

Commentary

How best to recruit the injured lung?

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Published: 20 June 2008

This article is online at <http://ccforum.com/content/12/3/159>

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Critical Care 2008, **12**:159 (doi:10.1186/cc6910)

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Abstract

Sustained re-opening of collapsed lung tissue (recruitment) requires the application of airway pressures that exceed those of the tidal cycle. The post-maneuver PEEP as well as the duration of high pressure application are also key factors in its success, with their accompanying potential for hemodynamic compromise. Although a wide variety of recruiting maneuvers have been described, the technique that strikes the best balance between efficacy and risk may well vary among patients with differing right heart loading status and lung properties.

'Opening' of airless units, or recruitment, not only improves pulmonary gas exchange, but also tends to limit tissue stress and ventilator-induced lung injury when the lung is repeatedly exposed to high end-inspiratory tidal pressures. Illustrated in the paper by Constantin and colleagues that appears in the previous issue of *Critical Care* [1], successful recruiting techniques recognize that sustained benefit depends not only on the magnitude of transpulmonary pressure applied during recruitment, but also on the duration and pattern of its application [2-5], and the level of post-recruitment positive end-expiratory pressure (PEEP) [6,7]. As computed tomography demonstrates, uniformly (as opposed to patchily) injured lungs are more likely to respond to interventions geared to restore patency of collapsible airspaces [8]. Because of viscoelastance and other time-dependent force-distributing phenomena, the tendency of a previously collapsed airway to open (or 'yield') is a function of both transpulmonary pressure and time [9]. Multiple cycles that reach the same peak pressure may be needed to achieve the full effect.

Specialized 'recruitment' maneuvers (RMs) such as intermittent sighs, sustained applications of high pressure and brief exposures to increased PEEP with preserved tidal volumes or driving pressure acknowledge this interplay of high airway pressure and duration of its application. Because some lung units open at pressures that exceed those

normally encountered during tidal breathing, RMs are especially helpful when the tidal ventilation pattern that precedes them involves low end-inspiratory pressures, as during small tidal volume ('lung protective') ventilation. Conversely, RMs cannot be expected to have an impressive result if nearly all potentially recruitable tissue has already been opened and kept patent by PEEP or by favorable body orientation. Prone positioning should be considered a form of RM [10]. As the weight of the heart is relieved from the dependent portions of the lungs and the pleural pressure gradient redistributes, trans-alveolar forces increase in the dorsal zones of the lung. Once the patient has been repositioned, these forces are sustained, helping to maintain patency of alveoli that are opened by increased local pressure.

'Biologically variable' and 'noisy' ventilatory patterns have been reported to achieve better oxygenation than does a monotonously uniform pattern of unchanging tidal volume associated with the same minute ventilation [11-13]. The contribution of irregularity of these patterns remains of uncertain significance. Thus, whether it is biological variability or just periodic achievement of high pressure amplitude that benefits patients remains to be determined.

Because recruitment occurs to some extent throughout most of the lung capacity range, applying high pressure to open the lung is always a trade-off between over distending some units and recruiting others. A wide variety of RMs have been described; the best technique is currently unknown and may well vary with specific circumstances. The work of Constantin and colleagues [1] illustrates that not all RMs are equivalent, either from the standpoint of efficacy or adverse side effects. Although a reasonable RM is unlikely to damage the lung, the risk of hemodynamic compromise occurring during and for a short while after the maneuver is considerable, especially with sustained high inflating pressure applied to less recruitable

PEEP = positive end-expiratory pressure; RM = recruitment maneuver.

lungs [14,15]. When sustained pressure is applied without relief, mean and peak airway pressures become equivalent. This elevation of mean airway pressure imposes an extraordinary backpressure to impede venous return and presents a high afterload to the right ventricle for the period of its application. Successful recruitment tends to minimize the peril. The prior work of Grasso and colleagues [14] and Lim and colleagues [15] accords nicely with that of Constantin and colleagues [1] in highlighting such hemodynamic issues and in illustrating that intermittent high pressure is better tolerated than sustained high pressure. In experimental models, pneumonia appears to be the condition with greatest risk for hypotension during the RM [15].

Mean airway pressure can be reduced considerably while maintaining the same peak airway pressure value - the airspace component of the actual recruiting pressure - by applying tidal ventilation with a high plateau pressure for a brief period (for example, pressure controlled ventilation). Because pressures exceeding 60 cmH₂O may be required to re-open some units [16], it is clear that 'tidal' forms of recruitment are more likely to be both successful and well tolerated than sustained inflation. Once opened, the applied end-expiratory pressure should be released in stages, using oxygenation and/or expiratory deflation mechanics to identify the appropriate PEEP that sustains nearly full recruitment. Almost invariably, that sustaining level of post-recruitment PEEP is higher than the initial value.

Before we embrace the 'open lung' concept and its indispensable instrument of RMs, it is important not only to understand the principles of recruitment but also to ask whether open lung techniques should be applied - and to whom. Opening and closure of lung units may not always be harmful. For example, when relatively low pressures are required to ventilate effectively and surfactant function is well preserved, any lung damaging effect of tidal opening and closing should be modest. Airless tissue is not likely to be subject to ventilator-induced lung injury - the adjacent healthy lung is. In many instances the pressure cost of recruitment may exceed the benefit of recruiting a few more units. Apart from initial PEEP selection, where RMs are essential, RMs are logically reserved for instances in which deterioration of oxygen exchange or mechanics has been observed (as after airway suctioning) or a new clinical event requires adjustment of PEEP and tidal volume. Based on its apparent efficacy and safety, the extended sigh reported by Constantin and colleagues [1] may be one attractive option.

Competing interests

The author declares that they have no competing interests.

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