

Health Care Plan for Hydrogen Fluoride Spill, Gumi, Korea

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At 3:43 p.m. on September 27, 2012, leakage of anhydrous hydrofluoric acid occurred in a chemical plant in the Gumi industrial complex, Gyeongsangbuk-do, Korea. The accidental release of approximately 8 tons of the gas killed five people who were directly exposed to the highly concentrated hydrogen fluoride.

Hydrogen fluoride exists as a liquid under 19.5°C and has a strong irritating odor (1). The gas and liquid forms can contact and damage the eyes and skin, and the respiratory tract can be damaged by inhalation of the gas form. Reaction to the exposure can be immediate and symptoms appear within 3 days at the latest. Temporal shortening of breath and/or respiratory stimulation symptoms such as coughing are initiated. Contact with the eyes or skin causes symptoms ranging from irritation to severe burn. Digestion with the gastrointestinal tract causes irritation and tissue damage of the oral cavity, esophagus and stomach. Exposure to high concentrations of hydrogen fluoride causes hypocalcaemia and hypomagnesaemia, which can be lethal due to ventricular fibrillation caused by hyperkalemia or pulmonary edema (1-3).

Symptoms with exposure to hydrogen fluoride gas are almost always acute, since hydrogen fluoride is not metabolized and is excreted in the urine. Chronic exposure to hydrogen fluoride leads to the most severe damage that occurs in the skeletal system and associated tissues. Results of chronic exposure vary from osteofluorosis to crippling fluorosis with marked restriction of locomotion. The severe symptoms require a prolonged exposure, on the order of a decade, which has not been reported in Korea (4). Chronic exposure also causes functional disabilities of the liver and kidneys. Hydrogen fluoride has not been classified for carcinogenic effects, and, since they are able to cross the placenta, at low doses is thought to be essential for normal fetal development in humans. No reproductive effects due to hydrogen fluoride are known. Thus, osteofluorosis and impairment of liver and kidneys are not expected outcomes in the 27 September 2012 accident.

In Bongsan-ri, which is near the industrial complex, death of plants was reported. However, fluoride odor was not detected in the air or was the compound measurable. As well, water quality

measurements were under baseline. However, if airborne, hydrogen fluoride can be deposited by precipitation in soil, groundwater, freshwater and seawater, thus necessitating continuous monitoring. Also, attention should be given to the impact of hydrofluoric acid present on the surface of the soil or plants for agricultural work and intake of the products (5). Avoidance of agricultural works is recommended and protective mask and gloves must be worn if such work is inevitable. In addition, health effects on consumption of residual hydrofluoric acid on grains, fruits and livestock in affected area must be strictly measured, for not only health of local residents, but also to avoid the economic disadvantage incurred by declined sales of affected products.

If there is any possibility of contamination by hydrofluoric acid, evacuation to an unexposed region is essential. Contaminated parts of the body must be washed with clean running water and require prompt medical care if damage has occurred. Respiratory exposure is treated by clean running water and evacuation to an unexposed area. Eye related symptoms are addressed by washing the affected eyelid for at least 20 min, removal of contact lens if appropriate, and seeking treatment by an ophthalmologist. Packing with ice on the eyes can be useful but rubbing is not recommended. Pain or rash on the skin should be treated by cleansing with running water. During washing, contaminated clothes must be removed and kept away from contact with others. Application of calcium ointment is helpful. If soreness or pain of the mouth with swallowing develops from oral exposure, drinking a large quantity of liquid such as water or milk is prudent. Vomiting should be avoided. Taking antacids containing calcium or magnesium can help (1, 2). Concerning skin lesions, topical application of 2.5% calcium ointment with of Lido-Hyal® (a mixture of hyaluronidase 25 IU and 2% lidocaine) on the lesion is recommended, followed by injection of a twice the volume of Lido-Hyal intralesionally. Lidocaine is used for pain relief and hyaluronidase prevents tissue necrosis due to calcium gluconate (6). Palliative treatment is needed regardless of the exposure area, and electrolyte balance should be maintained.

Sequelae can occur when widely exposed to high concentra-

tions, including chronic lung disease, blindness, burn scars, and esophageal stricture. Fingertip injuries are troublesome with persistent pain, bone loss, and nail-bed injury. In 1987, in the state of Texas in the United States, a similar leakage of 18 tons of hydrofluoric acid occurred. Acute health effects including respiratory tract and irritation of eyes on local residents were recorded up to 2 yr following the accident (7). Therefore, follow-up surveys need to be done for residents exposed to the leakage.

Local residents are wise in being nervous about the outcome from such an accident (8), but may take some solace in the knowledge that most health effects after exposure appear almost immediately within 3 days, with chronic effects being rare. As a protective measure and for reassurance, the government should act swiftly following an incident, including monitoring the health effects of the residents. Especially, post-traumatic stress disorder and anxiety should be managed. A survey of the countryside for withered plants, affected crops and affected livestock should be done promptly, and continuous monitoring of soils, groundwater, freshwater and seawater should be arranged immediately.

Protocols in the event of a disaster caused by chemicals can and should be prepared in advance, including education of firefighters or public servants in the use of appropriate protective equipment and neutralizers (9). While hopefully not needed, this readiness is a wise course of action.

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