

Epidemiologic characteristics and outcomes of open globe injury in Shanghai

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Abstract

• **AIM:** To investigate the epidemiologic characteristics and outcomes of open globe injury in Shanghai.

• **METHODS:** A retrospective study was conducted for 148 unilateral open globe injury cases presenting to a tertiary referral hospital of Shanghai. Electronic medical records were reviewed and phone surveys were conducted to collect and analyze 1) background of patient; 2) setting of injury and clinical signs at presentation; 3) treatment procedure and outcome; 4) quality of life after injury.

• **RESULTS:** There were more male patients (77.03%) than females (22.97%), more temporary habitants (79.05%) than residents (20.95%). The subjects in this study presented a significantly lower constitutional status of education than that of the whole Shanghai population ($P < 0.001$). Occupational injury was the first cause of injuries (39.86%), followed by home accident (20.27%), road accident (16.89%), violent behavior (16.89%) and outdoor injury (6.08%). The 143 subjects (96.62%) were not wearing spectacles at the time of injury. Of all patients, 77 subjects (52.03%) had the outcome of no vision (including enucleation). The classification and regression tree (CART) prognosis presents 59.58% sensitivity to predict visual survival correctly and 80.19% specificity to predict no vision correctly. The patients whose injured eye had no vision reported more reduction of life quality.

• **CONCLUSION:** We found that male subject, temporary habitants, low educational status and no eyewear are risk factors of open globe injury in Shanghai. Occupational injury is the leading cause. CART analysis presents a certain agreement to the actual visual outcome. The injury imposes negative impact on quality of life especially in no vision cases. The education of eye protection may help to avoid the injury.

• **KEYWORDS:** ocular injury; globe penetration; epidemiology; risk factors; occupational injury

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INTRODUCTION

Ocular trauma is one of the major causes of ocular morbidity. The global incidence rate of ocular trauma was estimated to be 3.5 per 100 000 persons per year^[1]. It is one of leading indications for enucleation in China and in USA^[2-3]. Ocular trauma has a wide spectrum according to the nature and the location of the injury. Open globe injury, defined as a full-thickness injury of the eye wall, presents a severe damage of the eye and often results in poor outcome. Some prognostic models based on clinical signs at presentation, such as the ocular trauma score (OTS) and the classification and regression tree (CART) were created to predict the eventual vision survival^[4], but their sensitivity and specificity need to be further assessed. Another feature of ocular trauma is that the majority of injuries can be avoided if certain precautions are taken. The strategy for prevention is developed on basis of knowing the causes of injuries and the conditions of their occurrences. Previous studies have shown that socio-economic status, education, and nature of work are all important factors, but actually the epidemiology of ocular injury varies largely in different regions and between the populations^[5-10]. Shanghai is the most populous city in China, housing 14.3 million residents and 9.8 million temporary habitants^[11], but there is rare study available on epidemiology and outcomes of severe ocular injury. Therefore, we conducted a retrospective investigation on the cases of open globe injury presented in a tertiary referral hospital in Shanghai to investigate the epidemiologic characteristics and analyze the outcomes and quality of life after injury.

SUBJECTS AND METHODS

Study Population and Information Collection This study was a retrospective investigation conducted in Shanghai Ninth People's Hospital, a tertiary referral hospital located in the centre of Shanghai, specialized in facial trauma. The standard treatment protocol for a diagnosed open globe injury

consists of 1) urgent operative repair of globe and removal of intraocular foreign body within 24h of injury unless there is medical contraindication or delay in presentation; 2) continuous administration of intravenous antibiotics before and after operation for 48h; 3) postoperative administration of topical steroids and antibiotics. If the eye is severely injured and considered unsalvageable, primary enucleation is discussed by oculoplastic team with patient. Informed decision is left to patient. All patients are educated about eye protection and the risk of sympathetic ophthalmia during or after treatment. According to the consideration of further treatment, patients are referred to retina team for vitrectomy and retinal detachment repair or to oculoplastic team for enucleation. The treatment procedures are discussed with patients and the decisions are left to them.

The electronic medical records of all patients with the diagnosis of open globe injury from 1st January, 2011 to 31st December, 2015 were reviewed. Operating registers were searched for repair of open globe injury, repair of ruptured globe and enucleation. Patients who underwent open globe repair at a separate hospital were excluded from this study. The background of subjects was picked up from register system, including age, gender, educational status, residency status, current occupation. The medical records of subjects were categorized by the following columns: 1) the setting of injury including date of injury, cause of injury, wear of eye protective devices, use of alcohol or drugs; 2) previous medical history of general disease or ocular disease; 3) clinical signs at presentation including visual acuity, nature of injury, location of injury, relative afferent pupillary defect (RAPD), lid laceration, general status and other injury; 4) treatment after injury; 5) outcome after the procedure of treatment including visual acuity, ocular complication, primary or secondary enucleation and sympathetic ophthalmia.

Phone call surveys were then conducted to collect more information from the patients or their close family members. The survey consisted of 2 sections: 1) supplemental information of injury; 2) quality-of-life questionnaire.

The first section included: 1) confirmation of personal information; 2) confirmation of cause of injury, wear of eye protective devices and use of alcohol or drugs; 3) confirmation of ocular symptoms and general status at presentation; 4) confirmation of the treatment procedures, patient's decision on further treatment and outcome; 6) confirmation of the occurrence and the education of sympathetic ophthalmia; 7) current eye protection.

The second section included the following questions about the quality of life after eye injury:

- 1 Do you have obvious difficulty with judging distances when walking?
- 2 Do you have obvious difficulty with your vision when reading or watching TV?

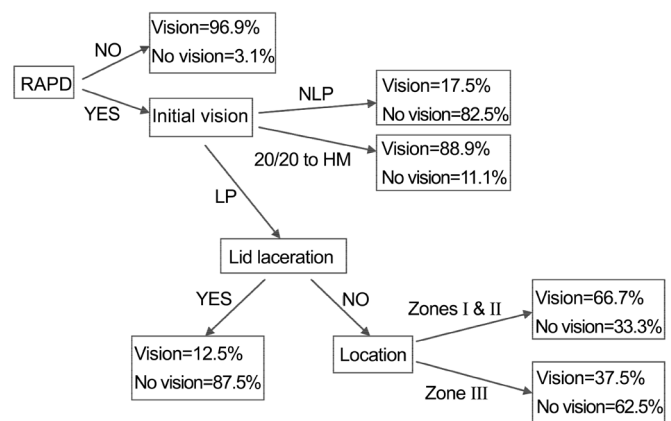


Figure 1 The prediction schema of vision survival and no vision by CART.

3 Do you feel that your appearance has obviously changed by the eye injury?

4 Do you feel that your eye injury has an obvious negative impact on your social life?

5 Has your employment status been changed after eye injury? (for those who had full-time employment before injury)

- A: No, I returned to my former job after treatment.
- B: Yes, my job was changed after injury.
- C: Yes, I'm unemployed after injury.

Patients uncontactable by phone call or unable to answer the questions were excluded from this study. Finally, 148 subjects were eligible for inclusion out of 171 open globe injury patients identified from the register system. The tenets of the Declaration of Helsinki were followed. As no personal information or photo of any certain patient was to be disclosed in publication, the Medical Ethics Committee of Shanghai 9th people's hospital did not require patient consent for this retrospective study.

Definition and Data Categorization The age of patient was defined as age at the time of injury. The residency status of the patient was classified into Shanghai resident and temporary habitants according to whether the registered address on his identity card was in Shanghai.

The education status was defined as the highest diploma of the subject, classified into 1) primary school degree or below; 2) junior middle school degree; 3) senior middle school degree; 4) university degree or above.

CART is a visual prognosis system created by Schmidt *et al*^[12] specially for open globe injury. One model of CART is to make a prediction between vision survival and no vision (Figure 1), which is important to guide following treatment. The CART analysis in this study was retrospectively conducted with the information collected from medical records and the prediction was then compared with actual outcome to evaluate the prediction of CART system. The clinical signs were classified in CART form. The initial visual acuity was defined as the visual acuity of the injured eye at presentation to hospital and was divided into 1) 20/20 to hand movement (HM); 2) light perception (LP); 3) no light perception (NLP).

Table 1 Comparison of the constitutional status of education of the open globe injury patients in this study and that of the whole Shanghai population n (%)

Educational status	Open globe injury patients in this study	Shanghai population ¹ (million)	Chi-square test
Primary school degree or below	47 (31.76)	5.05 (14.57)	$P < 0.001$
Junior middle school degree	61 (41.22)	4.83 (39.24)	
Senior middle school degree	36 (24.32)	8.39 (22.56)	
University degree or above	4 (2.70)	3.12 (23.63)	

¹The constitutional status of education in Shanghai population (including residents and temporary habitants in Shanghai) referred to the sixth national census of population in the year 2010^[14]. The open globe injury patients in this study presented a significantly lower constitutional status of education than that of the Shanghai population (Chi-square test, $P < 0.001$).

The wound location was defined according to the Ocular Trauma Classification Group. Zone I injuries were confined to the cornea and limbus. Zone II injuries involved the anterior 5 mm of the sclera (not extending into the retina). Zone III injuries involved full-thickness scleral defects more posterior than 5 mm from the limbus^[13].

Statistical Analysis The statistical analysis was performed with Excel 2007 (Microsoft Office, Microsoft Corporation, USA) and SPSS 14.0 (SPSS Inc, Chicago, IL, USA). The constitutional status of education of patients in this study was compared with that of Shanghai population. The associations of the clinical signs with the visual outcome were respectively evaluated by Chi-square test. A P value < 0.05 can confirm a notable coherence. The sensitivity and the specificity of CART prognosis were calculated. The questionnaires on quality of life and employment status after eye injury were analyzed for reliability and validity. A Cronbach's α value > 0.8 means very good reliability. A P value < 0.05 of Pearson Correlation test indicates significant validity. The quality of life and employment status was also assessed by Chi-square test between the vision survival group and no vision group. A P value < 0.05 indicates an obvious difference between 2 groups.

RESULTS

General Demographic Information The 148 subjects included were all Chinese. The injuries were all found unilateral, of which 74 cases at the right side, 74 at the left side. There were more male subjects ($n=114$, 77.03%) than females ($n=34$, 22.97%) in this study. The median age at injury was 41.5y in males and 50y in females. The distribution of age and gender were demonstrated with population pyramid in Figure 2. Shanghai residents accounted for 20.95% of the total subjects and temporary habitants accounted for 79.05%. Compared with the constitutional status of education of the whole Shanghai population^[14], the subjects in this study presented a significantly lower educational status (Table 1).

Causes of Injury The causes of open globe injury were classified into five kinds (Figure 3). Occupational injuries were the most common causes (39.86%) followed by home accident (20.27%), road accident (16.89%), violent behavior (16.89%) and outdoor injury (6.08%). Home accidents consisted of

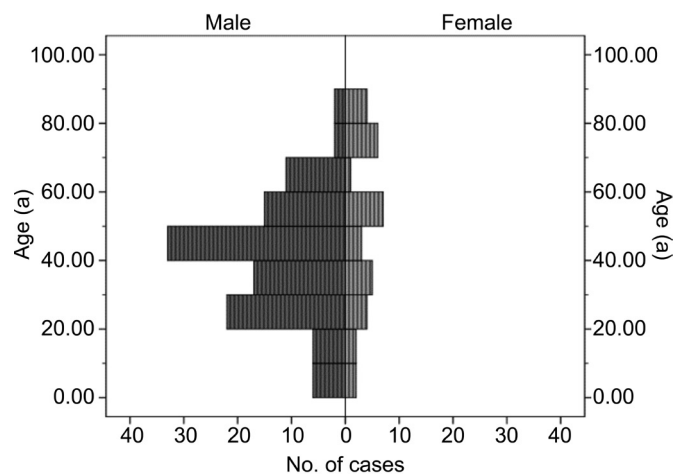


Figure 2 Graph showing the age and gender distributions of open globe injury patients.

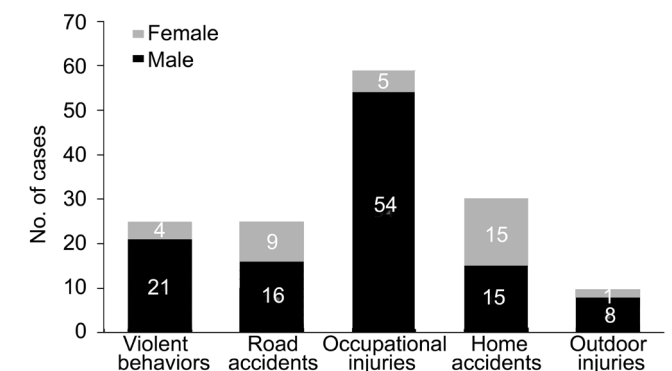


Figure 3 Graph showing the causes of open globe injury and distributions.

cooking accident, injury by sharp object and slip at home. Outdoor accidents included accidents by flying or thrown objects, firework explosions, sports *etc* except road accidents or assaults. Twenty-three subjects admitted alcohol use before injury including 5 in 25 road accident cases and 18 in 25 violent behavior cases. The 143 subjects (96.62%) did not wear any eye protective device (safety goggles or glasses) at the time of injury. Broken spectacles hurt the eye in 3 cases. Non-broken spectacles hurt the eye by impact in the rest 2 cases, in which one eye had laser-assisted *in situ* keratomileusis (LASIK) operation 10y before the injury, and the other was a blind glaucomatous eye before the injury.

Table 2 The predictive values of clinical signs and CART

Parameters	Final visual outcome		Chi-square test
	Visual survival	No vision	
Total cases	71 (47.97%)	77 (52.03%)	
RAPD			
Yes	63	77	$P=0.018$
No	8	0	
Initial vision			
1 (20/20 to HM)	29	2	$P=0.550$ between groups 1&2
2 (LP)	34	4	$P<0.001$ between groups (1+2)&3
3 (NLP)	8	71	
Lid laceration			
Yes	31	50	$P=0.101$
No	40	27	
Location			
Zone I&II	65	46	$P<0.001$
Zone III	6	31	
Mechanism			
Rupture	30	59	$P=0.006$
Laceration	41	18	
CART prediction			
Visual survival	42.30	15.25	$P<0.001$ Visual survival sensitivity=59.58%
No vision	28.70	61.75	No vision specificity=80.19%

Prognosis and Outcomes Of all patients, 77 subjects (52.03%) had the outcome of no vision (including enucleation). The presence of RAPD, the injury at the Zone III and rupture as the mechanism of injury were significant risk factors of no vision. The rank of initial vision was related to the visual outcome, in which group 1 (20/20 to HM) and the group 2 (LP) showed equal indication to high possibility of visual survival (Chi-square test, $P=0.550$), whereas the initial vision of NLP is strongly related to no vision outcome compared with the first 2 groups (Pearson Chi-square test, $P<0.001$). The CART prognosis showed a certain agreement to the actual visual outcome (Chi-square test $P<0.001$) with 59.58% sensitivity to predict visual survival correctly and 80.19% specificity to predict no vision correctly (Table 2).

Fifty-one subjects ended up by enucleation (14 primary enucleations and 37 secondary enucleations) accounting for 34.46% of total cases and 66.23% of final no vision eyes. All the enucleated eyes presented no light perception before operation. Of the 14 primary enucleation cases, 4 patients had general diseases including neurological injury, ancient cerebral vascular accident, schizophrenia and Parkinson's disease, 7 patients had no vision of the injured eye before the injury because of glaucoma, severe keratitis and ancient ocular injury. The major reasons for secondary enucleation decision focused on obvious eye atrophy (31 subjects, 83.78%), ocular pain (13 subjects, 35.14%), prophylaxis of sympathetic ophthalmia (3

subjects, 8.11%). No sympathetic ophthalmia was reported in this study, whereas 129 subjects (87.16%) said having the education about sympathetic ophthalmia. After injury, only 19 patients (12.84%) wore spectacles on purpose to protect the injured or the contralateral eye.

The questionnaire on quality of life and employment status after eye injury showed good reliability and validity (Tables 3, 4). The association between the visual outcome of the injured eye and the quality of life was evaluated. The patients whose injured eye lost vision reported more difficulties in visual function, more changes in appearance and more inadaptabilities in social life (Table 3), in addition, they had more risks of job change and unemployment after injury (Table 4).

DISCUSSION

Male gender, young age and low socio-educational status are generally considered as risk factors of ocular trauma^[5-10]. Similar to previous studies, this study demonstrated that open globe injury patients presented a dominant proportion of male subjects, a preponderance of temporary habitants and a significantly lower constitutional status of education than that of the whole Shanghai population. No laterality was found in these unilateral cases. The prevalence in females seemed stable with age, whereas most injuries in males happened in the range from 20y to 70y and peaked at the decade of 40y-50y. The age peak is later than those in other studies mainly because the first cause in this study for all subjects and for males was

Table 3 Quality of life after open globe injury

Visual outcome of the injured eye	No. of subjects investigated	Impact on vision and stereovision		Impact on appearance and social life		Two independent samples nonparametric test
		Difficulty in judging distances	Difficulty in reading or watching TV	Obvious appearance change	Negative impact on social life	
Vision survival	71	28 (39.44)	29 (40.85)	7 (9.86)	6 (8.45)	P<0.001
No vision	77	53 (68.83)	56 (72.73)	49 (63.64)	48 (62.34)	
Total cases	148	81 (54.73)	85 (57.43)	56 (37.84)	54 (36.49)	

Reliability analysis: Cronbach's $\alpha=0.896$ (very good reliability between item scores); Construct validity analysis: Pearson correlation tests between each item score and total score, $P<0.01$ (significant validity).

Table 4 Employment status after open globe injury

Visual outcome of injured eye	No. of subjects ¹	Employment status		² P
		Job change	Unemployed	
Vision survival	45	6 (13.33)	8 (17.78)	<0.001
No vision	50	14 (28.00)	24 (48.00)	
Total cases	95	20 (21.05)	32 (33.68)	

Reliability analysis: Cronbach's $\alpha=0.889$ (very good reliability between items scores); Construct validity analysis: Pearson correlation tests between each item score and total score, $P<0.05$ (significant validity). ¹Subjects who had full-time employment before injury. ²Two independent samples nonparametric test.

occupational injuries rather than violent behaviors or road accidents which may affect a younger population^[5,7-9]. Home accidents were the second cause for all subjects and the first cause for females, approving that home is a frequent place for open globe injury^[15-16]. The use of alcohol was not usual but also contributed to the occurrence of injury especially by the form of violent behaviors.

Despite the cases of broken spectacles and those of fragile blind eyes, the ocular injuries in this study were mostly related to non-wearing of spectacles. So we presume that spectacles, no matter eye protective device (EPD) or eyewear for myopia, can effectively prevent the eye from injury. Theoretically, the use of EPD is mandatory according to the practice policy concerning works like cutting metal, welding, grinding, drilling and hammering, but the fact revealed that the policy was not well followed in work practice. The reason for non-use of EPD was not investigated in this study, but strict implementation of EPD and compliance with the practice policy may surely reduce the rate of industrial work-related ocular injury. On the other hand, for activities not covered by eye safety policy, wearing spectacles may be a feasible solution. Actually, eyewear is quite common in China because of high prevalence of myopia. The 78.4% Chinese adolescents are myopic in urban area and 95.5% university students are myopic in Shanghai^[17-18]. High prevalence of myopia is related to high educational status^[19]. The subjects of study presented a lower constitutional status of education than that of Shanghai population. This may be the reason for their less common use of spectacles and indirectly more exposure to ocular trauma.

According to this study, the manipulation of CART analysis is quite feasible for clinical application. First of all, the signs

of CART are all ordinary clinical signs which are generally available from medical records and easy to get in emergency. Secondly, the CART prognosis presented a certain agreement to the actual visual outcome in this study. The prediction of vision survival or no vision may help to indicate different further treatments. However, when assessing the signs respectively, we found that the initial vision of NLP was a strong indication to no vision outcome, whereas the presence of lid laceration made no difference. To note, the rate of no vision outcome and enucleation seemed to be higher in this study compared with the others^[5-10,20-24]. It was mainly because of the referral bias. The open globe injury cases referred to Shanghai Ninth People's Hospital were most of high severity and their poor prognoses were also confirmed by CART prediction. In addition, the prognosis of open globe injury is usually quite poor despite the significant improvements in techniques of vitreoretinal surgery^[23-25].

Our survey revealed that most of the patients would not accept primary enucleation psychologically even for a non-salvageable eye. As a result, primary enucleation was rarely practiced unless the general status of the patient restricted further operation or the injury was the second strike for an already blind eye. Secondary enucleation was proposed to cases of severely damaged no vision eye, but the decision was also left to patient. Painful eye and prophylaxis of sympathetic ophthalmia are two indications for secondary enucleation mostly mentioned in the literature^[2,26]. But in this study, esthetic concern of obvious atrophic eye was the first motivation for secondary enucleation and orbital implantation. Since there was no report of sympathetic ophthalmia in this study, the morbidity was not able to be estimated, but the awareness rate of sympathetic ophthalmia was quite high among patients due to the education in hospital.

As the open globe injury is unilateral in most cases, quality of life after injury is presumed little affected as the uninjured eye can provide normal visual acuity as before. But in this study, those whose injured eye lost vision reported more obvious reduction of quality of life than vision survival group. We think it was partly due to more severe defect on stereovision and change on ocular appearance and partly due to psychological inadaptability to unexpected blindness of one eye. According to the result of this study and those in the literature, the subjects most affected by vision-threatening ocular injuries are

of productive age but in poor socio-economic status^[5-6,10], thus the impact of injury on employment status is of great concern. In our study, a total of 33.68% former full-time employees did not work after injury and 21.05% had their job changed. A previous study had the similar report that 40% patients didn't return to their former work after open globe injury^[27]. It's hard for us to presume whether visual defect or psychological barrier was the major factor that made the patients unable to be employed or unwilling to go back to work, but apparently the high unemployment brought socio-economic burden to the patient as well as to the society.

Considering the high risk for certain population and the poor prognosis of open globe injury, we think that the education of eye protection is an effective solution to avoid occurrence and recurrence of injury. However, the current implementation of eye protection was far from satisfying. Our survey found that most patients didn't take any eye protective measure even after the severe ocular injury. The ignorance of eye safety before injury as well as the neglect of eye protection after injury reflects the unawareness of the preventability of ocular injury. Thus, more eye care education should be given to the high risk population and the importance of wearing spectacles should be emphasized in workplace. On basis of the current fact revealed in this study, better strategies for ocular injury prevention, treatment and social readaptation after injury should be developed.

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