

ONLINE FIRST

Ocular Consequences of Bottle Rocket Injuries in Children and Adolescents

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Objective: To describe the spectrum of ocular injuries and associated visual morbidity in the pediatric and adolescent population caused by bottle rockets.

Methods: Retrospective review of consecutive medical records of patients 18 years or younger seen during a recent 4-year period. Outcome measures were ocular injuries at time of visit, interventions required, visual acuity at most recent follow-up, and most recent anatomic findings.

Results: Eleven eyes from 10 patients (8 boys and 2 girls aged 5-17 years) were identified. Significant ocular injuries included corneal epithelial defect (7 eyes), hyphema (6 eyes), traumatic iritis (2 eyes), iridodialysis (4 eyes), cataract (4 eyes), retinal dialysis (1 eye), and vitreous hemorrhage (2 eyes). Eight eyes required primary intervention (lensectomy in 4 eyes, corneal debridement in 2 eyes, globe

exploration in 1 eye, and retinal laser photocoagulation in 1 eye). Three patients required additional procedures. These secondary interventions included pars plana vitrectomy (1 eye), muscle surgery for sensory strabismus (1 eye), corneal debridement (1 eye), and intraocular lens placement (1 eye). Most recent visual acuity (10 eyes with follow-up) was 20/30 or better in 4 eyes and 20/200 or worse in 6 eyes (for 1 eye, the patient was unavailable for follow-up). Permanent visual impairment was typically due to traumatic maculopathy.

Conclusion: Bottle rockets can cause significant ocular injury in children, often with permanent loss of vision.

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FIREWORKS-RELATED INJURIES are frequently seen among patients admitted to the emergency department because fireworks are a popular means of expression during Independence Day and other celebrations in the United States. In 2006, a total of 11 deaths and approximately 9200 emergency department admissions resulted from fireworks-related injuries, with most affecting boys and 36% of injuries occurring in individuals younger than 15 years.¹ An estimated 1400 cases annually involve injury to the eyes.² A disproportionate number of cases of severe ocular morbidity and visual impairment are caused by bottle rockets.^{3,4}

A bottle rocket is approximately half the size of a normal firework and consists of 3 main parts: the core ("engine"), which is a tube filled with black powder or a similar explosive; the nose cone, which guides the flight of the firework and may contain explosive components or other decorative items; and a guide stick, which sta-

bilizes the rocket in flight. When ignited, the explosion propels the bottle rocket into the air, often setting off further colorful explosions, including star bursts, trails, or sparklers. Many manufacturers of bottle rockets also design them with whistles that shriek as the rockets climb into the air or explosives that make a concussive bang when they explode. The guide stick is typically stuck in the ground or braced in a bottle (hence the name) prior to launch. Injuries may result from direct high-velocity contact with the intact rocket, from parts of the rocket that may break off during flight, or from neighboring debris propelled by the force of the rocket's combustion.

Bottle rocket injuries, therefore, may bring significant costs to the individual, through loss of vision and decreased quality of life, and to society, through health care use and lost productivity. One step toward a rational discussion about the regulation of fireworks, particularly bottle rockets, is an analysis of the ocular complications that can result from their use.

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Table 1. Demographic and Historical Details of Children and Adolescents Treated for Ocular Injuries Associated With Bottle Rockets

Patient No./ Sex/Age, y	Date of Injury	Reported Method of Injury	Level of Involvement
1/M/7	July 2, 2006	Played with bottle rocket in hand	Active
2/M/17	July 5, 2007	When mowing lawn, struck in eye by bottle rocket launched by nearby children	Passive
3/F/5	July 5, 2008	Bottle rocket exploded nearby	Passive
4/M/13	October 12, 2006	Launched bottle rocket	Active
5/M/11	October 11, 2008	Struck in eye by bottle rocket	Active
6/M/6	July 7, 2008	Struck in eye by bottle rocket	Active
7/M/10	June 25, 2008	Bottle rocket exploded in front of eye	Active
8/M/15	June 23, 2008	Struck in eye by bottle rocket	Active
9/M/11	June 7, 2008	Struck in eye by bottle rocket	Active
10/F/17	June 11, 2009	Bent over bottle rocket to light it	Active

In addition, we hope that such studies will educate parents and children about the long-term repercussions of ocular injuries, guide pediatricians and ophthalmologists who care for and counsel these patients, and inform the public of the risks of bottle rockets. Several studies of ocular trauma have included bottle rocket injuries,⁴⁻⁶ but none, to our knowledge, has detailed the extent and long-term outcomes of such injuries in children and adolescents. The objectives of this retrospective study were to describe the spectrum of ocular injuries and the long-term sequelae resulting from bottle rocket injuries in children and adolescents.

METHODS

Approval from the institutional review board of Vanderbilt University Medical Center was obtained for this retrospective study. Consecutive medical records of all patients 18 years or younger seen in ophthalmic consultation through the Vanderbilt Children's Hospital emergency department between January 1, 2006, and December 31, 2009, were reviewed. Patients with a history of fireworks injury were selected for further study. Data collected included patient demographics (age and sex), date of the accident, method of injury, level of patient's involvement (having launched the bottle rocket or having been a bystander), visual acuity (VA) at first visit, ophthalmic findings at first visit, initial and secondary therapeutic interventions, VA at most recent follow-up, and anatomic findings at most recent follow-up.

RESULTS

Of 2385 consultation medical records reviewed, 10 patients with a history of bottle rocket injury were identified (**Table 1**). Eight patients were boys and 2 were girls. The median age was 11 years (range, 5-17 years). Interestingly, 8 of the 10 patients identified were injured within a month of July 4. Eight patients were launching bottle rockets at the time of injury, whereas 2 were bystanders. Nine of 10 patients were injured in 1 eye and 1 patient in both eyes. Use of protective eyewear was not recorded in any of the patients.

On first visit, 7 of the 11 eyes had VA of 20/200 or worse (**Table 2**). Injuries to the eyelids, anterior segment, and adnexa included periocular burns (3 eyes), eyelid laceration (1 eye), corneal epithelial defect (7 eyes), hyphema (6 eyes), traumatic iritis (1 eye), iridodialysis

(4 eyes), and cataract (4 eyes). Recorded injuries to the posterior segment included vitreous hemorrhage (2 eyes), intraretinal hemorrhage (2 eyes), commotio retinae (4 eyes), and retinal dialysis (1 eye). Eight of 11 eyes required primary intervention, which included lensectomy (4 eyes), corneal debridement (2 eyes), anterior vitrectomy (1 eye), globe exploration (1 eye), and retinal laser photocoagulation (1 eye).

Secondary interventions included pars plana vitrectomy (1 eye), muscle surgery for sensory strabismus (1 eye), corneal debridement (1 eye), and intraocular lens placement (1 eye). One patient was unavailable for follow-up. In 3 patients (patients 5, 8, and 9), no active or vision-threatening ocular abnormality was seen, and these patients were discharged to care in their local area. Of the remaining 6 patients (representing 6 eyes), follow-up was available for at least 3 months (range, 3-37 months). In all 6 eyes, VA was 20/200 or worse, with limited visual potential. Permanent VA loss was attributed to corneal scarring, traumatic maculopathy, or a traumatic macular hole.

COMMENT

This study demonstrates that bottle rockets can cause significant ocular injury in children and adolescents and, in turn, cause their parents and themselves to incur expenses through emergency department visits, surgical interventions, and days missed from school and work. It has been shown that half of all fireworks-related ocular injuries, particularly those leading to permanent blindness or enucleation, are caused by bottle rockets.¹ We specifically looked at bottle rocket-related ocular injuries because of the severity of these injuries compared with other fireworks-related ocular injuries,⁴ their high incidence in children,⁵ and the paucity of detailed clinical data for this subset of patients.¹

Our study confirmed that the preponderance of trauma patients are male, as shown by a previous epidemiologic study.⁴ The presence of adults was not uniformly documented in our records, but 1 study has shown that adult supervision was present in only 54% of pediatric fireworks-related injuries.² Indeed, adult supervision during fireworks launching may seem advisable, but it is not sufficient to prevent fireworks-related injuries in children.

Whereas most patients were launching bottle rockets at the time of injury, 2 were bystanders. In 1 of these

Table 2. Anatomic Findings and Therapeutic Interventions in Children and Adolescents With Ocular Injuries Associated With Bottle Rockets

Patient No.	Eye(s) Involved	VA in Injured Eye at First Visit	Injuries to Eyelids, Anterior Segment, and Adnexa	Injuries to Posterior Segment	Primary Surgical Intervention	Additional Procedures	Length of Follow-up	Most Recent VA	Anatomic Abnormalities at Most Recent Follow-up
1	OS	6/400	CED, hyphema, iridodialysis, partial thickness corneal laceration	Comotio retinae; preretinal, intraretinal, and subretinal hemorrhage; retinal dialysis	Retinal laser photocoagulation, debridement of corneal tissue	Debridement of cornea	35 mo	20/200	None
2	OD	HM	CED, hyphema, iridodialysis	None	None	None	0	NA	None
3	OD	CF at 0.3048 m	CED, microhyphema, iridodialysis, anterior cataract	Berlin edema	None	Medial and lateral rectus recession	3 mo	CF	Traumatic maculopathy/RPE loss
4	OS	HM	Microhyphema, iridodialysis, cataract	Traumatic macular hole	Pars plana lensectomy, synechiolysis	Secondary IOL placement, pars plana vitrectomy, macular hole repair, retinal detachment repair	37 mo	20/200	None
5	OS	20/20	CED, mild thermal keratopathy	None	None	None	3 d	20/30	Healed CED
6	OD	LP	Traumatic iritis, microhyphema	None	Lensectomy, anterior vitrectomy	None	9 mo	CF	Corneal scar, aphakia
7	OD	CF at 0.3048 m	Corneal laceration, hyphema, iridodialysis, cataract	Berlin edema, perifoveal intraretinal and subretinal hemorrhage, comotio retinae	Pars plana lensectomy	None	13 mo	20/400	Traumatic maculopathy/RPE loss
8	OD	20/50	Lid edema, subconjunctival hemorrhage, traumatic iritis	Berlin edema, vitreous hemorrhage, subhyaloid hemorrhage	None	None	15 d	20/25	Healed
9	OD, OS	20/25 OD	Fragments in fornices, CED	None	Debridement of corneal and conjunctival fragments	None	17 d	20/20	Healed
		20/20 OS	Fragments in fornices, CED	None	Debridement of corneal and conjunctival fragments	None	17 d	20/20	Healed
10	OS	20/400	Eyelid margin laceration, hyphema, traumatic cataract with anterior capsular rupture	Vitreous hemorrhage	Globe exploration, AC washout, vitrectomy, lensectomy	None	4 mo	20/400	Optic pallor, traumatic maculopathy

Abbreviations: AC, anterior chamber; CED, corneal epithelial defect; CF, count fingers; HM, hand motion; IOL, intraocular lens; LP, light perception; NA, not applicable; RPE, retinal pigment epithelium; VA, visual acuity.

cases, VA was reduced to finger counting. Also of note, none of the patients in this series were reported to have been wearing protective eyewear at the time of injury. Therefore, if children, adolescents, and parents choose to launch bottle rockets, it is important for parents not

only to supervise children and adolescents in the vicinity of bottle rockets but also to ensure that protective eyewear is being used.

Follow-up of at least 3 months was available for 6 of 11 eyes. In all 6 eyes, VA was 20/200 or worse. In the 4

eyes with significant visual loss, the residual anatomic defects still present at the most recent follow-up included traumatic maculopathy (3 eyes) and corneal scar with aphakia (1 eye).

The main limitations of this study include the retrospective retrieval of clinical information and the possibility of ascertainment bias. Because only the cases of patients who visited our emergency department were reviewed, it is possible that those reported here are more severe. Thus, one cannot draw any conclusions regarding the incidence of bottle rocket-related ocular injuries or the true spectrum of their severity.

In this series, 8 of the injuries occurred within 1 month of Fourth-of-July festivities. Therefore, during such times, parents, children, and adolescents need to be particularly aware of the potential danger of injuries from bottle rockets. Not surprisingly, the US Consumer Product Safety Commission prohibits the sale of certain dangerous types of fireworks, including large firecrackers that contain more than 50 mg of explosive powder and aerial fireworks that contain more than 130 mg of flash powder.⁷ Despite these federal regulations and state prohibitions, approximately one-third of fireworks-related deaths between 2000 and 2005 involved fireworks illegally sold to customers.⁸ Massachusetts, Delaware, New Jersey, New York, and Rhode Island are the only 5 states that ban the sale of all consumer fireworks. Whereas the US Consumer Product Safety Commission has issued mandatory safety regulations for firework devices and enforces them under the Federal Hazardous Substance Act, these regulations are clearly not enough to prevent the devastating ocular injuries incurred each year as a result of fireworks, particularly bottle rockets. Therefore, studies such as ours are important for the education of parents, children, adolescents, physicians, and the public regarding the repercussions of fireworks-related ocular injuries to active participants and to bystanders. Finally, studies such as ours can assist in modifying legislation to ban sales of bottle

rockets in an effort to eliminate unnecessary ocular trauma and visual loss.

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