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Occupational rhinitis — possible mechanisms of pathogenesis

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Abstract

Occupational rhinitis has been a prescribed industrial disease in the UK since 1907. It has only relatively recently received significant attention from otorhinolaryngologists although numerous studies have been performed in the past by occupational and industrial health physicians. At the present time the precise mechanisms of pathogenesis are unclear and would appear to be multiple.

Recently interest has arisen because of compensation claims. Diagnosis made on the basis of the clinical history is subject to two problems: firstly, there is difficulty in differentiating between occupational and non-occupational rhinitis, and secondly, clinical histories can easily be feigned. Physical signs would be a more reliable indicator of occupational damage to the nasal mucosa if they differ from the signs normally found in allergic or vasomotor rhinitis. In a series of 100 shipyard workers dry atrophic nasal mucosa was found in 66 and septal ulceration in two. From their clinical histories 78 individuals complained of nasal obstruction, 28 of epistaxis, 42 of hyposmia, 10 of anosmia and 90 of rhinorrhoea. Possible pathogenesis is described.

Key words: Rhinitis; Occupational exposure

Introduction

Occupational rhinitis has been a known entity for many years and recognized as such by the appropriate authorities in various countries including the UK. It has only relatively recently received significant attention from otorhinolaryngologists although numerous studies have been performed in the past by occupational and industrial health physicians. At the present time the precise mechanisms of pathogenesis are unclear and would appear to be multiple. Considerable work has been done in the field of occupational asthma and it is known that rhinitis symptoms often precede the onset of asthma (Kanerva and Vaheri, 1993). It is possible therefore that similar mechanisms are involved in the development of occupational rhinitis.

The major difficulty in performing a controlled trial relating to occupational rhinitis was that some individuals in the test group were pursuing civil industrial injury claims. However it was decided to study 100 ex-shipyard workers as an extended case report.

Materials and methods

A diagnosis of occupational rhinitis is made on a *balance of probability taking into account* the duration of exposure to irritants, the time of onset of the symptoms and the presence or absence of other predisposing factors to rhinitis. In this review of 100 ex-shipyard workers only those with no other likely predisposing factors to rhinitis have been included. Individuals who have known allergies, a strong family history of atopy or marked nasal septal deviation have been excluded as well as those currently smoking or using topical nasal sprays. The age range was 40–73 years with a mean of 56.2 years.

Each individual included in the case report worked in the double bottoms of ships and hence was within a confined space and exposed to welding, burning and paint fumes as well as dust and particulate matter from grinding. Duration of exposure ranged from 10 to 45 years.

The commonest symptoms (Table I) were nasal obstruction (78 per cent), nasal crusting (86 per cent) and rhinorrhoea (90 per cent). Partial or total loss of sense of smell was evident in 52 per cent as tested by smell bottles containing mint, vinegar, cloves, lemon essence, asafoetida and sal ammoniac. Individuals were tested with each smell bottle and asked to confirm whether or not the smell could be detected. This test was obviously subjective both on the part of the patient and the tester and therefore not necessarily reliable in some individuals. Those attempting to feign anosmia will often deny any sensation when subjected to the ammonia from sal ammoniac thus demonstrating the likelihood of a non-organic cause. Three such individuals were excluded from the series.

Nine patients (18 per cent) had received treatment for, or currently had, nasal polypi. Four patients (eight per cent) had proven chronic sinusitis based on clinical and radiological findings.

The nasal mucosal changes (Table II) were variable with a high incidence of mild to moderate atrophic changes with, or without, significant nasal crusting. Nasal septal ulceration was evident in two cases.

It is evident from Table I that nasal crusting, epistaxis,

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TABLE I
SYMPTOMS DESCRIBED IN 100 EX-SHIPYARD WORKERS WITH OCCUPATIONAL RHINITIS

Nasal obstruction	78
Nasal crusting	86
Bleeding	28
Rhinorrhoea	90
Chronic sinusitis	8
Nasal polypi	18
Partial loss of sense of smell	42
Anosmia	10

hyposmia and anosmia occur at a higher frequency than would be expected in a general rhinitis population. The figures in Table II indicate a significantly increased tendency to dry atrophic mucosa and crusting which is not a feature in general rhinitis (Mygind, 1986).

Possible mechanisms of pathogenesis

Direct effect of irritants on nasal mucosa

Any chemical substance which in the form of a gas, vapour, mist, dust or fumes has the potential to irritate or corrode the nasal mucosa may be a causal agent. Steel (1993) prepared a comprehensive list of substances capable of damaging the nasal mucosa. Many studies have been carried out in which long-term exposure to specific substances have been related to histopathological changes. Nickel exposure is known to result in dysplastic changes of the mucosa which can ultimately lead to malignant change (Doll *et al.*, 1970; Pedersen *et al.*, 1973; Torjussen *et al.*, 1979).

Functional disturbances and histopathological changes in the nasal mucosa due to oil mist have also been described (Irander *et al.*, 1980). Odkvist *et al.* (1985) reviewed 62 individuals of whom 21 were exposed to oil mist, 11 to styrene, 10 to solvents and 20 to formaldehyde. A similar number of controls were also reviewed. In the exposed individuals nasal mucosal changes occurred in the majority including loss of cilia, goblet cell hyperplasia, metaplasia and stratified squamous cell metaplasia. Normal ciliated, pseudostratified, epithelium was only seen in a few of the exposed cases unlike the control series in which normal epithelium was present in the majority. Holstrom *et al.*, (1989) demonstrated significant epithelial changes in middle turbinate biopsies of those exposed to formaldehyde when compared to the controls. There appeared to be no correlation between the duration of exposure, dose and the histological changes. Similar studies have shown morphological changes in the nasal mucosa as well as functional disturbances in individuals exposed to chromium, wood dust, copper, salt, dust, nickel and leather (Acheson *et al.*, 1968; Acheson *et al.*,1970; Hadfield, 1970; Askergren and Mellgren, 1975; Torjussen *et al.*, 1979; Hellquist *et al.*, 1983; Holstrom *et al.*, 1989).

It is therefore evident that both histopathological changes and functional disturbances occur as a result of exposure to various irritant substances. Assuming that these changes are reversible it is possible that the symptoms would resolve following cessation of such exposure. However if the chronic inflammatory process is irreversible then the functional disturbances will continue.

Allergic rhinitis

An allergic reaction does not occur on first exposure to a substance. The interval during which sensitization occurs varies from a few weeks to many years. Atopic individuals tend to develop allergy more readily than non-atopics. Atopy is defined as an ability to produce IgE antibodies readily on contact with common environmental allergens encountered in everyday life. It is present in approximately 25–30 per cent of unselected populations although the prevalence is lower after 50 years of age.

Allergy may be induced by the following mechanisms (Parkes, 1982):

(a) *Type I hypersensitivity*
This may be mediated by IgE antibody or in a non-atopic subject by short-term sensitizing IgG antibody. Allergens which may provoke this response include grain dusts, animal products, insect proteins, *Bacillus subtilis* enzymes and castor oil bean.

(b) *Type III hypersensitivity*
This may explain late onset of allergic rhinitis after an individual has been exposed to a particular irritant for a significant period of time. The mechanism of this is uncertain but it is possible that it is IgE mediated.

(c) *Activation of complement via the alternative pathway*
It is possible that this may be responsible in some cases but to what extent is not known.

(d) *Hapten linkage with proteins*
Substances of small molecular weight may act as haptens and form complete allergens. Examples include metallic salts, isocyanates and amino-ethinolemine. Both immediate and late responses can occur.

(e) *Irritation*
Many of the agents which cause allergic rhinitis may act as nonspecific irritants in high concentrations e.g. isocyanates, chlorine, formaldehyde. A single large exposure may result in permanent sensitization and provocation of symptoms by very low concentrations may subsequently occur. Inhalation of inert dusts may also stimulate symptoms as is well described in occupational asthma.

Allergies to epoxy resin have been demonstrated (Nielsen *et al.*, 1989). Kanerva and Vaheri (1993) described allergy to flour dust, wood dust, animal epithelia and natural fibres. These were demonstrated by prick tests, RAST and provocation tests. They also

TABLE II
CLINICAL APPEARANCE OF NASAL MUCOSA IN 100 EX-SHIPYARD WORKERS WITH OCCUPATIONAL RHINITIS

Dry atrophic mucosa and crusting	66
Hyperaemic nasal mucosa	24
Pale 'allergic looking' mucosa	8
Septal ulceration	2

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observed that occupational allergic rhinitis may proceed to bronchial asthma.

If these reactions parallel experiences with occupational asthma, as seems likely, workers with occupational rhinitis will need to be observed for possible development of persistent rhinitis even after removal from the work place exposure. Cross-reactivity is known to occur in sensitized individuals thus making their nasal mucosa more susceptible to general environmental changes including dust exposure and temperature change to which they might not otherwise have reacted. In this context it is likely that a significant proportion of sensitized individuals may not undergo resolution of symptoms following cessation of such exposure (Parkes, 1982; Hudson *et al.*, 1984).

Vasomotor rhinitis

Vasomotor rhinitis may be mediated by local and/or central vascular and autonomic dysfunction. This situation can be triggered by inhalants, chemicals, food, hormonal imbalance, trauma and infection. In the context of cross-reactivity previously described under allergic rhinitis it is apparent that a condition correlating to vasomotor rhinitis may occur as a result of past sensitization (Rea, 1993).

Nasal polypi

Nasal polypi are known to occur as a consequence of inflammatory changes in the nose and paranasal sinuses. These changes may be a result of sensitization (Rea, 1993), allergy or infection. It should be noted that the incidence of nasal polypi is not raised in allergic individuals nor is their pathogenesis fully understood (Drake-Lee, 1994). It is possible that the development of polypi may be precipitated by exposure to irritants.

Olfactory damage

Disorders of olfaction can occur as a consequence of rhinitis or as a direct effect of irritants on the olfactory receptors and their central connections. Following injury to the olfactory nerves their ends regenerate and a heightened or depressed sense of smell as seen in the chemically sensitive individual may result (Rea, 1993). Regeneration in terms of re-establishment of central connections is usually imperfect.

Toluene and xylene are known to travel directly up the olfactory nerves into the brain of mice who are excessively exposed. These solvents probably travel similarly in the chemically-sensitive human (Moller *et al.*, 1966; Rea, 1993). Emmett (1976) demonstrated parosmia and hyposmia induced by solvent exposure in a series of individuals.

Discussion

Occupational rhinitis receives little attention in the standard rhinology texts. Other than the classical nasal irritants, chrome and nickel, very little is documented about physical signs in the nose. The debate is centred on rhinitis symptoms in workers who have been exposed to dust, fumes, chemicals or allergens which do not feature in the standard ENT literature. Work has been performed in the experimental toxicology field using animal models. For example, ammonia exposure in mice has resulted in nasal mucosal changes such as metaplasia and a decrease in mucociliary transport resulting in accumulation of particulate matter in the nose, (Gaafar *et al.*, 1992).

The need for clarification is pressing because this is the area of civil claims and in these actions judgement is made on the balance of probability. This is fortunate because the evidence implicating an irritant as a potential causal factor in industrial rhinitis is likely to come from epidemiological studies. Epidemiology demonstrates only an association between a factor and a disease not a causal relationship.

The mechanism by which an irritant may cause the disease must be postulated. It would be reasonable to expect that nasal mucosa and respiratory mucosa may have similar susceptibilities to similar irritants at least as a starting point with which to analyse the causes of occupational rhinitis. Thus we would expect rhinitis to follow a similar course to that of occupational asthma.

In cases where a specific allergen is suspected immunological assessment may show specific antibodies such as caddis fly allergy in hydroelectric workers (Krawi *et al.*, 1994). In some industries, for example the shipyard industry, multiple potential allergens are present in the working environment. In such circumstances nasal provocation tests are generally impractical unless one particular allergen is strongly suspected and testing is possible for this. Standardization of allergens is presently unreliable in such situations and often their availability is limited or absent (Mygind and Weeke, 1985). We suggest that if a close approximation was found between rhinitis and asthma then the diagnosis of occupational rhinitis could be made with more confidence. If divergence between nasal and occupational pulmonary disease occurs the diagnosis of occupational rhinitis would be weak and challengeable.

In compensation claims the clinical history must always be carefully assessed and inconsistences sought. Physical signs are not easily feigned, in particular the incidence of dry mucosa, crusting and ulceration. These features would achieve a high level of concordance between observers. Hyperaemic mucosa is more subjective but still may be useful. It is important when recording physical signs that it is done descriptively, (e.g. pale, dry, etc) not implying a physiological or pathological process (e.g. congested). The latter term has such a wide interpretation that it can be meaningless.

With compensation claims now being pursued, it was not possible to perform a standard clinical trial but on the balance of probability this study would suggest that shipyard workers do suffer from occupational rhinitis. The weighting on clinical history should be less than that on physical signs such as nasal crusting, epistaxis and impaired sense of smell which do seem to have a higher incidence than in the general rhinitis population. The incidence of dry atrophic mucosa and crusting would appear to be the more reliable physical sign. Hyperaemic mucosa did occur in 24 cases, but this clinical judgement is more subjective. Septal ulceration occurred in two cases. At this level it would be imprudent to come to any firm judgement.

It would appear that several potential mechanisms are

involved in the pathogenesis of occupational rhinitis. The effects of chronic irritation of the nasal mucosa may be compounded by chemical sensitivity and subsequent allergic responses. The latter may be cumulative and permanently rendering the mucosa sensitive to further chemical or dust exposure and physical stimuli.

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