Other Modes of Ventilation

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Here, we describe very briefly some modes of ventilation that are relatively rarely used, but which theoretically have a rationale for future use in NIV. Many methods that are discreetly popular during invasive mechanical ventilation are, therefore, excluded.

8.1 Neurally Adjusted Ventilatory Assist

Unfortunately, despite the identical name, one of the two authors of this book has nothing to do with neurally adjusted ventilatory assist (NAVA) and will, therefore, never become rich in the case of an explosion of use of this form of ventilation, which remains one of the greatest innovations of recent years.

The functional principle underlying its design is ingenious. As highlighted by Fig. 8.1 all the assisted methods discussed so far are based on the principle that a patient activates the ventilator with a mechanical impulse (i.e., generation of a flow, pressure, or volume), recorded by the ventilator close to the upper airways and, therefore, a long way away from where the impulse to breathe starts (in the central nervous system). Furthermore, there are disorders, such as COPD, characterized by the presence of intrinsic PEEP (PEEPi), which must be overcome in any case to enable activation of the trigger.

Besides the force, the time necessary to overcome the component due to the PEEPi always creates a delay between the contraction of the respiratory muscles and the start of the ventilator support. This can lead to problems of synchrony and poor adaptation. NAVA resolves these problems by measuring the signal for the trigger directly at the level of the diaphragm, recording its electrical activity with an esophageal electrode. Theoretically, therefore, a response from the ventilator should be obtained almost concomitantly with diaphragmatic contraction and, therefore, totally independently of the presence or absence of PEEPi.

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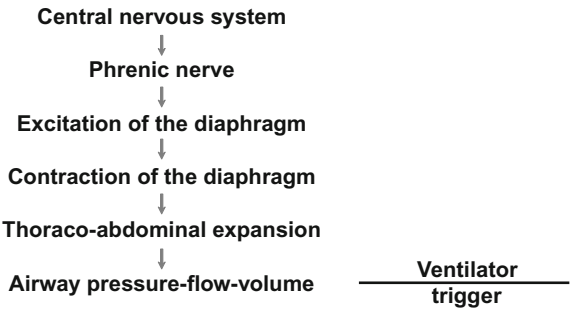

Fig. 8.1 The "journey" of the central respiratory impulse

Preliminary physiological studies have demonstrated how good this method is with respect to, for example, pressure support ventilation. However, it remains unclear whether and, if so, how NAVA can improve clinical outcomes and how much the improvement of the patient/ventilator interaction also during NIV, may change the clinical history. We would, however, like to point out that NAVA requires the introduction of an esophageal catheter, a procedure which is actually invasive, and so it is somewhat a contradiction to the principle of a non invasive method of ventilation.

8.2 Airway Pressure-Release Ventilation or Biphasic Positive Airway Pressure

Be careful! This method, which is currently popular in some German-speaking countries, was originally called airway pressure-release ventilation (APRV) and more recently is also called biphasic positive airway pressure (BiPAP). It must not be confused with the BiPAP ventilator, which enables bilevel ventilation, that is Pressure Support + CPAP/external PEEP. APRV, or BiPAP®, has so far only be used in intubated patients with hypoxic respiratory failure as an alternative to volume ventilation. It consists of two levels of CPAP which are applied for a given period of time between which the patient can breathe spontaneously exactly as if with a single CPAP. However, unlike this latter, during APRV the operator may regulate the I:E ratio and the respiratory rate; thus, if the patient is not breathing spontaneously, it is indistinguishable from pressure-controlled ventilation. The tidal volume depends on the patient's compliance and resistances and on the difference in pressure between the two levels of CPAP.

8.3 High Frequency Ventilation

This term is used for some modes of ventilation characterized by tidal volumes lower than the anatomical dead space and with frequencies between 60 and 3,000 cycles per minute. Some of these, such as high frequency jet ventilation, are applied with a semi-invasive system.

- *High frequency positive pressure ventilation* (HFPPV). This mode is conceptually identical to intermittent positive pressure ventilation, which uses low tidal volumes and high frequencies (between 60 and 100 cycles/min);
- *High frequency jet ventilation* (HFJV). During this form of ventilation a small catheter is placed in the central airways, guaranteeing a supply of gas at a frequency of 60–240 cycles/min. The inspiratory time is set at about 20–50 % of the total respiratory time, while it is not possible to preset the patient's tidal volume because the volume delivered by the ventilator is the sum of that supplied by the machine and that actively produced by the patient;
- *High frequency oscillation*. This mode of ventilation consists of a very small tidal volume (1–3 mL/kg) supplied by a high frequency piston (500–3,000 cycles/min). The gas is introduced using a flow system, while a small tube deals with the removal of CO_2;
- *Intrapulmonary percussive ventilation* (IPV). This is the only one of these methods applied non invasively with the main aim of removing bronchial secretions and improving the conditions so that the patient can undergo a cycle of NIV according to traditional dictates. As for HFPPV, IPV guarantees small volumes at high frequencies. For example, the "phasitron" system, working like a piston Venturi system, supported by compressed gas at a pressure from 0.8 to 3.5 bar, can generate from 80 to 650 cycles/min. IPV is indicated above all in patients with collections of secretions and difficulty in removing these secretions. We all know that the inability to eliminate bronchial secretions is one of the major limitations to the use of NIV but, as demonstrated in some studies, IPV could resolve this problem, restoring the conditions necessary for a trial of NIV. Nevertheless, it is important that the patient has a cough reflex, even if minimal, since it will be no help moving the secretions toward the oropharynx if the patient cannot then eliminate them. These devices, including an *in-exsufflator,* are also useful for chronic application in those neuromuscular pathologies in which weakness of the respiratory muscles makes it very difficult to eliminate secretions.

With the exception of IPV, the clinical use of these modes is limited because they seem to offer few advantages over the traditional techniques with regards to cardiovascular performance, intrapulmonary fluid accumulation, and gas exchange. The only fields of application are, therefore, limited to ventilation during bronchoscopy, laryngeal surgery, and the treatment of broncho-pleural fistulae that are proving resistant to closure. One further very interesting use that has given excellent clinical results is in the prevention of the development of chronic lung disease in premature babies and in those with neonatal bronchopulmonary dysplasia.

8.4 Volume-Assured Pressure Support Ventilation and Volume-Guaranteed Ventilation

This is a mode that has been almost completely abandoned in the intensive care unit, but has recently had a certain success during NIV, particularly in patients ventilated at home. Theoretically, the "real" volume assured pressure support ventilation (VAPS) combines the benefits of both pressure and volume ventilation. The operator decides the level of pressure support, a minimal tidal volume to reach and a peak inspiratory flow. During the first inspiratory phase, the algorithm of the ventilator extrapolates from the flow signal an estimated ideal volume that the patient will reach. If this is less than the minimum tidal volume, the ventilator supplies, within the same breath, the difference (Δ) in the volume needed to reach the target.

The major limit that we see in this algorithm concerns the calculation of the target volume based on the inspiratory flow which, as we know can increase in the presence of losses and therefore affect the calculation of the minimum guaranteed tidal volume, overestimating its value. In contrast, with ventilators for NIV or those for home use, the mechanism for integrating the volume is based on a progressive increase of pressure support. This particular type of ventilation can also be called volume-guaranteed ventilation. In other words, if the minimum volume is not reached for a few consecutive breaths, the ventilator will supply progressively increasing inspiratory pressures (up to a certain established upper limit), until the volume is raised above this threshold value. However, if the patient is able to generate a volume greater than the maximum established one, the ventilator will work in a different way, that is, gradually decreasing the inspiratory support. The advantage of these methods is that of theoretically ensuring effective ventilation in terms of tidal volume; the major disadvantage is that as the patient's clinical conditions change, he could need a greater minute volume. In this case, at least with some machines, the pressure support is reduced in response to an increased tidal volume, thus contrasting the patient's efforts to increase his ventilation. The ability of these modes of ventilation to compensate for non-intentional leaks depends, however, strictly on whether a "vented" (i.e., a non-rebreathing valve) or ''non-vented'' (true expiratory valve) circuit configuration is used. This difference must be taken into account as a possible risk when these modes are used with a "non-vented" circuit.

Suggested Reading

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