

Occupational Rhinitis Due to Steel Welding Fumes

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Exposure to welding fumes is a recognized respiratory hazard. Occupational asthma but not occupational rhinitis has been documented in workers exposed to steel welding fumes. We report a 26-year-old male with work-related rhinitis symptoms as well as lower airways symptoms suggestive of occupational asthma and metal fume fever associated with exposure to steel welding fumes. The diagnosis of occupational rhinitis was confirmed by specific inhalation challenge. Am. J. Ind. Med. © 2014 Wiley Periodicals, Inc.

KEY WORDS: rhinitis; occupational; occupational rhinitis; nasal challenge; welding; fumes; steel

INTRODUCTION

Exposure to welding fumes in the workplace is a serious and well-known respiratory hazard [Antonini et al., 2003]. Welders are exposed to fumes which can contain different gases (i.e., carbon monoxide, hydrogen fluoride, nitrogen oxide) and oxides of the metals in the material used for welding [Antonini et al., 2004]. Galvanized steel welding is commonly performed in the metal fabricating industry. Exposure to galvanized steel fumes can induce systemic effects such as metal fume fever but it also affects the lower airways causing occupational asthma (OA) and hypersensitivity pneumonitis [Malo and Cartier 1987; Vandenplas et al., 1995; Antonini et al., 2003]. The effect of welding fumes on the upper airways has been less documented and no cases of occupational rhinitis (OR) diagnosed by specific inhalation challenge (SIC) has been published. We describe a case of OR and hypersensitivity pneumonitis due to exposure to galvanized steel welding fumes.

CASE REPORT

A 26 year old welder exposed to galvanized fumes for 7 years was referred to our hospital for investigation of possible OA by SIC. He was a non-smoker with no previous history of asthma and rhinitis. After six months working as solder, he developed symptoms after exposure to steel fumes produced during metal-arc welding. Respiratory symptoms consisted of shortness of breath, cough, wheezing, nasal congestion, clear rhinorrhea and post-nasal drip. Besides, he also complained of fever and muscular aches. His symptoms usually started 2–3 hours after exposure to steel welding fumes and lasted for 24 hours. At that time, the patient underwent initial investigation of asthma, including a bronchial challenge test to methacholine with results within normal limits. Due to respiratory symptoms, he left work for 2 months, which resulted in a gradual improvement of the symptoms with only persistence of intermittent cough and rhinitis symptoms. When he returned to work, he continued having exacerbation of respiratory and systemic symptoms, always after having exposure to galvanized steel fumes. He was treated with inhaled beta-2 adrenergic agent and inhaled fluticasone. However, he never took the medications on a regular basis because the symptoms generally improved during the days with no exposure to fumes at work and during periods away from work. Five years later after the initial symptoms, the patient reported an increase in symptoms severity and further evaluations were carried out at our hospital. Skin prick test was done with a battery of 15 common inhaled allergens and revealed no immediate

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reaction. Lung function tests showed a forced expiratory volume in one second (FEV₁) of 4.13 L (95% predicted) and a FEV₁/FVC ratio of 66% (79% predicted). The provocative concentration of methacoline causing a 20% fall in FEV₁ (PC₂₀) was 0.25 mg/mL. Diffusing capacity for carbon monoxide and arterial blood gas were found within normal limits. Chest roentgenogram was normal.

The SICs were administered in four days. On each day, changes in nasal patency (total nasal volume) were also evaluated by acoustic rhinometry and changes in nasal inflammation by nasal lavage (NAL) [Castano et al., 2009; Vandenplas and Malo, 1997]. Inflammatory cells were counted in NAL before challenge as well as at 30 minutes and 6 hours after the challenge. In addition, white blood cells counts and oral temperature were monitored throughout the SIC procedure. A decrease in total nasal volume between 2 and 5 cm of $\geq 30\%$ from baseline values was defined as a clinically significant response to challenge according to published studies and recommended guidelines for performing nasal challenge test [Rondon et al., 2007] and recommended guidelines for performing nasal challenge test. [Dordal et al., 2011].

On the control day (Day-1 of the SIC procedure), the patient was asked to perform solder on black steel for 30 minutes in the hospital SIC shop and there were no significant changes in FEV₁ and total nasal volume as well as in white blood cells counts and oral temperature. On the specific challenge days, the patient was asked to solder galvanized steel for 10 minutes (Day-2), 30 minutes (Day-3) and 120 minutes (Day-4). No significant changes in lung functional parameters were observed on any of the specific challenge days (data not shown). By contrast, the SIC induced rhinitis symptoms and significant changes in total nasal volume on Day-2 and -3 (Fig. 1). The maximal percentage fall in total nasal volume from pre-challenge values on each day was 65% at 3-hour after exposure (Day-2), 41% at 2-hour after

exposure (Day-3), and 26% at 3-hour after exposure (Day-4) (Fig. 1). The analysis of NAL did not show significant increase in the number of neutrophils or eosinophils on any of the specific challenge days. However, the patient showed eosinophilia before and after challenge throughout the SIC procedure with the highest counts observed on Day-2 when the maximal fall in total nasal volume was recorded.

On Day-2 and -3, no fever or significant change in white blood counts was observed. On Day-4, white blood cells increased from 9,200/ml in the morning to 17,300/ml late in the afternoon. Fever was also observed with oral temperature rising after challenge to a maximum of 39°C.

Therefore, the SIC investigation confirmed a diagnosis of OR, ruled out a diagnosis of OA and suggested the presence of hypersensitivity pneumonitis. Two months later, the patient underwent another SIC procedure and the diagnosis of hypersensitivity pneumonitis was confirmed. Nasal responses were not followed-up at this time. The SIC comprised of another control day and one specific challenge day 48h later, during which the patient performed soldering on galvanized steel for 120 minutes. On the control day, the FEV₁ and FVC were stable throughout the observation period, the maximal temperature was 36.7°C and no leukocytosis was observed. By contrast, the exposure to galvanized steel induced a decline in FEV₁ of 10.6% (from 4.26L to 3.81L) and FVC from 6.36L to 5.82L. In addition, a 19% reduction in diffusion capacity for carbon monoxide was observed. The exposure induced muscle aches and chill and an increase in temperature to a maximum of 38.7°C that was associated with leukocytosis (14,100/ml with 86% of neutrophils). A chest X-ray showed no abnormalities.

The patient was advised to avoid further exposure to galvanized steel welding fumes which resulted in improvement of respiratory and systemic symptoms.

DISCUSSION

The reporting of cases of OR is increasing and new etiologic agents are identified every year. To the best of the authors' knowledge, this is the first report of OR case due to exposure to galvanized steel welding fumes confirmed by SIC. The diagnosis of OR was based on the medical and occupational history and confirmed by the results of the specific inhalation challenge. In our patient, the repeated exposure to galvanized steel welding fumes from the SIC procedure induced rhinitis symptoms and clinically significant nasal congestion. These changes were not observed when the patient underwent SIC by performing manual soldering on black steel.

The effect of welding fumes to the development of OA is well documented. Particularly, welding on steel has been reported to cause asthmatic reactions after SIC indicative of

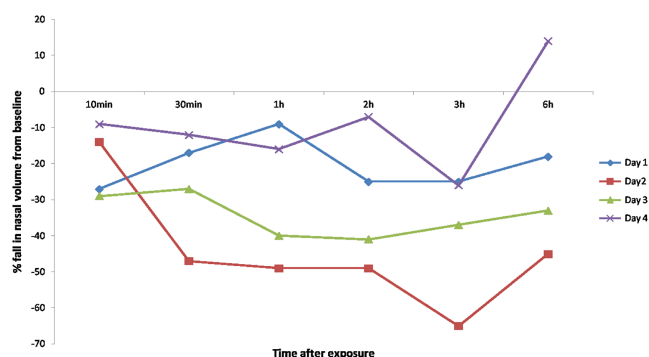


FIGURE 1. Changes in total nasal volume from baseline values after solder on black steel (Day-1) and solder on galvanized steel for 10 minutes (Day-2), 30 minutes (Day-3) and 120 minutes (Day-4).

OA [Malo and Cartier, 1987; Vandenplas et al., 1995; Hannu et al., 2007]. By contrast, the effects of steel welding fumes and gases on the upper airways have been less documented. The prevalence of nasal symptoms was 40.5% in a cohort of 351 welders apprentices [El-Zein et al., 2003]. An occupational survey showed that irritation in the upper airways related to welding was more significant among manual-arc welders than tungsten inert-gas welders. Study findings suggested that chronic rhinitis appeared to be associated with stainless steel manual-arc welding exposure [Kalliomaki et al., 1982]. Galvanized steel welding is known to produce hazardous fumes containing chromium and nickel which are recognized etiologic agents of OA [Antonini et al., 2004]. However, the pathogenic mechanism by which these metals induce the disease is unknown [Hannu et al., 2007]. An IgE-mediated mechanism has been proposed, but it has not been clearly demonstrated as patients showing a positive reaction to inhalation challenge do not consistently show skin reactivity to metal salts [Hannu et al., 2007].

The pathogenic mechanism of OR in our patient is unknown, but might also be related to exposure to fumes containing chromium and nickel. The harmful effects on the nasal mucosa of exposure to these metals are known. For example, they are causative agents of nasal septum perforations [Castano et al., 2007]. IgE-mediated mechanisms have been suggested for cases of OA. In our case, the patient showed eosinophilia in NAL samples collected before and after challenge during control and specific challenge days. However, skin reactivity to metal salts was not evaluated and skin prick tests with common aeroallergens showed negative results.

The pattern of nasal reaction elicited by repeated challenge exposure to steel welding fumes has not been characterized. Although a linear pattern can be postulated, non-linear patterns of the reactions can be hypothesized as well, including a tachyphylactic effect as documented for

asthmatic and rhinitic reactions after exposure to isocyanates by challenge test [Castano et al., 2013; Malo et al., 1999]. In our case, there was a significant decline in nasal volume on the first day of exposure to galvanized steel, followed by a reduced response on subsequent days. The observed pattern of reaction as illustrated in Figure 1 has been described for pharmacologic agents causing nasal congestion but not for potential “sensitizing” agents administered on day-to-day sequence. For example, repeated challenge with bradykinin leads to tachyphylaxis of nasal responses to challenge that are mediated by neurogenic mechanisms [Reynolds et al., 1999]. Another plausible explanation for the reduced nasal response on the subsequent days is that the nose was more blocked at baseline (pre-challenge) on the third and the fourth days compared with the previous days (Fig. 2).

CONSENT

Written informed consent was obtained from the patient for publication of this case report.

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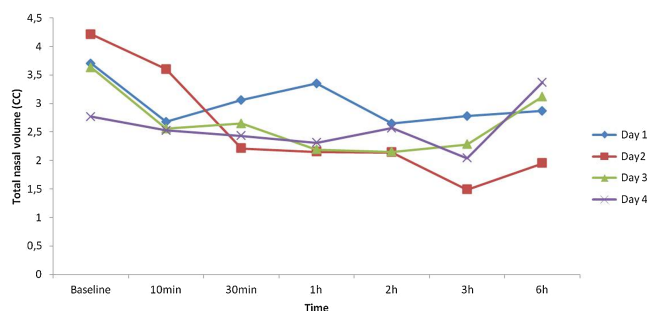


FIGURE 2. Changes in total nasal volume (absolute values) after solder on black steel (Day-1) and solder on galvanized steel for 10 minutes (Day-2), 30 minutes (Day-3) and 120 minutes (Day-4).

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The authors declare that there are no conflicts of interest.