Искусственная вентиляция легких: «полное затмение» сердца
(редакционная статья)

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Mechanical Ventilation. Total Eclipse of the Heart
(Editorial)

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Highlight

Примечание. Highlight - основные тезисы (в форме инфографики).
Резюме

Результаты последних крупных рандомизированных исследований свидетельствуют о том, что использование высокого положительного давления в конце выдоха (PEEP) при проведении искусственной вентиляции легких у пациентов без острого респираторного дистресс-синдрома (ОРДС) может приводить к увеличению смертности вследствие развития гипотензии и брадикардии. Тщательная оценка функции сердца, особенно правого желудочка, необходима перед назначением ИВЛ всем больным, включая COVID-19 и ОРДС. ИВЛ должна быть максимально не инвазивной, синхронизированной, минимально влиять на функцию сердца, ее проведение допускает умеренную гипоксию и гиперкапнию.

Ключевые слова: искусственная вентиляция легких; сердце

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Summary

Results from recent large randomized trials investigating the use of high PEEP in patients without ARDS all evidence that high levels may increase mortality due to hypotension and bradycardia. A careful assessment of cardiac function – with particular focus on the right ventricle – should be performed before planning our ventilation strategy in any setting, including COVID-19 and ARDS in general. Mechanical ventilation should be respectful in regards of heart function, and tolerant with moderate hypoxia and hypercapnia, noninvasive (as soon as possible) and synchronized.

Keywords: mechanical ventilation; heart

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When the Danish anesthesiologist Bjorn Ibsen introduced positive pressure ventilation in 1952, the history of medicine changed overnight. Providing a replacement of the respiratory muscles – in
the beginning by the hands of medical students and later mechanically when ventilators were introduced – led to the first Intensive Care Units (ICUs) and for the first time to focus attention on the lungs. The second dramatic breakthrough, the discovery of the role of positive end-expiratory pressure (PEEP) and its effects on survival, shortly followed. Experts of intensive care medicine lavished the most profound efforts over the following 60 years to understand ventilation pathophysiology. Their work led to the definition of ventilation strategies including low tidal volumes and high levels of PEEP.

Galen’s belief that the physical act of breathing was required for the heart to beat was considered the truth for over fifteen centuries. Although scientific progress disproved the theory, we should still try standing on the shoulders of giants to see further. As Galen noted, heart and lungs share the same close, restricted space – the thoracic cavity – and as such the two systems interact. Of course, the concept is not new: heart-lung interactions during mechanical ventilation have been studied in details over the last century and all the pathophysiology that lies beneath belongs to the cultural baggage of most medical professionals around the world. Nevertheless, sometimes we tend to forget it. When peripheral saturation drops on the monitor, it is not uncommon in everyday practice to raise the PEEP, forgetting the effects that this gesture might entail on the heart and the circulatory system.

Large randomized trials investigating the use of high PEEP have recently been published. In spite of the different clinical settings, and the different populations involved, all these trials row in the same direction: high levels of PEEP are probably harmful.

The PROBESE trial [1] compared higher level of PEEP (12 cmH₂O) and alveolar recruitment maneuvers with a lower level of PEEP (4 cmH₂O) in obese patients undergoing general anesthesia. While the study focused its complete attention on pulmonary complications, it is interesting to highlight how the incidence of hypotension and bradycardia almost doubled in the group receiving high levels of PEEP. Mortality also saw a 240% increase in the high PEEP group when compared to the low PEEP group (12/989 vs 5/987). This last data should not come as a surprise, as the milestone
POISE-2 study already demonstrated how hypotension during surgery independently correlates to mortality [2].

On the same note, the recent RELAx trial [3] studied the effects of different levels of PEEP in ICU patients without acute respiratory distress syndrome (ARDS). Although not statistically significant, mortality difference was increased in the high PEEP group (207/493 vs 183/476).

The surprising findings of the Alveolar Recruitment for ARDS Trial (ART) [4] questioned the use of high PEEP even in ARDS patients, in whom this strategy has been considered for years the cornerstone of correct clinical management. The trial, enrolling over 1000 patients, concluded that recruitment maneuvers together with high PEEP increased mortality (277/501 vs 251/509, p =0.041) and triggered a major debate which is still open.

With the current coronavirus disease 2019 (COVID19) pandemic bringing to the intensive care hundreds of thousands of patients with ARDS over the last year, the discussion over the optimal PEEP strategy is now hot. While randomized reports are still lacking, some researchers are raising concerns about the use of high PEEP in these patients [5].

The detrimental effects of high PEEP on the heart affect mostly (but not only) the right ventricle, in a complex interaction in which the right ventricle surely benefits of improved oxygenation but may suffer acute cor pulmonale. It looks evident that, even in the operative room, we must closely consider cardiac function when planning our ventilation strategy. This is especially true in patients suffering a known heart disease, but it cannot be limited to them: Turkbey et al. reported how in a large population of patients who were free from clinical cardiovascular disease, myocardial scars were detected in 8% of subjects at 10-years follow-up [6]. Also, subclinical right ventricular dysfunction has been previously associated with obesity, putting this population at increased risk when undergoing positive pressure ventilation.

Right ventricle has often been defined as “the forgotten chamber”, as its role in the circulatory system was previously overlooked. Recent literature, however, reevaluated its contribution and right ventricular dysfunction is now a well-established predictor of mortality in many settings.
COVID-19 entails right ventricular dysfunction due to the intrinsic characteristics of the disease, including tendency to pulmonary embolisms, increased pulmonary resistances due to ARDS and negative inotropic effects of cytokine storms. Matters of fact, right ventricular dysfunction was proven as a powerful predictor of higher mortality [7] in patients with COVID-19. While high PEEP in ARDS has been a longstanding dogma, recent findings suggest to use the utmost attention before setting a high level of PEEP even in that setting, or at least to carefully monitor right ventricular function during its use.

We should never, in any patient and at any moment, allow mechanical ventilation to induce hypotension or – worse – low cardiac output syndrome. The perfect management of ventilation should be protective, atraumatic, tolerant with moderate hypoxia and hypercapnia, noninvasive (as soon as possible) and synchronized.

Modern-era mechanical ventilation should work towards a holistic approach, in which heart and lungs are so intimately interconnected and explicable that can only by referenced – and treated – as a whole.

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