AbstractID: 11862 Title: A physics-based model that characterizes the positions of lung and lung tumor tissues as functions of tidal volume and airflow

Purpose: To develop a physics-based model that characterizes the positions of lung and lung tumor tissues as functions of tidal volume and airflow

Method and Materials: A physics model was developed to describe the trajectory of lung tissue during free breathing. The motion is separated into two independent components. One is cause by the local air filling, described by the pressure gradient and Young's modulus. Another is the hysteresis, which comes from the unmatched motion of neighboring tissues, described by the shear stress and shear modulus. The differential changes in tidal volume and airflow were used as starting points to determine the tissue motion as functions of tidal volume and airflow, respectively. The physical interpretation of $\boldsymbol{\alpha}$ was made by estimating its maximum using typical values of the Young's modulus and transmural pressure from the literature and compared against measured $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ distributions from 49 patients.

Results: This analysis lead to an equation that could be related to the published lung tissue motion; $\mathbf{x}= \mathbf{x}_0+\boldsymbol{\alpha}v+\boldsymbol{\beta}f$, where $\mathbf{r}$ is the position of a piece of tissue located at reference position $\mathbf{x}_0$. v is the tidal volume and f is airflow. $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ are each functions of $\mathbf{x}_0$ and relate tissue motion with tidal volume and airflow. The model-predicted maximum $\boldsymbol{\alpha}$ magnitude was 41.7mm/l. Maximum measured patient $\boldsymbol{\alpha}$ magnitudes ranged from 25.1mm/L to 76.9mm/L, encompassing the predicted value.

Conclusion: Basic physics principals could be used to generate a motion model that could be rewritten as a published free-breathing motion equation. The model was able to predict the magnitude of $\boldsymbol{\alpha}$, encompassing the measured values.

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