Sensitivity Analysis of Geometric Factors in Human Airway on Particle Deposition: Developing a Generic Mouth-Throat Model for Drug Delivery Testing

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Abstract

Background:

Drugs can be introduced into human body by several means such as pills, intravenous injection, and inhalation. Inhalation drug delivery is fast and effective, which has two main routes: orally inhaled and nasally inhaled. Due to its benefits of safety, lower-cost and convenience, the use of orally inhaled route becomes a growing trend in medical profession. However, the conventional standard United States Pharmacopeia induction port underestimates the deposition of orally inhaled aerosols. Therefore, it is necessary to replace it with a more appropriate and representative mouth-throat (MT) model. Making an exact same MT model according to human body is time-consuming and not realistic. Thus, relative importance of geometrical factors must be found that should be included in the generic mouth-throat model.

Objective:

The objective of this study was to analyze the sensitivity of each parameter that would affect the deposition of orally inhaled aerosols including particle size, density, input velocity and geometry factor. This study also aimed to find out the impacts on deposition fraction caused by the uncertainty of inlet parameters. Though many researches were done before, conclusions were not specific enough due to the limitations of analyzing software. In this study, further research were conducted based on previous and new data.

Methods:

Four existed MT models: realistic, elliptic, constant-diameter and USP were implemented. Original data were collected and organized from previous research. Complemental input data were added by using the Adaptive Design function in SmartUQ. Corresponding output data were calculated by using Fluent 6.3.26. The whole data were imported to SmartUQ in order to generate an emulator. Steps were repeated until a fitted surface response can be observed. These data were used to determine the sensitivity of each parameter by using the SA function in SmartUQ.

Results and Conclusion:

Oral cavity, glottis area and curvature can affect the deposition fraction. The glottis area and total airway volume have the most significant effects on the mouth-throat, while oral cavity has the least significant effects. Results of this study is a guidance in developing a generic MT model to replace the conventional USP IP.