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Intraocular foreign body injury in children: clinical characteristics and factors associated with endophthalmitis

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ABSTRACT

Background/Aims To analyse the clinical characteristics of intraocular foreign body (IOFB) injury in children and evaluate factors associated with endophthalmitis development.

Methods Patients aged <18 years with IOFB attending Zhongshan Ophthalmic Center between January 2003 and July 2016 were included retrospectively. Demographic features, clinical characteristics and factors associated with endophthalmitis development were analysed.

Results Consecutive subjects (n=484, 484 eyes) were included: mean age 10.12±4.54 years, 86.4% male. Fireworks (28.5%) were the most common cause of injury. Injury of uncertain cause (17.5%), fireworks (36.7%) and metal splatter (31.7%) accounted for most injuries in the 0–3, 4–12 and 13–17 years age groups, respectively. Plant branches (16.7%) and fireworks (31.1%) were the most common causes of injuries in females and males, respectively. Endophthalmitis occurred in 116 patients (24.0%), with metallic IOFB (OR=0.338, p=0.001), intraocular haemorrhage (OR=0.100, p<0.001) and uveal tissue prolapse (OR=0.206, p<0.001) conferring lower risk, while zone II wound (OR=4.336, p<0.001) and traumatic lens rupture (OR=2.567, p=0.028) were associated with higher risk.

Conclusion Clinical characteristics of children with IOFB injury differ from those of adults. Fireworks are the most common cause of injury, indicating a ban on children igniting fireworks should be advocated. Safety education and protective measures should vary by age and sex. Endophthalmitis is associated with zone II wound, traumatic lens rupture, IOFB material, intraocular haemorrhage and uveal tissue prolapse, which has clinical relevance.

INTRODUCTION

Intraocular foreign body (IOFB) injuries are a common and severe form of eye trauma, accounting for 18%–41% of all open-global injuries,[1] causing various complications and vision loss. Several studies have reported that hammering is the most common cause of injury, and metallic foreign bodies commonly cause IOFB injury in adults.[1 2] IOFB has been identified as a risk factor for post-traumatic endophthalmitis by numerous studies, and the reported incidence of IOFB-related endophthalmitis ranges from 6.4% to 16.76% in adult-dominated populations.[1 3 4] The location and material of IOFB have been identified as risk factors for IOFB-related endophthalmitis in several studies.[5 6]

Previous studies primarily enrolled people of all ages, with adults dominating study populations. The main causes of eye trauma are reported to differ between children, adolescents and adults in the USA.[7] The clinical features of paediatric post-traumatic endophthalmitis also differ from those of the condition in adults[8]; however, little information regarding IOFB injuries in children is available. Zhang *et al* described 11 children with posterior segment IOFBs and found materials in the playground and pencil lead at school were common causes of injury.[9]

In the present study, we reviewed 484 paediatric inpatients with the following aims: (1) to describe the clinical characteristics of eye injury in paediatric patients with IOFB; (2) to identify factors related to endophthalmitis following IOFB injury in children. Our findings represent important data that can guide future protective management of these preventable sight-threatening conditions.

METHODS

Population

Consecutive medical records of all patients aged <18 years with IOFB admitted to Zhongshan Ophthalmic Center, Guangzhou, in southern China, between January 2003 and July 2016, were retrospectively reviewed. Patients with only cornea foreign body, or perforation injury with the foreign body retained in the orbit, were excluded. The requirement for patient consent for inclusion was waived because of the retrospective nature of the study.

Procedures

Personal information, including age, sex, the time and cause of injury, the time of primary repair and IOFB removal were recorded. Each patient underwent ophthalmic examination by ophthalmologist. The characteristics of IOFB injury were recorded in the electronic medical record system. Wound entry sites were recorded as zone I (wound limited to the corneal area, including the corneoscleral limbus), zone II (5 mm posterior to the corneoscleral limbus) and zone III (posterior to the anterior 5 mm of the sclera). The number of IOFBs was counted and recorded. The location of the IOFB was classified as anterior segment (anterior chamber, iris and lens), posterior segment (vitreous body, retina and

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Table 1 Distribution of intraocular foreign body injuries according to sex and age group

	Total	Age group (years)		
Sex	(n=484)	0–3 (n=40)	4–12 (n=283)	13–17 (n=161)
Male	418 (86.4)	23 (57.5)	246 (86.9)	149 (92.5)
Female	66 (13.6)	17 (42.5)	37 (13.1)	12 (7.5)

Data are presented as numbers of subjects (percentage).

subretina) and coexisting (single foreign body retained from anterior segment to posterior segment or a plurality of foreign bodies distributed in both the anterior and posterior segments). The type of IOFB was identified and classified as metallic or non-metallic for this analysis. The presence of uveal tissue prolapse, traumatic lens rupture, hyphema and vitreous haemorrhage and endophthalmitis were recorded. All patients routinely received prophylactic topical levofloxacin and intravenous cefuroxime during primary repair and IOFB removal. When patients were clinically diagnosed with endophthalmitis, the intravenous antibiotics were changed to vancomycin and ceftazidime. Clindamycin was used when patients were allergic to cephalosporins. Intravitreal injections of vancomycin or cefuroxime were only used in patients with endophthalmitis or when there was a strong suspicion of infection.

Definitions

IOFB indicates any open-globe injuries with a retained intraocular foreign body, including penetrating, rupture or mixed injuries, based on the Birmingham Eye Trauma Terminology.[10] Diagnosis of endophthalmitis was chiefly based on clinical manifestations, including the presence of corneal oedema, hypopyon, anterior chamber cells and inflammation in the vitreous. Explosives were defined as materials such as tires, detonators and gunpowder, excluding fireworks. Intraocular haemorrhage was defined as patients with hyphema and/or vitreous haemorrhage. The population was divided into three groups according to age: 0–3, 4–12 and 13–17 years. The interval between open-globe injury and primary repair, or between open-globe injury and IOFB removal, was classified as either ≤24 hours or >24 hours.

Statistical analysis

All data were collected in an electronic database and cross-checked for errors. Statistical analysis was performed using SPSS V.16.0 (SPSS, Chicago, Illinois, USA). Categorical variables were analysed using the χ^2 test. Continuous variables were evaluated for normality, and means compared using a two-tailed t-test. Multiple logistic regression analysis was conducted to predict independent factors affecting the occurrence of endophthalmitis after an IOFB injury. P values <0.05 were considered to be statistically significant for all tests.

RESULTS

A total of 484 consecutive paediatric patients (484 eyes) with retained IOFBs were included in this study. The mean age of children with IOFBs was 10.12±4.54 years (range 1–17 years), with 418 (86.4%) males. As shown in table 1, the largest number of IOFB injuries (58.5%, n=283) occurred among children aged 4–12 years, followed by those aged 13–17 years (33.3%, n=161). The proportion of females was 42.5% in the 0–3 years age group and decreased with age, reaching 7.5% in the 13–17 years age group.

Causes of injuries are detailed in table 2. Overall, fireworks (28.5%, n=138), metal splatter (12.2%, n=59) and explosives (11.6%, n=56) were the most common causes of paediatric IOFB injury. The main causes differed among the age groups. Cause of injury was uncertain in 17.5% of patients aged 0–3 years, followed by scissors (15.0%) and fireworks (15.0%). In 4–12 years age group, firework injuries (36.7%) accounted for the highest proportion, followed by explosives (12.4%), and plant branch, as well as pencil injuries (11%). Metal splatter (31.7%) was the most common cause of injury among children aged 13–17 years. Fireworks (31.1%) accounted for a greater number of eye injuries in male patients, while plant branches (16.7%) were a leading cause of injury in females. The monthly distribution of injury causes is shown in table 3. Fireworks injuries were much more common in January and February, at 42.7% and 66.7%, respectively, while pencil injury was less common in January (1.3%), February (2.4%), and August (0%).

As shown in table 4, zone I was the most common wound entry site (65.7%). The majority of patients had only one IOFB (97.9%), and the most common location of IOFBs was in the posterior segment (62.0%), where 93.5% were located in the vitreous body. We classified IOFBs as 'metal' and 'non-metal', and most were non-metallic (63.2%).

A total of 116 (24.0%) eyes were clinically diagnosed with endophthalmitis, with a mean patient age of 8.74±4.39 years. None of these patients progressed to panophthalmitis. Aqueous/vitreous tap for culture was performed in 93 patients, and 26 specimens (28.0%) produced a positive microorganism culture, of which 2 showed dual infection. Therefore, a total of 28 microorganisms were isolated: 63.0% were Gram-positive bacteria, 29.6% were Gram-negative bacteria and 7.4% were fungi.

Table 2 Distribution of injury causes in 484 patients with intraocular foreign bodies

	Fireworks	Metal splatter	Explosives	Plant branch	Metal wire/stick	Pencil	Stone	Glass	Shotgun	Prod (non-metal)	Scissors	BB gun	Knife	Others*	Uncertain
Age (years)															
0–3	6 (15.0)	1 (2.5)	2 (5.0)	5 (12.5)	2 (5.0)	2 (5.0)	0 (0)	3 (7.5)	0 (0)	0 (0)	6 (15.0)	0 (0)	4 (10)	2 (5.0)	7 (17.5)
4–12	104 (36.7)	7 (2.5)	35 (12.4)	31 (11.0)	13 (4.6)	31 (11.0)	9 (3.2)	6 (2.1)	3 (1.1)	11 (3.9)	4 (1.4)	7 (2.5)	2 (0.7)	3 (1.1)	17 (6.0)
13–17	28 (17.4)	51 (31.7)	19 (11.8)	4 (2.5)	23 (14.3)	1 (0.6)	7 (4.4)	6 (3.7)	9 (5.6)	0 (0)	0 (0)	1 (0.6)	1 (0.6)	4 (2.5)	7 (4.4)
Sex															
Female	8 (12.1)	1 (1.5)	6 (9.1)	11 (16.7)	7 (10.6)	8 (12.1)	3 (4.6)	1 (1.5)	1 (1.5)	2 (3.0)	4 (6.1)	2 (3.0)	2 (3.0)	3 (4.6)	7 (10.6)
Male	130 (31.1)	58 (13.9)	50 (12.0)	29 (6.9)	31 (7.4)	26 (6.2)	13 (3.1)	14 (3.4)	11 (2.6)	9 (2.2)	6 (1.4)	6 (1.4)	5 (1.2)	6 (1.4)	24 (5.7)
Total	138 (28.5)	59 (12.2)	56 (11.6)	40 (8.3)	38 (7.9)	34 (7.0)	16 (3.3)	15 (3.1)	12 (2.5)	11 (2.3)	10 (2.1)	8 (1.7)	7 (1.5)	9 (1.9)	31 (6.4)

Data are presented as numbers of subjects (percentage).
*Others include toy, porcelain, fall from height, animal injury, accident.

Table 3 Distribution of injury causes by intraocular foreign body by month

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fireworks	32 (42.7)	56 (66.7)	17 (34.7)	6 (18.2)	6 (18.2)	0 (0)	2 (6.3)	5 (14.7)	3 (9.1)	5 (17.9)	4 (12.5)	2 (8.7)
Metal splatter	6 (8.0)	5 (6.0)	4 (8.2)	6 (18.2)	4 (12.1)	2 (7.1)	7 (21.9)	5 (14.7)	9 (27.3)	3 (10.7)	4 (12.5)	4 (17.4)
Explosives	9 (12.0)	4 (4.8)	6 (12.2)	9 (27.3)	5 (15.2)	2 (7.1)	5 (15.6)	4 (11.8)	4 (12.1)	2 (7.1)	3 (9.4)	3 (13.0)
Metal wire/stick	3 (4.0)	1 (1.2)	4 (8.2)	2 (6.1)	3 (9.1)	4 (14.3)	7 (21.9)	5 (14.7)	1 (3.0)	4 (14.3)	3 (9.4)	1 (4.3)
Plant	3 (4.0)	4 (4.8)	2 (4.1)	1 (3.0)	2 (6.1)	2 (7.1)	5 (15.6)	4 (11.8)	5 (15.2)	2 (7.1)	6 (18.8)	4 (17.4)
Pencil	1 (1.3)	2 (2.4)	4 (8.2)	6 (18.2)	8 (24.2)	3 (10.7)	1 (3.1)	0 (0)	1 (3.0)	2 (7.1)	4 (12.5)	2 (8.7)
All other causes	21 (28.0)	12 (14.3)	12 (24.5)	3 (9.1)	5 (15.2)	15 (53.6)	5 (15.6)	11 (32.4)	10 (30.3)	10 (35.7)	8 (25.0)	7 (30.4)
Total	75 (100)	84 (100)	49 (100)	33 (100)	33 (100)	28 (100)	32 (100)	34 (100)	33 (100)	28 (100)	32 (100)	23 (100)

Data are presented as numbers of subjects (percentage).

Coagulase-negative *Staphylococcus* and *Bacillus subtilis* were the most common isolates (14.8% each). Next, we evaluated associations between clinical characteristics and endophthalmitis. By univariate analysis, IOFB material, traumatic lens rupture ($p=0.001$ and $p=0.022$, respectively), uveal tissue prolapse and intraocular haemorrhage ($p<0.001$) differed significantly between patients with and without endophthalmitis (table 4). Timing of IOFB removal, and timing of primary repair were not significantly different between these two groups. Logistic regression analysis showed that zone II wounds (OR=4.336, $p<0.001$) and traumatic lens rupture (OR=2.567, $p=0.028$) conferred a higher risk of endophthalmitis, while metallic IOFB (OR=0.338, $p=0.001$), intraocular haemorrhage (OR=0.100, $p<0.001$) and uveal tissue prolapse (OR=0.206, $p<0.001$) were associated with lower risk. (table 5).

DISCUSSION

In this study, we analysed clinical data from 484 cases of IOFB injury in children in southern China. We found that males accounted for the largest proportion, fireworks were the most common cause of injury overall and the causes of injury varied according to age and sex. The incidence of endophthalmitis was 24.0% in our study, and traumatic lens rupture and wounds located in zone II were risk factors for the development of endophthalmitis, while uveal tissue prolapse, intraocular haemorrhage and IOFB material conferred a lower risk of endophthalmitis.

Our investigation demonstrated that IOFB injury occurred more often in boys than girls (418 vs 66) and primarily in children aged 4–12 years, which is similar to studies of paediatric ocular trauma in other settings.[11 12] The proportion of females was close to that of males in the youngest group (0–3 years) and decreased with age; this trend has also been reported by other studies of paediatric ocular trauma,[11 13 14] which may be explained by younger boys and girls both engaging in similar daily activities, while boys may participate in more hazardous activities when they grow older.[13]

Fireworks were the leading cause of IOFB injuries in our study, and this type of injury mainly occurred during Spring Festival, consistent with previous reports.[15 16] Li *et al* also reported that fireworks injury accounted for the majority of patients with IOFB aged 0–9 years in China.[17] Fireworks-related eye trauma mainly occurs in children, and is frequently severe and visually devastating.[15 18] The accidents involving fireworks diminished after children aged <18 years were prohibited from setting off fireworks in Finland.[19] In addition, Wisse reported that countries with restrictive legislation regarding fireworks report 87% fewer incidents of eye trauma.[20] Private firework displays are gradually being banned in China at present, which will have a positive effect on the prevention of IOFB injury in children.

A previous study showed that paediatric ocular trauma is mainly accidental and has an age-specific pattern.[11] We also found that the main cause of injury in children with retained IOFB differed among age groups. Uncertain cause, fireworks and metal splatter accounted for the majority of injuries in the 0–3, 4–12 and 13–17 age groups, respectively. Younger children, aged 0–3 years, may be unable to describe the cause of their injury exactly, which could explain the higher proportion of cases with uncertain cause in this age group. Lin reported that fireworks (41.6%) and splashing of foreign body (49.1%) injuries dominate in retained patients with IOFB aged 0–9 and 10–19 years, respectively, similar to our findings.[17] Older children have increased security awareness and an expanded range of independent activities, resulting in different causes of injury. In addition, male patients were more prone to injury with fireworks, while females were more likely to be injured by plant branches, likely reflecting the different activities of males and females when they were injured. Therefore, safety education and protective measures for IOFB injuries in children should vary according to age and sex.

The incidence of endophthalmitis in our series was approximately 24.0%. Previous studies of paediatric open-globe injury reported incidences of endophthalmitis in northern China and Taiwan of 12.9% and 9.6%, respectively.[21 22] IOFB is a risk factor for post-traumatic endophthalmitis, which could explain the higher incidence recorded in our study than those reported by studies of paediatric post-traumatic endophthalmitis in Eastern Asia. We reported that the incidence of endophthalmitis in patients with IOFB (average age 31.7 ± 12.5 years) was 16.4% in the same ophthalmic centre, similar to other studies of adult-dominated populations, including in China, the USA, Saudi Arabia and Iran (6.4%–16.76%).[1 4 23 24] Higher incidence of endophthalmitis was observed in our study than those of previous adult-dominated studies because children may be less able to recognise or explain their symptoms when injured, and cooperate less well during ocular examination and treatment, leading to increased incidence of endophthalmitis in paediatric patients.[25] Therefore, identification of factors related to endophthalmitis in children with retained IOFB is of great significance for the prevention and timely diagnosis of endophthalmitis following injury.

Little has been determined about factors associated with IOFB-related endophthalmitis in children to date. In our study, traumatic lens rupture and wound located in zone II were identified as risk factors for endophthalmitis. We found that patients with traumatic lens rupture had a higher risk of endophthalmitis, consistent with previous reports.[1 3 4 26] Whether wound location

Table 4 Univariate analysis of intraocular foreign body (IOFB) injury characteristics and the development of endophthalmitis

Factor	Total no. (%)	Endophthalmitis, no. (%)	P values
Sex			0.383
Female	66 (13.6)	18 (27.3)	
Male	418 (86.4)	98 (23.4)	
Age (years)			0.169
0–3	40 (8.3)	14 (35.0)	
4–12	283 (58.5)	75 (26.5)	
13–17	161 (33.3)	27 (16.8)	
IOFB material*			0.001
Non-metal	304 (63.2)	91 (29.9)	
Metal	177 (36.8)	25 (14.1)	
IOFB location†			0.701
Anterior segment	164 (34.0)	41 (25.0)	
Posterior segment	299 (62.0)	74 (24.7)	
Co-existing	19 (3.9)	6 (31.6)	
Wound location‡			0.050
Zone I	311 (65.7)	75 (24.1)	
Zone II	132 (27.9)	38 (28.7)	
Zone III	30 (6.3)	3 (10.0)	
Timing of primary repair§			0.088
≤24 hours	296 (61.5)	63 (21.3)	
>24 hours	185 (38.5)	53 (28.6)	
Timing of IOFB removal¶			
≤24 hours	46 (9.5)	11 (23.9)	0.569
>24 hours	436 (90.5)	105 (24.1)	
Self-sealing of wounds**			0.776
Yes	78 (19.1)	23 (29.5)	
No	331 (80.9)	93 (28.1)	
Uveal tissue prolapse††			<0.001
Yes	249 (54.6)	32 (12.9)	
No	207 (45.4)	84 (40.6)	
Intraocular hemorrhage‡‡			<0.001
Yes	220 (49.4)	16 (7.3)	
No	225 (50.6)	100 (44.4)	
Traumatic lens rupture§§			0.022
Yes	377 (82.3)	104 (27.6)	
No	81 (17.7)	11 (13.6)	

*Excluding 3 cases without complete data.
†Excluding 2 cases without complete data.
‡Excluding 11 cases without complete data.
§Excluding 3 cases without complete data.
¶Excluding 2 cases without complete data.
**Excluding 75 cases without complete data.
††Excluding 28 cases without complete data.
‡‡Excluding 39 cases without complete data.
§§Excluding 26 cases without complete data.

Table 5 Multivariate analysis of independent risk factors for endophthalmitis in patients with intraocular foreign bodies

Factor	P values	OR	95% CI
Metal	0.001	0.338	0.177 to 0.642
Zone II injury	0.000	4.336	2.142 to 8.778
Zone III injury	0.237	2.592	0.535 to 12.560
Uveal tissue prolapse	0.000	0.206	0.112 to 0.382
Intraocular haemorrhage	0.000	0.100	0.049 to 0.203
Traumatic lens rupture	0.028	2.567	1.105 to 5.964

is related to endophthalmitis remains controversial.[6 27] Faghihi *et al* found that wounds located in zone I were risk factors for post-traumatic endophthalmitis.[4] In contrast, we found that wounds located in zone II were more frequently associated with endophthalmitis than those in zone I. Wounds in zone II might be less likely to be detected during examination because of poor cooperation of children with ophthalmic examination, leading to delays in diagnosis and treatment. Furthermore, infants and young children have low scleral rigidity, and wounds in this population are hardly self-sealing, providing an entry route for microorganisms. All of these factors may increase the incidence of endophthalmitis in zone II wounds, relative to those in zone I.

Metallic objects were reported to account for 55%–91% of IOFB among adult-dominated patients[1 28]; however, whether IOFB material is a factor related to endophthalmitis is controversial. Some studies reported that the nature of the IOFB does not influence the development of endophthalmitis,[1 29] whereas several studies reported that organic IOFBs and wood clearly increase the risk of endophthalmitis.[5 30] In this study, we found that non-metallic foreign bodies accounted for the majority of IOFBs and were associated with a higher risk of endophthalmitis compared with metallic IOFBs (29.9% vs 14.1%, p=0.001). Work-related injuries, such as hammering, are the main cause of IOFB injury in adults,[28] while fireworks injuries accounted for the majority in our study, likely accounting for the difference in composition of IOFB material. The lower risk of endophthalmitis in patients with metal IOFBs could be explained by the fact that high-speed metallic objects may be self-sterilised with friction-generated heat, reducing the risk of endophthalmitis.[4]

Patients with intraocular haemorrhage and uveal tissue prolapse had a lower risk of endophthalmitis in our study. Whether intraocular tissue prolapse is a significant risk factor for post-traumatic endophthalmitis is the subject of disagreement.[4 31–33] The iris of children are more likely to form exudation membranes when stimulated than those of adults. Prolapsed uveal tissue and exudation membranes can directly block the entrance to the eye, functioning similarly to wound closure, and leading to a lower risk of endophthalmitis. The reduced risk of endophthalmitis in patients with intraocular haemorrhage may be due to the unlocking of the blood ocular barrier, causing the release of factors which inhibit microbial growth in ocular chambers.[4]

Although this study covers a relatively long time period (almost 13 years) and a total of 484 patients were enrolled, the retrospective nature of the investigation is a limitation. Prophylactic intravitreal antibiotic injection was considered to reduce the risk of post-traumatic endophthalmitis,[34 35] however, our data could not analyse the correlation between intravitreal antibiotic injection and endophthalmitis. This study did not analyse visual prognosis because patients attending this large tertiary hospital, particularly paediatric patients, come from all over the country, hindering follow-up. In addition, younger children cannot cooperate with visual testing, leading to incomplete data. Nevertheless, our study provides a large sample of valid data describing the clinical characteristics and factors associated with endophthalmitis in paediatric patients with IOFB.

In conclusion, we analysed the clinical characteristics of injury in patients with IOFB aged <18 years. In general, fireworks were the most common cause of injury, suggesting that calls for a total ban on personal fireworks should continue. While education about safety and measures to protect against IOFB injury in children should vary according to age and sex. Non-metallic IOFBs were much more common and had a higher risk of leading to the development of endophthalmitis. Zone II wounds and trauma

lens rupture were risk factors for the development of endophthalmitis, while uveal tissue prolapse and intraocular haemorrhage were associated with lower incidence of endophthalmitis, which should be considered in clinical practice.

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Contributors YY, ZHY and XFL conceived and designed the study. CCY, RJZ and LXL acquired the data. YY, CCY, FD and BSL analysed and interpreted the data. YY and CCY drafted the final manuscript.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval This study was conducted in compliance with the principles of the Declaration of Helsinki, and approved by the Institutional Ethics Committee of Zhongshan Ophthalmic Center (Guangzhou, China).

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