Commentary

Measurement of PEEP-induced alveolar recruitment: just a research tool?

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See related research by Lu *et al*., http://ccforum.com/content/10/3/R95

Abstract

For positive end-expiratory pressure (PEEP) to have lung protective efficacy in patients with acute respiratory distress syndrome, it must increase the end-expiratory lung volume through alveolar recruitment while avoiding lung over-inflation. PEEP may increase the end-expiratory lung volume either by increasing the proportion of aerated alveoli at end-expiration or by further inflating already ventilated lung regions. The optimal PEEP regimen is still a matter of debate. In theory, the ability to measure of PEEP-induced alveolar recruitment would be extremely useful in titrating PEEP at the bedside. However, until now this measurement has been confined to clinical research settings. Interesting work by Lu and coworkers, published in the previous issue of this journal, deals with the problem of measuring PEEP-induced alveolar recruitment. The 'gold standard' technique (i.e. the computed tomography method) is compared with the pressure-volume curve method. Because implementation of the latter method at the bedside would be relatively simple, that report, in addition to its intrinsic scientific value, may have important clinical implications.

In the previous issue of *Critical Care* Lu and coworkers [1], a group of well known scientists with long-term expertise in this area, address the issue of quantifying alveolar recruitment induced by the application of positive end-expiratory pressure (PEEP) in patients with acute respiratory distress syndrome (ARDS). The current 'gold standard' for this measurement is the computed tomography (CT) method [2-4], in which an end-expiratory spiral CT scan of the whole lung obtained at a given PEEP level is compared with one obtained at zero end-expiratory pressure (ZEEP). Although repeatedly validated, this method requires considerable expertise and exposes the patient to risks associated with transporting them from the intensive care unit to the imaging facility. In their study, Lu and coworkers compared the CT method with the pressure-volume (P-V) curve method, which, although currently used only in clinical research, could potentially be implemented at the bedside [1].

This elegant paper raises at least two important issues. First, from a scientific point of view, the approach is of great value. The P-V method has been used in several studies to evaluate the physiological effects of different ventilatory strategies in patients with ARDS [5-7]. According to the data presented by Lu and coworkers, the alveolar recruitment achieved with this method tightly correlates with that obtained using the 'gold standard', but the authors point out that the broad limits of agreement between the two methods indicate that they are not interchangeable. However, in evaluating the results, one should keep in mind that their study design could have led to a bias against the P-V method. Indeed, in 12 out of 19 patients the P-V curves at ZEEP were measured immediately after discontinuation of PEEP (principally for safety reasons, as suggested by the attending physician). In contrast, in the majority of previous studies the P-V curves at ZEEP were recorded after a 15-30 min period of mechanical ventilation at ZEEP, allowing complete lung de-recruitment to take place. The strong rationale behind this approach is that the shape of the P-V curve at ZEEP may differ substantially depending on whether it is measured after a period of ZEEP ventilation or immediately after removal of PEEP [5]. One may argue that in some patients a brief period of ZEEP ventilation is not clinically acceptable because of the resulting potential for hypoxia; undoubtedly this represents a limitation of the P-V method. Nevertheless, the difference between the original P-V method and the modified version used by Lu and coworkers in more than half of their patients might partly account for the broad limit of agreement with the 'gold standard' method.

The second important message of the report pertains to the potential usefulness of the P-V method in clinical practice. The P-V curve method requires the construction of two static

ARDS = acute respiratory distress syndrome; CT = computed tomography; FRC = functional residual capacity; PEEP = positive end-expiratory pressure; P-V = pressure-volume; ZEEP = zero end-expiratory pressure.

P-V curves (at PEEP and at ZEEP). These two curves must be plotted in the same volume-pressure coordinate system in order to relate both of them to the functional residual capacity (FRC) of the respiratory system at the time of testing. Consequently, the difference between the end-expiratory lung volume during mechanical ventilation at PEEP and the FRC must be assessed. This is achieved by disconnecting the patient from the ventilator and measuring the exhaled volume during a prolonged expiration at atmospheric pressure [5]. Performing all of these measurements is at present virtually impossible at the bedside, but it could be achieved through relatively simple software able to adequately control the ventilator. Interestingly, the option of measuring FRC with the inert gas wash in-wash out technique is now commercially available, which may permit noninvasive estimation of the end-expiratory lung volume.

Should the measurement of PEEP-induced alveolar recruitment be implemented in the next generation of mechanical ventilators? In other words, do we really need to measure PEEP-induced alveolar recruitment at the bedside? The 'cornerstone' ARDS Network protocol using low tidal volume ventilation does not require measurement of respiratory mechanics except for plateau pressure recording [8]. Inspired oxygen fraction and PEEP are set according to an empiric table, aiming at the lowest PEEP level compatible with a blood oxygenation target. A subsequent ARDS Network study [9], comparing the traditional lower PEEP strategy with higher PEEP, was inconclusive. In that study both the lower and higher PEEP strategies were table based. A recent study [10] challenged this approach, demonstrating that empirical PEEP setting frequently fails to induce alveolar recruitment and may increase the risk for alveolar over-inflation. Furthermore, a subsequent randomized multicentre trial [11], confirming previous findings [12,13], clearly indicated that a physiological PEEP setting strategy, based on P-V curve measurements, may reduce mortality in ARDS patients. In this regard, the implementation of bedside measurement of P-V curves and alveolar recruitment could facilitate development of clinically applicable protocols for approaching measurement of respiratory mechanics and its interpretation. This could improve our clinical awareness of the complexity of the ARDS scenario while we await a definitive evidence-based approach to the PEEP titration dilemma.

Competing interests

The authors declare that they have no competing interests

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