

7 cases of hydrofluoric acid burn in which calcium gluconate was effective for relief of severe pain

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We report 7 cases of chemical burns due to hydrofluoric acid (HF). The patients suffered from severe pain. However, the pain was relieved after treatment with calcium gluconate. 6 out of the 7 cases were men. At the accidental exposures, all the patients had been engaged in washing or cleaning work and received burns on their hands and/or fingers. In one case, the forearm was also involved. During such work, all the patients had used rubber gloves, but the gloves had pinholes. For the treatments, 4% calcium gluconate jelly was applied in 5 cases and 4 of 7 were subcutaneously injected with 8.5% calcium gluconate. The involved nails were removed in 5 cases. It is concluded that physicians should provide calcium gluconate jelly and subcutaneous injections to treat an HF burn and should not hesitate to remove the involved nails. To prevent chemical burn due to HF, education and reeducation of workers regarding the hazard of this chemical are necessary.

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Hydrofluoric acid (HF) is widely used for cleansing electronic products, as well as for the etching of glass, ceramics and metals. HF is one of the most corrosive inorganic acids and can produce progressive and serious tissue necrosis with severe pain. However, everyone is now easily able to buy a cleanser containing HF via the Internet. It is predicted that the number of the patients who do not know the danger of HF will increase. Herein we report 7 cases of chemical burns due to HF. All cases recovered without functional disorder after treatment with calcium gluconate.

Case Reports

All 7 cases are summarized in Table 1.

Case no. 1

A 30-year-old man entered our clinic complaining of severe pain in his right hand. He gave a history that he had been using HF 4 hr earlier for cleaning wood. 5 min after the exposure, he felt severe pain in the tip and subungual area of the right-hand fingers. He washed the hand vigorously with water, but the pain in his fingers kept getting worse. On examination, it was found that all digits on the right hand were erythematous and

oedematous, with severe pain. His subungual areas on the index, middle and ring fingers were pasty white (Fig. 1). He was given 2 injections of 8.5% calcium gluconate. However, the severe pain persisted. All the affected nails were removed and necrotic tissue in the subungual areas were debrided (Fig. 2). An ointment of 4% calcium gluconate jelly was then applied to the involved area. The pain was relieved in 3 days.

Case no. 2

A 26-year-old man, who had the job of cleaning tiles, sustained an HF burn to all fingers of his right hand. His glove had pinholes. He washed his hand with soap and water. About 16 hr later, severe pain arose in all his right-hand digits. He entered our hospital 16 hr later. On examination, it was found that all digits on his right hand were white and firmly oedematous, with severe pain. The skin around the subungual area of the right ring finger was black with an erythematous flare (Fig. 3). A 4% calcium gluconate jelly was applied and the nail of the ring finger was removed. He then obtained complete pain relief. No debridement was necessary.

Table 1. 7 cases of hydrofluoric acid (HF) burn

Case	Age (years)	Sex	Location	Concentration of HF	Occupation	Protection	Period up to appearance of symptoms	Period up to first consultation	Clinical appearances	Treatment	Treatment period
1	30	Male	All fingers of right hand	9% HF	Wood cleaning	Vinyl gloves	1 hr	4 hr	White maceration necrosis	Local injection of 8.5% gluconate Ointment of 4% calcium gluconate Removal of nail Debridement	48 days
2	26	Male	All fingers of right hand	Unknown	Tile cleaning	Rubber gloves	16 hr	16 hr	White maceration necrosis	Ointment of 4% calcium gluconate Removal of nail	24 days
3	43	Female	Both hands forearms	7% ammonium bifluoride	Tile cleaning	Rubber gloves	Unknown	3 days	Swelling redness white maceration pustulosis	Ointment of 4% calcium gluconate Removal of nail Topical corticosteroid	33 days
4	27	Male	Right hand	Unknown	Tile cleaning	Rubber gloves	Unknown	1 day	Swelling redness white maceration pustules	Ointment of 4% calcium gluconate Removal of nail	13 days
5	48	Male	Index fingers	0.1% ammonium bifluoride	Tile cleaning	Rubber gloves	1 hr	6 hr	Swelling redness white maceration	Local injection of 8.5% calcium gluconate Topical corticosteroid	15 days
6	21	Male	Right-hand right thumb	0.1% ammonium bifluoride	Tile cleaning	Rubber gloves	Unknown	6 hr	Only pain	Local injection of 8.5% calcium gluconate Removal of nail	33 days
7	29	Male	Left index finger	50% HF	Tile cleaning	Rubber gloves	Unknown	Unknown	Bullae white maceration	Local injection of 8.5% calcium gluconate Ointment of 4% calcium gluconate Debridement	13 days



Fig. 1. White nails of the right index, middle and ring fingers in Case no. 1.

Case no. 3

A 43-year-old woman had a history of using HF for cleaning tiles. The cleanser entered her gloves from her elbow. She vigorously washed her hand with water and applied a traditional oriental ointment, Shiunko[®], but the pain in her forearms and hands kept getting worse. She entered our hospital 3 days later. On examination, it was found that both her hands and forearms were erythematous and oedematous. There were pustules and scales on her elbows and wrists (Fig. 4). She complained of severe pain. A 4% calcium gluconate jelly was applied to the involved area. Her right index finger nail was removed. The pain dissipated in 6 days.

Case no. 4

A 27-year-old man, who had a job of cleaning tiles, sustained an HF burn on all fingers of his right hand. His glove had pinholes. The severe pain arose in all his right-hand fingers. He entered our hospital about 1 day later. On examination, it



Fig. 2. The nails of the right index, middle and ring fingers after debridement of necrotic tissue in Case no. 1.



Fig. 3. White nail and black periungual skin of the right ring finger in Case no. 2.

was found that all digits on his right hand were firmly oedematous and erythematous. A 4% calcium gluconate jelly was applied to the affected areas. The nail of his index finger was removed. He obtained complete relief of pain. No debridement was necessary.



Fig. 4. Erythema, oedema, pustulation and scaling of the left wrist in Case no. 3.

Case no. 5

A 48-year-old man, who had the job of cleaning tiles, sustained an HF burn to both index fingers. His glove had pinholes. He washed his hand with water. 1 hr later, numbness of both index fingers developed. He entered our hospital 6 hr later. On examination, it was found that both index fingers were erythematous and oedematous, with severe pain. The skin of the subungual area of both index fingers was white. He rejected removal of his nail. He was given injections of 8.5% calcium gluconate. 15 days later, serum pooled in the subungual area of both index fingers. He obtained complete relief of pain. No debridement was necessary.

Case no. 6

A 21-year-old man, who had the job of cleaning tiles, sustained an HF burn on his right hand. His glove had pinholes. He washed his hand with water. 1 hr later, numbness and severe pain followed in his right hand. He entered our hospital 6 hr later. On examination, it was found that his right hand was erythematous and oedematous. The subungual area on the thumb was white. He was given injections of 8.5% calcium gluconate. The nail of his thumb was removed. He obtained complete relief of pain. No debridement was necessary.

Case no. 7

A 29-year-old man, who had the job of cleaning tiles, sustained an HF burn to his left index finger. His glove had pinholes. He washed his hand with water. Severe pain soon arose in his left index finger. On examination, it was found that his left index finger was white and firmly oedematous and bullous. He was given injections of 8.5% calcium gluconate, and 4% calcium gluconate jelly was applied. He obtained complete relief of pain. The top of his left index finger was ulcerated. 9 days later, debridement was performed.

Discussion

Calcium gluconate was very effective for the relief of severe pain from a chemical burn due to HF. The chemical burn due to HF is characterized by rapidly developing massive tissue necrosis with severe pain. A 2-stage injury process for an HF burn is reported: a 1st stage of rapidly developing dehydration (coagulation necrosis); and a 2nd stage of delayed tissue destruction by penetration of HF into the deep subdermal tissue (1). The latter is due to binding of F^- ions with tissue

Ca^{++} ions. F^- ions readily penetrate the skin and move quickly to the deep tissue layers, causing liquefaction necrosis of the soft tissue and decalcification and corrosion of the bone, as well as the type of dehydration and corrosion of tissue which other mineral acids produce. Severe pain is probably derived from the release of K^+ ions from the peripheral nerve endings due to the depletion of Ca^{++} ions in the subdermal tissue (2). The process of tissue destruction and neutralization of HF can occur for days, unlike other acids that are rapidly neutralized.

The first and most critical treatment for an HF burn is immediate washing and cleansing of the affected area under an abundance of running cold water. Cold is thought to be beneficial because it restricts the flow of lymph and blood and hinders the development of oedema and the progression of the fluoride ion through the tissue (3).

Topical application of calcium gluconate has been suggested for the HF burn. In the presence of serum, calcium gluconate is only just capable of lowering the concentration of fluoride ions to a level at which their toxic effect is negligible (4). If the concentration of HF is high, calcium gluconate should be injected into the area of the burn until the pain is relieved. Approximately, 0.5 ml of 8.5% calcium gluconate per cm^2 of burned surface area is a rough guide to the usual effective dose. If the burn is on a finger or toe, the injection causes severe pain and care must be taken not to inject so much that circulation will be jeopardized. For a hand injury and first aid, calcium gluconate jelly should be massaged into the affected area for at least 15 min. Topical calcium gluconate treatment is much more effective if the application is started within 3 hr of the injury (1). The recurrence of pain indicates continued activity of the acid and the need for additional calcium gluconate (3).

For a hand injury, the nail involved must be removed in order to prevent pooling of HF under the nail, because HF readily penetrates the skin and goes quickly into the deep tissue layers, causing liquefaction necrosis of soft tissue and decalcification and corrosion of bone.

For large skin burns, hypocalcaemia may occur, and electrocardiogram monitoring should be instituted. If more than 1% of body surface area is involved, 6 calcium tablets in water should be given by mouth (5).

To prevent chemical burn due to HF, education and reeducation of workers regarding the hazard of this chemical are necessary (6). We have been sufficiently warned about such chemical burns and their treatment in both the medical and industrial worlds.

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