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Epidemiological and Clinical Analysis of Prognostic Factors in Visual Outcomes Following Severe Penetrating Eye Injuries

Bilalov E. N.
Professor (DSc), Head of the Department of Ophthalmology, Tashkent Medical Academy

Oralov B. A
Assistant (PhD), Department of Ophthalmology, Tashkent Medical Academy

Sobirova R. U.
Master's Student, Department of Ophthalmology, Tashkent Medical Academy

Abstract: Objective: Penetrating eye injuries (PEIs) remain a significant cause of vision impairment and loss, affecting individuals of all ages. A deeper understanding of factors influencing vision is crucial for improving treatment outcomes in patients with PEIs.

Materials and Methods: A retrospective analysis was conducted on medical records of 120 patients who sustained open globe injuries between January 2020 and January 2024 at the City Clinical Emergency Hospital. Data analyzed included age, gender, type, cause, and location of PEI, as well as initial visual acuity (VA) and final best-corrected visual acuity (BCVA). Open globe injuries were classified using the Birmingham Eye Trauma Terminology (BETT, 1998).

Results: The average patient age was 41.9 years. The male-to-female ratio was 8.4:1. The primary causes of injury were work-related accidents (38.3%), environmental factors (12.5%), and domestic injuries (15.8%). Penetrating injuries accounted for 43.5%, intraocular foreign bodies for 39.1%, and globe ruptures for 13%. Overall, 19.5% of patients achieved good final vision (BCVA $\geq$ 0.5), while 48.1% experienced severe visual impairment (BCVA $\leq$ 0.02) due to the eye injury.

Conclusions: Open globe injuries remain a significant and preventable cause of ocular morbidity. This study highlights that such injuries are a major factor contributing to vision impairment in the patient population under investigation.

Keywords: penetrating eye injuries; eye trauma; visual impairment.

Objective of the Study.

The aim of this study is to analyze the epidemiological and clinical characteristics of patients with penetrating eye injuries (PEI) and to identify prognostic factors that influence the recovery of visual functions. This information will contribute to the development of more effective treatment approaches and improve outcomes for open globe injuries.

Materials and Methods.

In this retrospective study, medical records of 120 patients with penetrating eye injuries (PEI) admitted to the ophthalmology department of the City Clinical Emergency Hospital from January 1, 2020, to January 1, 2024, were reviewed. This study adhered to the principles of the Declaration of Helsinki.

The clinical characteristics required for the analysis included the patients' age, gender, cause, and location of the injury, with the date of the trauma established from the medical records. Initial visual acuity, type of PEI, and primary diagnosis were also documented. Eye injuries were classified using the Birmingham Eye Trauma Terminology (BETT) [10], based on the following parameters: (1) type of PEI: globe rupture, penetrating trauma, intraocular foreign body (IOFB), perforating trauma; (2) wound location: zone I—cornea and limbus, zone II—anterior 5 mm of the sclera, zone III—full-thickness scleral defects >5 mm posterior to the limbus; (3) severity (measured by visual acuity on the

Snellen chart at initial examination): grade 1 (≥0.5), grade 2 (0.2–0.4), grade 3 (0.03–0.1), grade 4 (light perception, LP-0.02), and grade 5 (no light perception, NLP). Final BCVA was categorized using the same criteria. A poor outcome was defined as visual acuity less than 0.02 (grades 4 and 5).

Statistical analysis was performed using the Statistica 10 software (Statsoft, USA). Descriptive statistics, parametric and non-parametric comparisons were applied to all quantitative data. A p-value of <0.05 was considered statistically significant.

Study Results.

During the study period, a total of 120 patients were admitted with a diagnosis of penetrating eye injuries (PEI). The patients' ages at the time of injury ranged from 18 to 65 years, with a mean age of 41.5 ± 1.5 years (42.2 ± 1.5 years for men and 39.1 ± 6.1 years for women). Males accounted for 89.4% of the cases, resulting in a male-to-female ratio of 8.4:1. A statistically significant predominance of men was observed in the 18–59 age group, while women were more prevalent in the under-20 group.

Urban residents made up 46.2% of the total participants, while 53.8% were from rural areas (p>0.05). Ten patients (6.2%) admitted to consuming alcohol prior to the injury.

The leading causes of injury were work-related accidents (38.3%), environmental factors (12.5%), domestic injuries (15.8%), sports-related incidents (6.3%), agricultural injuries (6.2%), school accidents (6.7%), and injuries of unknown etiology (14.2%). No significant age-related differences were observed between injury location and patient age.

Most injuries were accidental, including falls, assaults, and unknown causes. The most frequent injury mechanisms were blunt trauma (contusions - 20%), penetrating wounds caused by glass and tree branches (18.3% and 10%, respectively). Patients with combined injuries made up the majority.

Among the patients, 43.5% presented with penetrating wounds, 39.1% had intraocular foreign bodies (IOFB), 13% had globe ruptures, and 2.5% had penetrating eye injuries.

A significant correlation was found between the type of PEI and the patient's age. It was determined that the incidence of globe ruptures was significantly higher in individuals aged 60 and older.

More than half of the patients with penetrating eye injuries also experienced damage to the iris, with hyphema observed in 58.3% of cases. Vitreous hemorrhage, aphakia, retinal injuries, and signs of endophthalmitis were observed in 40% of patients. The majority of injuries involved zone I (47.8%), followed by zone II (25.5%), and zone III (26.8%), which may partially explain the high prevalence of iris damage and hyphema.

Patients were admitted to the hospital an average of 2.0 ± 0.2 days after the injury (range: 1 to 30 days). Of the patients, 60.9% were hospitalized within the first 24 hours, 24.8% between 25–48 hours, 5.0% between 49–72 hours, and the remaining patients were admitted later.

In 81% of cases, the final visual acuity test was conducted within 30 days of the initial test. Factors such as age, gender, the time between initial and final visual acuity testing, and the interval between injury and hospitalization were considered as potential influences on the visual prognosis.

Data showed that an initial visual acuity of 0.02 or worse was the strongest predictor of poor visual outcomes. Initial symptoms such as iris dialysis, hypotony, vitreous hemorrhage, and prolapse were also significant predictors of poor visual outcomes (BCVA <0.02). Other factors, such as the injury zone, PEI type, retinal detachment, endophthalmitis, time to treatment, and the number of surgeries, were not statistically significant in the analysis.

The outcomes of penetrating injuries, including corneal scarring, scleral scars, vitreous hemorrhage, vitreous opacity, and lens dislocation, were significantly associated with the depth of injury and the presence of IOFB.

In our study, an initial grade 1 visual acuity was significantly associated with IOFB injuries. Grade 2 was significantly related to penetrating injuries, IOFB, and zone I injuries. Grade 4 (0.02–light perception) demonstrated a strong association with globe ruptures, while grade 5 (no light perception) was significantly linked to globe ruptures and penetrating injuries compared to IOFB and zone III injuries.

The analysis of initial and final visual acuity was evaluated and compared in 77 patients under observation. No statistically significant difference between the severity of injuries at initial and final examinations was found. In our study, 19.5% of injured eyes achieved good visual acuity (≥0.5). As for the type of PEI, final visual acuity in grade 5 (no light perception) was significantly associated with globe ruptures. Good visual outcomes (grade 1, ≥0.5) were significantly associated with IOFB injuries. In contrast, Atic's analysis showed a strong link between IOFB and poor visual outcomes [1, 17]. Our findings also indicated that the injury zone was correlated with visual outcomes, with zone III injuries resulting in significantly worse visual outcomes (no light perception) compared to zone I or II injuries. These findings are consistent with various studies [1, 3, 8, 13, 18].

When analyzing, an initial visual acuity of ≤0.02 (grades 4 and 5) was significantly associated with poor final visual outcomes ≤0.02. The analysis also demonstrated that iris dialysis, hypotony, vitreous hemorrhage, and vitreous prolapse were significantly linked to poor final BCVA <0.02 (grades 4 and 5) in this study.

In line with other researchers, our results revealed that initial visual acuity ≤0.02 [3, 4, 6, 7, 8, 9] and vitreous hemorrhage [3, 7, 11] are important prognostic factors for poor visual outcomes. Numerous studies have shown that globe rupture [13], retinal detachment [6, 7, 8, 12], lens dislocation [15, 19], larger wound sizes (>10 mm) [8], zone III injury [3, 7, 9, 14], and aphakia [7] were the most significant predictors of final visual outcomes in both univariate and multivariate analyses.

According to our findings, diagnoses made at the final follow-up visit, such as corneal scarring, glaucoma, traumatic cataract, vitreous opacity, and retinal detachment, were predominantly linked to globe ruptures and penetrating injuries. Traumatic cataract is the most common vision-limiting complication and can develop any time from the first day to several years after PEI [1]. We found no significant association between traumatic cataracts and poor visual outcomes. These results align with data published by Atic [1]; however, Fujikawa identified a significant correlation between lens damage and visual deterioration [3]. Atic et al. reported that retinal detachment is a predictor of poor outcomes [8], but our results did not confirm this finding.

Conclusion.

This study aimed to evaluate the epidemiological and clinical characteristics, as well as the visual and anatomical outcomes, following severe penetrating eye injuries (PEIs) in patients treated at the ophthalmology department of the City Clinical Emergency Hospital. The objective was to identify potential prognostic factors that influence eye injury outcomes.

The average patient age was 41.9 ± 1.5 years, which aligns with findings from other studies [5, 6]. Some authors report a younger average age for PEI patients [1], possibly due to demographic differences in their study populations.

A predominance of male patients (89.4%) was observed in this study, a trend also reflected in other epidemiological research, where male patients constituted between 66% and 96.7% of cases [6, 7, 14]. This male dominance is likely due to the higher exposure of men to hazardous situations in the workplace or during recreational activities. Our study also demonstrated that age is closely related to PEI, with a significantly higher incidence in males aged 18 to 59 years. This correlates with other research where the peak age for PEI in men ranged from 20 to 49 years (52.6%) [8], 21 to 50 years (55.03%) [6], and 41 to 60 years (40.9%) [12, 16].

Workplace injuries were the leading cause of PEI (38.3%), followed by injuries occurring outdoors or at home, which accounted for 28.3% of all cases. Similar to our findings, previous literature has

reported that most open-globe injuries are occupational, ranging from 22.0% to 50.0% of cases [1, 2, 3, 4, 6]. Other studies have indicated that home accidents are the most frequent location for eye trauma [1, 7]. Sharp objects were among the most common injury mechanisms in our study, with metal fragments, sharp tools, and broken glass accounting for 61.5% of cases, consistent with data published by Rahman [4]. In our series, the most frequent type of injury was penetrating (43.5%), followed by IOFB (39.1%) and globe ruptures (13%). Similarly, Batur et al. [13] also found that penetrating injuries (61.5% and 61.2%, respectively) were the most common type of open-globe trauma, followed by IOFB at 16.1% and 20.8%. Rahman et al. [4] and Fujikawa et al. [3] reported that globe ruptures (56% and 69.5%, respectively) were the most frequent injury type, followed by penetration (32%) and IOFB (9%) [4], or IOFB (20.3%) and penetration (10.2%) [3]. As in the literature, perforating injuries were rare in our series (2.5%), with reported frequencies varying from 0.7% to 26.7% [4, 5, 7, 13, 14].

Some limitations of our study should be noted. Firstly, it was conducted as a retrospective study, leading to a substantial amount of missing data. Secondly, there was variability in the follow-up duration, with some patients having relatively short observation periods.

In conclusion, patients with PEI require thorough examination both upon admission and throughout the follow-up period. This study confirms that certain clinical characteristics, such as initial visual acuity, iris dialysis, hypotony, vitreous hemorrhage, and vitreous prolapse, may hold predictive value for visual outcomes. Future prospective studies on PEI focusing on a more detailed evaluation of prognostic factors and functional outcomes could provide compelling evidence for developing more effective treatment strategies for PEI cases.

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Patient Consent:

This study was conducted in compliance with all ethical standards. All participants provided informed consent, fully understanding the study's objectives, methods, and potential risks.

Conflict of Interest Statement:

The authors declare no conflicts of interest regarding this publication.

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