To the Editor,

In the recent study on personalized optimal PEEP in hypoxemic patients during pressure support ventilation (PSV), Slobod and coworkers assessed collapse and overdistension by electric impedance tomography (EIT) during a PEEP trial [1]. Normally, this assessment is based on airway driving pressure (ΔPAW) and respiratory system compliance, but in this study, lung compliance (CL) and transpulmonary pressure by esophageal pressure were the basis of the analysis. They showed that the PEEP level with a balance between collapse and overdistension tended to coincide with the level where lung compliance is highest. Consequently, transpulmonary driving pressure (ΔPL) was lowest at this PEEP level, requiring the lowest inspiratory effort during PSV.

The authors should be commended for the important step to exchange respiratory system compliance and airway driving pressure for lung compliance and transpulmonary driving pressure because transpulmonary pressure is the pressure that directly affects lung tissue. In addition, it has been shown that the PEEP level with lowest airway driving pressure not necessarily coincides with the PEEP level with lowest transpulmonary driving pressure [2, 3].

Protective ventilation requires assessment of lung mechanics and optimal PEEP as early as possible after start of mechanical ventilation. It is unlikely that a method encompassing a time-consuming multi-PEEP step trial, EIT and esophageal pressure measurements will gain wide clinical acceptance, especially not very early in the course of ventilator treatment or in the operating theater.

However, the PEEP level where transpulmonary driving pressure is lowest can be determined by a rapid two-PEEP-step procedure without both EIT and esophageal pressure measurements [2, 3]. This method, the PEEP step method, is based on the fact that the change in end-expiratory lung volume (ΔEELV) following a PEEP change is determined by the size of the PEEP step (ΔPEEP) and the elastic properties of the lung only, ΔEELV = ΔPEEP × CL, i.e., the chest wall does not impede PEEP inflation. (Details of the determinants of ΔEELV in e-supplement). This is an effect of the chest wall striving outwards to a higher volume, 70–80% of total lung capacity during expirations, not only at functional residual capacity, but also at increased EELV and PEEP. If ΔEELV is measured as the cumulative difference in expiratory tidal volume (VT) between PEEP levels [4], lung compliance can be calculated, $CL_{PSM} = \frac{\Delta EELV}{\Delta PEEP}$.
and transpulmonary driving pressure, $\Delta PL = VT/CL_{PSM}$. Also, during PEEP inflation:

- Transpulmonary pressure increases as much as PEEP is increased.
- Transpulmonary driving pressure of a tidal volume equal to $\Delta EELV$ is equal to $\Delta PEEP$.
- Transpulmonary pressure at a certain lung volume is the same irrespective of whether this volume has been reached by tidal inflation or PEEP inflation, i.e., end-inspiratory transpulmonary plateau pressure from low PEEP level is equal to end-expiratory transpulmonary pressure of the high PEEP level.

Because of these features of PEEP inflation, a lung P/V curve can be calculated by a two-PEEP-step procedure from baseline PEEP to end-inspiration at the highest PEEP level. The PEEP level where transpulmonary driving pressure is lowest (least injurious) can then be calculated as the PEEP level half a tidal volume below the steepest point of the lung P/V curve.

Slobod and coworkers did not determine $\Delta EELV$ in their study, but it is possible to illustrate the performance of the PEEP step method by calculating $\Delta EELV$ as $\Delta PEEP \times CL$ between PEEP levels. This enabled the calculation of the complete lung P/V curve and optimal PEEP in the two extreme patients, patients 1 and 3 (Fig. 1). (For details, See Additional file 1: e-supplement.)

There is no safety limit determined for $\Delta PL$, but it can be deduced from the fact that the upper safety limit for $\Delta PAW$ is 15 cmH$_2$O and average ratio of $\Delta PL/\Delta PAW$ is 0.70, which results in a safety limit for $\Delta PL$ of $0.7 \times 15 = 10$ cmH$_2$O [2, 5]. Patient 1 has an overall lung compliance of 25 ml/cmH$_2$O, which is even lower than reported in severe ARDS [5]. Transpulmonary driving pressure at optimal PEEP is almost 10 cmH$_2$O in spite of a low tidal volume (320 ml). A PEEP increase to 12 cmH$_2$O would result in a $\Delta PL$ of 12.8 cmH$_2$O and an end-inspiratory transpulmonary plateau pressure of 25 cmH$_2$O, both dangerously high. In patient 3, with a moderately lowered overall lung compliance, a PEEP increase to 12 cmH$_2$O only causes a small increase in $\Delta PL$ to 6.3 cmH$_2$O and a transpulmonary plateau pressure of 18 cmH$_2$O, both well within the safety limits (Fig. 1).

In summary, a complete lung P/V curve and optimal PEEP with lowest transpulmonary driving pressure can be determined by a rapid two-PEEP-step procedure, where $\Delta EELV$ is determined by the ventilator pneumotachograph. Neither esophageal pressure nor EIT is required. The lung P/V curve can be used as clinical decision support to estimate the effect of changes in PEEP and tidal volume on transpulmonary driving and plateau pressure.

![Fig. 1](image-url)
Supplementary Information
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Additional file 1. E-supplement.

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Not applicable.

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OS holds shares in the Lung Barometry Sweden Company.

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