Decontamination of Hydrofluoric Acid Splashes (HF)

+How HF burns function

+ Review of handling effectiveness

+ Feedback

from Hexafluorine in the workplace

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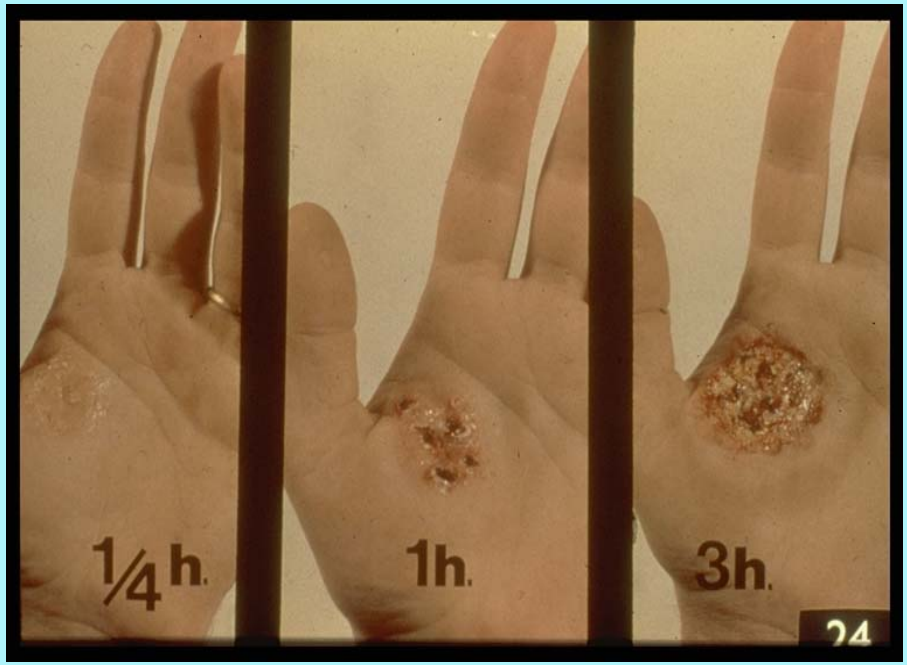
HYDROFLUORIQUE ACID
A DOUBLE RISK

- a corrosive attack due to H^+ ions
- penetration of F^- ions : a systemic effect



HF : a small weak acid

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EFFECTS OF THE HF BURN

📖 *Segal EB Chemical Health and Safety, 2000, 18-23*

- Concentration > 50% :
  immediate pain and fast necrosis
- Concentration 20%-50% :
  burn delayed from 1h to 8 h
- Concentration < 20% :
  pain and necrose delayed by more than 24h

HF burns with a lethal risk

Means of entry	% affected surface	HF Concentration
Burn by contact	1	anhydrous
Burn by contact	5	> 70%
Burn by contact	7	50-70%
Burn by contact	10	20-50%
Burn by contact	20	<20%
Prolonged exposure or long delay before treatment	minor HF burns	
Ingestion of HF		>5%
Inhalation of HF		>5%

Dunser MW, Burns, 2004, 391-398

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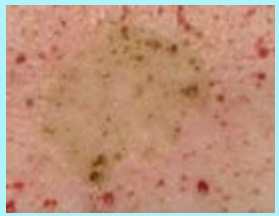
Evolution of a burn by 49% HF

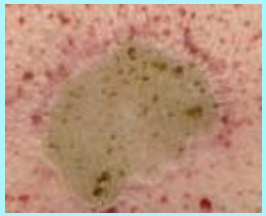
in pigs

10 s exposure + 30 s contact

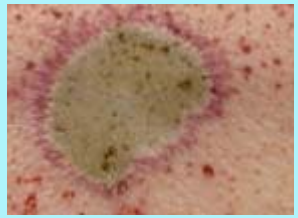


15 min

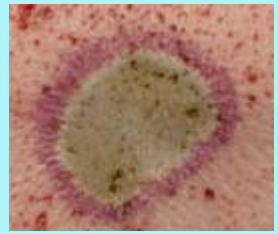
30 min



1 hour



2 hours



4 hours

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TO DECONTAMINATE HF SPLASHES

- Wash and undress as quickly as possible
- Take immediate action against the double risk : H+ and F- ions
- Use a single protocol for eye-related and skin-related acid splashes.

HYDROFLUORIC ACID

Examples of cutaneous burns

Dr O. GOUET, La Baule, France, Oct.1997

Case: Cutaneous contact with 70% HF, immediate rinsing with water, the necrosis appears after 2 minutes. Hospitalisation many hours later with acute pain, extensive necrosis, necessity of surgery with discharge incisions and iterative excisions followed by amputation.

Photo 1 : *Case n°1 : Hydrofluoric acid 70% initially*

Photo 2: Case n°1 - Hydrofluoric Acid 70% 4 days later after excision and discharge

Photos 3 and 4:Case N°1-Hydrofluoric Acid 70% 1 year later after surgical flaps, skin grafts, and physical therapy

A CASE REPORT

AVESTA (Outokumpu Stainless AB)
with water + calcium gluconate

- A 45 year old employee
- HF 70%
- valve checking
- immediate rinsing with water (15 min) then saline solution in the ambulance
- Hospital : Ca - IV injection
- and Mg + Ca-Glu gel
- 1 year off work

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Published cases with very concentrated HF

- Mayer (in 1985) 70% HF (water)
  - 10% of body surface affected - death
- Mullet (in 1996) 70% HF (water + GluCa)
  - 8% of body surface affected - death
- Tepperman (in 1980) 100% HF (water + GluCa)
  - 2.5% of body surface affected - death
- Camarasa (in 1983) 100% HF (water + GluCa)
  - Partial permanent incapacity, on sick leave for 1 year
  - After effects = wearing of mittens, sensitiveness to the cold
- Dunser (in 2004) 70% HF (water + GluCa)
  - 30% of body surface, improvement of the handling of the situation
  - no death, 25 day hospital stay

CLASSIC RINSING SOLUTIONS

Evolution of protocols

Rinsing methods	Advantages	Disadvantages
Water	- External surface rinsing - Dilution effect	- Long rinsing time (20mn) - Passive rinsing : no effect on H^+ et F^- - Hypotonicity : favours the penetration of F^- of H^+ ions - Risk of hypothermia
Water (Passive rinsing) **+ calcium Gluconate** (Secondary treatment)	- External surface rinsing - Dilution effect - Chelation of fluoride ions that have already penetrated the deep layers	- Long rinsing time (20mn) - Passive rinsing : no effect on H^+ et F^- - Hypotonicity : penetration of F^- of H^+ ions - Risk of hypothermia - Weak action on the corrosiveness (H+) - Multiple applications are necessary - Factor depending on the pain sensation of the patient

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Different treatments with water decontamination

- ✓ **calcium gluconate**
- ✓ **local application**
- ✓ **injection IV + DMSO to help the penetration of Glu Ca in fingernails and toenails**
- ✓ **Zephiran salts (benzalkonium chloride) ou Hyamine salts (benzethonium chloride)**
- ✓ **application of compresses in ice (not easy to do)**
- ✓ **Iodine based mixtures**
- ✓ **inhibition of apoptosis and of proteinase activity**

HEXAFLUORINE

- **First aid washing solution in cases of eye and skin HF splashes**
  - ✓ **deactivates H^+ ions**
  - ✓ **chelates F^- ions**
  - ✓ **hypertonic**
  - ✓ **rapid return to a physiological state**

HEXAFLUORINE

☞ Innocuousness and properties

- ✓ Non irritating for eyes and skin
- ✓ Non toxic (LD_{50} > 2000 mg/kg)
- ✓ Non sensitizing
- ✓ No side effects detected by the PREVOR medical devices vigilance system
- ✓ Immediate disappearance of pain
- ✓ Acts on all fluorides in an acidic environment (HF, BF_3, …)

HEXAFLUORINE

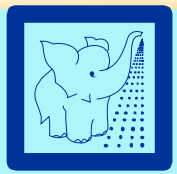
- WOESTE in Germany in 1997
  - Bath of hydrofluoric acid and hydrochloric acid
  - Dap Hexafluorine for body : no burns
  - Water rinsing of eyes : severe burns

- KRUPP in Germany in 1996
  - 38% HF
  - On the eye : no burns with Hexafluorine

- ALCAN in Germany in 1993
  - 2 workers with 5% HF : no burns with Hexafluorine

- ARC INTERNATIONAL in France in 1996
  - HF Vapours 70% face : no burns with Hexafluorine
  - (gluconate gel 1 day after)

Hall AH et al, SSA J, 2000, 14, 30-33



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HEXAFLUORINE

☞ *Mannesmann Series (1994-98)*

📖 *Mathieu L et al, Vet Hum toxicol 2001, 43(5), 263-265*

Ocular splashes	40%HF	6%HF /15%HNO_3
Number	1	1
Surface	1 eye	1 eye
First rinsing	Hexafluorine®	Hexafluorine®
Second rinsing	Hexafluorine®	Hexafluorine®
After effects	0	0
Secondary treatment	0	0
Sick leave	0	0

HEXAFLUORINE

☞ *Mannesmann Series (1994-98)*

📖 *Mathieu L et al, Vet Hum toxicol 2001, 43(5), 263-265*

Cutaneous splashes	40%HF	6%HF /15%HNO3
Number	5	5
% body surface	0.2 – 1 - 4.5 – 4.5 – 16.5	0.2 –2.25 – 4 – 4.5 – 10.5
First rinsing	Hexafluorine®	Hexafluorine®
Second rinsing	Hexafluorine®	Hexafluorine®
After effects	0	0
Secondary treatment	0	0
Sick leave	0	0

HEXAFLUORINE

Avesta (Outokumpu Sweden) Series (1998-99)

📖 *Soderberg K et al, Vet Hum toxicol 2004, 46(4), 216-218*

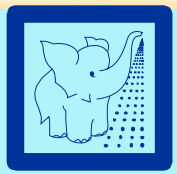
Case N°	Exposure	Cutaneous splashes	Contact time
2	70% HF	Left forearm – oral cavity	< 1 min
1	HF/HNO_3 pH=1	One thigh	< 1 min
2	HF/HNO_3 pH=1	Two thighs	1h–1h 30
2	HF/HNO_3 pH=1	Face + oral cavity – Forehead	< 1 min
3	HF/HNO_3 pH=1	Forearm – arm + hand – elbows	< 1 min
1	HF/HNO_3 pH=1	wrist	2 h

HEXAFLUORINE

Avesta Series(Outokumpu Sweden) (1998-99)

📖 *Soderberg K et al, Vet Hum toxicol 2004, 46(4), 216-218*

Case N°	Exposure	Ocular splashes	Contact time
1	HF (unknown concentration)	One eye	< 1 min
2	HF/HNO_3 pH=1	One eye	< 1 min
1	HF/HNO_3 pH=1	Two eyes	< 1 min
1	$HF/HNO_3/H_2SO_4$ pH=1	One eye + face	3 to 5 min



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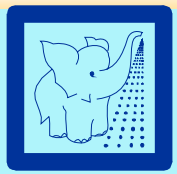
HEXAFLUORINE

Results of the Avesta Series Sweden (1998-99)

📖 *Soderberg K et al, Vet Hum toxicol 2004, 46(4), 216-218*

- No immediate pain sensation,
- No after effects,
- No secondary treatment (75% of cases),
- An average of one day of sick leave (σ = 1.1)



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Conclusion

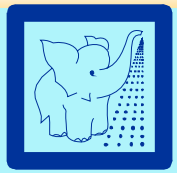
Hexafluorine constitutes an improvement of water rinsing in the treatment of hydrofluoric acid splashes.

In addition to the effects of surface washing, it acts both:

- on the H^+ corrosive ions
- and the F^- toxic ions

Used as a first aid treatment, Hexafluorine allows the prevention or minimisation of the appearance of hydrofluoric acid burns of the eyes and the skin.

When the duration of the contact is prolonged, Hexafluorine can be used to stop the evolution of chemical burns. A treatment allowing the chelation of calcium may then be put into effect.



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