Hydrofluoric acid burn: a case report

Roohi Qureshi, MD;[*] Ronald House, MD;[*] Eric Uhlig, MD;[†] Leon Genesove, MD;[‡] D. Linn Holness, MD[*]

ABSTRACT
A case of occupational hydrofluoric acid exposure is presented, accentuating the importance of eliciting an occupational history during the initial emergency department evaluation. Patients who present with major hydrofluoric acid burns are at risk for systemic complications, including potentially fatal hypocalcemia. Information regarding the accident and workplace circumstances may well allow the physician to anticipate the exposed patient's course. These patients should be considered occupational index cases that will require follow up by government occupational health services. Identification of potential hazards, risk assessment and enforcement of recommendations for change (such as engineering controls, personal protective equipment, education) may be key to preventing similar injuries in the future.

Key words: hydrofluoric acid burn, occupational exposure, index case

RÉSUMÉ
Nous présentons un cas d'exposition professionnelle à l'acide hydrofluorique, soulignant l'importance d'obtenir des renseignements sur l'occupation lors de l'évaluation initiale au département d'urgence. Les patients qui sont reçus à l'urgence pour des brûlures importantes causées par l'acide hydrofluorique sont susceptibles de développer des complications systémiques, notamment une hypocalcémie potentiellement fatale. L'information concernant les circonstances de l'accident et du lieu de travail peut permettre au médecin d'anticiper l'évolution des symptômes du patient. On doit considérer ces patients comme des probants qui nécessiteront un suivi de la part des services de santé au travail du gouvernement. L'identification des dangers potentiels, l'évaluation du risque et la mise en application de recommandations visant des changements (comme des contrôles d'ingénierie, de l'équipement de protection personnelle, l'éducation) peuvent être la clé de la prévention de blessures semblables dans le futur.

Introduction

Hydrofluoric acid is a strong inorganic acid. It is used in many industrial processes, including the production of semiconductors, high-octane gasoline, plastics, refrigerants, and the cleaning of stone and brick buildings. As with other acid burns, hydrofluoric acid can cause an initial caustic injury. The onset of erythema and pain may be delayed up to 24 hours after exposure with concentrations lower than 20%.[1] In addition, hydrofluoric acid exposures may lead to systemic complications due the potential for fluoride ions to penetrate the skin. Fluoride binds to calcium, increasing cell membrane permeability to potassium. This leads to neuronal depolarization, creating severe neuralgic-type pain.[2] Larger exposures may result in hypocalcemia, and burns involving as little as 2.5% of body surface area with concentrated hydrofluoric acid have caused fatal hypocalcemia-related cardiac arrythmias.[3]

We report a case of occupational hydrofluoric acid exposure with the aim of discussing both management and prevention of similar injuries. Identification of an occupational index case will be stressed because emergency

From the *Department of Occupational and Environmental Health, St. Michael's Hospital, Toronto, Ont., and the ‡Ontario Ministry of Labour. †Dr. Uhlig is an Occupational Health Consultant, Toronto.

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physicians must not only recognize the risk of additional occupational exposures but also know whom to contact to initiate a site investigation.

Case report

A 42-year-old male presented to the emergency department (ED) of St. Michael's Hospital, Toronto, Ont. (an inner city university teaching facility) at 0400 complaining of pain and blisters on the index and middle fingers of his right hand. He indicated that approximately 12 hours earlier, while cleaning the brick façade of a building, his hand had been splashed with a cleaning solution that he suspected to contain hydrofluoric acid. He had immediately wiped his hand clean and rinsed the site of contact for 10 minutes with water. He felt well until 4 hours after the incident when he began to develop blisters and increasing pain.

On examination, the worker was alert but complained of throbbing pain in his right hand. His pulse was regular at 100 beats/min, and his blood pressure was 120/80 mm Hg. There were blisters and edema on the dorsal aspect of the right index and middle fingers. The fingers had a mottled appearance and were exquisitely tender. There was no nail involvement. He had a decreased range of motion and slightly decreased capillary refill, but had normal pulses and sensation. His electrolytes and calcium were normal, and results of his electrocardiogram (ECG) showed normal sinus rhythm.

In the ED, the worker initially received 0.7cc of calcium gluconate, administered intradermally at sites of lesions, with no relief of pain, intramuscular tetanus toxoid, and acetaminophen with codeine for pain — but no local anaesthetic. He was seen by the plastic surgery service, who debrided the blisters and instituted hand soaks in a 1% calcium gluconate bath. His severe pain persisted. Eight hours after arrival a 5% intravenous calcium gluconate drip was started, at 250 cc/h, along with intravenous morphine. His serum calcium, potassium and ECG remained within normal limits. The intravenous infusion was discontinued because of failure to relieve the worker's pain and a Bier Block (25 cc of 5% calcium gluconate given intravenously (IV) with 40 mg xylocaine IV over 20 minutes) was performed with some success. He was admitted to the plastic surgery service, and continuous calcium gluconate soaks were performed over the next 24 hours with resolution of discomfort in the hand. An intra-arterial infusion of calcium gluconate was not initiated. He was discharged with instructions to apply calcium gluconate gel and dressings to the right hand and to keep it splinted and elevated.

The patient returned to the ED the next morning complaining of increasing pain; being an indigent, he had no funds to fill his analgesia prescription. On inspection, his wound appeared clean and improved from the day before. He was given 10 tablets of acetaminophen with codeine, discharged, and told to follow up in clinic in 3 days. When seen in follow-up he was found to have improved and required no further treatment.

Ministry of Labour investigation

The Ontario Ministry of Labour initiated follow up on the case after being contacted by the occupational medicine service. The Ministry assigned a medical officer to investigate the workplace, determine why the worker was injured and evaluate the potential risk for other employees.

The medical officer visited the employer and found that he was running a small brick-cleaning operation out of his truck, recruiting workers on a day-to-day basis at local shelters for the homeless. The work involved brushing methylene chloride onto building façades, then manually scraping off adherent paint. The surface would then be saturated with water and painted with a dilute hydrofluoric acid (15%) solution that would later be hosed off with water. The employer prepared the 15% hydrofluoric acid solution by diluting 60% hydrofluoric acid. The employer provided safety glasses, acid resistant gloves, safety boots, jacket and safety harnesses, but did not insist on their use.

Most of the transient workers did not use the safety gear routinely. The worker in this case was wearing a glove on his right hand but had cut off the fingertips, so as to be able to grasp the brush more easily. As a safety precaution, a bucket of water was provided in case first aid flushing was required. The bucket of water differed from the bucket of hydrofluoric acid only in colour. The medical officer interviewed the other workers and discovered that several of them had also previously suffered from hydrofluoric acid burns while working for this employer.

The Ministry of Labour investigation concluded with orders to improve work practices: the employer was asked to ensure that workers wear appropriate gloves and face shields, and that he provide an eyewash for eye exposures. He was not fined, and follow up was not possible because the employer shut down his business soon after the investigation.

Discussion

First aid

First aid is very important immediately after a hydrofluoric acid burn. Immediate irrigation of the affected area with water followed by application of a topical agent to neutralize fluoride ions minimizes injury. It is imperative that

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safety showers and eye-wash stations be easily accessible in each work area. The combination of calcium gluconate and dimethyl sulfoxide (DMSO) may have a significant role to play in first aid treatment because it has been shown to be comparable to injection treatments of calcium gluconate. This treatment also has the advantage of not requiring trained medical personnel for administration.[4] The use of DMSO is still controversial though, and not as widespread as the use of 2.5% calcium gluconate gel.[5] The gel may be secured with an occlusive barrier such as a latex glove or plastic wrap to improve absorption. Iced benzalkonium (Zephiran®) is another effective treatment that may be administered by untrained personnel.[6] Even small splashes of hydrofluoric acid on the skin should receive hospital treatment after first aid.

Initial treatment in the ED

Emergency caregivers should protect themselves from exposure to hydrofluoric acid with latex or vinyl gloves.[4] They may also require plastic aprons in cases where there is risk of contact with hydrofluoric acid through the patient's contaminated clothing.

Patients with exposure to hydrofluoric acid concentrations exceeding 50% experience immediate pain. Exposure to concentrations of less than 20% may have a delayed onset of pain (up to 24 hours later) due to slower tissue destruction.[2]

The initial treatment in this case consisted of intradermal injection of calcium gluconate (recommendation: titrate to endpoint of pain relief). Intradermal injection is usually reserved for cases of failure of gel treatment or for those cases that are more severe. Therapy should be continued until relief of pain is achieved. The use of local anaesthetics is not favoured because this may mask the adequacy of treatment.[7] In cases of extreme pain, however, local anaesthesia may be necessary although relief of pain can then no longer be used to guide therapy.[1] Regional intravenous perfusion of calcium gluconate for treatment of digital hydrofluoric acid burns has been reported.[8] However, intra-arterial calcium gluconate administration is recommended for the treatment of burns involving the hands, and especially the fingers.[9] For these cases, it is less painful and causes less mechanical trauma than repeated local injections. More importantly, it allows delivery of a much greater amount of calcium than the 0.5 cc/cm^2 volume limitation for local infiltration. Intra-arterial administration is especially advantageous in more severe burns, providing superior calcium distribution at the cellular level — assuming a large artery into the affected area is available. This saves the patient from having to suffer through the recommended nail removal when there is subungual involvement.[10]

Patient's occupational history

Emergency physicians should obtain an occupational history from any patient with a hydrofluoric acid burn and consult any available Material Safety Data Sheets from the workplace because these may be helpful in identifying any hazardous substances to which the worker may have been exposed. In eliciting the patient's history it is important to identify the concentration of acid, time and duration of exposure, how the exposure occurred, body parts affected, and first aid measures instituted. This information will help the physician to anticipate the patient's course following exposure.

Complications

Patients presenting with major hydrofluoric acid burns are at risk for systemic complications. They should have continuous ECG monitoring and frequent serum electrolyte measurements, including calcium, potassium and magnesium. Low calcium levels should be treated, if necessary, with intravenous calcium gluconate.[11] Use of dialysis is determined not only by the patient's clinical condition, but also by serum calcium and potassium levels. Serum fluoride concentrations are not useful after acute exposure but may be useful in evaluating chronic occupational exposure.[12]

The physician's obligation to report

As a general principle, when one patient presents with an occupational exposure, it is important to consider whether this represents an index case and whether there are others at the workplace who are at risk for similar exposures. In this case, the investigation revealed that there had been many workers at the same workplace who had experienced hydrofluoric acid burns, yet no effort had been made to modify work practices and eliminate the problem. Any physician who suspects that unacceptable hazards may exist in a workplace should contact the appropriate governmental occupational health service. Most workers fall under the jurisdiction of their provincial or territorial government agency (e.g., the Ontario Ministry of Labour, the Workers' Compensation Board of British Columbia). Each province and territory has its own occupational health and safety legislation. Federal employees and employees of companies that operate across provincial or international borders are under the jurisdiction of the federal government through Human Resources Development Canada.

Contact information for the responsible agencies all across Canada is listed at the Canadian Centre for Occupational Health and Safety Web site (www.ccohs.ca/osh

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answers/information/govt.html). Officers of these agencies are guaranteed right of access to workplaces to perform inspections. These agencies are well equipped to identify hazards, assess risk and to make and enforce recommendations for workplace changes with the help of their teams of inspectors, hygenists and occupational physicians.

Strategies for protection

When evaluating strategies for worker protection, the first to consider is engineering controls. Examples of engineering controls include 1) substitution, 2) process modification and 3) isolation. *Substitution* of the hydrofluoric acid for a less dangerous acid may be an option, depending on the process for which it is being used. *Process modification* may be used to minimize worker exposure to hydrofluoric acid. In this case, the worker hosed down the wall surface to remove the hydrofluoric acid that had been applied earlier. This presented an opportunity for hydrofluoric acid exposure through splashing onto the skin. Hydrofluoric acid was purchased in a concentrated form and diluted by the owner. Potential exposure to the concentrated hydrofluoric acid would be eliminated if the hydrofluoric acid were purchased in the more dilute form. *Isolation* of the material, of the process or of the workers may be effective in certain situations to minimize exposure to hydrofluoric acid.

When it is not possible to implement engineering controls to control the hazard, it may be necessary to protect the worker by using personal protective equipment. It is recommended that workers using hydrofluoric acid wear helmets, full face protection, polyvinylchloride suits, gauntlets and rubber boots, as indicated by the task they are performing with the acid.

Worker education and employer obligations

Education of the workers has an important role to play in accident prevention. In conjunction with education, labeling of hazardous materials in the workplace is highly effective. In Canada, the Workplace Hazardous Materials Information System (WHMIS) is a comprehensive national system for safe management of hazardous materials that is legislated by both federal and provincial jurisdictions.[13] WHMIS aims to ensure that workers are informed about the hazards in their workplace and that they receive appropriate training to enable them to work safely. This is accomplished in three ways. Firstly, WHMIS requires all chemical suppliers to label their products and to provide Material Safety Data Sheets (MSDSs). Secondly, it is the responsibility of employers to ensure that the products are correctly labeled and that MSDSs are readily available to the workers using the products. Thirdly, employers are responsible for implementing worker education programs that instruct workers about the contents of substances in their workplace. The significance of labels and MSDSs and how to work safely with hazardous materials needs also to be stressed.

Conclusion

Workers should be aware of the chemical hazards in their workplaces so that they can provide this information to caregivers. Risk to workers can be reduced through education and proper work practices. It is important for emergency physicians to identify index cases of occupational hazard exposure and notify appropriate authorities, therefore preventing further injury or exposure.

Competing interests: None declared.

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Correspondence to: Dr. Ron House, Department of Occupational and Environmental Health, St. Michael's Hospital, 30 Bond St., Toronto ON M5B 1W8; fax 416 867-3673, houser@smh.toronto.on.ca