Original Article

Characteristics and prognostic indicators of final visual acuity in pediatric open globe injury

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Abstract

Background: *Pediatric open globe injury is a common disease which not only brings about severe visual impairment in children but also results in huge economic burden for the society.*

Objective: *To evaluate the characteristics as well as prognostic factors associated with unfavorable postoperative visual acuity in pediatric open globe injury.*

Methods: *This was a prospective non – comparative case series recruiting 93 children aged from 3 to 15, and were admitted to The Pediatric Department of Ho Chi Minh City Eye Hospital with open globe injuries from November of 2013 to April of 2014. Duration of follow up was 6 months since the last operation. All the epidemiological and clinical characteristics as well as treatment outcomes were assessed. The association between prognostic indicators and unfavorable final visual acuity (< 20/200) was determined via multivariable logistic regression analysis.*

Results: *The mean age of the studied population was 9.04 ± 3.05. Injuries occurred more commonly in boys than in girls (the male to female ratio was 2.20). There were 63.44% of patients injured at home. 80.44% of children received open globe injuries while playing. Sharp objects made up the largest percentage of all causes (65.59%). Corneal laceration, accounted for 68.82%, was the commonest type of trauma. 71.95% of children had initial visual acuity lower than 20/200. 82 children were followed up until 6 months postoperatively and 75.61% of them had final best-corrected visual acuity ≥ 20/200. Incidence of complications was relatively low (< 10%). Prognostic factors associated with poor final visual acuity (< 20/200) were: central cornea-related injury, wound length ≥ 6 mm, vitreous hemorrhage, endophthalmitis and retinal detachment.*

Conclusion*: Our study results can be beneficial for health educational programs of open globe injuries prevention in children. Unfavourable prognostic indicators are likely to help pediatric ophthalmologists predict their patients' final visual acuity.*

Keywords*: pediatric open globe injury, prognostic indicators of final visual acuity.*

Eye SEA 2017; 12 (2) : 11-20
Full text. ***https://www.tci-thaijo.org/index.php/eyesea/index***

Introduction

Ocular trauma is a common condition which accounts for 10 to 15 % of all eye diseases.[1, 2] According to World Health Organization (WHO), it is estimated that there are approximately 55 million cases of eye trauma occurring annually.[3] Among them, 8 – 21% are children.[4, 5] Open globe injury can result in severe visual impairment, even blindness, to children.[6,7] Many studies point out that penetrating ocular trauma is one of the leading causes of unilateral non-congenital visual impairment in children.[8,9] According to blindness prevention programs of WHO, it is estimated that ocular trauma may bring about 1.6 million cases of blindness, 2.3 million cases of bilateral visual impairment and 19 million cases of unilateral visual impairment each year.[10] This condition not only leads to immediate low vision, but also causes children who are younger than 10 years old to have higher risk of developing amblyopia as a result of long-term sequelae after an eye trauma.[11] In addition, ocular trauma can bring about considerable economic burden, for instance, the total cost caused by ocular trauma in the United States in 1988 was estimated to reach 710 million dollars.[10, 12] This extremely high expense is obviously a severe burden for developing countries.[6]

Due to its popularity and severe consequence to health and economy, many studies of open globe injuries in children have been undertaken worldwide. However, In Vietnam, particularly in Ho Chi Minh City, there were no studies about the issue in the last 10 years. Therefore, we decided to carry out this research with the aims of evaluating the epidemiological and clinical characteristics, treatment outcomes as well as prognostic indicators of unfavourable best-corrected visual acuity (BCVA) in pediatric open globe injury.

Methods

This was a non-comparative prospective case series recruiting 93 children who were 3 to 15 years of age and diagnosed with open globe injury at Pediatric Department of Ho Chi Minh City Eye Hospital in Vietnam from November of 2013 to April of 2014. Duration of follow-up was 6 months after the final operation. Approval from the institutional research ethics board was obtained for the study.

Convenience sampling was our chosen method. We included children whose parents' consent for participating in the research could be given. Children with mental problems or eye disorders in which best-corrected visual acuity could not reach 20/20, for instance, amblyopia, cataract, retinoblastoma, etc. were excluded.

Epidemiologic variables evaluated were: age, gender, circumstances, causes of injury, places where the eye injury occurred. Clinical variables assessed were: types, locations, wound size, accompanied wounds and complications of eye trauma, initial visual acuity, final best-corrected visual acuity.

Types of injury was categorized according to the Ocular Trauma Classification Group: penetrating, perforating, intraocular foreign body, and rupture. Penetrating injury was defined as a single laceration of the eye wall, usually created by a sharp object. Perforating trauma referred to a 2 full-thickness laceration (entrance and exit) of the eye wall by the same entity, usually caused by sharp objects or projectiles. Rupture was defined as a full-thickness wound of the eye wall, often generated by a blunt object. The location of the open globe injury was classified as the following: zone I, wound involvement limited to the cornea; zone II, wound involving the sclera and no more posterior than 5 mm from the corneoscleral limbus; and zone III, wound involvement posterior to the anterior 5 mm of the sclera.[3] Wound

size was divided into 2 categories: ≥ 6 mm (half of the mean horizontal corneal diameter) and < 6 mm. Corneal lacerations were classified as central laceration (affecting the optical zone) and peripheral laceration. In our research, unfavourable final BCVA was defined as lower than 20/200 at which the patient's general abilities are restricted even with visual aids, according to a report published by the International Council of Ophthalmology in Sydney in 2002.[13] Other studies also classified final BCVA < 20/200 as a poor BCVA.[14, 15]

Categorical data were analysed with the Chi-squared test or Fisher's exact test. A logistic regression analysis was performed for risk factors predictive of a final unfavourable best-corrected visual acuity (< 20/200). Univariate analysis of all independent variables was initially performed and area under receiver operating characteristics curve was also calculated for statistically significant variables. Subsequently, those variables were entered into multivariate logistic regression model for further analysis. *P* value of < 0.05 was considered statistically significant. The statistical analysis was carried out using the R 3.3.1 software.

Results

Initially, our study recruited 93 children diagnosed with open globe injury. However, via the period of follow-up, 11 of them went missing. Ultimately, we had 82 children completing the research.

The mean age of our research population was 9.04 ± 3,50. Boys received open globe injury 2.20 times more frequently than girls ($p < 0.001$) (table 1).

Zone I wounds accounted for 68.82% of cases, followed by zone II (22.58%) and zone III (8.60%). Among cornea-related wounds which contained zone I and zone II injuries, central cornea-related lacerations made up 43.53 % cases while peripheral ones accounted for 56.47%. In addition, there were 40.86% of cases who had wound size ≥ 6mm and 59.14% of those having wounds size < 6 mm.

Types of open globe injuries respectively decreased in descending order of penetration (82.80%), rupture (10.75%), intraocular foreign body (5.38%) and perforation (1.08%) (table2). Intraocular foreign bodies were caused more commonly by missiles (27.27%) than by other causes (2.44%) (figure1). Retinal detachment were statistically more prevalent in sclera-related wounds (zone II and zone III) than in corneal laceration (zone I) (figure 2).

The most frequent accompanied wounds were those located in the anterior segment of the eye, such as iris prolapse (45.16%), cataract (38.70%) and hyphaema (20.43%). Posteriorly accompanied wounds were quite rare: vitreous prolapse (15.05%), vitreous hemorrhage (8.60%), vitreous foreign body (3.23%) and retinal detachment (2.15%) (table 3).

There were 71.95% of cases having initial visual acuity lower than 20/200. At 6 months after the last operation, 75.61% of patients had final BCVA ≥ 20/200 (figure 3).

Via the multivariate logistic regression analysis model, there were 5 traumatic features showing a statistically significant association with unfavourable final BCVA (< 20/200): central cornea-related laceration, wounds size ≥ 6mm, endophthalmitis, vitreous hemorrhage and retinal detachment (table 6).

Table 1. Epidemiological features of the study population

Features	Number of cases (n = 93)	Percentage %
Gender		
Male	64	68.82
Female	29	31.18
Mean age	9.04 ± 3.50	
Circumstances of injury		
Playing	75	80.66
Fighting	11	11.83
Work accidents	4	4.30
Traffic accidents	3	3.23
Causes of injury		
Sharp objects	61	65.59
Blunt objects	10	10.75
Missiles	11	11.83
Stork attack	6	6.45
Other	5	5.38
Places of injury		
Home	59	63.44
Street	19	20.43
School	11	11.83
Work place	4	4.30

Table 2. Clinical features of the study population

Features	Number of cases (n = 93)	Percentage %
Locations of injury		
Zone I	64	68.82
Zone II	21	22.58
Zone III	8	8.60
Wound size		
≥ 6 mm	38	40.86
< 6 mm	55	59.14
Types of injury		
Penetrating	77	82.80
Rupture	10	10.75
Intraocular foreign body	5	5.38
Perforationng	1	1.08

Table 3. Accompanied wounds

Accompanied wounds	Number of cases (n = 93)	Percentage %
Anterior chamber		
Hyphaema	19	20.43
Pus	6	6.45
Foreign body	2	2.15
Iris		
Iris prolapse	42	45.16
Iris laceration	6	6.45
Iris dialysis	4	4.30
Lens		
Opacification	36	38.70
Luxation	1	1.08
Vitreous		
Vitreous prolapse	14	15.05
Vitreous hemorrhage	8	8.60
Vitreous foreign body	3	3.23
Retinal detachment	2	2.15

Table 4. Complications of open globe injury

Complications	Number of cases (n=82)	Percentage %
Early		
Endophthalmitis	5	6.10
Elevated IOP	3	3.66
Hyphaema	2	2.44
Late		
Uveitis	3	3.66
Retinal detachment	2	2.44
Phthisis bulbi	2	2.44
Cataract	3	3.66
Pupillary membrane	2	2.44

Figure 1. Causes of intraocular foreign body (n=93)

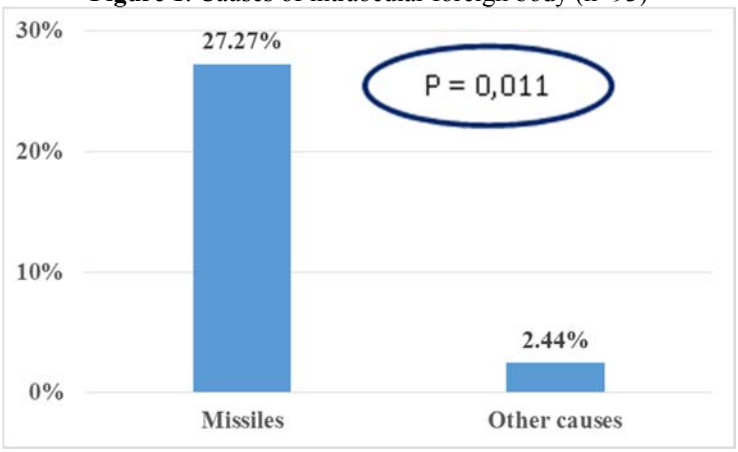

Figure 2. Retinal detachment caused by corneal laceration and sclera-related laceration (n = 82)

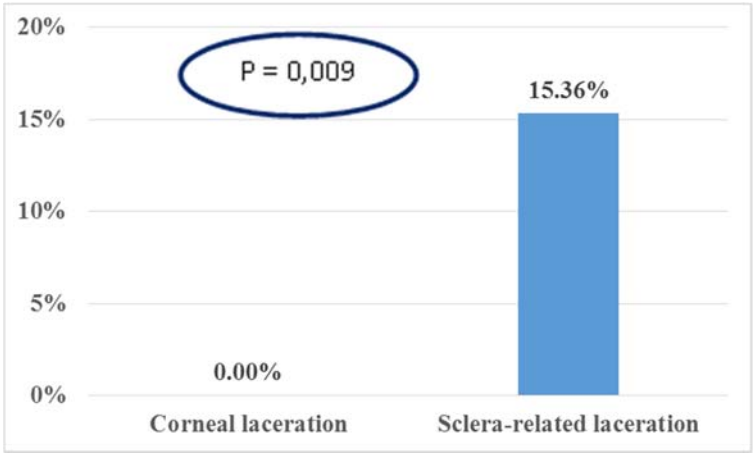

Figure 3. Initial visual acuity and final BCVA (n = 82)

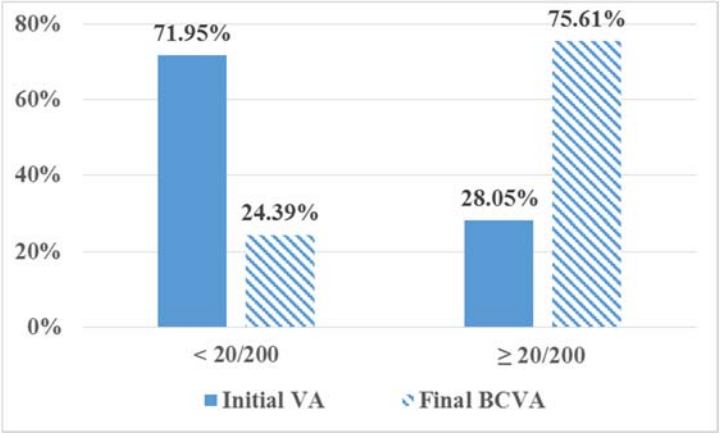

Table 5. Risk factors predictive of a final BCVA < 20/200 by univariate analysis

Features	Final BCVA		OR (CI 95%)	*p*	Area under ROC (CI 95%)
	< 20/200	≥ 20/200			
Age					
≤ 5	3	11	0.82 (0.17 - 3.00)	0.777	-
> 5	17	51	-		
Initial visual acuity					
< 20/200	19	40	10.45 (1.96 - 194.01)	**0.027**	0.652
≥ 20/200	1	22	-		(0.575 - 0.730)
Cornea-related laceration					
Central	12	19	3.89 (1.30 - 12.75)	**0.018**	0.664
Peripheral	6	37	-		(0.535 - 0.792)
Wound size					
> 6 mm	15	19	6.79 (2.28 - 23.42)	**0.001**	0.722
< 6 mm	5	43	-		(0.609 - 0.835)
Types of injury					
Rupture	4	5	2.85 (0.64 - 12.04)	0.150	-
Other	16	57	-		
Hyphaema					
Yes	7	11	2.50 (0.79 - 7.70)	0.111	-
No	13	51	-		
Iris prolapse					
Yes	7	28	0.65 (0.22 - 1.82)	0.426	-
No	13	34	-		
Cataract					
Yes	11	24	1.94 (0.70 - 5.48)	0.204	-
No	9	38	-		
Vitreous hemorrhage					
Yes	6	2	12.86 (2.65 - 94.44)	**0.003**	0.634
No	14	60	-		(0.529 - 0.739)
Vitreous foreign body					
Yes	2	1	6.78 (0.62 - 150.89)	0.127	-
No	18	61	-		
Retinal detachment					
Yes	3	1	10.76 (1.29 - 225.44)	**0.045**	0.567
No	17	61	-		(0.485 - 0.649)
Endophthalmitis					
Yes	4	1	15.25 (2.08 - 309.67)	**0.018**	0.592
No	16	61	-		(0.501 - 0.683)

Table 6. Risk factors predictive of a final BCVA < 20/200 by multvariate logistic analysis

Features	β	OR (CI 95%)	*p*
Initial visual acuity < 20/200	2.694	14.78 (0.89 - 987.17)	0.117
Central cornea-related laceration	3.182	24.10 (2.31 - 1090.93)	**0.030**
Wound size > 6 mm	2.900	18.17 (2.98 - 206.17)	**0.005**
Vitreous hemorrhage	4.606	100.09 (4.51 - 9677.88)	**0.014**
Retinal detachment	6.175	480.71 (9.46 - 926850.10)	**0.033**
Endopthalmitis	3.340	28.21 (1.86 - 1015.30)	**0.025**

Discussion

Characteristics of pediatric open globe injuries

Epidemiological features

Our study showed that boys were 2.20 times more likely to have open globe injury than girls with $p < 0.001$ (table 1). Other studies in the world revealed similar results in which the male to female ratio ranged from 1.42 to 5.52.[16, 17, 15] This is probably because boys tend to be more active than girls.

The mean age of our research population was 9.04 ± 3.50, which was quite the same as other studies' results (mean age ranges from 5 to 11.57).[14, 15, 18, 19]

In our research, children mostly received penetrating injuries from sharp objects while playing at home (table 1). This finding was fairly identical to previous studies in Vietnam (2001)[18], Nigeria (2015)[20], Turkey (2011)[16] and Canada (2013).[17] As a result, we recommend that parents should pay more attention to children's activities while they are playing at home. Also, sharp objects in children's surroundings should be hidden or removed to avoid potential open globe injuries to children.

Clinical features

As can be seen from table 2, zone I was the most common location of open globe injury, (accounting for 68.82% of cases), followed by zone II (22.58%) and lastly zone III (8.60%). This result was quite similar to studies in Taiwan (2009)[14], Vietnam (2001)[18] and Nigeria (2015).[20]

Types of open globe injury respectively decreased in descending order of penetration (82.80%), rupture (10.75%), intraocular foreign body (5.38%) and perforation (1.08%) (table 2). This finding was similar to studies in Germany (2000)[21] and Taiwan (2009).[14]

Via Fisher's exact test, it was shown that intraocular foreign body was caused more commonly by missiles (27.27%) than by other causes (2.44%) (figure 1) ($p = 0.011$). Therefore, pediatric ophthalmologists should suspect an intraocular foreign body when examining eye wounds caused by projectiles such as bullets, sling and so on until proved otherwise.

Besides, our study also pointed out that retinal detachments were statistically more prevalent in sclera-related wounds (zone II and zone III) than in corneal laceration (zone I) (figure 2). Hence, it is better to have a prudent plan of tight follow-up to early recognise retinal detachment in open globe injury associated with sclera (zone II and zone III).

Treatment outcomes

In our study, 71.95% of cases had initial visual acuity lower than 20/200 (figure 3). This finding was quite identical to studies in Turkey (2011)[16, 22] At the time of 6 months after the last operation, only 24.39% of children had final best-corrected visual acuity lower than 20/200 while 75.61% of them had final BCVA greater than 20/200 (figure 3). Studies in Turkey (2011),[16] Germany (2000),[21] and Taiwan (2009)[14] presented the same results as percentage of final BCVA ≥ 20/200 ranged from 70.37% to 72.58%.

Both early and late complications of penetrating ocular trauma in our research

were fairly low (under 10%) (table 4). This result was identical to previous studies of Huong Bui (2001)[18] and Lan Le (2002)[23] in Vietnam.

Prognostic indicators of unfavourable final best-corrected visual acuity

Via multivariate logistic regression analysis model, we found that there were 5 traumatic features showing a statistically significant association with unfavourable final BCVA (< 20/200): central cornea-related laceration, wounds size ≥ 6mm, endophthalmitis, vitreous hemorrhage and retinal detachment (table 6). These elements can bring about visual impairment as they affect either the media of the visual axis or the perceiving retina. Studies in Taiwan (2009),[14] Canada (2013),[17] Austria (2014)[24] also revealed similar results to our study. These unfavourable prognostic indicators are very helpful and clinically relevant as they can be feasibly and practically attained during patients' examination with little dependence on children's subjective feelings. In addition, it does not cost patients extra money nor risk their health in collecting these clinical data.

Apart from that, our research also pointed out that there was no statistically significant correlation between poor final BCVA and other characteristics, such as initial visual acuity lower than 20/200, age < 5, rupture, iris prolapse, hyphaema, cataract etc. (table 5)

Through univariate logistic regression analysis, initial visual acuity lower than 20/200 was significantly associated to unfavourable final BCVA (p = 0.027) (table 5). However, when having further analysis with multivariate logistic regression model, this relationship disappeared (p = 0.117) (table 6). Other research throughout the world presented controversial results: studies in Canada (2013)[17] and the United States (1998)[19] did not show a significant association between the two factors while those in China (2014)[15], Austria (2014)[24] and Turkey (2011)[22] did. This difference of results in studies may be explained by inaccuracy of recording initial visual acuity. Acar[16] supposed that it was almost impossible to have children's initial visual acuity correctly measured as they tended to be uncooperative due to pain. Hence, we recommend the conduction of further studies with elaborate measurement of initial visual acuity to clarify this association.

Conclusion

Open globe injury in children is a common condition which can be very dangerous. A profound understanding of this disease's characteristics is likely to be helpful in establishing a better treatment attitude as well as building up educational programs of penetrating ocular trauma prevention. Furthermore, unfavourable prognostic indicators including central cornea-related injury, wound length ≥ 6 mm, vitreous hemorrhage, endophthalmitis and retinal detachment can be useful for pediatric ophthalmologists to partially prognose patients' final BCVA. Last but not least, it is necessary to perform further studies to elucidate the association between other features of open globe injury and the final BCVA.

Conflicts of interest

The authors declare no conflicts of interest.

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