Nebulized aerosol deposition in a realistic nasal cast during inhalation and exhalation

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Drug delivery by aerosol is one of the most powerful tools used to treat lung diseases and also nasal cavity inflammations and infections. Drug delivery through the nose presents the advantage of targeting the zones of interest, thus allowing direct treatment and avoidance of the first-pass metabolism.

Improving the efficiency of nasal nebulizers consists of optimizing deposition in specific anatomical regions. The aim of this work was to study the influence of the particle size and the air flow rate during inhalation and exhalation process on nasal aerosol deposition.

In order to carry out this cartography, a nasal cast model was built from epoxy plastic based on CT-scans from a plastinated human head model (Durand *et al*, 2001). The nasal cast was dismantled in 4 parts and aerosol deposition was measured in different anatomical regions of the nasal cavity.

Aerosol was generated during 5 to 10 min using 3 different types of jet nebulizers loaded with fluorescein solution.

During the inhalation process, the nebulizer was connected to one nostril, while the second nostril was closed. A vacuum pump connected to an airflow meter was then connected to the nasopharynx through a filter to generate the inhalation flow rate. The tested flow rates and MMAD (mass median aerodynamic diameter) were 2; 7 and 15 L/min and 2 µm, 4.5 µm and 9.5 µm respectively.

During the exhalation process, a compressed air bottle connected to a humidifier and to a heater was used to achieve the exhalation flow rate via a T-piece connected to the nasopharynx. The nebulizer was connected to the model through the third entry of the T-piece. A nasal plug collected the non-deposited aerosols on a filter. The tested flow rates and MMAD were 2; 15 and 90 L/min and 1.1, 4.7 and 9.8 µm respectively. Finally, fluorescein marker was used as a tracer and the deposited concentration was deduced by measuring the absorbance with a spectrophotometer. Particle size penetrating into the maxillary sinuses was measured using a low flow cascade impactor.

A statistical study allowed the evaluation of the values allowing the maximum deposition in each nasal zone. Aerosol deposition distribution during inhalation and exhalation were found to be different. During inhalation, a maximal deposition was obtained in the nose and the nasal valve for the higher MMAD (9.5 µm) and lower flow rate (2 l/min). While during exhalation higher MMAD and flow rates (9.8µm and 90l/min) are recommended for a maximal nasal cavity deposition. The maximum deposition in the turbinates region was obtained for higher flow rates and MMAD during inhalation and exhalation. Finally the deposition in the sinus and ethmoids could not be predicted by using flow rate and particle size. The particle size penetrating into the maxillary sinuses of the nasal cast model had a constant 2µm MMAD size, whatever the flow rate.

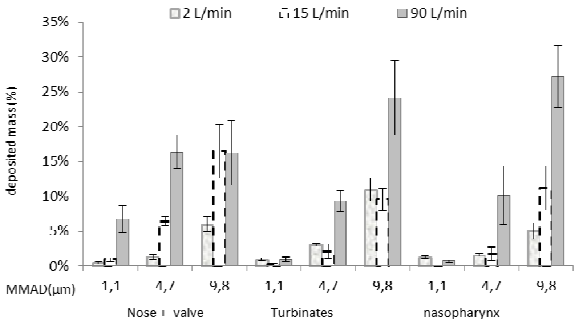

Figure 1 : Deposited mass in the nasal cast during exhalation

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Durand, M., Rusch, P., Granjon, D., Chantrel, G., Prades, J.M., Dubois, F., Esteve, D., Pouget, J.F., Martin, C. (2001)
Preliminary study of the deposition of aerosol in the maxillary sinuses using a plastinated model, J Aerosol Med. 14(1):83-93.