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Visualization of Pulmonary Airflow and Analysis of Pathogen Adhesion: A Study Using 3D Printed Respiratory Models

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Abstract

The number of patients with non-tuberculous mycobacterial lung disease (NTM) is increasing, mainly in Japan and the United States. This study aimed to visualize airflow in respiratory organs using 3D printed models and to clarify the mechanisms of disease onset.

1. Introduction

This research was initiated to understand NTM, which caused my grandmother's death and is still not well understood. The bacteria causing NTM are widespread and unavoidable. However, the fact that some people get infected while others do not raised the hypothesis that pulmonary airflow affects infection likelihood.

2. Methods

A lung model was created using PET bottles to understand the mechanism. Dry ice was used to visualize airflow inside the model. Subsequently, a lung model was created using a 3D printer and flour, mimicking bacteria, which was blown into the model. It was coated with spray adhesive. Specific areas were set for measurement, and the flour density was observed under a microscope.

3. Results

In the PET bottle model, the diaphragm installation was successful, but external air prevented accurate observation of airflow. In the 3D printed model, the flour adhesion density was highest at the branch points.

4. Discussion

The PET bottle model failed due to the inability to seal it completely, resulting in significant external air influence. In the 3D printed model, the highest particle adhesion at the branch points suggests that bacterial accumulation sites, or lesions, are likely to form at the bronchial or lung bifurcation. This phenomenon can be expressed by the equation $v=-\rho+550$.

5. Conclusion

This study revealed that bacteria are more likely to adhere and form lesions at the branch points within the lungs. Hence, during medical examinations, it is advisable to inspect the branch points.

6. References

Fujita, Jiro, Higa Tai, and Masao Kenyama. "Pathology of Pulmonary MAC Disease." Japanese Journal of Internal Medicine 96.2 (2007): 347-352.

7. Keywords Pulmonary airflow, pathogen adhesion, 3D printer