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EYÜP HORASANLI

AYDIN ACAR

BÜNYAMİN MUSLU

MELİH ÇAYÖNÜ

MURAT ÇİMENCAN

See next page for additional authors

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Authors
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Assessment of nasal mucociliary clearance in anesthetists

Eyüp HORASANLI[1], Aydın ACAR[2], Bünyamin MUSLU[3], Melih ÇAYÖNÜ[4,*], Murat ÇİMENCAN[5], Serkan KAYABAŞI[6]

[1]Department of Anesthesiology and Reanimation, Yıldırım Beyazıt University, Ankara, Turkey
[2]Department of Otorhinolaryngology, Ankara Numune Training and Research Hospital, Ankara, Turkey
[3]Department of Anesthesiology, Turgut Özal University Hospital, Ankara, Turkey
[4]Department of Otorhinolaryngology, Amasya University S.S. Training and Research Hospital, Amasya, Turkey
[5]Department of Anesthesiology, Bülent Ecevit University Hospital, Zonguldak, Turkey
[6]Department of Otorhinolaryngology, Aksaray State Hospital, Ankara, Turkey

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Background/aim: To assess mucociliary clearance in anesthetists who were exposed to waste anesthetic gases occupationally.

Materials and methods: The first group consisted of 30 anesthetists who had been working at least 2 years. The control group of 30 subjects was selected from hospital staff with no history of occupational exposure to waste anesthetic gases. Mucociliary clearance time was assessed by measuring the saccharine nasal transit time (SNTT).

Results: Thirty-six women and 24 men aged between 25 and 60 years were enrolled in the study. There were no differences between the anesthetist and control groups in terms of age, sex, height, or weight. The median SNTT for the anesthetists (10 min) was longer than that for the control group (8.3 min). The difference was significant ($P = 0.025$). In addition, there was a significant correlation between the SNTT and the working time ($P = 0.02$). Furthermore, anesthetists who had worked for 4 years or more had prolonged SNTT compared to those who had worked less than 4 years ($P < 0.001$).

Conclusion: The present study demonstrated the impairment of mucociliary clearance in anesthetists. Increasing impairment with increasing working time was also detected.

Key words: Anesthetic gases, anesthetists, mucociliary clearance, nasal mucosa

1. Introduction

Waste anesthetic gases can escape into the air of operating theaters from various components of the anesthesia delivery system during the clinical administration of inhaled anesthetics. In spite of advanced scavenging systems, the amount of waste gases in operating theaters depends on multiple factors, such as the type of anesthesia equipment (closed/open system), the anesthesia techniques (high/low flow rate, use of face masks or laryngeal mask airways, use of uncuffed tracheal tubes), and the methods of anesthetic induction (1–3). Recently, there have been important improvements in taking control of anesthetic gas pollution in health care facilities. Nonetheless, occupational exposure to waste anesthetic gases still occurs (1–3). To date, several studies have investigated the risk of exposure to anesthetic agents. These studies have assessed hematopoiesis, the central nervous system, and behavioral effects, and the effects of anesthetic agents on fertility, carcinogenicity, teratogenicity, and reproduction (1,4–7).

Mucociliary clearance is an important defense mechanism in the human respiratory system, and its impairment, either acquired or genetically determined, can lead to chronic infection of the upper and lower airways (8). Appropriate mucociliary clearance is possible only when there is proper ciliary movement and an adequate mucous blanket (9).

Saccharine nasal transit time (SNTT) has been established as a valid and reliable measure of mucociliary clearance (8–10). The effects of anesthetic gases on mucociliary clearance have also been investigated in studies performed before and after the patients received anesthesia (10–14).

A review of the literature revealed that investigation on mucociliary clearance in anesthetists has not been conducted to date. Thus, the aim of this study was to determine whether there were changes in SNTT in anesthetists who were exposed to waste anesthetic gases occupationally.

* Correspondence: melihcayonu@yahoo.com

2. Materials and methods

2.1. Study design and subjects

The study was approved by the Institutional Review Board of Ankara Numune Training and Research Hospital, and written informed consent was obtained from the subjects after the aim of the study was explained (01.04.2009-024647). This study was carried out in the otorhinolaryngology and anesthesiology clinics of Ankara Numune Training and Research Hospital and included 30 anesthetists who had been exposed to waste anesthetic gases for at least 2 years (Group 1). A group of 30 individuals were also enrolled in the study as the control group (Group 2). The control group was selected randomly from among hospital staff with no history of occupational exposure to waste anesthetic gases. All participants were evaluated with previous medical history, endoscopic nasal examination, and radiological examination. They were all free from apparent otorhinolaryngologic symptoms and signs. Pregnant women, smokers, and subjects with recent medication known to influence the bronchial mucus, marked septal deviation, nasal polyposis, current or history (within the past 3 weeks) of upper respiratory infection or attacks of allergic rhinitis, a history of nasal surgery or allergic reaction to any of the studied drugs, or cardiac, hepatic, and/or renal failure were excluded from the study.

All the operating rooms had active waste gas scavenging systems. All anesthetists were exposed to a complex mixture of anesthetic agents (nitrous oxide, isoflurane, sevoflurane, and desflurane) while working.

Mucociliary clearance time was assessed by measuring the SNTT. All saccharine tests were performed under the same climatic conditions (room temperature 23 °C, relative humidity 60%) and carried out by the same nurse who was blinded to the study and very experienced in the field of otorhinolaryngology. Briefly, more patient nares were subjectively determined before the study. Subjects were asked to sit head upright and a saccharine granule 1 mm in diameter was placed approximately 1 cm posterior from the anterior end of the inferior turbinate. The exact time of saccharine placement was recorded, and subjects were instructed to breathe through the nose with their mouth closed and to swallow every 30 s. The time until the first recognition of sweet taste was recorded, and represented the transport time of saccharin to the oropharynx. If no sweet taste was experienced within 30 min, it was a reason for exclusion from the study. However, all the enrolled subjects had an intact sense of taste.

2.2. Statistical analysis

Statistical analyses were performed using SPSS version 21.0 (SPSS Inc., Chicago, IL, USA). Sample size was calculated as 30 patients in each group to achieve a power of 80% and an alpha error of 0.05. The normal distribution of the variables was first evaluated using the Shapiro–Wilk test. The subjects' demographic data were compared using the Mann–Whitney U test or chi-squared test. The SNTT and working time of the anesthetists were compared using the Mann– Whitney U test. Correlation coefficients (Spearman's rho) were calculated for correlation between the SNTT and working time. The level of significance was set at 0.05.

3. Results

Thirty-six women and 24 men aged between 25 and 60 years were enrolled in the study. There were no differences between the groups in terms of age, sex, height, or weight (Table). The anesthetists' median working time was 4 years (ranging between 2 and 20 years) in Group 1. The median SNTT for Group 1 (10 min) was longer than that for Group 2 (8.3 min) (Figure 1) ($P = 0.025$). A significant difference was also detected between the 2 groups in terms of the SNTT after evaluating the effect of age on SNTT with linear regression (Figure 2). In addition, there was a significant correlation between the SNTT and the working time of the anesthetists ($P = 0.02$, $r = 0.45$) (Figure 3). The median SNTT for the anesthetists who had worked 4 years or more was 12.9 min; for those who had worked less than 4 years, it was 9.0 min. This difference was also significant ($P < 0.001$).

Table. Demographic data of the study groups (Group 1: anesthetists; Group 2: controls).

	Group 1	Group 2	P-value
Age (years)	34	38	0.2
Sex (M/F)	11/19	13/17	0.8
Height (cm)	162	171	0.1
Weight (kg)	62	71	0.08
Working time of anesthetists (years)	4.0	-	-

Data are given as median.

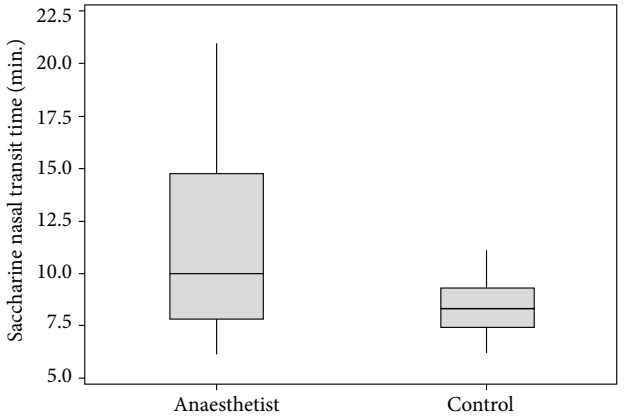

Figure 1. Saccharine nasal transit time according to the groups (box plot model).

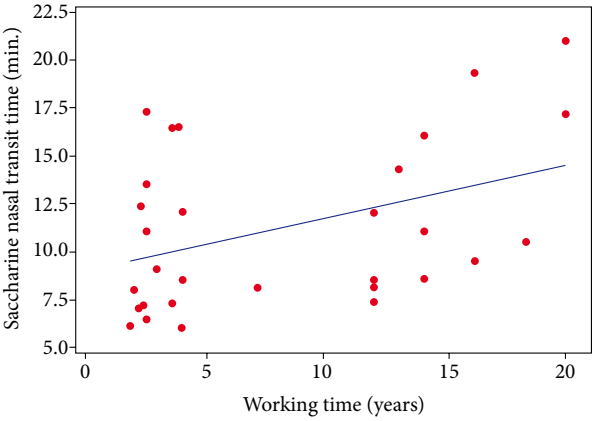

Figure 3. There was a significant positive interaction between saccharine nasal transit time and working time of anesthetists (P = 0.02, r = 0.45).

4. Discussion

The current investigation produced 2 major findings: (1) the mucociliary clearance time was significantly longer in anesthetists group than the control group; (2) as the working time of the anesthetists increased, the mucociliary clearance time increased.

The mucociliary mechanism is the natural best air cleaner, protecting the upper and lower respiratory tracts and the susceptible alveoli. The mucociliary mechanism constitutes the initial line of the airway defense system against harmful particles and other agents in the air (15). Inhaled noxious agents, such as particles, bacteria, and viruses are trapped in the mucus that covers the airways and are transported by the beat of the cilia to the pharynx, where the agents are either swallowed or coughed up (9). This mucociliary system can be impaired due to anatomical abnormalities and diseases of upper respiratory tract. A disturbance in the mucociliary clearance system leads to stagnation of secretions and secondary infections. Therefore, permanently decreased mucociliary clearance activity might predispose individuals to chronic sinusitis, chronic obstructive lung diseases, and bronchiectasis (15).

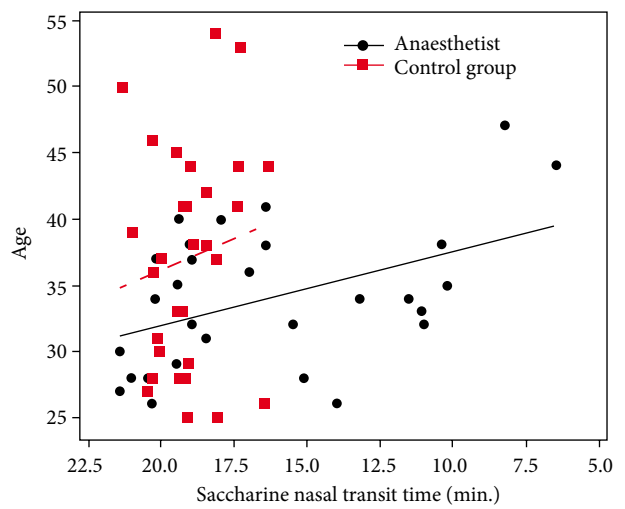

Figure 2. There was a significant increase in saccharine nasal transit time (SNTT) in anesthetists (P = 0.01, r = 0.7). (The difference between the 2 groups in terms of saccharine nasal transit time after evaluating the age factor with linear regression.)

Previous studies have shown anesthesia impairs mucociliary function in humans and animals and in vitro (12,16,17). Volatile anesthetics such as halothane, enflurane, isoflurane, and desflurane, and i.v. anesthetics such as thiopental may be responsible for reduced mucociliary transport (16). In patients undergoing general anesthesia, a number of anesthesia-related factors, such as high oxygen concentration, dry anesthetic gases, trauma caused by suction procedures, and the presence of a cuffed tracheal tube decrease mucociliary clearance (18–21). In addition, volatile anesthetics are known to have dose- and time-dependent inhibitory effects on airway ciliary motility and result in hampered bronchociliary clearance (12).

Raphael et al. (22) demonstrated reversible depression of human respiratory cilia beat frequency in vitro after exposure to 3 minimal alveolar concentrations (MAC) of halothane, enflurane, and isoflurane. In another study, Ledowski et al. (12) found that anesthesia with sevoflurane and remifentanil led to significant impairment in bronchociliary clearance compared to total intravenous anesthesia (TIVA) with propofol and remifentanil. Our findings support the results of Raphael and Butt, who found a significantly reduced ciliary beat frequency in patients anesthetized with isoflurane compared with TIVA with propofol and alfentanil (23). In contrast to our findings, Konrad et al. (14) did not find a difference in bronchial mucus transport velocity between preoperative values and

those assessed at the end of a combination anesthesia with isoflurane and fentanyl.

A review of the literature revealed that investigation of the effects of short-term exposure to anesthetic gases on SNTT is limited to a single study. Kesimci et al. (13) investigated the effect of 3 different routinely used volatile anesthetics on mucociliary clearance as assessed with SNTT. Each group received sevoflurane, isoflurane, or desflurane at 1 MAC after anesthesia induction with propofol, remifentanil, and tracheal intubation with cisatracurium. The authors found that SNTTs were the same before and after the anesthesia. The results did not demonstrate an impairment in mucociliary clearance.

There were several factors affecting mucociliary clearance, such as aging, upper respiratory tract infections, smoking, allergic rhinitis, nasal septum deviation, and climatic conditions (24–26). The possible confounding factors were questioned and examined before the volunteers participated in the study. In our study, it was clearly shown that the mucociliary mechanism was impaired in anesthetists whose had been working for at least 2 years. The most important difference between the operating theater and the other parts of the hospital was the air pollution of the operating theater caused by the waste anesthetic gases (27). We did not work on the direct relationship between the mucociliary clearance and exposure to waste anesthetic gases in this study. However, this pollution caused by the waste anesthetic gases might be responsible for the impairment of mucociliary clearance. Another important finding of this study was the increasing impairment of mucociliary clearance with the increasing working time of anesthetists. Although working time was not exactly the same with the amount of exposure to the pollution of operating theater, there was a positive correlation between the impairment of mucociliary clearance and working time. Anesthetists who worked 4 or more years had worse mucociliary clearance than those who worked less than 4 years. There might be cumulative effects of the waste anesthetics gases on the physiology of the respiratory system.

For all that, there were some limitations of this study. Further studies are needed to determine the reasons of mucociliary impairment in anesthetists and whether the changes in mucociliary clearance were irreversible or not. Moreover, it would be better to investigate another rhinologic parameter and/or conduct a survey for rhinologic complaints of the participants, which could indicate the clinical significance of these findings.

In conclusion, the present study demonstrated the impairment of mucociliary clearance in anesthetists as assessed with the SNTT. Increasing impairment with increasing working time was also detected.

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