Generation of terminal airway skeletons using synchrotron based x-ray tomographic microscopy

David Haberthür¹, Akira Tsuda², Marco Stampànoni³,⁴, Johannes Schittny¹
¹Institute of Anatomy, University of Bern, Switzerland, ²Physiology Program, Harvard School of Public Health, USA, ³Swiss Light Source, Paul Scherrer Institut, Villigen, Switzerland, ⁴Institute of Biomedical Engineering, University and ETH Zürich, Switzerland

(haberthuer,schittny)@ana.unibe.ch

INTRODUCTION

Subtle differences in the branching pattern of the acinar airways are crucial for airflow and particle deposition in the pulmonary gas-exchange area. Until now, the generation of skeletons of the gas-exchanging airways was limited by the resolution of the available three-dimensional imaging methods.

Using wide field synchrotron radiation based x-ray tomographic microscopy (SRXTM, Poster 1-7 and [1]), we generated large high resolution three dimensional datasets of heavy metal stained and paraffin embedded rat lung samples [2] at an isometric voxel length of 0.74 µm.

MATERIALS AND METHODS

At the beamline TOMCAT [4] at the Swiss Light Source (Paul Scherrer Institut, Switzerland) we obtained tomographic datasets of the distal-medial edge of the right lower lung lobe obtained at post-natal days 4–60. Independent acini have been extracted from the lung samples using a region growing algorithm. The acinar skeleton was extracted using a successive erosion technique based on the distance transformation [3] of the extracted segments (see figure 1). The three-dimensional topology of the resulting skeleton corresponds to the extracted acinus (see figure 2). All calculations and visualizations have been made with MeVisLab (Version 1.6.1, MeVis Research GmbH, Bremen, Germany).

RESULTS

Tomographic datasets covering a cylindrical field of view with a height of 1.4 mm and a diameter of approximately 4 mm have been obtained. We extracted three independent central terminal airway segments from all samples and the skeletons of these segments have been calculated and visualized as shown in figures 2 and 3.

DISCUSSION

Wide field SRXTM allows the unrestricted generation of acinar skeletons which we would like to use for the analysis of the 3D-structure of the gas-exchanging airways and air flow in the terminal airways throughout lung development. Using this method, we can divide the acinar tree into proximal and distal regions and analyze the complexity of the terminal airway tree. We would like to use it to study lung development as well as the deposition of particles in different regions in the terminal airway tree in the mammalian lung.

ACKNOWLEDGMENTS

This work has been funded by grant 3100A0-109874 of the Swiss National Science Foundation. We thank Mohammad Ouanella for the help with the preparation of the samples and beamline scientist Dr. Federica Marone for expert help with the reconstructions.

REFERENCES