The Journal of Laryngology & Otology
June 2005, Vol. **119,** pp. 443–447

Scintigraphic evaluation of nasal mucociliary activity in unılateral chronic otitis media

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Abstract

Mucociliary clearance is a key defence mechanism in human upper and lower airways. Although mucociliary activity is present in both ears of the patients, most cases of chronic otitis media are unilateral.

In this study, we aim to evaluate the difference between nasal mucociliary activity of the affected and non-affected sides in patients with unilateral chronic otitis media. Both nasal transport times of 36 patients with unilateral chronic otitis media were compared statistically with each other and with the control group by independent samples *t*-test. The nasal mucociliary transport times of the nasal cavity at the same side as the affected ear and as the non-affected ear are significantly different, in the same patients.

Our study shows that impaired or decreased nasal mucociliary activity may result in dysfunction of the eustachian tube and middle-ear ciliary activity, which plays an important role in the aetiopathogenesis of chronic otitis media.

Key words: Otitis Media; Mucociliary Clearance; Nasal Cavity; Scintigraphy

Introduction

The aetiology of chronic otitis media has been the subject of numerous investigations and much discussion, reflecting the complex nature of this condition.[1–3] The eustachian tube has three major functions: ventilation, clearance and protection of the middle ear. All three functions play an important role in protecting the middle ear from developing chronic otitis media. Abnormal function of the eustachian tube, with an impaired ability to equalize pressure differences, appears to be the most important factor in the pathogenesis of middle-ear diseases.[1–5] Other probable contributing factors are upper airway infections; recurrent otitis media; infection of the eustachian tube and nasopharynx; and allergy and ciliary dysfunction of the respiratory mucosa, especially in the middle ear.[4] Besides dysfunction of the musculature of the eustachian tube, inflammatory mediators, including prostaglandins, arachidonic acid metabolites, leukotrienes, and cytokines, have also been postulated in the pathogenesis of middle-ear diseases.[6]

Optimal tubal function depends not only upon equalization of the pressure but also upon a normal mucociliary clearance in the clean middle ear filled with air.[1] Mucociliary clearance is a key defence mechanism in human upper and lower airways, and its impairment, both acquired and genetically determined, predisposes to chronic infection of the nose, paranasal sinuses and respiratory tree.[7,8]

An important driving force in mucociliary transport is ciliary beat, so that mucociliary clearance can be decreased due to a decline in ciliary beat frequency (CBF). In type I (Ig E mediated) allergic reactions, such as those seen in patients with allergic rhinitis, several allergic inflammatory mediators are released from the nasal mucosa. These mediators may, in turn, be responsible for the decline in CBF, which then impairs mucociliary clearance.[6,9]

Morphologically, the ciliated mucosa in the middle ear and eustachian tube is of an identical nature to the nasal mucociliary epithelium.[1] Therefore, these nasal infections and allergic reactions may result in an impairment of mucociliary function in the middle ear as well as the eustachian tube and, thus, in the long term may contribute to otitis media becoming chronic.[1,4,7,8]

In this study, we aim to evaluate the difference between nasal mucociliary activity of the affected and non-affected sides in patients with unilateral chronic otitis media.

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Accepted for publication: 25 February 2005.

Materials and methods

Our materials were obtained from the ENT Department of the Osmangazi University Faculty of Medicine, between 1999 and 2003. All patients were diagnosed with unilateral chronic otitis media and had undergone a therapy protocol. This study included 36 patients whose mucociliary activity in both nasal cavities was evaluated by scintigraphy. Since smoking and septum deviation affect the mucociliary activity adversely, cigarette smokers and patients with severe septum deviation were excluded from the study. On the other hand, 18 healthy patients were included in this study as a control group and their nasal mucociliary transport times were measured.

While selecting suitable cases, it was noted that all had a unilateral discharge from one ear at least six months or more prior to screening, and tympanic membrane perforations detected by otoscopic examination. Patients with central tympanic membrane perforations and mucosal diseases were included, while attic perforations and squamous diseases were excluded from the study. In addition, all patients had to have been free of any known nasal allergy or asthma, drug usage and upper airway infection during the last month prior to screening. To eliminate mechanical obstructions and the presence of any nasal pathology, a nasal examination and radiological examination were performed, respectively.

Patients with unilateral chronic otitis media were evaluated by these methods:

(1) *History*: The presence of discharge from one ear, hearing loss, tinnitus, vertigo and nasal congestion were investigated. If present, the duration of symptoms, medical therapy and changes in symptoms after therapy were also noted. The presence of any other systemic illness was also asked.
(2) *Physical examination*: Classic ENT examination was performed. Temporal and paranasal computerized tomography of all cases were obtained and evaluated.
(3) *Evaluation of nasal mucociliary activity by scintigraphy*: All cases were evaluated by the scintigraphic test using the radioisotope technique in the Department of Nuclear Medicine in our hospital. Patients did not undergo any nasal medical therapy before the test. Nasal cavities were irrigated by 10 ml isotonic NaCl. The test room temperature was set to 21 ± 0.5ºC and humidity was about 50 per cent. Patients stayed in the test room one hour before the application of the test. During the test, patients were told to breathe normally, and to avoid coughing and moving.

In both control and study groups, Tc 99m-sulpur colloid was used for measuring nasal mucociliary transport time (mm/s). In the study group, the test was first applied to the nasal cavity on the same side as the chronic otitis media. Although the half-life period and total elimination time of Tc 99m were given as 6 h and 24 h, respectively, in order to avoid contamination and to obtain accurate results, we applied the test to the other nasal cavity 3–4 days later.

While the test was performed, the patients lay in the supine position with their heads extended. In the matrix of 128 × 128; 32 frame images with 32-second periods were obtained.

Tc 99m (0.02 ml volume and 20 μCi power) was placed at the anterior part of the inferior turbinate. The point the Tc 99m reached at the nasopharynx was accepted as a last point and the test was then terminated. In this study, the Starcam 400 AC/TGE gamma camera was used. The nasal transport time was detected by measuring the length of straight line drawn between the starting and last point of the Tc 99m.

At the end of the study, the nasal transport times of the nasal cavity on the same side as the chronic otitis media were compared with the other nasal cavity in the same patients. Then all the patients' results were compared with the control group results. Independent samples *t*-test was used statistically for this.

Results

Thirty-six patients, diagnosed with unilateral chronic otitis media, were included in this study. Nineteen of these patients were male and 17 were female. The mean age was 27.56 ± 7.49 (mean + SD) with a range of 17 to 54. The control group included 10 male and eight female healthy subjects. The mean age was 29.61 ± 6.61 (mean + SD), with a range of 19 to 38.

In patients with unilateral chronic otitis media, the nasal mucociliary transport times in the nasal cavity at the same side as the affected ear varied between 3.2 mm/s and 19.5 mm/s (mean 9.72 ± 4.35 mm/s). In the other nasal cavity of the same patients, the nasal mucociliary transport times were between 3.3 mm/s and 29.5 mm/s (with a mean of 14.36 mm/s).

In the control group, the nasal mucociliary transport times were between 6.8 mm/s and 28.7 mm/s (with a mean of 13.2 mm/s). Table I shows both nasal mucociliary transport times of patients with unilateral chronic otitis media, on the affected side and the non-affected side. Table II shows the nasal transport times of the control group.

The mean of both nasal transport times of the 36 patients with unilateral chronic otitis media (9.72 ± 4.35) were compared statistically with each other (14.36 (5.92) by independent samples *t*-test. There is a significant difference between the nasal mucociliary transport times of the nasal cavity on the same side as the affected ear and the non-affected ear, in the same patients ($t = 3.79$, SD = 70, $p = 0.0003$).

On the affected side of the nasal cavity, the nasal mucociliary transport times (mean = 9.72 ± 4.35) decreased when compared with the control group (mean = 13.16 ± 5.47, $t = 2.51$, SD = 52, $p = 0.015$ [$p < 0.05$*]).

https://doi.org/10.1258/0022215054273098 Published online by Cambridge University Press

TABLE I

NASAL MUCOCILIARY TRANSPORT RATES OF PATIENTS WITH UNILATERAL CHRONIC OTITIS MEDIA, AT THE AFFECTED SIDE AND NON-AFFECTED SIDE

No.	Age	Sex	Nasal transport rates at the the non-affected side (mm/s)	Nasal transport rates at the the affected side (mm/s)
1	17	M	9.5	21
2	18	M	19.5	22.4
3	20	M	9.8	14.3
4	21	M	5.3	7.6
5	22	F	7.7	12.6
6	22	M	6.6	8.1
7	24	F	4.3	19.8
8	29	M	7.6	9.1
9	31	F	11.5	11.9
10	31	F	9.8	15
11	32	M	14.4	14.2
12	32	F	9.7	11.8
13	33	F	6.3	10.7
14	35	M	17.5	29.5
15	36	M	9	11.3
16	38	M	18.8	25.9
17	31	F	6.9	13.4
18	32	M	9.8	22.3
19	34	M	8.2	11.2
20	34	F	9.7	11.2
21	25	F	5.8	9.2
22	27	M	3.2	3.3
23	23	F	3.7	5.4
24	26	F	12.7	16
25	32	M	9.9	13.2
26	54	F	10.2	14.8
27	34	F	8.6	13.8
28	26	M	18.4	20
29	26	M	8.9	12.2
30	17	M	9.5	21
31	18	F	19.5	22.4
32	20	M	9.8	14.4
33	22	F	6.3	7.9
34	24	F	7.7	11.7
35	22	M	6.6	8.7
36	24	F	7.3	19.8

Mean: 27.56

TABLE II

NASAL TRANSPORT RATES OF THE CONTROL GROUP

No.	Age	Sex	Nasal transport rate (mm/s)
1	19	F	6.8
2	23	M	9.8
3	23	F	13.1
4	27	M	15.2
5	32	F	19.3
6	33	M	28.7
7	37	M	10.9
8	38	M	10.2
9	39	F	9.5
10	21	M	8.9
11	23	F	8.5
12	24	F	12.3
13	27	M	8.3
14	27	M	15.2
15	32	F	19.3
16	33	M	18.7
17	37	F	11.9
18	38	M	10.2

Mean age: 29.61 ± 6.61(mean + SD)

When the nasal mucociliary transport times of the patients with unilateral chronic otitis media on the non-affected ear side (mean = 14.36 ± 5.92) were compared with the control group results (mean = 13.16 ± 5.47) there was no significant difference (t = 0.725, SD = 52, p = 0.472 [$p > 0.05^{ns}$]).

No correlation between the measurements of the patients and their age was detected p = 0.328 ($p > 0.05^{ns}$). Also there was no correlation between the results and the patients' gender p = 0.18 ($p > 0.05^{ns}$).

Discussion

Many causes have been suggested and established for the chronic nature of otitis media. Its prevalence varies as a result of genetic and sociocultural factors. Many studies have been conducted to evaluate these factors.[10] The immunological status of the subject, recurrent upper airway infections and mucociliary dysfunction play an important role in the aetiopathogenesis of chronic otitis media, in addition to genetic and sociocultural factors. In fact, recurrent upper airway infections and other factors affect both nasal cavities, but this contradicts the fact that chronic otitis media is usually unilateral. This should suggest another cause for unilateral chronic otitis media. This thesis was supported by our findings.

Mucociliary transport of the upper and lower airways is an important defence mechanism against inhaled particles, bacteria and viruses. However, mucociliary clearance may be impaired in patients with allergic rhinitis or allergic asthma.[9] Disorders of ciliary structure or function result in impaired clearance, and in turn result in chronic sinopulmonary disease manifested as chronic sinusitis, otitis media, nasal polyposis and ultimately bronchiectasis.[11]

In the pathogenesis of chronic otitis media the important role of the eustachian tube and nasal cavities has been shown by many studies. In particular, the mucociliary activity of the eustachian tube plays an important role in the clearance of effusion produced by the tympanic cavity in the middle ear.[12]

Karja *et al.*[13] reported the marked decrease in nasal mucociliary activity of children with otitis media with effusion. This study shows that decreased nasal mucociliary activity plays an important role in the pathogenesis of otitis media with effusion.

Impairment of mucociliary function may be due to loss of cilia, ultrastructural changes in cilia or decreased ciliary beating activity. Changes in the amount or composition of respiratory mucus and periciliary fluid may also effect ciliary beating. Microorganisms may impair mucociliary transport, by direct bacteria cellular contact, production of toxins or promotion of a destructive immune response. This leads to clinical signs of infection, and structural changes in ciliated mucosa may cause a decrease in mucociliary activity resulting in chronic otitis media, chronic sinusitis and other respiratory tract infections.[14] Tobacco smoke has a ciliostatic effect, and changes in viscoelastic properties of mucus result in impairment of the nasal mucociliary activity.[8] Though it is a bilateral effect, cigarette smokers are excluded from our present study.

https://doi.org/10.1258/0022215054273098 Published online by Cambridge University Press

It has been shown that the mucociliary epithelium of the nasal cavity, eustachian tube and middle ear are similar in nature. Ohashi *et al.*[15] showed that quantitative assessment of mucociliary activity present in tubatympanium requires biopsy materials of the eustachian mucosa, and this may result in further narrowing of the tubal lumen due to post-operative scarring, and all these lead to impairment of mucociliary activity which has already been decreased.

- **This study evaluates nasal mucociliary clearance in patients with unilateral chronic otitis media**
- **Nasal mucociliary clearance appears to be impaired on the side of the affected ear**
- **Impaired ciliary function may result in eustachian tube dysfunction which may play a part in the aetiology of chronic otitis media**

Assuming that the ciliated mucosa in the nasal cavity is morphologically similar to that in the middle ear and the eustachian tube, it is reasonable to investigate the mucociliary function in the nasal cavity on the presupposition that an action upon the mucociliary function in the nasal cavity would also be reflected in this function in the middle ear and eustachian tube. Birch and Elbrønd[1] have suggested a close relationship between impaired and/or abolished mucociliary function in the eustachian tube and that in the nasal cavity, and they have suggested that the mucociliary function in the nasal cavity is a good index of that in the eustachian tube.

Studies of the mucociliary function in man have been made since the 1830s, and measurement of the eustachian tube function with radioactive isotopes was presented in 1977.[12] The importance of the mucociliary clearance in many mucosal diseases necessitates ciliary rate evaluation. Measurement of ciliary activity with Tc 99m is a very accurate and repeatable technique that shows the pathophysiology of the disease. Tc 99m is a suitable radioisotope because the required radiation dose is minimal, it is easily detected and has no side effects for the patients. Therefore we also preferred to use Tc 99m in our present study for measuring nasal mucociliary activity for reflecting eustachian tube dysfunction in patients with unilateral chronic otitis media.

Mean nasal mucociliary transport times vary as a result of many factors including personal, sexual and methodological factors. In the literature, many studies are presented, and these show that in adults the mean mucociliary time ranges from 9.6 to 14.3 min.[1] In our study, the mean nasal transport time of the control group is 13.16 mm/min and this falls inside the reported normal range. However, in patients with unilateral chronic otitis media, the mean nasal transport time on the same side as the affected ear is 9.72 mm/min, indicating probable impairment. In some patients, the nasal transport time of the other side (14.36 mm/min) is accepted as normal.

According to these findings, in patients with unilateral chronic otitis media, the mucociliary transport times of the nasal cavity on the same side as the affected ear are significantly lower than those of the nasal cavity on the other side of the same patients and those of the control groups.

Our study shows that impaired or decreased nasal mucociliary activity may result in dysfunction of the eustachian tube and middle-ear ciliary activity, which plays an important role in the aetiopathogenesis of chronic otitis media. Mucociliary dysfunction in unilateral nasal cavity may be the cause of development of chronic otitis media on the same side, but further research studies should be performed in order to clarify the exact pathogenesis.

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Dr C Cingi takes responsibility for the integrity of the content of the paper.
Competing interests: None declared

https://doi.org/10.1258/0022215054273098 Published online by Cambridge University Press