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Is inhalation therapy noxious to the ciliated nasal epithelium?

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SUMMARY

It is well known from in vitro studies that the functional state of the ciliary epithelium is temperature-dependent. The ciliary beat is irreversibly arrested above about 40–45°C. We exposed 30 volunteers to inhalation therapy with hot moist vapour of about 50°C. The functional state of the nasal mucosa was assessed by counting ciliatry beat frequency and the percentage of dead and vital ciliated cells from a vital cytological sampling of the nose before and after treatment. The percentage of vital cells was the same whereas the ciliary beat frequency rose significantly. It is discussed that in the mucosal layer temperatures are not as high as in the inhaled vapour due to the air-conditioning capacity of the nose.

INTRODUCTION

A common kind of treatment for the symptoms of nasal infection and sinusitis is inhalation therapy which consists of the application of vapour of water with often some special ingredients mostly of vegetal origin. This is a well established form of treatment. Scientific studies about its effectiveness are scarce but there are nearly no doubts about its harmlessness. A very common kind of treatment is inhalation therapy at home using boiling water and a towel exposing the whole face to the heat and breathing the moist warm vapour. Recently a special kind of apparatus of plastics has been designed containing hot water and leading the vapour to an adaptor for mouth or nose for a very comfortable kind of inhalation therapy. We knew from our own experience and from measurements in those inhalers that the temperatures can easily exceed 40 and even 50°C. The widespread principle of "the warmer – the better" might lead to even higher temperatures. It is well known from in vitro studies that the activity of the ciliated epithelium is temperature-dependent. An irreversible arrest of ciliary motility is mentioned in the literature between 40 and 55°C (Proetz, 1953; Negus, 1958; Iravani, 1967; Mercke, 1974; Kennedy et al., 1981; Ohashi et al., 1983). With

electron microscopical methods even changes in structure of the ciliary carpet could be shown (Mecklenburg et al., 1974).

As in inhalation therapy temperatures can be reached that might be noxious to the cilia we performed a study to assess the ciliary activity of the nasal mucosa during inhalation therapy with moist heat.

METHODS

To assess the functional state of the nasal ciliated epithelium we used the technique of vital cytological sampling, which has already been published in detail elsewhere (Deitmer, 1986). A nylon brush of about 2 mm diameter is used to take a vital cytological sampling from the nasal mucosa of the patient. This is well tolerable without local anaesthesia. The harvested cells are transferred into a culture medium (Dulbecco's modified medium) at 37 °C and then immediately filled into a counting chamber (Fuchs-Rosenthal, Volume 0.00625 mm^3) usually used for haematological purposes. Under a phase contrast microscope the preparation can be observed with the temperature of 37 °C maintained by a heated microscopical stage. In the graduated chamber the number of totally harvested cells as well as the percentage of vital and dead ciliated cells and squamous cells can easily be determined.

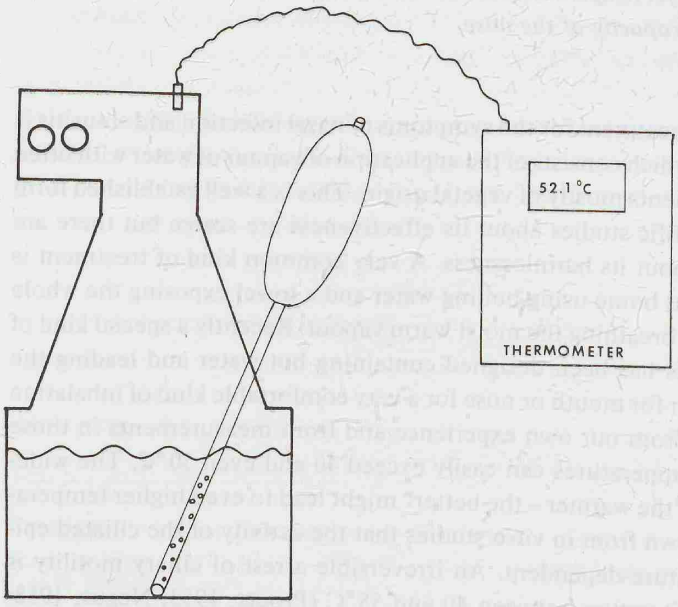

Figure 1. Inhaler with the thermometer installed.

The phase contrast microscope is provided with an integrated microphotometer, which has a photosensitive area of only a few micrometers in the plane of focus. Vital cells can be brought into this photosensitive area leading to varying extinctions representing their ciliary movement. The kind of electronic equipment allows the measurement of ciliary beat frequency. To find non-biased values we performed measurements for 10 subsequent seconds on 10 different most active cells of the preparation and calculated mean values and standard deviations.
Thirty healthy volunteers without nasal symptoms for at least three weeks aged between 16 and 35 years were exposed to nasal inhalation therapy using the device of the Bronchoforton Kombipak® (Figure 1). The inhaler was filled with boiling water from the tap and the patients started inhalation, when temperature was at their convenience. Inhalation time was limited to 10 min. During inhalation temperature of the vapour was measured by a digital thermometer in the nozzle of the inhalation device (Figure 1).
Vital cytological sampling from the nose was performed immediately before and after inhalation.

RESULTS

The mean temperature of the inhaled vapour was 50,5 °C with a standard deviation of 5,8 °C. The course of temperature was not declining, as there is a perlator in this device which is handdriven several times during inhalation leading air bubbles through the hot water and provoking more vapour. Each of these procedures leads to an immediate increase in temperature in the nozzle. Three of the patients endured inhalation temperatures of more than 60 °C.
The total cell count of the preparations before and after inhalation therapy as well as the percentages of the different cell types are outlined in Table 1.
Statistical tests (t-test) were performed comparing the percentages of the cell types before and after inhalation therapy. No significant differences could be found.

Table 1. Totally harvested cells and cell differentiation before and after inhalation of all 30 patients.

	before inhalation	after inhalation
total cells	301.17	270.37
vital ciliated cells	27.9%	26.2%
dead ciliated cells	53.3%	53.0%
squamous cells	18.8%	20.8%

The ciliary beat frequency calculated from 100 single measurements in each preparation are displayed in Table 2 including the standard deviation. The t-test revealed that the increase in ciliary beat frequency during inhalation was significant ($p < 0.03$).

Table 2. Ciliary beat frequency of the preparations before and after inhalation.

patient	before inhalation	after inhalation
1	12.4 (3.18)	11.7 (3.68)
2	9.8 (1.37)	10.9 (1.59)
3	9.1 (3.28)	11.3 (2.03)
4	9.7 (2.84)	10.3 (2.08)
5	6.0 (1.47)	6.1 (1.58)
6	9.8 (1.36)	11.6 (1.71)
7	6.5 (1.33)	8.4 (2.42)
8	5.6 (1.33)	6.1 (2.13)
9	5.9 (1.46)	12.6 (1.24)
10	6.3 (1.49)	5.4 (1.15)
11	10.1 (1.72)	11.6 (0.85)
12	7.5 (1.39)	6.2 (0.93)
13	10.1 (1.99)	8.6 (2.00)
14	9.2 (1.70)	7.5 (1.96)
15	5.5 (1.70)	7.9 (2.17)
16	8.9 (2.57)	9.9 (1.80)
17	11.5 (1.96)	11.1 (1.47)
18	4.9 (1.54)	7.3 (1.63)
19	8.2 (1.12)	13.2 (2.25)
20	7.6 (0.88)	9.4 (1.32)
21	5.5 (0.57)	10.8 (2.04)
22	5.5 (1.02)	6.5 (1.15)
23	4.2 (1.62)	4.8 (1.15)
24	10.0 (1.87)	9.2 (1.75)
25	10.6 (3.37)	8.5 (2.07)
26	9.4 (3.31)	12.3 (1.82)
27	12.6 (0.90)	10.5 (2.13)
28	9.6 (2.03)	11.6 (1.81)
29	8.8 (1.89)	6.1 (0.92)
30	6.9 (0.84)	8.4 (1.55)
mean:	8.25	9.19
sigma:	2.29	2.39

DISCUSSION

Clinical practice shows us beneficial effects of warm inhalation therapy on the symptoms of common cold and sinusitis. This kind of inhalation therapy leads to a decongestion of the nasal mucosa and it can be presumed, that the condensation of vapour on the nasal mucosa helps to liquify the secretions. Although it is well known that the number of vital ciliated cells decreases significantly during a a common cold (Pedersen et al., 1983), there must be kept in mind that the therapy applied for those diseases should not be noxious to the nasal mucosa. This must be suspected looking at the in vitro experiments on the temperature dependence of the ciliated cells.

With our methods no adverse effects could be discovered on the ciliated cells harvested from the nose by cytological sampling. No significant decrease in the percentage of vital cells could be found. The increase of ciliary beat frequency during inhalation therapy, which reaches the level of statistical significance, might be an effect of temperature increase in the nasal mucosa.

An explanation for these findings might be the experiments of Cole (1982), who examined the temperature modifying capacity of the nose and found only moderate temperature changes in the nasal mucosa. A moderate mucosal temperature during warm inhalation could be explained by an inverse effect of air conditioning, when the nose is not exposed to cold, but to relatively warmer air. The same seems to be true for a visit in a sauna, where still higher temperatures are reached without any discomfort to our nasal mucosa.

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