During the past several decades, we have come to appreciate that mechanical ventilation practices affect outcome in patients with acute lung injury (ALI) and acute respiratory distress syndrome (ARDS). Physiologic evidence suggests that overdistention of alveoli can lead to ventilator-induced lung injury, and cyclic opening and closing of alveoli is also injurious. ALI is a heterogeneous disease, so tidal volume (VT) is preferentially directed to more normal or recruitable lung units, and these areas may be more susceptible to repeated overinflation, overdistention, and tissue injury. In addition to animal and physiologic data, we know that low-VT ventilation improves survival in patients with ALI, and, furthermore, this mortality decrease is reinforced by strong anti-inflammatory biological effects, including lower levels of several key inflammatory cytokines in both plasma and bronchoalveolar lavage fluid in patients who receive low-VT ventilation.

Unlike low-VT ventilation, however, the use of recruitment maneuvers in the management of ALI remains controversial. For nearly 2 decades some investigators have advocated an "open-lung" approach to mechanical ventilation in ALI, where the goal is to have as few unrecruited alveoli as possible. To achieve this, recruitment maneuvers are used to recruit atelectatic alveoli, and an adequate level of positive end-expiratory pressure (PEEP), tailored to each patient, is then applied to keep the newly recruited lung open. This open-lung approach is believed to maximize gas exchange and minimize damage from cyclic opening and closing of alveoli. Studies of recruitment maneuvers have found that, yes, hypoxemia often does improve and atelectatic areas can be recruited, as demonstrated nicely on computed tomograms. Proponents of this strategy cite the above physiologic data and point out that the procedure is reasonably safe. The most important question, however, is not whether alveoli can be recruited or oxygenation improves, but, rather, whether recruitment maneuvers change clinical outcomes of patients with ALI.

In this issue of Respiratory Care, Meade and colleagues present a well-done study of scheduled recruitment maneuvers in 28 patients with ALI. The study helps to answer this important clinical question concerning a disease that affects over 200,000 people annually in the United States. The study was a randomized controlled trial (RCT) of a recruitment maneuver at continuous positive airway pressure of 35 cm H2O for 20 s, and if the response to the initial maneuver was equivocal, then subsequent recruitment maneuvers were performed with either greater inflation pressure or longer inflation time. Each subject could receive up to 6 recruitment maneuvers. The study population was reasonably generalizable; they had a high severity of illness at baseline, and the majority of patients had sepsis or pneumonia as their ALI risk factor. Perhaps unexpectedly, though, only 8 of the 28 patients had an equivocal response, and neither increasing the inflation pressure nor duration was beneficial in those patients. To the initial recruitment maneuver 16 subjects had a negative response (decreased oxyhemoglobin saturation or systolic blood pressure), and only 4 subjects had a positive response. Thus, 20 of the 28 subjects did not proceed along the study’s randomization arm. There was also a high incidence of adverse events.

The fact that the large majority of the subjects had either no response or a negative response to the initial recruitment maneuver is similar to results of prior studies. The ARDS Network conducted an RCT of 72 patients in the high-PEEP arm of the ALVEOLI study, which randomized subjects to recruitment maneuvers on either even or odd days, with sham recruitment maneuvers on the alternate days. That study found that the response to recruitment maneuvers was highly variable, and even in the patients whose oxygen saturation increased, the response was brief. Additionally, the only RCT to randomize participants to receive or not receive a recruitment maneuver found that the initial increase in the ratio of Pao2/FIO2 returned to baseline just 30 min after the recruitment maneuver.

Interestingly, the same investigators of the study in this issue of Respiratory Care were also the investigators of the recently published RCT, "Ventilation Strategy Using Low Tidal Volumes, Recruitment Maneuvers, and High Positive End-Expiratory Pressure for Acute Lung Injury and Acute Respiratory Distress Syndrome." That study, which included 983 patients, compared the ARDS Network low-VT ventilation strategy to an open-lung strategy.
that included pressure-control mode with plateau pressure $\leq 40 \text{ cm H}_2\text{O}$, target VT of 6 mL/kg predicted body weight, recruitment maneuvers (40 s breath-hold at 40 cm H$_2$O airway pressure) at enrollment and with each ventilator disconnect, and PEEP adjusted according to $F_{O_2}$. That study found that, although patients in the experimental group had less refractory hypoxemia and fewer deaths due to hypoxemia, there were no significant differences in mortality, duration of mechanical ventilation, or intensive-care-unit or hospital stay. Additionally, 22% of patients who received one or more recruitment maneuvers had an associated complication.

Some may argue that the study in the present issue$^{14}$ is really a descriptive study of recruitment maneuvers in a series of patients with ALI, since so few of the participants underwent subsequent recruitment maneuvers beyond the initial maneuver. Some may also point out that the subjects were not receiving “standard care,” since they were ventilated with a pressure-control mode and many subjects were receiving nitric oxide, per standard practice at participating centers at the time of enrollment. Others may say that we have not disproven the clinical efficacy of recruitment maneuvers, because no large RCT has ever compared receiving recruitment maneuvers to not receiving them. And a final assertion is that, in order to realize the full benefits from recruitment maneuvers, the injured lung must be maintained in the “open” state after the recruitment maneuver by applying the PEEP required to sustain the recruited open lung.$^{20}$ All of these points may be true. However, the study$^{14}$ is part of a growing body of literature that suggests that the routine use of recruitment maneuvers in unselected patients with ALI is not beneficial and may actually be harmful. Based on subgroup data from the study “Ventilation Strategy Using Low Tidal Volumes, Recruitment Maneuvers, and High Positive End-Expiratory Pressure for Acute Lung Injury and Acute Respiratory Distress Syndrome,” it may be that the patients who most benefit from recruitment maneuvers are those who have the most lung edema and are most at risk of dying from refractory hypoxemia.$^{10}$ However, the majority of deaths in ALI/ARDS are not due to insupportable gas exchange, but rather to non-pulmonary organ failure; only 10–15% of patients die of refractory hypoxemia.$^{21}$ Therefore, using a therapy in the general ALI population that may benefit only a small subset of patients is unlikely to result in benefit.$^{21}$

Based on current data from clinical studies, the routine use of recruitment maneuvers in unselected patients with ALI cannot be recommended. To determine if recruitment maneuvers are effective in patients with the most severely injured lungs, an appropriately powered RCT of appropriately selected patients must be performed.

**REFERENCES**


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