SCINTIGRAPHIC evaluation of the EASYNOSE nasal nebuliser in a nasal cast model.

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Introduction

The EASYNOSE new nasal nebuliser has recently proved its efficacy to target nasal cavities including ethmoid and maxillary sinuses of healthy volunteers and to limit lung penetration(1). However, in vivo scintigraphy studies analysing nasal aerosol deposition have some limitations to quantify precisely the aerosol deposition due to the determination of regions of interest (ROIs) within the nasal cavities(2,3). Therefore, these in vivo studies don’t allow reliability of results. The use of in vitro models very close to human nasal cavities should bring more precision in the quantification of the nasal aerosol deposition.

In this study, the efficacy of the EasyNose nebuliser to target nasal cavities, and in particular the regions of ethmoid and maxillary sinuses (MS), identified sites of infection(4), was evaluated by scintigraphic method in two new nasal casts, in order to improve reliability of previously obtained in vivo results.

Material and Methods

Nasal casts

Two models were made from a healthy volunteer’s sinus CT-scan: one with the original scanner sizes (woman nasal cavities or small model) and the second larger (similar to man nasal cavities or large model). Models were built in 4 independent areas:

- Area 1: nose and nasal valve;
- Area 2 and 3: osteomastoid complex (OMC) and sinuses;
- Area 4: spheno- and rhino-pharynx.

Nebulisation experiments

Fig. 2 shows how the nasal cast model was connected to the EasyNose and to a respiratory pump. For each experiment the nebuliser was filled with 3 mL of Tc-99m-DTPA (74MBq).

After nebulisation (10 min), 2 min-images were recorded (1-γ camera Siemens for the lung filter & the nasal cast (lateral view of the nasal cast profile) and anterior view of each area).

The NASA/LUNG repartition and the distribution of nasal aerosol deposited in each area was determined. Aerosol deposited in MS and in ethmoid was also determined, using specific ROIs.

Determination of MS and ethmoid ROIs

ROIs of both models were determined by applying radioactive ink solution with a brush on each area of the models. Images of the NASAL FOSSA alone (including ethmoid), the MAXILLARY SINUSES alone and the NASAL FOSSA + MAXILLARY SINUSES, were recorded.

From these images, ROIs were defined for MS and for ethmoid (in areas 1, 2, 3) and then applied on aerosol images to determine aerosol activity deposited in these anatomical regions.

Results

Aerosol deposition images (Fig. 4)

Profile images of both models obtained after EasyNose nebulisation showed a peripheral deposition of aerosol in the nasal cavities.

Repartition Nasal-Lung (Table 1)

For both models, < 99% of the aerosol was deposited in the nasal cast and < 1% in the lung (filter). Results are in accordance with in vivo results of aerosol deposition obtained in healthy volunteer with the same nebuliser(1). Moreover, results validate experimental conditions for the simulation of the presence of a soft palate.

Aerosol distribution in nasal cast (Table 2)

The aerosol distribution from areas 1 to 4 was similar for both models with a maximal value in the area 1, due to the restriction passage of nasal valve(5,6), and then a slower decrease until the area 4 (rhinopharynx). The difference between both models may be due to a difference in the size of the anatomical structures of models such as nostrils or the nasal valve passage.

Table 1: In vivo aerosol deposition obtained with the EasyNose nebuliser (1): (1) for the nasal cavities and at the lung filter (expressed in % of total deposited aerosol). (2) in each area of the nasal cast expressed in % of deposited aerosol into the nasal cavities.

<table>
<thead>
<tr>
<th>Area</th>
<th>Nasal cast (%)</th>
<th>Lung (%)</th>
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<tbody>
<tr>
<td>Area 1</td>
<td>20.3 ± 3.0%</td>
<td>9.3 ± 4.2%</td>
</tr>
<tr>
<td>Area 2</td>
<td>42.3 ± 6.5%</td>
<td>41.7 ± 3.2%</td>
</tr>
<tr>
<td>Area 3</td>
<td>17.2 ± 1.3%</td>
<td>12.7 ± 1.6%</td>
</tr>
<tr>
<td>Area 4</td>
<td>15.0 ± 1.9%</td>
<td>9.3 ± 3.4%</td>
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Small model (n=3)

99.4 ± 0.1% 0.6 ± 0.1% 75.1 ± 7.3% 13.0 ± 3.5% 15.0 ± 3.5% 6.1 ± 0.9%

Large model (n=3)

99.2 ± 0.6% 0.8 ± 0.4% 63.3 ± 2.6% 21.4 ± 1.1% 22.6 ± 1.1% 12.7 ± 1.4%

Table 2: In vitro aerosol deposition into the ethmoid and into the MS and into both cast of MS expressed in % of the aerosol deposited into the nasal cavity.

<table>
<thead>
<tr>
<th>Area</th>
<th>Ethmoid (%)</th>
<th>Maxillary sinuses (%)</th>
<th>MAX (OMC and sinuses) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small model</td>
<td>15.0 ± 5.2%</td>
<td>17.2 ± 4.2%</td>
<td>32.8 ± 5.2%</td>
</tr>
<tr>
<td>Large model</td>
<td>20.3 ± 1.3%</td>
<td>9.3 ± 0.4%</td>
<td>42.3 ± 8.3%</td>
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Conclusions

This study demonstrates that the EASYNOSE nebuliser is effective to target nasal cavities, and is adapted for NASAL TREATMENT. It allows a peripheral deposition of aerosol in the nasal cavities, beyond the nasal valve, including maxillary sinuses and ethmoid, and predicts a minimal lung deposition.

The limitation of the scintigraphic method described in in vivo aerosol deposition studies (quantification problem due to anatomical localisation) remains present for in vitro studies using nasal casts very close to human. The possibility to examine independently the different parts of our models has improved the reliability of image processing.

References