TOMOGRAPHY IMAGING AND DIGITAL VOLUME CORRELATION OF THE LUNG DURING MECHANICAL VENTILATION

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Introduction

The study of lung mechanics to improve understanding of disease is important to futureproof resilience against potential novel threats to lung health. Medical imaging provides insight to lung health and function in a given instant. Dynamic imaging provides mechanical insight to enhance understanding of lung function. The use of digital volume correlation (DVC) in combination with high-resolution micro-CT imaging and *in situ* mechanics is gaining popularity for quantifying the mechanical behavior of various materials and structures. Techniques such as DVC have been used to characterize different biomaterials, including bone [1-3] and lung [4,5] among others.

Biomaterials, in particular soft tissues like the lung, exhibit time-dependent behavior. Therefore, the use of synchrotron radiation at SPring-8, Japan, was important to maximize imaging speed, and spatial resolution, to capture the lung architecture. This study aimed to use synchrotron radiation-based micro-CT and *in situ* mechanical ventilation to study the strain distributions in the lung in health and disease. Comparisons between lung groups in this mouse model were made. The results obtained from this experiment will be of fundamental significance for correlating relationships between microscale and macroscale measurements and the potential impact on patient management guidelines for mechanical ventilation.

Methods

Freshly culled mice had their lungs mechanically ventilated and imaged at various time points during the respiratory cycle. No live animals or human subjects were tested in this study. Alongside a control group, one group underwent alveolar lavage to remove surfactant from the airways. Pressure-Volume (P-V) characteristics were recorded to capture any differences in the initial mechanical state as well as potential changes during the experiment. A sequence of tomograms were collected from the lungs within the intact thoracic cavity. Digital volume correlation (DVC) was used to compute the three-dimensional strain field at the alveolar level from the time sequence of reconstructed tomograms.

Results

DVC analysis was performed using DaVis, LaVision. Images were downsized to 16bit *.raww images, with the background (such as the rib cage) segmented and removed. A sequence of images was collected for each sample and processed in DaVis. Full-field 3D strains of each lung sample were computed with sub-volume sizes screened to minimize errors in the computed strains. Figure 1 shows an example result computed for the lung images. It highlights global observations of inter-lobular slip as well as localized regions of poor ventilation (with the blue deformation contours).

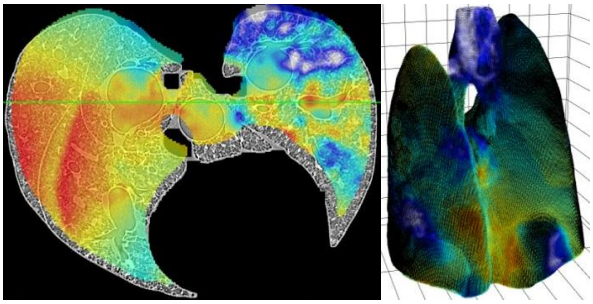

Figure 1: An example DVC result showing regional displacements. (Left) a cross-sectional view overlaid on the raw image slice; and (right) the overall lung volume.

Discussion

A methodology for *in situ* mechanical ventilation of rodent lungs with synchrotron radiation-based micro-CT was presented. Here whole lungs were imaged to highlight global as well as local trends in inflation behavior for diseased and healthy lungs. Comparisons of healthy and surfactant-free samples were performed. Architectural differences between groups were clearly observed. Their respective strain fields were quantified and compared in the context of their global lung compliance differences, measured via their P-V relationship. Methods and results shown here will inform on localized alveolar parameters for disease modelling, providing enhanced validation. Insight to local versus global strain and, therefore, loading/burden of the lung will also contribute towards structural health monitoring and management of diseased lungs.

References

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