Design and Creation of a Temperature and Moisture Controlled Three-Dimensional Tracheobronchial Lung-Airway

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EXTENDED ABSTRACT

Inhalers and nebulizers are usually used in treatments for asthma and other chronic respiratory system disorders. They are used to deliver medication directly to the patient's lungs, which offers less side effects and more direct treatment compared to oral medications. Several different models for inhalers and nebulizers are available; however, all rely on the airflow dynamics of the lung airways in order to deliver the medication to the appropriate location in the lungs. Accurate dosage prediction may lead to better patient care.

Due to the lack of *in-vitro* aerosol particle deposition studies in a temperature and humidity controlled lung airway model, a senior design team at Mercer University was formed. This team consists of three biomedical engineers, Kristin Marko, Mario do Nascimento, and Jamie Oakley. Kristin Marko was responsible for the computational aspect due to previous experiences in this field. Mario do Nascimento used his programming and electrical background to program and interface the electrical components, while Jamie Oakley was responsible for casting of airway models and data collection.

Preliminary research yielded a three-dimensional (3D) model of the subject-specific airways which was imported to ANSYS CFX to test computational fluid dynamics and thermal energy (i.e., temperature) distribution. The research concluded that there is significant temperature (approximately 13°) difference between the mouth and the exits of the tracheobronchial airways based on different mass flow rates of inhalation. It was also determined that more rapid breathing, as in the case of an asthma attack, causes less of a temperature change through the airway system. The two aspects of this design project include the creation of a humidity controlled 3D tracheobronchial airway environment and the construction of a temperature controlled environment for the model. The airway was created using polyurethane foam cast around a three dimensional subject-specific upper respiratory model of a healthy male. The model was housed in a Plexiglas box, whose temperature and humidity were monitored using a microcontroller, temperature sensors and a Relative Humidity Sensor.

The temperature and moisture controlled airway models were built and will be tested using a mono-dispersed inhalation aerosol delivery system. Experimental results, such as aerosol delivery and deposition in the airway, will be compared to computational results.