

CORRESPONDENCE



# The calculation of mechanical power is not suitable for intra-patient monitoring under pressure-controlled ventilation

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## Original correspondence from Dr. Zhao et al.

Dear Editor,

We read with interest the paper by Serpa Neto et al. showing that mechanical power (MP) of ventilation is independently associated with in-hospital mortality and other outcomes in critically ill invasively ventilated patients [1]. Although MP might become a practical clinical outcome predictor, we would like to point out that MP calculation may not be suitable for intra-individual monitoring of ventilator-related causes of lung injury under pressure-controlled ventilation.

Serpa Neto et al. used a simplified equation for MP calculation [2], which is suitable in patients under volume-controlled ventilation. In pressure-controlled mode,  $R_{aw}$  cannot be substituted by  $(P_{peak} - P_{plat})/Flow$  and Flow by  $V_T/T_{insp}$ . Further, an increase in  $V_T$  is always negatively weighted in both original and simplified calculations, while the effect of recruitment is neglected. Considering the original calculation in [2]:

$$MP = 0.098 \times RR$$

$$\times \left[ V_T \times (P_{plat} - PEEP) \times \frac{1}{2} + V_T \times R_{aw} \times Flow + V_T \times PEEP \right]$$

MP increases when the patient's respiratory system compliance  $C_{rs}$  increases, assuming the ventilator settings are unchanged. The effect of derecruitment on MP

calculation is highlighted in Fig. 1. During an example PEEP titration procedure,  $C_{rs}$  and  $V_T$  fell in the course of a decremental PEEP trial. Both the original and the simplified equations for MP calculation rendered the lowest values at zero end-expiratory pressure which would not have been the "ideal" PEEP.

We presume that inter-patient comparison using MP could be reasonable even under pressure-controlled ventilation since higher  $V_T$  is associated with higher mortality [3]. Therefore, it would be interesting to learn if the Serpa Neto et al.'s results [1] would have changed with a separate analysis of volume-controlled and pressure-controlled subgroups.

## Rebuttal from Drs. Serpa Neto and Schultz

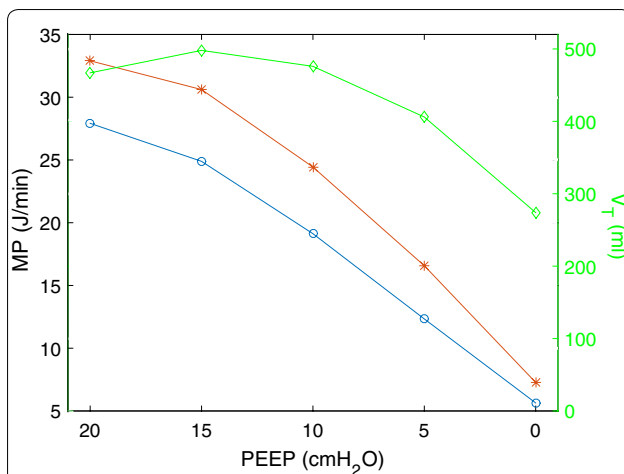
We thank Drs. Zhao and colleagues for their comment on our work. We completely agree that the simplified equation used for calculation of the mechanical power (MP) may not be correct for patients under pressure-controlled ventilation (PCV). Although the applied ventilatory mode was not always recorded in the two databases we used in the analysis, we think that the majority of the patients were ventilated with volume-controlled ventilation (VCV) as the data considered intensive care units from North America where VCV is almost exclusively used. Also, we tried to prevent patients on PCV being included in the analysis by ignoring all patients in whom plateau pressure was lacking or not reliably documented. However, since the mode was not explicitly recorded for all patients, it is impossible to run a sensitivity analysis according to ventilatory mode.

Regarding the relationship between positive end-expiratory pressure (PEEP) and MP, we also agree that

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**Fig. 1** An example of mechanical power (MP) calculation during decremental PEEP titration under pressure-controlled ventilation. Blue circles, MP calculated with the simplified equation; red stars, MP calculated with the original equation. (For comparison, mean tidal volumes ( $V_T$ ) at decremental PEEP steps are shown as green diamonds)

the so-called power equation may not be suitable [4]. First, there is no mechanical movement with volume displacement resulting in variation of PEEP. Second, when including PEEP into the equation, a linear and positive relationship between MP and PEEP is obtained, while a U-shaped relationship could be more appropriate [4, 5]. Thus, a reduction in PEEP would result in a lower MP when using the ‘power equation’, while lower PEEP does not necessarily reduce the risk of VILI and maybe even worsen outcomes in ARDS patients [5].

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#### Compliance with ethical standards

#### Conflicts of interest

The authors declared that they have no conflict of interest.

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