Better Physiology does not Necessarily Translate Into Improved Clinical Outcome

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We read with interest the contribution from Prof. Hedenstierna stating that optimum positive end-expiratory pressure (PEEP) in patients undergoing general anesthesia and in critically ill patients in intensive care is a compromise, but it is better than nothing. We will focus on the application of PEEP during surgery, and its possible effects to improve clinical outcome in the postoperative period.

Certainly, we agree that anesthesia associated with paralysis induces reduction in lung volumes, closure of the peripheral airways and atelectasis formation. These changes may result in alterations in gas-exchange and mechanical properties of the respiratory system (1). Theoretical calculations suggested the development of high pressures around lung areas with uneven aeration (2). Experimental studies in healthy (3, 4) and diseased (5) lungs showed that inspiratory pressure, i.e. stress, and repetitive opening and closing of alveolar and peripheral airways may promote damage to the extracellular matrix (6) and the activation of inflammatory process. Other studies using imaging techniques showed that application of higher levels of PEEP reduce the opening and closing of atelectatic areas in both healthy (7-9) and diseased (10) lungs. Based on these theoretical and experimental physiological data, Prof. Hedenstierna suggests that closed airways and collapsed alveoli should be reopened and kept open during the anesthesia, thus minimizing ventilator induced lung injury. However, other experimental studies showed that the inflammatory response of atelectatic areas are negligible if they do not undergo repetitive opening and closure, i.e. atelectrauma (11). Furthermore, once atelectrauma occurs, the associated inflammatory response is comparatively lower than with volutrauma (12), if present at all (13).

Conclusion 1: *ex vivo and in vivo experimental data do not clearly and fully support the concept of open lung ventilation in healthy lungs.*

Furthermore, it has been recommended to keep the lung open during the post-operative period, since atelectasis may remain for several days in this period, thus leading to more negative consequences than during the anesthesia itself. Additionally, it is mentioned that recent large number of multicenter studies on "protective ventilation" and postoperative lung complications have not sufficiently taken the emergence from anesthesia into account and have not had any control over lung aeration postoperatively (14-17). Some important facts must be emphasized: 1) to date there is evidence that abdominal and cardiothoracic surgery reduce the lung volume. However, there is no clinical evidence that the reduction in lung volume is associated with major atelectasis formation, even after open abdominal surgery (1); 2) alterations in respirato-

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ry function is not always correlated with the reduction in lung volume or atelectasis; 3) no clinical study has shown that atelectasis in the postoperative period is associated with increased risk to develop pulmonary complications or worse outcome; and 4) application of preventive physiotherapy or continuous positive airway pressure or positive pressure ventilations have not been shown to reduce complications after surgery.

Conclusion 2: *there is no clinical evidence that keeping the lung open in the postoperative period may improve clinical outcome.*

Prof. Hedenstierna also suggest to apply a recruitment maneuver with an increase in airway pressure of 40 cmH2O or even higher for a limited period of time, and then set optimal PEEP to achieve the best respiratory system compliance or aerated volume by using an imaging technique available at the bedside such as electric impedance technique (EIT). First, the pressure required to open lung units vary among patients, and lower pressures might be enough. Second, recruitment depends not only on the pressure magnitude but also time (18). Third, as shown in a recent randomized controlled trial, recruitment of the lungs with pressures ranging from 30 to 35 cmH2O improved the respiratory system compliance, without affecting outcome (16). Additionally, an individual patient data meta-analysis clearly demonstrated that an increase in PEEP that improves respiratory system compliance is not associated with better outcome (19). Although we do recognize the potential of bedside techniques like electrical impedance tomography (EIT) to individualize respiratory management during surgery, its beneficial effects on patient outcome is unproven. Independent of the method used for titration, whether compliance, EIT or oxygenation, PEEP will always represent a compromise between tidal recruitment/derecruitment and overdistension (20).

Conclusion 3: *an "optimal PEEP" vary depending on the target; thus, cannot be used to improve outcome.*

In short, there is no doubt that the use of PEEP combined with lung recruitment maneuvers are able to improve respiratory function and decrease atelectasis as well as tidal recruitment/derecruitment during the intra- and postoperative periods. However, these beneficial effects do not translate into improved outcome, and high airway pressures can impair intraoperative hemodynamics.

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