



Comité Technique Européen du Fluor (CTEF)

Working Group on
Storage, Transport and Safety (STS)



GUIDELINES IN CASE OF AN EXPOSURE WITH HYDROGEN FLUORIDE (AHF) OR HYDROFLUORIC ACID SOLUTIONS (HF)



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GUIDELINES IN CASE OF AN EXPOSURE WITH HYDROGEN FLUORIDE (AHF) OR HYDROFLUORIC ACID SOLUTIONS (HF)

PREFACE

Anhydrous hydrogen fluoride/ hydrofluoric acid (AHF/HF) is essential in the chemical industry and there is a need for HF to be produced, transported, stored and used.

The AHF/HF industry has a very good safety record; nevertheless, the European AHF/HF producers, acting within EUROFLUOR (previously CTEF) have drawn up this document to promote continuous improvement in the standards of safety associated with AHF/HF handling.

This Recommendation is based on the various measures taken by member companies of EUROFLUOR.

It in no way is intended as a substitute for the various national or international regulations, which should be respected in an integral manner.

It results from the understanding and many years of experience of the AHF/HF producers in their respective countries at the date of issue of this particular document.

Established in good faith, this recommendation should not be used as a standard or a comprehensive specification, but rather as a guide, which should, in each particular case, be adapted and utilised in consultation with an AHF/HF manufacturer, supplier or user, or other experts in the field.

It has been assumed in the preparation of this publication that the user will ensure that the contents are relevant to the application selected and are correctly applied by appropriately qualified and experienced people for whose guidance it has been prepared.

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The contents of this recommendation are based on the most authoritative information available at the time of writing and on good engineering practice, but it is essential to take account of appropriate subsequent technical developments or legislative changes. It is the intent of EUROFLUOR that this guideline be periodically reviewed and updated to reflect developments in industry practices and evolution of technology. Users of this guideline are urged to use the most recent edition of it, and to consult with an AHF/HF manufacturer before implementing it in detail.

This edition of the document has been drawn up by a Working Group "Storage, Transport and Safety" to whom all suggestions concerning possible revision should be addressed through the offices of EUROFLUOR. It may not be reproduced in whole or in part without the authorisation of EUROFLUOR or member's companies.

AHF is acronym for anhydrous hydrogen fluoride.

HF is acronym for hydrofluoric acid solutions of any concentration below 100%.



GUIDELINES IN CASE OF AN EXPOSURE WITH HYDROGEN FLUORIDE (AHF) OR HYDROFLUORIC ACID SOLUTIONS (HF)

1. INTRODUCTION – GENERAL REMARKS

Hydrogen fluoride (HF) is essential for chemical industry and therefore, there is a need for HF to be produced, transported, stored and used.

HF is primarily an industrial raw material. It is used in stainless steel manufacturing, iron and steel foundries, metal finishing, aluminum production, inorganic and organic chemical manufacturing, petroleum refining, mineral processing, glassmaking, electronic components, refrigerant gases, and in the production of several medications and anesthetic gases¹.

The AHF / HF industry has a very good safety record; nevertheless, the European HF producers, acting within EUROFLUOR have drawn up this document to promote continuous improvement in the standards of safety associated with HF handling.

These recommendations are based on the various measures taken by member companies of the CTEF.

The edition of this document has been drawn up by “The Storage, Transportation and Safety Work Group” together with “The Medical Work Group” to whom all suggestions concerning possible revision should be addressed through the offices of EUROFLUOR. It may not be reproduced in whole or in part without the written authorization of EUROFLUOR or of its member companies.

Exposures to HF are usually very serious, HF will penetrate any tissue it comes in contact with and has the potential for significant complications due to the injury produced in the contact area and the systemic toxic effects basically due to fluoride toxicity. Concentrated HF, liquid or vapor, may cause severe burns, metabolic imbalances, pulmonary edema, blindness and life threatening cardiac arrhythmias. Even moderate exposures to concentrated HF may rapidly progress to a fatality if left untreated².

Every effort must be made to prevent exposure to hydrofluoric acid or hydrogen fluoride³. If exposure does occur, the specialized procedures which follow are recommended to avoid the very serious consequences that might otherwise occur.

¹ Information obtained from: CTEF.- Comité Technique Européen du Fluor, ACC.- American Chemistry Council, and ANIQ.- Asociación Nacional de la Industria Química.

² From ATSDR's Toxicology Profile for Fluorides, Agency for Toxic Substances and Disease Registry, of the Health and Human Services USA.

³ Basic Principle of Occupational Health “If your goal is zero occupational accidents and illnesses, you must strive for zero over-exposure to physical, chemical, biological and psycho-social risk agents.



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2. GUIDELINES FOR FIRST AID AND MEDICAL TREATMENT

GENERAL INFORMATION:

Hydrofluoric Acid exposures are different from other acid exposures because:

- HF penetrates all tissue it comes in contact with and does not remain on their surface⁴.
- Once absorbed HF rapidly dissociates into ionic Hydrogen and Fluoride⁴.
- Hydrogen is in this context of little importance, Fluoride migrates and continues to destroy deep tissue layers as it migrates and will create soluble and insoluble compounds that are the basis for the systemic toxic effects⁴.
- And unlike other acids that are rapidly removed or neutralized, the corrosive and toxic effects may continue for days if left untreated.

Hydrogen Fluoride is corrosive to the skin, eyes, and the mucous membranes of the respiratory and digestive tracts. And is readily absorbed into the body causing acute and severe toxic systemic effects, mainly attributable to a rapidly developing serum hypocalcemia caused by the formation of calcium fluoride or fluoroapatite, serum hypomagnesaemia and serum hyperkalemia⁴.

HF skin burns are usually accompanied by severe pain which is thought to be due to irritation of nerve endings by increased level of potassium ions entering the extra-cellular space to compensate for the reduced levels of calcium ions which have been bound to the fluoride. Relief of pain is an important guide to the success of the treatment; therefore local anesthesia **needs to be** avoided⁵.

The extent and the intensity of these systemic complications are directly related to the amount of HF absorbed, and the concentration of the HF when in solution. There are also indications that subcutaneous deposits of HF under the burnt area may be responsible for an **ongoing** supply of fluoride ions to the circulation⁶.

Symptoms of serious intoxications include hypotension, hypocalcaemia tetany, and/or laryngospasm, often respiratory failure (possibly due to pulmonary hypertension),

⁴ ATSDR's *Toxicology Profile for Fluorides*, Agency for Toxic Substances and Disease Registry, Department of Health and Human Services USA.

⁵ T. D. Brown.- *The Treatment of Hydrofluoric Acid Burns*.
The Journal of the Society of Occupational Medicine, Vol. 24, No. 3, July 1974, pp 80-89.

⁶ Buckingham F.M. *Surgery: A Radical Approach to Severe Hydrofluoric Acid Burns*. Journal of Occupational Medicine, Vol. 30, No. 11, pp 873-874 1988



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ventricular tachycardia, ventricular fibrillation and cardiac arrest. Renal and hepatic functions may be impaired and muscular damage may be secondary to tetany⁷.

Speed is essential. Delays in first aid care or medical treatment or improper medical treatment will likely result in greater damage or may, in some cases, result in a fatal outcome.

3. LIST OF APPENDICES

Appendix 1: First Aid and medical treatment for HF exposure

These are useful for training of medical staff, first aid teams and as a fast reminder for those that have no experience and normally do not see HF exposures regularly. They can also be sent with the patient to the medical facility where definitive treatment will be provided. Attending physicians will greatly benefit from the information provided in the algorithms avoiding loss of time and improving patient prognosis.

Appendix 2: First Aid Form on Patient to Hospital

It is strongly recommended that a first aid form should be filled out by the person who has given first aid and that should be sent with the patient to the hospital or clinic to inform the attending physician on the actions already taken.

Appendix 3: Emergency Kit Contents

A list of contents for a first aid kit for hydrofluoric acid exposures. It is recommended that this kit be kept available as close as possible to the place where accidental exposures may occur.

Appendix 4: Recipes for preparation of gels and solutions

The recipes of calcium gluconate gel, and the solutions of calcium gluconate for nebulization, injection, and eye irrigation that are intended for those situations where the gel or the solutions are not available and you have to make them. However, notice that the preparations are difficult and should be preferably carried out by a qualified pharmacist.

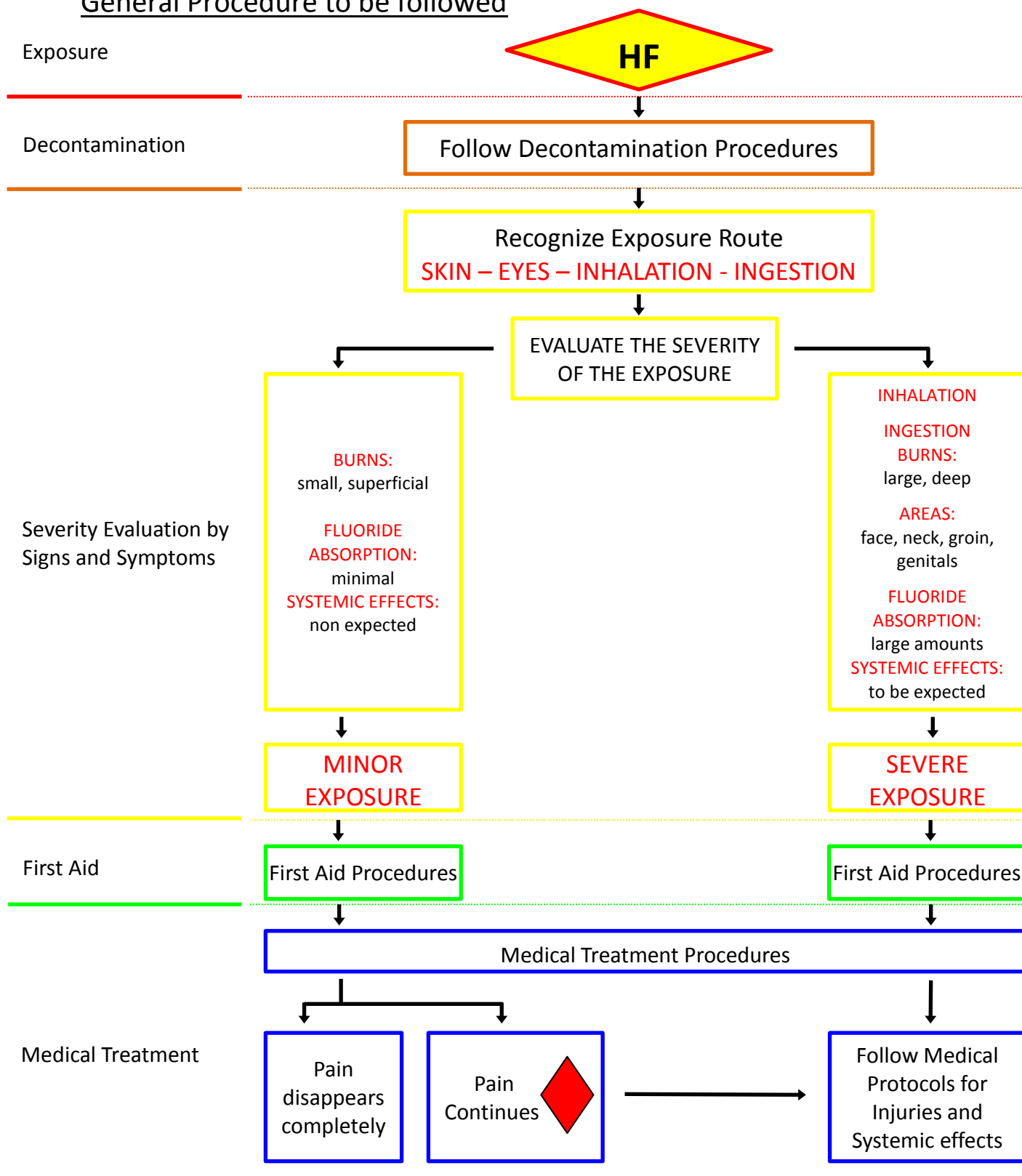
Appendix 5: References

⁷ Upfal, Doyle, Medical Management of Hydrofluoric Acid Exposure.- Journal of Occupational Medicine, Vol. 32, No. 8 August 1990. Plus all references to this article.

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APPENDIX 1: FIRST AID AND MEDICAL TREATMENT FOR HF EXPOSURE

General Procedure to be followed





GUIDELINES IN CASE OF AN EXPOSURE WITH HYDROGEN FLUORIDE (AHF) OR HYDROFLUORIC ACID SOLUTIONS (HF)

Skin

Exposure

SKIN

Decontamination

Decontamination Procedures for AHF & Aqueous HF Solutions

- Go to the nearest source of clean water or safety shower
- Open the water valve
- Remove **all** your clothing, shoes and jewelry under the safety shower
- Finally, while closing your eyes and facing the water flow, remove your goggles or respirator face mask
- **WASH WITH COPIOUS AMOUNT OF CLEAN WATER FOR ONE MINUTE** (respectively until Calcium Gluconate is available)

Decontamination Procedures for AHF/HF containing Tars & Oils and not water soluble substances

- Protecting your hands with PVC, Nitrile or Neoprene gloves proceed to:
- Mechanically remove the tar or oil using gauze, tongue depressor, paper towels etc.
- Consider all discarded materials hazardous waste and handle them appropriately
- Use hydrophobic substances (like oil) to remove leftover tar, oil or substances
 - Remove oil residue thoroughly by washing with soap & water
 - Or use a citrus oil solvent and water and then
 - **WASH WITH COPIOUS AMOUNT OF CLEAN WATER FOR ONE MINUTE** (respectively until Calcium Gluconate is available)

Severity Evaluation by
Signs and Symptoms

- Exposure to solutions of $\text{HF} < 30\%$
- Exposed body surface to $< 20 \text{ cm}^2$
- Injury and/or pain appears up to 48 hours after exposure
- Superficial injuries
- Tissue is whitish, no blistering, no swelling
- Patient is conscious, stable, cooperative
- No systemic toxic effect

MINOR EXPOSURE

First Aid Procedures

- Exposure to solutions of $\text{HF} > 30\%$ or **AHF**
- Exposed body surface to $> 20 \text{ cm}^2$
- Injury appears immediately after exposure, with severe pain, redness/ blanching
- Exposure of the face, groin, genitals or neck
- Patient is unconscious and unstable
- Cardiac arrhythmia (irregular heart beats)
- Systemic toxic effects present

SEVERE EXPOSURE

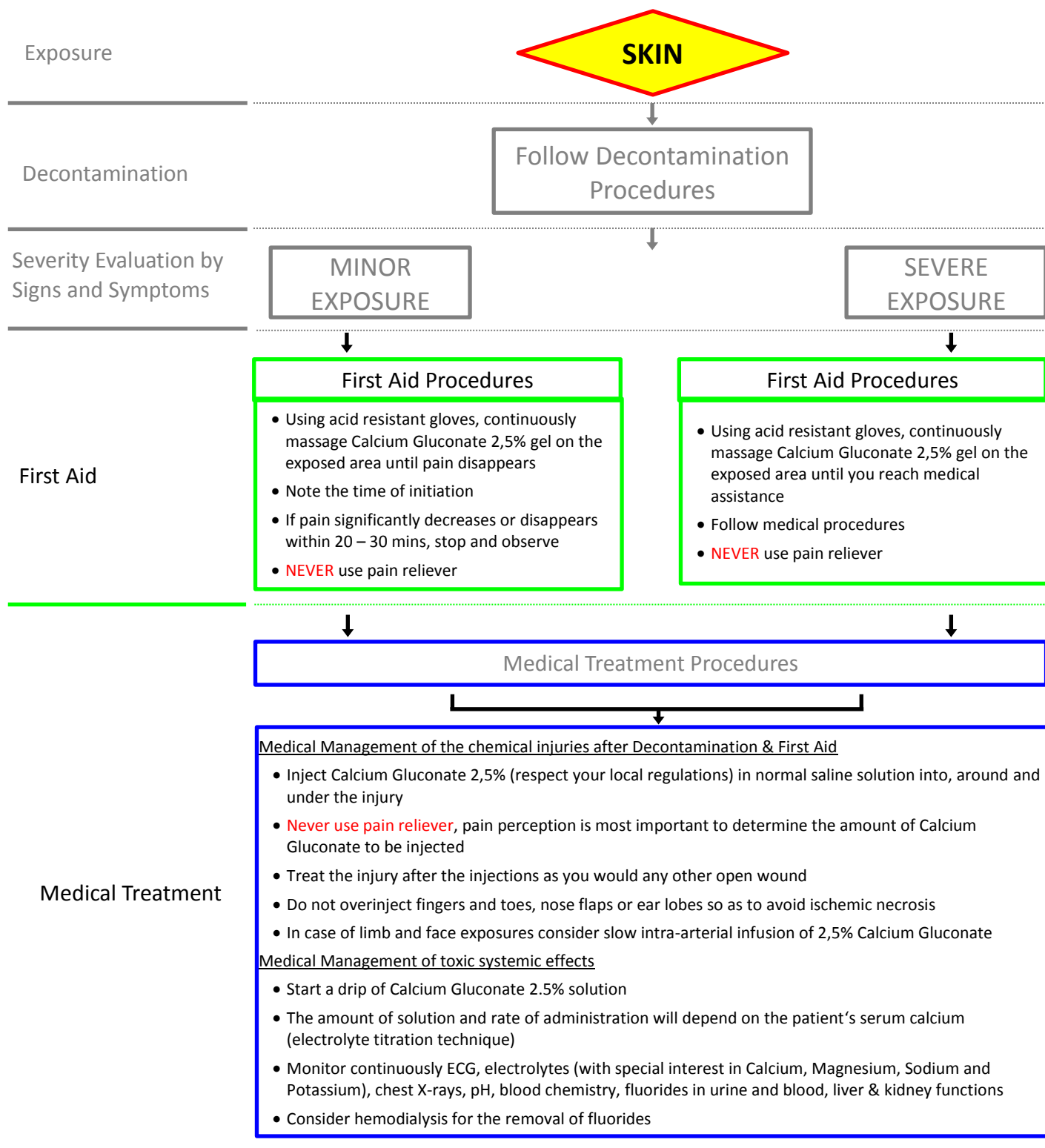
First Aid Procedures

Medical Treatment Procedures

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GUIDELINES IN CASE OF AN EXPOSURE WITH HYDROGEN FLUORIDE (AHF) OR HYDROFLUORIC ACID SOLUTIONS (HF)

Eye

Exposure



Decontamination

Decontamination Procedure

- Go to the nearest Eye Wash or clean source of water
- Open the water valve
- Remove contact lenses
- Put your eye(s) in the water flow
- Open and close your eye lids for 5 min. maximum. If you cannot open them, use your fingers with gloves to maintain your eyes lids open or ask for help.
- The use of anaesthetics may help for decontamination of the eye

Severity Evaluation by
Signs and Symptoms

Severity

All exposures are considered serious because of the danger of vision loss
Consider the following information

Exposure Effects on	Minor Exposures	Severe Exposures
Skin (near the eye)	Minor irritation, reddening or swelling	Severe irritation – evidence of chemical burns of the eye lids and peri-ocular skin
Conjunctiva	Minimal irritation and reddening	Severe irritation, reddening and swelling, possible ulcerations
Cornea	No evidence of injury or minor irritation	Corneal opacification, pitting or ulceration with vision loss and intense pain
Vision	No evidence of vision loss	Vision loss that can be temporary if it is only due to corneal opacification or permanent vision loss if retinal death occurs due to increased intraocular pressure

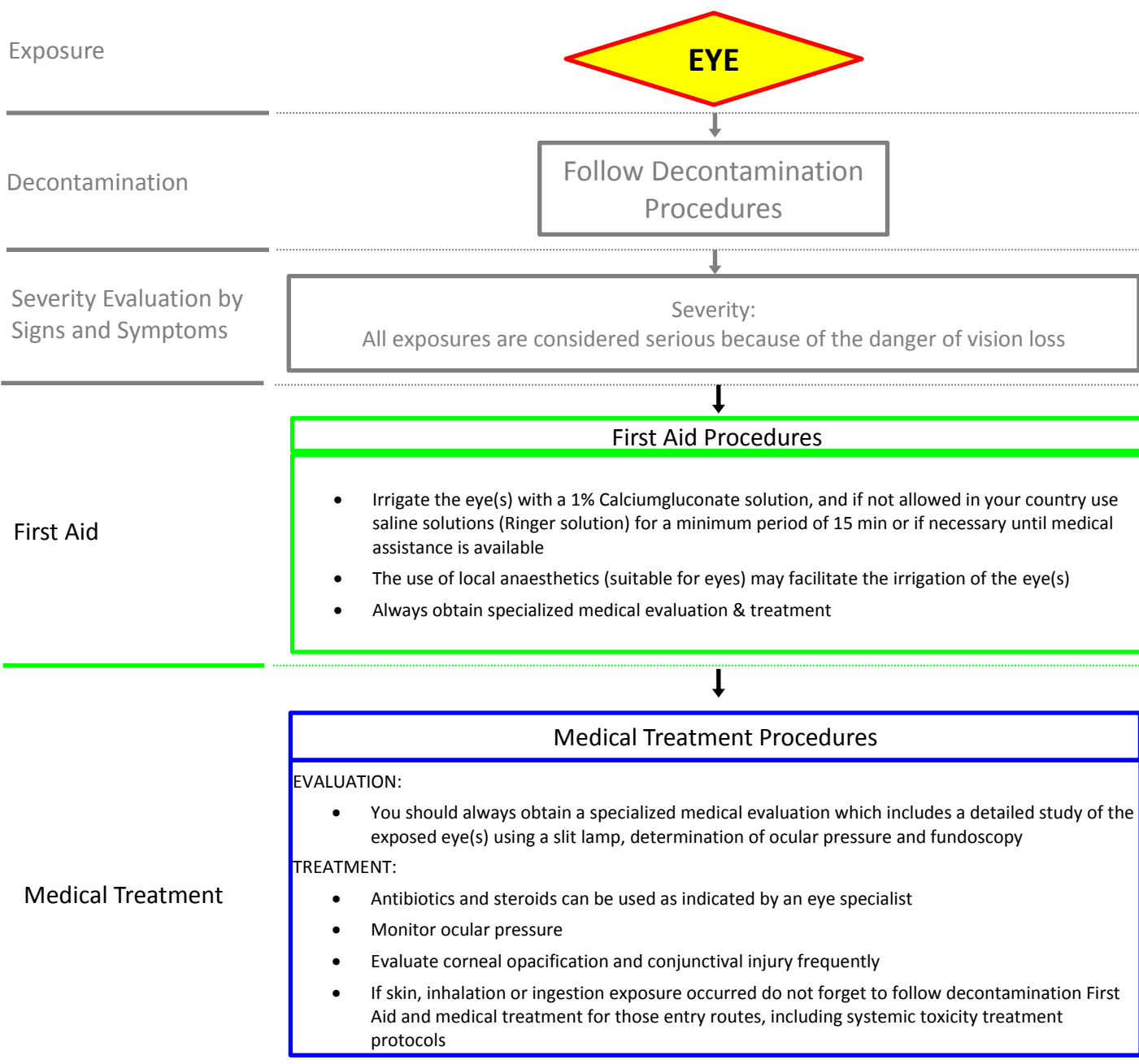
First Aid Procedures

Medical Treatment Procedures

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GUIDELINES IN CASE OF AN EXPOSURE WITH HYDROGEN FLUORIDE (AHF) OR HYDROFLUORIC ACID SOLUTIONS (HF)



OTHER EYE TREATMENTS FOR HF EXPOSURE

A subconjunctival injection of a 1% calcium gluconate solution.

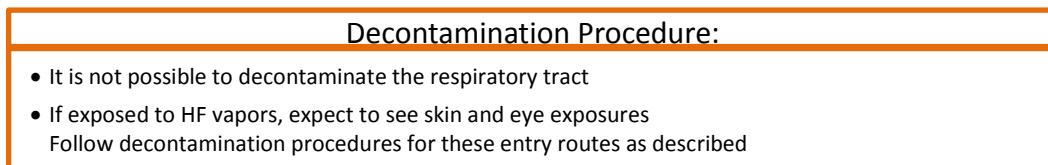
GUIDELINES IN CASE OF AN EXPOSURE WITH HYDROGEN FLUORIDE (AHF) OR HYDROFLUORIC ACID SOLUTIONS (HF)

Inhalation

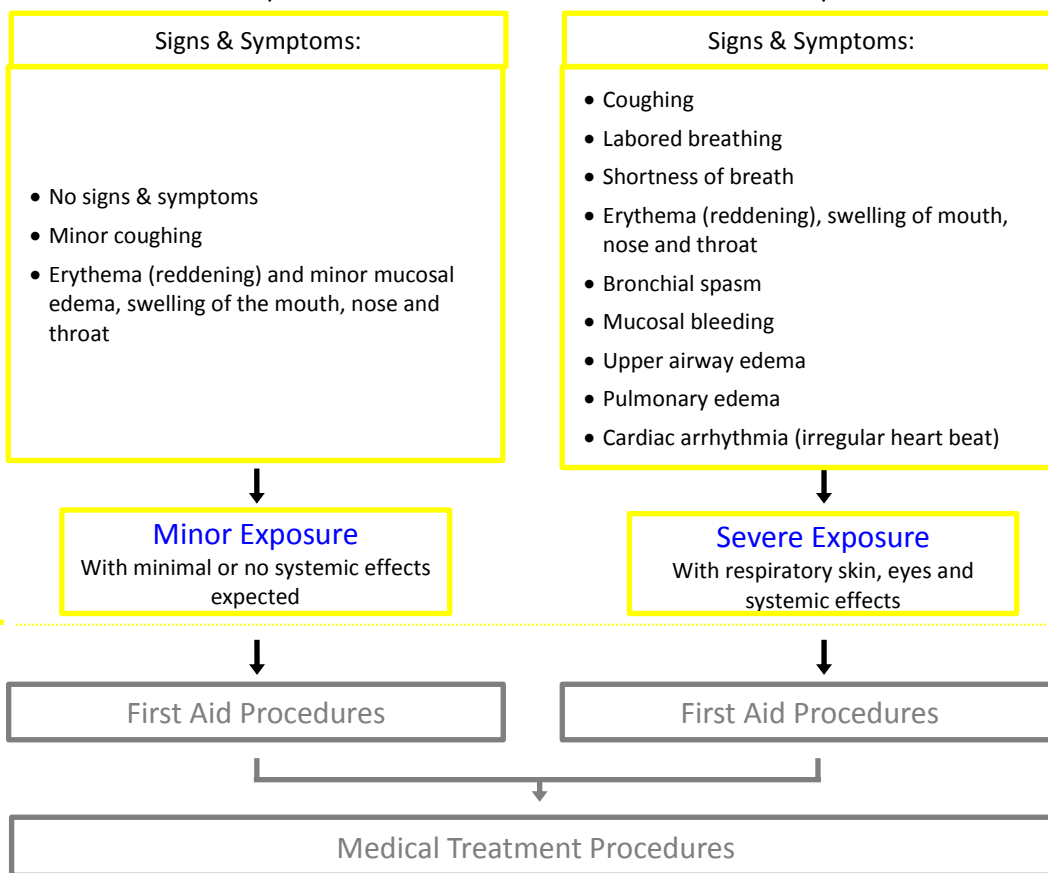
Exposure



Decontamination



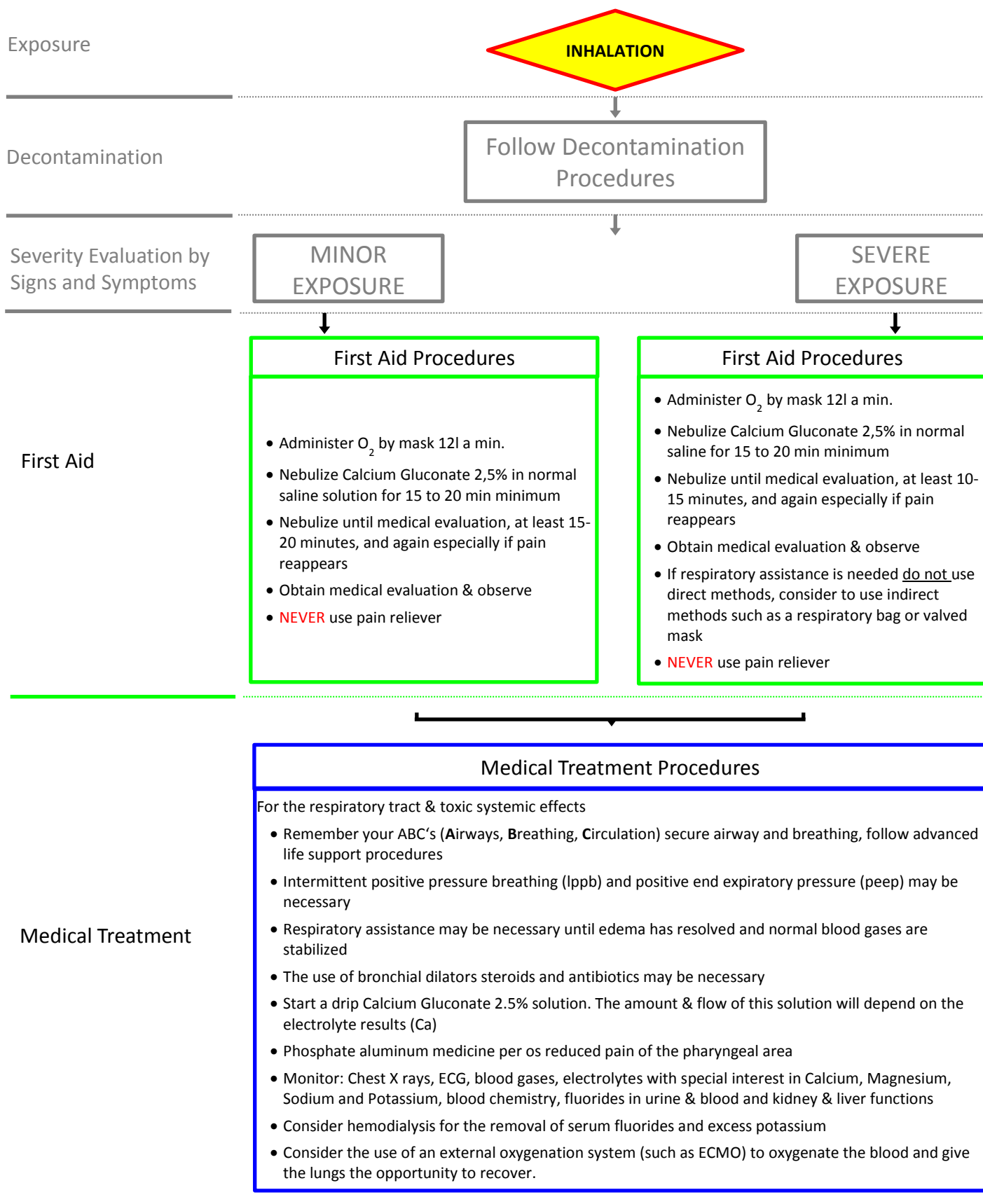
Severity Evaluation by
Signs and Symptoms



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GUIDELINES IN CASE OF AN EXPOSURE WITH HYDROGEN FLUORIDE (AHF) OR HYDROFLUORIC ACID SOLUTIONS (HF)

Ingestion

Exposure

INGESTION

Decontamination

Decontamination Procedure:

- It is not possible to decontaminate the Gastro Intestinal (G.I.) tract
- If skin or eyes have been exposed decontamination & treatment procedures should be followed

Severity Evaluation by
Signs and Symptoms

Severity:

All exposures are considered severe because of the high probability of systemic toxic effects and G.I. complications

Signs & Symptoms:

- Erythema (reddening) of the oral mucosa (mouth)
- Oral injury – ulcerations
- Dysphagia (difficulty in swallowing)
- Bleeding of the oral cavity (mouth)
- Systemic toxicity should be expected
- Possible bronchial or pulmonary injury due to aspiration if vomiting occurs
- Cardiac arrhythmia (irregular heart beat)
- Death may occur

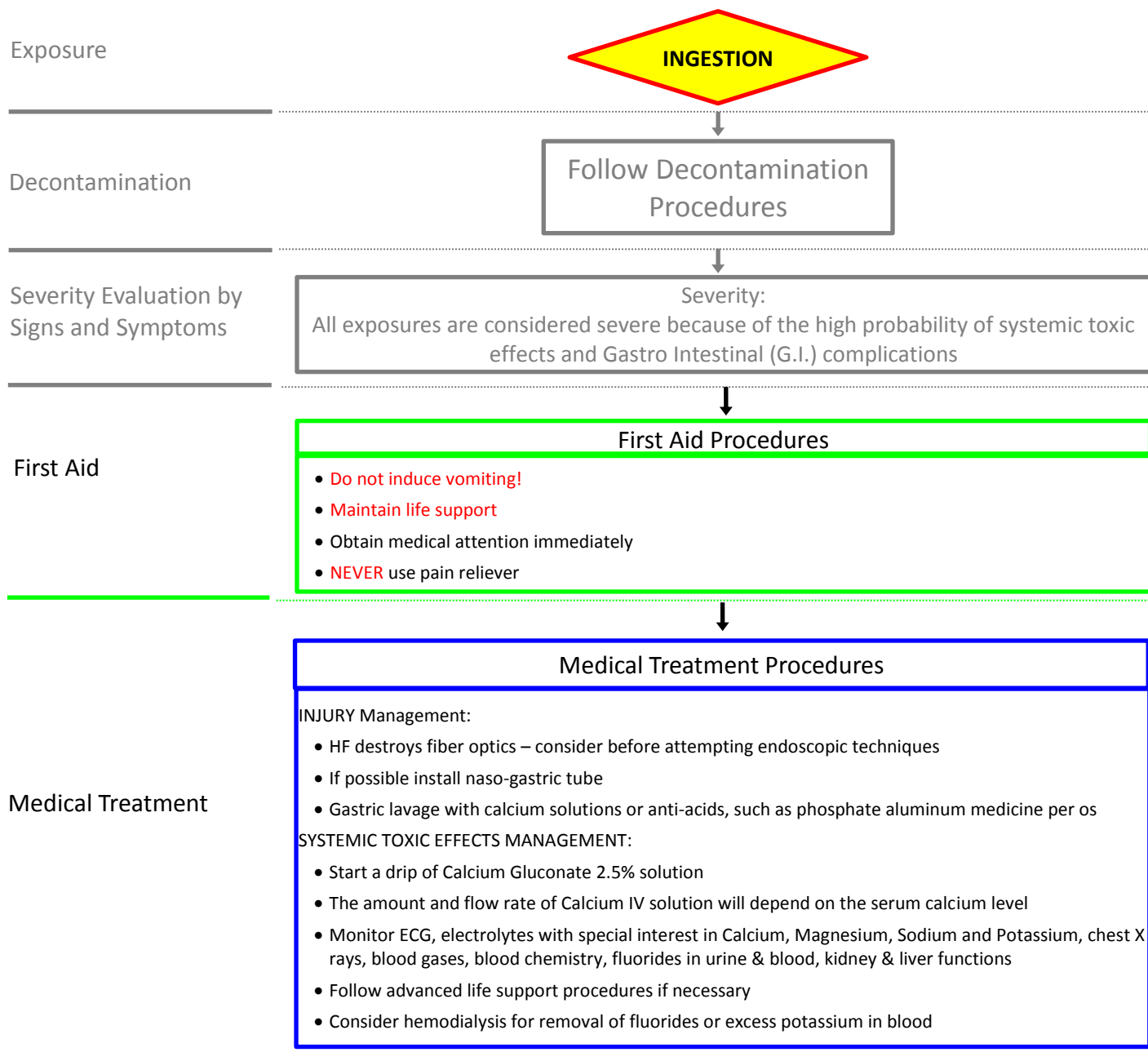
First Aid Procedures

Medical Treatment Procedures

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GUIDELINES IN CASE OF AN EXPOSURE WITH HYDROGEN FLUORIDE (AHF) OR HYDROFLUORIC ACID SOLUTIONS (HF)

APPENDIX 2: FIRST AID FORM ON PATIENT TO HOSPITAL

Form to accompany patient to hospital
(please note advice to hospital on unique treatment needed by fluoride burns!)

Please make sure that hospital staff is aware of the unique characteristics of injuries caused by AHF/ HF exposures and the fact that the systemic toxic effects of the exposure will require prompt serum monitoring of fluorides, calcium, magnesium and sodium, and calcium replacement by infusion.

FIRST AID MANAGEMENT OF HYDROFLUORIC ACID INJURIES

Name _____

Sex M / F Age _____ Date and time _____

DIAGNOSTIC (TICK APPROPRIATE)

This patient was exposed to

- ☐ Anhydrous Hydrogen Fluoride
☐ HF 70% solution
☐ HF _____% solution (specify)
☐ Other Fluoride? (specify _____)

Exposure date _____ Exposure Time _____ am/pm

Nature of exposure: ☐ Inhalation ☐ Skin ☐ Eyes ☐ Ingestion

Degree of exposure: ☐ Slight ☐ Severe

TREATMENT GIVEN (TICK APPROPRIATE)

- ☐ Lavage, decontamination of the skin. Duration _____ min.
☐ Lavage, decontamination of the eyes. Duration _____ min.
☐ Calcium Gluconate gel Duration _____ min.
☐ Eye irrigation with a 1% calcium gluconate solution. Duration _____ min.
☐ Nebulization of a 2.5% solution of calcium gluconate. Duration _____ min.
☐ Basic life support.
☐ Other (specify _____)

AHF/HF is corrosive and toxic and may cause:

1. Severe and painful burns of the skin
2. Irritation of air ways that can lead to bronchitis or even pulmonary oedema
3. Asphyxia
4. Severe and painful burns of the eyes
5. Blindness
6. Severe and painful burns of the digestive track
7. Serious toxic systemic effects, that will require specialized metabolic, surgical, thoracic, ophthalmic intervention (Intensive Care)

Note: All or any of the above effects may be delayed in onset and/or be accompanied by toxic systemic effects.

- ☐ Dr
☐ Nurse
☐ 1st Aider

Name and signature

Date _____ Time _____ am/pm place _____

Note to First Aider: Patients should be accompanied by a doctor or nurse whenever possible

FOR FURTHER MEDICAL INFORMATION

Telephone _____

Name _____

GUIDELINES IN CASE OF AN EXPOSURE WITH HYDROGEN FLUORIDE (AHF) OR HYDROFLUORIC ACID SOLUTIONS (HF)

APPENDIX 3: EMERGENCY KIT CONTENTS



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Management of hydrogen fluoride injury Notes for health professionals

First aid kit for hydrofluoric acid injuries

Instructions: The AHF/HF First Aid Kit should be placed in a controlled area near workplaces where the possibility of an exposure exists, such as production areas, storage areas, and in transportation vehicles.

The KIT should be sealed and only opened for emergency use or for periodical inspection.

Content of the kit

☑ A FULL SET OF UPDATED DECONTAMINATION AND FIRST AID PROCEDURES.

☑ For skin exposures

- Pairs of gloves (PVC, Nitrile or Neoprene);
- tubes of calcium gluconate gel at a 2.5% concentration;
- aluminized plastic sheets.

☑ For eye exposures

- 1 litter of a 1% calcium gluconate irrigation solution;
- 1 IV tubing set and 1 nasal O₂ cannula for calcium gluconate administration.

☑ For inhalation exposures

- Equipment for O₂ administration and nebulizing
- 500 cc. of a 2.5% calcium gluconate nebulizing solution
- respiratory bag.

☑ For general use

- Pairs of scissors for clothing removal and general use;
- flashlight;
- packs of sterile gauze;
- tourniquets;
- coldpacks;
- IV infuser.

☑ For medical use only

- Ampoules of a 10% calcium gluconate solution;
- long stainless steel needles and disposal containers;
- 1 bottle of a local eye anaesthetic;
- sterile syringes;
- tube of water soluble lubricating gel (for calcium gluconate gel preparation);
- set of airway cannulas;
- valved ventilation masks.

Note: These are minimum quantities and may need adjustment depending on the number of potential exposure victims. Kits should be inspected once every 3 months. Used or outdated materials should be replaced immediately. The calcium gel and solutions should be protected from light, extreme heat or cold.

The following should be written on the outside

CAUTION!

To be opened only if an AHF/HF exposure occurs. If the seal on this kit is broken an immediate inspection should be made by an authorised, competent person.

Disclaimer

The recommendations presented in this document are based on the experiences and best practices adopted by member companies of Eurofluor. They are in no way intended as a substitute for the relevant national or international regulations, which should be fully complied with. Eurofluor and its members make no guarantee and assume no liability whatsoever for the use or the interpretation of any of the information contained in this document.



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APPENDIX 4: RECIPES FOR PREPARATION OF GELS AND SOLUTIONS

CALCIUM GLUCONATE 2.5% GEL

Mix one 10cc's of a 10% calcium gluconate solution with 30cc's of a water soluble lubricant to obtain 40cc's of calcium gluconate 2.5% gel by weight

CALCIUM GLUCONATE 2.5% SOLUTION FOR NEBULIZATION OR FOR INJECTION

To obtain 100cc's of a 2.5% calcium gluconate solution, mix 75cc's of a normal saline solution with 25cc's of a 10% solution of calcium gluconate.

To obtain 1000cc's of a 2.5% calcium gluconate solution, mix 750cc's of a normal saline solution with 250cc's of a 10% solution of calcium gluconate.

CALCIUM GLUCONATE 1% SOLUTION

Mix 900cc of normal saline solution with 100cc of a 10% of a calcium gluconate solution.



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APPENDIX 5: REFERENCES

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