The Use of Mechanical Insufflation-Exsufflation Via Artificial Airways

During the past 20 years, airway clearance techniques have been the subject of increasing scientific interest. Cough augmentation with mechanical insufflation-exsufflation is part of this trend. No fewer than 23 studies, of which 21 were published in the past 10 years, have improved the level of evidence on this technique.[1-23] As suggested in Figure 1, the availability of insufflation-exsufflation in Europe since 2002 has increased the number of studies in this field. The addition of knowledge on insufflation-exsufflation recently accelerated, as evidenced by 10 original studies published during the last 4 years.[14-23]

The particularity of insufflation-exsufflation is that it provides a mechanical assistance to compensate for deficits in both the inspiratory and expulsive phase of cough in patients with low respiratory muscle strength. Often associated with noninvasive mechanical ventilation,[1,19,22] insufflation-exsufflation is used in adults, children, and even infants.[22] To my knowledge, 3 insufflation-exsufflation devices are available on the market: CoughAssist (Philips Respironics, Murrysville, Pennsylvania); Pegaso (Dima Italia, Bologna, Italia); and Clearway (B&D Electromedical, Warwickshire, United Kingdom). To date, the efficacy, safety, and tolerance of insufflation-exsufflation have been investigated in patients with only one of these 3 devices, the CoughAssist.

We must remember that an insufflation-exsufflation device that uses a noninvasive mask does not create a cough *ex nihilo*. Indeed, assisted cough requires the active participation of the patient who, although very weak, must perform a cough maneuver that includes glottal closure. In this case, weak but existing cough is amplified by the insufflation-exsufflation device. In contrast, when insufflation-exsufflation is used with an invasive interface, the cough maneuver is not essential. The insufflation-exsufflation device can create an artificial cough, even in unconscious, sedated patients.

Insufflation-Exsufflation via Noninvasive Interface: Cough is Amplified

As previously mentioned, the use of insufflation-exsufflation via noninvasive interface requires the patient's active participation. The device acts as an amplifier of the ineffective spontaneous cough. At least partial glottal closure is required before the expulsive phase of the cough. In the total absence of glottal control, insufflation-exsufflation is ineffective.[8]

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In very weak patients with restrictive respiratory syndromes and upper airway encumbrance, but not in patients with obstructive respiratory syndromes, the capacity of the insufflation-exsufflation device to produce expiratory cough flows at a higher rate than any manual or instrumental cough augmentation technique is well documented.[1,2,5,20] In addition, insufflation-exsufflation may prevent hospitalizations[18,19] and avoid the need for tracheostomy or intubation.[12] It reduces dyspnea,[11] shortens upper-airway-clearance sessions,[16] and stabilizes or improves blood gases.[11,14,16] The level of evidence on the effectiveness of insufflation-exsufflation is considered sufficient to recommend its use in very weak patients with ineffective cough.[24] A large number of patients from occidental countries may benefit from insufflation-exsufflation, provided they have major, explicit, and proven cough deficit. However, the high price of insufflation-exsufflation devices deprives countries with limited financial resources of this technique.

Insufflation-Exsufflation via Invasive Interface: Coughing is Simulated

Despite promising results,[6,13] the use of insufflation-exsufflation in invasive conditions is not yet common. In the presence of an invasive interface, using insufflation-exsufflation is possible via an adapter to an endotracheal or tracheostomy tube (Fig. 2). In this case, neither the patient's spontaneous coughing nor glottis control is necessary, because the pressures generated by the insufflation-exsufflation device are directly applied into the trachea (ie, the subglottic area).

By contrast to the use of insufflation-exsufflation with a noninvasive interface, the production of high expiratory flow through an artificial airways is totally independent of the patient's effort. As suggested in Figure 2, it is convenient to superficially introduce a suction catheter into the cannula through the tracheal adapter. Ideally, the catheter

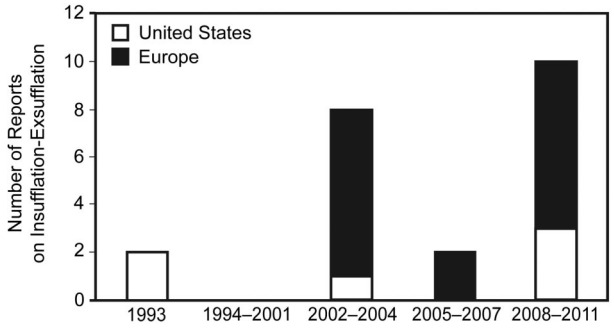

Fig. 1. History of studies on mechanical in-exsufflation.

will not extend beyond the tube, to avoid any contact with the tracheal mucosa. This precaution may avoid granuloma, bleeding, and irritation of mucous membranes.[25] Prolonged use is possible in unconscious patients under ventilatory support, because the inspiratory positive pressure during insufflation can provide rudimentary ventilatory support.

In recent studies, the CoughAssist was applied to tracheotomized patients with spinal cord injury[3,13] or neuromuscular disease.[6,9] Insufflation-exsufflation was compared to endotracheal suctioning on a cannula with inflated cuff.[6] Patients found the CoughAssist more effective, less irritating, less painful, less tiring, and more comfortable and convenient than suctioning.[3,6] To date, however, adequate insufflation-exsufflation settings for artificial airways are not well known.

We know that increasing the inspiratory or expiratory time does not affect the maximum expiratory flow during exsufflation, whereas increasing the inspiratory and/or expiratory pressure increases the maximum expiratory flow.[21] In the current issue of RESPIRATORY CARE, Guérin et al[23] report an in vitro study of insufflation-exsufflation with the CoughAssist, with several sizes of endotracheal and tracheostomy tube, and with several lung model compliance and resistance settings. Their study did not aim at showing any evidence on the effectiveness of insufflation-exsufflation technology, but at measuring the impact of artificial airways on expiratory flows and volumes. As expected, the artificial airways significantly reduced the maximum expiratory flow during insufflation-exsufflation with the CoughAssist. For a given expiratory pressure, the narrowest internal diameter of artificial airway corresponded to the lowest peak expiratory flow. However, Guérin et al suggest future studies to confirm these in vitro observations in in vivo conditions. The additional finding that an increase in airway resistance or decrease in thoraco-pulmonary compliance decreased the expiratory cough flow is consistent with previous findings by Sancho and co-workers.[10] Interestingly, Table 5 from Guérin et al[23] suggests the pressures necessary to generate effective assisted expiratory flows under various conditions of resistance and compliance as a function of artificial airway tube diameter. These data are relevant for clinicians because they provide a tool that is immediately useful in clinical practice in the intensive care unit.

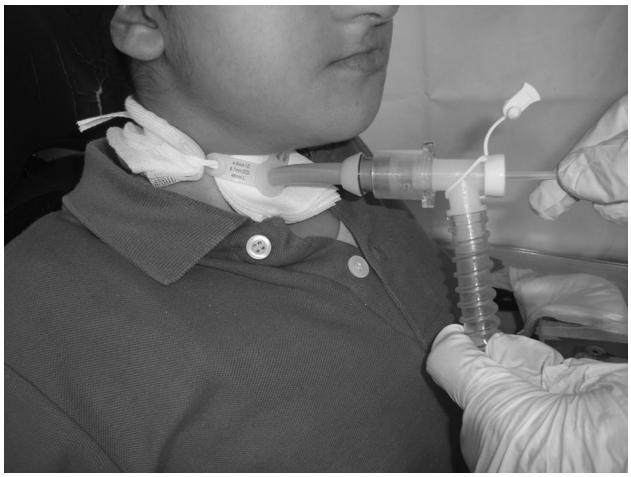

Fig. 2. Suctioning during a mechanical insufflation-exsufflation treatment via a tracheal adapter.

My impression is that the use of insufflation-exsufflation in the coming years will increase in patients ventilated via artificial airways and presenting major difficulties for airway clearance in the intensive care unit. The interest of the study by Guérin et al[23] is that they controlled the experimental conditions of their in vitro investigation, such as airway resistance and thoraco-pulmonary compliance.

Whatever insufflation-exsufflation is used via invasive or noninvasive interface, the time has come to "fine tune" insufflation-exsufflation indications and settings depending on the patient's characteristics rather than to further demonstrate insufflation-exsufflation effectiveness. The study by Guérin et al[23] illustrates well these new targets.

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