MODELING AEROSOL DELIVERY IN STENOSED AND STENTED TRACHEAS CONSIDERING DIFFERENT BREATHING CONDITIONS

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Introduction

Chronic obstructive lung diseases have a worldwide prevalence of about 10% and it is estimated that in 2030 will become the third cause of death in the world [1]. Aerosol therapy by inhalation is the main strategy for treating such disorders. Unfortunately, inhalers, nebulizers and other devices are not optimized to specific patients and lesions so that the drug delivered tends to deposit and reach different regions of the airways. The computational fluid dynamics has been widely used for assessing transport and deposition of aerosolized particles within healthy airways [2]. Fewer works focused on bronchial obstructions [3], stenosed and stented tracheas. The goal of this work is the analysis of the aerosol transport and deposition in such situations for improving delivering strategies.

Materials and Methods

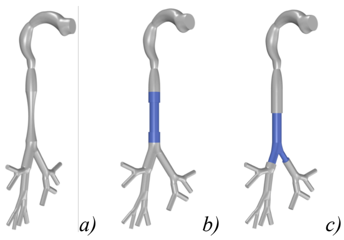

Figure 1: Airways stenosed a) and stented models b) and c).

The parametric geometries consist in two tracheal stenoses (symmetric and asymmetric), using 20, 30 and 50% lumen reduction (Fig. 1a) and two stented models, tracheal and carina Dumon prosthesis with a thickness of 1 and 1.5mm (Fig. 1b and 1c). Realistic forced breathing flows were obtained through a spirometry before and after prosthesis implantation. Light and normal activities were estimated in both cases. The airflow was considered as steady and turbulent using particle sizes of 1, 5, 10 and 15µm.

Results

Small particles (1 to 5µm) tend to reach the lower airways independently on the degree of stenosis. The deposition fraction (DF) ranges between 0 and 4% (Fig. 2). For the stented airways, the DF ranges between 0 and 6% (Fig. 3). For particles of 10 to 15µm, the DF in the upper airways tends to increase in both stenosed and stented situations. For the stenosed tracheas, the deposition increases especially at the carina due to the reduction of the lumen in both symmetric and asymmetric models at 12 and 18L/min. Higher flows (90L/min) promote a decrease of deposition.

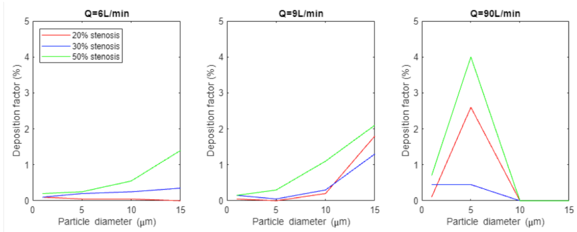

Figure 2: Deposition fraction within stenosed tracheas.

For the airways in the presence of the prostheses, the deposition increases in the stented regions, especially at the carina and at the stents upper extremity. Again, the deposition decreases at higher flow (180L/min).

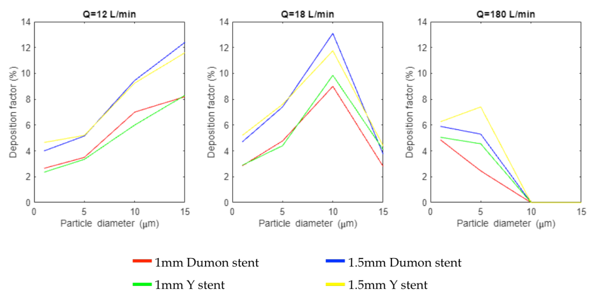

Figure 3: Deposition fraction within stented tracheas.

Discussion

Stented airways show increased drug depositions in the regions where the device is located as these reduce the tracheal lumen. Tracheal endo-prostheses promote several disorders such as inflammation, tissue reaction among others. Side effects of local aerosol overdoses around stented areas are unknown and need further investigations.

References

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3. P. Singh et al, Int J Environ Res Public Health, 17(3):1119, 2020.

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