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High-frequency percussive ventilation: An old mode with a great future*

Hypoxemia and atelectasis are well-known and serious complications of one-lung ventilation (1). Intubation using a double-lumen tube facilitates independent lung ventilation, which alleviates hypoxemia, increases lung volume, and overcomes atelectasis in one-lung ventilation. However, the double-lumen tube does not function optimally in high-resistance airways and hinders access for suctioning secretions (2, 3).

High-frequency ventilation is characterized by breathing frequencies higher than 1 Hz where tidal volumes of 1–3 mL/kg are less than the dead space (4). High-frequency percussive ventilation (HFPV) is a mode of high-frequency ventilation that delivers small bursts of gas at 300–600 cycles per minute and relies on chest wall elastic recoil pressure for passive exhalation. HFPV is designed to be used in conjunction with mechanical ventilation or as a stand-alone treatment. The amplitude of pressure oscillations depends on the pulsatile flow amplitude and on the impedance of the respiratory system. Therefore, flow oscillations can be delivered on top of mechanical breaths or on top of spontaneous breathing (5, 6). Nowadays, high-frequency ventilation modes are a late option to sustain adequate gas exchange in adult patients with acute respiratory distress syndrome (4), and HFPV has led to improved oxygenation in cohort studies of patients with acute brain injury (7), acute respiratory distress syndrome (8), or acute smoke inhalation (9). In parallel, HFPV has been used to facilitate high-frequency–assisted airway clearance by vibrating the cilia layer. However, there is not enough data to consider HFPV superior to other techniques of high-frequency–assisted airway clearance like chest wall compression or chest wall oscillation (10, 11).

In this issue of *Critical Care Medicine*, Lucangelo et al (12) report the results of a randomized study on a novel use of HFPV in patients undergoing elective partial lung resection. After patients were placed in lateral decubitus and dependent lung ventilation was instituted, the nondependent lung was randomized to receive either humidified continuous positive airway pressure at 5 cm H_2O or HFPV at a percussion rate of 500 cycles per minute and a mean pulsatile pressure of 5 cm H_2O. After the surgical procedure was completed, patients had the same standard of care until hospital discharge. Interestingly, patients in the HFPV group had significantly better oxygenation and airway clearance of secretions, as well as a higher probability of being discharged earlier to the ward.

The study by Lucangelo et al (12) is important because it demonstrates that HFPV is efficacious not only in increasing Pa_{O_2} during one-lung ventilation, but also in improving clearance of secretions, thus, enabling better outcome. These results from the well-controlled perioperative period might also have importance in the more general critical care arena. HFPV helps mobilize secretions from the periphery of the lung to larger airways; however, eliminating secretions depends on the patient's ability to cough them up or, in intubated patients, on the health-care team's ability to aspirate them. This is clear in the article by Lucangelo et al (12), where although the final amount of secretions was the same in both groups, it was eliminated 1 day earlier in the HFPV group. In critically ill patients, secretion removal is crucial. We can speculate that in patients with effective cough, early-assisted airway clearance might increase the number of ventilator-free days, decreasing episodes of nosocomial lung infections and extubation failures. In fact, Clini et al (13) recently reported that the addition of percussive ventilation to the usual chest physiotherapy routine in tracheostomized patients

*See also p. 1663.

Key Words: one-lung ventilation; hypoxemia; lung resection; high-frequency percussive ventilation; lung secretions; mechanical ventilation

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improved gas exchange and expiratory muscle performance and reduced the incidence of pneumonia. However, these potential benefits might be totally lost in patients who are unable to expectorate, like patients with neuromuscular diseases or intensive care unit–acquired weakness, where secretions, although present in the airways, are extremely difficult to be mechanically suctioned.

Several points must be considered before the broad application of HFPV in mechanically ventilated critically ill patients. First, adding HFPV to conventional ventilation reduces humidity and a heated humidifier on the inspiratory line would be necessary to provide adequate humidification (14). Second, mechanical loads, such as those caused by alterations in resistance and compliance, affect flow, volume, airway pressure, and their waveforms (6, 14). Third, in conjunction with a driving ventilator, intrapulmonary percussive ventilation may add pressure and volume to tidal ventilation and generate intrinsic positive end-expiratory pressure (14). Fourth, before HFPV can be considered suitable for standard intensive care practice, evidence needs to be accumulated to demonstrate better patient–ventilator interaction with HFPV and the absence of significant adverse effects. Finally, when HFPV is added to current ventilators it could adversely affect the ventilator's ability to monitor pressures and volumes and may cause the ventilator alarm to go off incessantly.

In conclusion, HFPV is an old but very attractive technique. In short-term use, HFPV helps earlier secretion mobilization with some clinical benefits and no adverse effects. However, before broadly applying HFPV in intensive care patients, it is necessary to determine which subgroups of patients might benefit most from HFPV, and further technological developments are necessary to ensure that the technique does not alter ventilator function.

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