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LETTER TO THE EDITOR

Reply to Drs. Monjezi and Jamaati: Dynamic alveolar mechanics are more than a soap bubble on a capillary tube

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TO THE EDITOR: We appreciate the opportunity to respond to comments by Monjezi and Jamaati (3) in reference to our manuscript in the *Journal of Applied Physiology* (4). We believe the reader has oversimplified the complexity of dynamic alveolar mechanics using LaPlace's equation and soap bubble model. The reader states, ". . . *collapsed alveolus can be considered as a tiny balloon.*" Applying LaPlace's model to alveolar inflation is anatomically and physiologically inaccurate and does not account for shared alveolar walls, interdependence, heterogeneity, nor the complex interwoven elastin and collagen fibers resulting in alveolar recoil and preventing overdistension. H. D. Prange succinctly described this common error in *LaPlace's Law and the Alveolus: A Misconception of Anatomy and a Misapplication of Physics*. Critical opening and closing pressures are not overlooked in our model as we have shown they are not only *pressure* but also *time* sensitive (1). For example, we demonstrated that all alveoli do not recruit immediately following application of 40 cmH_2O airway pressure but rather recruit progressively at multiple time points over a 40-s time period. Thus it is not just the amount of pressure but also the duration of time this pressure is applied that identifies the critical opening pressure (1). This time lag from when the force is either applied or removed and alveoli begin to open or collapse is modeled as a spring and dashpot.

The reader also commented on the "customary way" of clinically setting/describing inverse I:E ratio. Although correctly stated that the I:E ratio is linked with conventional modes, our technique using a personalized method of airway pressure release ventilation (APRV) is simply continuous positive airway pressure (CPAP) with a brief release. Unlike I:E ratios, the time cycles of CPAP and release phases are not linked and can be adjusted independently based on viscoelastic properties of the lung. The patient's neural drive is independent of the ventilator cycle as they can breathe at any time. The statement that an increased I:E ratio is not recommended because . . . "*shorter expiratory time increases the risk of air trapping in lung units with high expiratory resistance (auto-PEEP) and its associated development of pulmonary barotrauma, hypercapnia, and hemodynamic instability*" refers to modes where patients can inhale but not exhale. In our method of APRV, the expiratory valve uses an open CPAP system and patients can breathe spontaneously with minimal intrathoracic pressure change. Furthermore, the open breathing CPAP decreases dynamic hyperinflation.

Lastly, the reader suggests that prolonged inspiratory time in ARDS patients would exacerbate alveolar collapse by causing pendelluft and uses the LaPlace soap bubble model for this hypothesis. As stated above, we have shown with direct visualization of subpleural alveoli that prolonged pressure/time in ARDS animal models causes continued alveolar recruitment with no alveolar collapse from pendelluft (1). Our knowledge of dynamic alveolar mechanics and the mechanisms of ventilator induced lung injury (VILI) resulted in the development of a personalized and adaptive mechanical breath set in the APRV mode. When preemptively applied, this led to a reduction in the incidence and mortality associated with ARDS in trauma patients (2).

AUTHOR CONTRIBUTIONS

G.F.N., J.S., P.L.A., N.M.H., and L.A.G. drafted manuscript; G.F.N., J.S., M.K.-S., P.L.A., H.A., N.M.H., and L.A.G. edited and revised manuscript; G.F.N., J.S., M.K.-S., P.L.A., H.A., N.M.H., and L.A.G. approved final version of manuscript.

DISCLOSURES

P.L.A., G.F.N., and N.M.H. have presented and received honoraria and/or travel reimbursement at event(s) sponsored by Dräger Medical Systems, Inc., outside of the published work. P.L.A., G.F.N., N.M.H., and L.A.G. have lectured for Intensive Care Online Network, Inc. (ICON). N.M.H. is the founder of ICON, of which P.L.A. is an employee. N.M.H. holds patents on a method of initiating, managing and/or weaning airway pressure release ventilation, as well as controlling a ventilator in accordance with the same, but these patents are not commercialized, licensed, nor royalty producing. The authors maintain that industry had no role in the design and conduct of the study; the collection, management, analysis, or interpretation of the data; nor the preparation, review, or approval of the manuscript.

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