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High frequency ventilation in neonatology:twenty years later

Twenty years ago it was hard to understand, and even to accept, that a new approach to mechanical ventilation with a tidal volume lower than the dead space was plausible. The foundation of classic physiology was not helpful to account for such apparent contradiction and we physicians were forced to learn new concepts, e.g. facilitated diffusion or the Pendelluft phenomenon, and to express respiratory rates in hertz instead of breaths per minute.[1]

We were in awe when we realized, among other things, that the chest of a newborn infant under high frequency oscillatory ventilation (HFOV) would vibrate, but not produce wall movements; that it was important to examine the chest, abdomen and lower limbs in order to assess ventilation; and that one of the management strategies for hypercapnia was to reduce frequency.

HFOV was first used in a newborn infant at the Neonatology Division of Sanatorio Otamendi on September 28th, 1995. The ventilator used then was the classic and still prevailing SensorMedics®. The onset of this new ventilation mode was preceded by a two-year training provided to some of the neonatologists (mostly conducted abroad), followed by the training of rest of the medical and nurse staff.

Back then, it was not possible to imagine how much we still had to learn, especially how much this new technology would improve newborn infant care and, at the same time, help us understand the pathophysiology of several infant respiratory conditions.

In the first years after the introduction of HFOV, neonatologists were pervaded by the results of a relevant multicenter study called HIFI,[2] which included 673 patients and had demonstrated a high survival rate in newborn infants who did not respond to traditional ventilation but also revealed a strong association with brain bleeding and periventricular leukomalacia. Several years and new studies were required to understand that such untoward effects were basically related to hyperventilation and hypocapnia, whose harmful effects were relatively unknown at that time.

The term "alveolar recruitment" is conceptually linked to HFOV and that is where it probably started and from where it spread out to other ventilation techniques. Today we know that the administration of surfactants improves pulmonary compliance but, at the same time, it is a great alveolar "recruiter," and that positive end expiratory pressure (PEEP) contributes to stabilizing the functional residual capacity by maintaining a constant lung volume. We have also learnt that, with traditional ventilation modes, the lungs stabilize after reaching an optimal lung volume, which is then maintained to a large extent by an adequate PEEP, while with HFOV continuous distension pressure plays such role.

Trying to optimize lung volume entails moving along the pressure-volume loop, in that narrow area between a collapse (atelectasis) and overdistension and, once alveolar recruitment is achieved, staying in the zone of underinflation leads to a better gas exchange in association with improved respiratory stability. It is critical to keep such constant volume, and closed aspiration systems and the administration of surfactants are of great help.

It is essential to take into account the concept of "silent recruitment", a phenomenon that continues after achieving an optimal lung volume, in order to prevent overdistension and the resulting reduction in venous return and patient hemodynamic impairment. An excessive lung volume should be noticed through radiology, the movement (vibration) of the chest, the so-called "insufficient ultrasound window" (not seeing the heart), or signs indicative of a compromised venous return. Correctly adjusting parameters and adapting them according to the patient's course are a constant challenge.

Modern ventilators with flow sensors allow to synchronize and control tidal volume delivery and help to reduce lung injuries to a minimum. In addition, flow-volume loops allow to identify situations that call for special attention. However, not even the most advanced technological systems can replace a highly trained individual who is committed to providing patients with a continuum of care.

The hope to find in HFOV an option capable of reducing lung injuries in very low birth weight newborn infants and, consequently, the incidence of bronchopulmonary dysplasia, was not reflected in the different studies that looked to demonstrate such benefits.[3] Although these studies confirmed that HFOV was safe, a long time had to elapse by until myths surrounding its association with harmful effects on the central nervous system were finally dispatched.

In 2004, after almost ten years of using HFOV, the following article was published: "Experience with the first 100 patients treated with high frequency oscillatory ventilation: results in acute stages and follow-up."[4] The article described a 20% mortality rate in acute conditions and a 15% mortality rate during the first year of life, a very good response in homogenous lung diseases with high oxygenation rates (>20) in 71 patients and in the management of air leaks in 29 patients. No increase was observed in neurological complications in acute stages (ultrasounds performed before and after applying HFOV), nor during follow-up (more than 90% of patients had received follow-up up to one year of life).

As with all new procedures, the HFOV required to be refined through successive experiences until it became an effective and safe technique. HFOV is nowadays accepted worldwide as a rescue mode for patients who do not respond to traditional ventilation, those with different types of air leaks and also those with hemorrhagic pulmonary edema.[5] Besides, in newborn infants with persistent pulmonary hypertension, nitric oxide administered during HFOV is more effective than when used with traditional ventilation.[6]

Almost twenty years later, in the era of non-invasive ventilation return, HFOV may probably find its place in this field.[7]■

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