters to individual patient needs.

In conclusion, although our understanding of device–patient interactions still needs to be improved, in the era of personalized respiratory care, individualized titration—continuously assessed throughout the course of neuromuscular diseases—represents a reasonable and clinically sound approach. Well-validated, non-invasive tools are already available to support clinical decision-making.

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Ethics in publishing

1. Does your research involve experimentation on animals?:

No

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No

3. Does your study include a clinical trial?:

No

4. Are all data shown in the figures and tables also shown in the text of the Results section and discussed in the Conclusions?:

No

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Figure 1. *Suggested clinical pathway for titration and adaptation of MI-E therapy based on tolerance, disease progression, and cough effectiveness.*

MI-E: Mechanical insufflation-exsufflation. VC: Vital capacity. CPF: Cough peak flow. MIP: Maximum inspiratory pressure. MEP: Maximum expiratory pressure. SNIP: sniff inspiratory pressure.

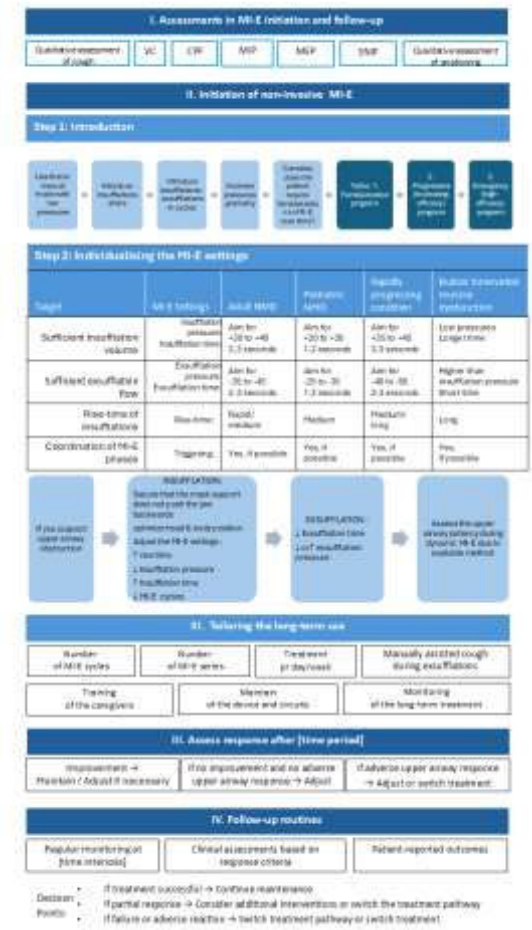

Figure 2. Overview of the main MI-E devices currently available on the market. The different terminology used by manufacturers for insufflation, exsufflation, and pause settings is highlighted in bold. The table also shows the various ways in which rise time, trigger, and oscillation parameters are defined.

Name: Company:	Comfort cough II SEOIL PACIFIC CORP	Clearo Breas	BiWaze ABM	EOVE 70 Air Liquide	PEGASO PLUS Dimla	Synclara Baxter	Cera Lowenstein	Libera MPR
								
Modes:	Manual / Auto	Manual / Auto / Programmed Auto	Manual / Auto	Manual / Auto	Manual / Auto	Manual / Auto	Manual / Auto	Manual / Auto
Settings:								
Insufflation pressure: Insufflation time: Insufflation trigger: Rise time:	**IP** 0 to 70cmH2O 0.0 to 5.0 seconds Cough Sync (off to 9) Low, Med, High	**Insp** 3 to 70 cmH2O 0.5 to 5 seconds Flow (off to 9) 1–10 (10–90% of TI)	**Insp Pressure** 0 to 70 0 to 5 seconds (off to 10) Low, Medium, High	**Ins Pressure** 5 to 70 0.5 to 5 seconds (off to 3) 0 to 5	**I** 0 to 70 hPa 0.5 to 9.9 seconds (Off to 9) 1, 2, 3	**Inhale** 0 to 70 cmH2O 0 to 5 seconds (off, low, med, high) None	0 to 70 hPa 0 to 10 seconds Flow (off to 4) 1 to 4	**Pressure IN** 0 to 70 0 to 10 seconds 0.1 to 5 sec 10 levels
Exsufflation pressure: Exsufflation time: Pause time:	**EP** 0 to -70cmH2O 0.0 to 5.0 seconds 0.0 to 5.0 seconds	**EXS** -3 to -70 cmH2O 0.5 to 5 seconds 0.5 to 5 seconds	**Exp Pressure** 0 to -70 0 to 5 seconds 0 to 5 seconds	**Exh Pressure** 0 to -70 0.5 to 5 seconds Off 0.5 to 5 seconds	**E** to -70 hPa 0.5 to 9.9 seconds 0.5 to 9.9 seconds	**Exhale** 0 to 70 cmH2O 0 to 5 seconds 0 to 5 seconds	0 to 70 hPa 0 to 10 seconds 0 to 10 seconds	**Pressure EX** 0 to 70 0 to 10 seconds 0 to 10 seconds
Positive pressure on pause	No option	No option	**Pause Pressure** 0 to 15	**PEEP** 0 to 20 cmH20	No option	**PAP 0 to 30 cmH20**	No option	**PEEP** 0 to 20 cmH20
Oscillations: Amplitude: Frequency: Pre-set / profile:	OFF/Inhale/exhale/both 1 to 10 cmH2O 1 to 20 Hz 9	OFF/Inhale/exhale/both 1 to 10 cmH2O 1 to 20 Hz 4	OFF/Inhale/exhale/both 1 to 5 cmH2O 5 to 20 Hz 10	OFF/Inhale/exhale/both 1 to 3 4 to 20 Hz 3	OFF/Inhale/exhale/both 1 to 15 hPa 1 to 20 Hz	OFF/Inhale/exhale/both 1 to 10 cmH2O 1 to 20 Hz 10	OFF/Inhale/exhale/both 1 to 10 cmH2O 1 to 20 Hz 4	OFF/Inhale/exhale/both 1 to 20 cmH2O 1 to 20 Hz 5
Monitoring:								
Exsufflation assisted expiratory flow: Tidal volume: Heart rate SpO2 PIP PEF	✓ ✓ (Inspiratory) ✓ ✓	✓ ✓ (Inspiratory) ✓ ✓	✓ ✓ (Expiratory)	✓ ✓ (Inspiratory) ✓ ✓	✓ ✓ (Inspiratory) ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ (Expiratory) ✓ ✓ ✓
Additional features:	High frequency chest wall oscillation	Stepped insufflations, recruitment breaths, treat repeat (manual recording), IPPB and NIV	Separate airway path with proprietary tubing	IPPB	Intrapulmonary percussive ventilation	Sigh, program preset prescriptions		Step for auto air stacking, Mc Cough (tailored therapy), EFA, IPPB, and CPAP.