Occupational asthma caused by powder paint in the automotive industry

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Occupational asthma (OA) is characterised by a variable airflow limitation and/or airway hyperresponsiveness (AHR) associated with inflammation due to causes and conditions attributable to a particular occupational environment and not to stimuli encountered outside of the workplace[1]. Diisocyanates are the most common cause of OA in the automotive industry. Powder-painting is an alternative to solvent-based spray painting, and the triglycidylisocyanurate (TGIC) [2], respectively the organic acid anhydrides are identified as themain causal agents of OA[3].

We investigated a 41-year-old woman (ex-smoker with a 20 pack-year history) experiencing asthma on exposure to powder-painting containing aluminium hydroxide, whose specific inhalation challenge (SIC) and environmental assessment provided evidence that this is the most likely causal agent.

This previously healthy patient (with no personal or family history of allergy) had been working for more than 20 years as a control agent in a company specializing in the manufacture of wipers (9 years in the packaging section, respectively 11 years in the control department in the proximity of the painting and drying area of the wiper arms). Five-years ago she had progressively complained of respiratory symptoms (dry cough, dyspnoea, and wheezing), clearly modulated by work-related exposure. The detailed interrogatory identified in her professional environment an indirect exposure to the painting-powderapplied towiper arms containing aluminium hydroxide (20-25%).Skin prick-tests to aeroallergens and to the painting-powder (humidified with the water)on a normal reactive skin (negative control 0 mm, positive control 7 mm) were negative. Chest computed-tomography scan was normal. Functional respiratory tests showed a minimal airway obstruction with a forced expiratory volume in the first second (FEV1) at 2.59L (88% of predicted value), a forced vital capacity
(FVC) at 3.95L (116% of predicted value), FEV1/FVC=0.66, total lung capacity (TLC) at 5.10L (99%), and a transfer factor for carbon monoxide (DLCO) at 75%. The fraction of bronchial exhaled nitric oxide (FeNO), measured during a work period, was normal (4.15 ppb). Her controller asthma treatment was a fixed association by formoterol/fluticasone 20/500 µg/day. Methacholine challenge test during a work period confirmed the presence of an AHR a 27% decrease in FEV1 (2.4L at baseline to 1.7L for a cumulative dose (PD20) of 80 µg of methacholine 1%), associated with asthma symptoms (chest pain, cough and wheezing). Serial monitoring of peak expiratory flow (PEF) at and away from work over a 3-week period allowed the calculation of an OASYS score of 3.9 (normal, <2.5) with a positive predictive value for OA at 83%. A SIC was realized with the painting-powder after stopping her controller asthma treatment 72 hours before. Briefly, the patient was gradually exposed (10 sec, 1 min, 5 min) to the powder and FEV1 was measured after each exposure period. SIC showed an immediate (for the third step of exposure, i.e. 5 min) positive reaction, leading to asthma symptoms and a 16% decrease in FEV1, and followed with return to the baseline state after inhalation of 400 µg of salbutamol. No ocular or nasal associated symptom was present. The monitoring of several parameters before and after SIC showed the airway induced eosinophilic inflammation in the sputum samples analysis (1% vs 8%) without modification of FeNO (5.93 ppb vs 5.70 ppb). The patient was hospitalized for 24 hours clinical and functional respiratory monitoring (measures of FEV1 at 30, respectively 60 minutes after SIC, and of PEF1x/hour in the first 6 hours, followed by twice daily) and she did not experience a late asthmatic reaction. These results confirmed the diagnosis of OA induced by the exposure to the painting-powder containing aluminum hydroxide. The patient changed the position in the company with cessation of the exposure to painting-powder and symptom resolution.

OA has been previously described in the aluminium industry in smelters and welders as well as in factories producing aluminium salts [4–6]. If the exposure to fluorides or aminoethyl ethanolamine was incriminate as possible aetiologies in aluminium smelters [4,6], several data showed that aluminium can cause asthmatic reactions even in the absence of these products [4,7]. To the best of our knowledge, an OA induced by aluminium hydroxide exposure was never described before.

Aluminium hydroxide is a mineral gibbsite, amphoteric in the nature, with both basic and acidic properties and low-molecular-weight of 0.078 kDa (LMW). The mechanism
responsible for the induction of asthma in the present subject is still unknown. Some studies have suggested that LMW agents can act as haptens and induce an IgE sensitization response, and other data T lymphocyte-mediated hypersensitivity reactions [8]. The subject studied did not show immediate skin reactivity to painting-powder containing aluminium hydroxide.

The present case has several typical characteristics for the LMW-OA phenotype as described recently[9]: absence of atopy or other work-related diseases as rhinitis, conjunctivitis, urticaria, high AHR, paucigranulocytic inflammatory sputum profile and normal FeNO level. Currently, the LMW-OA phenotype is associated with a higher prevalence of late asthmatic reaction on SIC but the studied subject presented only an early reaction. In this case, SIC did not increase significantly FeNO level which it is also described more frequently in this phenotype [9,10]. The post-challenge increase in the sputum eosinophil count was significant and similar to the value reported by previous studies [9] confirming the switch from the paucigranulocytic to the eosinophilic inflammatory pattern induced by the exposure to the causal agent. This data could suggest that the sputum eosinophil count could be a better predictive biomarker for the OA that the FeNO level.

We documented a case of OA induced by a painting-powder rarely employed in the automotive industry. In the absence of other causal agents such as TGIC or organic acid anhydrides in this painting-powder, the aluminium hydroxide seems to be the most likely aetiology in this case.

The subject did not have a direct exposure to the causal agent because she did not work in the production sector. The detailed history focused on work exposures and the temporal relationship between exposure and symptom onsets have led to the suspicion and the confirmation of OA.

The diagnosis of OA remains a challenge for clinicians, needs a rigorous stepwise approach, a better standardization and generalization of diagnosis tests of OA including SIC and biomarkers.

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Conflicts of Interest

The authors declare that they have no conflicts of interest.

References


**Figure:**

Changes in FEV1 during challenge tests

FEV1: forced expiratory volume in one second

SIC: specific inhalation challenge

BDT: bronchodilator therapy