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Effect of nasal lavage on nasal symptoms and physiology in wood industry workers*

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SUMMARY

Nasal complaints and impaired nasal physiology are common in various occupational environments. Saline lavage has been recommended as treatment but has not yet been sufficiently evaluated. In this cross-sectional study of 45 wood industry workers, a significant decrease in nasal symptoms (such as obstruction, posterior secretions, itching, irritation and sneezing) was seen after a 3-week treatment with Rhinomer®, which contains de-ionized, sterilized, isotonic seawater. Nasal peak expiratory flow (NPEF), especially in workers with nasal complaints, and nasal mucociliary clearance also improved significantly. The treatment, according to participants, was simple to perform and there were only a few side effects.

Keywords: nasal lavage, wood dust, mucociliary clearance, nasal peak flow, rhinitis

INTRODUCTION

Lavage for nasal cleaning has been recommended for a long time. In 1895, the nose was described in an Editorial in *The British Medical Journal* as: "...one of the dirtiest organs in the body and it should be washed daily with saline." Recently, saline lavage has been recommended for the treatment of rhinitis by the International Consensus Report on the Diagnosis and Treatment of Rhinitis (Lund, 1994).

Theoretically, nasal lavage is indicated for treating dryness of the nose, as seen in atrophic rhinitis or after irradiation, but also for reducing crusts post-operatively or crusting associated with Wegener's disease and collagenoses. Lavage can reduce the load of irritants in certain work environments and also the amount of surface mediators and cells involved in inflammatory reactions, both allergic and non-allergic.

Nasal complaints and impaired nasal physiology have been reported to occur in various occupational environments – i.e., exposure to formaldehyde (Holmström and Wilhelmsson, 1988), solvents (Hellquist et al., 1983) and phtalic anhydride (Nielsen et al., 1992). Wood dust is a well-known local nasal irritant and exposure is often related to a high frequency of nasal complaints (Wilhelmsson and Drettner, 1984). Inflammation of the nasal lining has also been reported in animal experiments (Guney et al., 1987). The risk of developing sino-nasal carcinomas following long-term exposure to wood dust is well known (Acheson et al., 1968). Impaired mucociliary clearance and increased resistance to nasal breathing following wood dust exposure have also been reported (Wilhelmsson and Drettner, 1984) and these may contribute to the development of tumours, because of the prolonged length of time that noxious agents can act on the nasal lining.

Very few studies have been done to estimate the effect of nasal lavage on nasal complaints and still fewer to study nasal pathophysiology. The aim of this study was to evaluate the effect of regular nasal lavage on nasal symptoms, nasal peak expiratory flow and mucociliary clearance in a group workers in the furniture industry exposed to wood dust.

MATERIAL AND METHODS

Subjects

This was a cross-sectional study covering all employees engaged in sanding, sawing, cutting and milling pure wood in five different wood-processing plants. Inclusion was based only on exposure and informed consent, but not on nasal complaints. Forty-eight out of 49 furniture workers agreed to participate in the trial. The subjects were mainly exposed to dust from spruce, pine, birch, beech and oak. Levels of exposure to wood dust were assessed in an elaborate study of all workplaces and interviews with the subjects, supervisors and safety engineers. No measurements were done but conditions were compared with

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data from other studies (Holmström et al., 1989). On this basis, it was estimated that one-quarter of the workers were, on average, exposed to wood dust (total dust) in the range of 2-5 mg/m^3, one-quarter to 1-2 mg/m^3 and the rest to <1 mg/m^3.
Demographic data are listed in Table 1. The diagnosis of allergic rhinitis, based on answers to the questionnaire, was made in 11/48 (23%). Nasal hyperreactivity was reported by 22/48 (46%), defined as nasal irritation (sneezing, rhinorrhoea or blocked nose) when exposed to fumes, odours, dietary or climatic factors. The study was approved by the Ethics Committee of the Karolinska Institute, Stockholm.

Table 1. Demographic data in 48 furniture workers.

age	44±11.8 (range: 21-60)
sex (male/female)	34/14
years in wood industry	18±13.2 (range: 1.5-43)
smokers	12 (25%)
allergic rhinitis	11 (23%)
nasal operations	5 (10%)
nasal medication	14 (30%)

Methods
A questionnaire was distributed before the medical examination to obtain information about general nasal complaints, atopy, hyperreactivity and work conditions.
Medical examinations were performed by an ENT specialist, three times during the study: (1) at inclusion; (2) after three weeks of treatment with nasal lavage; and (3) three weeks after stopping the treatment with nasal lavage (Figure 1). The examinations were performed during work time at the plants, near the work station.

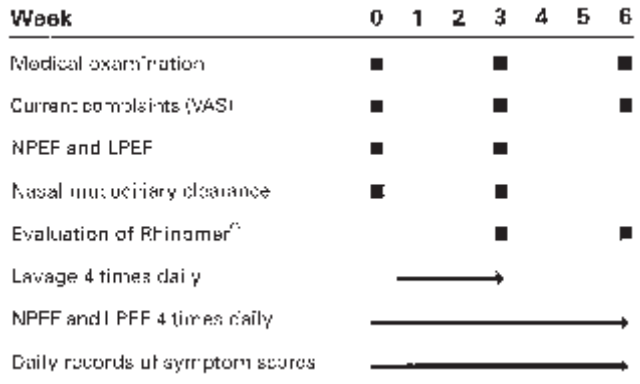

Figure 1. The study protocol.

Current symptoms were evaluated with a visual analogue scale (VAS; 0-100 mm) at the time of the medical examinations. The following nasal symptoms were asked about: nasal obstruction, anterior and posterior secretions, sense of smell, itching, irritation and sneezing. At visits 2 and 3, the effect of nasal lavage was also assessed with VAS.
The subjects were also asked to keep a daily record of their nasal symptoms from weeks 0-6, regarding obstruction, secretions, itching and sneezing. A four-grade scale was used (0: no; 1: mild; 2: moderate; 3: severe symptoms).

Nasal lavage was performed on workdays four times daily (before, after and twice during work). Rhinomer® force 2 (in France, the trademark is Physiomer®, Goemar Laboratories, Saint Malo, France) was used for lavage. This is a new product containing de-ionized, sterilized isotonic seawater, packed under high pressure, in a plastic bottle for repeated use. The pressure in the water stream is adequate for lavage of the nasal cavity and not only for moisturizing the mucosal membrane. Three ml of the water is ejected from the bottle per second. Since the subjects were told to count slowly to three while pressing the nozzle, every lavage on each side contained about 9 ml water.
Nasal peak expiratory flow (NPEF; in l/min) was measured with a mini-Wright Peak Flow Meter (AIRMED, UK) to which an anaesthetic mask (Laerdahl, Norway) was connected. Air flow was measured with the subject in an upright position after the nose was blown. The mean value of the two best measurements of three was used for the calculations. Lung peak expiratory flow (LPEF) was assessed with the usual mouth piece of the mini-Wright peak flow meter and calculated in the same way as the NPEF. Recordings of NPEF and LPEF were done four times daily before lavage. To minimize the effect on NPEF of pulmonary and other factors not related to treatment, the blockage index ([LPEF-NPEF]/LPEF) was also used for the statistical calculations.
Mucociliary clearance (MCC) was evaluated with Cardiogreen® (Becton Dickinson Microbiology Systems, Cockeysville, Maryland, US), a green solution, which was placed on both sides of the inferior turbinate 1 cm behind the anterior border of the turbinate and on the nasal septum on both sides. The subjects were asked to blow their nose before the test, and not to sniff during the study and to breath orally. The time was measured until a green colour was seen in the nasopharynx. A transport time exceeding 20 min was regarded as abnormal.
The protocol used for the study is shown in Figure 1. Week "0" was a running-in period for learning how to perform NPEF and LPEF and for recording symptoms without lavage.

Statistical analysis
Continuous variables recorded on three or more occasions were analysed, using 2-way analysis of variance and Tukey's studentized range for paired comparisons. For analysis of the individual differences in PEF ratios, the Wilcoxon signed-rank test was used. The changes in frequency of patients with MCC >20 min were analysed with the sign test.

RESULTS
Of the 48 subjects included, three never started the lavages (one because of long-term leave, one changed his mind and refused and one because his work made it impossible for him to do lavages). Thus, 45 subjects started the lavage study, but not all of them were able to participate in all three medical examinations, because of changes in work times and sick leaves.
In the questionnaires, perennial nasal complaints were reported by 27/48 (56%) and daily nasal complaints by 26/48 (54%). Nasal obstruction was the commonest symptom reported by 25/48 (52%) and nasal secretions were reported by 20/48 (42%). Of the

27 subjects with nasal complaints, 22 (82%) regarded their nasal symptoms as most marked at work. Ocular complaints were reported by 12/48 (25%) and lower airway complaints by 16/48 (33%). Since many of the subjects had nasal complaints, various types of nasal medication were used (13/45 [29%]) but not regularly in all cases. Thus, 4 used nasal steroids, 1 an antihistamine, 7 an α-adrenergic agonist nasal spray and 1 homeopathic nose-drops. Two subjects had used nasal lavage before.

After treatment with Rhinomer® for three weeks, the VAS values decreased significantly for nasal obstruction, posterior secretions, itching, irritation and sneezing (Table 2). The amount of anterior secretions decreased and the sense of smell improved, but not significantly. After lavage, all nasal complaints returned to a level equal to or worse than those before treatment (Figure 2).

Table 2. Nasal complaints in 48 furniture workers.

annual complaints	27 (56%)
daily complaints	26 (54%)
obstruction	25 (52%)
secretions	20 (42%)
impaired sense of smell	6 (13%)
itching	7 (15%)

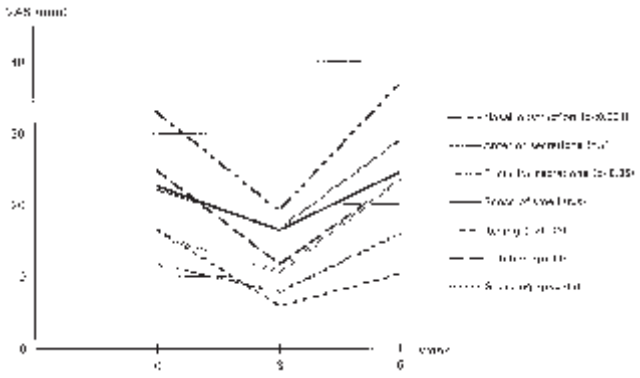

Figure 2. Mean scores for various nasal symptoms during the study (0: before treatment; 3: after three weeks of treatment; 6: three weeks after treatment was stopped).

The daily records on nasal symptoms during the study showed a significant reduction in nasal obstruction during treatment with Rhinomer® ($p<0.05$) and an increase afterwards ($p<0.01$). Daily records on the amount of secretions, itching and sneezing showed no significant changes during the study.

The mean value for NPEF was 315.2±16.1 (range: 110-540) at the first medical examination and 353.5±18.7 (range: 150-660) at the second after nasal lavage for 3 weeks ($p<0.05$). The difference in the blockage index between the first and second examinations also showed better nasal flow, but was not significant ($p<0.06$). However, if the analysis was confined to the group of workers with nasal complaints (n=26), the improvement in the blockage index was significant ($p<0.05$). The increase in NPEF was noted first one week after starting the lavage and it persisted during weeks 4-5 (1-2 weeks after the lavage was stopped; Table 3). No significant change was detected in LPEF at any time in the study.

Table 3. Mean NPEF values before (week 0), during (weeks 1-3) and after nasal lavage (weeks 4-5); n: number of subjects.

week	NPEF	n
0	301	44
1	304	44
2	325	43
3	317	43
4	327	41
5	320	42

Nasal mucociliary clearance exceeded 20 min in 12/44 (27%) before lavage and in 2/40 (5%) after three weeks of lavage. Of the 40 subjects examined at both visits, 9/40 (23%) had a transport time exceeding 20 min before lavage. The improvement was significant ($p<0.05$).

Nasal examination revealed no significant changes between visits 1 and 2 concerning colour of the nasal lining or secretion. Nasal crusting, however, less frequent at visit 2 (10/40) than at visit 1 (15/40) in the 40 subjects who were examined twice. Crusting was assessed as mild in all 10 cases at visit 2, while 5/15 at visit 1 had severe crusting.

Almost all subjects stated that nasal lavage with Rhinomer® was simple to perform (44/45 [98%]). After three weeks of treatment, 39/44 (88%), seen at visit 2, wanted to continue treatment with Rhinomer®. At visit 3, 3 weeks after they stopped treatment, 33/40 (83%) wished to start the treatment again.

Apart from the nasal symptoms, 11/45 (24%) stated that nasal lavage had had positive effects on sore throat and 12/45 (27%) reported positive effects on their lower airways – i.e., easier to breath (11) and reduction in bronchial secretions (2).

One subject, having allergic rhinitis treated with local steroids, stopped nasal lavage because of an increase in allergic symptoms. No other major complication or negative side effect was seen but one subject reported increased problems with anterior epistaxis and another subject complained of throat irritation.

DISCUSSION

This study investigated the effect of nasal lavage on nasal symptoms, NPEF and MCC in a group of workers exposed to wood dust. Although the study design was cross-sectional and daily nasal complaints were reported by only 56% of the group, the number of drop-outs was very low (one subject). However, even if not all participants could take part in all medical examinations because of work shifts, sickness and vacations, the number of workers investigated was sufficient for statistical evaluations.

By using a cross-sectional study design, we were also able to include a sub-group of workers (44%) who had no complaints of nasal discomfort. Of the entire group, 88% wanted to continue nasal lavage. This would suggest that even those who denied having symptoms experienced nasal discomfort not reported in the questionnaire.

In recent years, there have been some reports about the effects of treatment with nasal saline lavage. In the care of post-ethmoidectomy crusting, Pigret and Jankowski (1996) found pres-

surized seawater useful, and Rhinomer® has also been used post-operatively (Seppey et al., 1996). Spraggs et al. (1995) found nasal alkaline douching to be more effective than nasal steroid drops, ephedrine drops or no treatment in post-operative care, 10-14 days after endonasal surgery. In the treatment of perennial non-allergic rhinitis, Spector et al. (1982) showed a significant relief of symptoms with nasal saline, but no effect on eosinophils in nasal smear. Symptom relief has also been noted in allergic and non-allergic rhinitis when using saline with a metered dose pump (Nuutinen et al., 1986). In allergic rhinitis, nasal irrigation with saline has been shown to lower the levels of histamine in the nose up to 6 h after irrigation and leukotriene C_4 up to 4 h (Georgitis, 1994). This effect on inflammatory mediators in nasal secretions supports the clinical efficacy reported for nasal irrigation.

It must be kept in mind that the various studies of nasal lavage/irrigation are not always comparable since the methods used for lavage differ and the methods per se are difficult to standardize, that is to ensure that the amount of water and distribution of water in the nose are the same on each occasion. Even the quality and composition of the water can vary. In this study, some of these problems have been solved since the stream of water is constant with Rhinomer® until the bottle is empty. Moreover, the subjects were instructed (in writing) that it was important to spray the saline solution into the nose in the same way every time.

Nasal mucociliary function was studied by determining the transport time of Cardiogreen. This is a more objective method than the saccharine test and therefore should be used when performing MCC repeatedly. In the first test, MCC exceeded 20 min in 12/44 (27%) of the subjects, which is a higher figure than we have found in earlier studies of control groups not exposed to wood dust (range: 0-3%), but it is comparable to other wood dust-exposed work groups (Wilhelmsson and Drettner, 1984; Holmström and Wilhelmsson, 1988; Åhman et al., 1996). The lower figure after only three weeks of lavage is significant. It was found in earlier studies of ciliary function after exposure to formaldehyde that it takes several weeks before ciliary function recovers after exposure has ceased (Kerns et al., 1983; Chang et al., 1983). It takes several weeks to replace the loss of cilia after an upper airway tract infection with normal epithelium (Jörgenssen et al., 1989). Exposure to wood dust causes loss of cilia and reduces the height of the respiratory epithelium towards that of squamous epithelium (Wilhelmsson and Drettner, 1984). These changes are probably reversible but the amount of time involved remains unknown, especially if exposure is ongoing. Lavage four times daily probably has no effect at all on such changes. The tendency towards improved MCC may be due to better rheological properties of the secretions after lavage.

The patency of the nasal passages was assessed with NPEF, a cheap and reliable method suitable for visualizing nasal obstruction in relation to occupational exposure (Åhman, 1992). The test is easier to perform and more suitable for field studies than rhinomanometry and the two techniques correlate well to each other (Holmström et al., 1990). However, NPEF varies greatly in a healthy population and is mainly appropriate for serial measurements in individual subjects. We also believe that expiratory peak flow is preferable to inspiratory peak flow because of the effects of a forced inspiratory manoeuvre on the nasal valves. The positive effect on both NPEF and the subjective feeling of nasal obstruction in other groups of workers with nasal complaints indicates a true treatment effect.

Approximately 50% of the workers in furniture industries complain of nasal discomfort (Wilhelmsson and Drettner, 1984; Holmström and Wilhelmsson, 1988). The distribution of symptoms in our study group was comparable to that in others. Nasal complaints in such environments comprise mainly cases of non-allergic chronic rhinitis. We have seen increased levels of eosinophil cationic protein in nasal lavage in furniture workers and increased levels of albumin, indicating inflammatory capillary leakage (Granstrand et al., 1997). The therapeutic effects of lavage in the environment studied may be explained in different ways. The load of noxious substances on the mucosa is probably reduced. The wood dust will thus have a shorter time to disturb the mucosa, the secretions and the mucociliary function. The effects of inflammatory cells and mediators may be reduced as well as the crusts and viscous secretions. The effect on inflammatory mediators has already been shown (Georgitis, 1994).

The effect on nasal symptoms, as measured with VAS, mainly seen in the form of nasal obstruction ($p<0.001$), itching and irritation ($p<0.01$). There was also a significant effect on posterior secretions and the need to blow the nose ($p<0.05$ both). Nasal obstruction was the only symptom that showed a significant improvement on daily records during treatment and a recurrence of this after lavage was stopped ($p<0.01$).

The only side effect occurred in a subject with allergic rhinitis treated with daily nasal insufflations of budesonide powder. Her cat allergy became worse, probably because she used the lavage after the powder. She was unwilling to reenter the study and lavage her nose before using the powder. The occurrence of interference of nasal lavage with intranasally administered drugs should be evaluated further.

Since no other major complication was seen, we find no contraindications to the frequent use of nasal lavage as a method of relieving nasal complaints in dust-exposed groups. However, different control measures to reduce the workers exposure to wood dust to an acceptable level is always of primary importance. The study group also showed great interest in continuing lavage. At the end of the study, three weeks after rinsing was stopped, 80% wished to recommence the treatment, many of them had no nasal complaints on entry to the study. This might indicate that the workers are used to a nasal function which is not optimal.

To conclude, we found that nasal lavage with Rhinomer® relieved the nasal symptoms in furniture workers and that the method was simple and safe to perform. It must, however, be emphasized that the use of nasal lavage should be regarded only as a method of treating symptoms caused by poor working conditions.

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