

Hidden trauma: shedding light on the relationship between gun violence and infertility

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Objective: To study the existing data on the relationship between penetrating abdominopelvic injuries and fertility guidance on managing fertility concerns of these patients using a case report and scoping review.

Design: Case report and scoping review.

Setting: Not applicable.

Patient(s): People who have experienced abdominopelvic trauma from gun violence or in the course of combat.

Intervention(s): None.

Main Outcome Measure(s): We extracted case report data from electronic health records. We performed a scoping review using PubMed and Scopus. Search terms were related to penetrating abdominopelvic trauma, gunshot wounds (GSW), war, and fertility/infertility. We evaluated the study year, age and race, mechanism of injury, fertility outcomes, and how fertility concerns were addressed with patients who experienced penetrating abdominopelvic trauma.

Result(s): In the case report, the couple had 10 years of infertility. The male partner experienced an abdominopelvic GSW before attempting to conceive. After evaluation, he was diagnosed with retrograde ejaculation. He recalled being advised that his GSW might affect his future fertility. The couple has discontinued care.

For the scoping review, 879 sources were identified and 25 studies were included in the review. Among the studies conducted in the United States, most patients included were African American.

Eighty-eight percent ($n = 22$) of the sources acknowledged the importance of fertility or used fertility-related outcome measures. One study commented on how to address fertility concerns with victims of abdominopelvic penetrating trauma.

Conclusion(s): There is a paucity of data on the intersection of penetrating abdominopelvic injuries and fertility or guidance on how to discuss fertility issues with patients. (Fertil Steril Rep® 2022;3:66–79. ©2021 by American Society for Reproductive Medicine.)

Key Words: Infertility, gun violence, gunshot wounds, trauma

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Gun violence is a pervasive issue in the United States. There are over 80,000 visits to the emergency department each year for

nonfatal firearm injuries, and these injuries are most commonly the result of an assault (1). Approximately 20% of firearm assaults result in abdomino-

pelvic injuries (2). Penetrating abdominopelvic injuries such as gunshot wounds (GSW) may impact future fertility, especially when urologic or gynecologic in nature. However, current data are limited on how to manage patients with penetrating abdominopelvic injuries to optimize future fertility. Neither the American Urologic Association urotrauma guidelines, the American Association for the Surgery of Trauma, nor the American Society for Reproductive Medicine currently provides guidance on counseling patients about the potential fertility issues

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associated with these injuries (3). The American College of Obstetricians and Gynecologists provides a guideline, “Caring for Patients Who Have Experienced Trauma” however, trauma is broadly defined to include both physical and psychological harms in the document, and there is no guidance on fertility-related discussions (4).

Understanding the long-term effects of gun violence on fertility may identify an unrecognized contributor to infertility. Using age and sex-adjusted life expectancy rates, cause of death, and birth rates, investigators Wilson and Daly (5) demonstrated a regional relationship between lowered life expectancy and earlier reproductive timing in zip codes most affected by gun violence in Chicago in the 1980s and 1990s. Not only may gun violence influence behaviors, quality of life, and life expectancy, but in addition, it is possible that it could directly influence the ability to conceive through the anatomic injuries obtained. In the United States, because of well-documented structural racism, people of color are disproportionately affected by gun violence (1, 2, 6, 7). Increasing provider awareness at all touch-points for gun violence victims, from their primary care physicians to reproductive health subspecialists, could aid in promoting fertility health equity.

We present a case report demonstrating the potential influence of penetrating trauma on fertility. Following this case report, we will present a scoping review with two objectives: first, to assess the existing data on the relationship between penetrating abdominopelvic injuries and fertility; second, to evaluate the available guidance on counseling and managing the fertility concerns of these patients.

MATERIALS AND METHODS

Protocol

We observed the Preferred Reporting Items for Systematic Reviews and Meta-analysis Protocols (PRISMA) to conduct our scoping review. To be included in the review, we sought studies (case reports, case series, retrospective and prospective cohorts, case-control studies, and reviews) that closely aligned with our primary objectives. The included studies met the following criteria:

- The title or abstract included the mechanism of an injury specified as gun violence or penetrating abdominopelvic trauma due to a violent act.
- The title or abstract reports on outcomes related to the genitourinary tract or fertility.
- The title or abstract discusses the management of these injuries.
- Includes humans only.
- English is the primary language.
- The full manuscript is accessible at the time of the review.
- No location restrictions.
- Publication range – Open.

Studies meeting the following criteria were excluded:

- Full text is unavailable.
- Written in a language other than English.

- Studies do not comment on penetrating trauma and genitourinary injury or fertility outcomes.
- Studies specify spinal injury cord trauma as the primary trauma, despite consequent penetrating abdominopelvic trauma.
- Studies focus on intimate partner violence, sexual violence, marital violence, genital mutilation, domestic violence, domestic abuse, reproductive coercion, sexual abuse, interpersonal violence, rape, or other forms of trauma.
- Populations that included pregnant women.
- Ethical or opinion pieces, legal proceedings.

Sources were identified through PubMed and Scopus searches conducted from June 1, 2021, to July 15, 2021, using the search MeSH terms:

“Wounds, Penetrating” AND “Infertility”
 “Wounds, Penetrating” AND “Fertility”
 “Wounds, Gunshot” AND “Infertility”
 “Wounds, Gunshot” AND “Fertility”
 “War-Related Injuries” AND “Infertility”
 “War-Related Injuries” AND “Fertility”
 “Gun Violence” AND “Infertility”
 “Gun Violence” AND “Fertility”

Potential sources were evaluated by two reviewers, AA and AN. Any discrepancies about study inclusion were resolved by discussion between the reviewers. Relevant data from included sources were recorded in a data-charting form describing the investigators, study title, country of origin, date retrieved, the year the study was published, the population, primary results, and whether studies addressed fertility or made recommendations about fertility discussions. Studies were assessed for trends in addressing fertility issues and fertility counseling.

Case Report Development

Relevant data about the patient were retrieved using an electronic medical record system. This included the primary concern, medical history, physical examination, and relevant laboratory results, and indicated treatment. This case report (IRB21-1234) was exempt from the University of Chicago Institutional Review Board as a single case report excluding protected health information.

RESULTS

Case Report

History of present illness. The patient was a 37-year-old gravida 0 with 10 years of primary infertility at the time of presentation. Five years before her presentation, she initiated a fertility evaluation that demonstrated unilateral tubal occlusion and bilateral hydrosalpinges (Table 1). Her male partner was not evaluated. At the time, she was informed that her likelihood of fertility was low. However, she decided that she and her partner would continue trying to conceive with regular intercourse 3–4 times per week. The couple did not report any sexual dysfunction. After 5 additional years of trying to conceive, she presented to our clinic for additional fertility care.

TABLE 1**Female patient's relevant laboratory values and evaluation.**

Follicle stimulating hormone 11.2 IU/mL, estradiol level 37 pg/mL
 Thyroid Stimulating Hormone 0.54 mIU/L
 Antimüllerian hormone level 1.25 ng/mL
 Prenatal testing was negative
 Saline sonohysterogram: Bilateral hydrosalpinges, left tubal patency,
 uterine cavity normal

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The partner was a 42-year-old medically healthy man. He was the victim of gun violence and had suffered an abdominal GSW that required an exploratory laparotomy, although he did not recall what surgical procedures were performed. He had a daughter from a previous relationship conceived before his GSW injury. He was a smoker with no other toxic exposures. His semen analyses demonstrated teratospermia and low volume, asthenospermia, and oligospermia (Table 2). Together these findings were concerning for retrograde ejaculation. After treatment with pseudoephedrine and sodium bicarbonate, his semen parameters improved marginally. The total motile count of 7.4×10^6 in the final specimen was still suboptimal for intrauterine insemination.

Follow up. After reviewing the results with the patient and partner, the partner recalled that at the time of his laparotomy for his GSW, he was told that his injury was “very low” and that having children in the future may be difficult. This information was new to the female patient. The male partner was diagnosed with retrograde ejaculation. Two treatment approaches were offered. First, a trial of intrauterine insemination with treatment for retrograde ejaculation was proposed. Multiple ejaculates per insemination would be likely. The second treatment approach included in vitro fertilization with preimplantation genetic testing for aneuploidy, interval bilateral salpingectomy after euploid embryos were obtained, and frozen embryo transfer of a single euploid embryo. The patient chose to do intrauterine insemination, initiated a cycle, but neither she nor her partner presented for insemination. She has now decided not to pursue treatment.

Scoping Review

Selection of sources of evidence. A total of 879 sources were identified through searches of PubMed and Scopus or through examining the references of the included studies. After 112

duplicates were excluded, 767 sources were examined for potential inclusion. A total of 718 sources were excluded by their title or abstract, and there were 6 studies excluded because their full text could not be retrieved. We reviewed the full text of 43 studies. After the review, 18 studies were excluded for the following reasons: the mechanism of injury did not include gunshot or other penetrating abdominopelvic trauma ($n = 16$), the study did not include humans ($n = 1$), or the source was an editorial which was an excluded source ($n = 1$). Twenty-five sources were included in the scoping review including case reports/series ($n = 6$), retrospective cohort studies ($n = 12$), reviews ($n = 5$), a case-control study ($n = 1$), and a cross-sectional qualitative study ($n = 1$) (Fig. 1).

Demographics. Twenty-five studies and reviews met the criteria to be included in the scoping review. These studies addressed the management of such injuries or fertility-related outcomes. Among the included studies, the age range of patients affected by penetrating abdominopelvic trauma was 5–83 years, although most people were <35 years. Nine of the sources included in the review came from the studies of veterans or victims of war (Table 3). Among studies in the United States, when race was reported, most civilian patients affected by penetrating trauma were African American (13, 22). Mattocks et al. (22) performed a retrospective cohort study of women veterans deployed for Operations Enduring Freedom, Iraqi Freedom, and New Dawn. Women in this cohort who were given an ICD-9 diagnosis of infertility were significantly more likely to be young, obese, African American, or impacted by a service-related disability or sexual trauma.

Female injuries. Penetrating trauma to reproductive structures (uterus, fallopian tubes, or ovaries) is rare and represented <0.1% of injuries in the National Trauma Databank between 2007 and 2015 (29). In our review, we identified four studies that explicitly reviewed the female experience (26, 29, 31, 32). Rivas et al. (32) conducted a retrospective cohort study of 313 women who had experienced gynecologic trauma reported to the National Trauma Databank between 2011 and 2013. The investigators demonstrated that although most reported traumas were blunt trauma, 21% resulted from penetrating trauma. Most gynecologic traumas resulted in injury to the ovaries or fallopian tubes (74.8%), whereas the uterus was injured in a minority of cases (25.2%). Importantly, gunshot trauma more often resulted in salpingo-oophorectomy rather than an attempt to repair the injured tissue. While this study shed light on the surgical approach to gynecologic traumas,

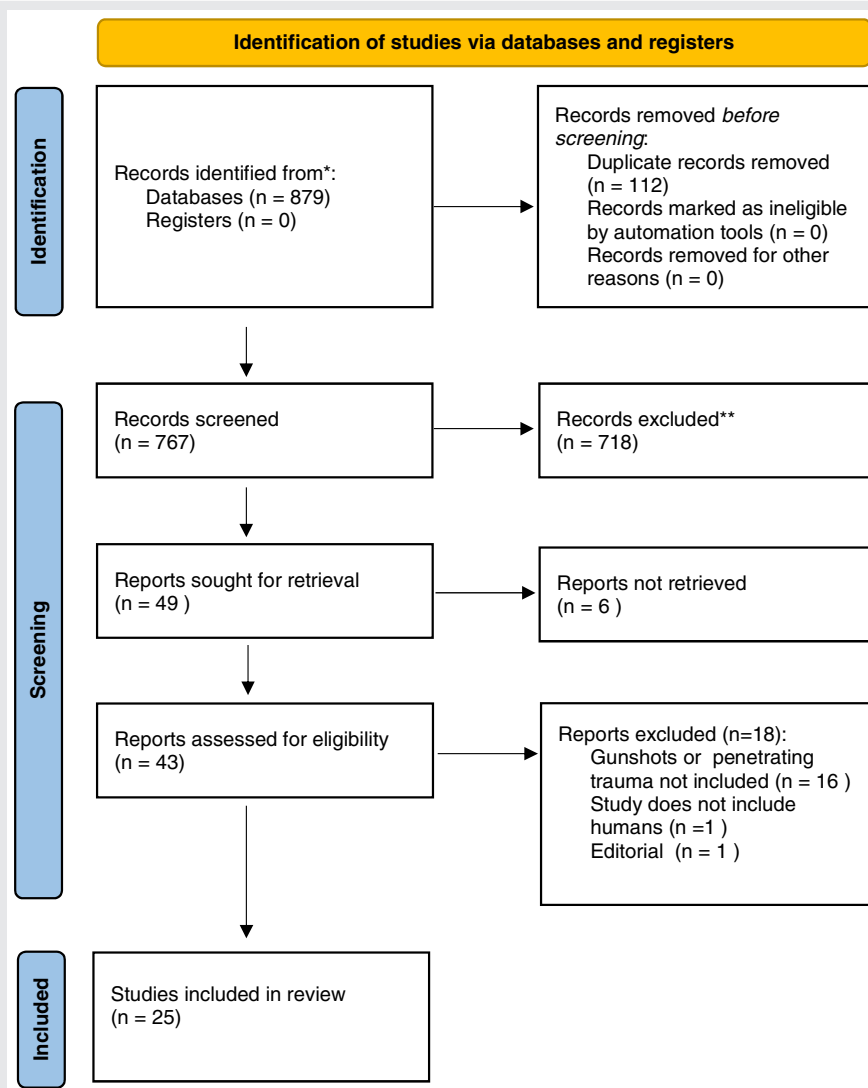
TABLE 2**A male patient's relevant laboratory and evaluation results**

Semen analysis no.	Volume (mL)	Concentration (10^6 /mL)	Motility (%)	Morphology (%)	Total motile count (10^6)
1	0.1	6.4	31	3	—
2	0.4	11.9	52	11	2.5
3 ^a	1.0	12.6	58	19	7.3

Note: ^aAfter treatment with pseudoephedrine and sodium bicarbonate; Post-ejaculate urine specimen with 1.9 M sperm and 36% motility.

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FIGURE 1



Preferred Reporting Items for Systematic Reviews and Meta-Analyses-Scoping review flow diagram.

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it did not address how to discuss these injuries with patients or manage expectations around future fertility (32).

Male injuries. In our review, most studies examined the impact of violence and war on male fertility. Penetrating abdominopelvic trauma often involves the male external genitalia. Multiple sources described managing severe penetrating injuries to the scrotum with orchiectomy and, in some cases, bilateral orchiectomy (8, 11, 19). A general review of the epidemiology of genitourinary trauma estimates that orchiectomy is required in 25%–65% of patients with scrotal trauma (33). While uncommon overall, male genital injuries can result in significant long-term morbidity with fertility sequelae such as erectile dysfunction, hormonal dysfunction, primary spermatogenic dysfunction, or psychological distress. Similar to the current literature

on female injuries, our review did not identify studies that clearly discussed long-term management of these fertility issues in the posttrauma setting.

Management of injuries. Most included studies and reviews focused on the epidemiology of penetrating abdominopelvic injuries or the surgical management of these injuries. Eighty-eight percent (n = 22) of the studies acknowledged the importance of the injury to fertility or used fertility-related variables (potency, endocrine profile) as an outcome measure (Table 3). People with war-related injuries to pelvic structures often experienced other injuries, including limb amputations or traumatic brain injuries (24, 28). Civilian studies typically did not comment on additional injuries. Most urologic studies advocated for either scrotal ultrasounds and/or early exploration for clear testicular injuries.

TABLE 3

Summary of sources.

Author	Location	Year	Study design	Study population	Findings	Acknowledged fertility concerns	Guidance on fertility discussion
Cass et al. (8)	United States	1988	Case series	5 patients presenting to a medical center with testicular trauma (4 with gunshot wounds)	Range of outcomes with some patients having no impact to testosterone or semen analyses vs. another with low testicular volume. Nature of injury (blunt vs. penetrating) may affect future hormonal profile and semen analysis	Yes	No
Blank et al. (9)	United States	1990	Case report	1 patient, history of abdominal gunshot wound, multiple reparative surgeries and infertility	Patient diagnosed with anejaculation. Successful pregnancy after ZIFT	Yes	No
Cass et al. (10)	United States	1991	Retrospective cohort study	91 testicular injuries in 86 patients (5 bilateral), 14 injuries from gunshot violence	More bilateral testicular injury based on gunshot injuries (29%). The importance of early surgical exploration for testicular trauma	Yes	No
Lin et al. (11)	United States	1998	Retrospective cohort study	10 patients with unilateral testicular trauma from gunshots, stabs or blunt trauma and controls (sperm donors with proven fertility)	Testicular salvage may be more beneficial for maintaining endocrine function than orchiectomy	Yes	No
Dorairajan et al. (12)	India	2001	Case report	20 y/o man with stab injury to scrotum	Plan made for interval vasovasostomy but patient was lost to follow up	No	No
Mohr et al. (13)	United States	2003	Retrospective cohort study	116 men with external genital trauma to either the scrotum, testes, penis or urethra	AAST grading can identify patients with genital injuries requiring operative management. No patients who participated in follow up complained of infertility	Yes	No

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TABLE 3

Continued.

Author	Location	Year	Study design	Study population	Findings	Acknowledged fertility concerns	Guidance on fertility discussion
Maconochie et al. (14)	United Kingdom	2004	Retrospective cohort study	Gulf veterans (n = 24,379) and non-gulf veterans (n = 18,439) who answered a questionnaire about their fertility	There was a higher risk of infertility defined as the inability to conceive among Gulf War veterans OR, 1.41; CI 1.05 to 1.89. There was a higher risk of infertility defined as the inability to have a live birth OR, 1.50; CI 0.18 to 1.89. There was a longer time to conception for Gulf veterans that ultimately did conceive	Yes	No
Van der horst et al. (15)	Germany	2004	Review	None	Early surgical intervention for genital injuries, especially those caused by hard objects is important to limit the risk of infection	Yes	No
Kazemnejad et al. (16)	Iran	2005	Retrospective cohort study	667 couples in Iran undergoing IVF with ICSI including 121 couples with male-factor infertility who were victims of war	There was no negative impact of war injuries on success with IVF with ICSI	Yes	No
Rosenstein and Alsikafi (17)	United States	2006	Review	None	Delays in proper evaluation of urethral injuries can lead to long-term urologic issues. Penetrating trauma to urethra most often caused by firearms, should be evaluated with retrograde urethrography	Yes	No

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TABLE 3

Continued.

Author	Location	Year	Study design	Study population	Findings	Acknowledged fertility concerns	Guidance on fertility discussion
Kobeissi et al. (18)	Lebanon	2008	Case control	120 male infertility cases and 100 fertile male controls, primary outcome semen analysis	Men with infertility had an increased odds of being exposed to war-related trauma in the Lebanese Civil War	Yes	No
Phonsombat et al. (19)	United States	2008	Retrospective cohort study	110 patients with external penetrating genitourinary trauma during 1977–2006	Suggested management includes initial evaluation by trauma surgeons and urologist followed by formal exploration for injuries that penetrate fascia. Testicular salvage is higher with GSW compared with stab wounds. 13 out of 14 patients with follow-up data available on potency had regained baseline sexual function, the other person was impotent because of spinal cord injury	No	No
Boscolo-berto et al. (20)	Italy	2011	Case report	35 y/o male who experienced a transpelvic gunshot wound during the Balkan conflict and male infertility because of obstructive azoospermia	Patient diagnosed with CBAVD due to CFTR mutation	Yes	No

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TABLE 3

Continued.

Author	Location	Year	Study design	Study population	Findings	Acknowledged fertility concerns	Guidance on fertility discussion
Lucas et al. (21)	United Kingdom	2014	Cross-sectional qualitative study	13 men with urogenital injuries from deployment treated at the UK specialist military rehabilitation facility; injuries included unilateral orchiectomy (n = 3), unilateral orchiectomy with damage to remaining testicular (n = 3) bilateral orchiectomy (n = 5) penile injuries (n = 10), scrotal injuries (n = 5) and hypogonadism (n = 1)	Sexual function was highly rated and for 8/13 patients, their pelvic injury was more important to them than losing limbs. Patients were most satisfied when they knew the full implications of their injuries on fertility at the time of treatment	Yes	Yes
Mattocks et al. (22)	United States	2015	Retrospective cohort study	Women veterans deployed to OEF, OIF or OND who experienced infertility and treatment identified through ICD-9 and CPT codes,	1.9% of women received an infertility diagnosis. Women with a service-related disability were more likely to have infertility. Few women had specific GU injuries which included "closed uterus injury" n = 3, open wound of vulva n = 3 open wound of vagina n = 3 or contusion of genital organs n = 1. Many women received fertility care outside of the VA system	Yes	No
Healy et al. (23)	United States	2016	Case series	6 service men with extensive testicular tissue loss due to genitourinary injuries sustained from dismantled IEDs during OEF (24)	Sperm from Seminal Vesicle Sperm Aspiration successfully fertilized oocytes and in one patient lead to a live birth from IVF with ICSI	Yes	No

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TABLE 3

Continued.

Author	Location	Year	Study design	Study population	Findings	Acknowledged fertility concerns	Guidance on fertility discussion
Churukanti et al. (25)	United States	2016	Case series	64 patients with penetrating scrotal trauma who survived their injuries (70% due to gunshots)	Scrotal ultrasound was highly sensitive and specific for assessing significant scrotal trauma after a penetrating injury. Two bilateral orchiectomies and nine unilateral orchiectomies were performed. There was no difference in rate of orchiectomy between the scrotal ultrasound and non-ultrasound group	Yes	No
Lopez et al. (26)	United States	2017	Review	None	Important for urogenital injuries to be treated appropriately to avoid long-term negative issues to fertility and quality of life. In the case of gunshot injuries, crush injuries or other pelvic trauma, advocates for "Resuscitative Endovascular Balloon Occlusion of the Aorta"	Yes	No
Wang et al. (27)	United States	2017	Review	None	Ultrasound may be a helpful first step in evaluating for testicular rupture in people scrotal trauma	No	No
Janak et al. (28)	United States	2017	Retrospective cohort study	1367 service men with at least one genitourinary injury diagnosed by ICD-9 CM code between 2001 and 2013 while deployed for OIF or OEF	The loss of one or both testes in 146 men, 1.2% (n = 17) men had bilateral orchiectomies. Comorbid conditions often included TB, pelvic fracture, colorectal injury and amputations	Yes	No

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TABLE 3

Continued.

Author	Location	Year	Study design	Study population	Findings	Acknowledged fertility concerns	Guidance on fertility discussion
Grigorian et al. (29)	United States	2018	Retrospective cohort study	Women \geq 16 y who experienced trauma requiring surgical treatment from the NTDB between 2007 and 2015	Pelvic gynecologic trauma is rare (<0.1% of injuries, n = 1938 cases). An ISS score of 25 or more predicts hysterectomy. Women with gunshot wounds have a higher risk of salpingo-oophorectomy.	Yes	No
Balzano and Hudak (30)	United States	2018	Review	None	Genitourinary injuries represent a small but consistent proportion of injuries on the battle field. Because of improvements to protective equipment, more service members are surviving their injuries. Long-term care of service members with complex genitourinary injuries requires a multidisciplinary team	Yes	No
Reed et al. (31)	United States	2018	Retrospective cohort study	Women veterans deployed for OIF/OEF who experienced trauma registered to the Department of Defense Trauma Registry	1.4% (n = 20) of GU trauma injuries were experienced by women veterans. The median ISS was 21, most were injured by IEDs, 2 from gunshot. There were no injuries to uterus or fallopian tubes or ovaries	Yes	No

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TABLE 3

Continued.

Author	Location	Year	Study design	Study population	Findings	Acknowledged fertility concerns	Guidance on fertility discussion
Nnamani et al. (24)	United States	2019	Retrospective cohort study	12,923 injured veterans identified from the DoDTR during OEF/OIF and ND who also received care from the Veterans Health Administration	A minority of servicemen with GU injuries in the DoDTR were also registered as having a GU injury in the VHA database demonstrating a discrepancy between immediate combat treatment and follow up with veterans affairs and an opportunity to improve continuity of care. More urinary symptoms, sexual dysfunction and TBI in those with GU injuries	Yes	No
Rivas et al. (32)	United States	2020	Retrospective cohort study	313 women aged ≥ 16 who experienced gynecologic trauma registered to the National Trauma Database between 2011 to 2013	A minority of cases, 21% (n = 68) were the result of penetrating trauma. Ovarian and fallopian tube trauma more common. Nonoperative management was more common	Yes	No

Note: AAST = American Association for the Surgery of Trauma; CBAVD = Congenital Bilateral Absence of the Vas Deferens; CFTR = cystic fibrosis transmembrane conductance regulator; CPT = current procedural terminology; DoDTR = Department of Defense Trauma Registry; ICSI = intracytoplasmic sperm injection; IED = improvised explosive device; IVF = in vitro fertilization; ISS = injury severity score; OEF = Operation Enduring Freedom; OIF = Operation Iraqi Freedom; OND = Operation New Dawn; NTDB = National Trauma Data Bank; TBI = traumatic brain injury; VHA = Veterans Health Administration; ZIFT = zygote intrafallopian transfer.

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Combat injuries. With advancements in surgical technique and improvements to body armor to protect the head and upper torso, the prevalence of people surviving complex pelvic injuries, commonly from improvised explosive devices, has increased (34). Consequently, a substantial proportion of studies included in this scoping review focused on veterans and victims of war ($n = 10$). Exposure to war, either as a veteran or civilian victim of war, was associated with an increased risk of infertility in the studies included in this review when infertility was the primary outcome ($n = 3$) (Table 3) (14, 18, 22). All combat-related studies commented on the potential relevance of abdominopelvic injuries on future fertility or used infertility and treatment success as a primary outcome (Table 3).

Interestingly, in a retrospective cohort study of veterans who served in Operation Iraqi Freedom and Operation Enduring Freedom, Janak et al. (28) noted that in their clinical practice, they “anecdotally identified previously fertile men who sustained severe blast injury to the pelvis and were (months or years later) subsequently found to have testicular atrophy and biopsy confirmed nonobstructive azoospermia despite no evidence of overt testicular injury at the time of initial presentation, presumably due to delayed effects from the initial blast injury. For many of these men, paternity is no longer possible without the use of donor sperm, which is not a covered benefit for current or former US service members” (28). These observations raise the possibility that there may be long-term fertility consequences from abdominopelvic trauma related to blast injury even when injuries do not directly harm reproductive structures.

In contrast, a minority of sources in this review that included civilians did not address fertility concerns at all in their results or discussion ($n = 3$) (Table 3).

Communicating fertility concerns. Although many studies acknowledged that fertility might be a concern after penetrating abdominopelvic trauma or combat-related injuries, most studies ($n = 24$) did not provide a framework for how providers might discuss the potential impacts of these injuries on future fertility or sexual function (Table 3).

One study by Lucas et al. (21) addressed how to disclose the nature of the penetrating reproductive injury with the patient. The investigators of this qualitative study interviewed 13 men who experienced urogenital injuries while deployed by the United Kingdom. Common themes expressed by the men included a desire to understand the full impact of their injuries on their future fertility early in their treatment journey, and they valued learning about their injuries from professionals with expertise in this area. Most of these men also rated the importance of their genital injuries higher than other combat-related injuries such as limb loss. The investigators advocated for fertility preservation once the injury is recognized, follow-up, and comprehensive fertility and psychological care after these injuries.

No studies described a process of longitudinal follow-up to address fertility issues for patients with penetrating genitourinary trauma.

Fertility interventions. Although the long-term fertility outcomes for people experiencing penetrating abdominopelvic

trauma are extremely limited, some case reports and series focused on novel strategies to address infertility in this population. Techniques included zygote intrafallopian transfer or seminal vesical sperm aspiration for use with intracytoplasmic sperm injection with subsequent successful pregnancies (9, 23). The utility of certain fertility preservation techniques depends on the context of the injury. Trauma that occurs during combat may be anticipated and addressed with predeployment oocyte or sperm cryopreservation, whereas the options for civilian trauma are more limited. Fortunately, the field of infertility care has evolved to include many treatments that would be successful in this population. However, the accessibility of these treatments is often limited because many who experience gun violence are also socioeconomically disadvantaged.

DISCUSSION

This scoping review identified 25 studies and reviews that addressed penetrating abdominopelvic trauma, its management, or implications for fertility-related outcomes. Although injuries to reproductive organs after penetrating trauma are relatively rare in women, they represent about 3%–10% of injuries among men (27, 29, 31). Among sources included in this review, there were associations between people experiencing war trauma and the incidence of infertility. However, no studies specifically explored a direct relationship between penetrating abdominopelvic trauma and infertility. The case reports included in this review often described direct trauma to the genitalia, sometimes with negative impacts on the endocrine function or gametogenesis. It is possible that querying infertility in a larger cohort of people experiencing direct penetrating abdominopelvic trauma may reveal a clear relationship. Over the time period of the study, thousands of people have been affected by penetrating abdominopelvic trauma; therefore, understanding the reproductive issues in this population could have a significant impact on their quality of life.

Most of the studies in this review focused on direct trauma to the reproductive organs, although Janak et al. (28) acknowledged that it is possible that some injuries to the reproductive structures may go undetected in the immediate postinjury period. Only one study explored the importance of counseling patients about their future reproductive potential. No studies provided a framework for a discussion and follow-up to address potential endocrine dysregulation and infertility that victims of gun violence may experience. There is a clear knowledge and process gap that needs to be filled around the impact of gun violence on future fertility.

This case report and scoping review have limitations. Case reports often discuss rare events which may not be widely applicable. Our case hopefully demonstrated the importance of understanding the possible intersections between gun violence and infertility. Moreover, scoping reviews may not comprehensively assess the available literature in the way that makes systematic reviews so valuable. Yet, scoping reviews have a role as a preliminary exploration of a topic when it is not clear what data exists around a specific subject matter.

The implementation of a scoping review in our study has some additional limitations. We used a narrowly-defined set of search terms to precisely address our primary question. Other studies may have met the criteria but were left undetected if their titles and keywords did not fit our search terms. For example, we excluded studies centered on interpersonal violence and sexual violence. Although these are important topics and may sometimes coincide with penetrating trauma, the subjects raised were often beyond the scope of this review. Additionally, only studies written in English with an easily accessible full text were included. It is possible that some valuable studies may have been excluded; however, in our review, there were only six candidate studies without full text available. Our investigational strategy models a comprehensive search that most English-speaking providers who deal with civilian gun violence might use.

Other medical issues that were not the subject of our primary objectives were raised in multiple sources for this review and deserve attention. Many of the case reports described a variable incidence of sexual dysfunction or hypogonadism (8, 11, 21). In addition to future fertility, sexual dysfunction was a concern among veterans experiencing abdominopelvic trauma in the qualitative study from Lucas et al. (21). Given the intersection between sexual dysfunction and infertility, including sexual dysfunction as a search term may have broadened our cohort of sources. However, the treatments for sexual dysfunction differ from the treatments for infertility, and because many of the etiologies for infertility are not as readily recognizable as sexual dysfunction, this scoping review focused on infertility.

Posttraumatic stress disorder (PTSD) was often co-diagnosed in trauma patients included in this review (22, 24, 28). Our findings are consistent with other work on surgical trauma and PTSD demonstrating that PTSD affects approximately 21% of people who survive their traumatic injuries (35). Importantly, there is a well-established connection between PTSD and sexual dysfunction (36). In addition, people with PTSD may experience dysregulation of the hypothalamic-pituitary axis, even in the absence of a direct traumatic brain injury (37). Just as the injuries to reproductive organs may occur concurrently with other trauma, the ways that these injuries influence fertility are inextricably related to endocrine concerns, mental health, and functional abilities that may also impact future fertility. In addition, some people may self-medicate with marijuana to address PTSD symptoms; however, this can negatively impact semen parameters or potentially fertility (38).

This review demonstrates increased interest in the epidemiology and management of penetrating abdominopelvic injuries such as GSWs, as most studies were completed after the year 2000. Most of these injuries occur among people during the peak of their reproductive years. Furthermore, in the United States, African Americans are disproportionately affected by gun violence. The intersection of gun violence, race, and fertility may represent a previously unrecognized contribution to infertility among people of color. Future studies on the prevalence of infertility among victims of gun violence may assist providers in understanding how to

include this in their differential diagnosis for a patient seeking reproductive assistance.

CONCLUSION

In the United States, gun violence is a significant public health issue. Up to 1 in 10 male trauma patients will experience urogenital trauma after a GSW. Despite the prevalence of abdominopelvic GSWs, there is a concerning paucity of data on the intersection of these injuries and fertility. Furthermore, there is limited guidance on how to discuss issues of fertility with victims of gun violence who experience abdominopelvic trauma and the ideal follow-up regimen. A systematic framework to address penetrating trauma that may affect fertility has the potential to vastly improve fertility and potentially the quality of life for victims of gun violence who are often in the prime of their reproductive years.

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