

Early versus delayed emergency department presentation and visual outcomes after ocular caustic chemical exposure.

Alec Chaleff, Brittany Perzia, Wei Hou, Timothy Chou*

Department of Ophthalmology, Renaissance School of Medicine, Stony Brook University, New York, USA

Abstract

Purpose: To identify if the incident to emergency department (ED) presentation time is associated with final visual outcomes in patients with chemical ocular exposures.

Methods: A retrospective chart review was performed at our Level I trauma center on all patients who presented to our ED with a chemical eye injury between May 2013 and March 2020. Ocular examination findings, patient characteristics, time from incident to presentation, and ocular surface irrigation information were recorded and analyzed for all patients who met inclusion criteria.

Results: A total of 24 patients (35 eyes) met the inclusion criteria. 20 patients (83%) had alkaline chemical exposure, 3 (20%) had acidic exposure, and 1 patient (4%) was exposed to an unidentified chemical. 23 of the 24 patients (96%) self-irrigated prior to presentation for an unspecified duration. 13 patients (54%) presented by 60 minutes and 11 patients (46%) presented greater than 60 minutes after the ocular chemical exposure. The difference between the final measured visual outcome and the time to ED presentation in eyes with 20/30 or better vision at presentation and 20/40 or worse vision at presentation was not statistically significant in either group ($p>0.5$). There was also no statistically significant difference among an additional five clinical ocular factors and time to ED presentation between these two groups ($p>0.5$).

Conclusion: Our findings suggest that clinicians should emphasize thorough and rapid initiation of ocular surface irrigation at the site of injury rather than rapid presentation to the ED for this purpose.

Keywords: Alkaline eye burn, Acid eye burn, Ocular surface chemical injury, Ocular irrigation.

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Introduction

Caustic chemical ocular surface exposure is a common presenting scenario in an emergency department (ED). An estimated 7%-18% of all ocular trauma is due to ocular chemical or thermal burns, with hundreds of thousands of cases reported annually in the United States [1,2]. An ophthalmologist is rarely immediately available in the ED when patients present with chemical eye injuries; however, EDs are frequently capable of providing acute, effective, and comprehensive treatment in these scenarios. An ocular chemical burn is a true emergency and the standard of care is copious and immediate ocular surface irrigation with balanced salt solution or water [3]. The American National Standards Institute (ANSI) and International Safety Equipment Association (ISEA) have a defined standard that eyewashes be capable of delivering flushing fluid to the eyes at no less than 1500 milliliters per minute for 15 minutes [4]. Eyewashes that meet this performance standard provide irrigation that is non-injurious to the user in a controlled, bilateral fashion. Personal experience of the authors, however, reveals that these specific guidelines are infrequently clinically followed in the ED patient care settings, and the rate at which the fluid is delivered often varies considerably.

In an emergency setting, time to treatment is a well-established prognostic factor. Decreased time to coronary artery reperfusion, for example, was found to lower mortality in

numerous studies during the 1990s. This eventually gave rise to the 2004 and 2007 ST-elevation myocardial infarction (STEMI) guidelines [5]. In November 2006, the Door-to-Balloon (D2B) Alliance launched in order to improve the median D2B time based on recommendations to provide coronary reperfusion within 90 minutes in indicated patients [5,6]. In January 2005, this goal was met in 44.2% of patients, and by September 2010, it was met by 91.4% of patients. In patients with STEMI, faster reperfusion times and improved care systems are associated with reduced morbidity and mortality rates [6]. We draw a parallel to this widely implemented and successful example to illustrate the enormous impact of a time sensitive intervention.

In this study, we do not intend to reiterate or further study the underlying mechanisms and pathophysiology of ocular surface burns, which has been well described previously [3,7]. There is known variability in the caustic substances exposed to, the type of irrigation fluid used, the volume of irrigation used, the rate and manner in which the fluid is delivered, accidental injury versus assault, and whether or not irrigation was provided at the scene of the injury. The goal of the present study was to determine if rapid presentation to an ED for definitive acute treatment (e.g. ocular surface irrigation) resulted in improved visual outcomes compared to delayed presentations. To our knowledge, this is the first investigation of its kind.

Materials and Methods

A retrospective chart review was performed at our Level I trauma center on all patients who presented to our emergency department with a chemical eye injury between May 2013 and March 2020. This study was performed as a quality improvement initiative and was given IRB exemption by review of our Clinical Research Coordinator at our Department of Ophthalmology. The Tenets of the Declaration of Helsinki were adhered to. The retrospective nature of the study obviated the need for informed consent.

Patients were included in this study if: the patient was at least 18 years of age, the chemical eye exposure was determined to be acute by history, the time from injury to hospital presentation could be determined, a physician from our ophthalmology service directly examined the patient within one day, and the patient received at least one additional follow up examination by our ophthalmology service within 30 days. Patient demographics and ocular examination, including visual acuity, time from incident to ED presentation, ocular pH, grade of injury, and ocular surface irrigation information were recorded using data from the electronic medical records. The presence of five additional clinical factors directly attributable to the injury in the affected eye at ED presentation and at last follow up were also recorded: any subjective ocular complaint, any corneal or conjunctival injury, the need for a procedure such as an amniotic membrane graft, history of hospitalization due to the initial injury, and ongoing treatment with topical or systemic medications (other than artificial tears).

The results were compiled and analyzed for statistical significance using Fisher's Exact test to compare the relationship between the final measured visual outcome and the time to emergency department presentation in eyes with 20/30 or better vision at presentation and eyes with 20/40 or worse vision at presentation. The Mann-Whitney U test was also utilized to analyze the relationship between the presence of an additional five ocular exam factors attributable to the injury, as noted above, and the time to emergency department presentation in order to address the possibility of worse outcomes without manifestation as a reduction in visual acuity.

Results

A total of 145 patients were identified for analysis and 24 patients (35 injured eyes) met the inclusion criteria. Reasons for exclusion included: patients did not receive an initial or follow up evaluation by a physician from our ophthalmology service (n=108), patients were less than 18 years of age (n=7), patients did not receive irrigation in the ED (n=4), and a time of incident to ED presentation could not be determined (n=2). The median age of patients in our study was 49 years, with a minimum of 23 years and maximum of 83 years. There were 15 males (63%) and 9 females (37%). 7 patients (29%) reported current tobacco use. 18 patients (75%) self-identified as Caucasian, 3 patients (13%) as Hispanic, 1 patient (4%) as African American, and 2 patients (8%) chose not to self-identify. All patients were injured by accident and 9 patients (38%) experienced occupational associated injuries. 23 of the

24 patients (96%) self-irrigated with water prior to presentation for an unspecified amount of time. 11 patients (46%) had bilateral involvement, 8 patients (33%) had only left eye involvement, and 5 patients (21%) had only right eye involvement. 20 patients (83%) had alkaline chemical exposure, 3 patients (20%) had acidic chemical exposure, and 1 patient (4%) was exposed to an unspecified chemical.

Critical to our review, 13 patients (54%) presented by 60 minutes or less after the chemical ocular exposure (early group) and 11 patients (46%) presented greater than 60 minutes after the ocular chemical exposure (late/delayed group). The mean time to presentation was 208 minutes with a standard deviation of 338 minutes. The first quartile was 38 minutes, the third quartile was 180 minutes, and the interquartile range was 143 minutes. The median time to presentation was 60 minutes with a minimum time of 10 minutes and maximum time of 1440 minutes. 21 patients (88%) were treated with normal saline for ocular surface irrigation, 1 patient (4%) was treated with lactated Ringer's, 1 patient (4%) was treated with water, and 1 patient (4%) was treated with an unspecified irrigating fluid. The median volume of irrigation received in the ED was 1 liter, with a range of 1 liter to 9 liters. The pH was recorded on presentation in 20 patients (83%). The median pH was 7.0 with a range from 6.5 to 8.5. One patient (4%) required hospitalization due to the systemic severity of the chemical burn. 4 patients (17%) required a procedure to treat the chemical burn (amniotic membrane grafting). 18 patients (75%) had injuries that were classified as Grade I on the Hughes classification scheme and 6 patients (25%) were classified as Grade II [3].

There were no patients with Grade III or IV injuries in this study. Regarding Grade I injuries, 10 patients presented early and 8 presented late. Regarding Grade II injuries, 3 presented early and 3 presented late. 4 patients (7 eyes), all with grade II injuries, received amniotic membrane. The median number of follow up visits after the first week was 1 with a minimum of 0 and a maximum of 34. This high number of follow up visits was due to persistent patient ocular irritation, photophobia, and discomfort. Either fluorescein, rose bengal, or lissamine green was used to determine degree of staining due to ocular surface injury. Our findings ranged from no staining to near total epithelial defects.

Table 1. Visual acuity on presentation eyes overall.

Presentation Eyes Overall		
	20/30 or better	20/40 or worse
Within 60 minutes	16 (80%)	4 (20%)
Greater than 60 minutes	11 (73%)	4 (27%)

Overall, 27 eyes (77%) had 20/30 or better vision at presentation and 8 eyes (23%) had 20/40 or worse. Regarding patients who presented within 60 minutes of the incident (13 patients, 20 eyes), 16 eyes (80%) had 20/30 or better vision at presentation and 4 eyes (20%) had 20/40 or worse vision. On

follow up, 18 eyes (90%) had 20/30 or better vision at follow up and 2 eyes (10%) had 20/40 or worse vision (Tables 1,2).

Table 2. Visual acuity on follow up eyes overall.

Follow Up Eyes Overall		
	20/30 or better	20/40 or worse
Within 60 minutes	18 (90%)	2 (10%)
Greater than 60 minutes	13 (87%)	2 (13%)

Regarding the 11 patients (15 eyes) who presented to the ED greater than 1 hour from the time of injury, 11 eyes (73%) had 20/30 or better vision at presentation and 4 (27%) eyes had 20/40 or worse vision. On follow up, 13 eyes (87%) had 20/30 vision or better at follow up and 2 (13%) eyes had 20/40 or worse vision at follow up (Tables 1,2). Regarding eyes with 20/30 vision or better at presentation (27 eyes overall), 15 eyes had 20/30 vision or better at follow up while 1 eye had 20/40 or worse vision when presented within 60 minutes. Regarding eyes that presented more than 60 minutes after injury, 10 eyes had follow up vision 20/30 or better while 1 eye had 20/40 vision or worse (Table 3). Regarding eyes with 20/40 vision or worse at presentation (8 eyes overall), 3 eyes improved to 20/30 vision or better at follow up while 1 eye had worse than 20/40 vision when presented within 60 minutes. Finally, regarding eyes that presented greater than 60 minutes, 3 eyes had follow up vision 20/30 or better while 1 eye had 20/40 or worse (Table 4).

Table 3. Follow up visual acuity in eyes that presented with 20/30 vision or better.

Eyes with 20/30 Vision or Better at Presentation		
	Follow up 20/30 or better	Follow up 20/40 or worse
Within 60 minutes	15 (56%)	1 (4%)
Greater than 60 minutes	10 (37%)	1 (4%)

Table 4. Follow up visual acuity in eyes that presented with 20/40 vision or worse.

Eyes with 20/40 or Worse at Presentation		
	Follow up 20/30 or better	Follow up 20/40 or worse
Within 60 minutes	3 (38%)	1 (13%)
Greater than 60 minutes	3 (38%)	1 (13%)

The Fisher's exact test was used to determine if there was a significant difference in final visual outcome in early versus late presenting eyes when controlling for baseline presenting visual acuity. In both groups, the difference was not significant (Fischer's Exact test statistic value=1.000, at $p<0.05$). In addition, the Mann-Whitney U test indicated there was no significant difference between these two groups regarding the presence of an additional five ocular exam factors and the time

to emergency department presentation (U value=15.5, p value=0.75; Table 5).

Table 5. Presence or absence of an additional 5 clinical ocular factors directly attributable to the injury in the affected eye at ED presentation and at last follow up.

Additional Clinical Ocular Factors						
	0	1	2	3	4	5
Early presenter	4 (17%)	3 (13%)	4 (17%)	1 (14%)	1 (4%)	0 (0%)
Late Presenter	3 (13%)	4 (17%)	2 (8%)	0 (0%)	2 (8%)	0 (0%)

*Presence of any factor=1 point

- Any persistent subjective ocular complaint attributable to injury
- Any persistent corneal or conjunctival injury attributable to injury
- Need for any procedure attributable to injury
- Hospitalization due to the initial injury
- Ongoing treatment with topical or systemic medications (other than artificial tears) due to injury

Discussion

The present study examines a relatively small group of patients, who presented over a seven-year period, to our facility with chemical ocular surface injuries. Our facility is the Suffolk County's only Level I trauma center and has one of the best survival rates among the seriously injured in New York State [8]. We believe the inclusion criteria were appropriately chosen to allow for the most reliable ocular examination as possible while still permitting a variety of patient presentations. The data indicates that nearly all patients (96%) performed self-irrigation in some capacity prior to treatment in the emergency department, which may reflect the public's understanding of the urgency and benefit of prompt irrigation after caustic chemical ocular exposure. Our patients had largely mild to moderate injuries, with no grade III or IV injuries based on the Hughes classification scheme. The amount of Grade I and II injuries was approximately the same between the early and late presenting groups. We also found that 80% of eyes with rapid emergency department arrival within 60 minutes of injury had relatively preserved visual acuity on presentation, which improved to 90% on follow up. Regarding the delayed presentation group, 73% of eyes had preserved visual acuity on presentation, which improved to 87% overall on follow up. When baseline presenting visual acuity was accounted for, there was no significant difference in final visual outcome at follow up.

Overall, there was no significant difference in best corrected visual acuity at follow up noted in eyes who presented early versus late after the injury. It is possible that the amount irrigated in those who performed self-irrigation was sufficient to dilute the ocular chemical concentration to arrest the acute damage; with the further, more "complete" irrigation to a normal pH in the emergency department being less time sensitive than the initial irrigation. 60 minutes was chosen as the time split in this study because the median time to presentation was 60 minutes and a prior similar study utilized a 60-minute time distinction [9].

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Clinical experience demonstrates that ocular surface injury may not necessarily result in decreased visual acuity. In an attempt to obtain the highest sensitivity for a failure of the patient to return to his or her ocular baseline, we compared whether the presence of additional clinical ocular factors was associated with delayed emergency department presentations. The presence of these factors, however, could not be directly attributable to the presentation time.

There are several limitations to our study. First, our study was small and retrospective in nature, limiting statistical power. There were 4 patients in this analysis in which a precise time to presentation could not be determined but could be approximated. 2 of these patients were placed in the early group given that the injury occurred “just prior to arrival.” It was estimated that one occurred 10 minutes prior to arrival and the other 30 minutes prior to arrival. 2 patients were placed in the delayed group as they presented as a transfer from an outside facility given the logistics of travel from that facility. It was estimated that one occurred 4 hours prior to arrival and the other 6 hours prior to arrival. We also included both acidic and alkaline injuries in our study, when it is known that alkaline injuries are responsible for the most severe chemical ocular injuries [3]. In addition, the patient’s baseline visual acuity was not known and this may have affected our results. The visual acuity was obtained by different providers and this may also have affected our results. Grade III and IV injuries were not included and the results may not generalizable to this population. Finally, the type of irrigation fluid used, the volume of irrigation used, the rate and manner the fluid was delivered, and modality of irrigation prior to arrival were all not controlled for.

Despite these limitations, we believe our study has several strengths and allows us to appropriately draw conclusions. Upon retrospective review, data was near complete overall with the ocular examination and follow up performed by our ophthalmology department physicians. A variety of patient injuries were included, including alkali, acidic, bilateral, unilateral, occupational, and accidental, which increases the generalizability of our results. Patients were irrigated until a normal pH was achieved, which provided for a consistent end point. The majority of the injuries were mild, which is commonly seen in clinical practice. We also separated the 20/30 vision or better and 20/40 vision or worse vision groups at presentation to better control for baseline visual acuity.

It is well known that speed at which ocular irrigation is initiated has an impact on the prognosis of chemical eye burns [7,9]. This has been well documented from both the pathophysiological and clinical outcome standpoint despite the wide variety of patient presentations, volume of fluid irrigated, and type of fluid used [3,7,9].

Conclusion

To our knowledge, this is the first paper that specifically studies the relationship between time of incident injury to emergency department presentation time and visual outcome in patients with caustic chemical ocular injuries. Based on our

data, clinicians should emphasize thorough and rapid initiation of ocular surface irrigation at the site of injury rather than rapid presentation to the emergency department setting for this purpose. We should still encourage patients to present to the emergency department for completion of treatment and management of associated non-ocular chemical burns. A study with a larger cohort would be of benefit to confirm these findings.

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***Correspondence to**

Dr. Timothy Chou

Department of Ophthalmology

Renaissance School of Medicine Stony Brook University

New York

USA

Email: timothy.chou@stonybrookmedicine.edu