Occupational Asthma due to alumina exposure

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Alumina, also known as aluminum oxide (Al_2O_3), is a naturally occurring mineral with a high melting point (2072 °C) and remarkable hardness. Alumina is known for its versatility, featuring high porosity, the ability to absorb heavy metals and contaminants, and exceptional density, hardness, and wear resistance. This makes it invaluable as an electrical insulator, in the production of mill balls, and in equipment for water and gas purification. It is also used to obtain aluminum. At respiratory level, exposure to aluminum or its derivatives in welding workers can cause pneumoconiosis, with or without progression to fibrosis [1], occupational asthma (OA) due to potassium aluminum tetrafluoride [2] and potroom asthma [3]. This last entity, mainly reported in aluminum smelters, is characterized by the appearance of respiratory symptoms similar to asthma in workers producing aluminum using electrolytic cells. It is unclear whether the cause is direct exposure to aluminum or exposure to fluorides associated with these industrial processes [3,4]

To our knowledge, there are no reports in the literature of asthma secondary to exposure to alumina dust. Here we present the first case of OA due to alumina demonstrated through specific inhalation challenge (SIC).

The patient was a 41-year-old man, a smoker of 40 packs/year, obese (BMI 37), with no other relevant history. He had worked for 15 years in the construction of outdoor swimming pools and for the last three years in a company that manufactured absorbent material for insulating purposes, using alumina as raw material. To produce this material, the patient mixed alumina powder with sodium bicarbonate and potassium permanganate for eight hours a day, five days a week. He wore an FFP2 mask at work for respiratory protection.

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Two months after starting the job, he developed rhinitis, conjunctivitis, dry cough and dyspnea. The symptoms began early, approximately one hour after arriving at work, improved with inhaled beta-adrenergics and were clearly work-related, as they abated on weekends and during vacation periods or periods of sick leave.

Respiratory auscultation was normal. A blood test showed an eosinophil level of 300/mm^3, IgE level 902 KU/L and a positive ImmunoCAP Phadiatop test (Phadia AB, Uppsala, Sweden) (41.60 KUA/L). Forced spirometry showed a forced expiratory volume in the first second (FEV_1) of 3.59L (75%, z-score -1.92) and an FEV_1/FVC ratio of 71% (z-score -1.28). The methacholine test was positive, with PC_{20} 6.6 mg/mL and exhaled fraction of nitric oxide (FeNO) 7 ppm. Chest tomography showed nonspecific bronchial thickening.

Given the suspicion of OA due to alumina, a SIC was performed following the recommendations of the European Respiratory Society (ERS) [5]. Briefly, the patient was exposed on successive days for increasing times to a mixture of 20 g of alumina powder with 150 g of lactose in a 7 m^3 challenge cabinet and tipping the mixture from one tray to another at 30 cm from the face. FEV_1 was measured every day prior to exposure, at 10-minute intervals during the first hour after exposure and every hour thereafter for a maximum of 12 hours. The day before the exposure, the patient was tested with placebo (powdered lactose). On the first day after a 10-minute exposure to alumina, the patient presented a progressive drop in FEV_1 seven hours after exposure that reached a maximum of 19% between 10 and 12 hours of exposure (Figure 1). This fall was accompanied by mild bronchospasm that required treatment with inhaled bronchodilators. At 24 hours after exposure, the PC_{20} to methacholine was 4 mg/mL and the FeNO 11 ppb.

OA is a disease characterized by variable airway obstruction and/or bronchial hyperresponsiveness due to causes and conditions attributable exclusively to a specific work environment [6]. It is estimated that the average proportion of asthma cases in adults attributable to occupational exposure is between 10% and 15% and is currently the most common work-related respiratory pathology in

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developed countries [7]. More than 400 agents have been described in its genesis. Among them, metals are especially important, with platinum, nickel, chromium, cobalt, zinc and manganese being the most frequently involved [8] The present description suggests that aluminum should be added to this list.

The tests confirmed the relationship between alumina and the development of OA, but do not allow us to establish the mechanism via which this pathology develops. The high IgE levels, the presentation of atopy and the high eosinophil rate may suggest an IgE-mediated mechanism; however, the late reaction on the SIC might suggest that the immunological mechanism involved was independent of IgE. This last option may be supported by the observation of neutrophilia and elevated IL-8 in induced sputum recorded by Sikkeland et al [9] in 15 healthy subjects exposed to alumina through a SIC performed to assess its ability to generate inflammation in the airway.

In fact, the mechanism involved in the genesis of OA when the agent is a metal is not well defined. Among the possibilities proposed are exposure to platinum in which basically the mechanism involved in the development of asthma is IgE-dependent or exposure to other agents such as chromium or nickel, in which the mechanism can be either IgE-dependent or not [6].

The differential diagnosis of OA due to aluminum must be established with “potroom asthma” and with OA due to other derivatives of aluminum or other metals. It is essential to conclusively determine the source of exposure and the type of industrial process involved in order to identify the agent. While potroom asthma has been related to exposure to different agents that are released during the smelting process [3], other activities such as aluminum welding have been related to the development of OA, demonstrated by exposure to potassium aluminum tetrafluoride [2].

In conclusion, given the increase in the use of aluminum, and especially alumina in multiple industrial processes, exposure to these elements should be acknowledged as a possible cause of respiratory pathology (especially OA). This would make it possible to provide rapid response to potentially affected patients and to implement primary prevention measures designed to avoid future cases.

The patient has given consent for publication.

Conflict of interest

The authors do not have conflicts of interest related to this paper.

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Figure 1. Result of specific inhalation challenge to alumina powder.