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Gunshot wounds to the lower urinary tract: A single-institution experience

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Abstract

BACKGROUND—This study aimed to analyze characteristics and outcomes of gunshot wounds to the lower urinary tract at our Level I trauma center. Our hypothesis is that gunshot wounds to the lower urinary tract have characteristic bullet trajectories, injury patterns, and associated injuries.

METHODS—Our prospective trauma database was composed of reviewed gunshot wounds to the lower urinary tract including the pelvic ureter, bladder, or urethra from 1989 through 2011.

RESULTS—We identified 50 patients (median age, 25 years; range, 3–53 years) with lower urinary tract injury. There was a mean of 2.3 bullets per patient (range, 1–8), with 26 patients injured from a single bullet. Urologic injury involving only the bladder occurred in 72% (36 of 50) of the patients. Ureteral injury was diagnosed in 20% (10 of 50) of the patients. Bullet trajectory was known in the majority of multiple bullet injuries and all cases involving a single bullet. All patients but one were managed operatively. During exploration, 90% (34 of 38) with transmural bladder injury had recognized bladder entry and exit wounds. Overall, 80% (40 of 50) had concurrent gastrointestinal injury. In patients with a single gunshot wound to the lower urinary tract, 58% (15 of 26) sustained concomitant intestinal injury, and 23% (6 of 26) sustained rectal injury. Of 20 posteroanterior gunshot wounds, 80% had buttock entry. All 10 single-bullet buttock-entry gunshot wounds injured the bladder. Isolated ureteral injury was associated with lower abdominal entry and anteroposterior trajectory. Urethral injury occurred in 4, with 75% upper-thigh entry.

CONCLUSION—Penetrating injuries to the lower urinary tract most commonly involve the bladder. During exploration for gunshot wounds to the bladder, two injury sites should be

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AUTHORSHIP

J.W.M., S.P.P., J.B.M., and B.N.B. designed this study. N.M.C., S.P.P., S.D.B., and H.S.B. conducted the literature searches. N.M.C., S.P.P., J.B.M., S.D.B., and H.S.B. collected the data, which N.M.C., S.P.P., and J.B.M. analyzed. N.M.C., J.W.M., S.P.P., J.B.M., and B.N.B. contributed to data interpretation. N.M.C. wrote the manuscript, which J.W.M., S.P.P., S.D.B., H.S.B., and B.N.B. critically revised.

DISCLOSURE

The authors declare no conflicts of interest.

expected because failure to close may lead to complications. Gunshot wounds to the lower urinary tract often occur with concomitant bowel injury, with buttock entry. A multidisciplinary approach involving general surgery is imperative.

Keywords

Penetrating trauma; gunshot wound; bladder; lower urinary tract; management

During 2000 to 2008, two thirds of the 86,112 homicides in the United States resulted from firearms.[1] This confirms that penetrating trauma remains an important issue, particularly at urban trauma centers. While some literature has looked at penetrating trauma affecting the kidney[2–4] and external genitalia,[5,6] there is limited research regarding penetrating trauma affecting the lower urinary tract (LUT) (Table 1). Renal trauma is increasingly being managed nonoperatively; however, LUT trauma is still predominantly managed surgically. This is related to associated injuries of transpelvic gunshot wounds (GSWs) and complex pelvic anatomy, involving the urogenital and gastrointestinal systems, vascular structures, and bones.

Of the patients who experience traumatic injuries, 3% to 10% will have urinary tract involvement, with the kidney, bladder, urethra, and ureter most frequently involved, respectively.[7] Penetrating injury to the bladder occurs in 3.6% of abdominal GSWs, 13% of penetrating injuries to the rectum, and 20% of penetrating injuries to the buttock.[8] Gross hematuria is the cardinal sign. While cystography is recommended to rule out penetrating bladder injury, this may be forfeited in lieu of emergent operative intervention.

We evaluate our management of GSW to the LUT and assess outcomes to see if there are variables that warrant recognition in the primary evaluation that may impact urologic decision making.

PATIENTS AND METHODS

We reviewed our prospectively collected database at San Francisco General Hospital, a Level I trauma center, from 1989 through 2011 to analyze GSW to the LUT. Variables relating to mechanism of injury, initial evaluation, management, and outcome were studied. The institutional review board at University of California, San Francisco, granted permission to collect such data.

Injuries were evaluated in the emergency room by the trauma surgery team, with urologic consultation. If the patient was unstable, operative exploration without preoperative imaging was performed. However, a hemodynamically stable patient with a pelvic GSW was evaluated with diagnostic peritoneal lavage, computed tomographic (CT) scan, cystogram, retrograde urethrography, and proctoscopy in various combinations as indicated.

Patients with GSW to the pelvic ureter, bladder, or urethra were included. GSW to the kidneys, proximal ureter, or external genitalia that did not involve the LUT as well as impalement injuries were excluded. Patient follow-up consisted of one clinic appointment within 4 weeks of hospital discharge.

RESULTS

GSW to the LUT were identified in 50 patients (Table 2), with a median age of 25 years (range, 3–53 years). Most patients were male (94%, 47 of 50). There were five pediatric patients. There was a mean of 2.3 bullets per patient, with 26 patients sustaining injury from a single bullet. Perioperative mortality occurred in two from multiple GSWs to the chest. Gross hematuria was observed in 72%. All patients but one were managed operatively.

Overall

Urologic Injury—Overall, 84% (42 of 50) had bladder injury, with 38 transmural and 4 contusions. Isolated bladder injury occurred in 36 patients, and a combination of bladder and ureteral injuries occurred in 6 patients. Of the 10 patients (20%) with ureteral injury, all had unilateral injury, and 4 had sole urologic injury. The four patients who had GSW to the urethra sustained no other urologic injury.

Concomitant Gastrointestinal-Urologic Injury—Overall, 80% (40 of 50) sustained concomitant bowel injury. Intestinal injury was evident in 60% (30 of 50), and rectal injury was evident in 34% (17 of 50). Fecal diversion was performed in all but one. This 5-year-old had a rectal serosal injury that was oversewed.

Bullet Trajectory and Associated Injuries—Bullet trajectory is determined by the synthesis of information provided by patient history, physical examination of entry and exit wounds, and radiographic imaging. Of the 47 patients with known bullet trajectory, anteroposterior (AP) trajectory was associated with 71% intestinal (17 of 24) and 33% rectal (8 of 24) injuries. Posteroanterior (PA) trajectory was associated with 45% intestinal (9 of 20) and 35% rectal (7 of 20) injuries. Therefore, while AP and PA bullet trajectory demonstrated equivalent rectal injury rates, AP trajectory was 1.6 times more likely to be associated with intestinal injury compared with PA. Of the 20 PA GSW, 80% (16 of 20) had associated buttock entry. Most AP GSWs had lower abdominal entry (16 of 24, 67%), with all isolated ureteral injuries occurring with lower abdomen entry and AP trajectory.

Single Bullet

Urologic Injury—Since a single GSW demonstrates a more discernable trajectory than cases involving multiple bullets, closer injury pattern associations could be analyzed. GSW from a single bullet occurred in 26 patients, with bladder injury in 81% (21 of 26) of these.

Concomitant Injury—Relative to patients with multiple GSWs, there were equivalent rates of concurrent intestinal injury but a 33% reduced chance of rectal injury (Table 2). All six patients initially identified with rectal involvement from a single GSW underwent fecal diversion.

Bullet Trajectory and Associated Injuries—All cases involving a solitary bullet had an identifiable entry and exit wound that permitted discernable trajectory assessment. A single GSW in the AP trajectory was 1.8 times (83 of 45) more likely to result in

concomitant intestinal injury versus PA trajectory, paralleling the findings for multiple bullet GSWs to the LUT.

All 10 patients with buttock entry from a single GSW had bladder injury, while 7 also had combination gastrointestinal injury (5 intestinal, 3 rectal). Of 9 patients sustaining GSW with a lower abdominal entry site, all sustained gastrointestinal injury (8 intestinal, 3 rectal), with bladder injury in 7 and ureteral injury in 2 patients.

Urologic Injury

Bladder—All patients with clinical or radiographic diagnosis of bladder injury were surgically explored except one. During bladder exploration, the bladder was opened anteriorly on the peritoneal surface for thorough evaluation. Posterior bladder injuries were closed in a single full-thickness layer, and anterior injuries were closed in two layers. A Foley catheter was used for bladder drainage, with suprapubic tube (SPT) placement at surgeon's discretion.

More than 90% (34 of 36) of transmural bladder injuries were noted to have both entry and exit bladder wounds, representing a through-and-through path of the bullet. Of the 42 patients with GSW to the bladder, 50% occurred from cases with a single bullet, and most had combined injury to the gastrointestinal tract (82%). Rates of gastrointestinal injury were similar with extraperitoneal and intraperitoneal bladder injuries. There was a higher likelihood of rectal injury with extraperitoneal bladder injury. Intraperitoneal-only bladder injuries were observed with a strong intestinal injury association.

Ureteral—Most of the 10 ureteral injuries were identified during intraoperative evaluation with open bladder direct visualization of the ureteral orifices. Ureteral injury was managed with ureteroneocystotomy (7), ureterouretostomy (2), and stenting (1). If distal ureteral or ureteral orifice injuries were present, ureteral reimplantion was performed. Ureterouretostomy was performed if the ureteral injury was deemed not amenable to reimplantation. Ureteral stenting occurred for ureteral contusions. Of the four isolated ureteral injuries, initial evaluation demonstrated gross hematuria in 50% and absence of any hematuria in 50%.

Urethral—GSW to the urethra occurred in 4 patients, with 75% upper thigh entry. Two posterior urethral injuries were managed with primary realignment. Two anterior urethral injuries had concomitant corpora cavernosal injury. One pendulous urethral injury was repaired primarily following debridement and repair of concomitant corporal injury. The other anterior urethral injury involved 8 cm of the pendulous urethra. Months after repair of the corpora cavernosal injury and SPT placement, a fasciocutaneous penile flap was used for urethral reconstruction.

TREATMENT OUTCOMES AND COMPLICATIONS

There were four postoperative urologic complications (8%), including two urinary tract infections, one urinoma, and one rectovesical fistula. The urinoma resulted from an anastomotic ureteroureterotstomy leak, successfully managed by percutaneous urinoma

drainage and prolonged ureteral stenting. The patient who developed a rectovesical fistula had initial repair of anterior bladder and cecum injuries. Postoperatively, there was a massive pelvic bleed, with significant hematuria. Cystoscopy demonstrated posterior bladder neck injury, anoscopy revealed full-thickness rectal injury, and reexploration confirmed a rectovesical fistula. The bladder neck was repaired and a diverting colostomy was performed.

The one patient managed nonoperatively sustained a single lateral trajectory GSW through the groin. CT cystography revealed an extraperitoneal bladder injury, successfully managed by Foley catheterization. Initial evaluation also included rectal contrast studies and sigmoidoscopy. Five days after injury, feculent discharge from the bullet entry site proved to be a rectocutaneous fistula. The drainage did not contain urine. A dedicated cystogram at that time showed absence of contrast extravasation from the bladder. The patient remained clinically stable, and the rectocutaneous fistula closed with conservative management. Although no urologic morbidity resulted from our nonoperative approach, initial bladder exploration may have revealed the rectal injury, which potentially could have altered the prolonged hospital course.

DISCUSSION

Evaluation

Urinary tract injury occurs in 6% to 11% of patients admitted for GSW.[2,9,10] Physical examination should include evaluation of entry and exit bullet wounds, ecchymosis, blood at the urethral meatus, digital rectal examination, and presence of hematuria. Radiographic imaging may be limited by the patient's hemodynamic status, such that complete injury evaluation is conducted during operative exploration.

Bladder

Penetrating injuries to the bladder constitute 5.5% to 30% of total bladder trauma.[11] Patients commonly have associated nonurologic injuries with high morbidity and a 12% to 22% estimated mortality.[12]

In our series, bladder injury constituted more than 80% of the LUT injury. All single-bullet buttock GSW injured the bladder, and all but one lower abdominal single GSW had concomitant intestinal involvement. Since contrast extravasation on cystography does not typically correlate with degree of bladder injury, we recommend operative repair of GSW to the bladder.[11,13]

In addition, as evidenced by our cohort, most patients with bladder GSW had two sites of transmural injury, which may not be apparent on cystography. Thorough examination of the bladder and bladder neck is important, specifically looking for two sites of bladder injury. Bladder exploration also provides access to ureteral orifices and can facilitate proper evaluation of ureters. Ureteral injury can be readily assessed by observation of efflux of urine at the level of the ureteral orifice or passage of a feeding tube up the ureter.

To date, there is no consensus whether combined rectal and bladder injuries should be managed differently from isolated injuries. Rectovesical fistulas, urinoma, and abscess formation are more likely in combination with posterior bladder and rectal trauma because of proximity. In our series, fecal diversion for rectal injury occurred in 16 of 17 patients. We recommend that combination rectal and bladder GSW be treated with fecal diversion and bladder repair, with adequate drain placement, and using interposing tissue between injury sites with nonoverlapping suture lines. Crispen et al.[14] reported that combined rectal and bladder injuries may benefit from omental flap interposition to decrease fistula and urinoma formation. In cases of combination rectal and bladder injury, bladder drainage with both urethral catheter and SPT placement should be considered. Antegrade urethrography can be performed to assess for urethral extravasation, with the SPT left open if extravasation is identified. Moreover, in cases of significant pelvic and lower extremity orthopedic injury, when long-term walking is anticipated to be limited, SPT placement will avoid the risk of ventral urethral erosion that can occur with prolonged urethral catheterization.

Ureter

Penetrating injury to the ureter is estimated in 2.2% to 5% of abdominal GSW.[15] Ureteral injuries are typically difficult to diagnose and require a high index of suspicion. Variables that limit acute ureteral injury diagnosis include suboptimal ureteral opacification on CT scan during the acute phase and delayed presentation of ureteral injury from tissue destruction and necrosis secondary to the blast effect of a GSW. Delayed ureteral injury can present with constitutional symptoms such as fever, nausea, or vomiting; urinoma or abscess formation; ureteral stricture; or compromised ipsilateral renal function.

Associated injury to one or more intra-abdominal organs occurs in more than 85% of ureteral cases, most commonly the small intestine.[16] While hematuria typically occurs with bladder injury, we found hematuria (microscopic or gross) was present only in 1 of 4 patients with isolated ureteral injury. While contrast extravasation or absence of distal ureteral opacification on CTurogram is suggestive of a ureteral injury, we believe that the most reliable method of assessing ureteral integrity remains via direct intraoperative inspection. Preoperative imaging was concerning for ureteral injury in less than one third of our cases. Either intravenous or retrograde contrast or dye can be administered to rule out ureteral injury. Penetrating ureteral injuries involving GSW should be treated operatively. Surgical principles include adequate mobilization and debridement, spatulated ends, and a tension-free, water-tight anastomosis. A high-velocity missile nearby the ureter may result in progression of ureteral injury that may not initially be apparent. Ureteral contusions or cases with unclear evidence of obvious ureteral injury may be evaluated with retrograde pyelography and ureteral stenting as needed.

Urethra

Urethral injury has been described in 15% to 29% of GSW to the penis.[17] Of the four patients with GSW involving the urethra in our series, 75% had upper-thigh entry. Controversy exists regarding optimal management of GSW involving the urethra. In a combined analysis of 59 cases, 73% underwent primary repair, whereas 27% had initial SPT bladder drainage with delayed reconstruction as needed. The reported stricture rate was six

times greater for urinary diversion than primary repair, with diversion patients requiring additional procedures.[6] Conversely, another series of 19 men with posterior urethral gunshot injuries reports an 87% success rate for acute placement of an SPT and delayed urethral reconstruction (mean, 8 months after injury). Benefits of SPT placement and delayed repair include shorter initial operative time, which is important in a trauma patient, minimized blood loss, decreased risk of pelvic abscess, and a high success rate of delayed perineal urethroplasty. Primary endoscopic realignment shares similar benefits of primary repair, with a possible lower stricture formation rate versus SPT placement alone.[18] Penetrating GSW to the urethra are not uniform, and more life-threatening concomitant injuries may support expeditious bladder drainage. While some cite urethral GSW as warranting immediate surgical exploration and repair,[19] we endorse SPT placement, with urethral realignment at the surgeon's discretion, depending on the patient's clinical status and extent of injury. We do advocate primary repair of the urethra with concomitant bladder neck or rectal injury or with complete urethral disruption and a "pie in the sky" bladder, which is typically seen following blunt rather than penetrating urethral injury.[18]

Combination of Gastrointestinal Urologic Injuries

A missed gastrointestinal injury can have devastating consequences, and when a combined rectal-urologic tract injury is overlooked, the result can be significant. Therefore, it is imperative to recognize the potential damage of a bullet to the gluteal or lower abdominal area, even in the absence of hematuria or hematochezia. A heme-negative rectal examination should not preclude proctoscopy, which may need to be performed under anesthesia to permit adequate evaluation. Franko et al.[20] report that in 17 combined rectal and urologic injuries, rectovesical fistulas formed in 24%, and abscess formed in 18%. Crispen et al.[14] note an 8% fistula and 8% urinoma rates.

Treatment Outcomes

Some literature supports conservative management of select GSW. While GSW to the pelvis are associated with injury to extraperitoneal organs such as rectum, bladder, and ureters, hemodynamically stable patients were admitted for sigmoidoscopy and close observation with serial clinical examination.[21] Velhamos et al.[22] report that 32% with GSW to the buttocks were initially managed operatively with significant intra-abdominal injury in 29%. The 68% managed nonoperatively with serial examination sustained no morbidity and no missed injuries. Navasaria et al.[23] report that none of the 63 stable patients managed nonoperatively for GSW to the pelvis required delayed laparotomy. It is suggested that conservative management with close monitoring may avoid surgery for some without resulting in missed clinically significant injury.

Others advocate surgical exploration of GSW to the pelvis because even in the absence of shock or signs of internal injury, rates of mortality for nonoperative management exceed that for surgical management. Moreover, some patients with significant injury may lack abnormal physical findings.[24,25]

Study limitations include poor long-term follow-up, which may be an inherent problem in the setting of trauma. Although our data are from a single hospital, the long-term study

means different surgical teams providing care. Decision to explore, repair, and divert is likely to vary based on surgeon judgment. This may result in different treatment patterns and outcomes. In addition, the evaluation of bullet trajectory, especially with multiple GSWs may be subjective. With contemporary efforts shifting to more nonoperative approaches in managing penetrating injuries, more research needs to be performed to clarify optimal nonoperative schemes and outcomes.

CONCLUSION

In this series, GSW to the LUT were typically managed operatively. With the bladder as the most frequently injured LUT organ, we confirmed that the majority of these injuries revealed an entrance and exit wound. Thorough bladder investigation for two sites of injury is important because unrecognized injuries may risk increased morbidity, including fistula formation. In addition, since many patients are taken to the operating room with limited preoperative LUT imaging, it is imperative to assess for ureteral injury. Concomitant bowel injury is common with transpelvic GSWs. The urologist should ensure general surgery evaluation to rule out bowel injury. To date, there is no consensus regarding the management of combined gastrointestinal-LUT injuries. Further evaluation may provide evidence to support whether the management should differ from isolated injuries and who can safely be managed nonoperatively.

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TABLE 1

Prevalence of Associated Injuries for GSW of the LUT

Reference	Year	GSW to Bladder	Ureter	Urethra
Present series	2011	42	10	4 (3 PR)
Navasaria et al.[23]	2011	58	14	—
Najibi et al.[2]	2010	58	12	9 (4 PR)
Kunkle et al.[6]	2008	—	—	12 (8 PR)
Tausch et al.[18]	2007	—	—	19 (15 DEL)
Cavalcanti et al.[26]	2006	—	—	14 (12 PR)
Crispen et al.[14]	2005	40	—	—
Mohr et al.[17]	2003	—	—	9 (5 PR)
Tiguert et al.[2]	2000	5	—	4 (4 DEL)

Em dashes indicate not applicable entries.

DEL, delayed repair; PR, primary repair.

TABLE 2

GSW Characteristics

	≥1 GSW (n = 50), n (%)	Single GSW (n = 26), n (%)
Urologic injury		
Bladder injury total	42 (84)	21 (81)
Transmural	38 (38/42, 90%)	17 (17/21, 69%)
Bladder wall contusion	4 (4/42, 10%)	3 (3/21, 12%)
Through-and-through injury	34 (34/38, 90%)	16 (100% of operated patients)
Bladder only injury	36 (72)	18 (69)
Transmural	32 (68)	15 (58)
Extraperitoneal	14 (28)	8 (31)
Intraperitoneal	5 (10)	2 (8)
Both	13 (26)	8 (31)
Bladder and ureter	6 (12)	3 (12)
Extraperitoneal	4 (8)	1 (4)
Intraperitoneal	0	0
Both	2 (4)	2 (8)
Ureteral injury total	10 (20)	5 (19)
Ureter only injury	4 (8)	2 (8)
Urethral injury	4 (8)	3 (12)
Concomitant injury		
Gastrointestinal injury	40 (80)	18 (69)
Intestine	30 (60)	15 (58)
Rectum	17 (34)	6 (23)
Both	6 (12)	3 (12)
Major vascular injury	13 (26)	4 (15)
Extremity injury	11 (22)	2 (8)
Pelvic fracture	5 (10)	2 (8)
Chest injury	7 (14)	0
Known bullet trajectory	47	26
AP	24	12
Bladder	19 (79)	9 (75)
Ureter	5 (21)	2 (17)
Urethra	2 (8)	1 (8)
Intestine	17 (71)	10 (83)
Rectum	8 (33)	3 (25)
Most common entry, lower abdomen		
PA	20	11
Bladder	18 (90)	10 (91)
Ureter	5 (25)	3 (27)
Urethra	1 (5)	1 (9)
Intestine	9 (45)	5 (45)

	≥1 GSW (n = 50), n (%)	Single GSW (n = 26), n (%)
Rectum	7 (35)	3 (27)
Most common entry, buttock Lateral	3	3