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Recruitment by sustained inflation: time for a change

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A key objective of avoiding ventilator-induced lung injury (VILI) is to minimize the number of lung units subjected to amplified tensions at points of stress focusing. These high-risk units tend to occur at the junctions of closed and open lung units, and although they are relatively few in number, many investigators believe that VILI propagates from these zones rather than from continuously aerated alveoli that are repeatedly overstretched. Eliminating these interfaces is the primary objective of an “open lung” approach to safe ventilation [1]. It has been known for more than two decades that some collapsed but potentially aeratable units within the acutely injured lung may require opening pressures that exceed safe limits for ongoing tidal ventilation and that the process of tissue recruitment continues (albeit at a progressively declining rate) until further expansion is constrained by total lung capacity [2]. Once opened, most (but not all) lung units may continue to remain patent at combinations of positive end-expiratory pressure (PEEP) and tidal volume that do not pose undue risk for iatrogenic injury.

Because opening sticky (absorptive) atelectasis is a process that requires brief but cumulative exposure to high transpulmonary pressure, use of a recruiting maneuver (RM) is a prerequisite to decrementally setting PEEP. This requirement can be met by either sustaining

very high and unrelieved inflation pressure for a non-physiological duration or by repeating tidal cycles that simultaneously achieve a high peak inflation pressure and transiently employ an elevated PEEP during the recruiting process. In the current issue of *Intensive Care Medicine*, Arnal et al. [3] provide clear evidence that, during the recruiting effort, the incremental gain achieved by sustained inflation (SI) wanes progressively as the risk for adverse consequences builds. The reported data support the notion that the optimal duration of sustained inflation is significantly less than now in common use. I fully agree with this assessment as the data are both persuasive and logically appealing. However, in another sense, attempting to fine-tune this venerable form of recruiting methodology is like polishing an antique that is outmoded for modern use.

At relatively low tidal pressures, multiple tidal cycles must be delivered after a step change in PEEP before the functional residual capacity (FRC) stabilizes at its final higher value [4]. However, although exposure time is clearly a component of the recruiting process, time of application is not an equal partner with airway pressure; of the two, pressure is clearly the more important variable. The higher the applied pressure, the less time is needed for opening to occur and the less time is needed to complete the opening process [5]. (Prone positioning, however, is one familiar type of recruiting maneuver that may not be completed for hours, during which secretions slowly drain to unplug airways and lymphatic drainage of edematous dorsal tissues improves.)

A variety of recruiting techniques have been described that are based on the principle of cumulative exposure to nonphysiological transpulmonary pressures. The first to be introduced—and until quite recently the most widely employed—was the application of 35–40 cmH₂O airway pressure for 30–40 s. On rare occasion, even higher pressures may be needed to pry open large numbers of the most stubborn lung units, with some authors describing

success with pressures that considerably exceed 50 cmH₂O [6, 7]. Because optimal duration of high pressure application varies inversely with pressure amplitude, the effective time of application may not be nearly as long as traditionally used at the bedside, as the data of this study indicate [3].

The reasoning behind the traditional 40 s duration of SI remains unclear. Perhaps its origins were rooted in anesthetic rather than intensive care practice. As already noted, as many as 10 breathing cycles spanning approximately that long may be needed to realize the full benefit from a step change in low-level PEEP in normal anesthetized subjects [4]. Although the partially collapsed lungs of experimental animals tend to open in a series of avalanches, the cumulative duration of the high-pressure phase of these cycles is not lengthy [8].

Sustaining high airway pressure comes at the potentially serious but short-lived cost of applying excessive right ventricular afterload and impeding venous return, especially when ventilation occurs in a passive subject. Adverse hemodynamic effects are unusual when extensive recruitment occurs during the RM but more frequent when it does not [9]. Such behavior suggests that right ventricular afterloading rather than raised intrapleural pressure may be causative of hypotension in failed RMs. As clinical experience with the hyperinflation of auto-PEEP has taught us, preservation of spontaneous inspiratory efforts nullifies most adverse hemodynamic effects of lung expansion [10]. Moreover, there is good reason to believe that the distribution of recruiting forces and the efficacy of lung expansion maneuvers would improve if spontaneous inspiratory efforts are preserved.

The findings reported by Arnal et al. [3] are hardly surprising, given the results of laboratory intercomparisons of recruiting maneuver techniques [11]. In these studies, sustaining high pressure was no more effective than using pressure-controlled ventilation (PCV) that achieved the same plateau value but was associated with more profound hypotension. Although always better tolerated, the relative advantage of PCV varied with the model of lung injury, with pneumonia-caused acute respiratory distress syndrome (ARDS) less recruitment responsive and hemodynamically more vulnerable than other injury types. A simple comparison of pressure waveforms reveals that the mean airway and alveolar pressures experienced during SI are equivalent to the peak applied pressure, whereas the mean airway pressure associated with PCV is closer to the PEEP than the peak pressure. Two other advantages of using a ventilating type of RM to accomplish recruitment are that CO₂ is cleared during the procedure, and sufficient time elapses during the RM to enable hemodynamic responses to stabilize and for the oximeter to compute its reported rolling average.

Although sustained inflation is commonly deployed and is still actively researched as a recruiting technique, there are good reasons to retire it from clinical practice. Stepwise approaches to the maximum applied pressure are perhaps more effective than abrupt applications of the same peak pressure, and the graded rise of mean pressure is generally better tolerated [12]. If used at all, sustained inflation with high pressure should be well monitored and applied only for limited duration. Better yet, clinicians are well advised to relegate this once useful clinical tool to the growing archive of historically instructive but now obsolete methodologies.

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