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Case report

The clinical effectiveness of the intravenous infusion of calcium gluconate for treatment of hydrofluoric acid burn of distal limbs

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Dear Editor,

Zhejiang Province, located in the southeast China, is a chemical industrial area with a high incidence of chemical burns. In recent years, when the large chemical corporations expanded their plants and increased production, lots of private enterprises and sole proprietorships also arise and enlarge their production scale [1]. Subsequently, work-related chemical burns keep on the rise. According to incomplete statistics, hundreds of patients suffer from the chemical burns each year in Zhejiang Province.

Hydrofluoric acid (HF), a dangerous inorganic acid, has been widely used in plastic manufacturing, industrial cleaning, glass corrosion, semiconductor fabrication, and other industrial fields [2–4]. HF burns occur not only in the workplace, but also in homes and offices [5–7]. HF has a strong corrosion function on biological tissues. The aqueous form of HF is a weak acid due to the high electronegativity of fluoride ion, such that dilute concentrations remain relatively non-ionised. Hence, HF can easily reach deep tissues through intact skin and the lipid barrier, and can generate insoluble salts in combination with calcium and magnesium ions, resulting in increased permeability of the cell membrane for potassium ions, nerve polarization, severe pain, and progressive tissue necrosis [8,9]. Clinical manifestations of HF burns depend on the route of exposure, concentration of the acid, duration of contact, and penetrability or resistance of the tissue exposed [3]. When exposed to the high-concentration HF, the regional skin reveals some degree of surface damage, and intense pain that is easily perceived. When contacting low-concentration HF, such obvious pain may not happen quickly, but delayed skin injuries and pain become inevitable [10]. Among all chemicals resulting in chemical burns, HF has now become the

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most common substance to cause chemical injuries in some regions of China [1].

Critical measures to treat HF burns include blocking progressive injury resulting from fluoride ions. To date, water irrigation and calcium gluconate gel have been recommended as the mainstay of HF burns treatment [4,11], which could be beneficial for the patients with minor HF burns. Based on the fact that distal limbs become the most common body parts of HF injuries [8], some methods, i.e., arterial or intravenous infusion of calcium gluconate, have been developed. Arterial infusion of can directly transport calcium ions to the burn regions, and then combine with fluoride ions [12,13]. So far, arterial infusion has become an increasing popular method for HF burns of the distal limbs. However, Some researchers indicated that the Bier block technique can be a potential alternative to arterial infusion [14]. This technique, initiated by the German surgeon August Gustav Bier in 1908, was originally used for intravenous regional anesthesia [15,16]. Hence this technique was named as Bier block. The rationale behind the Bier block is to exsanguinate the extremity, apply an arterial tourniquet to isolate it from circulation, and inject local anesthetic into the extremities venous system. As early as in 1992, Henry first used the Bier block technique to treat HF burn by regional intravenous infusion of calcium gluconate [17]. Then, Graudins et al. [14] and Ryan et al. [18] also used this method to treat HF burns. However, their reported cases were small, and the clinical effectiveness of intravenous infusion was insufficient. Herein, we report 31 cases of HF burns of the distal human limbs treated using this technique, and introduce our treatment experience.

All 31 patients, including 26 males and 5 females, were collected from the Department of Burns at Zhejiang Quhua Hospital and the Wound Care Center of the Second Affiliated Hospital of Zhejiang University from 2007 to 2012. The age range for all the cases was 18–50 years old, with a mean age of 37.3 years old. All cases were associated with their respective occupations, and included 10 cases of direct contact, 19 cases of broken rubber gloves or shoe covers, and 2 cases of leakage through cotton work gloves. Table 1 lists the demographic and clinical characteristics of the 31 patients. Of the 31 patients, 28 cases had hand burns: 23 limited to finger injury, and the other 5 accompanied by hand palm or back injuries, referring to a total of 47 burned fingers (Fig. 1). The remaining 3 patients had foot burns: their wounds were mainly distributed on the foot pelma, distal back, and toes. Any patients with inhalation injury, disturbance of consciousness, severe diseases of important organs, and other HF injuries beyond the distal limbs were excluded. Patients under the age of 14 years old were also excluded. Each patient did not receive the same or similar treatments related to calcium gluconate postburn. After pre-treatments, i.e., lavage with water for 15 min and wet compressing with 10% calcium gluconate solution for 15 min, the patients with visual analogy score (VAS) [19] scores <4.0 were also excluded.

Eligible patients were treated by the intravenous infusion of calcium gluconate as previously described [14,20], but with a minor modification. Briefly, an intravenous cannula was placed on the dorsum of the affected hand or foot (Fig. 2A and B). After the affected limb was lifted for 1 min, a double-cuffed pneumatic tourniquet was applied above the elbow or

Table 1 – Demographic characteristics and clinical features of 31 patients.

Variable	Number (case)	Percentage (%)
Gender		
Male	26	83.9
Female	5	16.1
Age		
18–30	7	22.6
31–40	12	38.7
41–50	11	35.5
51–60	1	3.2
Burn sites		
Right hand	9	29
Left hand	15	48.4
Double hands	4	12.9
Single foot	2	6.5
Double feet	1	3.2
Burn area (TBSA)		
<1%	30	96.8
1–2%	1	3.2
The time when receiving infusion after injury		
<12	11	35.5
12–24	11	35.5
24–48	8	25.8
>48	1	3.2

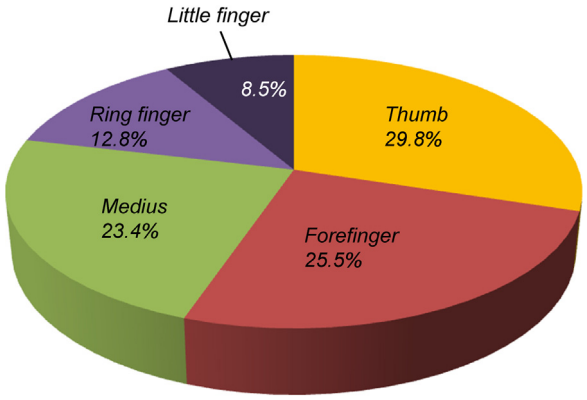

Fig. 1 – The distribution situation of 47 burned fingers of 28 patients.

on the upper part of the crus and inflated to 40 kPa above the systolic blood pressure (Fig. 2C). Elastic bandage colligation was then conducted on the affected limb from the proximal cannula to the distal pneumatic tourniquet, using a pressure of about 8 kPa. A total of 15 ml of 10% calcium gluconate diluted with 35 ml of 0.9% saline solution was infused carefully by the intravenous cannula, which was completed in 2 min (Fig. 2D). After ischemia was maintained for 20 min, the rubber tourniquet was strapped below the elbow or above the ankle. Following cuff release, the rubber tourniquet was sequentially removed from the proximal to distal end with a time interval of 2 min (Fig. 2E and F). Finally, the elastic bandage was removed. For patients with bilateral limbs, one affected limb received regional infusion firstly, followed by the other. During the above process, the dynamic electrocardiograph monitoring was necessary. Furthermore, the subsequent wound treatment was conducted using the following procedure if