

Can Gas Trapping at Low Lung Volumes Reduce Total Lung Capacity?

D.G. Frazer, W.G. McKinney, K. A. Friend and S. Tomblin
E&CTB, HELD, National Institute for Occupational Safety and Health,
1095 Willowdale Rd, Morgantown, WV 26505 (wbg4@cdc.gov)

Introduction & Relevance

In the past we have examined many characteristics of the mechanism responsible for gas trapping in excised lungs [1,2]. Even though there is evidence that gas is trapped during lung inflation [2] and remains trapped at maximum lung volume [3], the effects of gas trapping on the mechanical properties of the lung during expansion are not well understood. The objective of this study was to determine how gas trapped in the lung at low lung volumes affects lung expansion by answering the question, "Does trapped gas aid in holding the lung open by interdependent forces, or does the trapped gas interfere with lung expansion?" In the first case, trapped gas would be expected to reduce the energy required to expand the lung while, in the second case, more energy would be required for lung expansion.

Materials & Methods

In order to examine this problem, excised rat lungs were inflated-deflated under two conditions. First, vacuum degassed excised lungs were inflated-deflated for 7 inflation-deflation cycles between -5 cm H₂O and a P_{Lmax} of $+30$ cm H₂O at a rate of 3.82 ml/min. Total lung capacity (TLC) was defined as the volume of the lung at P_{Lmax} . Next, the lungs were vacuum degassed and inflated-deflated (3.82 ml/min) for two inflation-deflation cycles between $+30$ and -5 cm H₂O. During the third cycle the lungs are inflated to $\frac{1}{2}$ TLC and deflated once again to -5 cm H₂O. In subsequent inflation-deflation cycles the lung was inflated-deflated by increasing lung volume on each cycle by a volume equal to the volume of trapped gas on the previous cycle. In this manner the change in lung volume was kept the same for each inflation-deflation cycle. Total lung capacity (measured at $P_{Lmax} = +30$ cm H₂O) was reached after 5 to 7 inflation-deflation cycles.

Results & Discussion

Changes in TLC between the second and last inflation-deflation cycles were measured, and comparisons were made between the two sets of P-V curves recorded for each lung ($n=3$). In the first case, where gas was trapped as the lung was inflated to TLC during each cycle, there was a $5.27 \pm 0.62\%$ variation in TLC of each cycle. In the second case where gas was trapped at lower lung volumes as the lung was gradually reopened, TLC was reduced by $14.3 \pm 1.63\%$.

Conclusions

These results are consistent with a model of the gas trapping process in which gas trapped at low lung volumes increases the energy required to reopen closed portions of the lung. When TLC is defined by a maximum transpulmonary pressure, there is a reduction in TLC caused by trapped gas at low lung volumes because there is not enough energy available to reopen the lung periphery.

References

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