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Firework-related genitourinary trauma: a single institution case series

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Abstract

Purpose The clinical impact of firework-related genitourinary trauma remains unknown. In this study, we aim to characterize injury patterns, interventions, and clinical outcomes of firework-related genitourinary injuries and evaluate the relationship with certain firework types.

Methods A retrospective case series was conducted for patients treated at a level I trauma center from 2005 to 2019 who experienced firework-related genitourinary trauma. Fifteen patients sustained firework-related genitourinary injuries. Injury patterns, operative interventions, clinical outcomes, as well as details of firework type were examined.

Results Firework-related genitourinary injuries were identified in 15 trauma patients. Mean age was 29.7 years (± 14.3, standard deviation), all (100%) patients were male, and most (11; 73.3%) were Caucasian. Average length of stay (LOS) was 10.5 days, and 4 (26.7%) patients required ICU admission. Ten (66.7%) patients underwent 28 operative interventions (mean 1.9 per patient), 7 (46.7%) of whom underwent 15 urologic specific intervention (mean 1.0 per patient). No injury-related deaths occurred. Considering firework type, 10 (66.7%) patients had mortar or shell-related injuries, while 3 (20.0%) involved firecrackers, and 2 (13.3%) involved bottle rockets. All (100%) patients sustained injuries that occurred with the use of legally obtained fireworks and 11 (73.3%) were active users.

Conclusions Firework-related genitourinary injuries occurred most frequently in young men, lead to polytrauma with the scrotum and penis being the most common urologic sites, had high operative rates, and were most commonly associated with legally obtained fireworks, specifically mortar and shell fireworks. Further investigation is needed to understand the long-term sequelae of these injuries.

Keywords Firework · Explosive · Trauma · Genitourinary

Introduction

Firework-related injuries are a known public health problem in the United States and around the world. The United States Consumer Product Safety Commission (USCPC) estimates that approximately 9100 firework-related injuries were treated at United States (US) emergency departments in 2018 alone with a prevalence of 2.8 injuries per 100,000 individuals, with no significant improvement since the late 1990s [1]. Although firework sales and the use are regulated at the federal level, enforcement and further restriction vary widely at the state and local level. This presents a unique public health challenge to injury prevention, as firework-related injuries are more common in areas with less restrictive local legislation [2]. Better understanding of the relationship between firework types and injury patterns can help clinicians, public health practitioners, and legislators develop optimized treatment and prevention strategies.

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Further, in the acute setting, clinicians can improve screening, triage, and interventions to reduce short- and long-term morbidity.

Several studies have been conducted to evaluate injury patterns and demographics of firework-related injuries, showing that firework injuries most often occur in young men less than 20 years of age, are most commonly diagnosed as burns, and tend to involve the head and neck or upper extremities [3, 4]. The vast majority of injuries are minor and are typically addressed in the emergency department, not requiring inpatient admission or operative intervention. Not surprisingly, most firework-related injuries are concentrated around cultural celebrations, such as Independence Day in the United States, Diwali in India, and New Year's Day in many countries across the world [5]. Recently, interest in describing the relationship between firework type and severity of injury have shown significant morbidity-related mortar and shell fireworks, often leading to permanent impairment of the eyes and/or hands [6–8].

In major centers for urologic trauma, firework-related urologic injury is a rare, but a potentially devastating, occurrence. National datasets evaluating the current epidemiology of urologic trauma describe many kidney, ureter, bladder, and urethral injuries related to blunt and penetrating trauma; however; there is a paucity of data regarding blast and firework-related genitourinary trauma, including prevalence, injury pattern, and clinical outcomes, especially in cases of severe firework-related injury requiring hospital admission or surgery [9]. Using data from a large level 1 trauma/burn center, we sought to characterize injury patterns, interventions, and clinical outcomes of firework-related genitourinary injuries and evaluate the relationship with certain firework types.

Materials and methods

After Institutional Review Board approval was obtained, a retrospective case series was conducted on patients treated at a level 1 trauma center from 2005 to 2019. Our institutional trauma registry and patient database was queried for patients with Internal Classification of Diseases, Ninth Revision (ICD-9) codes E923, E923.2, S30, S30.9, and S39.9, and ICD-10 codes W39 and W40.9. Verified via chart review, all patients with firework-related genitourinary injuries were eligible for inclusion in the case series, including patients that were admitted for their injuries requiring or not requiring surgical intervention, as well as those not requiring inpatient admission and treated non-operatively or in the outpatient setting.

The medical record was reviewed to identify firework type (homemade, shells/mortars, rockets, firecrackers, Roman candles, sparklers, and unknown), firework use (active user, bystander), patient demographics (gender, age, and race), hospital disposition (floor admission, intensive care unit (ICU), and operating room (OR)), injury complex, and interventions. Basic descriptive statistical methods were utilized. We examined demographic characteristics, fireworks use behavior, admission disposition, and number of operations to calculate proportions and means by fireworks type. To assess the amount of surgical care required to treat injuries, we examined the relationship between fireworks type and number of operations.

Results

A total of 15 patients sustaining genitourinary firework-related injuries were identified that met inclusion criteria. Table 1 displays characteristics of the study population, while Table 2 displays rates of injury based on firework type. Table 3 displays injury and surgical intervention details for all patients. Cohort patients were aged 11 to 63 years with a mean of 29.7 years (± 14.3, SD) and median of 27 years. All (100%) patients were male. In terms of race, 11 (73.3%) patients were Caucasian, 3 (20.0%) African American, and 1 (6.7%) Hispanic. Ten (66.7%) patients underwent operative intervention for their injury complex, while 7 (46.7%) underwent urologic-specific operative intervention. Of the cohort 5 (33.3%) underwent scrotal exploration, of which 1 (6.7%) required testicular rupture repair, 2 (13.3%) required spermatic cord hematoma evacuation, and 2 (13.3%) required bilateral orchiectomy due to unsalvageable testicular injury. Three (20.0%) patients underwent penile laceration repair or penile debridement. One (6.7%) patient underwent exploratory laparotomy with cystorrhaphy for intraperitoneal bladder rupture as well as multiple intraabdominal organ injuries. Number of operations ranged from 0 to 6, with a mean of 1.9 operations and median of 1.0 operations. Number of urologic specific operations ranged from 0 to 6, with a mean of 1.0 and median of 0 operations. Subsequent operations were commonly washouts or reconstructive in nature as described in Table 3. The length of inpatient hospitalization ranged from 1 to 26 days, with a mean of 10.5 days and median of 9 days. No injury-related deaths occurred in this cohort. Eleven (73.3%) patients were the active firework user, while 4 (26.7%) were bystanders. In terms of firework type, 10 (66.7%) injuries were due to shell or mortar-type fireworks, 3 (20.0%) to firecrackers, and 2 (13.3%) to rockets. There were no injuries related to sparklers, Roman candles, or homemade explosives in this cohort. All (100%) patients' sustained injuries that occurred with the use of legally obtained fireworks, and 11 (73.3%) were active users. All (100%) patients were amateurs with no professional firework or ballistic experience. Patients with shell or mortar-type firework-related injuries underwent the most

Table 1 Characteristics of study population, overall, and stratified by firework type

	Overall $n=15$ (1%)	Shell/mortar $n=10$ (%)	Bottle rocket $n=2$ (%)	Firecracker $n=3$ (%)
Age (mean ± SD, years)	29.7 ± 14.3	27.4 ± 11.5	31.5 ± 15.5	36 ± 19.1
< 18 years	4 (26.7)	2 (20.0)	1 (50)	1 (33.3)
≥ 18 years	11 (73.3)	8 (80.0)	1 (50)	2 (66.6)
Gender				
Male	15 (100.0)	10 (100.0)	2 (100)	2 (100)
Race/ethnicity				
White	11 (73.3)	8 (80.0)	1 (50)	2 (33.3)
Black	3 (20.0)	2 (20.0)	1 (50)	0 (0.0)
Hispanic	1 (6.7)	0 (0.0)	0 (0.0)	1 (66.6)
Use behavior				
Active user	11 (73.3)	8 (80.0)	1 (50)	2 (66.6)
Bystander	4 (26.7)	2 (20.0)	1 (50)	1 (33.3)
Hospital disposition				
Floor	8 (66.7)	7 (70.0)	2 (100)	1 (33.3)
ICU	4 (33.3)	3 (30.0)	0 (0.0)	1 (33.3)
Discharged	1 (6.7)	0 (0.0)	0 (0.0)	1 (33.3)
Number of operations (mean ± SD)	1.9 ± 2.1	2.6 ± 2.2	0.5 ± 0.5	0.3 ± 0.5
Number of urologic operations (mean ± SD)	1.0 ± 1.7	1.4 ± 1.9	0.5 ± 0.5	0.0 ± 0.0

Table 2 Firework type and associated injury rate

Firework type	Description	Regulation	Injuries
Homemade	Improvised explosive devices including pipe bombs, sparkler bombs, and cannon bombs	Illegal	0% ($n=0$)
Shells/mortars	Shells are spherical explosives launched into the sky from a grounded tube or mortar	Legal	66.7% ($n=10$)
Firecrackers	Small, paper-wrapped tubes containing pyrotechnic pellets causing noise and light upon ignition	Legal < 50 mg Illegal > 50 mg	20.0% ($n=3$)
Rockets	A tube explosive attached to a wooden stick, intended to be launched into the air and explode	Legal	13.3% ($n=2$)
Roman candles	Heavy cardboard tube explosive intended to expel serial pyrotechnic pellets	Legal	0% ($n=0$)
Sparklers	Sticks or wires coated in pyrotechnic composition that produces a shower of sparks upon ignition	Legal	0% ($n=0$)

operative interventions with an average of 2.6 operations and 1.4 urologic-specific intervention.

Discussion

This study represents the first known series of firework-related genitourinary injuries. In this case series, these injuries occurred most frequently in men, lead to polytrauma with the scrotum and penis being the most common sites of urologic injury, had lengthy hospitalizations and high operative rates requiring more than one intervention on average, and were most commonly associated with mortar and shell fireworks. Importantly, this reflects the highly morbid nature of firework-related genitourinary injuries, warranting the need for improved triage mechanisms as well as prevention efforts. Certainly, further population-based studies and multi-institutional collaborations will be needed to further elucidate such injury patterns; however, our data brings attention to this rare, but devastating trauma.

The findings of our case series support prior studies demonstrating the younger demographic associated with firework-related injuries. Several population-level studies have demonstrated that the vast majority of firework-related injuries occur in children and teenagers with the risk of injury declining with age; however, this disproportionately reflects minor injuries, such as superficial burns [4, 7]. In various case series in patients with more severe injury complexes requiring inpatient admission and/or surgical intervention, average age was in the early to mid-20 s [10, 11]. Average age in this series was 29.7 years, likely reflecting a bias towards an older patient population as further

Table 3 Summary of injuries and interventions

Patient	Firework type	Urologic injuries	Other injuries	Interventions
16 yo M	Rocket	Partial thickness burns to lateral scrotum	Partial thickness burns to right medial thigh, right hand	None
47 yo M	Rocket	Scrotal swelling and bruising with two avulsion wounds, bilateral testicular rupture	Partial thickness burns to bilateral thighs	1. **Cystoscopy, scrotal exploration, bilateral simple orchiectomy, scrotoplasty, and closure**
24 yo M	Firecracker	Superficial burns to scrotum and penis with sloughing skin, meatal swelling	Partial thickness burns to hands, arms, bilateral thighs, left buttock	1. Excision/debridement and autograft of left buttock and bilateral thighs
21 yo M	Firecracker	Partial thickness second degree burn to penis	Partial to full thickness burns to bilateral lower extremities	None
63 yo M	Firecracker	Superficial abrasion to left lateral scrotum	None	None
14 yo M	Mortar	Superficial genital burns	Burns to neck, torso, bilateral upper and lower extremities, 40% TBSA	None
23 yo M	Mortar	Scrotal avulsion, left testicular rupture	Left hand blast injury (devastating), right index fingertip amputation, right 4th index extensor tendon injury, right corneal abrasion, bilateral thigh soft tissue avulsion injuries	1. **Scrotal exploration, left testicular debridement and repair, scrotoplasty**, bilateral thigh wound exploration, extensive reconstruction of bilateral hands
37 yo M	Mortar	Avulsion injury to right groin and scrotum	Left third digit fracture	1. **Scrotal exploration, right spermatic cord hematoma evacuation, wound closure**
11 yo M	Mortar	Partial thickness burns to groin and genitalia	Left thumb blister	None
32 yo M	Mortar	Burns and degloving injury to penis and scrotum, left testicular hematocele, traumatic priapism	Partial thickness burns to thighs	1. **Penile, scrotal & perineal exploration, debridement of blast injury tissue, excision of penile shaft skin, drainage of left testis hematocele**, rigid proctoscopy, **cystoscopy, phenylephrine irrigation of priapism** 2. **Repeat exploration and debridement** 3. **Repeat exploration and debridement, treatment of priapism** 4. **Harvest and application of split thickness skin graft to penis, scrotoplasty**
35 yo M	Mortar	Intraperitoneal bladder injury	Soft tissue abdominal blast injury, multiple small bowel and mesenteric injuries, splenic injury	1. Exploratory laparotomy, small bowel resection, **cystorrhaphy**, temporary abdominal closure 2. Reopening laparotomy, small bowel resection, temporary abdominal closure 3. Reopening laparotomy, incision and drainage of necrotic tissue 4. Reopening laparotomy, debridement of skin, subcutaneous tissue, muscle, temporary abdominal closure 5. Reopening laparotomy, debridement of skin, subcutaneous tissue, muscle, temporary abdominal closure 6. Reopening laparotomy, washout, closure of abdominal wall

Table 3 (continued)

Patient	Firework type	Urologic injuries	Other injuries	Interventions
16 yo M	Mortar	Dorsal penile avulsion injury	Near amputation of right upper extremity, right ear laceration, bilateral tympanic membrane rupture, left globe rupture, superficial burns/abrasions to chest and abdomen	1. **Penile wound debridement and closure**, right upper extremity distal forearm amputation, right ear wound closure, repair of left open globe injury, repair of eyebrow laceration, right eye foreign body removal 2. Temporary keratoprosthesis and keratoplasty, vitrectomy, intraocular foreign body removal
51 yo M	Mortar	Penile degloving injury, left traumatic orchiectomy from blast, ruptured right testicle, scrotal avulsion, perineal wound/burns	Thigh burns, left buttock blast injury, rectal injury	1. **Perineal debridement, scrotal exploration, completion left orchiectomy, right orchiectomy, penile debridement, suprapubic cystostomy**, loop colostomy 2. **Perineal and scrotal debridement** **3. Exam under anesthesia, penile, scrotal, perineal, and perirectal debridement** **4. Debridement of glans penis, penile shaft, and scrotum** **5. Split thickness skin graft to penis** **6. Exam under anesthesia, wound washout, suprapubic tube exchange**
27 yo M	Mortar	Edematous scrotum and penis	Partial thickness burns to abdomen, groin, bilateral thighs, right 4th and 5th digit fractures	1. Closed reduction and percutaneous pinning of right finger fracture
28 yo M	Mortar	Contusion and ecchymosis over mid penile shaft	Bilateral injuries including partial digit amputations, puncture wounds to abdomen	1. Bilateral hand reconstruction 2. Bilateral hand reconstruction

*In the "Interventions" column, each number represents a separate operation. All procedures listed for each number represent all procedures performed during that particular operation. Urologic specific procedures are bolded

described below. The trend of such injuries occurring in younger demographics is worrisome in light of the possibility of long-term morbidity, although this has yet to be further investigated.

As expected, our study demonstrates a strong correlation of genitourinary injury, morbidity, and number of operations with the use of shell/mortar fireworks. With the majority of patients in our series sustaining injuries secondary to shell/mortar fireworks and requiring 2.6 operations on average and lengthy hospital admission, further triage, screening, and management strategies are warranted in this high-risk population. Although we expected burn injuries to be highly prevalent, the severity of other injuries is striking, including soft tissue avulsion injuries, testicular injuries, and intraabdominal injuries. In a prior study by Sandvall et al., a similar relationship was identified with the majority of patients experiencing soft tissue injury of the upper extremities related to shell/mortar fireworks [6]. This injury profile is more similar to that seen with military explosives and high energy ballistics. Therefore, the question arises as to whether or not this class of fireworks should have unique regulations as reducing the availability/access to such fireworks may be an important preventative intervention. Further, as all injuries sustained in our cohort were from legally obtained fireworks involving amateur users, restricting use to trained professionals should also be considered. Clinically, a higher index of suspicion for occult injury should be taken when evaluating patients with shell/mortar firework-related injuries. This may include standardized urologic consultation or imaging protocols for blast injuries involving the pelvis or genitourinary structures as seemingly superficial injuries (bruising, abrasions) may involve occult deeper injuries, for example, scrotal bruising/abrasions with underlying testicular rupture.

Importantly, the long-term morbidity and sequalae of these injuries need further investigation given the known association of genitourinary injuries with sexual and voiding dysfunction. In this series, two patients in their 20 s underwent bilateral orchiectomy leading to sterility, a dire consequence for men considering future children. Unfortunately, with poor follow-up in trauma patients in general, the rates of sexual and voiding dysfunction remain unknown; however, warrants future investigation. A recent study by Johnsen et al. suggests that in men with traumatic pelvic fractures with associated urethral injuries, there is a high rate of sexual and voiding dysfunction that often times goes unrecognized [12]. Multiple studies in the trauma literature also demonstrate poor sexual function and quality of life after trauma associated pelvic fracture [13, 14]. This brings attention to the long-term follow-up needed in this population to address their specific urologic needs.

As a small case series, this study has several limitations including its small cohort size, retrospective nature, and lack of long-term follow-up. Identification of our patient cohort was subject to many biases, including deficient coding practices likely leading to omission of minor injuries, inability to capture patients not presenting to hospital/clinics, and relative exclusion of pediatric patients except for those transferred to our trauma center with severe injuries. Therefore, the denominator of firework-related genitourinary injuries is difficult to characterize, and the patients included in this cohort represent the most severe cases and an older demographic. In order to gain a more robust understanding of firework-related genitourinary injuries, further multi-institutional collaborations and population-level studies are needed.

Conclusions

In our study population, firework-related genitourinary injuries occurred in a young men, lead to polytrauma with the scrotum and penis being the most commonly involved urologic sites. These firework-related injuries were associated with lengthy hospitalizations and high operative rates. Importantly, we found that most of these injuries were secondary to mortar or shell fireworks, typically legally obtained and by amateur users. Given the highly morbid nature of these injuries, improved triage mechanisms with high suspicion for urologic injury as well as preventative public health measures are warranted.

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