Stereological characterization of individual acini using high-resolution x-ray tomographic microscopy

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Rationale

The difficulty of characterizing individual respiratory functional units of the lung from two-dimensional physical sections leads to a limited knowledge about biological parameters like volume and surface of these so-called acini.

By using high-resolution tomographic microscopic imaging we were able to extract individual acini from rat lung samples to stereologically assess their individual volume and surface.

Methods

Large, high-resolution (isotropic voxel size of 1.48 µm) tomographic datasets [1] of lung samples of three rats were recorded at the TOMCAT beamline at the Swiss Light Source in Villigen, Switzerland. In these tomographic datasets we isolated single acini by semi-automatically closing the transitory bronchioles at the transition from conducting to gas-exchanging airways.

43 individual acini were stereologically analyzed. Intersections of the acinar surface with line probes were used to estimate the acinar surface area and the volume of the acini was assessed with point counting.

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Results

Acini were extracted from the distal-medial area of the right lower rat lung lobe. Their mean volume was estimated to be $1.554\,\mathrm{mm}^3$ and their mean surface area to be $0.756\,\mathrm{cm}^2$. Assuming that the acini possess a similar size throughout the different regions in the lung, we calculated a number of acini per animal of approximately 5200. Based on the same assumption we calculated an alveolar surface area of $3410\,\mathrm{cm}^2$ per animal.

Conclusions

Both, acinar volume and mean acinar number match data published for *one* rat by Rodriguez et al. [2], where the mean volume was found to be $1.98\,\mathrm{mm}^3$ and the total number of acini was 4023. Vasilescu et al. [3] performed a micro-tomographic study of *mice* and found the mean volume of the acini to be $0.36\,\mathrm{mm}^3$, i. e. a value approximately 5 times smaller than the value we found for our *rat* lung samples ($1.554\,\mathrm{mm}^3$).

Further investigations will focus on additional stereological parameters like the alveolar number per acinus. The proposed method allows for the non-destructive and semi-automatic extraction of individual acini for manual stereological or automatic analysis of parameters like volume and surface.

We can automatically calculate the volume of individual acini and match the accuracy of manual stereological assessment method while performing the analysis orders of magnitude faster. This makes it possible to assess the volume of large numbers of acini in large high-resolution tomographic datasets.

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References

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