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Barely benign: The dangers of BB and other nonpowder guns

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ABSTRACT

Objective: To characterize the risks of nonpowder guns commonly used by children for recreation.
Methods: We conducted a retrospective review of children ≤18 years of age treated for nonpowder gun injuries at a pediatric level I trauma center during 2013–2017. Demographics, injury characteristics, treatments, and outcomes were reviewed and analyzed using descriptive statistics.
Results: Forty-six cases were identified; of these, 78% were male and the median age was 10 years (IQR 7–13). All guns were either ball-bearing or pellet guns. Eighty-five percent (38/46) of injuries were penetrating. The most common location was the head and neck (28%), followed by the anterior torso (26%) and eye (24%). Significant injuries that penetrated organs or body cavities occurred in 39% (18/46) and included subarachnoid hemorrhage; lung, liver, and kidney lacerations; pulmonary artery injury; and tracheal injury. Nine percent (4/26) were admitted to the intensive care unit, 37% (17/46) underwent surgery, and there were no deaths.
Discussion: Injuries from recreational nonpowder guns such as ball-bearing or pellet guns can cause severe injuries in children. A thorough penetrating trauma workup should always be undertaken. Safety precautions should be taken when using these guns and access to young children should be restricted.
Level of evidence: Prognosis level IV

Nonpowder guns (NPGs), such as ball-bearing (BB), pellet, paintball, or airsoft guns, use compressed air to launch a projectile. Between 2001 and 2011, more than 145,000 children less than 19 years old were injured by NPGs in the United States, and nearly 22,000 NPG-related injuries are treated in pediatric emergency departments each year [1]. Treatment for children with NPG injuries varies depending on the injury's severity, often including computed tomography scans, bedside procedures, angiography, and operative intervention [2]. Since most NPGs fire 'low-velocity' projectiles, and perhaps since these guns are often labeled as toys, it is commonly believed that they can result in only superficial, minor injuries. Serious injuries may be overlooked owing to the lack of standard collateral damage seen with 'traditional' gunshot injuries [3]. The purpose of this study is to review the types of injuries and outcomes from NPGs in a large pediatric cohort in order to better understand the risk profile. We hypothesize that NPGs can cause severe injuries.

1. Materials and methods

1.1. Patient selection and study design

Following IRB approval by Baylor College of Medicine, the institutional trauma registry at an urban pediatric level 1 trauma center was queried for all patients 18 years of age or younger who presented after sustaining NPG wounds between January 2003 and December 2017. Patients presenting with multiple wounds were considered a single case.

Data variables collected included gender, age at presentation, length of hospital stay (LOS), number of injuries, wound location, wound depth, emergency department (ED) disposition, ED procedures, operating room (OR) procedures, intensive care unit (ICU) admission, major complications, and follow-up appointment details. Wound locations were coded as head and neck, eye, upper extremity, lower extremity, anterior trunk, groin, back, or buttocks. When available, wound depth was recorded in centimeters; if numerical information was not available, it was recorded as "superficial" or "penetrating." "Penetrating" projectiles were those that lodged in a muscle body or entered a body cavity or internal organ. Injuries were categorized as significant if they entered a body cavity or injured an organ. For patients with penetrating wounds, free text descriptions were collected. For patients undergoing ED procedures, type of procedure and details were recorded; for those

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undergoing OR procedures, operation type, details, and coding information were collected.

1.2. Data analysis

Descriptive statistics were calculated and analyzed using Microsoft Excel (2018; v.16.16.8). The data collected were solely descriptive and no comparative tests of significance were performed.

2. Results

2.1. Cohort description

Of the 46 cases analyzed, 78% (36) were male, and the median age was 10 years (IQR 7–13 years old). Eighty-five percent (39/46) of injuries were penetrating wounds, defined as projectiles entering and lodging within soft tissue or a body cavity. The rest were superficial soft tissue injuries or graze injuries (Table 1). The most common locations were the head and neck (28%), followed by the anterior torso (26%) and eye (24%) (Fig. 1).

Although the exact type of NPG was generally not documented in the medical record, all recorded references were to either BB or pellet guns. The median length of stay (LOS) in the ED was 5.9 h (IQR 3.7–24.3 h). Twenty-six patients (56.5%) were discharged from the ED and 20 (44%) were admitted. For admitted patients, the median LOS was 24.3 h (IQR 19.3–46.2 h). Four (9%) were admitted to the ICU, with median LOS 121.7 h (IQR 46–229 h). One patient received a blood transfusion. Of the 26 patients discharged from the ED, 6 (23%) underwent a procedure. These were minor procedures, such as projectile removal, suturing and stapling, and splinting injured digits. Seventeen patients (85% of admitted patients, 37% of all patients) underwent surgery. The projectile was extracted from seventeen patients though these were not all the same patients as those undergoing surgery.

2.2. Significant injuries

There were 18 (39%) injuries that we categorized as significant, as they entered a body cavity or injured an organ. Thoracic injuries were most common, followed by abdominal (Fig. 2).

Table 1
Descriptive characteristics of injury population.

Total # of Cases	46
Demographic Information	
Median Age (range)	9.8 (7.25–12.48)
Gender (% Male)	78.3 ($n = 36$)
# Bullets	1 (all)
Penetrating (%)	84.8 ($n = 39$)
Superficial (%)	15.2 ($n = 7$)
Admissions	
Total Admissions (%)	43.5 ($n = 20$)
ICU Admissions (%)	8.7 ($n = 4$)
Procedure Location	
ER (%)	13.0 ($n = 6$)
OR (%)	37.0 ($n = 17$)
ER Discharge (%)	56.5 ($n = 26$)
Length of Stay (h)	
All patients (median)	5.9 (3.73–24.32)
Admitted Patients (median)	24.3 (19.33–46.20)
ICU Patients (median)	121.7 (45.95–229.02)
>24 Hours (%)	27.7 ($n = 13$)
# Follow-ups	1 (0–2)

Summary table of descriptive characteristics of patients presenting with nonpowder gun injuries.

2.2.1. Ocular

Eleven ocular injuries were noted, with 4 (36%) retained projectiles: 2 in a sinus cavity, and 1 each in the orbital space and globe itself. The majority (64%) of ocular injuries resulted in distorted pupils and/or traumatic hyphema. In one patient, vision was significantly affected from opacification of the posterior capsule after 2 months. The patient subsequently underwent extraction and capsulotomy. Another patient developed increased intraocular pressure but was lost to follow-up.

2.2.2. Head and neck

Three patients, either shot in the eye or face, were found to have pellets retained in a maxillary sinus which were not removed. In one patient, a pellet penetrated the frontal bone and caused a subarachnoid hemorrhage with intraparenchymal contusion and pneumocephalus (Fig. 3). Five patients sustained wounds to the neck. The two most significant were penetration into the tongue base from the left lateral neck (Fig. 4), and a tracheal injury. In the latter patient, the pellet tracked from above the sternal notch to just inferior of the aortic arch. There was extensive air in the mediastinum noted on CT and crepitus on exam but no evidence of vascular injury. At neck exploration, a perforation per was found in the trachea and primary repair was performed.

2.2.3. Thoracic

Of seven thoracic injuries, two had lung penetration and three settled within the pleural space. One patient developed a hydropneumothorax, and one sustained a rib fracture and foreign-body pulmonary reaction owing to an imbedded pellet that ultimately required wedge resection.

2.2.4. Mediastinum

The most significant injury was from a BB that penetrated the chest in a 1-year-old child, causing cardiac tamponade and near cardiac arrest (Fig. 5). The child was taken emergently for sternotomy to evacuate the tamponade, and a small perforation in the main pulmonary artery was identified and repaired. The patient required a 3-day ICU admission and was the only patient in this series requiring a blood transfusion. She made a full recovery.

2.2.5. Abdominal

Four abdominal injuries were observed. In one, a projectile traversed the liver and lodged in the right kidney but did not require surgery. Another had liver and renal lacerations that did not initially require operative management, but within a month developed an 11 cm liver abscess around a pellet fragment. In one case, epigastric penetration resulted in diagnostic laparotomy with the pellet found adherent to the omentum. The fourth abdominal injury was a mesenteric hematoma from a penetrating pellet wound near the duodenum at the ligament of Treitz (Fig. 6).

2.3. Additional surgical interventions

A scrotal injury in a 12-year-old necessitated exploration as well as incision and drainage. It was found that the Dartos muscle was not violated. Another child who was shot in the foot required open repair for a comminuted fracture of a proximal phalanx. Finally, one patient presented with both entrance and exit wounds to the right hand, requiring surgical repair of a metacarpal fracture.

3. Discussion

Approximately 14,000 NPG injuries occur in pediatric patients each year [4]. The U.S. Consumer Product Safety Commission reported more than 100,000 injuries in children between 2001 and 2013 and approximately 4 deaths per year, which are probably an underrepresentation of

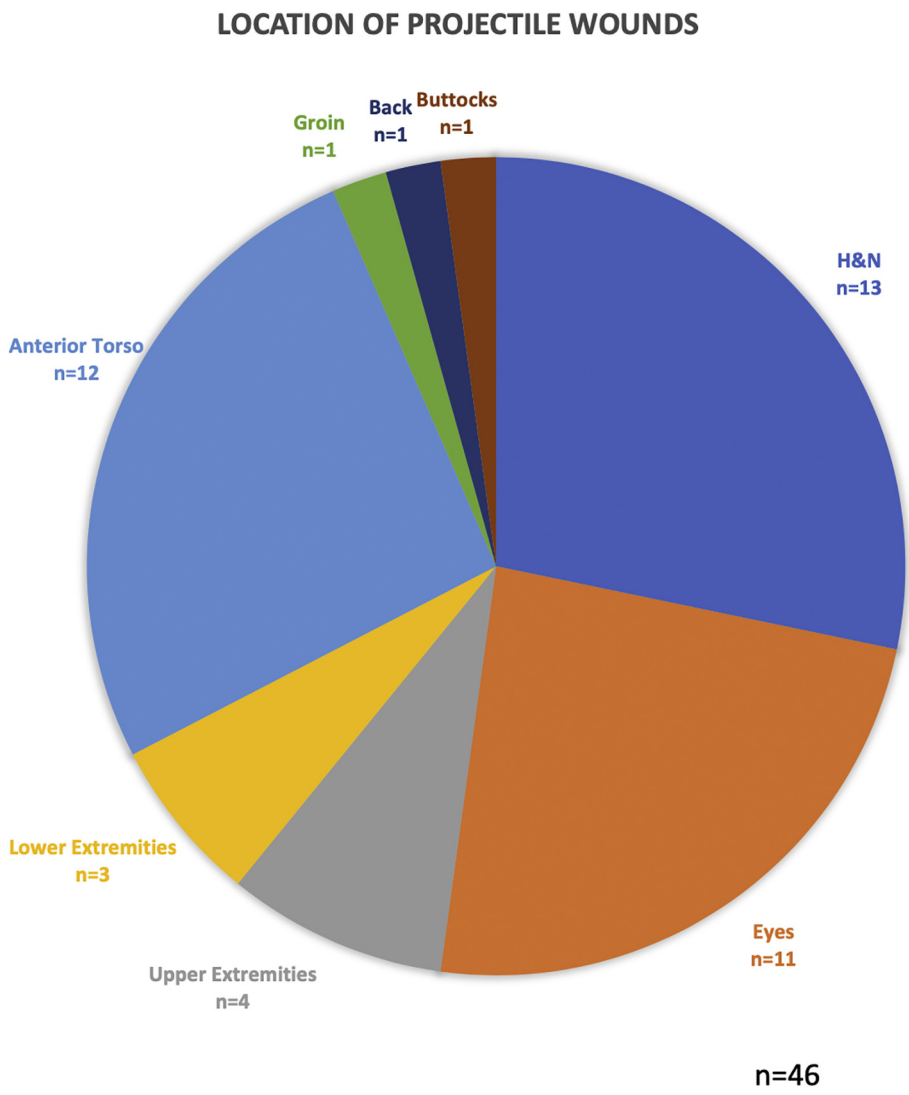

Fig. 1. Bullet penetration location for all injuries.

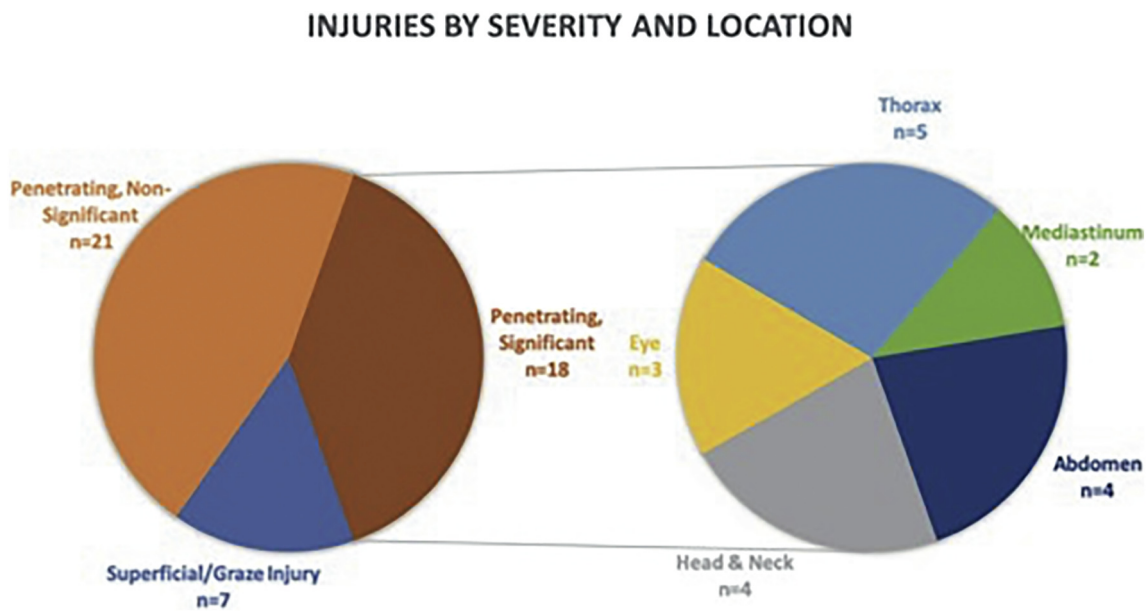

Fig. 2. Distribution of injury severity, with breakdown of significant penetrating wounds by location of injury. A wound was considered significant if it entered an organ or body cavity.

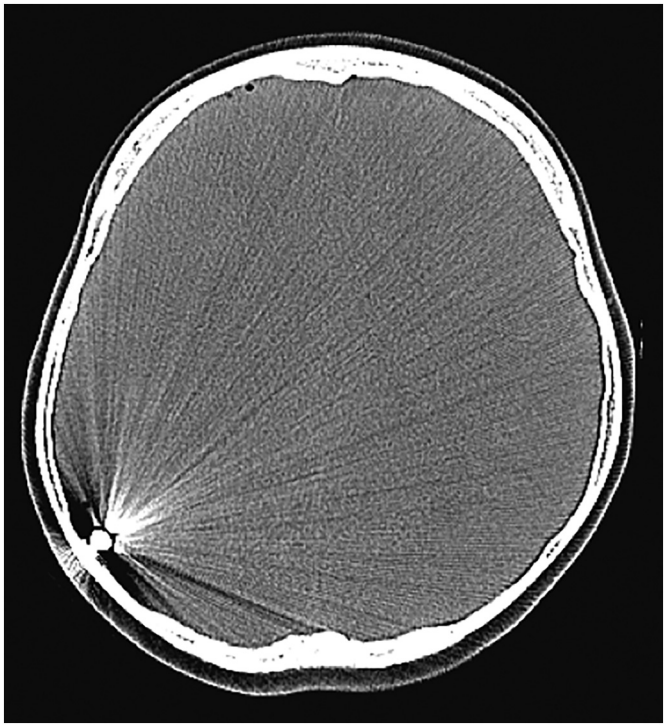

Fig. 3. Axial computerized tomography (CT) image demonstrating a projectile from a ball-bearing gun, which penetrated the frontal bone and settled in the parieto-occipital region and resulted in subarachnoid hemorrhage.

the actual volume [3,5,6]. NPG injuries are often overlooked given the presumed lower velocity of the projectile and lack of gross tissue damage when compared to traditional firearms. In reality, these guns can have muzzle velocities from 150 ft/s to 1200 ft/s – the muzzle velocities of traditional firearm pistols are 750 ft/s to 1450 ft/s – and therefore are capable of causing serious injuries [4]. Despite these risks, only 24 states regulate nonpowder guns to some degree and only 13 states restrict sales to a child, defined as anywhere from less than 12 years to less than 18 years of age [7].

Despite a clinically benign picture, 60%–90% of BB gun injuries cause visceral injury [5]. A 2011 analysis of head and neck NPG injuries by Dandu, et al., revealed that 92.3% of patients were released from the emergency department [8]. Though our study looked at injuries to all body parts, only 56.5% were discharged from the emergency room, with the remaining patients admitted. Our median LOS was 5.9 h for all patients; this increased to 19.4 h for operative cases. This is shorter than the median of 1 day presented by Veenstra, et al. [2].

Though the majority of patients did not have the projectile removed, in our practice we have not found any short or long-term complications related to leaving these in place. Rather, these are removed only when superficial and easily accessible, or if extraction is feasible as part of a larger operation (e.g., tracheal repair).

Our study represents the largest single-center analysis of NPG injuries to date, with 39% being significant injuries that penetrated organs or body cavities. Operation was required in 37% of patients with significant penetrating injuries in our cohort. This supports our claim that NPG injuries cannot be overlooked and improperly disregarded. The results of this study show that NPGs can cause permanent ocular trauma and internal organ damage. Given the small size of NPG projectiles and lower velocity than most firearms, these injuries are less likely to cause major bleeding than firearm injuries in similar locations [3]; however, they can still be life-threatening, and should be taken seriously. Emergency room providers should not be reassured by the small caliber hole caused by the projectile. Based on the experience at our institution, NPG injuries are triaged no differently than injuries from firearms.

Importantly, this study serves as an update and reminder to a new generation of physicians 23 years after Bond, et al.'s report of the dangers of NPGs [9]. In their single-institution study from 1989 to 1994, 16 children were injured. This included three cranial penetrations resulting in neurologic deficits, one episode of cardiac tamponade, and multiple bowel and tracheal perforations. Over the same five-year period, 33 air gun deaths were reported nationally owing to injuries common to both Bond, et al.'s and our cohort: cranial and cardiac injuries. They similarly conclude that NPG injuries should be treated as any other gunshot wound [9]. However, the continued persistence and severity of these injuries suggest that we should not relegate awareness to historical cohorts but need constant reminders of our position as patient safety advocates, regardless of personal politics.

Unfortunately, the person handling the gun was not consistently recorded in our cohort. When noted, the handler was often a young sibling, friend, or the victim themselves, which are the most common situations [10]. Firearm deaths, now the second leading cause of death in children [11], most commonly occur accidentally when children play with guns [10,12]. Although most attention focuses on traditional

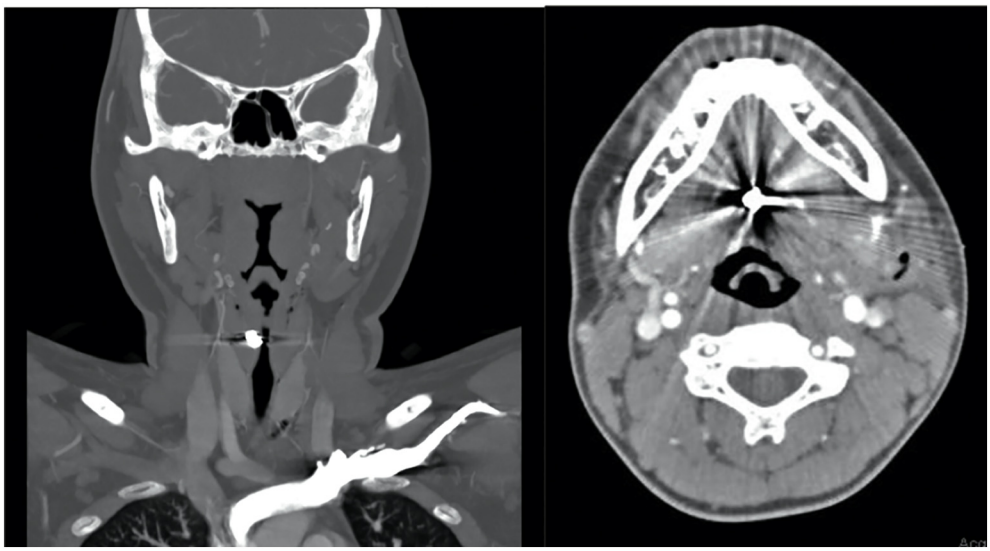

Fig. 4. Imaging of a patient shot in the left lateral neck revealed submandibular edema and hemorrhage with the pellet lodged in the midline tongue base and just lateral to the right vocal cord.

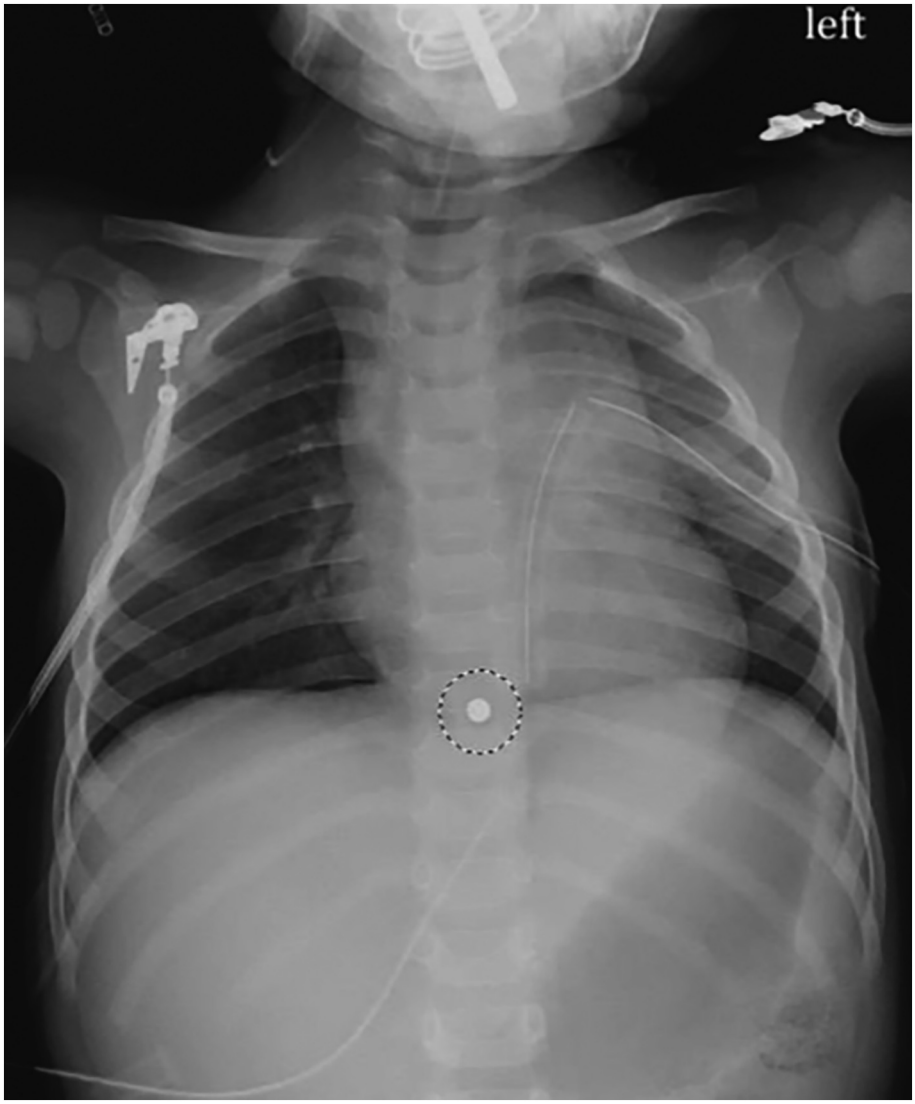

Fig. 5. Chest radiograph of pellet that had injured the pulmonary artery then penetrated the pericardial sac, causing tamponade and near-arrest.

Fig. 6. Axial CT of a lodged projectile at the aortaduodenal junction near the ligament of Trietz.

handguns and rifles, our study indicates that NPGs should be considered in a similar category of danger. Young children are unlikely to be effectively trained in gun safety and should, for their well-being, be kept from freely handling firearms.

A major limitation of this study is the short follow-up time, as the true costs and consequences of NPG injury may take several months to years to develop. Moreover, the retrospective design lends itself to incomplete or inconsistently reported data. Lastly, our series represents a single tertiary hospital with its own practice patterns and patient population that may affect the generalizability of our results.

In conclusion, this is the largest series of nonpowder gun (BB/pellet) injuries in the pediatric population to date and demonstrates that severe and even life-threatening injuries can occur from these recreational devices. External findings may be subtle, but a thorough trauma evaluation should be performed to identify all injuries. Additionally, pediatric providers should counsel parents on the risks these guns pose and advocate for restricted access to children.

Author contributions

BN conceptualized the project. BN and JH were responsible for study design. JH and HT were responsible for literature review, chart review, analysis of the raw data, and preparation of figs. JH prepared the manuscript and revised it according to feedback provided by BN, who was involved in critical revision and improvements in study presentation. All authors approved the final manuscript.

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None.

Declaration of competing interest

There are no conflicts of interest. The authors report no proprietary or commercial interest in any concept discussed in this article.

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