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Nasal mucus clearance

by

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Summary

Nasal mucus clearance (N.M.C.) varies with geographical conditions. Studies on the evaluation of this important function have so far been done only in the western part of the world, but now the normal values of N.M.C. in India have been established by measuring the transportation of saccharine crystals through the nose. This has been compared with the values obtained in various diseases of the nasal and lower respiratory tracts, thus establishing the prognostic and diagnostic importance of measuring the nasal mucus clearance.

It is an undisputed fact that the nose, with its mucociliary mechanism, is nature's best air-conditioner, which protects the upper and lower respiratory tracts and the delicate alveoli. The mucus film, with its immunologically active ingredients, its adsorbent power and its water content makes the inhaled air almost sterile, sufficiently humid and on a par with the body temperature. The conveyor belt of cilia underneath the mucus film renovates the mucus film at regular intervals so that its functions are uninterrupted. This mucociliary mechanism can be easily impaired by structural abnormalities of the nose and paranasal sinuses and also by lower respiratory tract disease. Whether mucociliary impairment is the cause or the effect of nasal, paranasal or lower respiratory tract diseases, is still a controversial point.

Ciliary function can be assessed either directly by electron microscopic studies or indirectly by assessing the mucus transport or clearance. Early studies were based on direct observation of dyes or particles deposited on the nasal mucosa (Hilding, 1931; Tremble, 1948; Evert, 1965). Greater sophistication was added to these methods by Proctor and Wagner (1965), who used radioactive microdroplets and observed their transportation by serial scanning. Quinlan *et al.* (1969) and Andersen *et al.* (1971) used single radio-active resin particles, while Yergin *et al.* (1978) used radioactive telflon discs. Andersen *et al.* (1974) used a simpler method which consisted of depositing a small particle of saccharin on the nasal mucosa and noting the time that it took the subject to report a sweet taste. This method has been since used by many others and it was modified by Ginzel and Ellum (1980) and by Hady *et al.* (1983), who used saccharin sky blue technique so that dual observations could be made.

Nasal mucus clearance studies done have previously been done mostly in western countries and absolutely no attention has been paid to physiological norms in the eastern part of the world, including India. The habitat, habits, facial configuration and weather are all quite different in the West and the East and one is therefore tempted to think that the values established in the West may not be true for the Indian subcontinent. Hence it was decided first to establish the normal values of Nasal Mucus Clearance, and then to study its deviations in various nasal/extranasal pathologies. After surveying the resources and feasibility of the various methods described, the saccharin method was found to be most simple, convenient, economical and uncomplicated. It can also be done without

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costly and complicated equipment. The minimum detectable concentration (M.D.C.) of saccharin is 0.000023 M, while that of sugar is 0.01 M, thus making the saccharin test more sensitive.

Material

It was initially thought that changes in temperature and humidity might influence the Nasal Mucus Clearance (N.M.C.), but a study done on 25 medical students in different temperatures and humidity, ranging from 15°C to 42°C and from 20–100 per cent respectively, showed no significant differences in N.M.C. Proctor *et al.* (1978) also reported that relative humidities ranging from 9–70 per cent and temperatures ranging from 7°C to 39°C had no significant effect on the mucociliary mechanism.

Normal values were established by studying 150 subjects between the ages of 18 and 35 years. They were all non-smokers, they had no nasal pathology and they had had no recent attacks of upper respiratory tract infection. One hundred and eight were male and 42 were females. A study was also done on patients of various nasal and chest diseases.

Method

The method followed that described by Anderson *et al.* (1974). A 1 mm. diameter particle was placed approximately 1 cm. from the anterior end of the inferior turbinate, and the time required to perceive a sweet taste was noted. All the patients were tested in identical environmental conditions and they were instructed not to sniff, inhale or exhale forcefully, and to refrain from any nasal manipulation. They were asked to swallow every 30 seconds and to report the first change in their sensation of taste. As the subjects were not told the nature of the particles, the reliability of the procedure was ensured. If the subject did not perceive any change of taste after 20 minutes, he was then subjected to other tests of ciliary function.

Results (Table I)

The normal mean value of N.M.C. obtained after studying 150 subjects was 7 m. 10 sec., with a range of 5 m. 20 sec. to 11 m. 40 sec.; three subjects perceived no change. The results in various nasal pathologies were as follows:

1. *The deviated nasal septum (25 patients)*

All these patients underwent surgery to the septum in the form of either septoplasty or septorhinoplasty or submucous resection. The N.M.C. was studied pre-operatively, and 6 weeks after the operation, to evaluate the prognosis. These patients were divided in three groups:

Group A

Group A consisted of 21 patients (84 per cent) who had nasal obstruction and headache as their main complaints; their pre-operative N.M.C. was prolonged by at least 6 minutes. These patients were completely relieved symptomatically after surgery and N.M.C. 6 weeks later showed a return to normal values.

Group B

Group B consisted of 2 patients (8 per cent) whose N.M.C. was prolonged by 5 minutes. Post-operatively their symptoms were relieved but N.M.C. remained prolonged.

Group C

Group C consisted of 2 patients (8 per cent) who had mild symptoms and in whom N.M.C. was near-normal. Post-operatively they were not relieved of their symptoms and there was no change in N.M.C..

3. *Atrophic rhinitis (35 patients)*

Twenty patients with very early changes showed N.M.C. prolonged by 10 minutes or more, while 15 patients with extensive atrophic changes showed variable results: most of

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TABLE I
RESULTS

Sr. No.	Pathology	No. of patients	Pre-operative—N.M.C.	Post-operative/Post treatment		Remarks
				N.M.C.	Symptoms	
1.	Normal	150	7 min. 10 sec.	—	—	3 static
2.	D.N.S.	25				
	Group A	21 (84%	Prolonged by 8–10 m.	Return to near normal	Relieved completely	—
	Group B	2 (8%)	Prolonged by 6–10 m.	No change	Relieved partly	Probable irreversible change
	Group C	2 (8%)	Prolonged by 2 m.	No change	No change	Wrong selection for surgery
3.	Atrophic rhinitis	35				
	Early	20	Prolonged by 10 min. or more	—	—	—
	Late	15	Variable	—	—	—
4.	V.M.R.	50	Prolonged by average 5 m.	Return to normal	Relieved	Permanent relief after cryodestruction of vidian nasal branches
5.	Chronic maxillary sinusitis	18				
	Early		2–6 m.	—	—	Hyperactive cilia
	Late		Prolonged or static	—	—	Ciliary damage
6.	Bronchiectasis	12	Static	—	—	Generalised ciliary pathology in respiratory tract
7.	Kartagener syndrome	2	Static	—	—	Congenital ciliary paralysis

them perceived no change but a few recorded N.M.C. times of only 2–3 minutes.

3. *Vaso-motor rhinitis (50 patients)*

Forty-five patients with V.M.R., with nasal obstruction as the predominant symptom, had N.M.C. prolonged by an average of 5 minutes. When treated with steroids and antihistaminics, these patients showed a temporary reduction in the time of N.M.C. Five patients suffering from V.M.R., with nasal discharge as the predominant symptom, showed a reduction in N.M.C. time, some of them recording a time as low as 1 m. 10 sec. These patients were resistant to any type of treatment, and post-treatment evaluation was therefore not possible.

4. *Chronic maxillary sinusitis (30 patients)*

Group A consisted of 18 patients (60 per cent) who had symptoms which had been present from 2 months to 6 months; all of them recorded N.M.C. ranging from 4–6 minutes. Group B contained 12 patients (40 per cent) who had had symptoms for more than 1 year; they showed either no change or a prolonged N.M.C.

5. *Bronchiectasis (12 patients)*

All of these patients recorded static N.M.C.

6. *Kartagener's syndrome (2 patients)*

These patients (with dexto-cardia, situs inversus, bronchiectasis and agenesis or hypoplasia of the frontal sinuses) showed a static N.M.C.

Discussion

The values of N.M.C. reported in other studies have been established mostly in western countries and they are not applicable to other parts of the world. This fact has become clear from the present study. As mentioned earlier, the habits, habitat, climate and facial configuration must all play a significant part in the differences seen in normal values. Previous studies, done in a totally different environment, show slower nasal mucus clearance (N.M.C.) than those in the present study. Vinther and Elbrond (1978) found the average N.M.C. to be 10.1 minutes, while Puchelle *et al.* (1981) recorded N.M.C. ranges between 7 minutes to 35 minutes. Principato (1979) found the normal transit time to vary from 15 m. to 20 m. While most of these studies recorded a slower transport of mucus, Yergin *et al.* (1978) recorded a N.M.C. time of 7.2 minutes; this corresponds with the present study.

A study done by the present author in Chandigarh, North India, showed an average N.M.C. time 6 m. 11 sec., with a range from 5 minutes to 8 minutes (Golhar and Arora, 1981). It is thus evident that normal values can differ from place to place, and it is desirable that each otolaryngologist should establish the normal N.M.C. value in his own place of work.

The nasal mucus clearance may be grossly altered in certain nasal pathologies, and in some instances, after correction of the underlying pathology, the value may return to its normal level. This makes the saccharin test a very sensitive index, not only for the diagnosis but also for the prognosis of various disorders of the nasal and lower respiratory tracts.

In deviated nasal septum we could differentiate three groups of patients: Group A consisted of patients with pathological obstruction and obstructive symptoms; the N.M.C. in these cases was prolonged considerably but after correction of the obstruction and the restoration of normal physiology, the N.M.C. returned to its normal value. As compared to this, Group C patients had no significant change in N.M.C. pre-operatively, and they were not relieved of their symptoms even after surgery. Hady *et al.* (1983) and Quinlan *et al.* (1969) recorded prolongation of N.M.C. in deviated nasal septum, but no previous study has recorded N.M.C. after correction of the obstruction.

In early atrophic rhinitis there is partial ciliary loss and immobility; hence N.M.C. is greatly prolonged. However, in late cases the results are variable, owing either to the

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absence of transportation or to mechanical forces which push the saccharin crystals through a roomy cavity.

In vaso-motor rhinitis of obstructive type there was ciliary sluggishness which, when treated with a combination of steroids and antihistamines, recovered. After stopping the treatment the ciliary sluggishness recurred within a short time. Definitive treatment, in the form of cryodestruction of the nasal branches of the vidian nerve have resulted in complete recovery of ciliary function (Golhar and Arora, 1981).

In chronic sinusitis of recent onset, N.M.C. was found to be quicker and Hady *et al.* (1983) also recorded similar results. Proetz (1953) stated, that in cases of chronic sinusitis, the cilia may function actively, even when they are bathed in pus. Fabricant (1945) suggested that inflammatory and allergic reactions in the nose and paranasal sinuses were associated with changes in the hydrogen ion concentration of the nasal mucus, the nasal secretions tending to be alkaline in reaction; this is a suitable medium for ciliary activity. In late cases of sinusitis the N.M.C. was found to be slower; this could be due to chronic infection paralysing and destroying the cilia, and ultimately showing the transportation of mucus.

A definite correlation between lower respiratory tract diseases and N.M.C. can be seen in the results obtained in cases of bronchiectasis and Kartagener's syndrome. Whether the bronchiectasis is a result of nasal mucociliary insufficiency or there is a generalized muco-ciliary stasis in the whole respiratory tract, is a subject of debate and it needs further investigation.

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