The mean acinar volume shows a much lager increase than the total lung volume

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Introduction

THE pulmonary acinus (gas-exchange area which is ventilated by one purely conducting airway) represents the functional unit of the lung parenchyma. Due a restricted availability of high resolution three-dimensional imaging methods the knowledge about the development of the pulmonary acini is limited. Using synchrotron radiation based tomographic microscopy [1] we developed a method to evaluate the volume of single acini throughout postnatal lung development.

Materials and Methods

LARGE, high resolution tomographic dataset of rat lungs (postnatal days 4 to 60, prepared according to Tschanz and Burri [2]) were scanned at the beamline TOMCAT ([3] , Swiss Light Source, Paul Scherrer Institute, Villigen, Switzerland).

MULTIPLE, independently acquired synchrotron-based x-ray tomographic scans were combined and merged in vertical and horizontal direction [1], to increase the field of view of the tomographic dataset while keeping the resolution at the desired level of 1.48 µm per pixel.

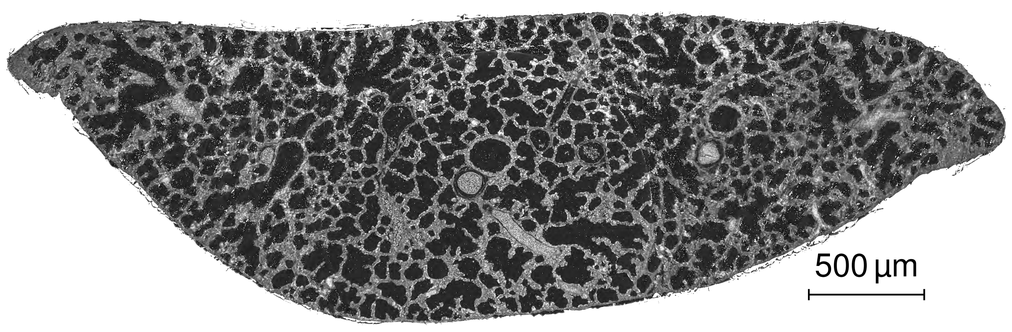


Figure 1: *Rotated and cropped slice 969 of one tomographic dataset of a rat lung sample obtained at day 4. The horizontal length of the slice is 2888 pixel at 1.48 µm per pixel.*

AIRWAY segments were extracted using a threshold interval based region growing algorithm. Up to 126 individual acini were isolated for each timepoint. The transitory bronchioles have been semi-automatically closed with three-dimensional discs (segmentation breakpoints nicknamed manhole covers, see Figure 2). The volume of each acinus was subsequently determined by simple voxel counting.

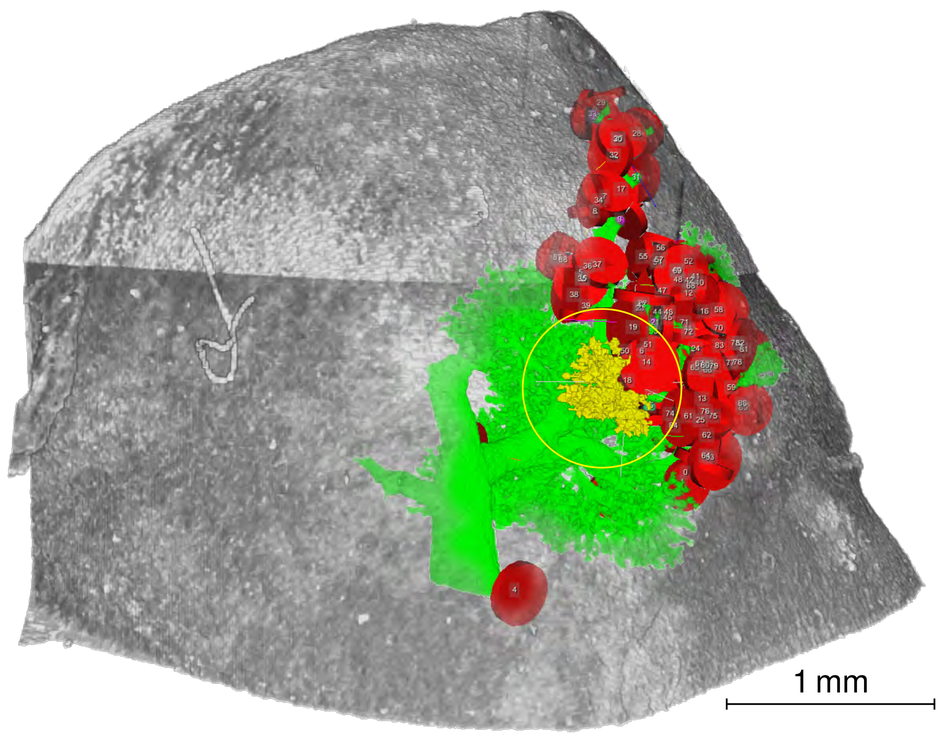
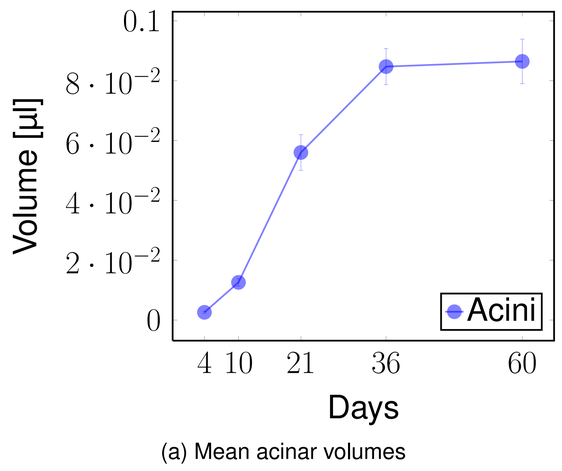


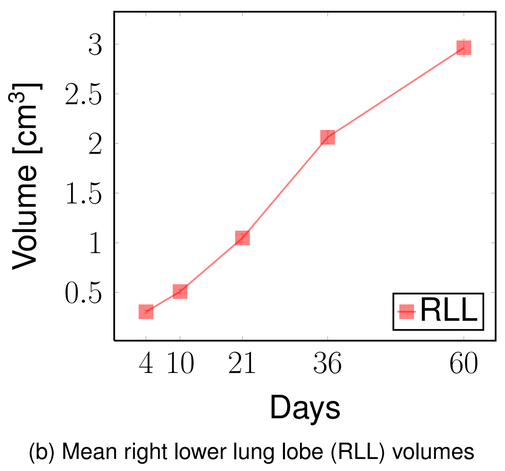
Figure 2: *Two stacked X-ray tomographic wide field scans [1] of a right lower lung lobe (RLL) of a rat obtained postnatally at day 4 merged to one dataset. One large airway segment (green) has been extracted using a threshold interval based region growing algorithm. The red discs represent the manhole covers separating individual acini from the conducting airways. These manhole covers permit to extract and segmented single acini; one such acinus is shown inside the yellow circle.*

Results

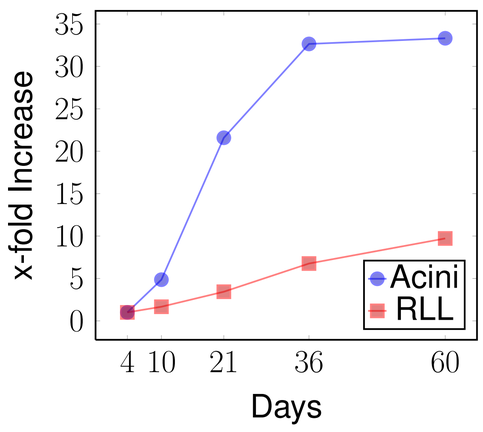
WE observed an approximately thirty-three-fold increase of the mean acinar volume during the postnatal lung development from days 4 to 60 (33.25-fold, from 0.002 60 µl to 0.086 46 µl). During the same period the volume of the right lower lung lobe increases only approximately ten-fold (9.72-fold, from 0.305 cm^3 to 2.964 cm^3, see [4]), which results in an acinar growth 3.4 times larger than the right lower lung lobe volume.



(a) Mean acinar volumes



(b) Mean right lower lung lobe (RLL) volumes



(c) Volume increase based on day 4

Figure 3: *Plot of increase in Volume for both Acini (●) and right lower lung lobe (RLL, ■). While the volume of the right lower lung lobe increases approximately 10-fold over the first 2 months after birth, we see an approximately 33-fold increase in mean volume for the extracted acini from day 4 to 60.*

Discussion

WE hypothesize that this large increase of the acinar volume can only be achieved by a conversion of the 2 to 4 most distal purely conducting airways into alveolar ducts between birth and adulthood. As a consequence 4 to 16 small acini have to be merged to a larger one. We expect that the increased complexity of the adult acini influences both ventilation and particle deposition.

Acknowledgments

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