Materials & Methods

Airway Replicas:

This study was approved by the Health Research Ethics Board (HREB) of the University of Alberta.

Five realistic adult hollow conducting airway replicas were built based on segmentation of CT scans of subjects with healthy airways. Additionally, an idealized geometry was designed to mimic airway deposition in realistic and idealized pediatric central conducting airway replicas of children.

Table 1. Summary of subject information and airway diameters of adult replicas. Generations 0 (Gen. 0) to 4 are shown, where Gen. 0 are the trachea, Gen. 1 are the main bronchi, Gen. 2 are the lobar bronchi, and Gen. 3 are the segmental bronchi. Diameters are given as the average (standard deviation) for each generation.

<table>
<thead>
<tr>
<th>Generation</th>
<th>Diameter 1 (mm)</th>
<th>Diameter 2 (mm)</th>
<th>Diameter 3 (mm)</th>
<th>Diameter 4 (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gen. 0</td>
<td>3.0 ± 0.2</td>
<td>2.5 ± 0.1</td>
<td>2.0 ± 0.1</td>
<td>1.5 ± 0.1</td>
</tr>
<tr>
<td>Gen. 1</td>
<td>6.0 ± 0.4</td>
<td>5.5 ± 0.3</td>
<td>5.0 ± 0.2</td>
<td>4.5 ± 0.1</td>
</tr>
<tr>
<td>Gen. 2</td>
<td>12.0 ± 0.8</td>
<td>11.5 ± 0.7</td>
<td>11.0 ± 0.6</td>
<td>10.5 ± 0.5</td>
</tr>
<tr>
<td>Gen. 3</td>
<td>24.0 ± 1.6</td>
<td>23.5 ± 1.5</td>
<td>23.0 ± 1.4</td>
<td>22.5 ± 1.3</td>
</tr>
<tr>
<td>Gen. 4</td>
<td>48.0 ± 3.2</td>
<td>47.5 ± 3.1</td>
<td>47.0 ± 3.0</td>
<td>46.5 ± 2.9</td>
</tr>
</tbody>
</table>

Table 2. Summary of subject information and airway diameters of child replicas. Table headings are the same as described above for Table 1.

Deposition Experiments:

Monodisperse (GSD = 1.22) DEHS aerosols ranging in diameter between 3.5 to 5.5 µm were produced by a condensation aerosol generator (Model 3475, Topas, Dresden, Germany). Aerosol size was monitored using an aerodynamic particle sizer (Model 3321, TSI Inc., MN, USA). Aerosol and make-up air were drawn by vacuum through airway replicas positioned in an exposure chamber. For adult replicas, steady flow rates of 60 l/min and 90 l/min were used. For child replicas, flow rate was adjusted between 4.8 and 9.3 l/min to match expected mean inspiratory flow rate during tidal breathing at rest for each subject.

Aerosol deposition was determined by gravimetry using a calibrated analytical balance to weigh replicas and all downstream filters before and after each experimental run.

Empirical Correlation:

Generational deposition in adult and child replicas was predicted using the Chan and Lippmann correlation:

\[ \eta_{deposition} = 1 - \prod_{i=0}^{4} (1 - \eta_i) \]

Idealized Geometry:

An idealized 4.8 year old child central conducting airway geometry was designed by scaling the idealized adult geometry proposed by Zhang and Finlay (2005). An isotropic scale factor was determined using the Chan and Lippmann correlation to match the average total deposition in the 4.8 year old child replicas.

Acknowledgements

References