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Case Study

Four Cases of Chemical Burns Thought to Be Caused by Exposure to Chromic Acid Mist

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Chromium is widely used in various industries. The toxicity of chromium and its various compounds is associated mainly with chromium in oxidation state VI. Chromium (VI) compounds are powerful oxidants in acidic conditions; chromic acid and its salts are corrosive or irritating, and chromates sensitize the skin[1]. Occupational dermal exposure to chromium can result in percutaneous absorption and harmful effects to the skin. The major clinical problems in the primary irritation dermatoses are ulcers, which are often called chrome holes or chrome sores[2].

Although many reports have described chronic effects on humans of long-term chromium exposure, few have described chemical burns caused by chromium acid mist.

We describe here cases of chemical burns thought to be due to acute exposure to chromic acid mist.

Case Report

Four male patients (ages 34, 37, 53, and 55) were engaged in stripping off walls in an aluminum rolling factory at night (from 8:00 p.m. to 5:00 a.m.) in the summer. They were not employees of the factory, and were working on request. They had not worked there previously. They wore working clothes, leather gloves, and antidust masks. They noted irritation of their eyes, which became reddish about an hour after starting the work. They also noted painless, non-itchy brown spots mainly on the torso and extremities at the end of the work. After work, the ocular irritation and redness persisted (Fig. 1), and the brown spots gradually became black ulcers in two patients (Nos. 1 and 2), as shown in Fig. 2. They also developed dry cough. In addition, they reported that the leather gloves they had worn shrunk soon after starting the job. They reported that they had not experienced these types of symptoms previously.

The four patients underwent medical examinations at hospital A soon after completing the job. One of them (No. 1) also underwent a medical examination at hospital B about 24 h after exposure. The other three patients (Nos. 2–4) underwent medical examinations at hospital C about 60 h after exposure. Although they underwent medical examinations at various hospitals, the cause of their chemical burns could not be determined.

About 5 wk after injury, they came to our hospital. In two of the four patients (Nos. 1 and 2), black skin ulcers were still scattered mainly on the extremities. WBC counts were 7,900/μl and 13,100/μl, respectively. Biochemical findings and results of urinalysis were normal except for ALT (101 IU/l and 61 IU/l). In the other two patients (Nos. 3 and 4), dermatological findings were almost normal except for some small brown spots. WBC counts were 6,200/μl and 11,300/μl, respectively, and biochemical findings and results of urinalysis were all normal. There were no significant findings on CT of the lungs in patient No. 2 at our hospital, although a reticular shadow was noted on CT at hospital C.

Given the characteristic black ulcers and glove shrinkage, we suspected that the dermatological changes had resulted from a strong acid, such as hydrofluoric acid or chromic acid. We were able to obtain serum from patient No. 1 at hospital B and measured fluoride ion and chromium concentration. Although the serum fluoride ion level was beneath the limit of detection (5 μg/dl), the serum chromium level was 0.15 μg/dl. We then obtained serum samples from patients 2, 3, and 4 obtained at hospital C and measured the chromium concentrations in them. Although the chromium levels in patients 3 and 4 were beneath the limit of detection,

Fig. 1. Redness in eyes after work.

Fig. 2. Black ulcer on leg the day after exposure.

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Fig. 3. Ulcer, which exhibited improvement about 5 months after exposure.

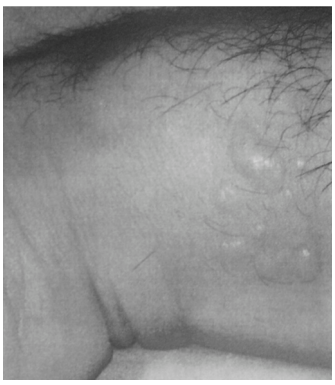

Fig. 4. Serous papules, which appeared suddenly on the hands about 6 months after exposure.

the chromium level in patient 2 was 0.04 μg/d*l*.

The serum chromium levels of three unexposed staff members of our hospital were all beneath the limit of detection, as were those of all the four patients at our hospital.

Although the WBC counts of patients 2 and 4 were over 10,000/μl on the first medical examination at our hospital, that of patient 2 decreased to within normal range about three months after exposure while that of patient 4 decreased to within normal range about two months after exposure without medication. The patients' coughs gradually recovered and their ulcers have improved, as shown in Fig. 3.

Six months after exposure, serous papules appeared on both hands of patient 1 (Fig. 4). Although patch tests for various metals were performed at another hospital, no evidence of allergy to metals was obtained, including chromium. The papules disappeared within a few days without medication.

Discussion

Chromium appears in three forms, chromium metals and alloys, trivalent chromium compounds (CrIII), and hexavalent chromium compounds (CrVI)[3]. Of these, CrVI compounds are considered the most hazardous, and it has been found that the amount of chromium absorbed is related both to the concentration of CrVI and time of exposure[4].

Chromium ulcers caused by chromic acid typically arise only on the skin, and are round or oval growths with reddish edges and necrotic centers. They are not usually painful. They are believed to result directly from the effects of chromate ions[1]. The findings for the dermal ulcers observed soon after injury in our patients were similar to these characteristics, as shown in Fig. 2.

The half-life of Cr(VI) is approximately 39 h after ingestion of a bolus dose of potassium dichromate in drinking water[5]. In addition, elimination of chromium from serum has been found to be describable with an open two-compartment model, with half-lives of 3.16 ± 2.63 h for phase 1 and 50 ± 27 h for phase 2[6]. The normal range of chromium concentration in serum of non-exposed individuals has been reported to be below 0.025 μg/dl[7] and 0.0061–0.0654 μg/dl[8]. These findings suggest that it is reasonable that chromium could have been detected in serum of patients 1 and 2 at 24 or 60 h after injury, though in none of the patients at our hospital.

The serum samples taken at other hospitals were stored in regular refrigerators for several weeks. Total chromium was measured without speciation of chromium forms by atomic absorption spectrometry. Serum chromium levels should thus have been little affected by storage.

Most of the four patients exhibited increase in WBC soon after exposure, and had a dry cough. There are reports that chromium causes bronchial hyper-responsiveness[9], and that high concentrations of chromic acid mist cause coughing, chest pain, and dyspnea as well as pulmonary congestion visible on radiographs[5]. Moreover, interstitial pneumonia has been caused by inhalation of fumes of nickel and chromium[10]. We therefore believe that the pulmonary findings in these patients were due to irritation of bronchi and inflammation of the bronchi or lungs by chromium.

Although it could not be clearly determined whether chromium had been used at the work site, since we could obtain no detailed information on the factory, the findings obtained suggested that the chemical burns resulted from chromic acid.

Chromium is a very common skin sensitizer. Sensitization is reported to require about 6–9 months, but can occur in less than 3 months[11]. Although serous papules appeared in patient 2, he reported no contact with

the chemical agents used in the factory with his skin. Moreover, patch testing for various metals (Al, Co, Sn, Fe, Pt, Pd, Mn, In, Ag, Cr, Ni, Zn, Au, Cu, Hg) was performed, but yielded no evidence of allergy to these metals. Fregert *et al*.[12] reported that skin-patch testing for chromium was positive in 8–15% of all patients suffering from eczema. We were thus unable to clearly determine whether a relationship existed between this patient's serous papules and chromium exposure.

In the present case, injuries occurred because the patients lacked knowledge concerning the substances used in the factory and wore inappropriate clothing. To prevent injury in workplaces, it is important to determine which chemical substances are used there and to use appropriate means of protection against them.

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