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Case report

Ocular foam round injury: A case report and literature review

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ABSTRACT

Purpose: To report the case of a 25-year-old male who sustained significant ocular trauma from a confirmed foam round. To review the scientific literature on kinetic impact projectiles and legislation currently proposed to regulate their use.

Observations: A 25-year-old male presented to the emergency department with acute pain and vision loss in his left eye after being struck by a foam round. Initial exam showed significant periorbital ecchymosis, multiple eyelid lacerations, microhyphema, and vitreous hemorrhage. Computed tomography revealed fractures of the inferior and medial orbital walls. Optical coherence tomography also demonstrated full-thickness macular hole. Microhyphema resolved after 15 days with steroid and mydriatic drops. Vision at 60 days after injury stabilized at 20/60. Repeat OCT at this time revealed closure of the macular hole. Care for the patient is ongoing.

Conclusions and Importance: Foam rounds can cause a pattern of vision-threatening ocular trauma similar to that of rubber bullets with the additional risk of chemical injury. During the George Floyd protests, isolated reports of significant foam round-related ocular injuries have been reported in the press, but systematic epidemiologic and clinical data on the subject remains lacking. While accurate identification of the causative weapon is not required in the management of ocular trauma, it may impact advocacy efforts undertaken by physicians and the subsequent legislative efforts they inspire. Current state and federal law does not adequately protect individuals from these munitions. Multiple proposals in Congress aptly recognize the significant risk of blinding injury and mortality posed by all kinetic impact projectiles.

Introduction

Greater awareness of the significant ocular injuries and potential mortality associated with kinetic impact projectiles, such as rubber bullets and foam rounds, have mobilized efforts to ban these munitions from being used against civilian populations in the United States. However, the epidemiology and pattern of injury caused by foam rounds remain poorly understood.

Case report

A 25-year-old male with no previous medical history presented to the emergency department with acute vision loss and pain in the left eye after being struck by a projectile during a protest. He believed that he had been hit by a rubber bullet, but the projectile obtained by the patient was subsequently identified as a foam round (Fig. 1a). A green powdery substance was dispersed around the site of injury. At the time of presentation, he demonstrated an intact airway, breathing, and circulation and denied any history of recent alcohol or drug use. Vital signs at triage were within normal limits except for a reduced heart rate of 47.

On initial exam, the patient reported 10/10, stabbing pain in the left eye that worsened with downgaze. He also reported reduced vision in the left eye with photophobia, floaters, and photopsia. Examination of the right eye was within normal limits. The left eye demonstrated reduced vision at 20/50 with the near card. Intraocular pressure (IOP) was measured to be 14 mmHg by Tono-Pen. Pupil was round and reactive to light. The patient reported direct photophobia but denied consensual photophobia. Extraocular motility exam was significant for −2 inferior gaze restriction on the left side. pH testing was not performed.

Examination of the left adnexa revealed diffuse periorbital ecchymosis and edema. Two lacerations were noted: one 3-cm laceration on the upper eyelid and a 2-cm laceration located just inferior to the lower eyelid. Neither involved the eyelid margins or the canalicular system

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Fig. 1. Photographs after injury **a.** Foam marking round as recovered by the patient in Cincinnati, Ohio, USA. **b.** external photograph demonstrating significant periorbital ecchymosis and edema and eyelid lacerations to the left upper eyelid and just inferior to the lower eyelid.

(Fig. 1b). A green pigment was found dispersed over the ocular surface and eyelids. The conjunctiva revealed diffuse 1+ injection with a localized subconjunctival hemorrhage temporally. The cornea was clear and without signs of ulceration or chemical injury. Examination of the anterior chamber demonstrated 4+ nonlayered RBC and an iris hemorrhage at 3 o'clock. Detailed dilated fundus exam was limited by significant microhyphema and patient discomfort.

Orbital CT revealed fractures involving both the inferior and medial walls of the left orbit and layering hemorrhage in the left maxillary sinus. No signs of an open globe were noted on imaging (Fig. 2).

The green pigment was irrigated from the left eye with normal saline. Both eyelid lacerations were repaired. Treatment for the microhyphema was initiated with Pred Forte QID and tropicamide BID. The orbital fractures were managed conservatively, without surgical intervention.

The day after the injury, the patient's vision had worsened to 20/300 in the left eye and improved with pinhole to 20/200. IOP remained within normal range at 17 mmHg. Pupils were reactive but now demonstrated posterior synechiae. Dilated fundus exam revealed inferior vitreous hemorrhage without signs of retinal tear or detachment. OCT revealed a full-thickness macular hole with cystoid macular edema (Fig. 3a). Frequency of Pred Forte was increased to once every hour, and consultation with the Retina Service was scheduled for management of the vitreous hemorrhage and macular hole.

The patient was examined again at three days post-injury. He reported improved pain, edema, and diplopia. Vision in the left eye was 20/200 with improvement to 20/100 with pinhole. No posterior synechiae was appreciated. The patient continued to have −1 inferior gaze restriction.

On the fifth day after injury, vision in the left eye improved to 20/50, and IOP remained stable at 14 mmHg. Forced ductions demonstrated full range of motion, and axial positions of the eyes, measured with a Hertel exophthalmometer, were 17 and 18 mm, respectively. Persistent binocular diplopia due to orbital inflammation was treated with oral steroids. With improvement in the microhyphema, Pred Forte was decreased to QID.

The patient continued to demonstrate progressive improvement in vision, diplopia, and pain at his subsequent four visits. IOP remained stable throughout. At his last visit (60 days after injury), his vision had stabilized to 20/60, with improvement to 20/50 with pinhole. IOP was 14. Vitreous hemorrhage showed signs of gradual resolution. Repeat OCT revealed closure of the full-thickness macular hole with nasal IS/OS drop out (Fig. 3b).

Care for the patient is ongoing.

Discussion

Kinetic impact projectiles (KIP) refer to a class of less-lethal munition designed to inflict pain and incapacitate individuals without penetration. There are many different types of KIPs, including rubber bullets and foam rounds, but all forms have been implicated in causing severe injury, permanent disability, and death.

The propensity of KIPs for causing significant ocular trauma is well-documented in the scientific literature. In 2017, a bean bag round, or flexible baton round, caused traumatic globe evisceration and basilar skull fracture.[1] More recently, Ifantides et al. describe a case of globe rupture likely caused by a foam round during the 2020 George Floyd protests.[2] A meta-analysis showed that 85% of all KIP-related ocular injuries globally resulted in permanent blindness. 3% of all KIP-related injuries resulted in death.[3]

Foam or sponge rounds were designed for precision as a "point-of-aim, point-of-impact, direct-fire round." The high velocity at which foam rounds are fired improves the accuracy of these rounds, but also exponentially increases the kinetic energy transmitted upon impact. Although the "foam" tip is designed to attenuate some of this energy, general recommendations suggest a minimum range of 32 feet (10 meters) and avoidance of vulnerable parts of the body, such as the head and torso. These rounds achieve even higher velocities in the closed position for extended range (Table 1). The foam tip can be loaded with an array of irritant or marking payloads, as was observed in this case.

There are no reports of confirmed ocular foam round injuries in the scientific literature, even when such injuries are reported or published. In a case series of 11 patients by Suyama et al., foam rounds were just as likely to cause blunt trauma as rubber bullets and were more likely to

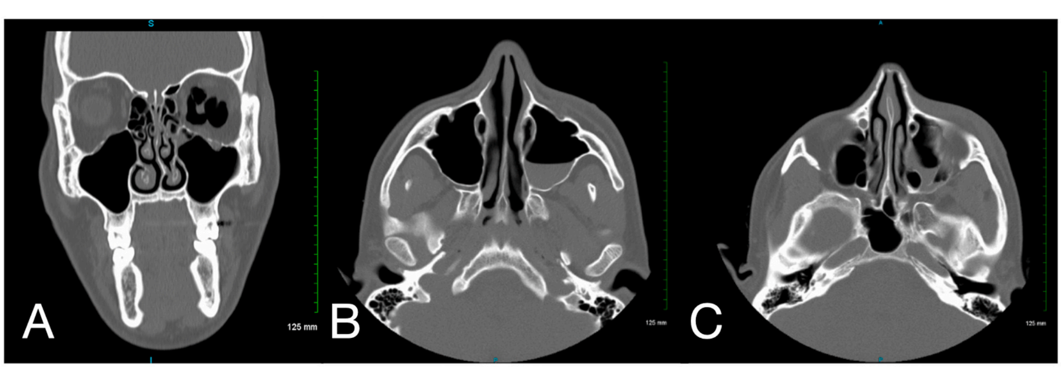

Fig. 2. Non-contrast CT of the orbits. **a** Sagittal bone window reveals fracture of the inferior orbital wall with intraconal gas. **b** Sagittal bone window shows layering hemorrhage in the left maxillary sinus **c** Changes to the inferior rectus as it passes over the fractured fragment of the orbital floor.

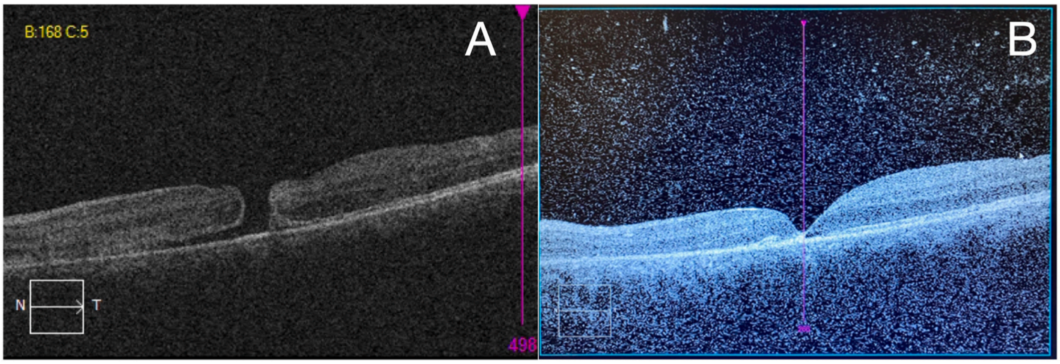

Fig. 3. OCT of the macula. **a** OCT demonstrating full-thickness macular hole at injury. **b** Follow-up OCT 60 days after injury demonstrates closure of the macular hole and IS/OS drop-out nasally.

Table 1
Technical specifications of less-lethal munitions.

	Diameter	Weight	Velocity (Muzzle)	Recommended Range	Kinetic Energy (Muzzle)
Anti-Riot Baton Round Rubber bullet, Northern Ireland, 1970	38 mm	174 g	60 m/s	40 m to 100 m	313 J
L2A1 Baton Round Plastic Bullet	38 mm	131 g	63 m/s	20 m–50 m	260 J
Flexible Baton-12 Standard Bean Bag Round	26 cm (fully deployed)	100 g	67 m/s	15 m effective range	160 J
Direct Impact® 40mm Adjustable Range Round, Marking Foam Round	40 mm	44 g	82 m/s (opened) 110 m/s (closed)	1.5 m–40 m (opened) 40 m–70 m (closed)	147 J (opened) 266 J (closed)

Table 2
Injuries due to less-lethal munitions.

	Study	Country/ Region	Study Period	# of patients	Head and Neck Injuries	Ocular Injuries	Mortality
Rubber bullet	Millar	England	1975	90	19 (21%) head and neck injury 32 (36%) facial fractures 3 (3%) skull fractures	2 (2%) bilateral blinding injury 7 (8%) unilateral blinding injury 5 (6%) severe unilateral vision loss	1 (1%)
	Lavy	Israel-Palestine	2003	42	n/a	23 (54%) lid/skin lacerations 17 (40%) hyphema 16 (38%) ruptured globe 14 (33%) orbital fracture 11 (26%) retinal damage 8 (19%) vitreous hemorrhage	n/a
	Chauvin	France	2016–2019	43	12 (28%) facial fractures 2 (5%) brain injury	25 (58%) orbital fractures 25 (58%) open globe injury 10 (23%) retinal bruising 10 (23%) hyphema 3 (7%) iridodialysis 1 (2%) lens dislocation 2 (5%) traumatic cataract	n/a
	Haar	Worldwide	1990–2017	1984	121 (6%)	310 (15%) ocular injury 261 (13%) permanent blindness	53 (3%)
Plastic Bullet	Rocke	England	1983	99	5 (5%) facial fractures 6 (6%) skull fractures with brain injury 2 (2%) skull fractures without brain injury 1 (1%) brain injury without skull fracture	0 blind both eyes 1 (1%) blind one eye 1 (1%) severe loss of vision in one eye	3 (3%)
	Sutter	Switzerland	2000–2001	5	n/a	5 (100%) ocular concussion 3 (60%) anterior segment injury 2 (40%) anterior and posterior segment injury	n/a
Bean Bag	De Brito	California, USA	1996–2000	40	5 (13%) head and neck injury 3 (8%) facial lacerations	1 (3%) globe rupture 1 (3%) orbital fracture	0
	Wehrmann	Missouri, USA	2017	1	multiple facial/skull fractures	1 globe evisceration	n/a
Foam Round	Suyama	Ohio, USA	2001	11	2 (18%) facial lacerations 2 (18%) head laceration 1 (9%) post-concussive syndrome	n/a	n/a
	Shaw	California, USA	2005	1	1 forehead laceration 1 intracranial trauma	n/a	1

cause lacerative injuries.[4] The lacerations may be due to the coarse texture of the foam tip exerting traction on the skin. Though four of these cases involved injuries to the head, no ocular involvement was reported.

Foam rounds were also implicated in two cases where they caused severe internal organ injury with minimal effect on incapacitation. In one lethal case, an inmate sustained a shot to the head from approximately 53 feet (16 meters). Though he suffered a 5 cm laceration on his forehead, he remained combative until he lost consciousness an hour later. He died 47 days later due to intracranial trauma.[5] In a separate autopsy study, foam rounds fired from 25 feet (8 meters) failed to incapacitate an aggressive individual but still caused unexpectedly severe pulmonary contusion. The amount of force generated by the round was deemed sufficient to rupture the contents of the eye.[6]

Clinical features of this case support previous studies that have documented significant lacerative and blunt injuries from foam rounds. Additionally, the pattern of injury resembles that of rubber bullets, which often cause orbital fracture, lid laceration, hyphema, retinal trauma, and globe rupture (Table 2).

Foam rounds can be loaded with an assortment of irritant or marking payloads, including oleoresin capsicum (OC, pepper spray), chloroacetophenone (CN, Mace®), and orthochlorobenzalmalononitrile (CS, tear gas).[7] Technical documents describe the green marking pigment observed in this case as chemically inert but also disclose potential exposures to a number of chemicals linked to harmful effects on the eye. While there are no cases of chemical injury secondary to foam rounds in the literature, clinicians may consider pH testing and thorough irrigation when foam round injury is suspected.

Conclusion

This is the first case report to describe a pattern of ocular injury caused by a confirmed foam marking round. The pattern of multiple, concomitant injuries to ocular structures resemble descriptions of injuries caused by rubber bullets in the literature. Although the marking pigment appears to be inert, chemical injury to the eye should be considered given the potential involvement of irritants, like pepper spray. Euphemistic terms, such as "foam" and "sponge," do not accurately reflect the significant energy transferred by these rounds. While these munitions are lighter than traditional rubber bullets and feature collapsing tips, they can be fired at high velocities and cause unexpectedly severe trauma.

In recent civil protests across the US, there have been isolated reports in the press about significant injuries caused by foam rounds, including the blinding of photojournalist Linda Tirado in Minneapolis.[8] Multiple factors contribute to the challenge of estimating the prevalence of foam round and KIPs generally. Less-lethal munitions are sold globally with little regulatory oversight. Additionally, police are not required to document the use of KIPs and other less-lethal weapons. As this case demonstrates, traumatic and chemical injuries may also be misattributed to rubber bullets or tear gas. Injured victims are seldom able to recover the specific projectile used against them.

A recent survey of 115 ophthalmology residency program directors showed approximately 27% of programs that responded cared for patients with ophthalmic injuries related to the 2020 George Floyd protests.[9] Another study searched for eye injuries caused by all consumer products in the National Electronic Injury Surveillance System. This study showed a statistically significant mean annual decrease in weighted national estimates of KIPs. However, it was not able to comment on the role of KIPs during the 2020 George Floyd protests, and the validity of this metric in tracking the use of munitions of law enforcement is unknown.[10]

The lack of epidemiologic data is paralleled by the use of outdated terminology in the scientific literature. All three studies on foam rounds retrieved for this review were published during the 1990s and used the terms "rubber bullets" and "foam rounds" interchangeably. While this practice may have been acceptable for the time, there is evidence that public discussion around these munitions is becoming more specific. Responding to questions regarding the blinding injury of Linda Tirado, the Minneapolis Police Department responded, "We use 40mm less-lethal foam marking rounds. We do not use rubber bullets".[11] This ambiguity also makes it difficult to confidently interpret the findings of more recent studies on "40mm rubber bullets" that do not further specify the type of round used.[12]

In June 2020, the American Academy of Ophthalmology (AAO) called for domestic law enforcement to end the use of rubber bullets against protesters, a statement that was subsequently endorsed by other medical organizations.[13] Local police departments, cities, and states have issued orders limiting the use of KIPs. State and federal legislation prohibiting the use of chemical munitions and all KIPs followed. Representative Brendan Boyle of Pennsylvania and Senator Jessica Ramos of New York introduced legislation to prevent the use of non-lethal munitions in crowd control situations in their respective states.[14] Senators Edward J. Markey and Bernie Sanders introduced the *No Tear Gas or Projectiles Act*, which establishes a framework to prohibit and impose civil penalties for the use of riot control agents and KIPs by law enforcement officers.[15]

In October 2020, Representative Marcia Fudge of Ohio proposed the *Analyzing KIPs Against Americans Act* to study the public health effects of KIPs in the United States.[16] This study may collect data on the frequency and severity of injuries caused by the use of KIPs and conduct a demographic and racial analysis of individuals impacted by their use.

While foam rounds and other KIPs are "less-lethal" than traditional firearms, they are by no means non-lethal or harmless; they pose a significant risk of injury, permanent disability, and death. Even in patients that retain vision after ophthalmic trauma, the risk of future complications, such as cataracts, glaucoma, and peripheral retinal tears, increases dramatically. In a young population, these injuries may have long-term implications on well-being, occupational potential, and future vision of our patients.

Patient consent

The patient consented to the publication of the case in writing.

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Authorship

All authors attest that they meet the current ICMJE criteria for Authorship.

Credit author statement

Hyun Jun Kim: Writing - Original Draft, Project administration, **Sameerah Alkhairy**: Data curation, **Lisa D Kelly**: Conceptualization, Writing - Reviewing, and editing, and Supervision.

Declaration of competing interest

None.

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