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Airspace diameter map - a quantitative measurement of all pulmonary airspace to characterize structural lung diseases

Morphology, Cystic fibrosis, Animal models

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Stereological estimations significantly contributed to our anatomical and physiological understanding of the lung. Typically, these estimations represent an average over the entire lung parenchyma. However, most structural lung diseases show a very inhomogeneous pattern of alterations. Therefore, we developed a novel protocol where all pulmonary airspaces are analyzed, and regional differences are easily detected. Our pipeline starts with high-resolution synchrotron radiation x-ray tomographic microscopy (SRXTM) and consists of (i) image segmentation with the combination of the free machine-learning tool Ilastik and ImageJ and (ii) calculation of a whole lung airspace diameter distribution using a diameter map function from the pi2 software. To evaluate the new pipeline, adult lungs with CF-like disease (b-ENaC-transgenic mice) or elastase-induced emphysema were compared to healthy controls. We were able to show the distribution of airspace diameters throughout the whole lung as well as separately for the conducting airways and the gas-exchange area. In biological context, we observed a dilatation of parenchymal airspaces in mice with CF-like lung disease and elastase-induced emphysema. Comparable results were obtained when analyzing lungs imaged with µCT, suggesting that our pipeline is applicable to different kinds of imaging modalities. We conclude that the airspace diameter map is very well suited for a detailed analysis of unevenly distributed structural alterations of the lung.