IMPACT OF MMAD, ACCOUSTIC AIRFLOW AND BREATHING PATTERNS ON INTRASINUS DRUG DEPOSITION IN A REALISTIC NASAL CAST

L. Leclerc¹, J. Pourchez¹, G. Aubert², L. Vecellio³, S. Le Guellec³, M. Cottier¹, M. Durand¹,4

1- LINA, EA 4624, F-42023, Saint-Etienne, France.
2- Laboratoire d'Antibiologie, CHU Saint-Etienne, France.
3- DTF Aerodrug, Faculté de médecine ; CEPR INSERM U1100 - EA6305 ; Université François Rabelais, Tours, France
4- Centre Hospitalier Emile Roux, F-43012, Le Puy en Velay, France.

INTRODUCTION

Targeting delivery of nebulized drug into the maxillary sinuses is a main issue to improve clinical outcomes in patients with sinus disorders.

To enhance the drug deposition in sinuses, the impact of a 100 Hertz (Hz) acoustic frequency airflow, airborne particle size and breathing features were investigated using a realistic replica of a nasal cast.

This replica was obtained from a fully validated (anatomically and geometrically) plastinated model created in our laboratory with a well-known aerodynamic comportment.

RESULTS

-> Based on visual scan comparison, nasal replica didn't show significative anatomy difference to plastinated specimen.
-> The results of intrasinus drug deposition clearly demonstrate that aerosol can penetrate into the maxillary sinuses. We confirmed that a 100 Hz acoustic airflow led to increase the deposition of drug into the maxillary sinus by a factor 2-3.
-> Moreover we assessed the optimal 3 µm MMAD allowing a major drug deposition in the maxillary sinuses.
-> Drug deposition differences were observed for the various breathing patterns.

CONCLUSION

-> Acoustic airflow, breathing mode and aerosol size lead to disparate drug deposition pattern confirming existence of specific transport mechanisms.
-> We emphasized in this study that 3 µm aerosol inhalation with acoustic airflow could improve benefits of drug deposition for the patients. Moreover breathing pattern seems also to be an important factor.

METHODS

1) Nasal cast replica

- Human oral airways segmenting from high resolution computed tomography (CT) scan images ;
- Rapid prototyping technology ➔ realistic replica of the airways ;
- CT scan to ensure high quality fabrication ;
- Anatomical and geometrical validation using several techniques such as endoscopy.

2) Aerosol experimental setup

Using gentamicin as a marker, 168 experiments of intrasinusal drug deposition after nebulizations were performed on the nasal cast with various parameters :
- Breathing pattern
- MMAD (Mass Median Aerodynamic Diameter)
- Acoustic airflow

<table>
<thead>
<tr>
<th>BREATHING PATTERN</th>
<th>MMAD (µm)</th>
<th>ACCOUSTIC AIRFLOW</th>
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</thead>
<tbody>
<tr>
<td>Buccal breathing</td>
<td>3 µm</td>
<td>Without pressure waves</td>
</tr>
<tr>
<td>Slow nasal breathing</td>
<td>9 µm</td>
<td>100 Hz acoustic airflow</td>
</tr>
<tr>
<td>Normal nasal breathing</td>
<td>550 nm</td>
<td>Without pressure waves</td>
</tr>
</tbody>
</table>

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