·Investigation·

Characteristics and visual outcomes of patients hospitalized for ocular trauma in central China: 2006–2011

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Abstract

• AIM: To complete the data of ocular trauma in central China, as a well-known tertiary referral center for ocular trauma, we documented the epidemiological characteristics and visual outcomes of patients hospitalized for ocular trauma in this region.

• METHODS: A retrospective study of patients hospitalized for ocular trauma in central China from 2006 to 2011 was performed.

• RESULTS: This study included 5964 eyes of 5799 patients. The average age was 35.5±21.8y with a male-to-female ratio of 2.8:1. The most common age was 45-59y age group. Most patients were farmers and workers (51.9%). The most common injuries were firework related (24.5%), road traffic related (24.2%), and work related (15.0%). Among the most common causative agents were firecrackers (24.5%), followed by metal/knife/scissors (21.4%). Most injuries occurred in January (14.2%), February (27.0%), and August (10.0%). There were 8.5% patients with ocular injuries combined with other injuries. The incidence of open ocular injuries (4585 eyes, 76.9%) was higher than closed ocular injuries (939 eyes, 15.7%). The incidences of chemical and thermal ocular injuries were 1.2% and 0.6%. Ocular trauma score (OTS) predicted final visual acuity at non light perception (NLP), 20/200-20/50 and 20/40 with a sensitivity of 100%, and light perception (LP) /hand motion (HM) and 1/200-19/200 with a specificity of 100%.

• CONCLUSION: This study provides recent epidemiological data of patients hospitalized for ocular trauma in central China. Some factors influencing the visual outcome include time interval between injury and visit to the clinic, wound location, open or closed globe injury, initial visual acuity, and OTS.

• **KEYWORDS:** ocular trauma score; ocular trauma; visual acuity

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INTRODUCTION

Ocular trauma is a common cause of visual morbidity. It causes extreme psychological and emotional stress to victims, as well as an economic burden to society. Worldwide, every year there are approximately 1.6 million people blinded from ocular injuries, and approximately 2.3 million people with bilateral low vision resulting from eye injuries [1]. In the United States, there are approximately 2.5 million cases of eye trauma every year, resulting in approximately 50 000 people that lose partial or full vision [2]. In addition, the rates at which eye injuries require hospitalization are in the range of 4.9-89 per 10 million in developing countries[3-7].

Although ocular trauma data have been reported for the United States[8], Ireland[4], Greece[9], Singapore[10], and Korea[11], complete ocular trauma data for China have still not been obtained. China is the world's most populous country, so it is difficult to obtain complete data, although some regions have already reported results. Wang *et al* [12] listed the characteristics of ocular traumas in northern China , and Cao *et al* [13] reported the epidemiology of ocular injuries in southern China. Our hospital in central China is a well-known tertiary referral center for ocular trauma, so ocular trauma patients are transferred to our hospital, making our data representative of ocular trauma in our region.

SUBJECTS AND METHODS

Subjects All reported cases were from the Department of Ophthalmology, the First Affiliated Hospital of Zhengzhou University, from January 2006 to December 2011. Our department is a well-known ocular trauma center in China that offers specialized care for patients of all ages with specific and complicated ocular or orbital diseases and

conditions. It houses a 24h ophthalmic emergency department to treat minor and major ocular injuries. When trauma patients in central China are hospitalized for further treatment, they are usually transferred to our center. This provides the opportunity to obtain comprehensive data on the characteristics and visual outcomes of patients hospitalized for ocular trauma in central China.

Our study adhered to the tenets of the Declaration of Helsinki. All medical records were anonymous, and all information was used only for research purposes. Informed written or oral consent was given by the patients and the next of kin. Informed written or oral consent was also given by caregivers or guardians on behalf of minors who were involved in the study. The procedures were approved by the Ethics Committee of the Medical College, the First Affiliated Hospital of Zhengzhou University.

Methods Ocular trauma was defined as any injury affecting the eye or adnexa that required hospital admission and had a principal or secondary discharge diagnosis from the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM). Records of all patients were classified by the standardized international classification of ocular trauma (Birmingham Eye Trauma Terminology, BETT)[14], which divided ocular injuries into those involving blunt force, resulting in contusion (closed globe injury) or rupture (open globe injury), and those involving sharp force, resulting in lamellar laceration (closed globe injury) or penetrating, perforating, and intraocular foreign body laceration (open globe injury). Wound location was defined by the Ocular Trauma Classification Group. Zone I injuries were confined to the cornea, zone II injuries confined to the anterior 5 mm of the sclera and zone III injuries involved more posterior than 5 mm from the limbus[15].

Patients' data included age, gender, occupational categories, place of residence, date and cause of injury, initial and final best corrected visual acuity, anatomical site, location and nature of injury, clinical diagnosis, and primary and secondary treatment and follow-up. The patients were classified into five age groups (0-14, 15-29, 30-44, 45-59, and 60 plus years) based on the criteria used in the China Injury Surveillance System and the National Statistical Yearbook. The data were classified into 10 groups based on the places where eye injuries occurred: work-related injuries, home-related injuries, school-related injuries, sport-related injuries, road traffic-related injuries, violence-related injuries, animal-related injuries, chemical injuries, firework-related injuries, and other various injuries. The initial visual acuity was the best corrected Snellen visual acuity in the affected eye at the time of presentation. The final visual acuity was measured at the last follow-up (the least duration of follow-up was 1y).

Table 1 Ocular trauma score

Variables	Raw points
Initial vision	
NLP	60
LP/HM	70
1/200-19/200	80
20/200-20/50	90
<20/40	100
Rupture	-23
Endophthalmitis	-17
Perforating or penetrating injury	-14
Retinal detachment	-11
Afferent pupillary defect	-10

NLP: Non light perception; LP: Light perception; HM: Hand motion.

The OTS was developed by Kuhn *et al*[16] in 2002 which was based on the eye injury registry databases of the United States and Hungary . The OTS is a simplified categorical system for standardized assessment and visual prognosis associated with ocular injuries. Certain numerical values classified as OTS variables (visual acuity, rupture, endophthalmitis, perforating injury, retinal detachment, and afferent pupillary defect) at presentation were summarized and classified as OTS categories (Table 1). The likelihood of final visual acuities (NLP, LP/HM, 1/200-19/200, 20/200-20/50, and ≥20/40) in the OTS categories (1 to 5) was calculated. The sensitivity and specificity of OTS were then calculated.

Statistical Analysis Data were analyzed with SPSS software, version 18.0 (SPSS, Inc., Chicago, IL, USA). Frequency distributions were calculated for injury types and causes. Statistical analyses of the quantitative data, including descriptive statistics and parametric and nonparametric comparisons were performed for all variables. Frequency analyses were performed using the Pearson's Chi-square test. A one-way analysis of variance (ANOVA) was used to evaluate differences in parametric variables. Categorical evaluations were performed for the numeric scores representing the likelihood of the final visual acuity in the OTS study. Correlation analyses were performed using the Spearman's test. All P values in our study were two-sided, and a value of less than 0.05 was considered statistically significant.

RESULTS

This study occurred from January 2006 to December 2011, and included 5964 eyes of 5799 patients who were admitted to our hospital with eye trauma (958 cases in 2006, 925 cases in 2007, 941 cases in 2008, 975 cases in 2009, 1003 cases in 2010, and 997 cases in 2011). Patients' ages ranged from 2mo to 86y with a mean age and standard deviation of 35.5±21.8y. Within this patient population, 4285 were male (73.9%) and 1514 were female (26.1%) (P=0.01, Pearson's Chi-square

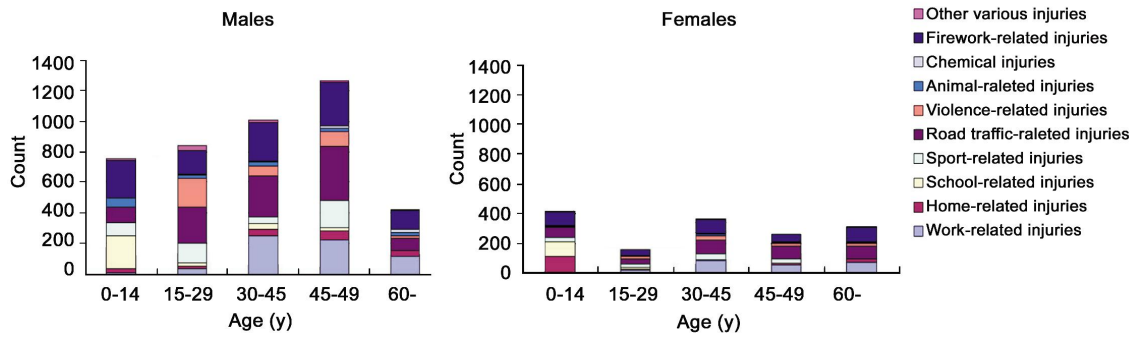

Figure 1 Frequency of types of eye injuries by age and gender.

test). The ratio of male to female was 2.8:1. The mean ages were 31.4±12.7y for male patients and 37.2±9.3y for female patients (P=0.02, t-test). The most common ages of patients were 45-59y (26.2%), 30-44y (23.7%), and 0-14y (20.2%). The common ages for male patients were 30-59y (52.9%) and 0-14y (27.6%) for female patients. Patients under 2y of age involved 317 eyes (5.3%). Right eye injuries involved 2894 cases, left eye injuries involved 2740 cases, and bilateral eye injuries involved 165 cases. There was no significant difference between the frequencies of with respect to laterality. Most patients in our study were farmers and workers (51.9%), while students accounted for 18.3%.

Urban residents accounted for 28.6%, and rural residents accounted for 71.4% of the patient population. The total hospitalization time, including other departments such as surgical neurology, orthopedics, and neurology, was in the range of 1-193d. The average hospitalization time in the Ophthalmology Department was 10.8d (1-27d).

The most frequent injuries among all cases were firework related (24.5%), road traffic related (24.2%), and work related (15.0%). For male patients, the most common injuries were firework related (24.6%), road traffic related (24.4%), work related (14.8%), and sport related (10.2%). For female patients, the common injuries were firework related (24.4%), road traffic related (23.7%), work related (15.3%), and home related (10.1%). The results were similar with respect to injury type between genders (P=0.001; Pearson's Chi-square test).

The most common injury types for male and female patients in different age groups were shown in Figure 1.

Injuries caused by electric bicycles accounted for 15.1% of all cases. Injuries caused by animals accounted for 2.9% of cases.

There were numerous types of causative agents (Table 2). The most common causative agent was the firecracker (24.5%), followed by metal/knife/scissors (21.4%). Most of the chemical trauma were caused by alkalis (44 eyes, 63.8%), lime (10 eyes, 14.5%), acids (9 eyes, 13.0%) and others (6 eyes, 8.7%).

The time interval between injury and visit to the clinic was 6h (20.9%), 6-12h (42.4%), 12-24h (20.3%), and greater than 1d (16.4%; Table 3). There was a significant difference in the final visual acuity between patients who arrived in the hospital within 24h and those who arrived over 24h after an injury (P< 0.01; Pearson's Chi-square test).

Table 2 Types of causative agents

Types of causative agents	Male	Female	Total	Percentage (%)
Fire cracker	1053	369	1422	24.5
Metal/knife/scissor	984	256	1240	21.4
Electric bicycle	682	195	877	15.1
Steel/iron	356	277	633	10.9
Motor	364	164	528	9.1
Stick	304	57	361	6.2
Fist	154	35	189	3.3
Stone	129	56	185	3.2
Animal	144	26	170	2.9
Chemical injury	49	20	69	1.2
Thermal injury	9	25	34	0.6
Gun bullet	12	14	26	0.4
Others	45	20	65	1.1

Table 3 Time interval between the injuries to the visit to the clinics

Time interval	Cases	Percentage (%)
＜6h	1213	20.9
6-12h	2458	42.4
12-24h	1177	20.3
＞1d	951	16.4

Most of the injuries occurred in January (14.2%), February (27.0%), and August (10.0%). The common injury types occurring in January were road traffic related (44.1%), work related (14.9%), and home related (12.5%). The most common injury types occurring in February were firework related (77.8%). The firework-related injuries in February accounted for 12.5% of all firework-related injuries.

There were 91.5% patients with a single ocular injury, and 8.5% patients with combined injuries involving injuries outside the eye. The injuries outside the eye included head and facial trauma (84.3%; brain damage, skull fractures, and nasal injuries), limb injuries (18.7%; bone fractures and soft tissue damage), abdominal injuries (8.3%), and chest injuries (6.3%). The sum was over 100%, because some patients had compound injuries. For patients with injuries outside the eye, the most common injuries were caused by car accidents

(82.9%), violence (11.3%), and fireworks (2.2%).

The incidence of open ocular injuries (4585 eyes, 76.9%) was higher than closed ocular injuries (939 eyes, 15.7%; Table 4). There were 1477 cases complicated with accessory injuries (11.5%). The clinical manifestation in open ocular injuries included traumatic cataract (25.0%), endophthalmitis (16.8%), intraocular foreign bodies (16.6%), retinal detachment (15.0%), vitreous hemorrhage (8.0%), lens luxation (7.7%), and secondary glaucoma (6.0%; Table 5). Hyphema was noticed in 50 eyes in closed injury. Of these cases, the most common complication were iridodialysis (124 eyes, 13.2%), cataract (92 eyes, 9.9%) and glaucoma (48 eyes, 5.2%).

The results of wound location involved zone I injuries (3556 eyes, 77.6%), zone II injuries (984 eyes, 21.5%), and zone III injuries (45 eyes, 1.0%). In zone III open globe injuries, there was a worse visual prognosis than that of injuries in zone I and zone II ($P<0.01$, ANOVA test).

There were 946 cases (15.9%) treated by conservative medical treatment. Surgeries were performed on 5018 eyes. The most common surgeries were debridement and suture (4556 eyes, 76.4%), posterior vitrectomy (1957 eyes, 33.1%), and lens extraction (1523 eyes, 25.5%). The percentage of enucleation was 4.1% (Table 6). The surgical intervention for chemical trauma was performed in 60 eyes (87.0%) in the form of amniotic membrane (46 eyes, 76.7%), symblepharon release (11 eyes, 18.3%), lamellar keratoplasty (7 eyes, 11.7%).

Initial visual acuities were ≥20/40 in 214 eyes (3.6%), 20/200-20/50 in 456 eyes (7.6%), and NLP in 786 eyes (13.2%). Final visual acuities were ≥20/40 in 421 eyes (7.1%), 20/200-20/50 in 548 eyes (9.2%), and NLP in 510 eyes (8.6%) (Table 7). In cases with hyphema, the visual acuity was 0.62±0.37 (range, NLP to 20/20). The initial visual acuity was correlated with final visual acuity (Spearman's correlation coefficient = 0.68, $P<0.001$).

Open globe injuries and closed ocular injuries had different prognoses ($P<0.001$, Pearson's Chi-square test). In the last follow-up, visual acuity at NLP was 8.0% in open globe injuries and 0.3% in closed ocular injuries. The final visual acuity at LP/HM was 24.5% in open globe injuries and 5.3% in closed ocular injuries. The final visual acuity at ≥20/40 was 5.7% in open globe injuries and 0.5% in closed ocular injuries. The closed ocular injuries had better final vision than open globe injuries.

OTS was correlated with final visual acuity as shown in Table 8. The patients with higher scores in higher grades had better vision. Predictive vision was shown in Table 9, showing that OTS predicts NLP, 20/200-20/50 and ≥20/40 with a sensitivity of 100%, and predicts LP/HM and 1/200-19/200 at a specificity of 100%.

Table 4 Clinical manifestation of hospitalized for ocular trauma (1st January, 2006- 31st December, 2011)

Clinical manifestation	Eyes	Percentage (%)
Open ocular injury		
Penetrating injury/perforating injury	2368	39.7
Rupture	1458	24.4
Intraocular foreign body	759	12.7
Closed ocular injury		
Lamellar laceration	45	0.8
Contusion	894	15.0
Chemical injury	69	1.2
Thermal injury	34	0.6
Accessory injury		
Orbital fracture	315	5.3
Lacrimal laceration	478	8.0
Eyelid laceration	684	11.5
Others	35	0.6

Table 5 The clinical manifestation of open ocular injuries

Clinical manifestation	Eyes	Percentage (%)
Traumatic cataract	1145	25.0
Lens luxation	354	7.7
Secondary glaucoma	275	6.0
Endophthalmitis	768	16.8
Vitreous hemorrhage	365	8.0
Retinal detachment	687	15.0
Intraocular foreign body	759	16.6
Others	584	12.7

Due to a patient will have a variety of clinical manifestations, the percentage of the total number will exceed 100%.

Table 6 Management reports from initial presentation to final follow up in eye injury cases

Treatment	Cases	Percentage (%)
Medical conservative treatment	946	15.9
Debridement and suture	4556	76.4
Lens extraction	1523	25.5
Posterior vitrectomy	1975	33.1
Anterior irrigation	125	2.1
Enucleation	246	4.1
Antiglaucoma surgery	358	6.0
Lacrimal apparatus repair	564	9.5
Orbital fracture repair	24	0.4
Others	648	10.9

Due to a variety of patients have combined surgery, there will be two or more surgical treatment options. Percentage is more than 100%.

DISCUSSION

Our study involved a large sampling that included the medical records of approximately 6000 cases of ocular trauma from 2006 to 2011. In each age group, there were more male patients than female patients. The most common patients were male patients aged 30-59y, who were usually the worker in the family, thus, ocular trauma could cause significant economic and psychological burdens.

Patients aged younger than 2y comprised 317 eyes (5.3%).

Table 7 The initial and final visual acuity

Visual acuity	Initial visual acuity		Final visual acuity (last follow-up)	
	Frequencies	Percentage (%)	Frequencies	Percentage (%)
NLP	786	13.2	510	8.6
LP/HM	2368	39.7	1803	30.2
1/200-19/200	1689	28.3	1998	33.5
20/200-20/50	456	7.6	548	9.2
≥20/40	214	3.6	421	7.1
Others[1]	451	7.6	684	11.5

[1]Others: No vision because the vision can not be tested due to the young age.

Table 8 Correlation of the final visual acuity category with the OTS in 5280 eyes

OTS	Final visual acuity category				
	NLP	LP/HM	1/200-19/200	20/200-20/50	≥20/40
0-44	256	172	34	14	5
45-65	220	1245	510	230	55
66-80	31	357	1025	224	145
81-91	3	15	415	78	182
92-100	0	14	14	2	34

OTS: Ocular trauma score; Spearman's correlation coefficient= 0.67, P<0.01.

Table 9 Comparison of predictive vision based on OTS and corrected vision at the last follow up

Grade of vision	Corrected vision at the last follow up (eyes)	Predictive vision based on OTS (eyes)	Sensitivity (%)	Specificity (%)
NLP	510	1009	100	89.5
LP/HM	1803	870	48.3	100
1/200 to 19/200	1998	729	36.5	100
20/200 to 20/50	548	1061	100	89.2
≥20/40	421	1640	100	74.9

OTS: Ocular trauma score; NLP: Non light perception; LP: Light perception; HM: Hand motion.

Although this is not a high number, ocular trauma in children could compromise their visual acuity, character development, and career choices, which could affect their remaining lives. To avoid pediatric ocular trauma, more attention should be addressed to the following: 1) when children light or watch fireworks, parents or guardians should protect them from danger, and large fireworks should never be lit by children; 2) schools should try to avoid potential injuries from stationery (pen, pencil, knife, or scissors), school tables, or desks, and from extracurricular activities such as physical exercise, and 3) because pediatric ocular trauma resulting from traffic accidents was frequent, greater precautions including the use of child safety seats should be practiced to avoid ocular harm involving vehicles.

Our data show that firework-related injuries are serious health and social problems as well as other reports[17-19]. Some ocular traumas are partially seasonal, with ocular trauma in January and February accounting for 14.2% and 27.0% of all injuries, respectively, which was higher than other months. There are many celebrations in January and February, such as the Solar New Year and the Lunar New Year, and 77.8% of ocular traumas in February involved fireworks, while firework-related injuries in February accounted for 97.5% of all firework-related injuries. Consistent with another report[16], fireworks are therefore the most common cause of ocular traumas. The Chinese government has regulated the place and time of lighting fireworks, but the rate of ocular injuries caused by fireworks is still high for the following possible reasons. First, in China, there are regulations that allow children under 14y of age to light firecrackers without guardians. Many kids are hurt by fireworks because they do not know how to protect themselves. Second, sometimes the eyes of elderly people were injured because they could not see the lighter clearly or they could not leave quickly after lighting a firecracker. Third, although the maximal firecracker weight is limited to 50 g, similar restrictions on the type of pneumatic tool or detonator are not made. Finally, some patients were injured by homemade firecrackers, which are usually loaded with powerful explosives.

The other most prevalent cause of ocular trauma was vehicle-related injury, almost a quarter of eye injuries. In our region, there are 9 national highways and more than 20 regional local highways and total mileage of expressways ranks first in China. Most of the road traffic-related injuries occurred in January and August. The main reason for the high rate of road traffic-related injuries was bad weather (*e.g.*

rain, snow, and frost). There are poor traffic conditions during this month, and people more frequently also go outside to celebrate. The high rate in August was associated with high temperatures when many people are outside.

Compared with mechanical eye injuries, road traffic-related injuries are more serious [20-22]. Our data suggest that when treating ocular trauma patients, it is important to examine the patients carefully to identify other possible injuries outside the eye. When questioning the patient, it is therefore important to inquire about conscious conditions, head problems, and chest pain or limb movement. When patients have other serious injuries that endanger their life, the most dangerous conditions such as stroke, cerebral injuries, or airway problems should be treated first.

The incidence of open globe injuries in our area is higher than in other areas [5,13]. This result differed from the reports from Nigeria [23] and New Zealand [24]. Compared with other reports, the rates of serious lens, endophthalmitis and retinal problems were higher in this region. It is possible that some of the more serious patients were transferred to our hospital.

Hyphema also was an important issue which caused visual decrease. The association of hyphema with the final vision was not noticed in our study as other reference[25]. The lack of detailed medical records in hyphema was the main reason which should be improved in the future study.

The chemical injury is emergenct. Most of the cases accepted more than one surgery. So the sum of percentage of operation is beyond 100%. This was different form other reports[26,27].

OTS was used to evaluate final visual outcome. OTS has good predictive ability in predicting the visual outcome of pediatric penetrating injuries, open globe injuries, and weapons-related injuries [28-32]. Our data showed that the sensitivity of OTS predicting vision at NLP, 20/200-20/50, and ≥ 20/40 was 100%. The specificity of OTS in predicting vision at LP/HM, 1/200-19/200 was 100%.

Based upon our data, five factors are important in the prognosis of visual outcomes: 1) there was a significant difference in the final visual acuity between the patients who arrived in the hospital within 24h and those who arrived 24h after the injury; 2) zone III open globe injuries had a worse visual prognosis than zone I and zone II injuries; 3) initial visual acuity correlated with final visual acuity; 4) open globe injuries and closed ocular injuries had different prognoses; and 5) patients with a higher score and higher grade in OTS had better vision.

There were several limitations of our study. A long-term follow-up system and a national eye injury surveillance system were not yet established. In addition, the prevalence or incidence of ocular trauma could not be calculated.

Despite these limitations, this study remains one of the large sample size studies to reveal the clinical characteristics of patients hospitalized for ocular trauma. Some factors influencing the visual outcome include time interval between injury and visit to the clinic, wound location, open or closed globe injury, initial visual acuity, and OTS.

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