



Gunshot wound injury to the genitourinary tract: a 4-year retrospective review at an academic level 1 trauma center

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Background: Firearm injuries increased significantly during the coronavirus disease 2019 (COVID-19) pandemic. We aimed to describe our experience with patients admitted to a level 1 trauma center with gunshot-related trauma to the genitourinary (GU) tract before and during COVID-19 pandemic.

Methods: Patients sustaining gunshot-related trauma to the adrenals, kidneys, ureters, bladder, scrotum, testicles, penis, and urethra between January 1, 2018 and December 31, 2021 were identified from our institutional trauma database. Patient charts were queried to extract demographic information, management, and follow-up.

Results: A total of 117 patients met inclusion criteria with 39 (33%) of GU injuries occurring pre-COVID, and 78 (67%) occurring during or post-COVID. Seventy-two (62%) presented with kidney injury. Patients injured in the pre-COVID period were more likely to participate in a follow-up visit by 2.17 times at 60 days ($P=0.017$), 1.98 times at 90 days ($P=0.030$), and 2.04 times at 1-year ($P=0.014$) than during COVID. Pre-COVID, 46% of patients were injured in the city's northwestern region and 54% from other areas, during COVID 24% of patients came from the northwestern region compared to 76% from other areas ($P=0.029$).

Conclusions: Gunshot wounds (GSW) involving the GU tract increased during the COVID-19 pandemic, with renal injury most frequent. Follow-up visits declined by around half during the pandemic, primarily at 60 days, 90 days, and 1 year post-injury. The number of patients admitted with urologic injuries pre-COVID versus during COVID was significantly different depending on the patient's area of residence. More work is needed to evaluate the outcomes of traumatic GU injuries due to GSW pre- and post-pandemic.

Keywords: Urologic; trauma; gunshot wounds (GSW); injuries; penetrating

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Introduction

Since the onset of the coronavirus disease 2019 (COVID-19) pandemic in March 2020, the United States has seen a concomitant increase in firearm injuries (1). In the city of Louisville, Kentucky, gun violence has been increasing for years, but substantially rose during the pandemic (2,3). In

fact, in Louisville, greater years of potential life lost (YPLL) were attributable to firearm fatalities than the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) itself (2). In the first year of the COVID-19 pandemic alone, there were nearly 1.7× as many YPLL lost due to all-cause gun violence than in the year preceding the pandemic (2). However, the

city of Louisville is not at equal risk of gun violence; the city's northwestern, or "West End", which is home to historically "redlined" neighborhoods—or neighborhoods receiving the lowest appraisal gradings, indicating their desirability for investment, by the Homeowner's Loan Corporation in the 1930s—is disproportionately impacted by gun violence compared to the Louisville community as a whole (2,4).

The urogenital tract is involved in 10% of trauma cases, with nearly 1 in 10 abdominal traumas including an associated genitourinary (GU) injury and around two-thirds of those involving trauma to external genitalia (5-7). GU injuries include adrenal, kidney, ureteral, bladder, scrotal, testicular, penile, and urethral injuries. Of these, the kidneys are the most commonly injured GU organ in the United States, and blunt trauma, like motor vehicle accident, bicycle-related accident, or sports-related injuries, is the most common mechanism (2,6,8).

Despite the pervasiveness of firearm injuries in the United States, much literature regarding penetrating trauma to the GU tract are reported from military settings (9). In the active military setting, the external genitalia is the most commonly affected portion of the GU system, with scrotal involvement reported in nearly 30%, penile involvement in around 14%, and testicular involvement in close to 10% of GU injuries (5). These penetrating injuries, however, occur

primarily due to explosive fragments and ground-level devices, like mortar shells, improvised explosive devices, and landmines, rather than bullet injury (5). The observed differences in involved GU organs between civilian and military populations is likely due to a number of factors including differences in mechanisms of injury, as well as the availability of military body armor to protect abdominal organs like the kidneys and ureters, leaving the external genitalia more vulnerable to penetrating devices (5). While there are several studies investigating specific subsets of GU injuries independently, like those to the external genitalia, research regarding gunshot wounds (GSW) to the GU tract in the civilian population is limited (7,9-14).

In addition to observing an increase in gun violence, the COVID-19 pandemic also posed problems for patient follow-up and ambulatory care. With stay-at-home orders in place, fear of virus exposure, and the financial repercussions of the pandemic, many United States adults forewent outpatient medical care after the onset of the pandemic (15). GU trauma patients, at baseline, represent a population for whom outpatient follow-up is universally poor, with studies indicating one-third of patients treated for GSWs to the external genitalia were completely lost to follow-up, and another one-third were lost to follow-up after the first appointment post-injury (9).

Just as gun violence throughout the nation has notably increased in the COVID-19 pandemic, the occurrence of gunshot-inflicted trauma involving the GU system treated by our hospital system has notably increased as well (2). We hypothesized that GU trauma increased during the pandemic compared to pre-COVID rates and that patients were less likely to participate in outpatient follow-up. We address our hypothesis with a descriptive analysis of penetrating gunshot-inflicted GU trauma in our level 1 trauma center in the years preceding and during the COVID-19 pandemic. We also compare outpatient follow-up in the pre-COVID versus during COVID periods. We present this article in accordance with the STROBE reporting checklist (available at <https://tau.amegroups.com/article/view/10.21037/tau-23-466/rc>).

Methods

After approval by the University of Louisville Institutional Review Board (approval #22.0183), the Inpatient Trauma and Emergency Room Database and the University of Louisville Hospital and Affiliated Academic and Healthcare Sites Databases were retrospectively reviewed to identify

Highlight box

Key findings

- Gunshot wounds involving the genitourinary (GU) tract increased during the coronavirus disease 2019 (COVID-19) pandemic, with renal injury predominating while follow-up visits declined. The number of patients admitted with urologic firearm injuries pre- and during-COVID significantly differed depending on geographic location of the injury.

What is known and what is new?

- Gun violence is increasing, particularly since the COVID-19 pandemic.
- This manuscript shows the field of Urology is implicated in the growing literature describing increasing firearm injuries. We also observed a broadening of zip codes in which firearm injuries occurred, suggesting firearm injuries are not only increasing in number, but becoming more ubiquitous.

What is the implication, and what should change now?

- Further evaluations of the long-term outcomes of traumatic ballistic GU injuries pre- and post-pandemic are needed, as well as examination of the trends in location of injury occurrence on a national level.

trauma patients who received Urology consultation from January 1, 2018 to December 31, 2021, due to GU trauma secondary to a GSW. Informed consent was waived due to the retrospective nature of the study. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The pre-COVID interval was defined as January 1, 2018 through January 31, 2020 (760 days), and the COVID interval was defined as March 6, 2020, after the first confirmed case of COVID-19 in Kentucky, through December 31, 2021 (665 days). Inclusion criteria were patients sustaining gunshot-related trauma to the GU organs (defined as the adrenals, kidneys, ureters, bladder, scrotum, testicles, penis, and urethra) between January 1, 2018 through December 31, 2021. Exclusion criteria were GU trauma related to knife wounds, motor vehicle accidents, and/or other blunt trauma mechanisms. We examined three zip codes 40210, 40211, and 40212, that accounted for the highest density of injuries in comparison to other zip codes in the northwest region. All other zip codes in the trauma catchment registry were classified as “other areas” which included Louisville, southern Indiana and western Kentucky.

Individual patient charts were then reviewed to extract demographic information, injury and admission dates, mechanism of injuries, operative reports, diagnostic and laboratory test results, associated GU injuries, comorbid conditions, clinical and hospital reports, and associated outcomes.

Statistical analysis

Demographic data was summarized with descriptive statistics such as counts and percentages, along with mean and standard deviation. Pearson’s chi-square was used to analyze categorical data, while general linear modeling using a standard negative binomial regression was used to analyze the number of follow up visits by COVID periods. Data for this is presented in table format displaying estimated means, incidence rate ratios and 95% confidence intervals. All P values were 2-tailed, and the significance level was set by convention at $P < 0.05$. SPSS 28.0 was used to analyze the data.

Results

There were a total of 1,752 adult GSW injuries treated at this urban level 1 trauma center in time periods defined as pre-COVID (January 1, 2018 through January 31, 2020)

and during-COVID (March 6, 2020 through December 31, 2021). Of these GSW injuries, 117 (7%) had trauma to the GU system, with 39 (33%) occurring during the pre-COVID period, while 78 (67%) occurring during the COVID period. Accounting for the different number of days in the two time periods, the data reveals on average that 1 GSW GU injury occurred every 19.5 days during the pre-COVID period (760 days \div 39 GU injuries), while 1 GSW GU injury occurred every 8.5 days during the COVID-period (665 days \div 78 GU injuries). The most common race/ethnicity was Black/African American (84; 76%), followed by white (26; 23%), and Hispanic (1; 1%). Mean age at the time of injury was 29.1 years (11.2%) and 101 (86%) were male. About one-third (31; 32%) of patients lived in the city’s northwest region, while 66 (68%) were from “other” areas. The number of patients admitted with urological injuries pre-COVID versus during COVID was significantly different depending on the patient’s area of residence. Pre-COVID, 46% of patients came from the northwest region and 54% from other areas, during COVID 24% of patients came from the northwest region compared to 75% from other areas ($P = 0.029$). Twenty-six (22%) patients died after sustaining the GSW, while 91 (78%) survived their injuries. The overall frequency of GSW to the GU system increased during the study period (Table 1).

Injury to the GU system most commonly included the kidney (72; 62%), bladder (17; 15%), and ureter (4; 3%). Some patients had injuries involving more than 1 GU organ, of which the ureter and kidney (3; 3%), bladder and ureter (2; 2%), and testicle and scrotum (2; 2%) were the most frequent (Table 2). Table 3 shows the characteristics of GSW injuries to the GU tract in the pre-COVID versus during COVID periods. GSW injuries to the kidney increased from 19 (49%) pre-COVID to 53 (68%) during-COVID.

No significant difference was found between the pre-COVID and during-COVID periods on whether patients had a follow up visit [pre-COVID: 17/31 (55%); during-COVID: 26/57 (46%), $P = 0.408$]. Regarding the number of follow up visits, Table 4 shows pre-COVID visits were almost or over twice the visits during the COVID pandemic with significance difference being achieved at 60 days, 90 days, and 1 year follow up ($P < 0.05$).

Discussion

The purpose of this study was to describe GSWs involving

Table 1 Patient characteristics by COVID time period

Patient characteristics	Total (1,425 days, N=117)	Pre-COVID (760 days, N=39)	During-COVID (665 days, N=78)	P value
Gender				0.013
Male	101 [86]	38 [97]	63 [81]	
Female	16 [14]	1 [3]	15 [19]	
Frequency of GU GSW injuries occurring every ___ days, mean	12.2	19.5	8.5	<0.001
Race				0.071
Black/African American	84 [76]	31 [84]	53 [72]	
White	26 [23]	5 [13]	21 [28]	
Hispanic	1 [1]	1 [3]	0 [0]	
Asian	0 [0]	0 [0]	0 [0]	
American Indian/Alaskan Native	0 [0]	0 [0]	0 [0]	
Native Hawaiian or Pacific Islander	0 [0]	0 [0]	0 [0]	
Missing	6	2	4	
Mortality				0.084
Patient died	26 [22]	5 [13]	21 [27]	
Patient survived	91 [78]	34 [87]	57 [73]	
Area of Louisville				0.029
Northwestern region	31 [32]	16 [46]	15 [24]	
Other areas	66 [68]	19 [54]	47 [76]	
Missing	20	4	16	
Age (years)	29.1 (11.2)	31.0 (11.6)	28.2 (11.2)	0.204

Data are presented as frequency [percentage] or mean (standard deviation). COVID, novel coronavirus; GU, genitourinary; GSW, gunshot wound.

the GU tract in our level 1 trauma center in the years preceding and during the SARS-CoV-2 pandemic and compare outpatient follow-up. We performed a descriptive analysis of penetrating GU trauma secondary to GSWs using nearly four years of data from January 1, 2018 to December 31, 2021, and found 7.6% of admitted GSW injuries during the COVID time interval had a GU injury compared to 6.2% of admitted patients with GSW injuries during the pre-COVID interval (P=0.26). While considering the differing number of days in each interval, GU injuries increased from one occurrence every 19.5 days (pre-COVID) to one every 8.5 days (during-COVID).

Patients most frequently sustained renal trauma and few patients presented with more than one GU organ involved. GU injuries increased in our center after the onset of the COVID-19 pandemic, while follow-up at 60 days, 90 days,

and 1 year post-injury declined in this period. Over three-fourths of the patients in our cohort identified as Black/African American (76%) and nearly one-third (32%) were injured in the northwest region, while the other 68% were injured in other areas.

Our series demonstrated a predominance of kidney injuries (62%) among GSWs to the GU tract, which increased from pre-pandemic to pandemic times (49% *vs.* 68%). This is consistent with another review of a level 1 trauma centers which previously reported a 55% rate of kidney injury in GSWs to the GU tract (16). In contrast, other GSW series report external genital injuries are present in around two-thirds of all GU trauma (9). In our study, however, only 3% of penetrating GU injuries by GSW involved the scrotum, 1% involved the bilateral testes, and 1% involved the penis. Other retrospective

Table 2 GU organs involved in patients presenting with GSW injuries to the GU tract

GU organ	Frequency [%]
1 GU organ involved	
Kidney	72 [62]
Bladder	17 [15]
Ureter	4 [3]
Scrotum	3 [3]
Urethra	1 [1]
Penis	1 [1]
Perineum	1 [1]
>1 GU organ involved	
Ureter, kidney	3 [3]
Bladder, ureter	2 [2]
Testicle, scrotum	2 [2]
Kidney, bladder	1 [1]
Urethra, scrotum	1 [1]
Bladder, scrotum	1 [1]
Bilateral testicles	1 [1]
Kidney, bladder, ureter	1 [1]
Bladder, urethra, scrotum	1 [1]
Scrotum, penis, urethra	1 [1]
Bilateral testicles, penis	1 [1]
Urethra, ureter, kidney	1 [1]
Penis, urethra, testicle, scrotum	1 [1]
Ureter, kidney, bladder, urethra	1 [1]

GU, genitourinary; GSW, gunshot wound.

reviews found similar rates of scrotal (1.6%) and testicular (0.98%) involvement among their entire trauma population, rather than out of their GU injury population (7).

Penetrating GU injuries due to GSW increased from one occurrence every 19.5 days to one every 8.5 days during the COVID-19 pandemic. This finding is consistent with other series in the general trauma literature, which have shown increased gun violence from the year preceding the COVID-19 pandemic to the first year of the pandemic (2). Correspondingly, visits to the emergency department (ED) for firearm injury in the United States were higher in 2020, 2021, and 2022, than in 2019, before the onset of the pandemic, despite a decrease in overall numbers of ED

Table 3 GU organs involved in patients presenting with GSW injuries to the GU tract pre-COVID and during-COVID periods

GU organ	Pre-COVID, n [%]	During COVID, n [%]	P value
1 GU organ involved			0.457
Kidney	19 [49]	53 [68]	
Bladder	7 [18]	10 [13]	
Ureter	1 [3]	3 [4]	
Scrotum	1 [3]	2 [3]	
Urethra	1 [3]	0 [0]	
Penis	0 [0]	1 [1]	
Perineum	0 [0]	1 [1]	
>1 GU organ involved			
Ureter, kidney	0 [0]	3 [4]	
Bladder, ureter	2 [5]	0 [0]	
Testicle, scrotum	2 [5]	0 [0]	
Kidney, bladder	1 [3]	0 [0]	
Urethra, scrotum	1 [3]	0 [0]	
Bladder, scrotum	0 [0]	1 [1]	
Bilateral testicles	0 [0]	1 [1]	
Kidney, bladder, ureter	1 [3]	0 [0]	
Bladder, urethra, scrotum	1 [3]	0 [0]	
Scrotum, penis, urethra	1 [3]	0 [0]	
Bilateral testicles, penis	0 [0]	1 [1]	
Urethra, ureter, kidney	0 [0]	1 [1]	
Penis, urethra, testicle, scrotum	1 [3]	0 [0]	
Ureter, kidney, bladder, urethra	0 [0]	1 [1]	

GU, genitourinary; GSW, gunshot wound; COVID, novel coronavirus.

visits (1,17). Even prior to the COVID-19 pandemic, both firearm injuries as a whole and GSWs to the GU system were increasing in the United States over the past decade, with a substantial increase coinciding with the COVID-19 pandemic (2,3,9). While it has been theorized that the rise in gun violence during the COVID-19 pandemic may be related to factors such as stay-at-home orders, heightened stress in the pandemic, and decreased access to mental health care, our study neither addresses a causal relationship

Table 4 Comparison of outpatient follow-up in the pre-novel coronavirus period versus during COVID period[†]

Follow-up visit	Estimated mean	Standard error	Incident rate ratio	95% CI	P value
No. of 30-day follow-up visits				0.94–3.90	0.073
Pre-COVID	0.81	0.22	1.92		
During COVID	0.42	0.10	1.00 [‡]		
No. of 60-day follow-up visits				1.15–4.11	0.017
Pre-COVID	1.26	0.30	2.17		
During COVID	0.58	0.13	1.00 [‡]		
No. of 90-day follow-up visits				1.07–3.65	0.030
Pre-COVID	1.39	0.33	1.98		
During COVID	0.70	0.15	1.00 [‡]		
No. of 1-year follow-up visits				1.15–3.59	0.014
Pre-COVID	2.00	0.44	2.04		
During COVID	0.98	0.19	1.00 [‡]		

[†], results based on general linear modeling using a standard negative binomial regression; [‡], reflects referent group. COVID, novel coronavirus; CI, confidence interval.

between COVID-19 and firearm injury, nor does it address whether or not GU injuries by firearm were independently increasing in our region prior to the COVID-19 pandemic (18,19).

While firearm injuries to the GU tract increased, follow-up declined after the onset of the COVID-19 pandemic, with patients injured pre-COVID around two-times more likely to participate in a follow-up visit by 60 days, 90 days, and 1 year after injury than those injured during COVID (Table 4). Consistent with other studies of GU trauma patients, our proportion of patients presenting for outpatient follow-up pre-COVID was only around half (55%) (10). However, after the onset of the COVID-19 pandemic, less than half of patients (46%) presented for outpatient follow-up. Follow-up is generally poor across civilian studies of external genital trauma, with around one-third of patients lost to follow-up and another one-third failing to follow-up after their first appointment (9). This is significant, as follow-up is important to identify and manage complications including, but not limited to, UTI, urinoma, rectovesical fistula, renal failure, erectile dysfunction and urethral stenosis in cases of GSWs to the penis, and infertility in situations involving testicular trauma or trauma to the vas deferens (12,20,21).

In addition to the aforementioned complications of GU trauma, less-often considered complications of firearm injury include long-term mental health conditions and

implications for socioeconomic functioning as well. A retrospective review of nationwide trauma concluded 1 in 11 victims of firearm-related injuries are likely to be readmitted to the hospital with acute stress disorder or post-traumatic stress disorder within six months of initial injury (22). Firearm injury has been associated with worse long-term outcomes than similar injuries due to motor vehicle collision, including increased chronic pain, new functional limitations, and reduced physical health composite scores (23). Similarly, studies have shown lower employment and return to work rates, poor social functioning, and increased alcohol and substance abuse among firearm injury survivors (23).

Our study identified a clear racial and geographic disparity in the data, with over two-thirds of GSW victims in our population identifying as Black/African American and nearly one-third injured in only 3 of the 23 analyzed zip codes. The racial disparity in our data is significant, as race has been identified as an independent risk factor for worse outcomes after trauma, including lower rates of testicular salvage in genital trauma (24). Similarly, a previous study identified the impact of historical and institutional racism on modern gun violence and showed historically redlined neighborhoods (those receiving the lowest grade on the Home Owner's Loan Corporation maps from the 1930s) in our city have significantly more firearm injury today than neighborhoods previously listed in the highest-graded zones (4). This is evident in our data, as nearly one-third of

the gunshot victims were injured in the city's West End, an area primarily consisting of historically C- and D-graded neighborhoods (4). However, patients sustaining GSWs to the GU system in areas outside of the northwestern region increased from pre-COVID to during COVID, suggesting that although the community at large does not at equal risk of gun violence, the increase during the COVID-19 pandemic had widespread effects throughout the city.

This study is a retrospective review of our experience with penetrating GU trauma by GSW and has several limitations. First, patients were identified in our institutional trauma registry by involved organ. While the charts of all patients coded for GU injury were reviewed, it is possible patients with injuries to this area were not coded as such and were missed from our dataset, especially patients with polytrauma and those who died from their injuries. Not all data fields were complete either, notably patient demographic and geographic information, including race and location of injury. Our study also possesses the limitations inherent to retrospective design and the relatively small number of GU injuries available for analysis. Similarly, our cohort reflects the population admitted to our level 1 trauma center, which does not include those who did not present for hospital care and may differ from populations in community ED settings and tertiary hospitals in other areas. A multi-center study across several regions, both urban and rural, including patients not admitted to the hospital, would both address this limitation and capture patients with less severe injuries, like those treated in the outpatient setting, than those in our study population.

Conclusions

This study represents a novel investigation of penetrating GU trauma due to firearms during the COVID-19. Our study demonstrates an increase in firearm injuries to the GU tract as total GSW injuries increase. We found the kidneys are the most frequently injured GU organ by GSW. Our findings indicate a decline in patient follow-up post-GSW injury during the COVID pandemic. More work is needed to evaluate the outcomes of traumatic GU injuries due to GSW pre- and post-pandemic.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at <https://tau.amegroups.com/article/view/10.21037/tau-23-466/rc>

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at <https://tau.amegroups.com/article/view/10.21037/tau-23-466/coif>). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the University of Louisville Institutional Review Board (approval #22.0183). Informed consent was waived due to the retrospective nature of the study.

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