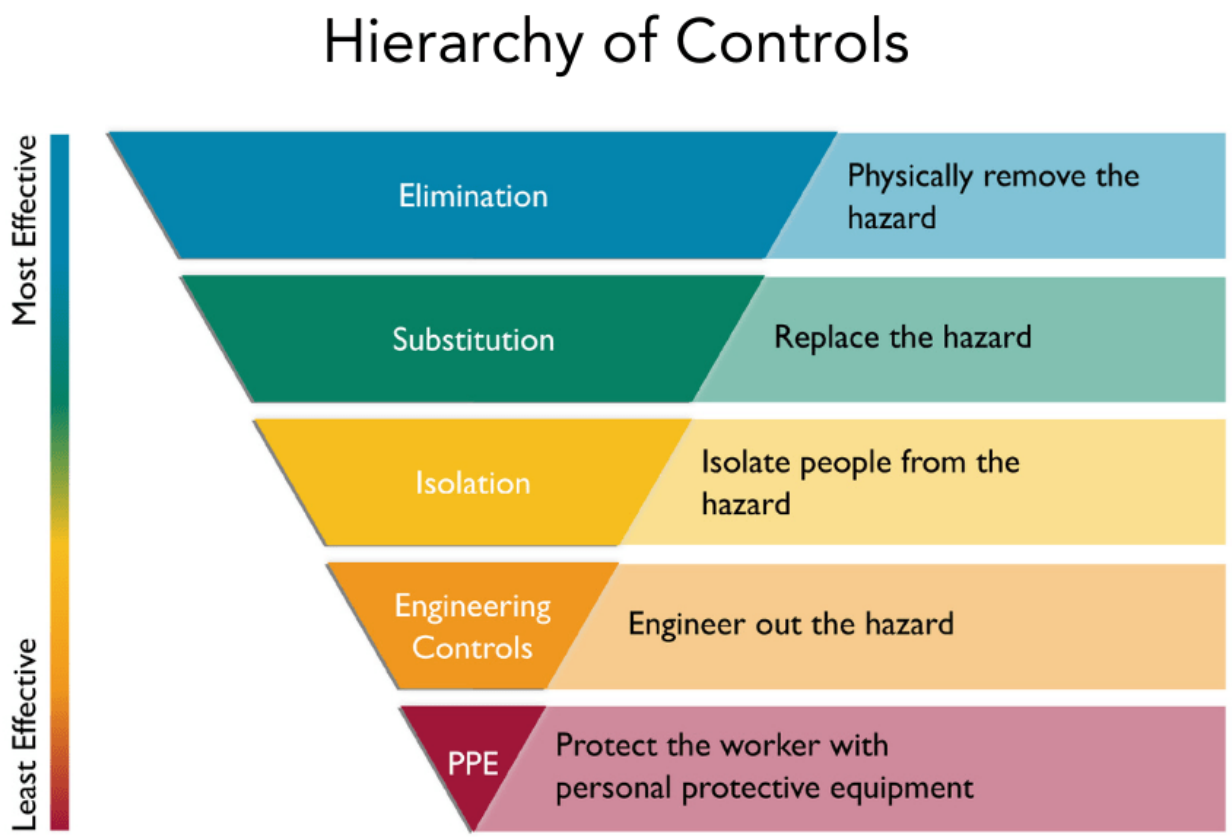
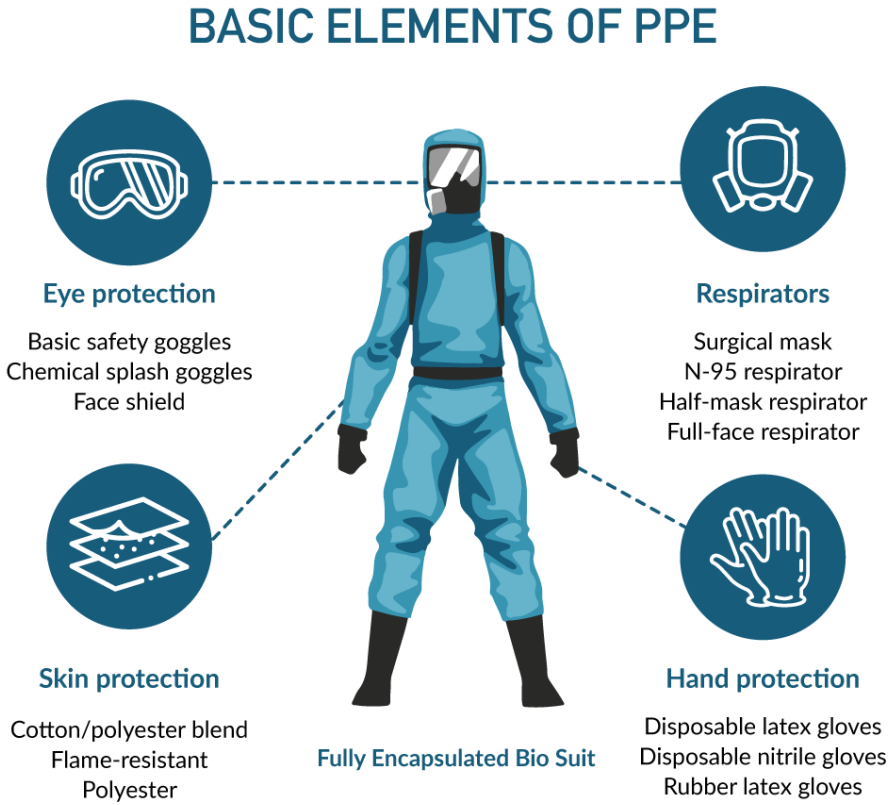
Beyond Water: Advancing Chemical Burn First Aid with Diphoterine®

PREVOR
ANTICIPATE AND SAVE
Toxicology Laboratory & Chemical Risk Management

levittsafety

Hierarchy of Controls





Case 1) Routine Maintenance, Not Routine Outcome

- In 2023, a 53-year-old industrial worker stepped into an alkali spill on his foot during routine maintenance.
- Exposure felt “silent” at first — no pain, continued working.
- Full-thickness burn discovered later multiple surgeries, skin grafts, long-term rehabilitation.

Presentation at ER

After 5th surgery

Source: Machado P, Barbosa T, Jarnalo M, Mendes M, Brito I, Horta R, Egipto P. The Silent Threat-Alkali Foot Burn: A Case Report. Ann Burns Fire Disasters. 2023 Dec 31;36(4):317-319. PMID: 38680237; PMCID: PMC11041924.

Case 2) Sudden Exposure

- 52-year-old male who presented emergently after an alkali chemical injury to his eyes.
- A dishwasher line exploded causing industrial grade dishwasher to splash directly onto his face. He reported instant vision loss in his right eye, and severe bilateral eye pain.
- When initially evaluated at an outside hospital, the reported pH was 9.0 in his right eye and 8.5 in his left eye. An open globe was ruled out and he was irrigated with 2L normal saline in both eyes during transfer.

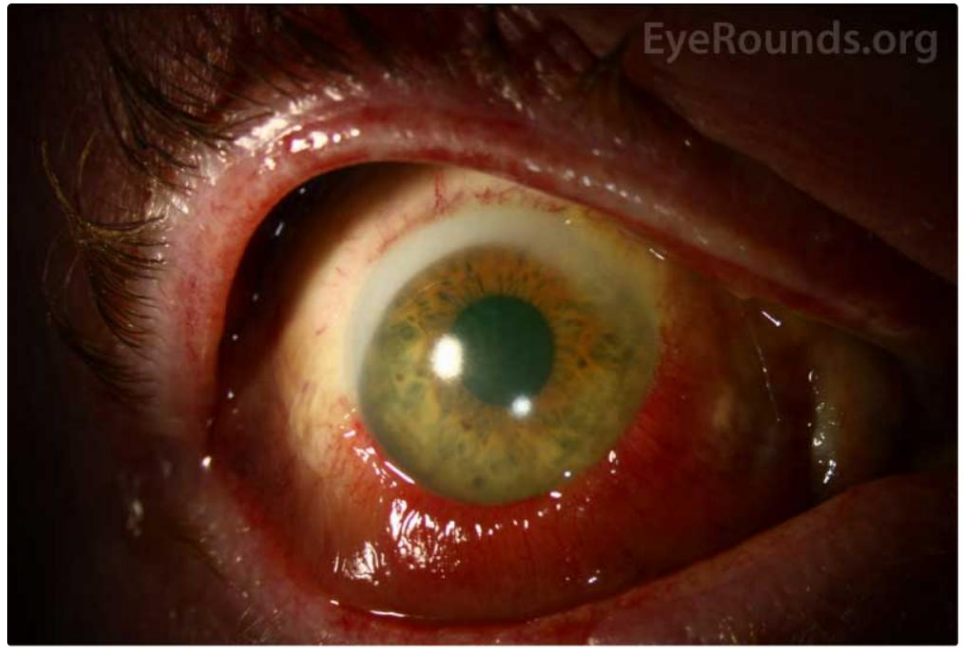
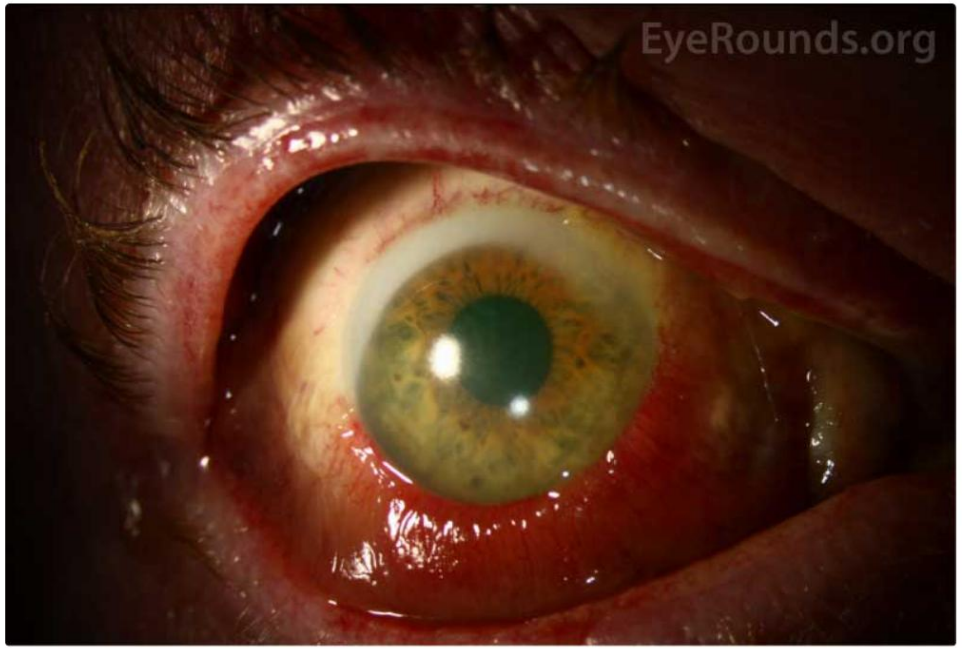


Figure 1. External photo of the left eye demonstrates subconjunctival hemorrhage and chemosis extending from 2:30 clockwise to 9 o'clock. Attention is drawn to a sector of limbal ischemia extending from 9 clockwise to 3 o'clock.

Yu CY, Diel RJ, Jiang L, Greiner MA. Chemical Eye Injuries: A Case Report and Tutorial. EyeRounds.org. February 28, 2022. Available from https://eyerounds.org/cases/307-chemical-eye-injury.htm

Case 2) Sudden Exposure

- Irrigated with another 9-10L of saline.
- At follow up 2 days later visual acuity in right eye diminished to light perception.
- Admitted for ocular surface reconstruction.
- Post op, the patient suffered a loss of the reconstructed membrane; was removed.
- Expereinced ongoing significant pain during recovery.
- At one month post op, decision was made due to continuing pain, guarded visual prognosis, and new concern for fungal keratitis, patient eleceted to proceed with enucleation.



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WCB Statistics – Chemical Burns

Metric (Avg. 2023-2024)	Alberta (WCB)	British Columbia (WorkSafeBC)
Total Annual Claims	~128,000	~143,000
Coded Chemical Burns (Nature 052)	**210 - 240** (est. per year)	**180 - 210** (est. per year)
% of All Burns	~12%	~10%
Avg. Days Lost per Event	**48 days**	**52 days**
Common Sector	Mining, Oil & Gas (Upstream)	Manufacturing & Pulp/Paper

Corrosive

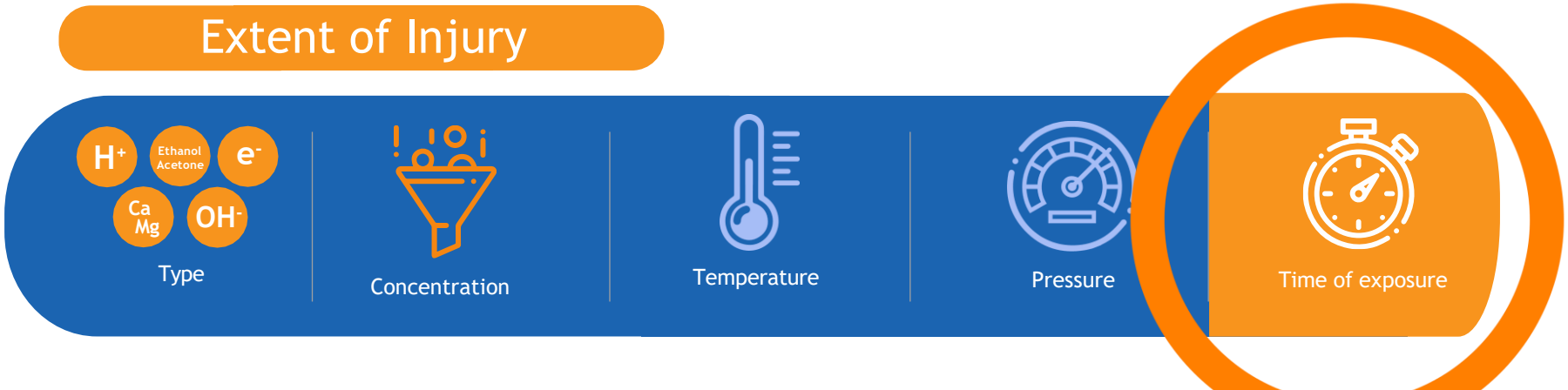
- High energy state
- Irreversible effects to biological tissue

Irritant

- Low energy state
- Reversible effects to biological tissue

More than **25,000 irritant and corrosive chemicals** are identified as having the **potential** to cause **chemical injuries.**

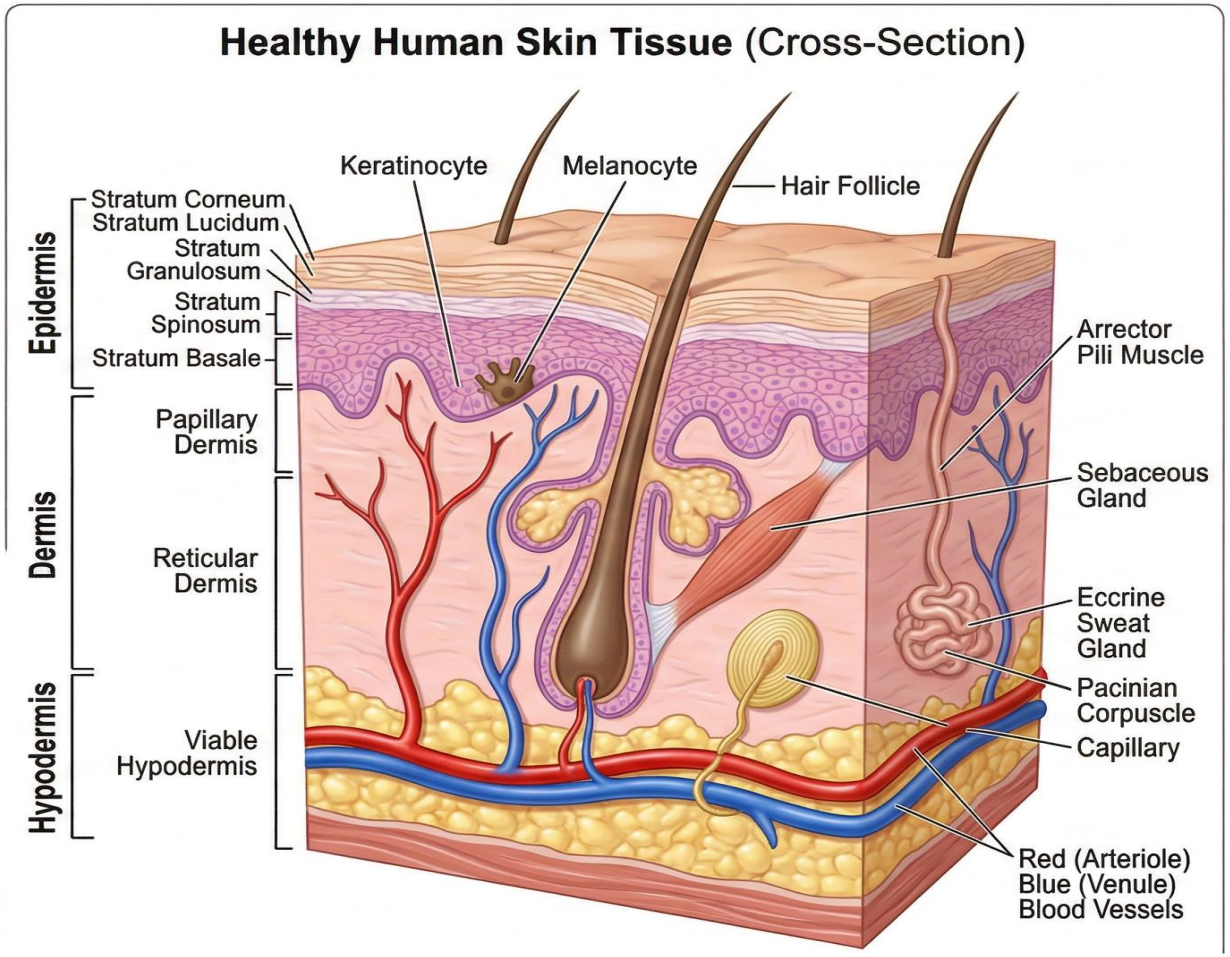
Extent of Injury

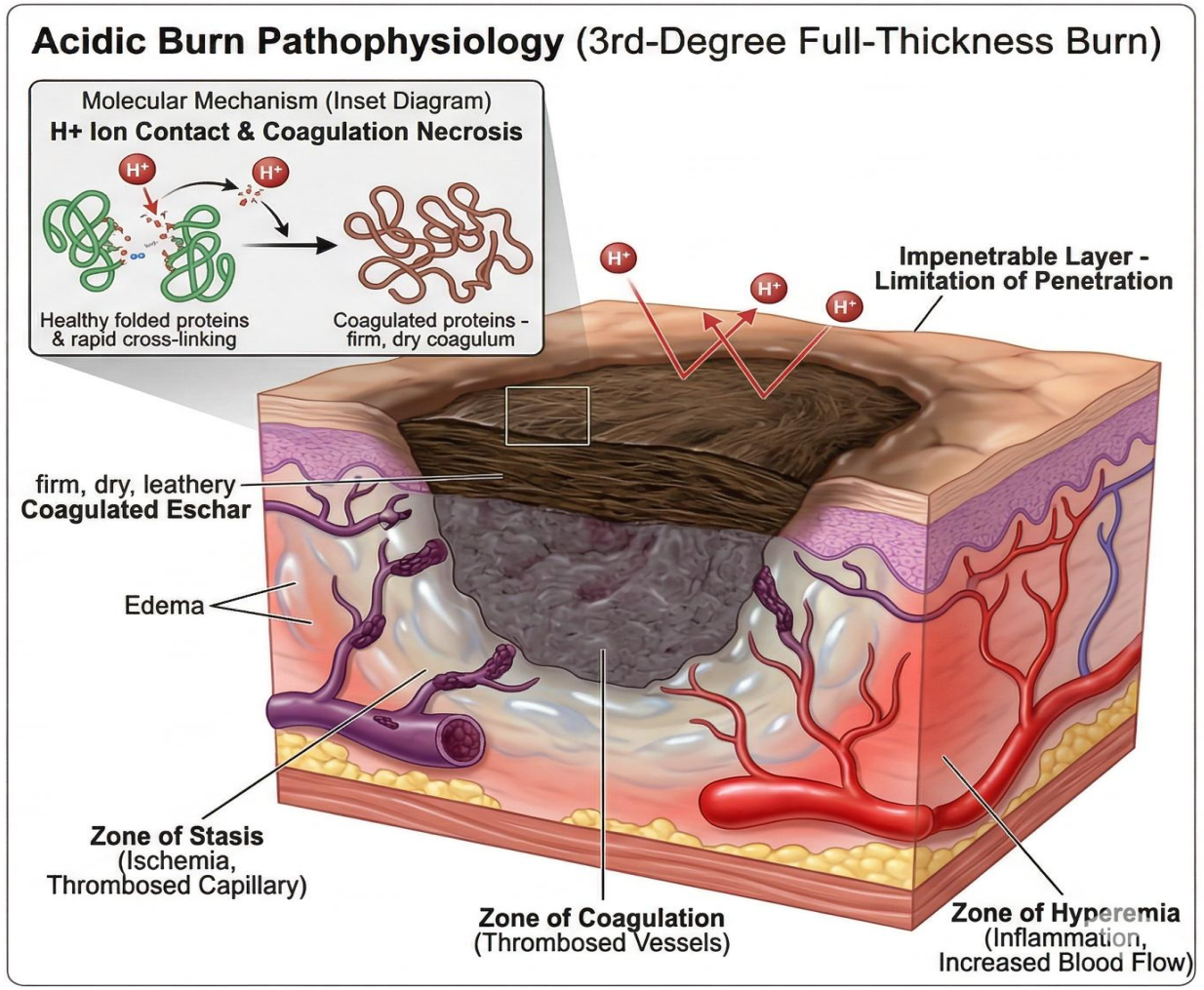


Pathophysiology of the Chemical Lesion

Pathophysiology of Chemical Lesions – Acid (H+)

Mechanism & Pathophysiology: Acidic Chemical Burn

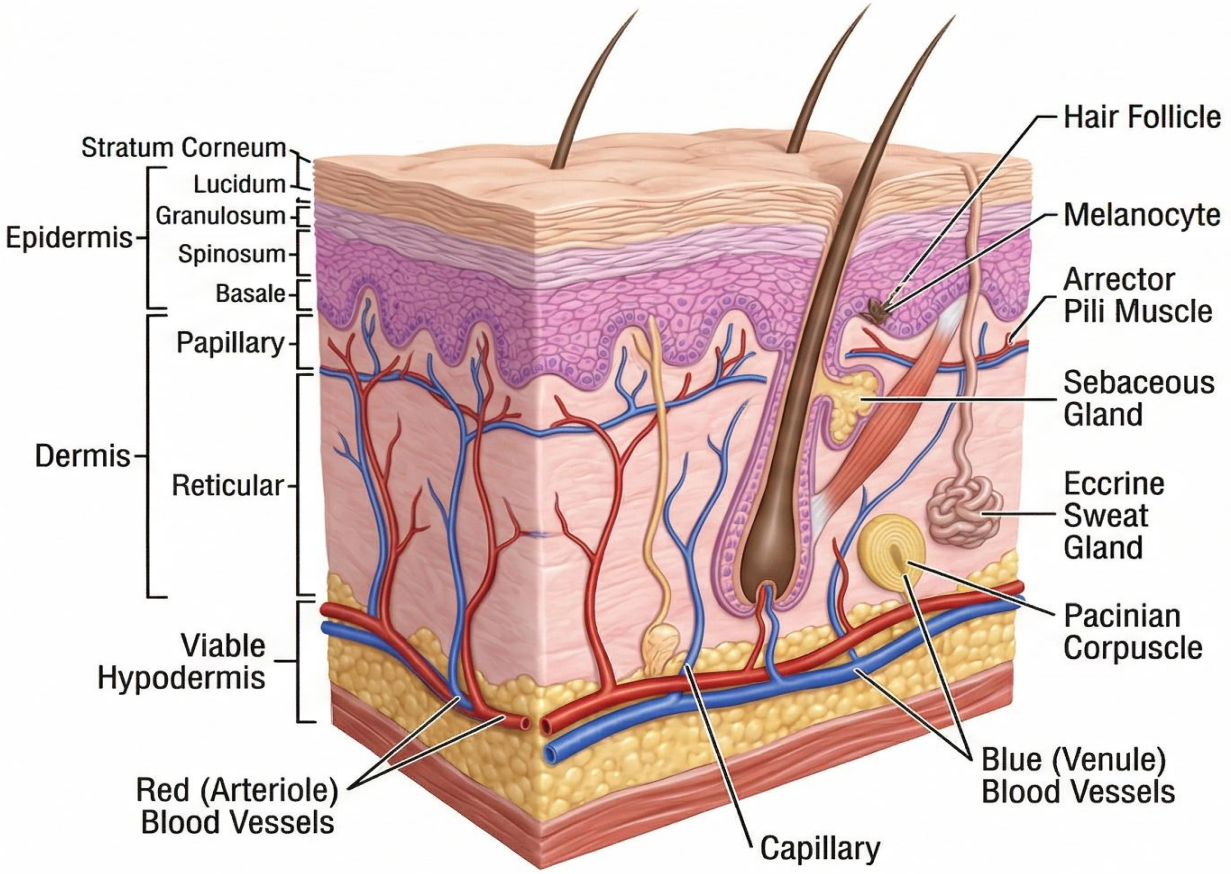




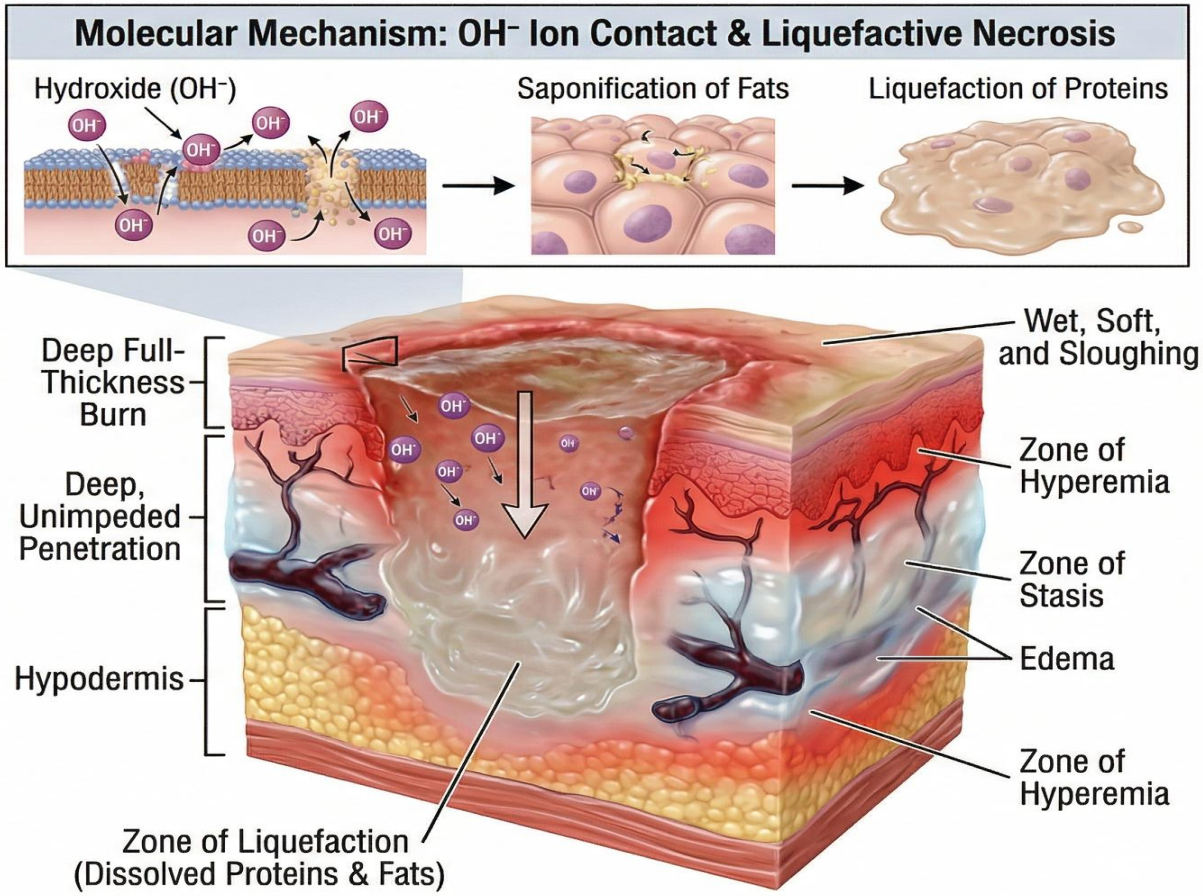
Pathophysiology of Chemical Lesions – Basic (OH-)

Mechanism & Pathophysiology: Basic (Alkaline) Chemical Burn

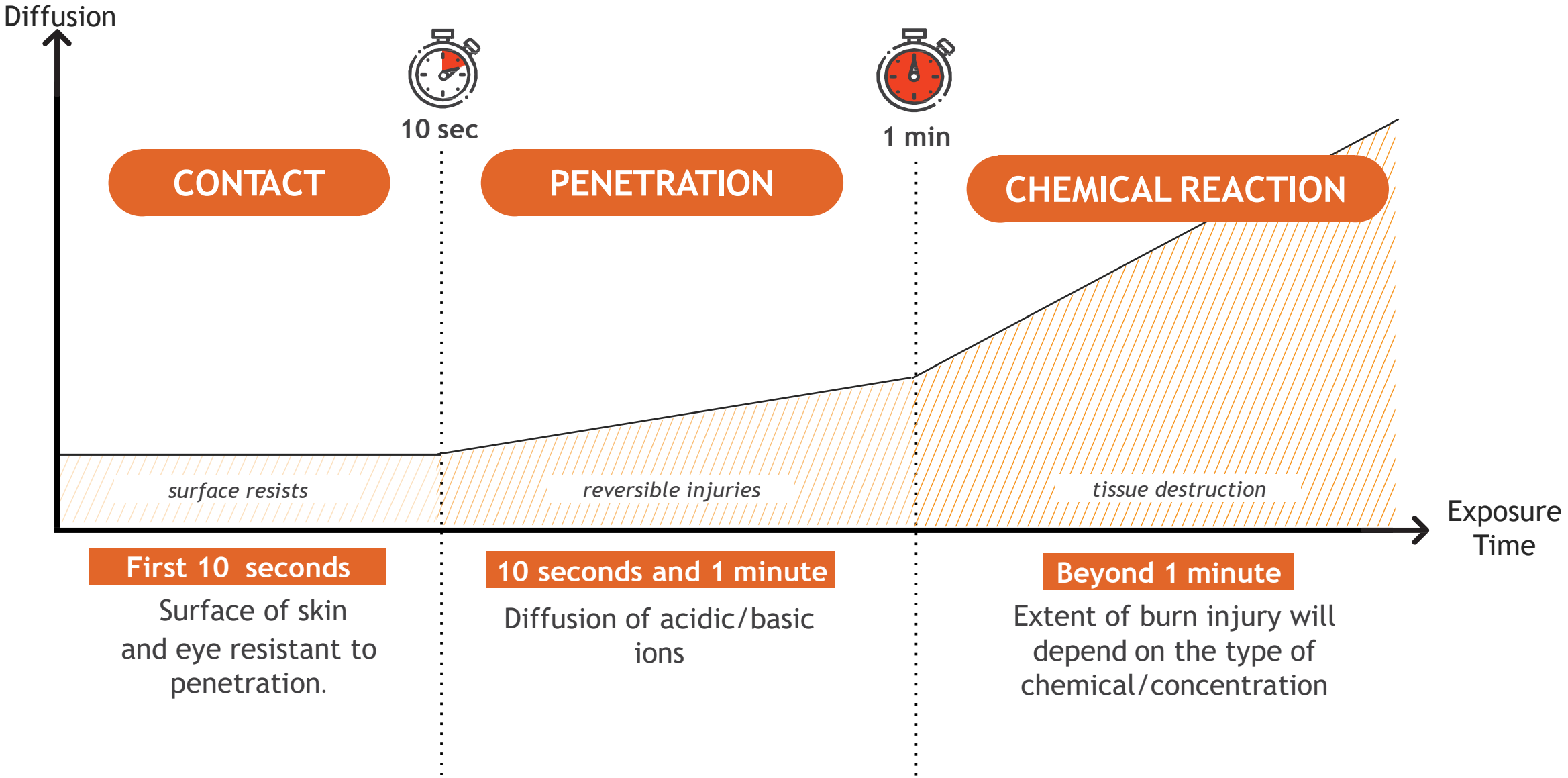
Healthy Human Skin Tissue (Cross-Section)



Alkaline Burn Pathophysiology (Deep Liquefactive Necrosis)

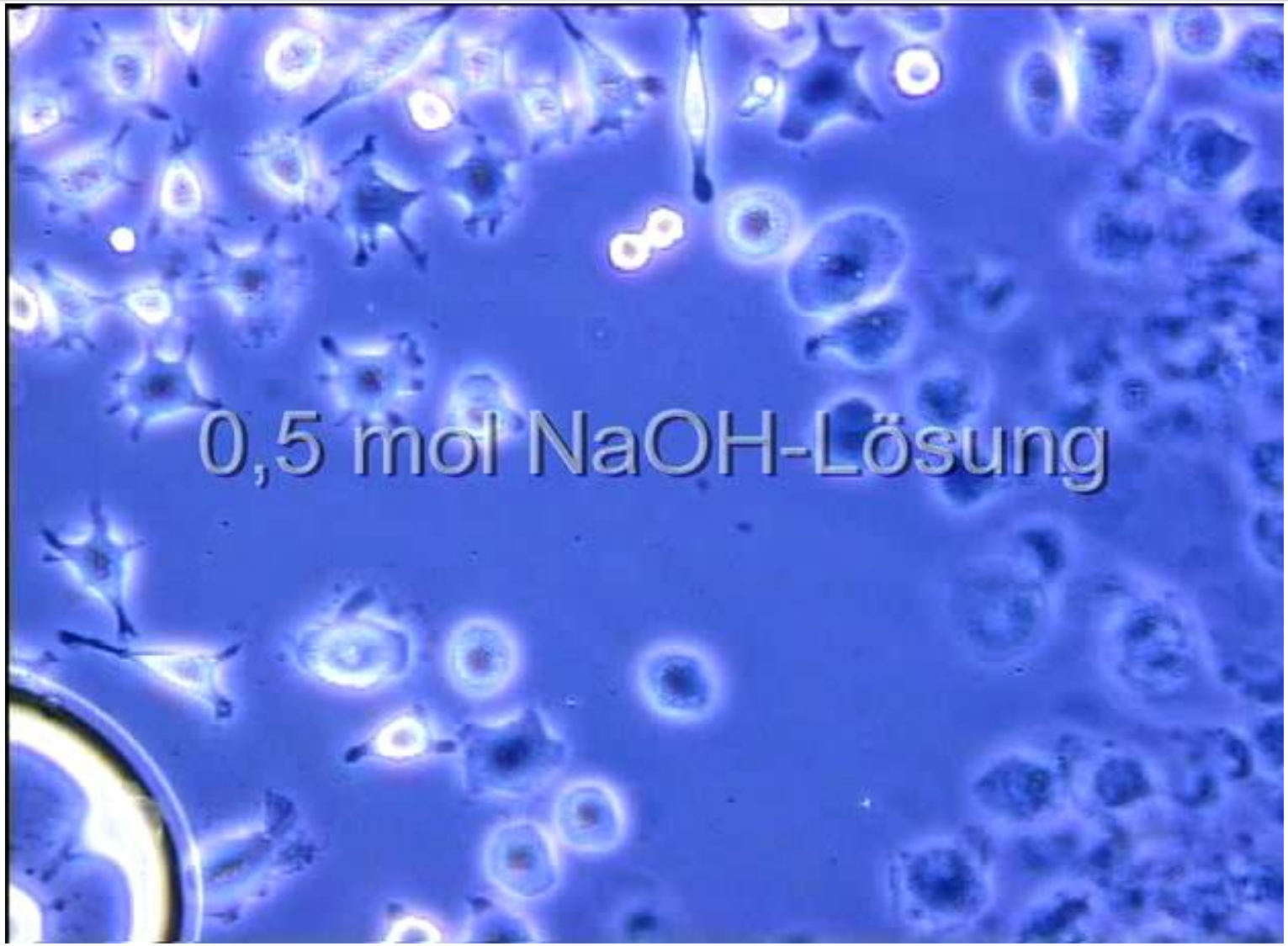


Time = Tissue


Diffusion
10 sec
1 min
CONTACT
PENETRATION
CHEMICAL REACTION
surface resists
reversible injuries
tissue destruction
Exposure Time
First 10 seconds
Surface of skin and eye resistant to penetration.
10 seconds and 1 minute
Diffusion of acidic/basic ions
Beyond 1 minute
Extent of burn injury will depend on the type of chemical/concentration

Tissue Cell Exposure to 4% to NaOH

(*Rabbit's cornea in ex-vivo*)



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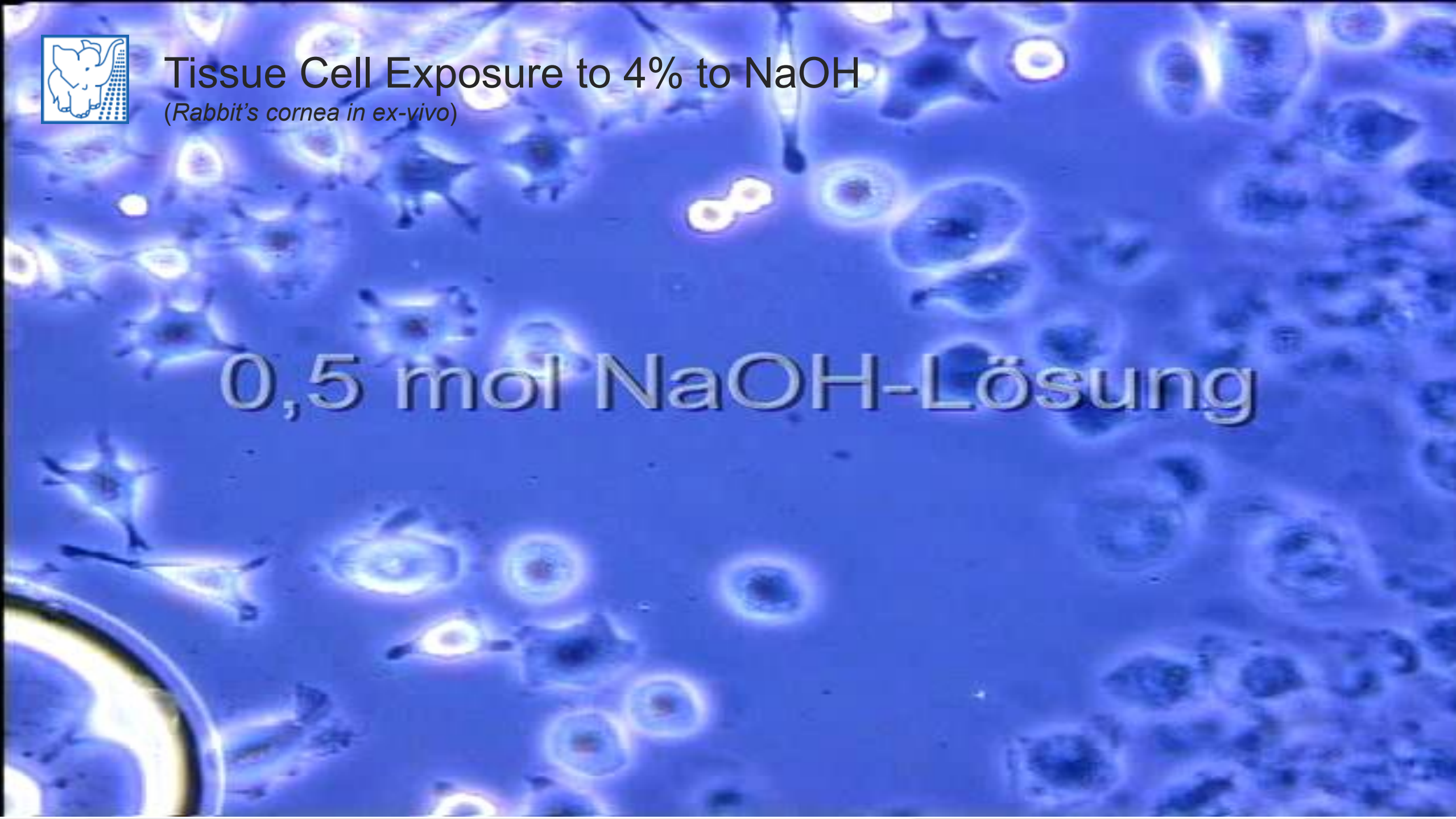


Chemical Burns - Water,Saline and Other Flushing Fluids; What They Can, and Cannot Do

Benefits of Water Rinsing ?

Mechanical Removal

Dilution

Single-Simple Protocol

Cooling Capacity

Limitations of Water Rinsing ?

Dilution

Squeegee Effect

Hypothermia

Intervention Time

Hypotonic Effect

ESEW Can Be Problematic

Water dilutes, it does not neutralise

- Water lowers concentration, but unless pH/reactivity is neutralized, the chemical stays active and injures tissue.
- Example (HCl): 10 mL concentrated HCl (~12 M) in 1 L water → ~0.12 M (pH ~0.9). Still corrosive (≤2). Diluted but dangerous.
- Alkalis (pH >11.5) penetrate deeply, keep burning until neutralized.
- Acids remain corrosive at low pH even after dilution.

Water - Hypothermia

Long flushing times with cold water (less than 16˚C (60˚F)) can cause hypothermia and may result in not rinsing or showering for the full recommended time (ANSI 2014).
Ref: https://www.ccohs.ca/oshanswers/safety_haz/emer_showers.html

What are the signs and symptoms of hypothermia?
The following are warnings signs of hypothermia:

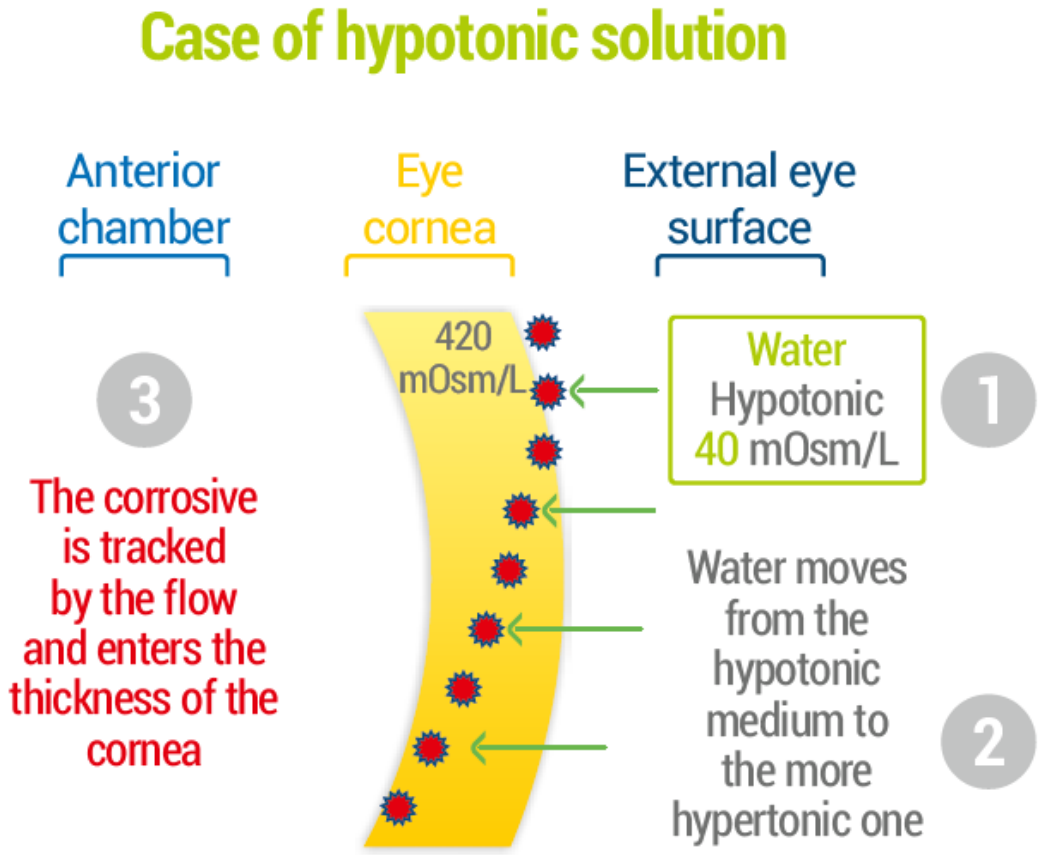
Adults:

Shivering
Exhaustion or feeling very tired
Confusion
Fumbling hands
Memory loss
Slurred speech
Drowsiness

ANSI Z358.1 Rinsing Must Begin: 10 sec/55 ft.

- Can the victim find the showers?
- Is the path clear?
- Will they remove their clothes in front of co-workers?
- Is their vision impaired?
- Do they need assistance from a co-worker?
- Are they even near a shower?
- What is their emotional state?

Water - Hypotonic Effect of Water on Tissue Cells



The Squegee Effect

90% Sulphuric Acid Exposure

- Rinsed immediately with water
- Continued rinsing at worksite and hospital
- 33% of the body with grade II burns
- 58 days in hospital
- Extensive LTD's
- Emotional difficulties

Ref. Wen J. Occup Health & Emerg Rescue. 2017 Feb, 35(1):2

Flushing options besides water?

EYEWASH SOLUTIONS

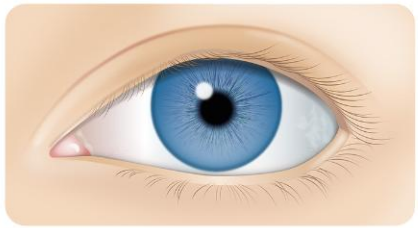
EN 15154 (-2 AND -4)

PREVOR

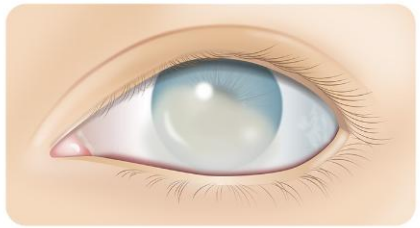
TYPE	WATER CONNECTION ?	WASHING (MECHANICAL EFFECT)	STERILE	LOW VOLUME REQUIRED	VERSATILITY	SAFE	ACTIVE
/	/	Remove the chemical on the surface	Avoids bacteriological contamination	Requires a small quantity	Works on all families of chemicals	Prevents over-accidents	Stops the aggressiveness of the chemical product
EYEWASH SOLUTION	WITH	✓	✗	✗	✓	✓	✗
STERILIZED WATER	WITHOUT	✓	✓	✗	✓	✓	✗
SALINE SOLUTION	WITHOUT	✓	✓	✗	✓	✓	✗
BUFFER SOLUTION	WITHOUT	✓	✓	✓	✗	✗	✓
AMPHOTERIC AND CHELATING SOLUTION	WITHOUT						

Buffered Saline and its risks

- Buffered saline is commonly found in bottled eyewash (check your eyewash SDS)
- Phosphate has a neutralizing effect on acids and alkalis, but if phosphate comes in contact with calcium ions, there is a reaction that can cause calcification.
- Calcium ions can be commonly found in the industrial space, especially when working with cement, concrete and/or lime.



Healthy eye



Eye with Corneal calcification

> *Our study revealed frightening results. In my opinion, phosphate buffered eye wash should be banned and removed from the market. To eliminate the risk of corneal calcification you should use a phosphate-free eye wash. I can recommend phosphate-free rinsing solutions.*

References:
Schrage NF, Abu Sabah, Hermanns, Panfil,Dutescu RM: Irrigation with phosphate-buffered saline causes corneal calcification during treatment of ocular burns; Burns (2019) in press

Schrage NF (2010) Current Recommendations for optimum treatment of chemical eye burns. Moist swabs, compresses, phosphate buffers, and other forms of malpractice.

Schrage NF, Frentz M, Reim M. (2010) Changing the composition of buffered eye-drops prevents undesired side effects. Br J Ophthalmol 94(11):1519-1522.

Schrage NF, Schlossmacher B, Aschenbrenner W, Langefeld S. (2001) Phosphate buffer in alkali eye burns as an inducer of experimental corneal calcification. Burns 27(5):459-464.

Diphoterine® - An Advanced Approach to Chemical Exposures

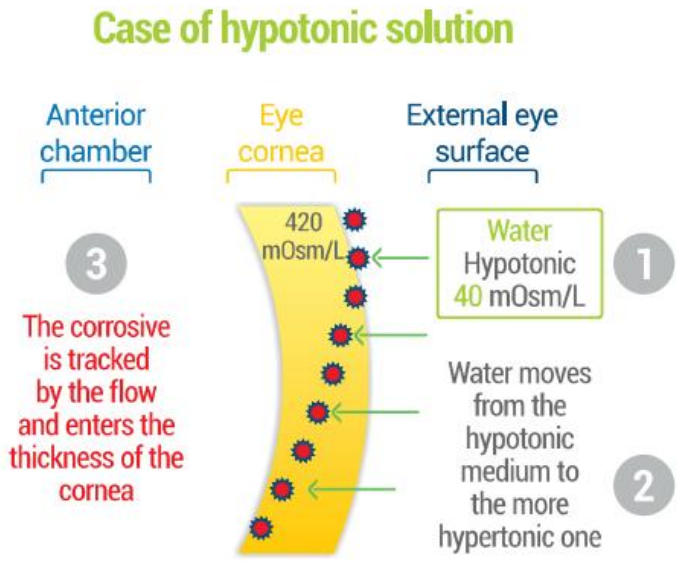
DIPHOTERINE® solution

Hypertonic - Chelating - Amphoteric

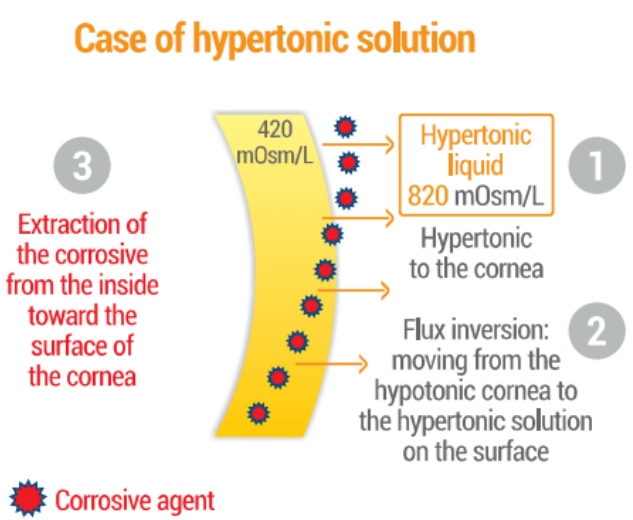
- Effective Mechanical Removal
- Prevents Further Penetration
- Reverse Osmotic Flow
- Binds & Restores Physiological pH
- Extends Response Time

Hypertonic Solution – Draw out dangerous ions

- Hypertonic solution creates osmotic gradient
- Actively draws chemical molecules *out of tissue* (reduces penetration)
- Complements amphoteric action to neutralize acids & bases externally
- **Clinical relevance:** Less deep injury → smaller grafts, faster healing

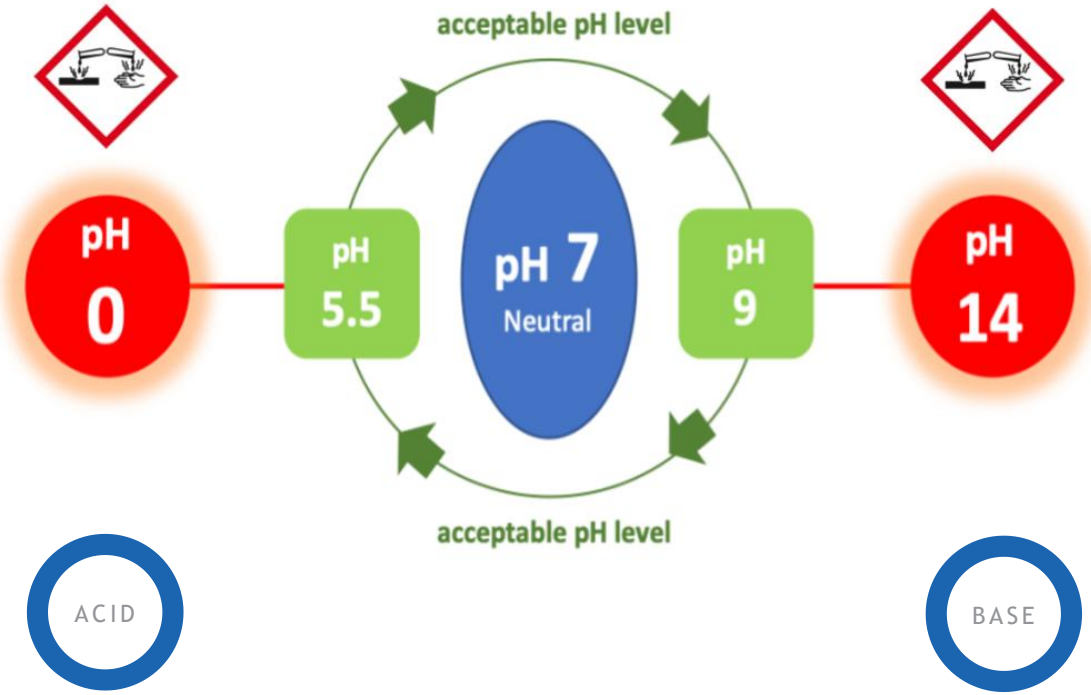


DIPHOTERINE®



Chelating Solution – Restore Tissue Physiological pH

DIPHOTERINE®



Amphoteric and Polyvalent - Performs on all Classes of Chemicals

DIPHOTERINE®

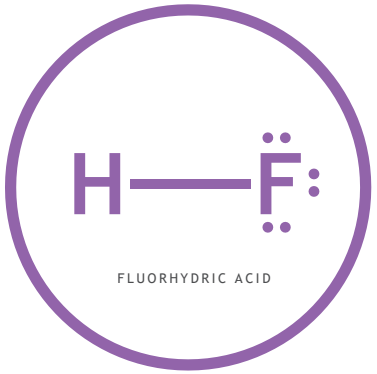
Regularly Published List of Tested Chemicals

POLYVALENT

- ACID — H^+ — H_2SO_4
- BASES — OH^- — NaOH
- OXYDIZING AGENTS DONORS — e^- — H_2O_2
- REDUCING AGENTS ACCEPTORS — e^- — Na_2SO_3
- CHELATING AGENTS — Ca, Mg
- Solvents — DMSO — Dimethyl Sulfoxide
- ALKYLATING AGENTS — Pesticide — Agriculture agents

HEXAFLUORINE®

Active for

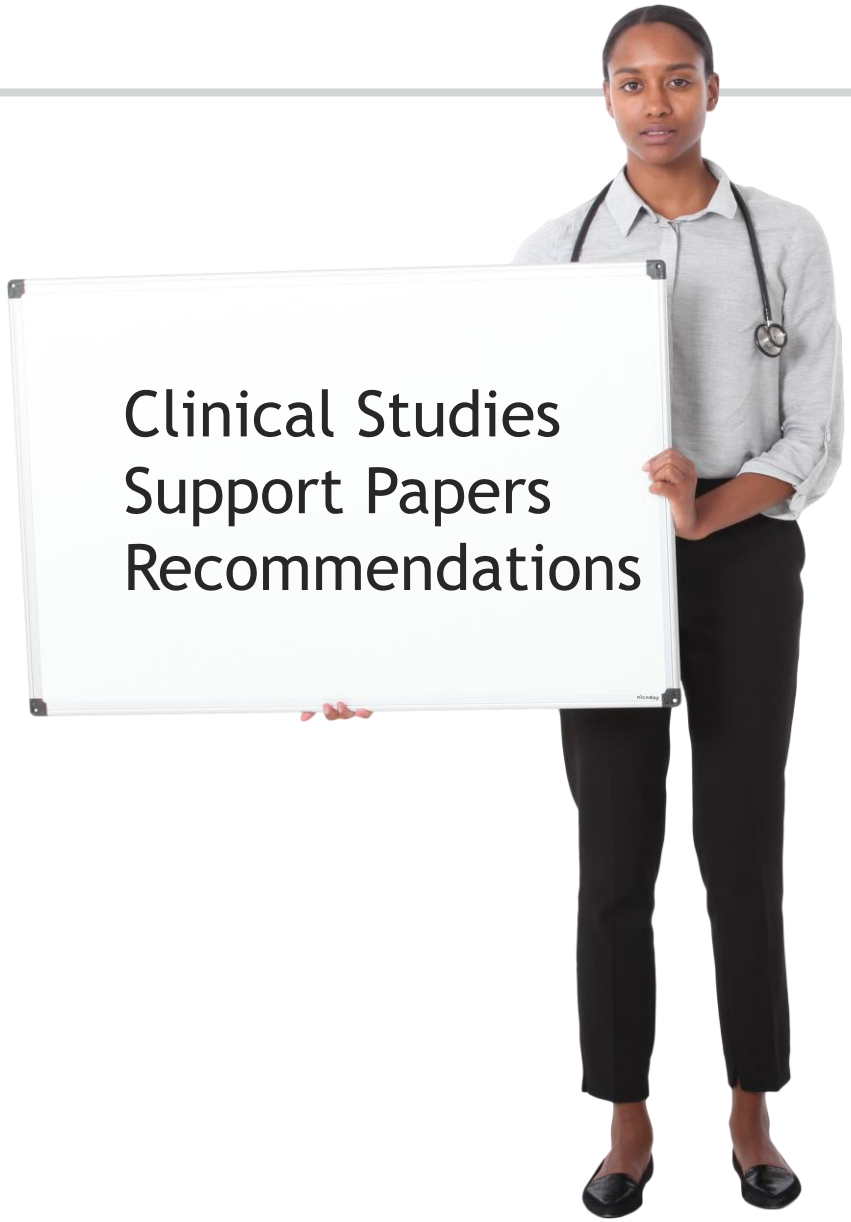


Water vs Diphoterine® - pH Demonstration

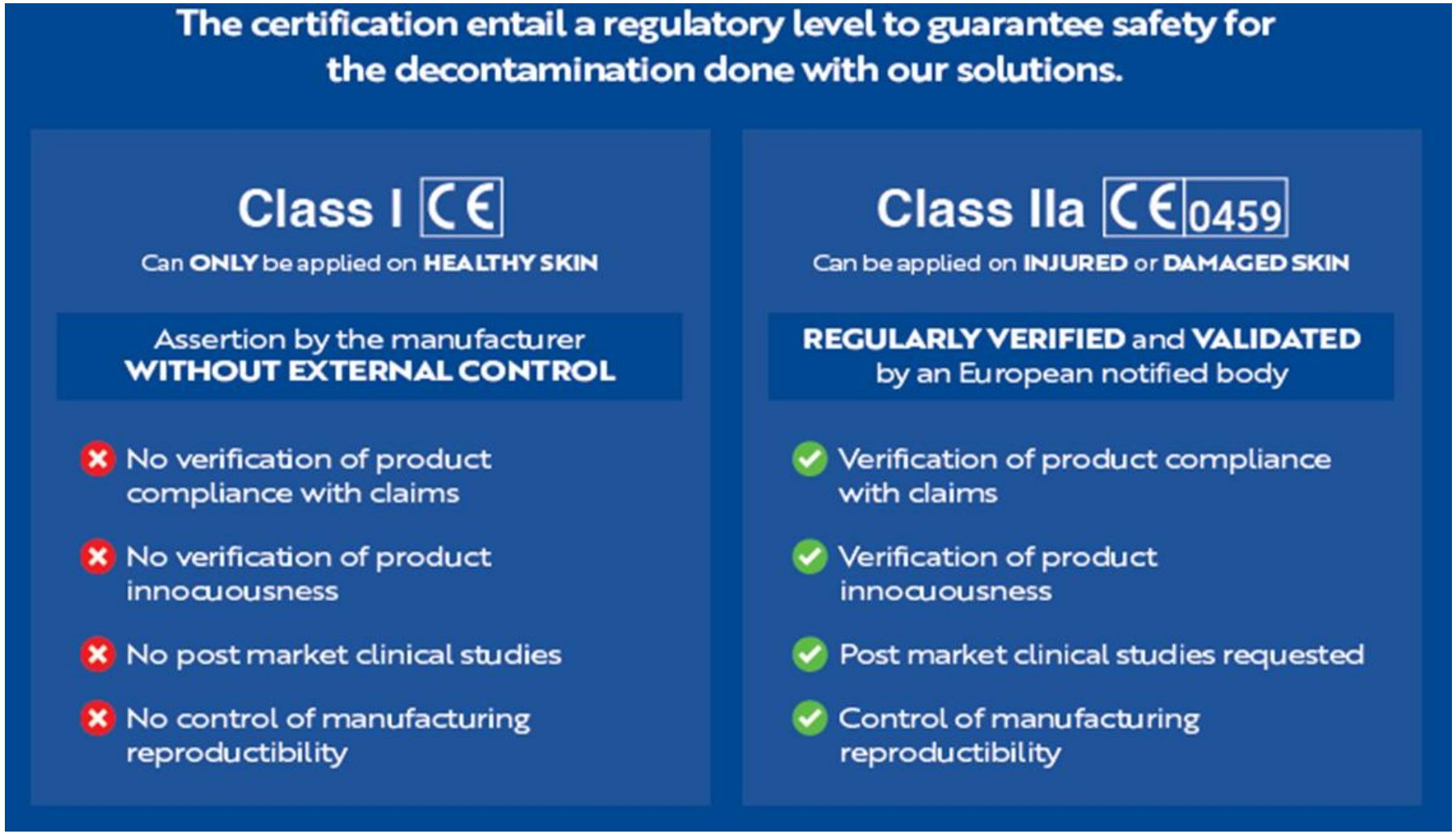
Actions & Mechanism

Actions & Mechanism

Supports For Its Use



A note about Class 2A Medical Devices – Comparing Class 1 to Class 2



Comparative evaluation of eye and skin chemical splash decontamination Solutions vs Diphoterine and Hexafluorine

FEATURE

Comparative evaluation of the active eye and skin chemical splash decontamination solutions Diphoterine and Hexafluorine with water and other rinsing solutions: Effects on burn severity and healing

By Laurence Mathieu, François Burgher, Joël Blomet

(EINECS; 100,204 substances) and the European List of Notified Chemical Substances (ELINCS; 3,827 sub-

potential burn. Historically, water was the usual decontamination method. This was a great advance in limiting

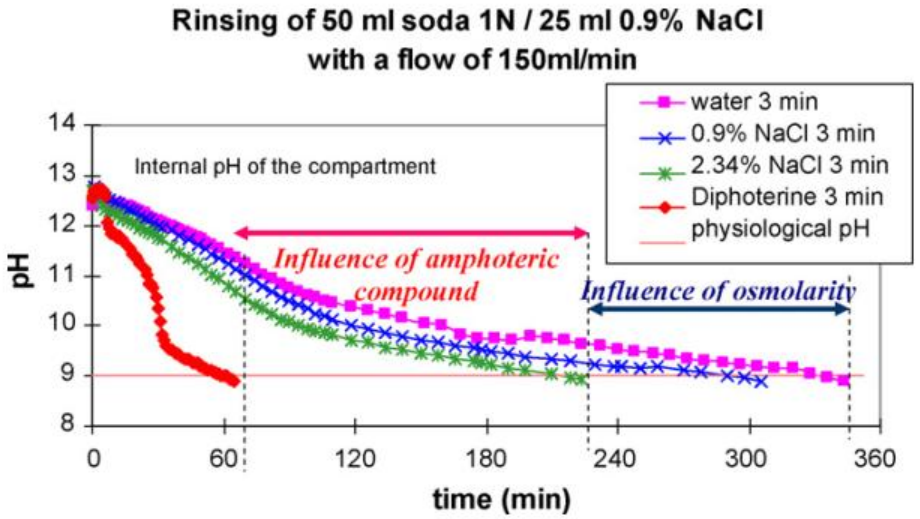


Figure 4. Influence of osmotic pressure and amphoteric properties on rinsing effectiveness.

Reported chemical splashes Study ‘91 through ‘99 and ALCOA Study 2010

> Reported chemical splashes washed with Diphoterine®

Year	No of cases	Company / country	Aggressive Product	Body surface
1999	1	Knoll AG Germany	96% Sulphuric acid	Cheek
1998	1	Giesecke & Debrient Germany	100% Nitric acid	Hand
1993	1	Mewa Germany	50% Soda*	Forearm
1991	1	Alusuisse France	Soda flakes	Left eye
1991	2	Orgachim	98% Sulphuric acid	Face + neck + shoulders ; (id + legs)

Results : no sequelae, no secondary care, no worktime lost**

(Presented at Occupational Hygiene 2000, Manchester, UK, April the 11th-13th 2000)

Dr. Girard, Rhodia, La Rochelle, France ; Mr. Uellner, Martinswerk, Bergheim, Germany ; Dr. Nehles, Mannesmann, Remscheid, Germany.

** soda : sodium hydroxide*

*** cream ointment for case n°1*

> CASE SERIES

ALCOA STUDY

Severity scale and associated signs	DAP first	Water first
1 (No sign)	73 (52,9%)	9 (21,4%)
2 (Erythema)	54 (39,1%)	23 (54,8%)
3 (Blisters)	10 (7,2%)	8 (19,0%)
4 (More serious)	1 (0,7%)	2 (4,8%)
TOTAL	138 (100%)	42 (100%)

> ALCOA Australia Study, 2010

Conducted by Dr. Donoghue on 180 cases of alkali skin splashes from the 1st of May 2005 to the 30th of April 2008.

Criteria used :

1 : Time elapsed from the chemical splash to the clinical assessment.

2 : Time elapsed from the chemical splash to the application of Diphoterine®.

3 : Percentage of skin surface splashed by the chemical.

Conclusions of the study :

"Applying Diphoterine® first was associated with significantly better outcomes following alkali skin splashes than applying water first".

("Diphoterine® for alkali chemical splashes to the skin at alumina refineries" - International Journal of Dermatology 2010, 49, 894-900 / Dr A. Michael Donoghue)

Use of an Amphoteric Solution in Eye, Skin and Oral Chemical Exposures: Retrospective Multicenter Clinical Case Series

Journal of Clinical Toxicology

Fortin et al., J Clin Toxicol 2017, 7:2
DOI: 10.4172/2161-0495.1000343

Research Article OMICS International

Use of an Amphoteric Solution in Eye, Skin and Oral Chemical Exposures: Retrospective Multicenter Clinical Case Series

Fortin JL[1,2,3,4], **Fontaine M**[4], **Bodson L**[5], **Depil-Duvala A**[6], **Bitar MP**[1], **Macher JM**[1,7], **Paulin P**[3], **Ravat F**[4] **and Hall AH**[8,9*]

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[2]*Preventive Medicine, 82 Bergson Street, 42 000 Saint-Etienne, France*

[3]*Medical Department, Sdis 25, 10 Clairière Street, 25 042, Besançon Cedex, France*

[4]*Burn Intensive Care Unit, Saint Joseph Saint Luc Hospital, 20 Quai Claude Bernard, 69007 Lyon, France*

[5]*Emergency Department, University Hospital, Sart Tilman B, 4000 Liege, Belgium*

[6]*Emergency Department, St-Luc-St-Joseph Hospital, 20 Quai Claude Bernard, 69 007 Lyon, France*

[7]*Emergency Department, Nouvel Hôpital Street 26, 88100 Saint-Diė-des-Voges, France*

[8]*Toxicology Consulting and Medical Translating Services, P.O. Box 1255, Azle, Texas 76098, USA*

[9]*Colorado School of Public Health, University of Colorado-Denver, Denver, Colorado, USA*

[*]**Corresponding author:** Alan H Hall, Medical Toxicologist, Toxicology Consulting and Medical Translating Services, P.O. Box 1255, Azle, TX 76098-1255, USA, Tel: 1-307-399-1564; E-mail: OldEDDoc@gmail.com

Received date: February 22, 2017; **Accepted date:** March 21, 2017; **Published date:** March 27, 2017

CONCLUSION: Both in vitro and in vivo, Diphoterine® solution has been shown to be effective on eye, skin and mucous membrane chemical injuries.

For the best results, Diphoterine® solution flushing should begin as soon as possible after the chemical splash occurs in order to prevent or lessen lesion development.

DIPHOTERINE® FOR EMERGENT EYE/SKIN CHEMICAL SPLASHDECONTAMINATION: A REVIEW - AH Hall et al 2002

DIPHOTERINE® FOR EMERGENT EYE/SKIN CHEMICAL SPLASH DECONTAMINATION: A REVIEW

Alan H. Hall,[1] Jöel Blomet,[2] Laurence Mathieu[2]

[1]Department of Emergency Medicine, Division of Toxicology
Texas Tech University Health Sciences Center-El Paso, Del Paso, Texas
Toxicology Consulting and Medical Translating Services, Inc.
El Paso, TX, USA

[2]Laboratoire Prévor
Valmondois, France

A comparative study of the use of Diphoterine® in the Rhone Poulenc facility at La Rochelle,France, was performed from 1987-1992.23 Chemicals involved in eye/skin splashes were acids and sodium hydroxide. Diphoterine® and water decontamination were compared using outcome endpoints of lost work time and requirements for additional chemical irritation/burn treatment. During 1987-88,water decontamination was done; in 1989, Diphoterine® decontamination was added; data for 1990 were not reported; during 1991-92, some water decontamination was still done, but the majority of exposed workers were decontaminated with Diphoterine®. Use of Diphoterine® decontamination was directly related to decreased severity of irritation/burns following acid/alkali chemical eye/skin splashes and **no lost work time occurred in the last 2 years of the study** when the majority of exposed workers were decontaminated with Diphoterine®.

In a 3rd workplace, of 375 workers with eye/skin exposure to 5 priority chemicals (acrylates,98% sulfuric acid, oleum, 22% sodium hydroxide, or Diethyaminoacrylaye) had a significantly decreased incidence of lost work time, a significantly decreased incidence of long-term sequelae, and a non-significant trend for lesser Burn Center (skin decontamination) or ophthalomogical consultations as compared to water.24

Effect of initial Decontamination on 1136 clinical exposures with highly corrosive chemicals

GAVIN PUBLISHERS

OPEN ACCESS

Emergency Medicine Investigations

Wiesner N, et al. Emerg Med Inves 6: 10108.

DOI: 10.29011/2475-5605.010108

Research Article

Effect of initial Decontamination on 1136 clinical exposures with highly corrosive chemicals

Nicola Wiesner, Christiane Edelmann, Daniel Uthoff, Norbert Schrage*

Department of Ophthalmology, Hospital Cologne-Merheim, Cologne, Germany

***Corresponding author:** Norbert Schrage, Department of Ophthalmology, Hospital Cologne-Merheim, Cologne, ACTO eV, Germany

Citation: Wiesner N, Edelmann C, Uthoff D, Schrage N (2021) Effect of initial Decontamination on 1136 clinical exposures with highly corrosive chemicals. Emerg Med Inves 6: 10108. DOI: 10.29011/2475-5605.010108

Received Date: 12 March, 2021; **Accepted Date:** 27 March, 2021; **Published Date:** 31 March, 2021

Conclusions: Diphoterine®/Previn® solution in first and secondary aid rinsing fluid had less severe outcomes in Roper Hall classification in treating eye burns caused by aggressive corrosive agents. This clinical results support decades of experimental research. In the light of this clinical study, a randomized prospective study seems difficult to justify.

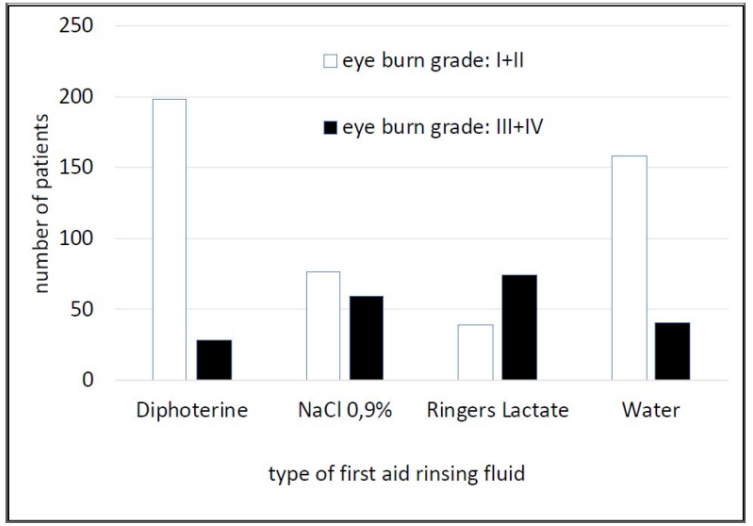
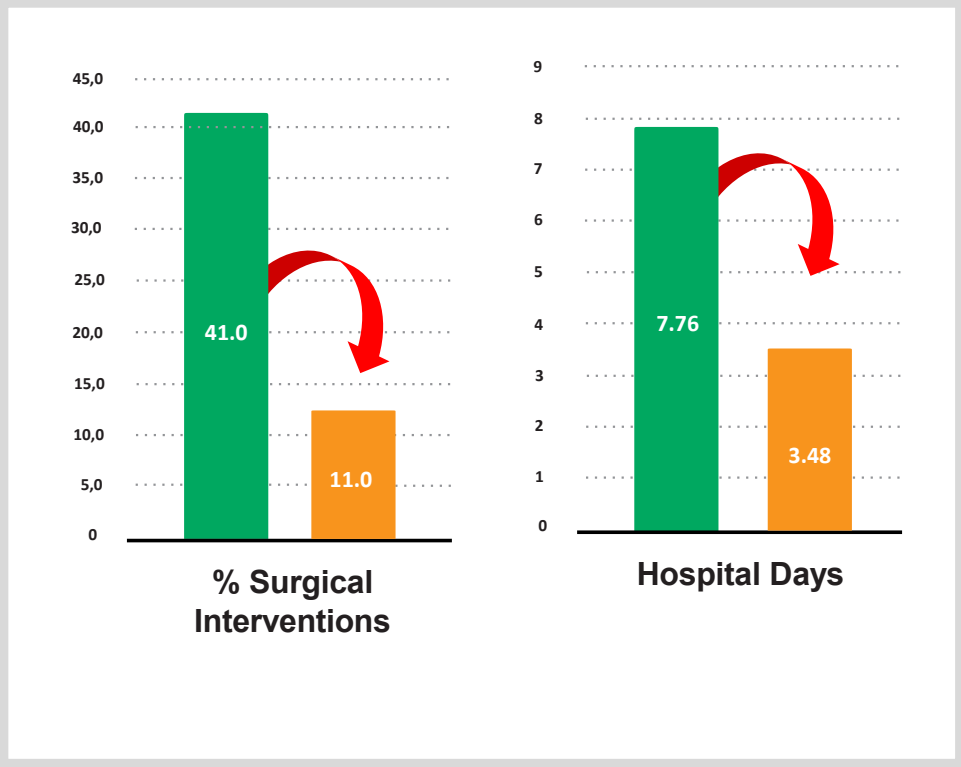


Figure 1: Decontamination of severe corrosives by first aid rinsing solutions. The grade III and IV group are proportional lower for Previn followed by water saline and ringers lactate. There is a significant shift from severe burns to healing burns if the appropriate rinsing solution is taken in first aid.

University of Ghent, Belgium Hospital Study

FIRST
24 Hrs



Exposure: Sulphuric Acid (97%)
1st wash: Water
2nd wash (1 hour later): Diphoterine®.

Verbelen J, Hoeksema H, Monstrey S, Diphotérine® et Hexafluorine® dans l'hôpital universitaire de Gand (Belgique): 4 années d'expériences, Belgium, BBA 2017

Diphoterine® solution reduced need for surgery and hospitalization days on 112 patients at Department of Emergencies in Ghent, Belgium.

Case Study – Delayed Rinsing Using an Amphoteric Solution

Case Study – Delayed Rinsing Using an Amphoteric Solution

- Dec 17, 2025. Days before Christmas and during an Alberta cold snap.
- Worker was required to carry caustic in a bucket from one building, exiting outside to enter another. Caustic was at a concentration of 50%.
- Goggles fogged up, could not see when they entered the building. Went to adjust goggles with their hand, not aware that some caustic had gotten on to their coveralls/hand.
- Completed his task. It was approximately 5 minutes before the worker noticed the delayed effects of the caustic on their skin.

Case Study – Delayed Rinsing Using an Amphoteric Solution

- Upon noticing the lesion, the worker proceeded to initiate flushing with Diphoterine, followed by water, followed by another rinse of Diphoterine.
- Assessed at ER that night. No further interventions were required, other than wound care education.

Case Study – Delayed Rinsing – The Healing Path

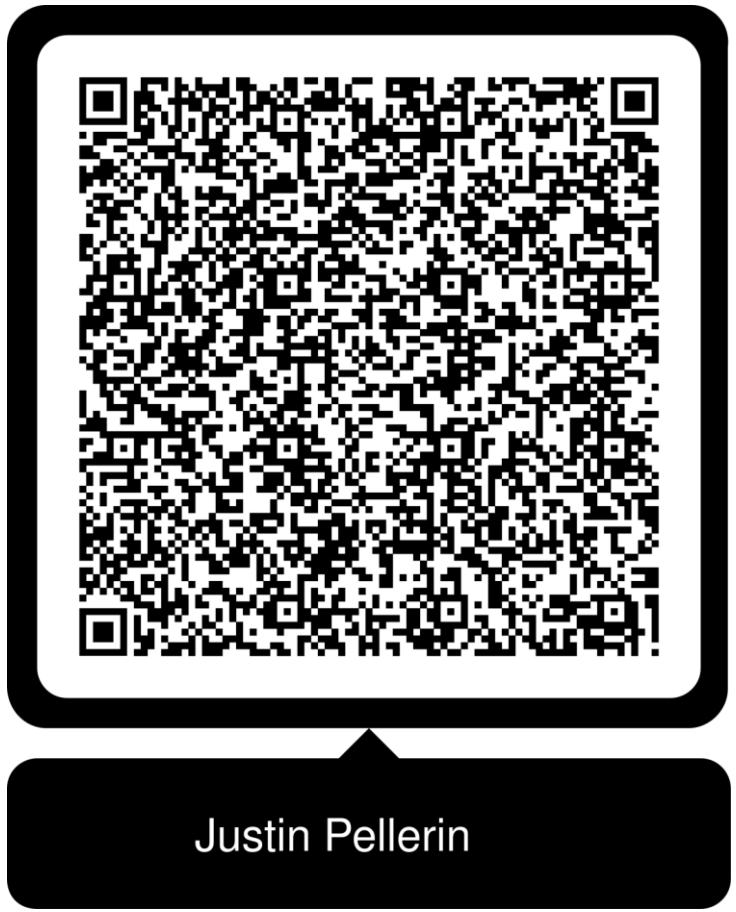
Dec 17, 2025 11:08pm

Dec 18, 2025 2:30pm

Dec 18, 2025 6:30pm

Case Study – Delayed Rinsing – The Healing Path

- You will see the weeping on the tissue. This is immune response, flushing the necrotic tissue out.
- Had water only been used in this delayed rinse, the caustic would have continued working deeper in to tissue, causing more pain and more tissue damage to the patient, potentially resulting in medical interventions, and resulting in lost time (LTI).
- Diphoterine® halted the process on the surface, drew out the dangerous ions, that left untouched would have wreaked havoc. It also stopped pain for the patient, making first aid and medical interventions (had they been required) easier on both patient, first aider, and clinicians.



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