Rhinology 26, 257-262, 1988

Radioisotopic method for nasal mucociliary function evaluation

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SUMMARY

In 13 healthy young adults, nasal mucociliary transport velocity was measured by means of albumine microsphere labeled with Tc^{99m} as a tracer. M+1SD of clearance velocity values and of the half time radioactivity ($T^1/_2$) resulted to be respectively $1.02 + 0.22$ cm/min and $1.07 + 0.24$ min. A significant correlation ($P < 0.05$) between half time clearance ($T^1/_2$) values of the radioactive particles and the mucociliary velocity ones could be detected, making $T^1/_2$ a reliable and rapidly obtainable parameter for determining nasal mucociliary function. Advantages and disadvantages of the different techniques are discussed.

INTRODUCTION

Mucociliary clearance represents one of the main aspecific defensive mechanisms of the respiratory tract, depending upon the intrinsic ciliary activity and upon the rheological properties of mucous and expecially of the periciliary fluid which coats the airways (Wanner, 1977).

The mucociliary transport time is a reliable index of upper and lower respiratory tract clearance function. Several methods have been used to evaluate the efficiency of nasal mucous transport. Coloured substances such as charcoal powder (Hilding, 1931), sulfactiazole (Ornston, 1946) and edicol-orange (Tremble, 1948) or sweet ones such as sodium saccharinate (Andersen et al., 1971), or a mixture of both of them (Passali et al., 1984; Ottaviani et al., 1987; Paludetti et al., 1987), were placed on the anterior third of the inferior turbinate and the time needed to visualize them on the posterior wall of the oropharynx or to feel their taste was regarded to represent the nasal mucociliary transport time. Radioisotope-labeled particles (Quinlan et al., 1969; Andersen et al., 1971; Guillerm et al., 1971) such as I^{131} (Proctor and Wagner, 1965), Cr^{51} (Simon et al., 1977) and Tc^{99m} (Harper et al., 1962) or of radioopaque ones (Yergin et al., 1978) have been also positioned on

the anterior third of the inferior turbinate and their progression within the nasal cavity were followed by means of a gamma camera or with serial X-rays. These methods share the advantage of directly measuring the mucous transport velocity, but need sophysticated and expensive tools and are not completely harmless for the patient.
The aim of this paper is to define the normal values of nasal mucociliary transport velocity in normal young adults using radioisotopic substances and to modify the method in order to reduce as much as possible the test duration without loosing in its reliability.

MATERIALS AND METHODS

13 healthy young adults without anatomical, clinical and roentgenological signs of nasal and paranasal sinuses diseases (nine males and three females) aged between 26 and 32 years (M=28), were investigated. Before testing they signed an informed consent according to up to date and internationally accepted standards.
Nasal mucociliary transport time was measured by placing under visual control and by means of a 1 cm micropipette behind the head of the inferior turbinate a 15μl drop of albumine microspheres labeled with Tc^{99m} for an overall radioactivity of 250 μCi.
The tested subject was in a sitting position with his head laterally placed under a Phogamma HP Nuclear Chicago gamma camera connected with an Intertechnique Cine 200 computer and was advised to breath normally and to avoid sniffing.
The duration of the test was 15 min and a picture was taken every 20 sec. The clearance velocity (cm/min) and the half time radioactivity ($T^1/_2$) of the labeled particles were calculated.
Previously the correspondence between the real distance covered by the radioactive marker and the distance that appears on the display has been calculated

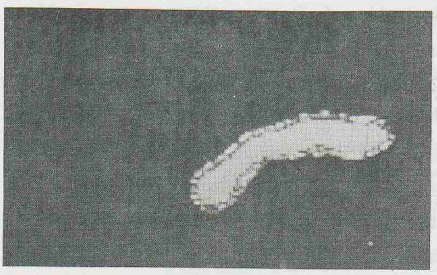

Figure 1. Computer obtained picture of the Tc^{99m} tagged drop course from the head of the inferior turbinate to the rhinopharynx.

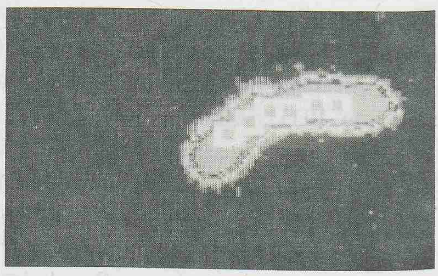

Figure 2. The course of the Tc^{99m} labeled particles have been divided in 6 ROIs in which the half time clearance ($T^1/_2$) has been calculated.

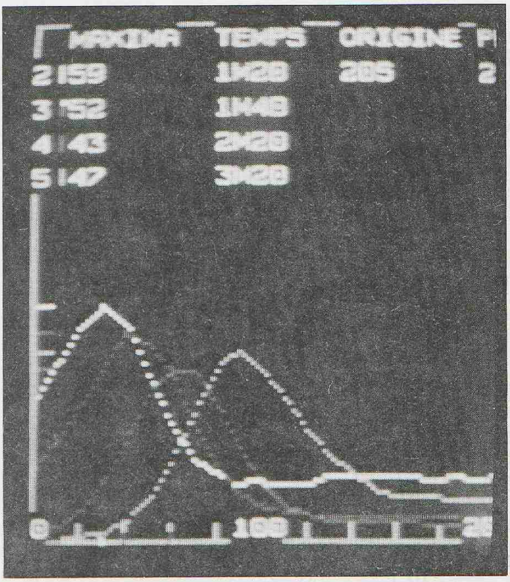

Figure 3. Activity/time curves are evaluated on a selected ROI.

(1 fixel = 0.33 cm). This has been obtained by placing the two radioactive markers at a distance of 10 cm and such distance has been measured on the display. In each fixel of the course of the particles the tracing's travelling time has been calculated as radioactivity peak within each fixel.
The tracer's route has been divided in 6 ROI (region of interest) with 1 cm length per side. On each of them the activity/time curve and the half time radioactivity ($T^1/_2$) were calculated.
The correlation between nasal mucociliary velocity values and the half time ones was carried out in order to identify the existence of a correlation between the two tests. The tests were performed at the same temperature and humidity conditions, in the same environment, at the same time and in the same position, in order to reduce the possible variables. The obtained data were compared to the saccharine mucociliary transport velocity values (Paludetti et al., 1984) by means of the unpaired Student's T test.

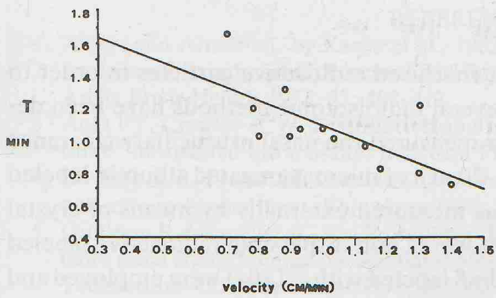

Figure 4. Scattergram demonstrating the correlation between clearance velocity (cm/min) and $T^1/_2$.

RESULTS

M ± 1SD of clearance velocity values resulted to be 1.02 ± 0.22 cm/min with a variance coefficient of 25.74.

The M ± SD of the half time radioactivity ($T^{1}/_{2}$) values resulted to be 1.07 ± 0.24 min with a variance coefficient of 26.27.

The single individual values are represented in Table 1.

Table 1. Single individual and M ± 1SD of clearance velocity and of half time radioactivity ($T^{1}/_{2}$) values.

velocity (cm/min)	$T^{1}/_{2}$ (min)
1.00	1.08
0.70	1.66
0.90	1.03
1.30	0.80
0.80	1.30
1.30	1.23
0.78	1.20
1.40	0.73
1.18	0.83
1.13	0.96
1.03	1.01
0.93	1.08
0.88	1.33
1.02 ± 0.22	1.07 ± 0.24

A statistically significant difference between mucociliary velocity data obtained with the saccharine method and with the radioisotopic method could be observed.

The correlation coefficient between nasal mucociliary velocity values and the half time radioactivity ($T^{1}/_{2}$) ones was $r = 0.69$ and resulted to be highly significant ($P \leqq 0.05$).

DISCUSSION

Since 1955, when Albert and Arnett first used radioactive particles in order to investigate mucociliary clearance, several radioisotopic methods have been described. In 1965 Proctor and Wagner measured the nasal mucociliary clearance using a saline solution containing 10-20 μCi of microaggregated albumin labeled with iodine I^{131} and radioactivity was measured externally by means of crystal scintillation detectors. In subsequent works non dispersible radioactive labeled particles (microspherules of Dowex J-x8 labeled with ^{99}Tc04) were employed and they were visualized by means of a gamma scintillation camera (Quinlan and Proctor, 1969).

More recently radiopaque teflon discs labeled with Tc^{99} or Cr^{51} (Simon et al., 1977), Tc^{99m} particles (Guillerm et al., 1971) and Tc^{99m} human serum albumin (Aoki and Crowley, 1976; Rossman et al., 1980; Karjia et al., 1982; Karjia and Nuutinen, 1983; McLean et al., 1984; Nuutinen, 1985; Burgersdijk et al., 1986; De España et al., 1987) were used.

Our nasal mucociliary velocity values are very similar to those of Karjia et al. (1982) and somewhat higher than those obtained by Proctor and Wagner (1965) and Quinlan et al. (1969).

On the basis of the obtained results we could not confirm Puchelle's (1981) results who observed a highly significant correlation between data obtained with saccharine particles and particles tagged with ^{99m} pertechnetate. In fact consistent differences in nasal mucociliary transport velocity have been observed with the different techniques.

Which one of these tests is the most suitable in determining the real mucociliary function is a difficult question to be answered. In fact on one side the saccharine particles are soluble in the mucous, even if they need some time to spread up in the mucous, and can therefore reach the rhinopharynx not only by means of the mucociliary transport mechanisms: on the other side the radioactive particles, namely albumine microspheres labeled with Tc^{99m} are employed as drops and therefore need a soluble medium.

Half time clearance ($T^{1}/_{2}$) data of the radioactive particles, that means the time needed by the 50 % of the radioactive markers to be cleared from the investigated site, are significantly correlated with those of the mucociliary velocity and are therefore reliable in determining mucociliary function. The possibility of measuring such parameter in only one of the ROIs in which the nasal cavity can be divided reduces dramatically the test's duration without reducing its reliability for clinical purposes.

REFERENCES

1. Albert and Arnett cit. by Karjia et al., 1982
2. Andersen I, Lundqvist G, Proctor DF. Human nasal function in a controlled climate. Archs Envir Health 1971; 23: 408-412.
3. Aoki FY, Crawley JCW. Distribution and removal of human serum albumin-technetium ^{99}m instilled intranasally. Br J Clin Pharmacol 1976; 3: 869-878.
4. De España R, Franch M, Garcia A, Pavia J. Measurement of nasal mucociliary transport rate in normal man. Rhinology 1986; 24: 241-247.
5. Guillerm R, Morcellet JL, Riu R, Redon P. Badré R, Hée J. Etude du drainage mucociliaire nasal chez l'homme par scintigraphies séquentielles d'une particule marquée au Technetium ^{99}. Annls Otolar 1971; 88: 303-310.

6. Harper PV, Andros G, Lathrop KA. Preliminary observations on the use of six hours ^{99m} Technetium as a tracer in Biology and Medicine. Argonne Cancer Research Hosp 1962; 18: 76-80.
7. Hilding A. Ciliary activity and course of secretion currents in the nose. Proc Mayo Clin 1931; 6: 825-838.
8. Karjia J, Nuutinen J, Karjalainen P. Radioisotopic method for measurement of nasal mucociliary activity. Arch Otolaryngol 1982; 108: 99-101.
9. Karjia J. Nuutinen J. Immotilie cilia syndrome in children: Int J Ped Otorhinolaryngol 1983; 5: 275-279.
10. MC Lean JA, Bacon JR, Mathews KP, Thrall JH, Banas JM, Hedden J, Bayne NK. Distribution and clearance of radioactive aerosol on the nasal mucosa. Rhinology 1984; 22: 65-75.
11. Nuutinen J. Activation of the impaired nasal mucociliary function. Acta Otolaryngol (Stockh) 1985; 99: 605-609.
12. Ornston DG. Office study of cilia. Archs Otolar 1946; 44: 19-24.
13. Ottaviani F, Rosignoli M, Paludetti G, Almadori G, Pagliari J, D'Alatri L. Reperti ultrastrutturali e funzionali della mucosa respiratoria nella sinusite mascellare cronica. Otorinolaringologia 1984; 34: 317-326.
14. Paludetti G, Todisco T, Damiani F, Tosti M, Tassoni A, Fasanella L. La clearance mucociliare nasale e l'ultrastruttura ciliare nel normale. Otorinolaringologia 1984; 34: 317-326.
15. Paludetti G, De Benedictis FM, Almadori G, Ottaviani F, Maurizi M, Todisco T. Nasal mucociliary clearance in children with seasonal allergic rhinitis. Pres ENT Immunol (in press).
16. Passali D, Bellussi L, Bianchini Ciampoli M, De Seta E. Experience in the determination of nasal mucociliary transport time. Acta Otolaryngol (Stockh) 1984; 97: 319-323.
17. Proctor DF, Wagner HN. Clearance of particles from the human nose. Arch Environ Health 1965; 11: 366-371.
18. Puchelle E, Aug F, Pham QT, Bertrand A. Comparison of three methods for measuring nasal mucociliary clearance in man. Acta Otolaryngol (Stockh) 1981; 91: 297-303.
19. Quinlan MF, Salman SD, Swift Dl. Measurement of mucociliary function in man. Am Rev Resp Dis 1969; 99: 13-23.
20. Rossman CM, Forrest JB, Ruffin RE, Newhouse MT. Immotile cilia syndrome in persons with and without Kartagener's syndrome. Am Rev Respir Dis 1980; 121: 1011-1016.
21. Simon H, Drettner B, Jung B. Messung der Schleimhauttransportes in menschlichen Nase mit ^{51}Cr markierten Harzkügelchen. Acta Otolaryngol (Stockh) 1977; 83: 378-389.
22. Tremble GE. Clinical observations in the movement of nasal cilia. An experimental study. Laryngoscope 1948; 58: 206-210.
23. Wanner A. State of the art. Clinical aspects of mucociliary transport. Am Rev Respir Dis 977; 116: 73-125.
24. Yergin B, Saketkoo K, Michaelson E, Serafini S, Kovitz K. Sackner M. A roentgenographic method for measuring nasal mucous velocity. J Appl Physiol 1978; 44: 964-972.

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