HEXAFLUORINE® SKIN DECONTAMINATION OF 49% HYDROFLUORIC ACID: PRELIMINARY STUDY IN AN IMMATURE DOMESTIC PIG

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Abstract

Objective: To determine a 49% hydrofluoric acid (HF) skin exposure period that will allow sufficient time to intervene with decontamination before a visible skin lesion develops. Also, to evaluate and compare the efficacy of Hexafluorine® skin decontamination to that of tap water when both are delivered similarly at 500 ml over 3 minutes following exposure to 49% HF at specified times. **Methods:** This study was approved by the testing facility's Animal Care and Use Committee. Twelve separate sites were used on the shaved and depilated back of an anesthetized 16.3 kg immature domestic pig. Each test skin site was exposed to 400 µL of 49% HF using a 25 mm Hill Top Chamber. HF exposure times, delay times to decontamination, and type of decontamination are listed below. Endpoints: subjective skin reaction scores (standard Draize scale) and digital photographs taken before HF exposure, after HF exposure, and at each post-decontamination observation point (2 minutes-4 hours). **Results:** All HF-exposed skin sites with no decontamination developed severe HF burns. For HF-exposed skin sites receiving decontamination, those treated with Hexafluorine® resulted in less severe burns than those treated with tap water, but tap water resulted in less severe burns than no decontamination. Efficacy (reducing the extent of HF burns) was best demonstrated when skin was exposed to 49% HF for 10 seconds followed by decontamination with Hexafluorine® after a 30-second delay. **Conclusion:** These first results have shown that following a 10 second skin exposure to 49% HF and additionnal 30 second delay to decontamination, the degree of burns decontaminated with Hexafluorine® were less severe than those decontaminated with water. This preliminary study shows that the delay to intervene and the chemical activity of the Hexafluorine® decontaminant plays a very important role in comparison to water. Once the model is completely qualified, a definitive study will be performed to assess efficacy of Hexafluorine® decontamination versus tap water using different HF concentrations and exposure times.

Introduction

Skin contact with hydrofluoric acid (HF) can result in serious burns as well as potentially fatal systemic toxicity. In 1999, 2,245 cases of HF exposure were reported to the APPCC Toxic Exposure Surveillance System (TESS) in the USA(1). Of these, the majority (1,711/2,245; 76%) were in adults and most were unintentional (2,193/2,245; 98%). 69% (1,559/2,245) were evaluated in a health care facility (HCF) and 86% (1,463/2,245) developed symptoms ranging from minor to major. There were 7 deaths.

Hexafluorine®, produced by the Laboratoire PREVOR in France, is a specific first aid rinsing solution for the decontamination of eye/skin hydrofluoric acid (HF) splashes. Because of its amphoteric, hypertonic and chelating properties, Hexafluorine® is able to activily bind both the hydrogen (H^+) and fluoride (F^-) ions. It has been shown to be efficacious for decontamination of HF-exposed workers (2-4).

The emergency treatment of chemical splashes is aimed at stopping the action of the chemical product before the burn has started. Two studies on emergency treatment of an HF burn have shown that for decontamination after 20 second exposure time and a 70% HF concentration, Hexafluorine® was more effective than water (5), but for decontamination after a 3 minute exposure time and a 50% HF concentration, burns appeared similar and Hexafluorine® was found not any more effective than water (6). The pig has been previously found to be one of the best animal models for the study of 38% HF burns (7,8). The aim of this preliminary study was to develop an in vivo domestic pig model for 1) determination of a 49% HF skin exposure duration that would allow for a sufficient period of time to intervene with decontamination and 2) evaluation and comparison of tap water versus Hexafluorine® decontamination of dermal lesions produced by contact with 49% HF for varied times.

Methods

This study was conducted by Honeywell, a major manufacturer of hydrofluoric acid (HF) in collaboration with Laboratoire PREVOR and the HF panel of the American Chemical Council (ACC). Financial support was provided by all three institutions. It was performed at WIL Research Laboratories, Ashland, Ohio, USA and had prior approval by the Animal Care and Use Committee. A volume of 400 µL of 49% HF was applied to the shaved and depilated back of an immature White domestic pig (approximately 16.3 Kgs) with a 25 mm Hill Top Chamber.

Hill Top Chamber

Preparation of the animal:

Removal of hair from backs and flanks under anesthesia by clipping about 48 hours prior to HF exposure. The skin was washed with Betadine surgical scrub after clipping to prevent infection. A depilatory agent (Nair) was applied to the skin for removal of hair stubble about 18 hours prior to HF exposure. After depilatory agent application, the skin was washed with Betadine surgical scrub to prevent infection.

Animal sedation and anesthetization:

Sedation - Atropine (0.05 mg/kg, tetrazol (3 mg/kg) and xylazine (1 mg/kg) administered intramuscularly.

Anesthesia - Animal was intubated and anesthesia was maintained using isoflurane Animal was maintained on a surgical plane of anesthesia during study period.

Decontamination Procedures

Side-by-side HF burn sites were rinsed with Hexafluorine® and tap water simultaneously Each HF burn site was rinsed with a volume of 500 mL decon in a 3-min period Simon Varistaltic Pump delivered decontaminant at a target flow rate of 166.6 mL per minute Polypropylene tubing was used to direct flow to skin sites There were various applications and delay to decontamination times (Table 1).

Dermal observations:

Erythema, edema were scored according to Draize. Other reactions, e.g., blanching and necrosis were described. Lesion sizes were measured and Digital photographs were taken before and at various times after HF burns (Table1).

Application sites were compared as follows :

- **No decontamination,**
- **Water decontamination**
- **Hexafluorine® decontamination.**

Table 1

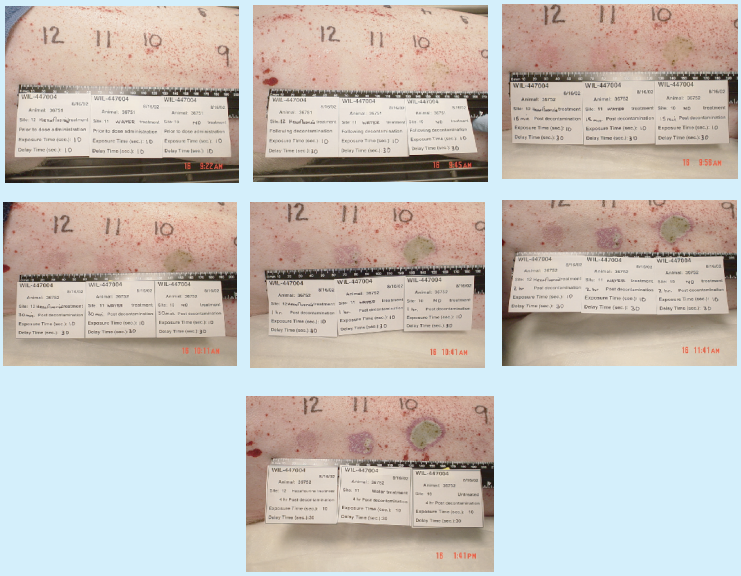
Site Number	HF Exposure Time (seconds)	Delay to Decontamination (seconds)	Type of Decontamination
1	30	N/A	None
2	15	N/A	None
3	10	N/A	None
4	5	N/A	None
5	10	60	Tap Water
6	10	60	Hexafluorine
7	5	N/A	None
8	5	10	Tap Water
9	5	10	Hexafluorine
10	10	N/A	None
11	10	30	Tap Water
12	10	30	Hexafluorine

Results

All HF-exposed skin sites with no decontamination developed severe HF burns. For HF-exposed skin sites receiving decontamination, those treated with Hexafluorine® resulted in less severe burns than those treated with tap water, but tap water resulted in less severe burns than no decontamination. Efficacy (reducing the extent of HF burns) was best demonstrated when skin was exposed to 49% HF for 10 seconds followed by decontamination with Hexafluorine® after a 30-second delay.

Photographs immediately after exposure

10 second exposure + 30 second delay - burn evolution over 4 hours



Conclusion

These first results have shown that following a 10 second skin exposure to 49% HF and additional 30 second delay to decontamination, the degree of burns decontaminated with Hexafluorine® were less severe than those decontaminated with water. This preliminary study shows that the delay to intervene and the chemical activity of the Hexafluorine® decontaminant plays a very important role in comparison to water. Once the model is completely qualified, a definitive will be performed to assess efficacy of Hexafluorine® decontamination versus tap water using different HF concentrations and exposure times.

References

(1) Litovitz TL, Klein-Schwartz W, White S et al. Annual report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. Am J Emerg Med 2000, 17, 517-574
(2)Mathieu L, Nehles J, Blomet J, Hall AH. Efficacy of Hexafluorine for emergent decontamination of hydrofluoric eye/skin splashes. Vet. Human Toxicol. 2001, 43,263-265
(3)Hall AH, Blomet J, Gross M, Nehles J. Hexafluorine for emergent decontamination of hydrofluoric acid eye/skin splashes SSA Journal Vol 14 - Summer 2000 pp 30-33
(4) Mathieu L, Hall AH, Nehles J, Barbe JM, Blomet J. Projections oculaires et cutanées d'acide fluorhydrique : A propos de 32 cas lavés avec l'Hexafluorine [Eye/skin splashes with Hydrofluoric Acid : Regarding 32 cases decontaminated with Hexafluorine]. JEUR. 2001, 14, p183, Abstract A69
(5) Josset P, Blomet J, Lym SK, et al: Theoretical and experimental evaluation of decontamination measures for burns with hydrofluoric acid. Proprietary data of Laboratoire PREVOR, Valmondois , France 1992.
(6) Höjer J, Personne M, Hultén P, Ludwigs U. Topical treatments for hydrofluoric acid burns : A blind controlled experimental study. Journal of Toxicology Clinical Toxicology 2002, 40, 7, 861-866
(7) Dunn BJ, MacKinnon MA, Knowlden NF, Billmaier DJ, Derelanko MJ, Rush GM, Naas DJ, Dahlgren RR. Topical treatments for hydrofluoric acid Dermal Burns. JOEM 1996, 38, 5, 507-514
(8) Dunn BJ, MacKinnon MA, Knowlden NF, Billmaier DJ, Derelanko MJ, Rush GM, Naas DJ, Dahlgren RR. Hydrofluoric acid dermal burns. JOM 1992, 34, 9, 902-909