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RHINOLOGY

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Alterations of nasal mucociliary transport in patients with hypertrophy of the inferior turbinates, deviations of the nasal septum and chronic sinusitis

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Abstract Mucociliary transport (MCT) represents the first barrier of the nasal fossae and paranasal sinuses against various biological and physical insults. We studied the nasal MCT time using a mixture of vegetable charcoal powder and 3% saccharin in three groups of patients suffering from hypertrophy of the inferior turbinates, deviations of the nasal septum or chronic sinusitis. The mean values of the nasal MCT in the first two groups were practically identical to the normal ones. In contrast, significantly delayed times were found in patients with chronic sinusitis ($P < 0.01$). Findings indicate that this delay is determined by an increase in viscoelasticity of the mucus following the acute release of mediators of inflammation, together with a reduction in the periciliary stratum, which slows down the metachronous wave of the MCT.

Key words Nasal mucociliary transport · Sinusitis · Turbinate hypertrophy · Septal deviation

Introduction

Mucociliary transport (MCT) is a physiological process that allows mucus to flow over an epithelial lamina of ciliated cells. It represents the first defensive barrier against biological and physical insults in the nasal fossae, paranasal sinuses and inferior respiratory tract, favoring the elimination of particles having a diameter between 0.5 and 5 μm. Nasal MCT depends on the number and length of the cilia of the epithelium, the frequency of the ciliary beat, the coordination of movement between the cilia of a single cell and contiguous ones, as well as the quantity and viscoelastic properties of the nasal fluid. Pathological situations apt to interfere with MCT expose the individual to contact with potential pathogens that significantly increase the work to be carried out by the immunological system. The aim of the present research was to verify the variations in MCT time in patients with symtomatic hypertrophy of the inferior turbinates, deviations of the nasal septum and chronic sinusitis. In previous studies pathological transport times were found in patients with chronic sinusitis [5, 10–12], but not turbinate hypertrophy [1, 2]. Additionally, if the impact of surgical procedures to correct septal deviations on MCT is considered, conflicting data have been reported [3, 4, 13, 14].

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Materials and methods

Between September 1996 and December 1996, nasal mucociliary transport time was evaluated in three groups of 40 patients; their ages varied from 13 to 63 (average age, 31 years). Group A consisted of patients with marked hypertrophy of the nasal turbinate, Group B contained patients with septal deviations and Group C included patients with chronic sinusitis. Group A patients had no histories of allergy. Skin prick tests, IgE estimations and nasal provocation tests (NPT) for the most common allergens and inhalants were negative. All patients showed a positive increase in nasal secretion and resistance following NPT made with cold water. On the basis of these results, patients were classified as suffering from vasomotor rhinitis. Group B patients had significant deviations of the nasal septum that rendered septoplasty advisable. Group C patients had symptoms of sinusitis lasting more than 3 months [12]. These patients were diagnosed on the basis of clinical symptoms, anterior rhinoscopy and CT examinations after 3 or more weeks of antibiotic therapy.

In both groups A and B nasal function tests were carried out 2 days before enrollment in the present study and included rhinomanometry and acoustic rhinometry under basal conditions and after administration of a topical vasoconstrictor. The result of the nasal decongestion test (NDT) was the criterion for including patients in either group A or B. With deviation of the septum, obstructive symptoms persisted and nasal resistance on one or both sides remained unchanged following the administration of tramazoline hydrochlorate as a topical vasoconstrictor (negative NDT).

Improvement to normal values suggested involvement of the mucosa as the principal pathological process and resulted in the patient being placed in group A. Repeat NDT 1 month after septoplasty confirmed the correctness of the selection criterion and was also validated subjectively by patients on a visual analogue scale.

The MCT time was calculated by positioning a mixture of charcoal powder with 3% saccharin at the head of the inferior turbinate, first in the more patent nasal fossa and then 1 h later in the other nasal fossa following careful lavage with physiological solution. Direct pharyngoscopy and saccharin movement through

the perception of gustatory sensation by the patient represented a twofold confirmation of charcoal transit from the nasal fossae to the back wall of the pharynx. The reference values used were 12.5 ± 3 min for charcoal and 17 ± 3 min for saccharin [7, 11]. In essence, the charcoal behaved like an inert element adhering to the mucous carpet and was transported by the latter passively, while saccharin spread into the fluid layer of the mucus in which it was soluble. Transport was considered to be blocked when both subjective and objective measurements proved negative 30 min after placing the saccharin-charcoal in the nose. The MCT time for each patient was calculated from the average of the values obtained in the two nasal fossae.

The test was always carried out at the same times in the morning, respecting the circadian rhythm of the MCT, which was considered to be more efficient between 7 and 10 a.m. and fell off thereafter to reach its lowest levels between 12 p.m. and 4 a.m. [6, 8]. The patients were maintained in the same position for the whole of the observation time and in a uniformly air-conditioned room, since variations of head position and temperature are apt to affect transport significantly.

All data were subjected to Student's t-test, with an error probability of 1%.

Results

The average values for MCT in the patients with hypertrophy of the inferior turbinates and septal deviation were practically identical to the physiological times relative to saccharin and charcoal powder. In patients with hypertrophy of the inferior turbinates, the average times were 11.9 min for charcoal powder and 17.5 min for saccharin (Table 1). In patients with septal deviations, times were 13.3 min for charcoal and 16.5 min for saccharin (Table 2). In contrast, patients with chronic sinusitis had an average transit time of 21.3 min for charcoal powder and 28 min for saccharin (Table 3). As shown in Tables 4 and 5, statistical comparisons between Group A and Group C and between Group B and Group C were found to be highly significant both with charcoal ($P < 0.01$) and with saccharin ($P < 0.01$).

Table 1 Results of MCT in patients with non-allergic hypertrophy of the inferior turbinates (40 patients, aged 13 to 63 years)

Methods	Normal values (min)	Mean value (min)	Variance	Student's *t*-test	*P*
Charcoal	12.5 ± 3	11.90	7.6	1.36	0.18
Saccharin	17 ± 3	17.5	3.0	1.80	0.08

Table 2 Results of MCT in patients with deviation of the nasal septum (40 patients, aged 13 to 63 years)

Methods	Normal values (min)	Mean value (min)	Variance	Student's *t*-test	*P*
Charcoal	12.5 ± 3	13.30	6.6	1.94	0.06
Saccharin	17 3	16.5	4.0	1.56	0.13

Table 3 Results of MCT in patients with chronic sinusitis (40 patients, aged 13 to 63 years)

Methods	Normal values (min)	Mean value (min)	Variance	Student's *t*-test	*P*
Charcoal	12.5 ± 3	21.30	8.6	18.76	< 0.01
Saccharin	17 ± 3	28	2.9	40.34	< 0.01

Table 4 Comparison between patient groups of MCT average values using charcoal powder for transport

Charcoal	Fischer F-test	Student's *t*-test	*P*
Group A vs group B	1.16	2.35	0.02
Group B vs group C	1.13	14.79	< 0.01
Group A vs group C	1.31	13.02	< 0.01

Table 5 Comparison between patient groups of average values of MCT following saccharin clearance

Saccharin	Fischer F-test	Student's *t*-test	*P*
Group A vs group B	1.35	2.33	0.03
Group B vs group C	1.04	27.07	< 0.01
Group A vs group C	1.40	27.27	< 0.01

Discussion

The reason for the marked reduction in MCT clearance in chronic sinusitis is still not clear. According to Majima et al. [5], underlying this occurrence is not a qualitative and quantitative alteration of the cilia, but a different interaction between mucus and ciliary activity. In our experience, nasal fluid and ciliary movement interact under physiological conditions, leading to transport regulated by the rheological properties of the mucus (based on viscosity, elasticity and adhesion), which depend essentially on its mucin content, its degree of hydration and the chemical-physical bonds at the interface between gel phase and cilia [9]. In the course of chronic inflammation of the paranasal sinuses, there is an increase in viscoelasticity of the mucus following the release of mediators of inflammation during the acute phases of the illness, together with a reduction in the periciliary stratum which slows down the metachronous wave of ciliary movement. By contrast, this finding is not present in merely obstructive pathologies, such as hypertrophic rhinitis or deviation of the septum, which can alter the air flow but not cause release of mediators typical of the inflammatory response.

It has been seen that an increase in the preciliary layer results from saline nebulization, leading to improvement of pathological changes [5]. The mixture of vegetable charcoal and saccharin powder at 3% proved to be useful and simple method for measuring nasal mucociliary transport time. Hypertrophy of the inferior turbinates and deviation of the nasal septum did not interfere significantly with MCT. In contrast, sinusitis must be considerated an inflammatory pathology that can involve the whole mucosa of nose and paranasal sinuses. In this way, the expression "rhinosinusitis" instead of sinusitis alone is, in our opinion, the most suitable.

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