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Occupational asthma due to soft corrosive soldering fluxes containing zinc chloride and ammonium chloride

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ABSTRACT Two cases of occupational asthma due to soft corrosive soldering fluxes used in metal jointing are described in which the diagnosis was based on work related deterioration in daily peak expiratory flow rate and positive responses in bronchial provocation tests. Both fluxes contained ammonium chloride and zinc chloride. Occupational asthma provoked by these agents has not previously been reported.

Introduction

Occupational asthma due to soft, non-corrosive soldering fluxes containing colophony is well recognised.[1-3] Corrosive soldering fluxes are used in plumbing and for the jointing of tins and radiators. There are no reports of lung disease due to such agents. We report two cases of occupational asthma caused by this type of soldering flux.

Case reports

CASE 1

A 56 year old man developed chest tightness and wheeze 18 months after beginning work making tins. The attacks initially occurred only on days when he was making tins, but subsequently he was affected when packing in a different area of the same room. Symptoms came on two to four hours after starting work, and he was often woken at night with breathlessness and wheeze. On two occasions he was admitted to hospital with acute severe asthma. His symptoms improved at weekends away from work and during holidays. He had no nasal symptoms.

During the manufacture of tins soldering was performed with a flux containing ammonium chloride and zinc chloride.

Serial measurements of peak expiratory flow at home and at work showed a work related deterioration in mean daily peak flow, which improved away from work (fig 1). The man was admitted to hospital for bronchial provocation tests, which simulated the soldering process at work except that the tin–lead solder itself was not used. The patient was asked to dip a new soldering iron tip heated to 350°C into the flux and then to remove it until the flux fumes ceased before dipping it in again. There was a 26% fall in FEV_1 after 15 minutes' exposure to the flux. Challenge with ammonium chloride produced a smaller immediate response, a 10% fall in FEV_1 at 10 minutes, and a later fall of 16% 7·5 hours after challenge. There was no change in FEV_1 after exposure to zinc chloride alone (fig 2). Results of other investigations are given in the table.

CASE 2

An 18 year old man noted symptoms of cough, wheeze, chest tightness, and sneezing while working in a small firm making and repairing car and truck radiators. Symptoms developed one year after he started at the workshop. They would come on five to six hours after the beginning of the working day, and persist during the evening and early hours of the morning, usually subsiding by the following morning. He was initially symptom free at weekends away from work and during holidays. Symptoms of wheezing and

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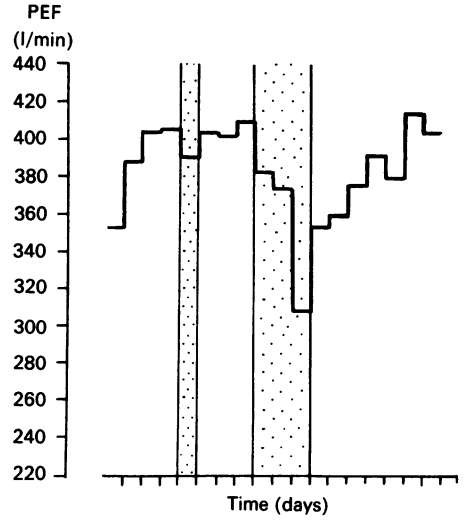

Fig 1 *Daily mean peak expiratory flow (PEF) in subject 1. Days at work have a stippled background. The daily mean peak expiratory flow falls progressively during the short three day period at work.*

chest tightness were also precipitated by exercise, upper respiratory tract infections, and eating bacon.

At work he regularly used a flux containing

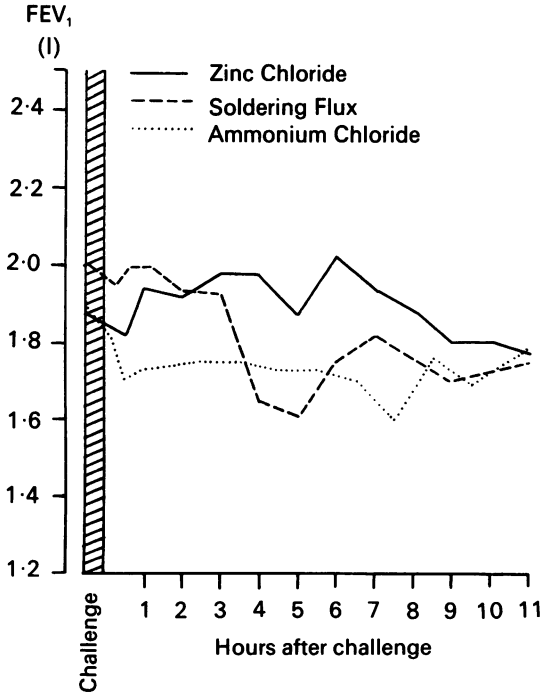

Fig 2 *FEV_1 for subject 1 after 15 minutes' exposure to zinc chloride, ammonium chloride, and the soldering flux, all heated to 350°C as described.*

Results of investigations (other than bronchial provocation tests) in the two cases

	Case 1	*Case 2*
Blood eosinophil count ($\times 10^9$/l)	0·20	0·22
Serum IgE (kU/l)	650	350
Skinprick responses to environmental allergens	Negative	Positive
Smoking	Ex-smoker	Smoker
PC_{20} to histamine (mg/ml) before challenge	8	0·5
FEV_1 (% predicted)	73·4	44·9
FEV_1/FVC (%) at presentation	57	47

ammonium chloride and zinc chloride when soldering radiators. His symptoms were more pronounced after this work but also occurred when he was performing other jobs in the same area of the workshop.

Measurements of peak expiratory flow two hourly from waking to sleeping at home and at work showed unequivocal work related deterioration. Recovery away from work took up to five days (fig 3). Bronchial provocation testing was carried out while he was an inpatient three months after the last exposure to the agent. There was an immediate reaction after 15 minutes' exposure to the flux heated intermittently, as in case 1, to 350°C by a soldering iron, with a fall in FEV_1 of 19%. There had been no change on the preceding day after challenge with normal saline as a control (fig 4). Bronchial responsiveness to inhaled histamine[4] increased after the active challenge, with a 10 fold fall in PC_{20} from 0·5 mg/ml before the challenge to 0·05 mg/ml 24 hours after challenge. Symptoms of

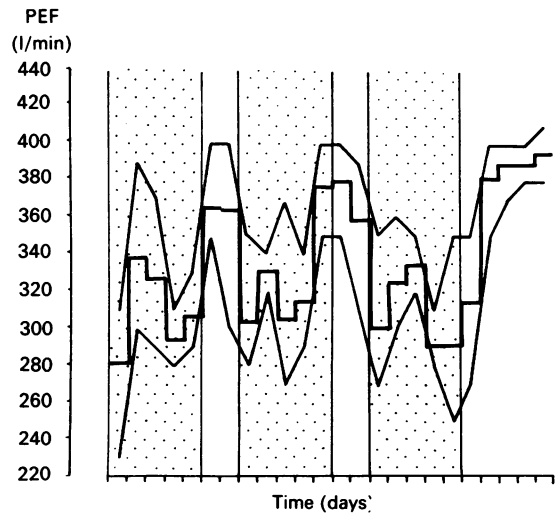

Fig 3 *Daily maximum (top line), mean (middle line), and minimum (bottom line) peak expiratory flow (PEF) in subject 2. Measurements are taken two hourly from waking to sleeping. Days at work have a stippled background. Inhaled salbutamol 200 μg was taken as required.*

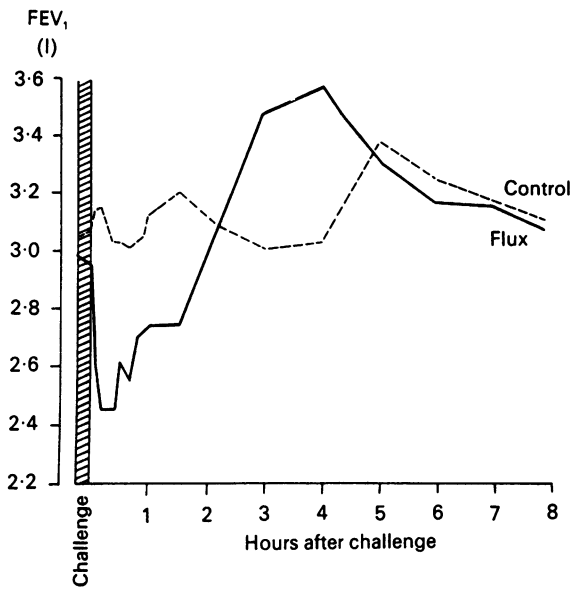

Fig 4 *FEV_1 in subject 2 after a 15 minute exposure to normal saline and the soldering flux heated to 350°C. The liquid was heated for 10 seconds every 30 seconds to produce fumes.*

chest tightness and wheeze were still present six months after the patient had avoided further exposure to the flux by leaving his job. Results of other investigations are listed in the table.

Because of the possibility of a primarily irritant reaction we challenged a control subject with asthma (one of the authors: FEV_1 4·3 l (111% predicted), PC_{20} histamine 4 mg/ml) with the flux used in the second case. There was no fall in FEV_1 or peak flow after 15 minutes' exposure to the fumes. During this challenge the airborne zinc concentration was 0·42 mg/l.

Discussion

Both patients developed classical symptoms of occupational asthma while working with a soldering flux containing ammonium chloride and zinc chloride. Symptoms occurred only after a latent period of at least 12 months in both cases. Both individuals had raised IgE concentrations and one showed positive skin test responses to common environmental allergens at the time of presentation.

The non-immediate reaction to the whole flux and the dual reaction to ammonium chloride in case 1 suggest an allergic basis for the asthma.

It could be argued that subject 2 had atopic asthma before exposure, and therefore showed an irritant immediate reaction to the fume. The striking change in bronchial responsiveness after challenge with the flux and the lack of any effect of the same challenge on someone with atopic asthma who had not been exposed favour a hypersensitivity reaction rather than an irritant effect. Change in non-specific responsiveness is usually seen after late and not after immediate reactions.[5] Possibly a late fall in FEV_1 was missed during sleep; the FEV_1 when subject 2 got up the following morning 20 hours after challenge was 8% lower (0·23 litres) than the values recorded before challenge. This fall did not occur after the control challenge. His continued bronchial hyperresponsiveness after removal from exposure to the substance may be due to pre-existing hyperresponsiveness, though prolonged bronchial hyperresponsiveness despite removal from exposure is well recognised in occupational asthma from other causes.[6,7] The patient had no symptoms before working with the flux, so exposure to the soldering flux seems likely to have been the cause rather than the trigger for his asthma. On balance we believe that the asthma in these two individuals was not irritant in nature, but was due to an allergic or some other hypersensitivity mechanism.

We have not convincingly shown which part of the flux was responsible for the asthma. Although ammonium chloride caused a fall in FEV_1 in subject 1, the magnitude of the response was less than with the whole flux, suggesting that it may not be the whole sensitising agent. Exposure to high concentrations of zinc chloride smoke has been described as a cause of respiratory distress and chest tightness,[8] though our first subject showed no reaction after challenge with zinc chloride solution. Unfortunately in the second case we were unable to challenge with the individual constituents of the flux.

Changes in dietary sodium chloride can alter bronchial responsiveness,[9] and it is possible that high concentrations of chloride ion in the bronchial wall affect bronchial smooth muscle contractility. In vitro, zinc chloride causes the release of histamine from rat macrophages,[10] so a direct local effect of repeated exposure to the fume containing these substances is a possible although putative cause.

Soft, corrosive soldering fluxes should be regarded as a possible cause of occupational asthma, and steps should be taken to minimise exposure to their fumes when heated.

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