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Injuries following a serious hydrofluoric acid leak: First aid and lessons

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ABSTRACT

Hydrofluoric acid is a dangerous inorganic acid that can cause local corrosion and systemic effects by ongoing absorption via the skin, mucosae, respiratory tract and digestive system. Recently, a serious toxic leak of low-concentration hydrofluoric acid solution occurred in the Pujiang area of Zhejiang Province, China. This accident resulted in 253 cases of chemical injury due to hydrofluoric acid exposure. Despite an immediate response by the local and provincial health-care system, as well as the local government, three people died due to acute poisoning and related complications. This article describes the events that took place leading to casualties as well as presenting the first-aid experience and the lessons learnt from this kind of mass injury.

1. Introduction

Hydrofluoric acid (HF) is a dangerous inorganic acid currently used in the chemical industry, electronics manufacturing, etching and cleaning, etc. [1]. HF can enter the body via the skin and mucosal layers, causing severe corrosive effects and even systemic toxicity. [2,3] It has been reported that HF can penetrate the skin in only 5 min [4], and this absorption process is further accelerated in the digestive and respiratory systems [5]. Severe HF poisoning can result in death within several hours of exposure. HF injury usually occurs in sporadic cases, with multiple cases being rare. Most HF burns are work related, and young males are most commonly involved [6]. Since the applications of HF have become increasingly widespread, HF injuries now occur relatively frequently in the workplace and even in the domestic setting [7]. According to documented cases in the literature, serious accidents resulting in large numbers of HF injuries have occasionally occurred in the past. For example, on the 27th of September in 2012, a leakage of about 8 t of HF gas in Gumi, South Korea, occurred, which killed five workers and injured 18 others, with thousands of local citizens complaining of respiratory symptoms [8]. In China, Qiu et al. reported 48 workers who were

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injured concurrently by leakage of rust remover containing a low concentration of HF [9]. Although the average burnt area was <2% of the total body surface area (TBSA), 13 patients simultaneously presented with symptoms of pharyngeal discomfort, chest tightness and nausea due to inhalation of the toxic vapour [9]. The boiling point of HF is only 19.5 °C in the anhydrous state, and its aqueous solution can release an irritating odour. Inhalation of HF leads to signs and symptoms such as chest tightness, pulmonary oedema and haemorrhage [10]. The higher the concentration of HF, the more likely it is to cause inhalation injuries; however, a low concentration of HF also has the potential to cause such injuries [1]. As is known, HF molecules can penetrate human tissues produce large numbers of fluoride ions that bind to calcium and magnesium ions, causing severe pain, progressive tissue necrosis, severe arrhythmia and even death [11–15]. Hence, the critical measures for the treatment of HF burns are to block the ongoing HF absorption and reduce the progressive destruction caused by fluoride ions.

Recently, a serious accident occurred due to a considerable leakage of HF in the Pujiang area of the Zhejiang Province in China, resulting in 253 cases of chemical injuries. Although treatment was administered as soon as possible, three people died of acute HF poisoning and related complications. This article presents a comprehensive review of not only the events leading to the collision but also the description of measures taken to treat patients with multiple injuries due to HF. The article finally draws upon the experience gained from the devastating event to introduce the lessons learnt for dealing with accidents of such a nature.

2. Accident presentation

Pujiang, located in the west of the Zhejiang Province, is a small agricultural town with a population of 400,000. Although there are more than three middle hospitals providing medical services, the medical level remains low compared with the surrounding areas.

At 22:00 on 7 May 2014, a multi-vehicle chain-reaction pile-up occurred at the Pujiang section of the Hangjinqu expressway (Fig. 1). The traffic accident, involving six vehicles, was initially caused by a single roll of industrial paper weighing ~0.9 t that fell from the first truck. The second truck screeched to a sudden halt, which caused the following van to collide with the guardrail and catch fire. A fourth truck entered the devastating pile-up, and it was sideswiped by a tank wagon travelling behind it. The impact from the collision resulted in a ~70-cm crack in the tank wagon, causing a large volume of the liquid chemical with a strong, irritating odour to leak from the broken tank. The chemicals leaked into the cab of the tank wagon, as well as the open roof of the sixth vehicle (a private car), which was located directly under the tank wagon.

The designated male driver of the car, along with the male passenger next to him, and the two male drivers of the tank wagon were immediately exposed to the liquid chemical and irritating vapour. The other drivers and passengers from the nearby vehicles successfully fled the accident scene, with no evident chemical exposure.

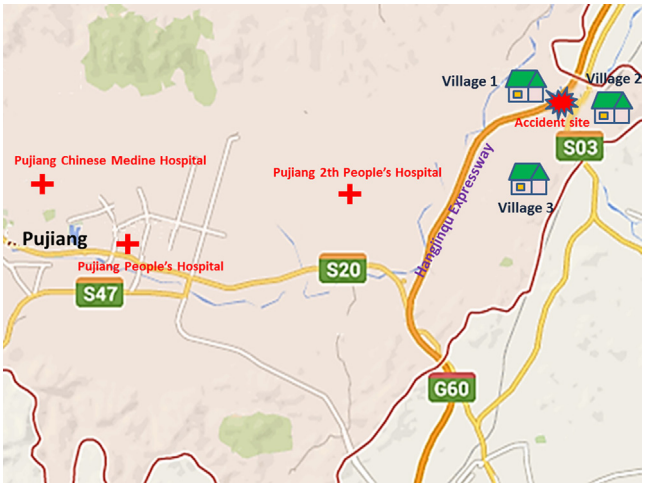

Fig. 1 – Location of the accident site and the hospitals in Pujiang. The straight distance on the map from the location of the accident to the nearest Pujiang Second People's Hospital was about 8.3 km, to the Pujiang People's Hospital 16 km and to the Pujiang Chinese Medicine Hospital 30 km.

Alerted by the vigorous flames, volunteer rescuers reached the collision site from the surrounding villages approximately 15 min after the accident, and they reported this fire accident to the superior departments. At that time, HF had not been identified as a potential threat. The volunteer rescue team immediately worked to extinguish the fire, and to decontaminate the exposed victims with copious lavage. The information regarding the HF leak was confirmed by the drivers of the tank wagon, which was then immediately reported to the local authorities. Meanwhile, the four patients directly exposed to HF were quickly sent to the nearby hospitals by ambulance. Subsequently, an emergency rescue programme was launched by the local government.

About 35 min after the accident, volunteer rescuers were replaced by professional firefighters, who were fully armed with the standard protective equipment, such as the chemical protective clothing and self-contained breathing apparatus. Most of the volunteer rescuers had suffered injuries due to inhalation of the irritating gas or contact with contaminated objects at the accident scene. Some bystanders and villagers downwind of the devastation site, as well as some subsequent environmental workers, simultaneously involved in the rescue mission soon became victims.

About 50 min after the accident, the emergency rescue programme was executed by the local government. All the staff members were divided into six groups, each group with different duties (listed in Table 1). An evacuation area with a diameter of 1.5 km was designated. At the accident scene, the firefighters acted to dilute the surrounding chemical leakage with copious amounts of water, and to neutralise the leaked HF with caustic lime powder. Meanwhile, the crack on the tank was also blocked. However, over the next few days, the damage caused by the chemical leakage did not limit itself to people as large amounts of crops in the surrounding area were also affected, gradually withering. Further investigation of the