



## **Mechanical insufflation/exsufflation: a room for improvement**

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Mechanical insufflation/exsufflation: a room for improvement.

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Mechanical insufflation/exsufflation is a technique used to facilitate the clearing of airways secretions in patients with a weak cough. It can be performed in the hospital setting, of notice in critically ill patients<sup>1,2</sup>, or at home in patients with chronic neuromuscular weakness<sup>3</sup>. With this technique a specific device first insufflates the respiratory system at a set pressure and then actively sucks it at a set negative pressure. Usually pressure is set at the same level with an opposite sign for insufflation and exsufflation. The goal of the treatment is to reach a targeted peak expiratory flow because the efficacy of cough, and hence clearing of airways, has been linked to it. A peak flow above 160 L/min has been assumed an efficient cough generated from the device<sup>4</sup>. In patients with encumbrance cough strength is part of the whole process of cough efficiency, the other one being the moving of the secretions towards the upper airways for their complete elimination to occur. It could, therefore, be speculated that the peak expiratory flow mainly serves to make the airways secretions available for being expelled and other variables are involved for moving them out. In this issue of Respiratory Care Volpe et al made a brilliant in vitro study to analyze the movement of mucus over a tube actuated with a mechanical insufflation/exsufflation device set at different combinations of flow and pressure<sup>5</sup>. They found that the peak expiratory flow alone did not contribute to the displacement of mucus towards the outlet of the respiratory system. In fact, they found that the lower the peak insufflation flow or the higher the ratio of peak exsufflation to insufflation flow or the greater the ratio of insufflation to exsufflation pressure, the greater the displacement of mucus towards the outlet of the respiratory system would be. To sum up, the higher the inspiratory flow relative to the expiratory flow the higher the risk for accumulation of secretions down to the respiratory system. It illustrates a mechanical rule: a cyclic and periodic process (Mechanical insufflation/exsufflation) requires asymmetry between its phases (insufflation and exsufflation) to induce a non-zero average displacement. In a pure

oscillating process the displacement induced by the active stroke is erased by the displacement induced by the recovery stroke.

There are some practical limitations in the study by Volpe et al<sup>5</sup>. The reproducibility to achieve the low insufflation flow manually has not been evaluated. It could be speculated as low in the daily practice according to the way they used to change the insufflation flow with the Model CM-3200. Other models of the same brand (CM-3400 or E70) should be assessed. Furthermore, it is impossible to manually adjust a low insufflation flow when the device is set in the automatic mode. Finally, from the mechanical point of view flow (or flow bias) is not in theory the most direct physical parameter nor the only one allowing explaining the movement of the mucus induced by a fluid flow. General mechanical laws predicts that mucus displacement depends on the shear stress (or force) exerted by the fluid to the mucus and on the rheological properties of the mucus<sup>6</sup>. In a given geometry the flow rate is clearly correlated to the shear stress. However if the geometry changes (e.g., adults to children, collapsibility of the airway) the same flow rate is associated to a different shear stress. The rheological behavior of the mucus is another key point. A viscoelastic and a shear-thinning behavior, possibly with some thixotropy, are often evoked. In other word, mucus is a very complex material and slight modification of its physical properties may have a strong impact on the movement of the mucus.

All these points suggest that future guidelines for an efficient setting of Mechanical insufflation/exsufflation should integrate “flow bias” that can be easily monitored, but may probably have to take account different categories of airway dimension and pathology.

This potential interest of low insufflation flow and pressure during mechanical insufflation/exsufflation, regardless its impact on mucus displacement, has been suggested in

patients with amyotrophic lateral sclerosis in whom the direct laryngeal visualization disclosed that higher insufflation pressure and flow promoted adduction of vocal folds<sup>7, 8</sup>.

Evidence-based medicine does not provide sufficient evidence to recommend the systematic use of mechanical insufflation/exsufflation in patients with chronic neuromuscular weakness<sup>9</sup>. Perhaps the negative results of the trials come from a suboptimal use of the device. Another potential implication of present results is the need for monitoring the flow during the procedure, which is currently lacking.

Beyond the case of mechanical insufflation/exsufflation present results shed light on the setting of inspiratory flow during mechanical ventilation. By observing upper airways with a fiber-optic bronchoscope during noninvasive ventilation in awake or sleeping normal subjects, Jounieaux et al found that higher inspiratory flow was associated with glottis adduction<sup>10, 11</sup>. Inspiratory flow setting has received a growing interest in patients with acute respiratory distress syndrome. Indeed, the new concept of mechanical power has pointed out the role of inspiratory flow as a contributor of ventilator-induced lung injury<sup>12, 13</sup>. The stress relaxation that follows tidal volume inflation can be assessed by the difference in airway pressure between the first zero flow and the plateau pressure. The magnitude of this decay correlated with lung edema formation in normal animals receiving invasive mechanical ventilation<sup>12</sup>. Furthermore, the magnitude of this decay is flow-dependent<sup>14</sup>. Therefore, it could be that lowering inspiratory flow is lung protective.

Present results should encourage further studies in patients during spontaneous breathing or under invasive mechanical ventilation, either at home or in the intensive care unit.

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