Noisy Mechanical Ventilation

Listen to the Melody

BIOLOGIC systems are characterized by variability, termed “noise,” rather than monotonous patterns. For example, two cells will have different chemical compositions, despite identical gene expression. The random nature of these fluctuations improves the fitness of both subcellular processes and organismal survival, when compared to deterministic systems. This phenomenon has been termed stochastic resonance, whereby noise added to a system improves its performance. However, there is no large-scale data showing patient mortality or morbidity benefits while using these newer modalities.

In this issue of Anesthesiology, Spieth and colleagues provide insight into novel spontaneous breathing modes of mechanical ventilation in acute lung injury (ALI). This study complements their previous work describing the importance of spontaneous breathing in acute lung injury. Using a porcine animal model, ALI was induced using surfactant depletion. When compared to more traditional modes of mechanical ventilation, noisy pressure support ventilation led to increased variability in respiratory pattern, resulting in improved ventilation/perfusion matching, lower mean airway pressures, and improved oxygenation. In this study, Spieth et al. used spontaneously breathing anesthetized pigs and the concept of noisy pressure support ventilation. A target mean pressure support value was designated at the value needed to maintain a tidal volume of 6 ml/kg. From this value, variability of up to 45% over a normal distribution was introduced into the pressure support levels (no higher than 40 cm H2O) that resulted in tidal volume variability. Looking specifically at 7.5%, 15%, 30%, and 45% variability from the mean, they determined that at moderate levels (15–30%) there was improvement in the Pao2/Fio2 ratio with no significant impact on hemodynamics or comfort of breathing.

Spieth and colleagues show that noisy pressure support ventilation in surfactant depleted ALI can improve oxygenation on a short-term basis. However, it has yet to be clearly illustrated that a quick improvement in this ratio can improve pulmonary function in the long run. In fact, there is no clear clinical evidence based on human trials that there is a significant improvement in patient mortality when the Pao2/Fio2 ratio is improved over a short period of time. The original ARDSNet low tidal volume versus traditional tidal volume multicenter study showed that patients who received larger tidal volumes had a statistically significant improvement in their Pao2/Fio2 ratio, but ultimately showed substantially increased mortality. This potential epiphenomenon has also been shown with high frequency oscillatory ventilation in adults with the acute respiratory distress syndrome (ARDS), although these studies have not been nearly as large as the ARDSNet trial. Therefore, rapid improvement in pulmonary function in ARDS/ALI does not necessarily translate to improvements in overall morbidity or mortality. However, improving oxygenation through increased mean airway pressure may be detrimental, whereby in the case of noisy ventilation, oxygenation is improved without concomitant increases in airway pressure.

Controlled mechanical ventilation is usually used in patients with ARDS and/or ALI. In most cases, to achieve ventilator synchrony, patients are administered sedatives and, less frequently, muscle relaxants. It is well accepted that patients on spontaneous breathing modes probably require less sedation. This sedation decrease alone can have significant beneficial effects on a patient’s hospital course (fewer ventilator days, decreased intensive care unit length of stay, less delirium, etc.)

The majority of experimental models have examined the efficacy of noisy ventilation in the setting of ALI. What about the use of noisy ventilation in normal lungs? Could this technique protect the lungs from inflamma-
Recruitment, noisy mechanical ventilation may limit action. It is intriguing to speculate that, in addition to lung which mechanical ventilation may stimulate inflammatory pathways such as the Toll-like receptor, through which mechanical ventilation may stimulate inflammation. It is against our nature, our behavior, to sustain variability in normal human physiology. It allows us not only to adapt to changes in our environment, but also derangements in our bodies. Controlled mechanical ventilation provides, for the most part, a breathing pattern that is very monotonous. It is against our nature, our behavior, to sustain this for a prolonged period of time. Thus, from an evolutionary standpoint, noisy pressure support ventilation may be an important component in the future treatment of ARDS/ALI.

Over the past decade, there has been interest in whether patients with ARDS/ALI on spontaneous modes of mechanical ventilation can achieve the same improvement in pulmonary function as those on controlled mechanical ventilation. If so, could this then lead to improvements in overall morbidity and mortality? This study by Spieth and colleagues reminds us of the importance of variability in normal human physiology. Should we be trying to achieve “normal” physiology in an individual with severe systems dysfunction? Stochastic resonance would suggest that we make a little noise; the time is here to translate these studies to the bedside.

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References