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CASE STUDY

Allergic alveolitis following exposure to epoxy polyester powder paint containing low amounts (<1%) of acid anhydrides

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ABSTRACT: Only one case report concerning allergic alveolitis caused by polyester powder paint has been published previously. The aim of this study was to determine whether phthalic anhydride (PA) or trimellitic anhydride (TMA) is the alveolitis-causing agent in such paint.

A 61 year old woman showed recurrent symptoms of chills, cough, and fever whilst at work. She was working in a plant where epoxy polyester powder paints were used to paint metal. The paint was found to contain low (<1%) amounts of TMA and PA.

The patient showed shadowing on chest radiographs. In bronchoalveolar lavage, lymphocytosis (67%) and a low T-helper/T-suppressor ratio (0.2) were found. Transfer factor was within normal limits, but a slight reduction was verified after re-exposure to the paint. The symptoms, exposure, reduction in transfer factor, findings on chest radiographs and bronchoalveolar lavage were consistent with allergic alveolitis.

In conclusion, the polyester powder paint used in the plant caused allergic alveolitis in this patient. Of the constituents in the paint, trimellitic anhydride and phthalic anhydride were the possible causative agents.
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Powder paints have been employed in metal painting during the past 20 yrs, and their use is still increasing. No solvents are needed but they are cured at high temperatures (180–240°C). The patient presented here was exposed to the dust and fume of epoxy polyester powder paint based on trimellitic and phthalic acids.

Epoxy resin, phthalic anhydride (PA) and trimellitic anhydride (TMA) are known to be sensitizers, causing allergic rhinitis and asthma [1]. Allergic alveolitis caused by TMA has not, so far, been reported, but PA has been considered as a potential alveolitis-causing agent [2, 3]. Only one case report concerning allergic alveolitis caused by a polyester powder paint has been reported previously [4]. We present a further case of alveolitis connected with use of polyester powder paint. The alveolitis-causing agents are presumed to be PA or TMA in the paint fumes.

Methods

The specific challenge test was performed according to the principles of the European Academy of Allergology and Immunology [5]. The test was performed in a 6 m^3 challenge chamber, where the patient was exposed to the epoxy polyester powder paint mixed with lactose (1:1). A placebo test was carried out with lactose. In the fume challenge, the paint was heated to 200°C and air samples were collected for acid anhydride analysis [6]. All the challenges lasted 30 min. The symptoms, body temperature, lung auscultation, peak flow and forced expiratory volume in one second (FEV_1), transfer factor and differential leucocyte count were followed-up throughout the challenge tests.

Bronchoscopy and bronchoalveolar lavage (BAL) were performed using techniques reported previously, and millipore and cytocentrifuge preparations of the specimens were made [7].

A routine skin-prick test was performed with 20 environmental inhalant allergens [8]. Hapten conjugates to human serum albumin (HSA) [9] from PA, TMA and epoxy (Epikote X27) were prepared for use in skin-prick tests and antibody determinations. Specific immunoglobulin E (IgE) antibodies against the conjugates were measured using the radioallergosorbent test (RAST) technique (Phadebas RAST method; Kabi Pharmacia AB, Sweden) [10]. Specific immunoglobulin G, M and A (IgG, IgM and IgA) antibodies against these antigens were measured using the enzyme-linked immunosorbent assay (ELISA) technique.

The concentrations of PA and TMA in the paint were assayed as methylesters by gas chromatography [11]. The paint suspected was found to contain free acid anhydrides (0.02% of PA and 0.03% of TMA).

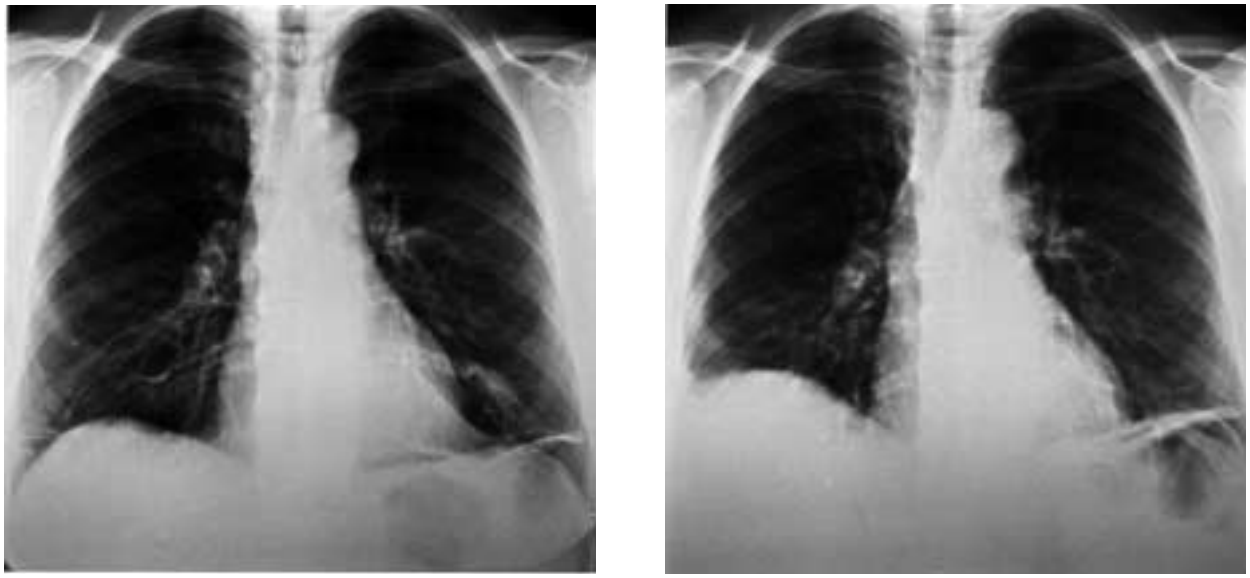

Fig. 1. – Chest radiographic images taken in a municipal health care centre. a) Bilateral thin atelectases are seen in the chest radiograph taken on March 2, 1993. A pneumonic infiltrate is seen anteriorly on the left side. b) In the chest radiograph taken on March 12th 1993, the right diaphragm is elevated, a small amount of fluid is seen in the right lateral corner, and the atelectasis on the left side is accentuated.

Case report

The patient was a 61 year old, nonsmoking woman, without atopic constitution. She had started working at a factory producing electric light equipment in 1985. During the previous 3 yrs, her task was to test, assemble and pack fluorescent lamps. The metal parts of the lamps were painted with a polyester powder paint in the same hall in which the patient worked, separated by only a partial wall reaching two thirds of the total height of the hall.

In February 1993, the patient experienced recurrent symptoms of chills, cough, shortness of breath and headache after days at work. During sick leaves and holidays, the symptoms were relieved. Her condition was at first considered to be a respiratory infection. At the beginning of March, crackles were heard on pulmonary auscultation on the right side. Leucocytosis (13.4–17.3×10^9 cells·L^{-1}), elevated C-reactive protein (CRP) (60–100 mg·L^{-1}), and erythrocyte sedimentation rate (ESR) (16–19 mm·h^{-1}) were found. On chest radiography, thin atelectases were noted (fig. 1). At the end of March, the patient saw the physician at the factory and suspicion of the connection between the symptoms and the work environment was raised. She returned to work, where she again experienced similar symptoms and fever 39.2°C. Her peak expiratory flow (PEF) decreased from 440 to 240 L·min^{-1} during the working day (fig. 2). Spirometry showed moderate combined ventilatory impairment, forced vital capacity (FVC) 1.7 L, 54% of predicted, FEV_1 1.4 L, 56% pred [12]. In a bronchodilatation test, FVC increased by 12% and FEV_1 by 10%.

It emerged that the filters of the air outlet ducts of the factory hall were totally blocked, thus preventing the exhaust ventilation. It is obvious that the paint fumes drifted from the painting area to the other parts of the hall.

The examination of the patient at the Finnish Institute of Occupational Health began at the end of April, 1993. Her chest radiograph and pulmonary auscultation findings were normal. Spirometry showed normal ventilatory function; FEV_1 2.89 L (112% pred); FVC 3.82 L (119% pred) [12]; and transfer factor was normal. On histamine challenge [13], no bronchial hyperreactivity was found. In the bicycle ergometer test, her exercise capacity was 142 W (108% pred [14]), without ischaemia, asthmatic reaction or hypoxaemia. No diagnostic virus

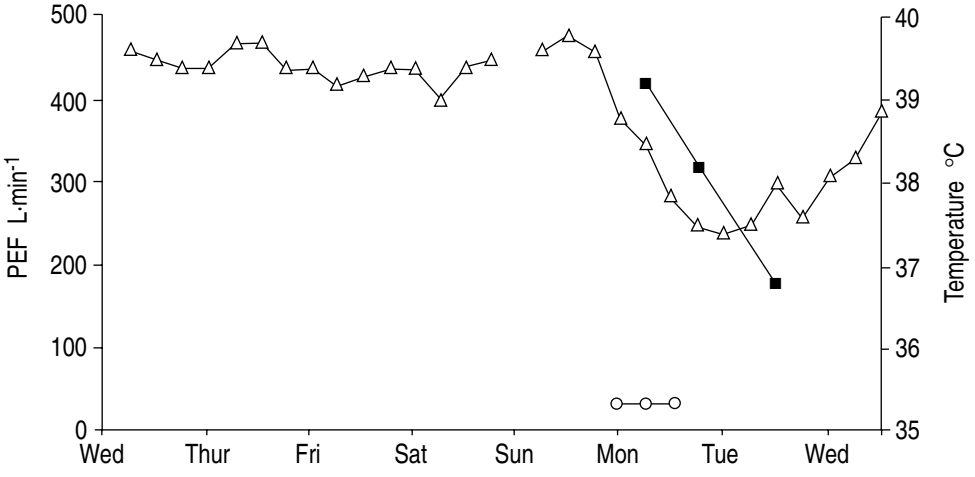

Fig. 2. – Peak expiratory flow (PEF) follow-up before the investigations at the Finnish Institute of Occupational Health. During most of the follow-up the patient was on sick leave. The only working day and the fever reaction during it are indicated. —△— : PEF: —○— : period at workplace; —■— : temperature.

antibody titres were found. Total serum IgE was 76 $kU \cdot L^{-1}$. In the skin-prick tests, slight reactions to dog epithelium, horse epithelium and dust mite were measured; the skin-prick test reactions to phthalic anhydride, trimellitic anhydride or epoxy resin were negative.

The inhalation challenge test with lactose was negative. Following epoxy polyester powder paint dust and fume challenge tests, a maximum depression of 14% of FEV_1 14 h after the challenge was measured. According to the safety data sheet, there was no hint that the paint could contain any anhydrides. It was, however, suspected to contain them [15]. Therefore, PA air samples were taken during the paint challenge test and later analyses revealed a concentration of 0.054 $mg \cdot m^{-3}$ of PA in the air. At that time, a method to measure TMA was not available.

The transfer factor [16] was within normal limits [12] during the challenge tests, but after the powder paint challenge it was reduced by 8%. The specific transfer factor decreased by 16%, but simultaneously the alveolar volume increased by 14%.

Bronchoalveolar lavage (BAL) was performed in June. The BAL cytology showed immunological activation: slightly increased total cell count (199×10^6 $cells \cdot L^{-1}$), lymphocytosis (67%), and a decreased T-helper/T-suppressor ratio of 0.2. In the follow-up, without any exposure, the transfer factor increased by 27%. BAL was repeated in October; and it was found that lymphocytosis has decreased to 38%, but the T-helper/T-suppressor ratio was still low (0.22). Subsequently, when TMA and PA were found in the paint, specific IgE, IgG, IgM and IgA antibody titres were also studied from the BAL supernatant specimen. However, they were not significantly higher than in normal controls. A higher antibody concentration was found in TMA-IgA antibodies and PA-IgM antibodies in the second BAL compared to the first BAL. The specific IgG in serum against TMA, PA and epoxy was negative.

Discussion

The allergic alveolitis of this patient was connected with the paint used in her workplace. The paint was shown to contain two potentially sensitizing and alveolitis-causing substances, TMA and PA. Besides the paints, no other aetiology for the symptoms could be shown. The clinical presentation of the disease, *i.e.* recurrent fever and dyspnoea at work, lymphocytosis in the BAL fluid, and a low T-helper/T-suppressor ratio were compatible with allergic alveolitis. The findings on chest radiography were not typical of acute alveolitis, but compatible with resolving alveolitis. At the very acute phase of the disease, the transfer factor had not been studied. Although the transfer factor was consistently within the reference values, there was a considerable improvement of 27% after the cessation of occupational exposure; this improvement can be construed as support for the diagnosis of alveolitis.

When the patient was examined, it was not known that the paints could contain acid anhydrides. Epoxy resins have been mentioned among the substances causing allergic alveolitis [17], although no case reports on allergic alveolitis caused by epoxy resins were found in the literature. Phthalic anhydride has been reported to cause hypersensitivity pneumonitis [2, 3]. No cases of alveolitis have been reported, though in some reports alveolitis may be involved in the respiratory disease caused by PA exposure [18, 19].

The alveolitis case reported by CARTIER *et al.* [4] has similarities with the present case caused by polyester paint. In that case report, however, the contents of the paint were not studied, although there was suspicion of the presence of TMA in the paint. The paint in the case studied by CARTIER *et al.* [4] most probably contained resins based on acid anhydrides, such as PA, TMA or pyromellitic anhydride, because most polyester powder paints are built on resins containing ortho-esters of these acids [15]. The ortho-ester resins have been found to decompose and generate anhydrides at elevated temperatures (150–280°C) [20]. For these substances, pyromellitic acid has been reported to cause alveolitis [21]. CARTIER *et al.* [4] exposed the patient to TMA, but the other acid anhydride constituents of the paint were not taken into account. Based on the present case, the alveolitis-causing substances identified in the powder paint, phthalic anhydride or trimellitic anhydride, would be the most probable causative agents of alveolitis rather than the insoluble polyester resin in the paint. However, in our own studies, challenge tests with pure PA or TMA were not practicable.

Acidic polyester powder paints contain small residues of acids and anhydrides used as starting compounds for paint resins [15]. When the painted objects are cured at elevated temperatures (180–240°C), the aromatic ortho-esters tend to decompose slightly and produce additional free anhydrides. The anhydrides sublime from the molten paint and appear as airborne fume [20, 22]. The exposure of the workers may, therefore, be both to the paint dust and the fume emitted from the curing oven. The fume is a mixture of vapour and very tiny condensed particles of the anhydrides (particle diameter <1 μm) [22]. The fume exposure may be especially high and dangerous due to the defective ventilation of the oven.

This case has shown that the use of polyester powder paints presents a risk for allergic alveolitis. We assume that this is due to the fact that they contain trace amounts of TMA, PA and resins which are released during the curing process. Consequently, the health risks of the heat-cured polyester resins should be indicated in the safety data sheet, so that workplaces would provide proper ventilation arrangements and adequate protection for the workers.

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