

WHAT'S NEW IN INTENSIVE CARE



When could airway plateau pressure above 30 cmH₂O be acceptable in ARDS patients?

Jean-Luc Diehl^{1,2,3*}  and Daniel Talmor⁴

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Limitation of plateau pressure (P_{plateau}) is critical for protection from ventilator-induced lung injury in patients with acute respiratory distress syndrome (ARDS) [1]. Limiting to a 30 cmH₂O threshold is a widely accepted recommendation for lung protection, in addition to the use of low tidal volume (V_T) and positive end-expiratory pressure (PEEP) [2]. Moreover, P_{plateau} is in of itself a powerful determinant of mortality in the general ARDS patient population [1], as well as being a component of other parameters associated with the risk of ventilator-induced lung injury and/or the clinical prognosis of ARDS patients, such as driving pressure or mechanical power [3, 4].

In this short piece, we will discuss two conditions in which allowing a P_{plateau} above 30 cmH₂O may be advisable in ARDS patients. The approach to these conditions is based on the concepts that:

- i. The respiratory changes in esophageal pressure (P_{es}) reflect the respiratory changes in pleural pressure, permitting to estimate the end-inspiratory trans-pulmonary pressure (P_L) in the non-dependent lung regions, after correcting P_{plateau} with the ratio of chest wall elastance (E_{CW}) on respiratory system elastance (E_{RS}).
- ii. The measured P_{es} values are a clinically relevant surrogate for pleural pressure values in the dependent lung regions.

We will discuss how to safely apply and monitor an elevated P_{plateau} in light of these concepts.

The first condition corresponds to ARDS patients with very high chest wall elastance (E_{CW}). Panels a and b of Fig. 1 illustrate such a situation. Esophageal (red line) and airway (blue line) pressures are displayed. PEEP was set to 8 cmH₂O, with resulting end-expiratory and end-inspiratory trans-pulmonary pressures (P_L) of 3 cmH₂O and 13 cmH₂O, respectively. These pressures, reflecting the stress applied to the lung structure, remained in a safe range [5]. The tidal difference in P_L (ΔP_L), the driving pressure of the lung, was near to the limit proposed by international experts [6]. In addition, it was shown that end-inspiratory P_L in the non-dependent lung ($P_{L,ER}$), at high risk of alveolar hyperinflation, can be estimated by the following calculation:

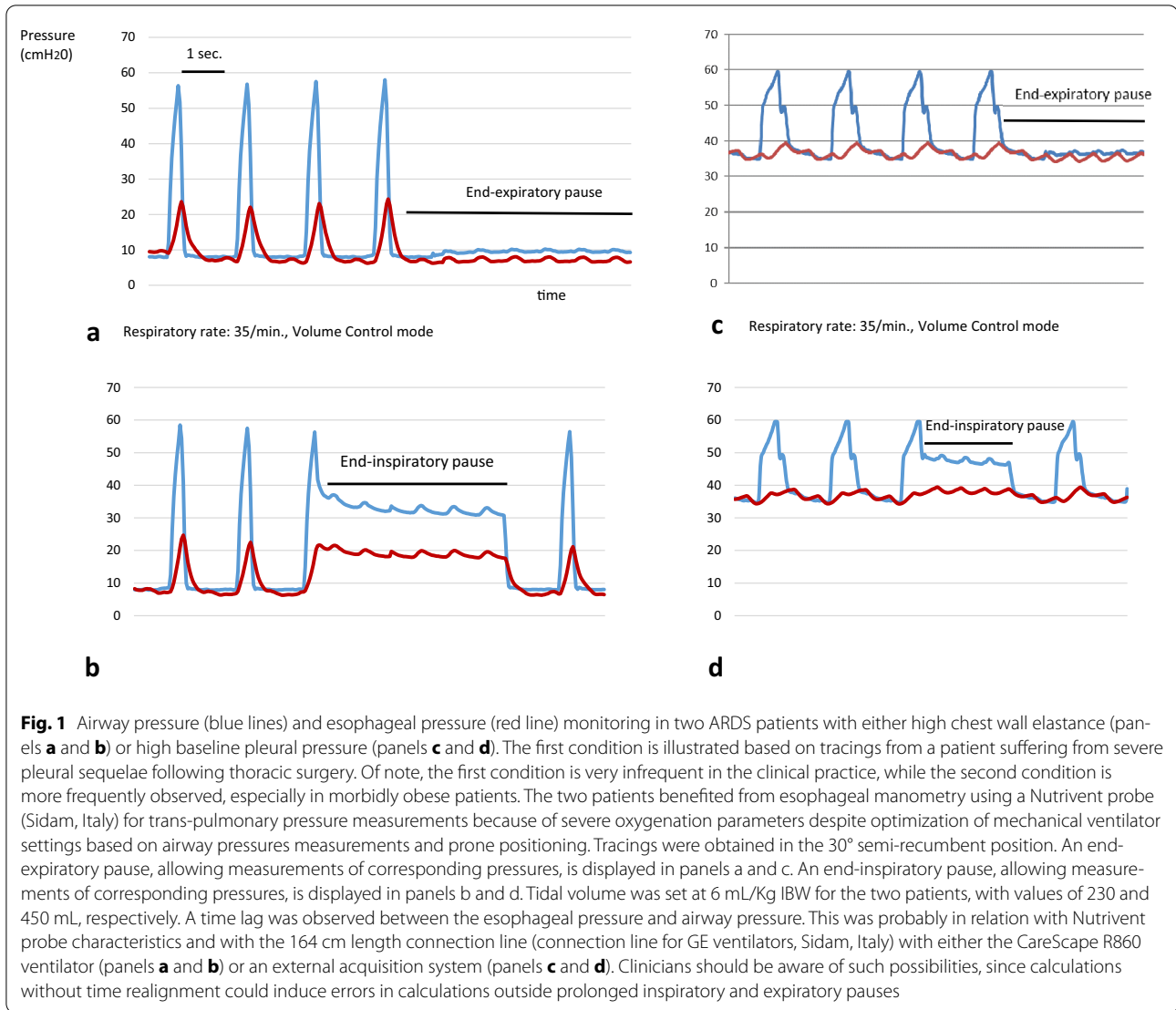
$P_{L,ER} = P_{\text{plateau}} - [P_{\text{plateau}} \times (E_{\text{CW}}/E_{\text{RS}})]$, also expressed as: $P_{L,ER} = P_{\text{plateau}} \times (E_L/E_{\text{RS}})$, best illustrating that variations in E_L/E_{RS} strongly influence $P_{L,ER}$ for a given plateau pressure.

$P_{L,ER}$ is the end-inspiratory trans-pulmonary pressure calculated from elastance ratio of chest wall to respiratory system (E_{RS}) [5, 7, 8]. The calculation indicated a $P_{L,ER}$ value largely below the proposed threshold of 22–25 cmH₂O, therefore, suggesting mechanical ventilation settings remaining in a safe range [5, 7]. Finally, the clinical validity of such an approach was previously demonstrated in a series of patients suffering from influenza A (H1N1)-associated ARDS referred for extracorporeal membrane oxygenation (ECMO) [8]. Among 14 patients, PEEP setting was optimized according to the above parameters, permitting to improve oxygenation parameters without ECMO support in half of the patients.

*Correspondence: jean-luc.diehl@aphp.fr

¹ Intensive Care Unit, Assistance Publique - Hôpitaux de Paris-Centre (APHP-CUP), Georges Pompidou European Hospital, Université de Paris, 75015 Paris, France

Full author information is available at the end of the article



The second condition corresponds to ARDS patients with a very high pleural pressure, as estimated by P_{es} monitoring. This situation can be present in obese patients, patients with fluid overload or abdominal distension. These patients have normal or near-normal E_{CW} values [9]. Panels **c** and **d** of Fig. 1 illustrate such a situation. While end-inspiratory P_{es} (Panel **d**) was only moderately higher than in the first situation (panel **b**), there was a major difference between the two conditions in end-expiratory P_{es} , which was found to be near to 34 cmH₂O (panels **C** and **D**). PEEP was set to 35 cmH₂O to achieve a positive end-expiratory P_L , avoiding end-expiratory lung collapse [5]. In spite of the elevated airway pressures, end-expiratory and end-inspiratory P_L were near to 2 cmH₂O and 9 cmH₂O, respectively. These values, along with the calculated ΔP_L , are all in a safe range. The

clinical validity of this approach has been shown in an observational series of 50 morbidly obese ARDS patients [10]. Titration of PEEP according to end-expiratory PL was associated to a decrease in mortality rate. Of note, the strategy also included lung recruitment maneuvers and a careful hemodynamic evaluation of the consequences of the proposed mechanical ventilation settings.

Not all evidence supports this approach, with a lower level of evidence as compared to other therapeutic approaches, such as particularly prone positioning. However, the approaches can be complementary, and partitioning chest wall and lung mechanics in prone position is clinically relevant. The EPVent-2 study evaluated in 200 moderate to severe ARDS patients the benefit of a PEEP titration guided by P_{es} , as compared to an empirical high PEEP-FiO₂ strategy [11]. There was no difference in a

composite endpoint incorporating death and mechanical ventilation free days. Importantly though, the control arm of this study received very high levels of PEEP, equal to those in the P_{ES} -guided group, a finding which may have blurred individual differences. These results do not support a systematic use of P_{es} -guided titration in all ARDS patients, but rather, in our view, a selection of ARDS patients in whom one can suspect increased pleural pressure. Ongoing secondary analysis of this trial will clarify these issues. While waiting further studies on this topic, such a selection could be based on the medical history of the patients and on baseline characteristics, such as BMI values. Of note, even if a rather good correlation ($R^2=0.45$) was found between end-expiratory P_{es} and BMI in a series of 51 ARDS patients [9], it is likely that other factors, such as the distribution of obesity (central, abdominal, etc.) and the abdominal elastance, are important to consider. In this way, adding end-expiratory lung volumes measurements to trans-pulmonary pressure measurements or calculations could help to select PEEP levels associated to the best compromise between recruitment and overdistension.

It is important to mention the need to avoid any deleterious hemodynamic consequences of the proposed approach. Indeed, as described in experimental and clinical studies, increases in positive pleural pressure influence central vascular pressures and venous return can affect systemic hemodynamics and can induce renal, liver or gut dysfunction [12–14]. Accordingly, careful monitoring of the hemodynamics and organ functions is mandatory in the above-mentioned conditions. Estimation of abdominal pressures and elastance, as permitted by bladder or gastric pressures monitoring devices, could be of value. Another important pitfall to mention is the influence of body position on the measured respiratory parameters: we previously described three ARDS patients with unusually large increases in $P_{plateau}$ while moving from supine to 45° semi-recumbent positions [15]. While this was in relation with a rise in pleural pressure in a morbidly obese patient, possibly in link with abdominal compression, this was in relation to an increase in lung elastance in the two other patients, with rare ARDS etiologies, implying to decrease the applied PEEP level [15]. Finally, technical pitfalls in relation to P_{es} monitoring should also be well known by the critical care physicians [6].

Author details

¹ Intensive Care Unit, Assistance Publique - Hôpitaux de Paris-Centre (APHP-CUP), Georges Pompidou European Hospital, Université de Paris, 75015 Paris, France. ² Innovative Therapies in Hemostasis, INSERM, Université de Paris, F-75006 Paris, France. ³ Biosurgical Research Lab (Carpentier Foundation), Assistance Publique - Hôpitaux de Paris-Centre (APHP-CUP), Georges Pompidou European Hospital, F-75015 Paris, France. ⁴ Department

of Anesthesia, Critical Care, and Pain Medicine, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA.

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