# Hydrofluoric Acid Burns: Effects on Burn Severity and Healing



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#### Aim

HF is a small and partially dissociated acid but it is a strong corrosive and toxic chemical with a potential lethal risk. It is commonly used in industry with specific prevention and safety rules. Until now, management of HF exposure has improved, based on both experimental and clinical results. Presented here are the results obtained with an active decontamination solution, Hexafluorine<sup>®</sup>, compared to water and/or calcium gluconate. **Methods** 

A review of the recent in vivo, ex vivo and clinical studies on chemical splash decontamination using Hexafluorine® was conducted.

## In vitro studies



Industrial case reports

5 case studies of emergency decontamination with Hexafluorine <sup>®</sup>								
Number Of cases	Splashed by	Affected body surface	Type of washing	Consequences/Results				
1	HF/HCI* Bath	Total immersion	*Hexafluorine <sup>®</sup> on the body, **Ocular washing with water	*Slight burns on the abdomen and the back **Serious burn on the left eye				
1	70% HF vapour	Right cheek	Hexafluorine®	Slight painless erythema. Application the next day with calcium gluconate gel, no lost work time				
1	38% HF	One eye	Hexafluorine®	No burns, no lost work time				
2	5% HF	body	Hexafluorine <sup>®</sup>	No burns, no lost work time				

Series of 10 cutaneous cases at the Mannesmann Plant (Remscheid, Germany,

Splash	40% HF	6% HF / 15% HNO <sub>3</sub>					
Number of cases	5	5					
% Affected area	0.2 – 1 – 4.5 – 4.5 – 16.5*	0.2 – 2.25 – 4 - 4.5 - 10.5					
First washing (on the site of the accident)	Hexafluorine®	Hexafluorine®					
Second washing (at the infirmary) Hexafluorine®		Hexafluorine®					

Series of 12 cutaneous cases at Outokumpu (AVESTA, various sites, Sweden) Decontamination with Hexafluorine®							
Number of Cases	Splashed with	Affected body surface	Duration of contact	Work loss			
2	70% HF	Left forearm– oral cavity	< 1 min	0 - 1			
1	HF/HNO <sub>3</sub> pH=1	One thigh	< 1 min	0			
2	HF/HNO <sub>3</sub> pH=1	Two thighs	1h - 1h30	2 - 2			
1	HF/HNO <sub>3</sub> pH=1*	Face	3 - 5 min	3			
2	HF/HNO <sub>3</sub> pH=1	Face + oral cavity – Forehead	< 1 min	1 - 1			
3	HF/HNO <sub>3</sub> pH=1	Forearm-arm – arm + hand – Two elbows	< 1 min	0 – 0 - 1			
1	HF/HNO <sub>3</sub> pH=1	Wrists	2 h	0			

*In vitro*, Hexafluorine<sup>®</sup> allowed a more rapid return to a physiological pH value than tap water.

Wate

Hexafluorine®

Water = 2.5% Calcium Gluconate

#### In vivo study

*In vivo* experiments were performed on rats with 70% HF, applied for 20s and Hexafluorine<sup>®</sup> washing was compared to tap water and calcium gluconate washing [1]. This model allowed both observations of diffusion and decontamination



whereas models, like 49% HF applied for 3 min, were too strong to compare data at the end of the experiment.



32 cases of industrial use of Hexafluorine<sup>®</sup> have also been reported, showing neither sequelae nor lost work time and no systemic effect.

## **Ex vivo studies**



*Ex vivo* studies on rabbit corneas (20s of exposure to 2.5% HF solution) showed that there was no burn (no opaque cornea) with Hexafluorine<sup>®</sup> washing compared to water and 1% calcium gluconate solution washing [2].

Also *ex vivo*, Hexafluorine<sup>®</sup> versus traditional water + calcium gluconate decontamination (20s of 70% HF exposure followed by 15min of tap water washing and then 1mg/cm<sup>2</sup> calcium gluconate application or 10min of Hexafluorine<sup>®</sup> washing), showed no burn on skin tissue of human explants exposed to 70% HF.

(a) HF exposure without decontamination – (b) HF exposure followed by 15 min of tap water washing – (c) HF exposure followed by 15 min of calcium gluconate1% washing – (d) HF exposure followed by 15 min Hexafluorine<sup>®</sup> washing







20s HF burn and tap water washing (15min) - Many edematous cells in basal epidermis with very clear cytoplasm and basal membrane disruption. Pyknotic nuclei and acidophilic cytoplasm in papillary dermis; same lesion but weaker in reticular dermis



20s HF burn and Hexafluorine® washing (10 min) – Good morphology in all layers of the skin.

#### Delayed use: One case report

Delayed use of Hexafluorine<sup>®</sup> 3 hours after the initial water washing followed by magnesium oxide treatment helped, with an associated calcium gluconate treatment, to decrease pain and to facilitate healing.









Evaluation of the lesions after tap water wshing and MgO treatment: pain and burn development







HF is a very hazardous chemical used worldwide and still causes many deaths. Only early decontamination helps to manage the development of the burn, preventing the lethal risk. Compared with water or normal saline, studies of eye/skin chemical splash decontamination with Hexafluorine<sup>®</sup> has shown its effectiveness in cases of early and

delayed management.

[1] Mathieu *et al.*, JCHAS. 14(4):32-39 (2007)
[2] Hall *et al.*, SSA J. 14: 30-33 (2000)
[3] Söderberg *et al.*, Vet. Hum. Toxicol. 46(4):216-218
[4] F. Spöler *et al.*, Burns. 34(4):549-55 (2008).
[5] Burgher *et al.*, EAPCCT 2009 Congress