• Review Article •

# Current status of emergency treatment of chemical eye burns in workplaces

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Received: 2020-01-06 Accepted: 2020-06-30

## Abstract

● Chemical eye burns present an avoidable, but frequent, occupational injury with potentially detrimental consequences for the quality of life and occupational rehabilitation of the injured. A periodical review of guidelines is required to assure the optimal emergency management. We reviewed the literature with emphasis on current German guidelines, primarily MEDLINE. If the crucial first-line measure, the injury prevention has failed and an eye burn has been sustained, the immediate and copious rinsing of the eye is the pivotal emergency treatment modality. Whereas the immediacy and sufficiency of the emergency rinsing are largely unanimous, there is an ongoing debate about the benefits and risks of specific rinsing solutions, and regular updates on guidelines and recommendations for the emergency treatment are warranted. The easiest and readily available rinsing solution is tap water, which fulfils the crucial criteria conveniently in most industrialized countries: purity, sterility, and neutral pH. Other rinsing solutions are proposing higher osmolality to stabilize the physiological pH, because of their superior buffering capacity. However, there is no compelling evidence for a substantial benefit, and some reports suggest that there could be unwanted side effects. In combination with the substantially increased expenditure and a more complex handling procedure, currently a general recommendation of any other solution than tap water is not warranted.

● **KEYWORDS:** eye burns; occupational medicine; emergency treatment; rinse solutions

**DOI:10.18240/ijo.2021.02.19**

**Citation:** Claassen K, Rodil Dos Anjos D, Broding HC. Current status of emergency treatment of chemical eye burns in workplaces. *Int J Ophthalmol* 2021;14(2):306-309

## INTRODUCTION

Eye injuries can be classified as either non-mechanical (chemical or thermal), non-globe or mechanical globe injuries[1]. Chemical eye burns can be further divided into alcohol caused, acid and alkali injuries[2]. They belong to the most detrimental and most avoidable injuries in the workplace[3], being the second most common occupational eye injuries following injuries by foreign objects[4]. Whereas the incidence of chemical eye burns varies vastly depending on socioeconomic and occupational circumstances, population-based studies suggest a lifetime risk of 1%[5]. While, according to Jonathan, about two million Americans in total injure their eyes by physical or chemical substances every year[6], and the number of occupational eye injuries in the US exceeds 280 000 per year. They represent 3.3% of all occupational injuries with chemical burns being the second-largest subgroup (after foreign bodies)[7]. The lack of wearing appropriate eye protection-whether it is available at the workplace or not–is the key risk factor for eye injuries in general and chemical burns in particular[8].

Burns with liquid, aerosolic or solid agents can cause disfiguring scars, visual impairment or blindness, and can be fatal in extreme cases[9]. Due to the rapid penetration through the cornea and anterior chamber, alkali burns may be more severe than acid burns[10]. The mechanism of ocular damage sustained after chemical exposure includes three main pathways[11]: ocular surface injury, repair and differentiation; corneal stromal matrix injury, repair and ulceration; corneal and stromal inflammation.

The occurrence and severity of tissue damage depends on the time between initial exposure and complete removal (or neutralization) of the corrosive agent. The degree of damage and the activation of self-promoting mechanisms are consequential[4,11].

Despite emergency treatment and novel treatment modalities such as immunosuppression and advanced surgical procedures, the likelihood of complete visual recovery is limited. Therefore the injury is potentially detrimental for the patient's quality of life and occupational rehabilitation[12].

Some aspects of the emergency intervention are largely cleared: most importantly the swiftness and sufficient duration of an emergency rinsing. Totally, 30min of irrigation are recommend with continuation for the next 24h[13].

There is an ongoing debate about the benefits and risks of specific rinsing solutions. That is why employers need to provide an established treatment for eye burns based on a workplace risk assessment and recommendations for or against certain solutions. Those have an undeniable economic impact. Therefore, regular updates on guidelines and recommendations for the emergency treatment of chemical eye burns are warranted.

The present paper evaluates the current evidence and opinions on the topic, and specifically examines the current German guidelines regarding their adequacy[14].

## EMERGENCY TREATMENT OF CHEMICAL EYE BURNS

**Methods** We searched the literature thoroughly with emphasis on current German guidelines, primarily MEDLINE, using the following search terms: 1) Eye burns [Medical Subject Heading (MeSH)]; 2) Emergency treatment (MeSH); rinse solutions (title or abstract words); 3) Occupational accident (MeSH); Industrial injury (MeSH).

The terms within one group were connected by the Boolean OR, and the groups among each other by the Boolean AND. The literature search was performed in March 2019, with an update in March 2020. The number of hits upon the last update was for #1: 2339, #2: 7465, #3: 13807, #1 AND #2: 14, #1 AND #3: 106 and for #1 AND #2 AND #3: 1. Due to the low number of hits, the lists #1 AND #3 were hand-searched for relevant articles. Searches in other databases failed to reveal additional studies of relevance.

**Treatment Components, Tap Water and Eye Rinsing Devices** The aim of emergency rinsing is to restore the physiologic pH of the eye as soon as possible. If the external pH has returned to normal, the aqueous pH within the eye follows within 30min[4]. The emergency treatment may include one or more of these three components[4,10-11,14-15]: neutral liquids that dilute and eventually remove the corrosive agent; rinsing solutions with a specific effect against the corrosive agent; rinsing solutions or medications that target the host reaction to the burn.

General requirements for eye rinsing solutions include sterility and purity; they must not contain microorganisms, particles, preservatives or undeclared ingredients, and their pH value has to be neutral (*i.e.*, ~7.2)[14]. In most industrialized countries, ordinary tap water fulfils the criteria conveniently, and there is abundant evidence for the benefit of immediate irrigation with tap water, even regarding the more aggressive alkali burns[16]. Thus, the importance of the immediate and copious rinsing of the affected eye with clear tap water as a neutral liquid is undisputed.

When available, special eye rinsing devices provide a higher volume flow across the ocular surface. They provide a convenient, and inexpensive tool to increase the efficacy of tap water rinsing and should be provided generously. Employees should be educated about the appropriate procedures in emergency eye rinsing. These solutions do not only remove the corrosive agent and possible reaction products. But also, thermal energy is released by chemical reaction.

**Specific Solutions–Benefits and Risks** Whereas clear sterile water is the mainstay of emergency eye burn treatment, a number of specific solutions for this purpose has been suggested under the assumption that they restore the pH quicker and/or suppress the pathophysiologic processes in the eye.

Ionic marine solutions and vegetable oils[17], Cederroth eye wash[18], isotonic saline solutions[19], or sodium EDTA claim to be used for this aim[8]. Highly specific decontaminants targeted at chemical agents are only available at specialized centers, not in the general industrial environment[9,19].

Ringer lactate solutions are often proposed because of their more physiological pH and osmolality[8], and therefore lesser tendency to cause corneal edema[20]. If pre-fabricated solutions are employed, opened containers must be discarded, because their contents are questionable in terms of purity and sterility. The immediacy of the intervention is absolutely pivotal for the prognosis, and therefore the acquisition of specific rinsing solutions should not delay the rinsing itself[14].

For some other proposed alternatives to water, such as the Diphoterine® solution, there is growing evidence of possible superiority in the duration and outcome of the healing process and in the treatment of pain[21]. However, the quality of the studies carried out allows wider scope for interpretation and a conflict of interest cannot be ruled out entirely[22].

The general problem of specific rinsing solutions is the time it takes the emergency helper to 1) determine the exact nature of the corrosive agent, 2) look up the required counteragent, 3) locate the agent and 4) apply it according to guidelines. Since immediate rinsing is mandatory, this would in essence require two educated helpers in action simultaneously. This luxury, however, cannot be assumed to be generally available.

Moreover, for none of the proposed alternatives to water there is currently compelling evidence of its superiority, and some solutions have been argued to be detrimental rather than beneficial, including isotonic saline solutions or phosphate buffer which have been claimed to be advantageous[23]. Whereas these issues are controversial, recommendation of any other rinsing solutions but water is currently not warranted considering the risks[24].

The post-emergency treatment of the chemically burned eye is a different issue, although early application is necessary[11,25], and therefore not subject of the review at hand. Anti-inflammatory and sometimes surgical treatments are recommended[26]. For a guideline regarding hospital treatment see Bore 2018[27]. Within the occupational context, the workplace has to be designed in a way that chemical eye injuries are avoided as best as possible in the first place[28].

## CONCLUSION

The importance of an immediate rinsing of the chemically burned eyes cannot be overemphasized, and this is often only achievable when ordinary tap water is being used. Thus, immediate access to water and preferably eye rinsing devices is mandatory in all workplaces where corrosive chemical substances are handled.

The application of Ringer lactate or phosphate buffered saline solutions has theoretical advantages in terms of a greater neutralizing capacity and an anti-edematous effect; however, there has been some doubt concerning their safety which has to be addressed by further studies. Moreover, their provision in workplaces requires expenditures in terms of purchasing, distribution, labeling and quality control. If specific rinsing solutions are provided in spite of that, they must be labeled regarding their content and their specific purpose, while the labeling has to be comprehensible for every person that may become involved in first aid. At the moment, the effort would probably be better invested in preventive measures, because, all benefits and risks of specific eye rinsing solutions aside, the best protection against chemically induced eye injuries is directed against the exposure rather than the actual damage.

## ACKNOWLEDGEMENTS

**Conflicts of Interest: Claassen K,** None; **Rodil Dos Anjos D,** None; **Broding HC,** None.

### REFERENCES


1 Mutie D, Mwangi N. Managing eye injuries. *Community Eye Health J* 2015;91:48-49.

2 Said D, Harminder D. Chemical burns acid or alkali, what's the difference? *Eye (Lond)* 2020;34:1299-1300.

3 Spector J, Fernandez WG. Chemical, thermal, and biological ocular exposures. *Emerg Med Clin North Am* 2008;26(1):125-136.

4 Quesada JM, Lloves JM, Delgado DV. Ocular chemical burns in the workplace: epidemiological characteristics. *Burns* 2020;46(5):1212-1218.

5 Loon SC, Tay WT, Saw SM, Wang JJ, Wong TY. Prevalence and risk factors of ocular trauma in an urban south-east Asian population: the Singapore Malay Eye Study. *Clin Exp Ophthalmol* 2009;37(4):362-367.

6 Pargament JM, Armenia J, Nerad JA. Physical and chemical injuries to eyes and eyelids. *Clin Dermatol* 2015;33(2):234-237.

7 Xiang HY, Stallones L, Chen GM, Smith GA. Work-related eye injuries treated in hospital emergency departments in the US. *Am J Ind Med* 2005;48(1):57-62.

8 Jones NP, Griffith GA. Eye injuries at work: a prospective population-based survey within the chemical industry. *Eye (Lond)* 1992;6(Pt 4):381-385.

9 Eyer F, Zilker T. Caustic injuries of the eye, skin and the gastrointestinal tract. *Ther Umsch* 2009;66(5):379-386.

10 Schrage N, Kuckelkorn R, Redbrake C. Primary management in chemical and thermal eye burns. *Dt Ärztebl* 2000;97(3):A104-A109.

11 Wagoner MD. Chemical injuries of the eye: current concepts in pathophysiology and therapy. *Surv Ophthalmol* 1997;41(4):275-313.

12 Kuckelkorn R, Kottek A, Schrage N, Reim M. Poor prognosis of severe chemical and thermal eye burns: the need for adequate emergency care and primary prevention. *Int Arch Occup Environ Health* 1995;67(4):281-284.

13 Stevens S. How to irrigate the eye. *Community Eye Health J* 2016;95:56.

14 Arbeitsgruppe Spülflüssigkeiten. Guideline "Requirements regarding rinsing fluids for first aid". 2013-06-01. https://www.bgrci.de/fileadmin/BGRCI/Downloads/DL_Praevention/Fachwissen/Erste_Hilfe/Guideline_Requirements_regarding_rinsing_fluids_for_first_aid.pdf.

15 Hodge C, Lawless M. Ocular emergencies. *Aust Fam Physician* 2008;37(7):506-509.

16 Ikeda N, Hayasaka S, Hayasaka Y, Watanabe K. Alkali burns of the eye: effect of immediate copious irrigation with tap water on their severity. *Ophthalmologica* 2006;220(4):225-228.

17 Said T, Dutot M, Labbé A, Warnet JM, Rat P. Ocular burn: rinsing and healing with ionic marine solutions and vegetable oils. *Ophthalmologica* 2009;223(1):52-59.

18 Rihawi S, Frentz M, Reim M, Schrage NF. Rinsing with isotonic saline solution for eye burns should be avoided. *Burns* 2008;34(7):1027-1032.

19 Mathieu L, Burgher F, Hall AH. Diphoterine chemical splash decontamination solution: skin sensitization study in the Guinea pig. *Cutan Ocul Toxicol* 2007;26(3):181-187.

20 Kompa S, Redbrake C, Hilgers C, Wüstemeyer H, Schrage N, Remky A. Effect of different irrigating solutions on aqueous humour pH changes, intraocular pressure and histological findings after induced alkali burns. *Acta Ophthalmol Scand* 2005;83(4):467-470.

21 Lynn DD, Zukin LM, Dellavalle R. The safety and efficacy of Diphoterine for ocular and cutaneous burns in humans. *Cutan Ocul*

*Toxicol* 2017;36:185-192.

22 Alexander KS, Wasiak J, Cleland H. Chemical burns: Diphoterine untangled. *Burns* 2018;44(4):752-766.

23 Kompa S, Redbrake C, Dunkel B, Weber A, Schrage N. Corneal calcification after chemical eye burns caused by eye drops containing phosphate buffer. *Burns* 2006;32(6):744-747.

24 Brandslund I, Damgaard AL. Corneal calcification after chemical eye burns caused by eye drops containing phosphate buffer. *Burns* 2008;34(8):1215.

25 Yoeruek E, Ziemssen F, Henke-Fahle S, Tatar O, Tura A, Grisanti S, Bartz-Schmidt KU, Szurman P, Tübingen Bevacizumab Study Group. Safety, penetration and efficacy of topically applied bevacizumab: evaluation of eyedrops in corneal neovascularization after chemical burn. *Acta Ophthalmol* 2008;86(3):322-328.

26 Struck HG. Chemical and thermal eye burns. *Klin Monbl Augenheilkd* 2016;233(11):1244-1253.

27 Bore M. Emergency management: chemical burns. *Community Eye Health* 2018;31(103):72.

28 Peate WF. Work-related eye injuries and illnesses. *Am Fam Physician* 2007;75(7):1017-1022.