Physician-Ordered Aerosol Therapy Versus Respiratory Therapist-Driven Aerosol Protocol: Effect on Resource Utilization

To the Editor:

The article by Kallam and colleagues¹ about the potential financial advantages of protocol-driven bronchodilator therapy provides an important perspective. However, there are no data about the validation of the scoring tool or the evidence supporting the correlation of the bronchodilator orders with the assessment score. While we await their report on their before-and-after project examining clinical outcomes, can they provide this missing information?

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The author has disclosed no conflicts of interest.

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The authors respond to: Physician-Ordered Aerosol Therapy Versus Respiratory Therapist-Driven Aerosol Protocol: Effect on Resource Utilization

We appreciate Ms Carroll's question. The respiratory-therapist-driven bronchodilator protocol we described¹ was based on one previously published.² Importantly, we would like to clarify that the aim of our study was not the validation of a tool. We just described a phase of a quality improvement project, which eventually showed that systematization and homogeneity of a process (bronchodilator administration) can, hypothetically, save costs, when compared with a heterogeneous physician-driven strategy. We are currently in the process of an-

alyzing the data from before and after implementation of this protocol. Our results should be available soon.

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Practice of Excessive F_{IO₂} and Effect on Pulmonary Outcomes in Mechanically Ventilated Patients With Acute Lung Injury

To the Editor:

Rachmale et al¹ evaluated prospectively the electronic medical records of 289 patients with acute lung injury, of whom 210 patients met their inclusion criteria, which were summarized in Table 1 in their article. One-hundred fifty-five patients (74%) were exposed to excessive oxygen.¹ Prolonged exposure to excessive oxygen correlated with worsening of the oxygenation index at 48 hours, in a dose-response manner, and more days on mechanical ventilation, longer ICU and hospital stay, and worsening lung function.¹ Given the importance of avoiding excessive F_{IO₂}, understanding oxygen delivery (D_{O₂}) and balancing that with oxygen consumption should be stressed in the education of nurses and

respiratory therapists. If D_{O₂} is reduced but remains above a critical value, oxygen consumption tends to be maintained at its normal value by increasing oxygen extraction.²

Oxygen delivery is commonly calculated using the equation:

$$D_{O_2} = (S_{aO_2}) (Hb) (1.34) + (P_{aO_2}) \times (0.003) \times CO \times 10$$

Where S_{aO₂} is percentage of oxygen saturation, Hb is hemoglobin, P_{aO₂} is the arterial partial pressure of oxygen, and CO is cardiac output. Increasing P_{aO₂} from 60 mm Hg to 100 mm Hg would only increase oxygen-hemoglobin concentration by around 10% (S_{pO₂} from 90% to 100%), and increase oxygen content from dissolved O₂ by 40 × 0.003 = 0.12 mL/L, which is negligible, considering that the normal D_{O₂} is approximately 1,000 mL/min. Further improvement in D_{O₂} occurs when treating anemia and optimizing the cardiac output. Therefore, treating the anemia or low cardiac output should be done first, and mild hypoxemia may be acceptable in some situations, as reported by Martin et al.³ They suggested that hypoxia triggers a complex network of cellular signaling pathways that may result in protective responses.³

Protocol-driven F_{IO₂} titration should be combined with a clear understanding that high F_{IO₂} only slightly increases D_{O₂}. Healthcare providers need to be educated on the fundamentals of D_{O₂} to avoid hyperoxygenation lung injury in mechanically ventilated patients.

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The authors have disclosed no conflicts of interest.

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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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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).¹ 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.^{2,3} 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} .⁴ 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.⁵ 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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