Using Recruitment Maneuvers to Decrease Tidal Volumes during One-lung Ventilation

N O anesthesiologist has failed to be amazed at the process of reexpanding the lung after thoracotomy. A long sustained breath turns a mealy atelectatic organ into a pink and airy one, one acinar unit at a time. During thoracic surgeries, the one ventilated lung has to sustain the patient. Overcoming hypoxemia is the battle for thoracic anesthesiologists. What is the best ventilatory strategy to improve oxygenation while minimizing lung injury during one-lung ventilation (OLV)?

Different strategies have been used to improve hypoxemia during OLV. Relatively high tidal volumes (10 ml/kg and greater) have been used to improve oxygenation in OLV. However, the use of these larger tidal volumes during OLV has been shown to be associated with lung injury.

Alveolar recruitment maneuvers (ARM) have been well studied and are now being used in many areas of ventilatory management. The underlying concept is that by expanding atelectatic areas of lungs with ARM, the subsequent administered tidal volume and ventilation stresses are distributed more uniformly. The effects of ARM are thought to last if moderate amounts of supplemental oxygen and positive end-expiratory pressure are used.

Given that background, Kozian et al. sought to compare the lung densities and lung mechanics produced in anesthetized piglets who all received ARM while the two lungs were ventilated and then received either larger or smaller tidal volumes during OLV. Therefore, all the animals received a recruitment maneuver as well as 5 cm H2O positive end-expiratory pressure, a standard inspiratory:expiratory ratio, and respiratory rates that were adjusted to achieve a specific carbon dioxide level. The ARM was followed by lower tidal volume ventilation (5 ml/kg) to one group during OLV. The second group received 10 ml/kg during OLV.

Kozian et al. used spiral computed tomography scans before and after they administered an ARM on the anesthetized piglets. Oxygenation was significantly improved by the ARM, as oxygen went from 138 to 191 mmHg. There was a drop of approximately 10% in cardiac index, mean arterial pressures, and heart rates, but these changes were transient. The ARM also improved lung density distributions, compliance, and oxygenation in the animals that received the ARM before the administration of the lower tidal volumes during OLV.

In contrast, the animals that received a larger tidal volume during OLV had reasonable oxygenation but an inhomogeneous distribution of densities in their ventilated lungs and increased mechanical stress in their one ventilated lung. The conclusion of the authors was that the combination of ARM and low tidal volume achieved improved oxygenation with improved tissue stretching. The ARM itself resulted in an increased fraction of normally aerated lung, and although the administration of 10 ml/kg led to further increased areas of aeration, the effect was seen only at end-inspiration because the lung density distribution was the same at end-expiration in both groups. This difference in aeration between end-inspiration and end-expiration suggests there may have been collapse and reopening in the lungs of the animals receiving the larger tidal volumes. Cyclic changes during mechanical ventilation have been associated with the release of inflammatory mediators in the lung.

Now the caveats: the work by Kozian et al. needs some additional study before we will know how to apply ARM in clinical practice. The experiments were done in healthy pigs, not in humans with various lung diseases. Some models of lung injury are worsened with recruitment maneuvers.

The authors performed the recruitment maneuvers only before lung isolation, which may be contraindicated in severe bullous disease, pneumothorax, or in patients with airway disruption. Although the authors cite evidence regarding lung injury caused by larger tidal volumes, they present no data regarding lung injury in this investigation. There are also no long-term outcome data in this report. Indeed, the animals were sacrificed before extubation, so there is not even data regarding recovery.

Whether or not the use of lower tidal volumes during OLV after recruitment improves long-term clinical outcomes is not known. In a large study of adult respiratory distress syndrome, recruitment improved ventilation parameters but not patient outcomes. We await additional investigations to guide us during our battle to improve gas exchange and outcomes for patients requiring OLV.
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References

ANESTHESIOLOGY REFLECTIONS

The Pirogov Medallion by Fedorova

In 1992 the Wood Library-Museum published Dr. Raymond Fink’s French-to-English translation of Researches, Practical and Physiological on Etherization, the 1847 classic by Nikolai Ivanovich Pirogov (1810–1881). One of Europe’s first surgeons to use ether anesthesia, Pirogov was featured on the obverse (left) of a medal designed in 1979 by Soviet sculptor and medalist G. A. Fedorova. On the reverse face, a cross and crescent may reflect his later work for the Russian Red Cross during the 1870 Franco-Prussian War and as a surgeon in the 1877 Russo-Turkish War. The scroll translates to: “For your services in the fields of humanitarian activities.” Markings beneath the scroll include: “MMD 79” (Moscow Mint, 1979) and also “No 2319” of a reported 3,000 minted out of Tombac, a 9:1 alloy of copper to zinc. One year later, the MMD minted at least 223 more Tombac medallions—the Bronze Medals for the 1980 Summer Olympics in Moscow. (Copyright © the American Society of Anesthesiologists, Inc. This image also appears in the Anesthesiology Reflections online collection available at www.anesthesiology.org.)

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