

# The Frequency of Chemical Injuries of the Eye in a Tertiary Referral Centre

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## SUMMARY

**Introduction** Chemical injuries can occur under various circumstances and may cause serious damage to the anterior segment of the eye.

**Objective** The aim of the study was to analyse the frequency of chemical injuries treated in a tertiary referral centre.

**Methods** The medical records of consecutive patients admitted for the chemical injury of the eye to the Clinic for Eye Diseases in Belgrade between January 1999 and December 2008 were retrospectively analysed in order to obtain data about proportions of injuries, demographical characteristics of patients, circumstances under which injuries happened, the chemicals involved, the severity of injury according to the Roper-Hall classification and the length of hospitalization.

**Results** Out of a total of 60,868 hospitalized patients, 148 (2.43/1,000) were treated for chemical injury of the eye, with the highest incidence observed during summer months. Men were over five times more often affected (84.5%) and most of the injured individuals belonged to the working-age population (mean age 44.4±16.2 years). The most common causative agents were alkalis (73.0%), while acids (18.2%) and other substances (8.8%) were less common. None of 35.1% patients for whom data were obtained used any protection while handling the chemicals. The vast majority of injuries were graded as grade II (31.1%) and III (42.6%) and the most severe ones were caused by alkalis. An average length of hospitalization was 17.7±24.1 days and correlated with the severity of injury.

**Conclusion** Chemical injuries are relatively common problem in the Emergency Ophthalmology. Constant education and usage of adequate protective equipment should be advised in order to prevent serious complications.

**Keywords:** chemical injury; eye; frequency; epidemiology

## INTRODUCTION

Chemical injuries of the anterior segment of the eye are common problem in the ophthalmology practice and can range from mild irritation to complete damage of the anterior segment. It is well known that both strong acids and strong alkalis can cause severe eye injuries and vision-threatening complications can occur if a large surface of the eye is involved (including cornea, limbus and conjunctiva) or if the functionality of the eyelids is lost [1-4].

Acids and alkaline agents have different mechanism of action and, therefore, cause various types of injuries. Acids precipitate tissue proteins, creating a barrier to further ocular penetration. Sulfuric, hydrofluoric and heavy metal acids are the exceptions to this rule. Sulfuric acid is the most common cause of injury, usually due to the explosion of a car battery. It reacts with the water in the tear film, producing heat sufficient to cauterize the corneal and conjunctival epithelium and therefore has great potential for permanent ocular damage. Hydrofluoric acid and heavy metal acids penetrate rapidly and destroy the corneal epithelium and stroma. Although acids do not usually cause deeper destruction of the eye, they can lead to corneal vascularization, scarring, and consequently reduced vision.

On the other hand, alkaline agents rapidly penetrate the cornea, reacting with the cellular lipids to form soaps. They essentially dissolve the cell membranes and continue destroying tissues, entering the anterior chamber and continue the destruction of the tissues within the eye for up to several days. Alkalis also dehydrate cells and destroy their enzymatic and structural proteins. The most severe effects occur if the pH exceeds 11.5. Penetration rates differ according to the type of base: ammonium hydroxide is one of the fastest penetrating bases, followed by sodium hydroxide, potassium hydroxide, and calcium hydroxide.

It is important to emphasize that precautionary measures can efficiently diminish the incidence and severity of chemical injuries. Therefore, public awareness must be raised and focused on their prevention. However, if the injury happened, adequate and timely treatment would significantly reduce the severity of injury and diminish the development of serious complications [5].

## OBJECTIVE

Due to the vision-threatening potential of the chemical injuries to the eye, we analysed the frequency of those injuries treated in a tertiary referral centre.

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**METHODS**

A retrospective analysis of the medical records of consecutive patients hospitalised for chemical injuries of the eye at the Department of Cornea and External Eye Diseases of the Clinic for Eye Diseases in Belgrade, in the period 1999–2008 was performed. This Department is the largest referral centre in Serbia. All patients underwent complete ophthalmological examination including anamnesis, visual acuity assessment, applanation tonometry, slit lamp examination and indirect ophthalmoscopy with 90D lens.

Data analysed in the study are: proportions of injuries, demographical characteristics of injured patients (age, sex), circumstances of injury occurrence (place where the accident happened, type of substances involved, use of protective equipment, whether one or both eyes were injured), the severity of injury graded by Roper-Hall classification (Table 1) [6] and length of hospitalisation.

Various grading systems are currently used to assess the severity of chemical injuries [6-10] and the Roper-Hall classification was used in this study because it involved the period when the newest classifications were not available.

The study was approved by the Ethics Board of the Clinical Center of Serbia.

Methods used for data analysis included Student’s t-test for comparison of numerical variables,  $\chi^2$  or Fischer’s exact test (as appropriate) for categorical variables and Spearman’s correlation. The level of statistical significance was 0.05.

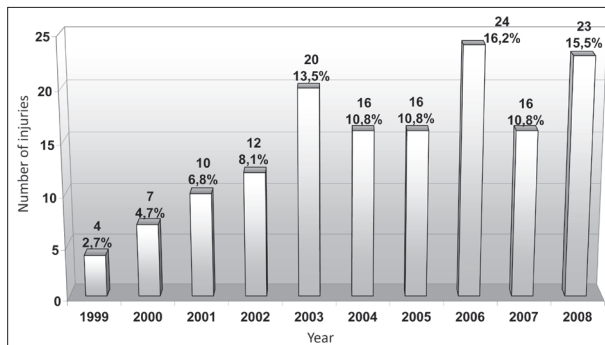
**RESULTS**

Out of total of 60 868 patients hospitalised during the study period, 148 were treated for chemical injury. The proportionate ratio was at the lowest level in 1999 (0.7/1,000) and at the highest in 2006 (4.0/1,000). The frequency of chemical injuries within all eye injuries increased over the observed period, with the minimum in 1999 (2.7%) and the peak in 2006 (16.2%) (Graph 1). Chemical injuries of the eye were present in 5.4% of all ocular traumas and increased over the study period (data available only for the period from 2002 to 2008) with the minimum in 2002 and the peak in 2006 (3.1% and 9.3%, respectively).

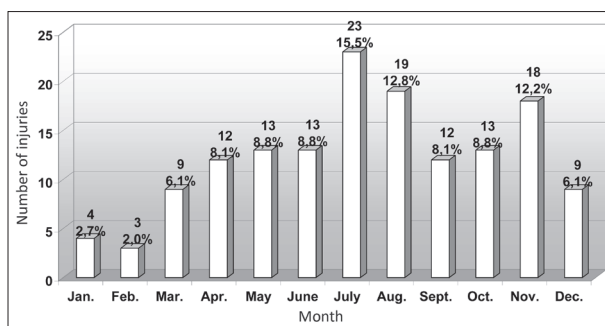
The frequency of chemical injuries varied significantly by month, with 28.8% of injuries occurring during two summer months (July and August) and less than 5% in two winter months (January and February) (Graph 2).

**Table 1.** The Roper-Hall classification of chemical injuries of the eye

Grade	Prognosis	Limbal ischemia	Corneal involvement
I	Good	None	Epithelial damage
II	Good	Less than 1/3	Corneal haze, iris details visible
III	Guarded	1/3 to 1/2	Total epithelial loss, stromal haze, iris details obscured
IV	Poor	Over 1/2	Cornea is opaque, iris and pupil are obscured



**Graph 1.** Chemical injuries as a proportion of all eye injuries in the period 1999–2008



**Graph 2.** Distribution of chemical injuries of the eye per month

**Table 2.** Clinical and demographical characteristics in a series of 148 patients with the chemical injuries of the eye

Variable	N	%	
Sex	Male	125	84.5
	Female	23	15.5
Age (years)	0–10	2	1.3
	11–20	5	3.4
	21–30	25	16.9
	31–40	32	21.6
	41–50	34	23.0
	51–60	25	16.9
	61–70	13	8.8
	≥81	10	6.8
Affected eye	Monocular	94	63.5
	Binocular	54	36.5
Place where the injury happened	At work	30	20.3
	At home	42	28.4
	Other	3	2.0
	N/A	73	49.3
Chemical substance involved	Lime	59	39.9
	Plaster	38	25.7
	Other alkalis	11	7.4
	Acids	27	18.2
	Other	13	8.8
Use of protective equipment	No protection	52	35.1
	N/A	96	64.9
Severity of injury by Roper-Hall classification	I	6	4.0
	II	46	31.1
	III	63	42.6
	IV	27	18.3
	N/A	6	4.0

Age (mean±SD): 44.4±16.2 years; range: 2–85 years  
 Length of hospitalisation (mean±SD): 17.7±24.1 days; range: 1–204 days  
 N – number of patients; N/A – data not available

There was a correlation between the month when the injury happened and the type of chemical substance involved ( $p < 0.05$ ), and the lime and plaster were the most common causative agents.

There was an obvious predominance of male patients, who were over five times more often injured (84.5%) (Table 2). However, there was no difference between genders in the monthly rates or in the severity of injury ( $p > 0.05$ ). Regarding the place where the injury occurred, men were more often injured at work, while women at home ( $p < 0.05$ ). Males were significantly more frequently affected by alkalis (76.0% of all men) as compared to females (56.5% of all women) ( $p < 0.05$ ).

The majority of patients (78.4%) belonged to the working-age population (mean age  $44.4 \pm 16.2$  years), but all age groups were represented (ranging from 2 to 85 years) (Table 2). Children under 10 and elderly people over 80 years of age were the least frequently injured (1.3% in both groups) (Table 2). Negative correlation between the age and severity of injury was observed ( $p < 0.05$ ), i.e., younger patients experienced more severe injuries.

Data about circumstances surrounding injuries included the place where the injury happened and usage of adequate protective equipment. Home-related injuries (28.4%) were slightly more frequent than work-related ones (20.3%). However, data about the place of injury were not available for 49.3% of injured people (Table 2). Injuries happened accidentally, such as in an explosion of a car battery (8% of all eye injuries) and rarely in a deliberate attack in order to harm a person, usually using sodium hydroxide (2% of all eye injuries). None of 35.1% patients for whom data were obtained used any protection while handling chemicals.

The most common chemicals causing the injury were alkalis (73.0%), while acids (18.2%) and other substances (superglue, detergents; 8.8%) were less common (Table 2). There was a significant correlation ( $p < 0.05$ ) between the type of the chemical substance involved and the severity of injury. The most severe injuries were caused by lime.

Injuries were predominantly monocular (63.5%), while binocular injuries were less frequent (Table 2). However, injuries were more severe if both eyes were affected ( $p < 0.05$ ).

The fact that the study was performed in a specialised institution could explain why the majority of treated injuries were classified as grade II and III (31.1% and 42.6%, respectively), while grade I injuries were the least frequent (4.1%) (Table 2). There was a correlation between the type of chemical substance and the severity of injury ( $p < 0.05$ ), and the most severe injuries were caused by lime (67.2% of injured suffered grade III and IV tissue damage).

An average length of hospitalisation was  $17.7 \pm 24.1$  days (ranging from 1 to 204 days) and correlated with the severity of the injury.

## DISCUSSION

Chemical injury of the eye represents a significant percentage of emergency-treated ocular traumas as shown in stud-

ies from Europe, United States (USA) and Asia (7.7-18%) [11-15]. Data from our study (5.4%) are below the lower limit of the reported range. Although studies by Nicaeus et al. [11] and Karaman et al. [12] were carried out in a tertiary centre as well, the fact that our study included only hospitalised patients, while patients not requiring admission were not included in the analysis, could explain lower frequencies.

Chemical injuries of the eye predominantly affect men, as shown in studies performed in Europe, USA and South America (66.7-83%) [13, 16-19] and higher frequency of males among injured was documented in our study as well (84.5%).

It is well known that severe injuries, especially those affecting one's ability to work, have an important impact on the quality of life and social and financial aspects as well. In our study, most of the injured belonged to the working-age population ( $44.4 \pm 16.2$  years), and 38.5% of injured were young adults (21-40 years old), which was quite similar to Cruz et al. [16], who found that 42% of the injured belonged to age group of 21-40 years.

Many people are injured at home while doing work for which they are not properly informed or without adequate protection. In our study, these injuries happened more often at home (28.4%) than at work (20.3%). Study of Kersjes et al. [20] from the USA showed that 84.4% of chemical injuries happened at home and involved commonly used household products, while on the other hand, results from Germany, UK and Norway showed that the majority of injuries occurred at work (50-72.9%) as a consequence of industrial accidents [17, 19, 21, 22].

It is well known that alkalis cause the most severe chemical injuries. In many studies performed worldwide, alkalis were the most common causative chemical agents (48-79.8%) [16, 17, 19, 23] and it was documented in our study as well (73%). This could be explained by widespread utilization of alkalis as household products and in the industry.

Adequate preventive measures are the most important step in reduction of the rate and severity of injuries. In every country, the use of protective equipment is usually obligatory and regulated by the law. Kuckelkorn et al. [23] reported that as many as 100% of the injured were not using protective equipment at the time of accident. In our study, none of 35.1% patients for whom data were obtained used any protection while handling the chemicals. Although collecting of the data about patient's history is mandatory and regulated by the hospital administration, the fact that there was no computerized system to store the data, could explain the lack of information in the observed period.

In two thirds of cases, the injuries involved one eye (63.5%), while binocular injuries were less frequent (36.5%) and similarly, Saini et al. [24] reported that 42.1% of patients had binocular injuries.

The most severe (grade III and IV) injuries were present in 60.8% of all chemical injuries. Considering the fact that this study was carried out in a tertiary referral centre, which deals with the most difficult cases and that only patients admitted to the hospital were included in

the study, this type of distribution could be expected. In the studies from India [24] and Sweden [25], which, like our study, analyzed the injuries of patients admitted to an Ophthalmology clinic, the results showed that the most frequent injuries were classified as lower grade. Saini et al. [24] found that 35.9% of injuries were grade III and IV, and Monestram et al. [25] reported that the lower grade injuries were the most prevalent. This could be explained by different inclusion criteria of the studies mentioned above i.e., the smaller population in the study of Swedish authors (Umeå 115,000) as opposed to our study (Belgrade, approximately 2,000,000) and shorter study period (1 year in Swedish study as opposed to 10 years in our study).

Luchik et al. [26] reported that the results of treatment mainly depended on the severity of the injury at the initial presentation. In our study, an average length of hospitalisation was  $17.7 \pm 24.1$  days and correlated with the severity of injury. Regarding the length of treatment, Gerard et al.

[27] reported that minor ocular burns (Roper-Hall grade I and II) healed within a period ranging from 3 to 38 days, and on the other hand, Kuckelkorn et al. [23] stated that an average length of treatment of severe eye injuries was  $5.2 \pm 4.1$  months, which indicated the difficulties in treatment and delayed recovery of affected eyes.

## CONCLUSION

Chemical injuries are relatively common problem in the Emergency ophthalmology. The aim of the study was to analyse the most frequent types of chemical injuries treated at a tertiary referral centre in a 10-year period and to identify the most common causes and the circumstances under which the injuries happened. Constant education and usage of adequate protective equipment should be advised in order to prevent the injuries.

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## Учесталост хемијских повреда ока лечених у терцијарном референтном центру

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### КРАТАК САДРЖАЈ

**Увод** Хемијске повреде ока могу настати под различитим околностима и узроковати тешка оштећења предњег сегмента ока.

**Циљ рада** Циљ рада је био да се утврди учесталост хемијских повреда ока код особа болнички лечених у референтној офталмолошкој установи терцијарног нивоа здравствене заштите у Србији.

**Методе рада** Урађена је ретроспективна анализа медицинске документације свих повређених особа хоспитализованих због хемијских повреда ока на Клиници за очне болести Клиничког центра Србије у периоду 1999–2008. године. Параметри посматрања били су: учесталост повређивања (по годинама и месецима), демографске одлике повређених особа, околности под којима су повреде настале, врста хемикалија које су узроковале повреду, тежина повреда према Ропер-Холовој (*Roper-Hall*) класификацији и дужина хоспитализације.

**Резултати** Од укупно 60.868 болнички лечених особа, 148 (2,43 на 1.000) лечено је због хемијских повреда ока. Најви-

ша учесталост повређивања уочена је током летњих месеци. Особе мушког пола су се око пет пута чешће повређивале (84,5%), а већина повређених припадала је радно способном становништву (44,4±16,2 година). Најчешћи узрочни агенси биле су базе (73,0%), док су киселине (18,2%) и друге супстанце (8,8%) биле ређе. Нико од 35,1% повређених за које постоје подаци није користио одговарајућу заштиту приликом рада с хемијским средствима. Најчешће су биле хемијске повреде другог (31,1%) и трећег (42,6%) степена. Најтеже повреде биле су узроковане базама. Просечна дужина хоспитализације била је 17,7±24,1 дан и корелирала је с тежином повреде.

**Закључак** Хемијске повреде ока су релативно чест проблем у ургентној офталмологији. Стална информисаност и коришћење одговарајуће заштитне опреме требало би да буду обавезни, како би се спречиле тешке компликације.

**Кључне речи:** хемијска повреда; око; учесталост; епидемиологија

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