Numerical Simulation of the Effect of Dynamic Glottis on Particle Deposition in Human Upper Respiratory Airway

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Abstract

Background: The glottis has the minimum cross-sectional area in the human upper respiratory airway, whose shape can dramatically affect the airflows inside the airway. However, the effect of the dynamic glottis has rarely been investigated due to the numerical complexities involved. Therefore, most previous studies have used airway models with a rigid glottis.

Objectives: The goal of this study was to numerically investigate the influence of a dynamic glottis on the airflow and particle deposition in an anatomically realistic mouth-lung model.

Methods: Computational Fluid Dynamics (CFD) method was used to simulate the fluid field. There were four variables in this study: inlet flow rate, breathing mode, movement of the larynx area, and the partial size. Three inlet flow rates were used in the study to imitate the slow, normal, and rapid breathing. A constant and sinusoidal function was used to reproduce the velocity changing during the human breathing, and a user define function was used to imitate the movement of the larynx area. Ten piratical sizes ranging from 1 to 30 μm were considered in this study.

Results: Results show that the greater particle size or the higher flow rate have a greater deposition rate, while other variables didn't make significant changes to the total deposition rate. The movement of the larynx didn't influence the deposition much at the normal and high-activity breathing conditions but did have a significant influence at the low flow rate, which caused a lower deposition rate at larynx and a higher deposition at lung. Concerning the breathing mode, the sinusoidal function caused a higher impact on deposition rate in the mouth and pharynx at low flow rates and a higher impact in the larynx and lungs at high flow rates.