Reply to Perlman

Zhenglong Chen

Biomedical Instrument Institute, School of Biomedical Engineering, Shanghai Jiao Tong University, Shanghai, China; and Department of Precise Medical Device, Shanghai Medical Instrumentation College, Shanghai, China

TO THE EDITOR: We have paid close attention to the new advances in pulmonary mechanics from Dr. Perlman’s group and herein thank Dr. Perlman for her interest in our model (3). Dr. Perlman believes that surface tension between adjacent alveoli tends to be equal due to diffusion and Marangoni effects and she further poses recent experimental evidence supporting her argument. But this is true only under the following two conditions: 1) the connected two alveoli share a common alveolar duct and 2) at high ventilation frequency. Dr. Perlman overlooks the additional situation in which the two adjacent alveoli share different alveolar ducts and/or their alveolar mouths are blocked by liquid plug. In this case, surface tension between two alveoli might well be different. Moreover, even for two adjacent and connected alveoli, the distribution of surface tension depends on ventilation frequency. Low ventilation frequency provides a nonuniform surfactant distribution (1).

In responding to the contention “only in an excised lung that has been degassed and reinflated with liquid can surface tension be zero,” what Dr. Perlman could again fail to consider is the case in which the airways leading to flooded alveoli are completely collapsed (2) so that these alveoli are disconnected with air-liquid interface and, therefore, surface tension equals zero. We highly acknowledge Dr. Perlman for pointing out that Fig.6 is an optical section above the height of the meniscus present in the alveolus. But on the other hand, it was from this representative image that we had the idea to perform the third simulation. In fact, if we admit the aforementioned situation, namely zero surface tension, is possible, this image we think can be used to support our conclusion—when one alveolus is completely flooded, the septum shared by its aerated neighbor would bulge into the flooded alveolus. Because a cross section of such two adjoining alveoli is exactly the same as Fig.6.

Dr. Perlman is correct in pointing out that the inconsistent use of $\lambda$ will introduce an error; however, only if we take $L_0$ in Eq. 1 as the value of known unstressed length as in Eq. 11, are we able to eliminate this error. We agree that a more accurate relation between $P_{av}$ and $R_b$ contributes to enhance credibility of our results. This is also the future direction. We disagree with Dr. Perlman on the third point. As we stated at the beginning of results, we obtained the length of SS’ by trial and error without assuming it increases proportionately with aerated alveolar walls. Actually, our simulation showed that if assuming SS’ proportionate increase then the calculated aerated alveolar geometries in cases 1 and 2 were identical, with constant angle SOS’ = 60°, which was apparently irreconcilable with the truth.

The present model is just a preliminary step in building a systematically theoretical framework to quantify lung injury. In this regard, a practical model should be able to estimate not only tension stress but shear stress with reporting confidence limits, as suggested by Dr. Perlman.

DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the author(s).

AUTHOR CONTRIBUTIONS

Author contributions: Z.-L.C. drafted manuscript.

REFERENCES