

3. Martin DS, Khosravi M, Grocott MPW, Mythen MM. Concepts in hypoxia reborn. *Crit Care* 2010;14(4):315.

DOI: 10.4187/respcare.02329

**The authors respond to: Practice of Excessive  $F_{IO_2}$  and Effect on Pulmonary Outcomes in Mechanically Ventilated Patients With Acute Lung Injury**

We thank Dr Alkhuja and Ms Duffy for reviewing our paper, their thoughtful insight about the physiology of oxygen delivery, and their call for education of health care staff about the same. We agree with their ideas about optimization of cardiac output and anemia for increasing oxygen delivery when required to do so. In our study we evaluated 289 patients, among whom 210 met our inclusion criteria, and 74% of those were exposed to excessive  $F_{IO_2}$ . On retrospective evaluation, we assessed for the nadir hemoglobin and cardiovascular status via the cardiovascular component of the Sequential Organ Failure Assessment (SOFA) score. The two groups were similar in these aspects during the period when excess oxygenation was assessed. We were limited by the retrospective nature of the study in assessing the course of actions taken to maintain optimal oxygenation prior to increasing the  $F_{IO_2}$ .

We also firmly believe in the education of respiratory therapists, nurses, medical trainees, and other healthcare providers about the role of the other determinants of oxygen delivery and their optimization prior to increasing the  $F_{IO_2}$ . Protocols and alert-based oxygen titration are other methods to reduce excessive  $F_{IO_2}$  and maintain appropriate  $F_{IO_2}$  titration in the ICU. At the same time, delineation of targets for "mild" or "acceptable" or permissive hypoxemia in various clinical situations needs to be studied further.

On behalf of all authors,

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The author has disclosed no conflicts of interest.

DOI: 10.4187/respcare.02608

**Dead Space Fraction: One of Many Choices to Assess PEEP Titration**

In their prospective trial on PEEP titration following recruitment maneuver in patients with ARDS, Fengmei et al provided a well controlled study on the effects of the ratio of dead space to tidal volume ( $V_D/V_T$ ).<sup>1</sup> Changes in compliance, functional residual capacity, and  $P_{aO_2}/F_{IO_2}$  after the recruitment maneuver were also reported. In the clinical arena it is sometimes difficult to obtain correct information on which PEEP level works best for a patient when there are interruptions on maintaining the patient in a "steady state," such as suctioning, turns, and general care. Fengmei et al mentioned in the discussion that the PEEP level corresponding to the maximum compliance after the recruitment maneuver was found to be 10 cm  $H_2O$ , which was lower than the PEEP corresponding to the minimal  $V_D/V_T$ . They also mentioned that the higher PEEP may increase  $V_D/V_T$ , leading to over-distention of well ventilated alveoli, or may reduce cardiac output, which may not be detected. This adds to the clinical relevance that too much PEEP may become just as detrimental to the lungs. Clearly, the lowest  $V_D/V_T$  should not be the end point of the exercise. The risks were explained in studies from several years ago.<sup>2,3</sup> The conclusion in this trial was that managing  $V_D/V_T$  may be clinically useful, but that particular parameter was one of the least statistically significant in their Table 2.

The trial gives insight into recruitment maneuvers and PEEP titration, and their subject group compares similarly to the outcomes of  $V_D/V_T$  from Raurich et al in terms of mortality and  $P_{aO_2}/F_{IO_2}$ .<sup>4</sup> The bedside clinician may not be able to spend the time or have the tools to obtain the best functional residual capacity and  $V_D/V_T$ , but may see a combination of increases and decreases to certain values from the devices that were described (NICO and Engström Carestation). When I am trying to find an optimal PEEP for the patient, especially if the patient is unstable, I look for the best of a combination of parameters. Certainly, optimizing compliance and  $V_D/V_T$ , as well as watching for any decrease in mean arterial pressure < 60 mm Hg, assists me in determining the best PEEP for the situation and avoiding over-distention or reduced cardiac output just to obtain the lowest  $V_D/V_T$ . Cap-

nography or functional residual capacity is useful in applying information gathering to estimate respiratory quotient and  $V_D/V_T$  breath by breath, which utilizes the equations described in the paper and appears robust enough to reduce the frequency to obtain multiple arterial blood gas values.<sup>5</sup> Some separate parameters of the study could be mentioned that could influence the strength of their results.

I am interested to know if Fengmei et al collected data for oxygen delivery, carbon dioxide clearance, and alveolar tidal volume, to see if their statistical information can be taken one step further. As the PEEP level is increased, those values are expected to rise until a certain point, which may indicate over-distention. The equations described for the NICO and Engström Carestation use similar samples from expiratory alveolar tidal volume, end-tidal carbon dioxide, oxygen delivery, and carbon dioxide clearance to obtain an estimated respiratory quotient. If multiple regression analysis can be done to determine the correlations between  $V_D/V_T$ , compliance, oxygen delivery, carbon dioxide clearance, alveolar tidal volume, and functional residual capacity, my suspicion is that  $r^2$  will still be quite high for most parameters, as most are derived under the same equation. The strength of many parameters may be just as useful as stand alone parameters. The values in Fengmei et al's Figure 1 seem to show that optimal PEEP is between 10 and 12 cm  $H_2O$ . It may help the bedside clinician to look at several values, including changes in  $V_D/V_T$ , in the decision making.

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**REFERENCES**

1. Fengmei F, Jin C, Songqiao L, Congshan Y, Yi Y. Dead space fraction changes during PEEP titration following lung recruitment in patients with ARDS. *Respir Care* 2012;57(10):1578-1585.
2. Suter PM, Fairley B, Isenberg MD. Optimum end-expiratory airway pressure in patients with acute pulmonary failure. *N Engl J Med* 1975;292(6):284-289.
3. Stokke DB. Review: artificial ventilation with positive end-expiratory pressure

## CORRESPONDENCE

- (PEEP). Historical background, terminology and pathophysiology. *Eur J Intensive Care Med* 1976;2(2):77-85.
4. Raurich JM, Vilar M, Colomar A, Ibáñez J, Ayestarán I, Pérez-Bárcena J, Llompert-Pou JA. Prognostic value of the pulmonary dead-space fraction during the early and intermediate phases of acute respiratory distress syndrome. *Respir Care* 2010;55(3):282-287.
  5. McSwain SD, Hamel DS, Smith PB, Gentile MA, Srinivasan S, Meliones JN, Cheifetz IM. End-tidal and arterial carbon dioxide measurements correlate across all levels of physiologic dead space. *Respir Care* 2010;55(3):288-293.

DOI: 10.4187/respcare.02337