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ORIGINAL PAPER

Shifting trends in demographic features of chemical eye injuries during COVID-19 pandemic

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Abstract
Objectives To evaluate the etiological cause distribution in chemical eye injuries during COVID-19 pandemic.
Methods In this retrospective case series, the medical records of patients, who presented with chemical eye injuries between March 30, 2020, and March 1, 2021, were evaluated and compared with the data covering 10 years before the pandemic.
Results Twenty-seven eyes of twenty-three patients (19 adults, 4 children) who presented in pandemic period were included. Alcohol-based hand sanitizer was one of the two most common agents (n = 6 eyes) in the pandemic era. In the last 10 years before the pandemic, 137 eyes of 102 patients were treated for chemical eye injuries. Injuries due to alcohol-based hand sanitizer increased from 3.1 to 21.1% among all patients, and from 0 to 75% among pediatric patients during the pandemic era compared to the pre-pandemic period. The increase was statistically significant both in all patients (p = .003) and in the pediatric patient group (p = .048).
Conclusion Due to COVID-19 pandemic, alcohol-based hand sanitizer use became more common. Consequently, the frequency of hand sanitizer related chemical injuries showed a 13-fold increase and the age group affected by such accidents is altered during the pandemic. Three out of four pediatric patients (75%) were injured with alcohol-based hand sanitizers, which draws attention to the fact that improperly placed hand sanitizer stations, being just at the eye level of children, can cause chemical eye injuries in the pediatric population even more.

Keywords Chemical eye injury · COVID-19 pandemic · Alcohol-based hand sanitizer · Chemical agents

Introduction

Chemical burns of the eye represent potentially blinding ocular emergencies that require immediate and intensive treatment [1]. They are responsible for approximately 11.5 to 22.1% of the ocular injuries [2]. Depending on the nature of the chemical agent and the duration of exposure, the severity of the injury can range from mild to extensive damage to the eye [3] Various prognostic classification schemes are available based on the extent of the ocular damage [4, 5].

In December 2019, a cluster of pneumonia cases were reported in Wuhan, China [6]. World Health Organization (WHO) later named the disease COVID-19 which was declared as a pandemic on 11 March,

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2020 [7]. Since then, various preventive strategies have been developed to reduce the contamination of the COVID-19 virus all around the world, using hand sanitizer being one of them. The accidental exposure of the hand sanitizers to ocular surface especially in pediatric population can cause ocular chemical burns since it contains a number of chemicals and irritants.

In the present study, it is aimed to investigate the changes in the etiological causes of chemical eye injuries and to evaluate the increase in alcohol-based hand sanitizer induced chemical eye injuries during the COVID-19 pandemic.

Methods

In this retrospective case series, the medical records of patients, who admitted with chemical eye injuries between March 30, 2020, and March 1, 2021, were evaluated and compared with the data covering 10 years before the pandemic.

This study was approved by Institutional Ethics Committee and was conducted in accordance with the Declaration of Helsinki.

Demographic and clinical data including age, gender, chemical injury agent, time interval between injury and presentation, type of the treatment (medical, amniotic membrane transplantation, limbal stem cell transplant, penetrating keratoplasty) were obtained from patients' medical records. At the initial and the final visits, ophthalmologic examination findings such as best corrected visual acuity (BCVA), size of the epithelial defect, presence of limbal stem cell deficiency, conjunctival involvement and secondary ocular complications were collected according to medical records and anterior segment photographs of the patients. The degree of chemical injury at presentation was graded according to "Dua classification"[4], from grade 1 to 6, based on the limbal and conjunctival involvements.

Patients that whose visual acuity could not be evaluated objectively, clinical ophthalmological examination could not be performed under optimal conditions, and patients whose examination and treatment records were not kept properly were not included in the study.

Statistical analysis for the data obtained from the study was performed using SPSS v.20.0 (IBM Co. Armonk, NY, USA). A p value of < 0.05 was considered as statistically significant.

Results

Twenty-seven eyes of 23 patients (19 adults, 4 children) with chemical eye injury were included in the study. The mean age of the patients was 33.2 ± 16.4 (range, 4–76) years with a female to male ratio of 4/19. Unilaterality and bilaterality ratios of injury were 82.6% (n:19) and 17.3% (n:4). All patients included in the study presented within the first 24 h of injury. The average admission time to hospital was 4.79 ± 6.28 (range 0.5–23) hours.

Eight eyes were injured with alkaline, and ten eyes were injured with acidic substances. The most common causative chemical agents were hydrochloric acid ($n = 6$ eyes, 22.2%) (cleaning agents, industrial materials) and alcohol-based hand sanitizers ($n = 6$ eyes, 22.2%). Other causative agents were: calcium hydroxide ($n = 3$ eyes, 11.1%), sodium hydroxide (n = 3 eyes, 11.1%) (bleach, airbag), paint thinner ($n = 2$ eyes, 7.4%), hydrofluoric acid ($n = 2$ eyes, 7.4%), other rare causes ($n = 5$ eyes, 18.6%). Only 4 children were present among the injuries and 3 of them were injured with alcohol-based hand sanitizers.

According to Dua classification, six eyes (22.2%) had grade 6; 2 eyes (7.4%) had grade 5; 6 eyes (22.2%) had grade 4; 8 eyes (29.6%) had grade 3; and 5 eyes (18.6%) had grade 1 chemical injuries. During the course of the injury, limbal stem cell deficiency occurred in 8 (29.6%) eyes. Elevated intraocular pressure was detected in only one eye which was controlled with topical anti-glaucomatous drop. Amniotic membrane transplantation was performed in 1 (3.7%) eye with Dua grade 6 ocular burn in order to manage the recurrent epithelial defect and prevent subsequent perforation. Symblepharon surgery was required in 1 (3.7%) eye. Mean BCVA was 0.40 ± 0.52 (range, 0–1.30) logMAR at the initial exam and increased to 0.07 ± 0.52 (range, 0–3.10) logMAR at the last visit. Mean follow-up time was 25.88 (range, 4–90) days.

In order to evaluate the effect of the COVID-19 pandemic on the etiology of ocular chemical injuries, the data of chemical eye injury patients who applied in the last 10 years before the pandemic were also analyzed. In the last 10 years before the pandemic (2010–2019), 137 eyes of 102 patients were treated for chemical eye injuries. The mean age of the patients was 42.6 ± 17.5 (range, 7–85) years with a female to male ratio of 16/86. 35 patients (34.3%) had bilateral

injury. 65 eyes (47.4%) were injured with alkaline and 55 (40.1%) eyes were injured with acidic substances. The most common causative chemical agents were hydrochloric acid (n = 38 eyes, 27.7%) (cleaning agents, industrial materials) and calcium hydroxide (n = 29 eyes, 21.2%). Other causative agents were: sodium hydroxide (n = 24 eyes, 17.6%), sodium hypochloride (n = 6 eyes, 4.4%), sulfuric acid (n = 6 eyes, 4.4%), paint thinner (n = 6 eyes, 4.4%), ammonia (n = 5 eyes, 3.6%), nitric acid (n = 5 eyes, 3.6), alcohol-based hand sanitizers (n = 5 eyes, 3.6%), other rare causes (n = 13 eyes, 9.5%). According to Dua classification, 25 eyes (18.2%) had grade 6; 24 eyes (17.5%) had grade 5; 22 eyes (16.1%) had grade 4; 19 eyes (13.9%) had grade 3; 21 eyes (15.3) had grade 2; and 26 eyes (19.0%) had grade 1 chemical injuries.

In our data of the last 10 years before pandemic, only 3 patients were injured with alcohol-based hand sanitizers and all of them were healthcare workers. On the other hand, 4 patients were injured with alcohol-based hand sanitizer during the pandemic period and none of them were healthcare workers. The annual frequency of alcohol-based hand sanitizer injury was found to be 0.3 before the pandemic whereas 4 in the pandemic era. When we compare the last 10 years before the pandemic with the pandemic period, alcohol-based hand sanitizer related injuries increased from 3.1 to 21.1%, and the increase was found to be statistically significant (p = 0.003) (Table 1).

In a subset analysis of pediatric patients, we found that only 5 children were injured in the last 10 years before the pandemic and none of them (0%) were injured with alcohol-based hand sanitizers. However, in the pandemic era, although it is a single year, 4 children presented with ocular chemical injury and three of them (75%) were injured with alcohol-based hand sanitizers. When the two periods were compared, the increase in alcohol-based hand sanitizer related injuries in the pediatric patient population was also significant. (p = 0.048) (Table 1).

In the last 10 years before the pandemic, a total of 5 children presented with chemical eye injuries, while in the pandemic period, in a single year, 4 children presented with chemical eye injuries. The pandemic increased the annual frequency of pediatric ocular injuries 0.5 to 4. A statistically significant increase in pediatric chemical eye injuries was found between the two periods (p = 0.036) (Table 1)

There was no significant difference between the pandemic and pre-pandemic periods for neither the severity of the chemical injury nor the etiological factors except the increase in alcohol-based hand sanitizer injuries.

Discussion

The world is facing a medical crisis due to the COVID-19 pandemic. The role of adequate hygiene and use of personal protective equipment in controlling the spread of infection in public places and healthcare institutions is inevitable [6, 7] COVID-19 infection may affect the eye and usually manifests with conjunctivitis-like symptoms such as redness, discharge and irritation [8] Ocular transmission of the virus through tears and conjunctival secretions is an alternative way of transmission and public awareness has been raised on this issue [9] Poyser et al. [10] reported a significant reduction in the number of infective conjunctivitis during the COVID-19 era. This can be explained by the fact that increased hygiene and social distance measures prevent the transmission of other conjunctivitis etiologies as well as the COVID-19 virus.

Although personal protective measures are crucial to prevent viral contamination, they can lead to unintended accidents with devastating complications if not used accurately and carefully. Sengillo et al. [11], reported photokeratitis in 7 patients due to inappropriate use of germicidal UV lamps as personal protective equipment against COVID-19 virus. The frequency of using hand sanitizer has also increased significantly during the pandemic [12] Lifestyle changes by the increased external use of sanitizing agents including hand sanitizers that contain various kind of chemicals may cause accidental mucous membrane irritations just as in the ocular surface.

Ocular chemical injury results from exposure of the ocular surface to corrosive substances. The causative agents can be alkaline, acidic, or neutral [1–3] Alkaline injuries are more common than acidic injuries due to their ubiquity in common industrial and household cleaning agents. Neutral chemical agents are the least common ones in this group [13] As presented in this study, contrary to the literature and our data for the last 10 years before the pandemic, neutral causes became more common during the

Table 1 Variables for ocular chemical eye injuries in pre-COVID era and COVID era

Variables	Pre-COVID Era	COVID Era	*p* value
Number of patients (n (%))	102 (81.6%)	23 (18.4%)	
Gender (n (%))			
Male	84 (82.4%)	19 (82.6%)	
Female	18 (17.6%)	4 (17.4%)	0.977
Ages			
Child ($\leq$ 18 years) (n (%))	5 (4.9%)	4 (17.4%)	0.036*
Adult ($>$ 18 years) (n (%))	97 (95.1%)	19 (82.6%)	
Chemical agent (n (%))			
Alkaline	49 (48.0%)	8 (34.8%)	
Acid	37 (36.3%)	7 (30.4%)	
Other/mixed	16 (15.7%)	8 (34.8%)	0.107
Chemical agent Alcohol based – hand sanitizer subtype (n (%))			
Child	0 (0%)	3 (75%)	0.048*
Total	3 (3.1%)	4 (21.1%)	0.003*

*$p < 0.05$ was considered significant

pandemic era due to the increased use of alcohol-based hand sanitizers a neutral chemical agent. Consequently, there is a shifting trend in the etiology of ocular chemical injuries.

While alkaline agents penetrate to the deeper structures of the eye, acid and neutral agents influence more superficial layers of the ocular surface [13]. In the present study, most of the neutral agent related eye injuries (66.6%) were occurred with alcohol-based hand sanitizer. The US Food and Drug Administration recommendation for alcohol-based hand sanitizer is 60 to 95% ethanol or isopropanol concentration [14]. Although alcohol is widely used in surgical procedures in ophthalmology, it is known to have a serious toxic effect on the ocular surface. As with all other corrosive agents, the cytotoxic effect of alcohol has also been reported to be related to its concentration [15]. Consequently, higher alcohol percentage of the hand sanitizer may have broader effect on eye and cause devastating complications such as limbal stem cell deficiency [16] In the present study, all alcohol-based hand sanitizers contained 70% ethyl alcohol and most of the eye injuries (70.3%) with alcohol based hand sanitizer presented with mild to moderate grade of chemical injury. These patients had better clinical outcomes which is possibly related with the relatively lower alcohol concentration.

As well documented, the prognosis of severe eye injuries tends to be poorer and the incidence of developing limbal stem cell deficiency (LSCD) is higher in these eyes [4, 12]. LSCD occurs due to impairment of the barrier function of limbus and is characterized with corneal neovascularization and opacification. Surgical treatment is indicated in the advanced stages of the LSCD. Limbal stem cell transplantation is an effective technique to achieve stable and avascular ocular surface [17, 18] Ozek et al. [19], performed limbal stem cell transplantation in 17 eyes with chemical burns and achieved success in 15 (88.2%) eyes. In the present study, the LSCD was present in 29.6% of the eyes and all of them were in mild stage; consequently, limbal stem cell transplantation was not indicated.

Au et al. [12] stated that before the COVID-19 outbreak, hand sanitizer-related injuries were extremely rare and often occurred in healthcare workers while on duty. In consistent with the literature, in our clinic, sanitizer-related ocular injury was present in only 3 patients (n = 5 eyes) before the last 10 years and all of them were healthcare workers. However, the frequency of hand sanitizer-related chemical injuries showed a 13-fold increase and the age group affected by such accidents is altered during the pandemic.

The incidence of chemical eye injury in the pediatric population is lower than in the adults [20].

Recently, hand sanitizer–induced ocular injury in pediatric population has been reported as a raising trend in the literature [21, 22]. In line with the literature, the frequency of pediatric chemical eye injury patients increased eightfold during the pandemic period compared to the pre-pandemic period in our data. In most public places, the hand sanitizers are placed at a waist-level height of an adult but at approximately eye level of a child, being approximately 85–110 cm [23]. Thus, especially children in younger ages (3–5 years-old, 85–120 cm height) are at a high risk of serious eye injuries due to the accidental ocular exposure during hand sanitizing [21, 22]. It is crucial to take some precautions to prevent such accidents in pediatric age. In public places, separate dispensers placed at lower levels for children will reduce the rate of these incidents. Children should be educated about the accurate use of hand sanitizers and families should be aware of the significance of chemical injuries due to hand sanitizers.

In conclusion, during the pandemic era, the etiological causes of ocular chemical injuries tend to be altered. Alcohol-based hand sanitizer related chemical eye injuries increased, especially in the pediatric population.

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Declarations

Conflict of interest The authors have no relevant financial or nonfinancial interests to disclose.

Ethical approval The study was approved by Institutional Ethics Committee of Ege University and followed the tenets of Helsinki Declaration.

Consent to participate Informed consent was obtained from all individual participants included in the study.

Consent for publication All authors read the final manuscript and give consent for the article to be published.

References

1. Singh P, Tyagi M, Kumar Y et al (2013) Ocular chemical injuries and their management. Oman J Ophthalmol 6(2):83–86. https://doi.org/10.4103/0974-620X.116624
2. Sharma N, Kaur M, Agarwal T et al (2018) Treatment of acute ocular chemical burns. Surv Ophthalmol 63(2):214–235. https://doi.org/10.1016/j.survophthal.2017.09.005
3. Ghosh S, Salvador-Culla B, Kotagiri A et al (2019) Acute chemical eye injury and limbal stem cell deficiency - a prospective study in the United Kingdom. Cornea 38(1):8–12. https://doi.org/10.1097/ICO.0000000000001739
4. Dua HS, King AJ, Joseph A (2001) A new classification of ocular surface burns. Br J Ophthalmol 85(11):1379–1383. https://doi.org/10.1136/bjo.85.11.1379
5. Roper-Hall MJ (1965) Thermal and chemical burns. Trans Ophthalmol Soc U K 85:631–653
6. Ho D, Low R, Tong L et al (2020) COVID-19 and the ocular surface: a review of transmission and manifestations. Ocul Immunol Inflamm 28(5):726–734. https://doi.org/10.1080/09273948.2020.1772313
7. Willcox MDP, Walsh K, Nichols JJ et al (2020) The ocular surface, coronaviruses and COVID-19. Clin Exp Optom 103(4):418–424. https://doi.org/10.1111/cxo.13088
8. Sezgin Akcay BI, Kardes E, Kiray G et al (2021) Evaluation of ocular symptoms in COVID-19 subjects in inpatient and outpatient settings. Int Ophthalmol 41(4):1541–1548. https://doi.org/10.1007/s10792-021-01728-x
9. DeBroff BM (2020) COVID-19: ocular manifestations, ocular secretions, and ocular portal of entry. Adv Ophthalmol Vis Syst 10(2):48–49. https://doi.org/10.15406/aovs.2020.10.00382
10. Poyser A, Deol SS, Osman L et al (2020) Impact of COVID-19 pandemic and lockdown on eye emergencies. Eur J Ophthalmol. https://doi.org/10.1177/1120672120974944
11. Sengillo JD, Kunkler AL, Medert C et al (2021) UV-Photokeratitis associated with germicidal lamps purchased during the COVID-19 pandemic. Ocul Immunol Inflamm 29(1):76–80. https://doi.org/10.1080/09273948.2020.1834587
12. Au SCL (2020) Hand sanitizer associated ocular chemical injury: a mini-review on its rise under COVID-19. Vis J Emerg Med 21:100881. https://doi.org/10.1016/j.visj.2020.100881
13. Yu CY, Diel RJ, Jiang L et al. (2021) Chemical eye injuries: a case report and tutorial. *EyeRounds.org*. https://eyerounds.org/cases/307-chemical-eye-injury.htm
14. Boyce JM, Pittet D (2002) Healthcare Infection Control Practices Advisory Committee; HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Guideline for Hand Hygiene in Health-Care Settings. Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Society for Healthcare Epidemiology of America/

Association for Professionals in Infection Control/Infectious Diseases Society of America. *MMWR Recomm Rep*, 51(RR-16):1-CE4
15. Oh JY, Yu JM, Ko JH (2013) Analysis of ethanol effects on corneal epithelium. Invest Ophthalmol Vis Sci 54(6):3852–3856. https://doi.org/10.1167/iovs.13-11717
16. Kim SY, Sah WJ, Lim YW et al (2002) Twenty percent alcohol toxicity on rabbit corneal epithelial cells: electron microscopic study. Cornea 21(4):388–392. https://doi.org/10.1097/00003226-200205000-00011
17. Unlu BH, Utine CA, Durak I (2021) Simple limbal epithelial transplantation in limbal stem cell deficiency after chemical eye injury. Eur Eye Res 1(1):47–52
18. Selver OB, Yagci A, Egrilmez S et al (2017) Limbal stem cell deficiency and treatment with stem cell transplantation. Turkish J Ophthalmol 47(5):285–291. https://doi.org/10.4274/tjo.72593
19. Ozek D, Karaca EE, Kemer OE (2021) Simple limbal epithelial transplantation method in the treatment of unilateral limbal stem cell deficiency due to chemical burn. Eur Eye Res 1(1):31–36
20. Haring RS, Sheffield ID, Channa R et al (2016) Epidemiologic trends of chemical ocular burns in the United States. JAMA Ophthalmol 134(10):1119–1124. https://doi.org/10.1001/jamaophthalmol.2016.2645
21. Yangzes S, Grewal S, Gailson T et al (2021) Hand sanitizer-induced ocular injury: a COVID-19 hazard in children. JAMA Ophthalmol 139(3):362–364. https://doi.org/10.1001/jamaophthalmol.2020.6351
22. Colby K (2021) Unintended consequences of hand sanitizer use in the coronavirus disease 2019 pandemic. JAMA Ophthalmol 139(3):352. https://doi.org/10.1001/jamaophthalmology.2020.6327
23. Cure L, Van Enk R (2015) Effect of hand sanitizer location on hand hygiene compliance. Am J Infect Control 43(9):917–921. https://doi.org/10.1016/j.ajic.2015.05.013