ORIGINAL STUDY

Outcomes of mucociliary clearance and rhinomanometrical changes in nasal pathology

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ABSTRACT

OBJECTIVE. The aim of the study was to determine the impact of the nasal pathologies over nasal mucociliary clearance and rhinomanometric parameters.

MATERIAL AND METHODS. This is a retrospective analytical observational clinical study during a period of 6 months, between 2014 and 2015. 123 subjects, 63 of whom had nasal pathology and 60 of whom were healthy controls, were enrolled in this study. The diagnosis of nasal pathology was made based on clinical examination, nasal endoscopy and anterior rhinomanometry. A methylene blue test was used to evaluate the mucociliary clearance.

RESULTS. The subjects with nasal pathology had nasal septum deviation (No=50), chronic rhinitis (No=42), rhinosinusitis (No=15) and nasal polyposis (No=17). The mean total air flow in inspiration in nasal pathology patients group was 546.7 ml/s (millilitre/second), with a median of 594 ml/s, comparing with the control group who had the mean air flow of 865.5 ml/s, with a median of 866.5 ml/s. In expiration, the mean air flow in those with nasal pathology was 603.9ml/s and a median of 611 ml/s, comparing with the control group who had the mean air flow of 871.1ml/s and a median around 872 ml/s. The mean time from the application of methylene blue liquid to first seeing it in patients with nasal pathology was 23.41 minutes for the right nostril and 23.32 minutes for the left nostril, comparing with the control group who had the mean of mucociliary clearance of 6.76 minutes for the right nostril and 6.93 minutes for the left one.

CONCLUSION. The results obtained in anterior rhinomanometry and methylene blue liquid test showed that nasal pathology does affect nasal physiology and it is an important factor to evaluate the mucociliary clearance.

KEYWORDS: mucociliary clearance, rhinomanometry, nasal pathology

INTRODUCTION

Physiological breathing is done through the nose and under normal conditions it is 6 l/ min (litter/ minutes), the maximum ventilation reaching to 50-70 l/min. Through the nostril, the air presents a laminar and turbulent flow, influencing thereby the function and condition of the pituitary mucosa[1-3].

During inspiration, the air enters in the nasal vestibule with an obliquely direction. From the aerodynamic point of view, this air is under laminar flow, which means that the different layers of the column air are mixed together. When inhaled, air reaches the nasal lumen, which is localized between the vestibule and the nasal cavity; there is a transformation of the laminar flow to a turbulent flow. Also, the direction of the air flow is influenced by the anatomy of the nasal cavity. Deviated septum or other minor associated pathologies can be as important as turbinate hyperplasia or septal perforation[4,5].

The transformation of the air flow from laminar to turbulent decreases the velocity of the inhaled air, thus prolonging the contact of the air with the mucosa, achieving in this way the olfactory function, the retention of the foreign particles, humidifying and warming the inhaled air.

Breathing is one of the key elements of life for all of us. Therefore, it is important to pay attention to the whole respiratory process. From the entrance gate to the last pulmonary alveoli in which people's vital gaseous exchange is realized, the respiratory tract may have the most diverse diseases. In a more or less man-

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ner, these conditions can influence the respiratory ability to provide the optimal amount of whole body oxygen required. Nasal pathology does not have a major response regarding all of the respiratory system functions, but through its role of gate-keeper it may be a precursor of subsequent complications. Nasal septum deviation, chronic rhinitis, rhinosinusitis and nasal polyposis are some of those nasal pathologies that can affect the normal function of the nose, causing nasal obstruction. Nasal obstruction is a symptom usually diagnosed by the patient's subjective complaint and the ENT examination can demonstrate the anatomic restriction of the nasal passages. But 62% of the patients who have visited an ENT specialist complained about nocturnal snoring as the main symptom.

The most important defensive mechanism of the nasal mucosa is the mucociliary device, which is designed to purify the inhaled air and to remove the foreign substances and particles from the nose, thus preventing them to reach the lower airways. To function properly, this mucociliary device requires an appropriate pH, temperature and humidity. The temperature has to be of 37°C and a relative humidity of 100%.

Rhinomanometry is an objective test that has been attempted to assess nasal airway patency. It measures the air pressure, both during normal inspiration and expiration, and the rate of airflow during breathing.

MATERIAL AND METHODS

This is an observational analytical retrospective clinical study performed during a period of six months, between December 1st, 2014 and June 1st, 2015. In this clinical study we examined a sample of 123 patients divided in two groups: the first group included 63 patients with nasal pathologies, such as nasal septum deviation, chronic rhinitis, rhinosinusitis and nasal polyposis, and it has been compared with the second group formed of 60 patients who had no associated pathology.

Clinical and paraclinical data were obtained by a detailed history and physical examinations, nasal endoscopy, rhinomanometry and evaluation of mucociliary clearance performed by the methylene blue method. The main symptoms that we have watched on patients with nasal pathology were: deformities of the nose and face, oral breathing, nasal secretions, allergies, perinasal skin irritation, tearing, nervousness, changes in the tone voice.

Rhinomanometry is a standard method of investigation that evaluates in the most objective possible way the nose breathing capacity. Nasal flow and transnasal pressure is measured in normal nasal inhalation and exhalation; the nasal resistance is measured as well. We chose anterior rhinomanometry to be performed in our study.

The mucociliary clearance registration in patients included in this study required their approval to achieve this measurement, because, in addition to the annoyance taste of the used substance, the duration of this investigation could be long. We chose the methylene blue method for several considerations: it is economic, practical, and it can eliminate patient's subjectivity. So our method consisted in moistening the lower nasal concha with a swab containing methylene blue and measuring the elapsed time that passed until this substance reached the posterior pharynx. To do this, we checked the pharynx with a lamp every minute to see blue streaks at this level.

One of the main roles of the rhinomanometry registration is represented by the possibility to verify the nasal resistance. This is achieved by the formula established in 1984 by the European Commission on Standardization of Rhinomanometry with the pressure set at 150 Pascals. Thus, we took into consideration all 4 situations and records: right nasal resistance on inspiration/ expiration and left nasal resistance on inspiration/ expiration.

RESULTS

A total of 123 patients were divided into 63 cases with nasal pathology, and 60 control subjects free from any nasal disease. There was no statistically significant difference between age and gender distribution in these two groups: cases and controls (p=0.39 for the age and p=0.31 for the sex) (Table 1).

Regarding the nasal pathology, the majority of the subjects had nasal septum deviation (No=50), followed by chronic rhinitis (No=42), rhinosinusitis (No=15) and nasal polyposis (No=17). It is well understood that because of these figures, we have also met in our study patients with associated nasal pathology. Thus, from the total of 63 patients, only 14 had a single nasal pathology, while the remaining 49 had 2 up to 4 associated nasal diseases.

We used the student test "T" to compare the two groups regarding anterior rhinomanometry. With a p<0.0001, the results have a significant statistical importance. In our patients, the mean total air flow in inspiration in those with nasal pathology was 546.7 ml/s, with a median of 594, comparing with the control group who had the mean air flow of 865.5 ml/s, with a median of 866.5ml/s (Table 2).

In expiration, the mean air flow in those patients with nasal pathology was 603.9ml/s and a median of 611, comparing with the control group who had the mean air flow of 871.1ml/s and the median of 872 ml/s.

Table 1
Sex distribution between the two groups

			Subjects		Total
			Cases	Controls	
SEX	F	Count	21	28	49
		% within SEX	42.9%	57.1%	100.0%
		% within SUBJECTS	33.3%	46.7%	39.8%
	M	Count	42	32	74
		% within SEX	56.8%	43.2%	100.0%
		% within SUBJECTS	66.7%	53.3%	60.2%
Total		Count	63	60	123
		% within SEX	51.2%	48.8%	100.0%
		% within SUBJECTS	100.0%	100.0%	100.0%

Table 2
Comparative of rhinomanometry results in inspiration and expiration between the two groups

Unpaired t test Inspiration		p< 0.0001	Unpaired t test Expiration		p< 0.0001
p value			p value		
	Cases	Controls		Cases	Controls
Number of values	63	60	Number of values	63	60
Minimum	81.00	818.0	Minimum	204.0	824.0
Median	594.0	866.5	Median	611.0	872.0
Maximum	779.0	912.0	Maximum	864.0	934.0
Mean	546.7	865.5	Mean	603.0	871.1
Std. Deviation	155.9	23.98	Std. Deviation	146.9	22.84

The mean time from the application of methylene blue liquid to the nostril until first seeing this to the posterior wall of the pharynx in patients with nasal pathology was 23.41 minutes for the right nostril and 23.32 minutes for the left nostril, comparing with the control group who had the mucociliary clearance mean value of 6.76 minutes for the right nostril and 6.93 minutes for the left one (Table 3).

Regarding the nasal resistance, we used the Mann - Whitney test, which is a nonparametric test because the values are not normally distributed. In all four situations, we have achieved a $p<0.0001$, which shows that the results are statistically significant. At the same time, this means an increase in nasal resistance in patients with nasal pathology, compared to control patients used in this study. The differences between the two groups expressed by percentage are: right nostril in inspiration - there is an increase in nasal resistance by 58% in patients with nasal pathology versus control; right nostril in expiration - an increase in nasal resistance by 42.8% in patients with nasal pathology; left nostril in inspiration - there is an increase in nasal resistance by 64.5% in patients with nasal pathology versus control; left nostril in expiration - there is an increase by 52.3% in patients with nasal disease (Table 4).

DISCUSSIONS

The results of our study were compared with the results found in the literature and with those of other studies from other medical researches and centers.

The purpose of this study was to demonstrate the changes of the mucociliary clearance in particular diseases, or to highlight the possible risk factors for its prolonged duration[6-9]. Rhinitis and chronic rhinosinusitis have an undeniable role in the mucociliary clearance decreased performance, according to a US

Table 3
Mucociliary clearance on the left and right nostril

Mucociliary clearance	right side p value < 0.0001		left side p value < 0.0001	
	cases	controls	cases	controls
Number of values	63	60	63	60
Minimum	13.00	5.000	11.00	5.000
Median	20.00	7.000	21.00	7.000
Maximum	60.00	9.000	60.00	10.00
Mean	23.41	6.767	23.32	6.933
Std. Deviation	10.00	1.125	8.585	1.133

Table 4
Nasal resistance on the right and left nostrils, in inspiration and expiration

	Right Inspiration		Right Expiration		Left inspiration		Left expiration	
	Mann Whitney test							
	p<0.0001		p<0.0001		p<0.0001		p<0.0001	
	cases	controls	cases	controls	cases	controls	cases	controls
Number of values	63	60	63	60	63	60	63	60
Minimum	0.0000	0.2700	0.0000	0.2400	0.0000	0.2200	0.0000	0.2300
Median	0.4900	0.3100	0.4500	0.3150	0.5100	0.3100	0.4800	0.3150
Maximum	8.330	0.4400	1.950	0.4100	3.330	0.4000	5.170	0.4100
Mean	0.7435	0.3223	0.5429	0.3178	0.6102	0.3200	0.5884	0.3185
Std. Deviation	1.118	0.03837	0.3841	0.03608	0.5325	0.04084	0.6329	0.03193

study from 2006, where are listed also as possible causes: the cilia beating frequency drops and nasal secretions viscosity alters.

In a study on patients with deviated septum, who underwent septoplasty intervention, it has been shown that this pathology has a direct effect on the mucociliary clearance and that surgery has good effects in restoration of the mucociliary function in affected patients[10].

A study from Serbia performed in 2013 highlights the importance of rhinomanometry in medical practice, emphasizing the objectivity of this procedure in the evaluation of nasal breathing in patients with pathology at this level[11].

Respiratory nasal flow is reduced in pathologies associated with obstruction, such as deviated septum, as it is reflected in the specialty literature[11]. At the same time, nasal conditions such as nasal polyposis, which is an obvious obstacle in the path of airflow, reduce the volume of circulating air.

As we have noted in this study, nasal resistance is closely related to the nasal flow. So, there is an inverse relationship between these two parameters. If nasal flow increases, nasal resistance will decrease, and if the nasal flow will decrease, the nasal resistance will increase, while the pressure remains constant at 150 Pa (Pascal). Therefore, pathologies of the nasal cavity that have an obstructive role, either through formal changes such as deviated septum or inflammation and secretions (rhinitis, rhinosinusitis) or obstructive tumors (polyps), have also a major influence over the nasal resistance[12].

According to those nasal pathologies, the results of our study show a decrease in inhaled nasal flow with 36.8% in patients with nasal pathologies comparing with controls. Regarding the exhaled nasal flow, we can see a decrease in it with 30.67% in patients with nasal diseases. Regarding nasal resistance, the measurements that we have made and the statistical results show the following conclusions: on the right nostril, there was an increase in nasal resistance by 58% in patients with nasal pathology versus controls in inspiration and by 42.8% in expiration; on the left nostril, there was an increase in nasal resistance by 64.5% in

patients with nasal pathology versus controls in inspiration and by 52.3% during expiration.

The mucociliary clearance measured in both nasal cavities had a statistically significant delay in patients with nasal pathology. For the left nostril, in patients free from nasal disease, we measured a mean time from the application of methylene blue liquid to the nostril until first seeing this to the posterior wall of the pharynx of 6.93 min ± 1.13 (minutes), compared with 23.32 min ± 8.5 in patients with nasal obstruction. For the right nostril, this time was 6.76 min ± 1.12 for healthy patients, comparing with 23.41 ± 10 in patients with nasal pathology.

CONCLUSIONS

The role of rhinomanometry is to identify the obstruction in the nasal cavity, but this method of investigation can not specify exactly which is the etiology of this obstruction.

The nasal pathology is an important factor that has an influence on mucociliary clearance.

Conflict of Interest: No conflict of interest was declared by the authors

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