Case Study

A Case of Occupational Asthma in Tunnel Workers Exposed to Isocyanates

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Occupational asthma is one of the most prevalent occupational lung diseases in the developed countries. The proportion of the cases of asthma in adults due to occupational exposure is estimated to be 15%. Because occupational asthma may cause long disability, it is important to identify the causes and remove the workers as soon as possible from the causal exposure. One of the main causes of occupational asthma is isocyanates. Because isocyanates are used in the production of polyurethane foams, adhesives, varnishes, insulating materials and hardeners, many cases of occupational asthma due to isocyanates have been reported in many different kinds of occupations.

Pneumoconiosis has been mainly recognized as the occupational lung disease in tunnel workers. There have been no reports of the occupational asthma due to isocyanates in tunnel workers in Japan, and so there has been less concern about asthma in tunnel workers than about pneumoconiosis. Here we report on a tunnel worker who has been exposed to isocyanate and developed asthma.

Case History and Clinical Findings

A 31-yr old man had no personal or family history of asthma, and had smoked 2 packs of cigarettes on a day. He had been employed as a tunnel worker in a small company for 7 yr. He had had a special health examination for pneumoconiosis every year and had no abnormality. In March 1999, he began to do "injection work" which involved polyurethane containing isocyanates for sealing and rock consolidation at the site of subway construction. The isocyanate was 100% polymeric MDI which consisted of 50% -[CH2C3H(NCO)]n-, 30% -[CH2C3H(NCO)]n- 15% -[CH2C3H(NCO)]n- and 5% -[CH2C3H(NCO)]n-. But no occupational safety and health education was carried out to prevent adverse health effects of isocyanates. In May 1999, he began to complain of wheezing and shortness of breath. Just after using polymeric MDI, the symptoms started following itching of the whole body and became prominent in about 2 h. The symptoms continued during the night, but improved on the holiday. Though he was admitted to a clinic and took drugs, he still complained of the symptoms. About a month later, he was finally admitted to our hospital. None of 12 co-workers exposed to polymeric MDI complained of wheezing or shortness of breath.

On admission, wheezing was heard in both lungs. He did not have a fever. Blood tests were normal. Total IgE antibodies were high (970 IU/ml). Both toluene diisocyanate (TDI)-specific IgE antibodies and methylene diphenyl diisocyanate (MDI)-specific IgE antibodies were positive. But other tests for common allergens were negative. A chest x-ray was normal. He began to take steroid, bronchodilator and anti-allergen drugs. We recommended that he should be relocated from "injection work" or use a gas mask during the exposure to polymeric MDI. He used a gas mask but could not be relocated from the work. He continued to complain of wheezing and shortness of breath, both at work and during night. Finally he was relocated from "injection work" in December 1999, and then he was free from the symptoms. Unfortunately we could not perform provocation test with polymeric MDI, because we could not obtain his informed consent. No information was available on the airborne concentration of the isocyanates.

Description of Isocyanate Exposure

The patient worked on subway construction by the New Austrian Tunneling Method (NATM), which is a worldwide practice in tunnel construction. The "NATM" is chiefly composed of the following operations: 1) drilling the rock; 2) removing the rock; 3) sealing and rock consolidation; 4) spraying concrete on the wall. The patient in the present case worked on "drilling the rock" and "sealing and rock consolidation".

"Sealing and rock consolidation" consists of the following operations. After the tunnel workers stab long bolts into the wall, they inject a mixture of polymeric MDI, polyol compounds, catalysts such as amines and a blowing agent to synthesize polyurethane as a hardener to consolidate the wall. The work is performed twice during a working day. It takes one or two hours for the work. The tunnel workers are mainly exposed to the vapor and aerosols of polymeric MDI, when they are injecting it into the rock. They are also slightly exposed to the vapor of polymeric MDI while the lid of the container is left open. They did not use gas masks but dust respirators during the work.
Discussion

The present patient was diagnosed with asthma due to polymeric MDI based on the following information: 1) He did not have pre-existing asthma before exposure to polymeric MDI; 2) The symptoms appeared after he had begun to do “injection work” in the isocyanate-containing environment and disappeared after he was relocated; 3) MDI-specific IgE antibodies were positive, but common allergen were negative; 4) Hypersensitivity pneumonitis was ruled out, because a chest x-ray was normal and he had no fever; 5) Because it is still controversial as to whether the amines can cause occupational asthma in workers exposed to isocyanates, it is difficult to identify the amines as the causal agents of occupational asthma in this case. 6) Although inorganic gases and respirable dust from blasting affected respiratory function and symptoms, the symptoms disappeared at the other tunnel workplace without isocyanates.

Isocyanates are often used in materials for hardeners in the “NATM”. Only Ulvestad B et al. reported about occupational asthma in tunnel workers. They compared 19 injection workers to 104 other tunnel workers with similar exposure, except for that to synthetic resins containing isocyanate. They found that injection workers exposed to isocyanates had a higher prevalence of asthma (26% versus 1%) and bronchial hyperresponsiveness to methacholine (14% versus 14%) than other tunnel workers not exposed. TDI-specific IgE antibody were found in 2 of the 19 injection workers, but in none of the other tunnel workers. Isocyanates-specific IgE antibodies results must be interpreted with great caution. Firstly there is cross-reactivity between TDI and MDI. It is a false-positive test result due to cross-reactivity that TDI-specific IgE antibodies were positive without exposure to TDI in this case. Secondly, current evidence suggests performance of the test for isocyanate-specific IgE antibody has low sensitivity and high positive predictive value (PPV). The test for isocyanates-specific IgE antibody is therefore not only useful as a screening tool for isocyanate-induced asthma, but may also be useful as a confirmatory test among workers in whom isocyanate-induced asthma is suspected. Accordingly, the present case suggests it should be recognized that some tunnel workers exposed to isocyanates develop asthma and that the finding of MDI-specific IgE antibody may be valuable in making a diagnosis of occupational asthma due to isocyanate.

Because polymeric MDI has low vapor pressure, its vapor is minimal at room temperature, but vapor and aerosol of polymeric MDI can be generated during the thermal generation of polyurethane due to its injection. Therefore, the workers must not only use dust respirators but also gas masks as protective devices for polymeric MDI.

We concluded that occupational safety and health management should be carried out for prevention of occupational asthma due to isocyanates the same as for pneumoconiosis in tunnel construction. Attention should especially be paid to tunnel workers in small companies where appropriate occupational health services are not provided. For example, occupational safety and health education and use of the gas mask should be carried out.

And when isocyanate-induced asthma is suspected in symptomatic workers, the test for isocyanate-specific IgE antibody should be considered to confirm occupational asthma.

References