Comparison of nasal and bronchial mucociliary clearance in young non-smokers

EDITH PUCHELLE, F. AUG, J. M. ZAHM AND A. BERTRAND

Unité de Recherche de Physiopathologie Respiratoire U. 14, INSERM, and *Service de Médecine Nucléaire, C.H.U. Vandoeuvre-les-Nancy, France

(Received 20 January/18 June 1981; accepted 29 June 1981)

Summary

1. Nasal and bronchial mucociliary clearance have been studied in ten non-smokers (aged 19–23 years). Nasal mucociliary transport was evaluated by measuring the transport rate of a single radioactive \(^{99m}\text{Tc}\) particle deposited on the nasal mucosa. Bronchial clearance was measured after inhalation of insoluble radioactive anionic particles (diameter 7.4 \(\pm\) 1.5 \(\mu\)m). The initial deposition of the aerosol and subsequent clearance over 1 h was monitored with a \(\gamma\)-camera.

2. The initial particle deposition was concentrated centrally and was similar in all subjects. The percentage of the total deposition located in the central zone was 78.2 \(\pm\) 5.8. The range for nasal transport rate (0–12.6 mm/min) and bronchial mucociliary clearance (18.1–77.0\%) was large.

3. An inverse relationship \((r_s = -0.63, P < 0.05)\) was observed between nasal transport rate and bronchial clearance, suggesting that, in young non-smokers, the lower the rate of the nasal mucociliary transport the faster the bronchial mucociliary clearance.

Key words: bronchial mucociliary clearance, nasal mucociliary transport, aerosol deposition, radioactive aerosol tracer.

Introduction

Noxious particles deposited in the respiratory tract are cleared by the mucociliary defence apparatus. Impairment of nasal and/or tracheobronchial transport, resulting from intrinsic abnormalities, may predispose to pulmonary disease [1, 2]. If low nasal transport rate is associated with low bronchial clearance, it may imply that the nasal mucus transport, which is easier to investigate than lung transport rate [1], is a good means of detecting abnormalities of the mucociliary system. Andersen et al. [1] found no significant association between tracheobronchial and nasal clearance as tested by the tagged resin-particle method. However, their data are difficult to interpret, since some subjects were ex-smokers and the initial site deposition was not controlled. The purpose of the present study is to compare nasal and bronchial mucociliary clearance to determine their association in young adults who are non-smokers.

Materials and methods

Subjects

Ten young men (aged 19–23 years) gave informed consent and received financial remuneration for their participation after being told the nature and purpose of the study. This investigation was approved by the Ethical Committee of the Research Unit. These subjects had never smoked and their FEV\(_1\)/VC expressed as a percentage of predicted values [3] was 104.8 \(\pm\) 6.0\%. Respiratory symptoms (cough, sputum, dyspnoea, wheezing, as well as symptoms of allergy, asthma, allergic rhinitis) were recorded from a physician-administered questionnaire.

Nasal transport rate

This was measured by a radioactive tracer
method similar to that used by Andersen et al. [4] and has been described more recently [5]. Spherical insoluble particles of a basic anion-exchange resin (Amberlite IRA 410; 250–350 μm) were labelled with 99mTc and had a radioactivity of 10 μCi. A single particle was deposited on the floor of a non-congestive nostril, 1 cm from the nasal mucocutaneous junction. Two externally fixed particles were used as controls. The subjects faced a γ-camera (Opticamera CGR) so that the sagittal plane of the nose was parallel to the screen. The transport of the tagged particle was measured for 30 min. The transport rate was calculated over a distance of 3·5 cm from the initial deposition site.

**Bronchial mucociliary clearance**

This was measured by a radioactive aerosol tracer technique [6]. The subjects inhaled an aerosol of resin particles (mean diameter 7·4 ± 1·5 μm), labelled with 99mTc, through a mouthpiece. The aerosol was dispersed with a spinning-disc generator and the particles were propelled by hot air into the mouthpiece at a constant flow rate (1·2 litres/s). At the end of a 5 min period of aerosol inhalation, the subject rinsed the mouth, then lay on a table with the thorax under the γ-camera. The total initial lung radioactivity was approximately 50 μCi. The decrease in total lung radioactivity after excluding the trachea was analysed by external counting with the gamma-camera. The clearance curves of the radioactive aerosol were obtained by monitoring with a computer (Informatek 15–35) the whole-lung radioactivity for 1 min every 10 min over a period of 1 h. None of the subjects coughed during the period of measurement. The data were corrected for radioactive decay and were expressed as a percentage of bronchial radioactivity cleared after 1 h.

The original distribution of particle deposition was systematically monitored by a computer analysis of the lung image obtained within 1 min of completing aerosol inhalation. The regional division of the lung for the analysis of deposition and mucociliary clearance efficiency has been described previously [7], and the method we used is derived from that described by Foster et al. [8] and by Bateman et al. [9]. An octagonal shape was superimposed on the anteroposterior image of the right-lung field. The standard octagonal shape included the basal segments close to the mediastinum. The total lung area was divided into five regions. The counts were calculated in the central region (zones 1, 2, 3) and in the peripheral region (zones 4, 5) related by area in the ratio 3 : 2. The aerosol penetration index, defined as the ratio of peripheral to central counts, was calculated for each subject.

The nasal transport rate and bronchial mucociliary clearance were measured on the same day at 1 h intervals. The study was carried out in an air-conditioned laboratory where the temperature and the relative humidity were 20·4 ± 1·0°C and 58·6 ± 8·0% respectively.

**Statistical values**

The values described in the text are means (±sd). As the number of subjects studied is small, the non-parametric Spearman regression test has been used for comparing bronchial mucociliary clearance and nasal mucociliary transport rate.

**Results**

The particles of radioactive aerosol were deposited predominantly in the central lung region.

The percentage of initial central lung radioactivity and aerosol penetration index values were (mean ± sd) 78·2 ± 5·8 and 0·286 ± 0·09 respectively. The small standard deviations imply that the individual variation of the initial site deposition is very low. No significant association could be demonstrated between the initial deposition of the radioactive aerosol and the bronchial mucociliary clearance. Table 1 lists the individual and mean values of nasal transport rate and bronchial mucociliary clearance. The range for nasal transport rate (0–12·6 mm/min) and bronchial mucociliary clearance (18·1–77·0%) is large. Of two subjects with zero nasal transport rate one stated he had allergic rhinitis and complained of occasional wheezing.

<table>
<thead>
<tr>
<th>Subject no.</th>
<th>Nasal transport rate (mm/min)</th>
<th>Bronchial clearance (% radioactivity cleared after 1 h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>77·0</td>
</tr>
<tr>
<td>2</td>
<td>4·9</td>
<td>34·4</td>
</tr>
<tr>
<td>3</td>
<td>1·3</td>
<td>42·1</td>
</tr>
<tr>
<td>4</td>
<td>3·5</td>
<td>39·1</td>
</tr>
<tr>
<td>5</td>
<td>12·6</td>
<td>19·1</td>
</tr>
<tr>
<td>6</td>
<td>2·8</td>
<td>37·9</td>
</tr>
<tr>
<td>7</td>
<td>2·6</td>
<td>63·0</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>33·4</td>
</tr>
<tr>
<td>9</td>
<td>4·6</td>
<td>18·1</td>
</tr>
<tr>
<td>10</td>
<td>3·9</td>
<td>39·5</td>
</tr>
<tr>
<td>Mean</td>
<td>3·6</td>
<td>40·4</td>
</tr>
<tr>
<td>SD</td>
<td>3·6</td>
<td>17·9</td>
</tr>
</tbody>
</table>
An inverse significant correlation ($r_s = -0.63$, $P < 0.05$) was obtained between nasal transport rate and bronchial mucociliary clearance, suggesting that, in young non-smokers, the lower the rate of the nasal mucociliary transport the faster the bronchial mucociliary clearance.

**Discussion**

Andersen et al. [1] reported that differences in tracheobronchial mucociliary clearance between pairs of monozygotic twins were frequently negatively correlated with differences in nasal clearance.

The negative and significant correlation observed in our study between nasal transport rate and bronchial mucociliary clearance corroborates their results. The mechanism whereby the subjects with low nasal clearance exhibit a faster bronchial clearance is not clear. According to Andersen et al. [1], the agent responsible for nasal mucociliary impairment might have given rise to a nasovagal reflex inducing bronchoconstriction. They suggested that this bronchoconstriction should result in a more proximal aerosol deposition with an apparently higher mucociliary transport. Our results do not support this hypothesis; we could not demonstrate any relationship between the nasal clearance rate and the initial aerosol deposition pattern. They have also suggested that the nasovagal reflex might increase mucociliary clearance by parasympathetic stimulation. We speculate that subjects with low nasal mucociliary clearance are more sensitive to bronchial irritants. Airway irritation stimulates bronchial parasympathetic receptors and produces an increase in mucus output and mucociliary clearance. The results of Phipps & Richardson [10], who showed that irritation of the nose resulted in an increase of mucous secretion, support our contention. Moreover, it has been demonstrated that cholinergic agents stimulate ciliary activity [11] and mucociliary transport in animals [12] and in humans [13]. Variations in the depth of penetration of the inhaled aerosol may be responsible for differences in lung mucociliary clearance [14]. For example, if the subjects with low nasal transport rate demonstrated a more proximal aerosol deposition, the mucociliary clearance should be higher in these subjects. The good reproducibility of our measurements of bronchial mucociliary clearance has been verified previously in healthy subjects of different ages [6]. Moreover, in the present study, we measured the initial aerosol site deposition in five lung regions. In all the subjects we observed a similar central deposition pattern with aerosol penetration index values ranging from 0.15 to 0.39. This relative similarity in the initial aerosol deposition, due to the large particle size of the test particles and the high flow rate used, supports the validity of our measurements of bronchial mucociliary clearance.

In a recent study we compared the nasal mucociliary transport rate measured by different methods on the same day and over a 24 h period in young subjects [5]. Despite large day to day variations, we observed a significant correlation between measurements carried out on the same day.

The large interindividual variations in bronchial mucociliary clearance and in nasal transport rate that we have observed in our group of subjects have already been reported, particularly in young subjects [15, 16]. Andersen et al. [4] found a mean nasal transport rate of 4.8 mm/min with a range of 0–23.6 mm/min in healthy young subjects. They pointed out that nearly half of their subjects exhibited abnormally slow nasal transport rate, corresponding in their experiment to an absence of transport over the 30 min of maximal observation. According to these authors, a slow nasal transport rate might predispose to infection or might occur as a result of infection up to 48 h before the onset of clinical symptoms. Of our ten young subjects, two exhibited an absent mucociliary transport. One complained of allergic rhinitis and wheezing, whereas the other reported no respiratory symptom. This latter subject exhibited the highest bronchial clearance (77% after 1 h).

Although our data suggest that the deficiency in nasal mucus transport in young adults is correlated with a speeding of bronchial mucociliary clearance, this should not necessarily be considered as a beneficial effect. This increase in bronchial mucus clearance is probably a pathophysiological response of the bronchial airways to inhaled irritants. This response may be temporary. In the long term, bronchial mucociliary impairment may occur in the young adults who have an abnormally low nasal mucociliary clearance. A longitudinal study of the nasal and bronchial mucociliary clearance in our group of young non-smoking adults should corroborate or invalidate this hypothesis.

**Acknowledgments**

This work was supported by grant no. 78-60 from Ministère de l’Environnement et du Cadre de Vie. We thank W. L. Dull for reviewing the
article, P. Biette for his technical assistance, M. C. Rohrer for the diagrams and P. Ulmer for typing the text.

References


