CHAPTER 4

WOUNDS OF THE BLADDER

GU Tract Structure	Ch 2 Kidney	Ch 3 Ureter	Ch 4,5 Bladder	Ch 6,7,8,11 Urethra	Ch 8,9 Scrotum Testis	Ch 8,9 Spermatic Cord	Ch 8,10 Penis
No. Patients With Injury to Structure	132	36	72	83	199	14	128
% of Total GU Injuries	19.1	5.2	10.4	12.0	32.8	2.0	18.5

GU: genitourinary

INTRODUCTION

The bladder, because of its deep location within the bony pelvis, is not often injured from blunt or penetrating trauma. Injuries of the urinary bladder are found at laparotomy in 4% to 5% of combat casualties with abdominal wounds.[1,2] However, bladder injury is more common in wounds of the lower abdomen, hips, thighs, perineum, and especially the buttocks.[3] Bladder injuries occurred in 72 (14.3%) of 503 patients and in 10.4% of the 692 urological injuries that occurred during the Vietnam War and were managed in Japan (see Table 2-1). The percentage of bladder wounds versus all urological injuries from 3 wars are compared in Table 4-1.[4] Although there is some difference in the percentage of bladder wounds seen in 2 series from the Republic of Vietnam,[4,5] there has been no significant change in the overall incidence since World War II. Of the bladder injuries that were incurred in Vietnam and managed in Japan by the authors (JNW and JWW), 57 (79%) of the 72 were caused by penetrating trauma, and 15 (21%) by blunt, nonpenetrating forces. This chapter is concerned with the 57 wounded soldiers with penetrating bladder wounds.

TABLE 4-1
COMPARISON OF BLADDER WOUNDS IN THREE WARS

War	%*
World War I	31.7[1]
World War II	14.5[2]
Vietnam War	14.7[3]
Authors' experience in Japan	10.4

*Expressed as the percentage of all genitourinary injuries

Data sources: (1) Young HH. Wounds of the urogenital tract in modern warfare. *J Urol.* 1942;47:59-108. (2) Kimbrough JC. War wounds of the urogenital tract. *J Urol.* 1946;55:179-189. (3) Salvatierra O Jr, Ridgon WO, Norris DM, Brady JW. Vietnam experience with 252 urological war injuries. *J Urol.* 1969;101:615-620. Adapted with permission from Selikowitz SM. Penetrating high-velocity genitourinary injuries, I: Statistics, mechanism, and renal wounds. *Urology.* 1977;9(4):373.

Over the centuries, bladder wounds have had a high mortality, especially when complicated by rupture or intraperitoneal perforation. These wounds were nearly uniformly fatal in ancient times.[6] The deep pelvic location of the bladder makes injury to associated organs likely, increasing the probability of serious complications. In 1942, Young, in his classic review of World War I urogenital wounds, wrote:

> In brief, injury of the bladder was rarely a simple, penetrating wound of that organ alone and was most frequently complicated by very serious lesions to other structures and organs with serious immediate and ultimate results, and in many cases, a high mortality.[7(p98)]

Despite the many truisms in this quotation, there has been a significant progressive reduction since World War I, World War II, and in the Korean War in the mortality of casualties whose spectrum of injuries include wounds of the bladder (Table 4-2).[1] The decrease in mortality is due to a combination of factors:

- protection of the trunk with nylon vests, which resulted in fewer lethal wounds to the abdomen in general;
- reduction in the time elapsed between injury and operation;
- thorough debridement;
- cystostomy for bladder drainage;
- drainage of the perivesical and retropubic space;
- adequate treatment of shock with intravenous fluids, including the nearly unlimited supply of blood and plasma;
- modern antibiotics; and
- use of respirators and suction devices.

TABLE 4-2
MORTALITY FROM BLADDER WOUNDS IN FOUR WARS

War	%
World War I	61[1,2]
World War II	30[3]
Korean War	9[4]
Vietnam War	9.7[5]

Data sources: (1) Fullerton A. Observations on bladder injury in warfare: A study of 53 cases. *Brit J Surg*. 1918;6:24–56. (2) Marshall DF. Urogenital wounds in an evacuation hospital. *J Urol*. 1946;55:119–132. (3) Forsee JH. Forward surgery of the severely wounded. *Am J Surg*. 1951;17:508–526. (4) Artz CD. Battle casualties in Korea: Studies of the surgical research team. In: Army Medical Services Graduate School. *The Battle Wound: Clinical Experiences*. Vol 3. Washington, DC: Army Medical Services Graduate School; 1955. (5) Hardaway RM III. Viet Nam wound analysis. *J Trauma*. 1978;18(9):635–643.

The mortality in the Vietnam War for bladder wounds of 9.7% is essentially unchanged from that in the Korean War. The stable mortality in these 2 wars may well reflect the rapid evacuation of the wounded casualty, as the mortality in hospitals in Vietnam of wounded was twice as high in patients admitted within 1 hour as in those admitted after 18 hours: 31% of all wounded patients in the Vietnam War were in a hospital within 1 hour of wounding, and 86% were admitted within 4 hours of wounding. Many patients were brought into the hospital who, in prior wars, would have been killed in action (died on the battlefield) or died before reaching a hospital. In Korea, time from wounding to hospitalization was 4 to 6 hours; the time was often much longer in the 2 world wars.[1]

Table 4-3 compares the mortality from abdominal wounds by organ for these wounds in World War II, Korea, and Vietnam.[1] The percentages are comparable because they all list deaths at hospitals for definitive surgery in the combat zone. A dramatic reduction in mortality is seen in all categories over time except for wounds of the bladder. The cause of death in abdominal/bladder wounds is not detailed in this report but more than likely was either from septic complications secondary to the high incidence of associated "contaminating" organ injuries (gastrointestinal [GI] tract, urethra, and ureter) or from associated major vascular injuries, which were not tabulated. Of the 45 patients with bladder wounds, 31 (69%) received transfusions of 10.45 units (500 mL) of whole blood per patient, suggesting that serious hemorrhage, shock, and death from vascular injuries likely occurred in some in this group. Currently in major trauma centers, hemorrhagic shock from pelvic vascular injuries caused by transpelvic gunshot wounds (GSWs) results in a greater than 50% mortality.[8,9]

Little has changed in the general principles of diagnosis and treatment of bladder wounds that evolved from the World War II experience. Aside from gross hematuria, the early symptoms of bladder perforation were believed to be of relatively little diagnostic clinical importance, often masked by shock and the multiplicity of associated injuries.[3] Kimbrough summarized the American experience in the European theater, emphasizing (1) the necessity of prompt diagnosis at the initial examination and primary operation and (2) that

> refinements of diagnostic techniques so splendidly described in standard text and current literature had little application in war surgery of the bladder.[10(p183)]

TABLE 4-3
PERCENTAGE MORTALITY FROM ABDOMINAL WOUNDS, BY ORGAN,* IN THREE WARS

Abdominal Organ	World War II %	Korean War %	Vietnam War %
Large Bowel	37	15	6.5
Small Bowel	30	13	5.6
Liver	27	16	8.5
Stomach	41	18	7.3
Kidney	35	25	7.8
Spleen	25	15	4.5
Bladder	30	9	9.7†
Pancreas	58	22	5.7
Ureter	41	50	10.5
% All Abdominal Wounds:	**21**	**12**	**4.5**
% All Wounds:	**3.3**	**2.4**	**1.8**

*There were 17,726 injuries in Vietnam. Data source: Hardaway RM III. Viet Nam wound analysis. *J Trauma*. 1978;18(9):635–643.

†Percentage of 45 bladder injuries in Vietnam

Reproduced with permission from Hardaway RM III. Viet Nam wound analysis. *J Trauma*. 1978;(18)9:636.

Lewis stressed the need and role of surgery in the early definitive diagnosis of bladder wounds, writing that

> when in doubt, it is safest to explore and drain the bladder. The scalpel is the safest emergency instrument.[11(p1404)]

Several broad principles and recommendations for the treatment of bladder wounds resulted from the urological experience of World War II:

1. control of hemorrhage and management of shock;
2. suprapubic cystostomy for bladder drainage;
3. primary suture repair of the bladder defect;
4. debridement and perivesical pelvic drainage;
5. recognition and treatment of associated wounds of the GI tract, ureter, and urethra; and
6. colostomy in all colorectal wounds.

During the Vietnam War, the basic guidelines that had evolved from the World War II experience were used, in general, by urologists in their initial treatment of these wounded casualties. In Vietnam, bladder injury was suspected in all lower abdominal or pelvic injuries, especially when associated with bloody urine on catheterization, urinary extravasation, or both. Cystography was not done in patients with penetrating wounds, as the results would not alter the decision to operate and explore the abdomen and pelvis.[5] All 57 patients had transabdominal intraperitoneal and bladder pelvic exploration with primary closure, resection of small-bowel injuries, and colostomy or cecostomy with resection, or both, as indicated for perforation of the large bowel, rectum, or both. Pelvic bleeding was usually treated by packing or suture ligation. Cystotomy with intravesical exploration, debridement, and primary single- or double-layer catgut closure were used to treat bladder perforations.

Several cases of massive bladder destruction, often associated with destruction of the posterior urethra, were managed by bladder reconstruction and anastomosis to the urogenital diaphragm over a stenting urethral catheter (see Chapter 7, Wounds of the Posterior Urethra and Prostate). There were no reports of urinary diversion in Vietnam in managing these extensive, destructive bladder and posterior urethral wounds. To exclude possible distal ureteral injury in wounds of the trigonal region and adjacent perivesical regions and to facilitate bladder repair, the ureters were catheterized. Injuries to the terminal ureter were treated by ureteral reimplantation and stenting. Ureteral contusions were managed with ureteral stenting.[5]

Most extensive wounds of the bladder were drained with suprapubic cystostomy (usually a large Malecot suprapubic tube) and often combined with a Foley urethral catheter, especially in associated injuries of the posterior urethra (Table 4-4). Twenty-four patients had suprapubic cystostomy combined with urethral Foley catheter drainage, including all 9 patients with posterior

TABLE 4-4
URINARY BLADDER DIVERSION IN VIETNAM

Type of Diversion	No. Patients
Suprapubic Cystostomy	20
Urethral Foley Catheter	13*
Suprapubic and Foley Catheters	24†
Total Patients:	**57**

*3 required suprapubic cystostomy in Japan
†9 patients had posterior urethral injuries

urethral injuries. Twenty patients had bladder drainage with a suprapubic tube only, and 13 had Foley urethral catheter drainage only (3 of the 13 required suprapubic drainage in Japan because of persistent vesical fistulae and inadequate bladder drainage). (See the Surgery and Treatment of Complications section in this chapter.)

All wounds of exit and entry were debrided and left open for delayed primary closure (DPC). Generally the pelvis was drained with anterior exiting Penrose drains. Two patients had coccygectomy in Vietnam as part of the initial treatment of their wounds to enhance pelvic debridement and drainage. Antibiotic therapy with penicillin, streptomycin, and chloromycetin was the standard of care.

All 57 patients arrived in Japan 4 to 30 days after their injuries—most commonly at 14 days. Approximately half of the patients had had a septic postinjury, postoperative course in Vietnam. They often arrived in Japan with elevated temperatures and with varying degrees of purulent and urinary pelvic and wound drainage, which were frequently associated with poorly functioning, often obstructing Penrose drains and tubes (see Table 4-11 in the Complications section, below).

WOUND ANALYSIS

We managed 57 patients with penetrating bladder wounds in Japan (Table 4-5). Of these wounds, 29 were caused by bullets, 26 by multiple fragments (from explosive devices such as mines), and 2 by penetrating impalement wounds: one soldier fell from a tank onto a stick, which perforated his rectum, prostatic urethra, and bladder base; and the other impalement wound occurred when a helicopter pilot crashed and fell backward onto the control stick, which perforated his rectum and bladder base.

The types of wounds of the bladder created by bullets ranged from lacerations of varying sizes to massive explosive tissue destruction of much of the bladder. Multiple fragment wounds (MFWs) generally created less destruction of the bladder and created 1 or more lacerations. Bladder damage from secondary missiles (bone fragments) created by high-velocity GSWs was occasionally reported. Bladder contusions were uncommon, occurring

TABLE 4-5
ETIOLOGY OF BLADDER WOUNDS

	Bladder Wounds	
Wounding Agent	**No.**	**%**
Bullets	29	51
Multiple Fragments	26	46
Impalement	2	3
Totals:	**57**	**100**

in 5 (8.7%) of 57 patients with bladder wounds, most often from MFWs, and were associated with significant other organ wounds in the abdomen and pelvis (multiple wounds) in 2 patients.

Of our 57 patients, 27 (47%) had 1 or more (total = 35 extravesical injuries) associated GU organ wounds (Table 4-6). The ureter was the organ most frequently injured in the 27 patients, and this resulted in significant complications (which we managed in Japan): sepsis, urinary extravasation and fistulae, hydronephrosis, and 1 death; ureteral reimplantation was required in 1 patient and nephroureterectomy in 2 (see Chapter 3, Ureteral Trauma). Most of the 13 ureteral injuries involved the distal third of the ureter. *Posterior* urethral wounds occurred in 9 (33%) of 27 of patients; these wounds are often associated with massive tissue-destructive wounds of the bladder and sphincteric mechanism, urinary extravasation, sepsis, and, in 1 case, urinary diversion (see Chapter 7, Wounds of the Posterior Urethra and Prostate, Case 7-7). Scrotal wounds associated with testicular injury occurred in 5 patients, requiring 3 orchiectomies and 1 partial orchiectomy. There were 3 anterior urethral wounds and 1 spermatic cord transection. One patient had wounds of the penis, scrotum, testis (orchiectomy), and ureteral transection in addition to his bladder wounds.

TABLE 4-6
ASSOCIATED GENITOURINARY ORGAN WOUNDS

GU Organ Wounded	No. Wounds	% of 27 Patients*
Ureter	13	48
Posterior Urethra and Prostate	9	33
Scrotum and Testis	5	19
Penis	4	15
Anterior Urethra	3	
Spermatic Cord	1	4
Total Organ Wounds:	**35***	

*Total patients with associated GU wounds = 27; some had > 1 associated organ wound
GU: genitourinary

Of 57 patients, 47 (82%) had 1 or more associated injuries to extravesical organs in the abdomen and pelvis, and 21 (37%) had 2 or more wounds to associated organs (Table 4-7), whereas 10 (18%) had no other associated-organ wounds except wounds of the soft tissues or long bones, or both, of the extremities.

Of 57 patients, 41 (72%) had 1 or more wounds—at about the same frequency—of the small bowel, colon, or rectum. The distribution of the GI wounds according to GI site and number of wounds in 41 patients with a total of 61 GI-tract wounds is detailed in Table 4-8. Twenty-two patients had a single GI-tract wound: rectum (11), small bowel (6), and colon (5). Multiple wounds to the GI tract occurred in 19 patients: small bowel–colon (11), small bowel–rectum (3), colo-rectum (3), colo-rectal–small bowel (1), and anal-rectal (1), accounting for 39 wounds involving multiple combination GI-tract sites of injury. The rectum was the most common single GI-tract wound site, and overall, the small bowel was the most common site of associated GI tract injury.

Wounds of the bony pelvis were the next most common site of associated injury, occurring in 18 (32%) of 57 patients. The frequency and particular site of injury are outlined in Table 4-9. The pubic symphysis was fractured in 10

TABLE 4-7
ASSOCIATED WOUNDS TO ABDOMINAL AND PELVIC ORGANS*

Injured Organ	Number of Injuries	Number of Patients	%† of All 57 Casualties With Injury
Total Injuries of Small Bowel-Colon-Rectum	61	41	72
Small Bowel	21	21	37
Colon	20	20	35
Rectum	19	19	33
Anus	1	1	2
Bony Pelvis	23	18	32
Ureter	13	13	23
Posterior Urethra and Prostate	9	9	16
Liver	3	3	5
Blood Vessels	5	3	5
Pancreas and/or Gallbladder	1	1	2
Total Organ Injuries:	**115**		

*In 47 (82%) of 57 patients with bladder wounds
†Total exceeds 100%, as many patients had multiple associated organ wounds (47 patients had 178 associated organ soft-tissue injuries), and 21 (45%) of 47 had 2 or more wounds to extravesical organs in the abdomen and pelvis

TABLE 4-8
DISTRIBUTION OF GASTROINTESTINAL WOUNDS

Single GI Site Wound	Number of Patients	Number of Organ Wounds
Rectum	11	11
Small Bowel	6	6
Colon	5	5
Totals:	**22***	**22**
Multiple GI Site Wounds		
Small Bowel-Colon	11	22
Small Bowel-Rectum	3	6
Colon-Rectum	3	6
Colon-Rectum-Small Bowel	1	3
Anus-Rectum	1	2
Totals:	**19†**	**39**

*41 total patients had GI site wounds; 22 had only 1 wound, and that to a single GI site
†41 total patients had GI site wounds; 19 had multiple GI-organ-site wounds
GI: gastrointestinal

(56%) of 18 patients with bony pelvic wounds. Twenty-eight percent of bony pelvic injuries involved the sacrum. The ileum and hip/acetabulum were each injured in 3 (17%) patients and the ischium in 2 (11%) patients. Eighteen patients had 1 or more injuries the pelvic

TABLE 4-9
DISTRIBUTION OF WOUNDS TO THE BONY PELVIS

Site of Bony Injury	No. of Injuries	% Injuries in 18 Patients*
Pubis	10	56
Sacrum	5	28
Ilium	3	17
Hip-Acetabulum	3	17
Ischium	2	11
Total Injuries:	**23**	

*18 total patients had 23 injuries to different pelvic bones; some patients had > 1 bone injured

bones, totaling 23 injuries.

There were 13 (23%) ureteral wounds in 57 patients; primarily, the wounds damaged the distal third of the ureter and accounted for the most common associated extravesical urological organ of injury (see Table 4-6). Nine (16%) of 57 patients had wounds of the posterior urethra.

The liver was injured in 3 (5%) of 57 patients, and there was 1 pancreatic-gallbladder injury. These injuries healed without complications. The 3 casualties with 5 pelvic vascular injuries were managed by (1) ligation of the superior glutaral artery, (2) repair of the common iliac vein, and (3) ligation of the internal iliac artery and vein, and ligation of the external iliac vein. No complications or sequelae developed from the treatment of these vascular injuries. Vascular injuries, especially combination injuries of the external iliac artery and vein, from transpelvic gunshot wounds have had a high mortality rate (> 50% in 1 series).[8] The low incidence (5%) of iliac vessel injury in our series may not reflect the true incidence of these wounds in Vietnam, as some patients with such wounds may not have survived.

In our series, the sites of missile wounds of entry were available from the records in 52 of the 57 patients with bladder wounds (Table 4-10). The most frequent sites of entry of missiles were through the abdomen in 26 (50%) of 52 patients and the buttocks in 23 (44%) of 52. Less-frequent sites of entry were the perineum (15%), the groin (8%), and the hip in 2 (4%) of 52 patients. Several patients had more than one site of missile entry: 52 patients had 63 wounds of entry. Of the 26 patients with abdominal wounds of entry, 16 (62%) were wounded by fragments and 10 (38%) by bullets, whereas 18 (78%) of 23 patients sustained buttocks wounds of entry from bullets and only 5 (22%) of 23 from missile fragments. The high incidence of gunshot wounds of entry to the buttocks implies that these wounds occurred in firefights in situations of ambush by the enemy.

Data regarding the incidence and extent of associated wounds of the soft tissue and long bones of the extremities were incomplete, and were included in patient records primarily when such wounds were extensive. Nevertheless, 11 patients had 1 or more major soft-tissue wounds and long-bone fractures involving the lower or upper extremities, or both, including all 4 extremities in 1 patient. MFWs accounted for 9 such wounded casualties, and 2 had GSWs, which resulted in the only known extremity amputation among the 57 patients with bladder wounds.

TABLE 4-10
MISSILE WOUNDS: SITES OF ENTRY

Missile Entry Site	No. Wounds of Entry	% of Patients*
Abdomen	26	50
Buttocks	23	44
Perineum	8	15
Groin	4	8
Hip	2	4
Total Wounds of Entry:	**63**	

*52 total patients; some had > 1 missile wound of entry

COMPLICATIONS

Significant complications occurred in 33 (58%) of 57 patients with various forms of local or systemic infection (abscesses and Gram-negative bacteremia), with these associated severe sequelae being most common and serious (Table 4-11). When the patients arrived in Japan, 23 of them had 1 or more abscesses that required some form of enhanced drainage. Fifteen (45%) of the 33 patients developed sepsis including Gram-negative septicemia in 5; acute pyelonephritis associated with vesicorenal reflux and bacteremia in 5; peritonitis in 3; and

TABLE 4-11
MAJOR COMPLICATIONS IN PATIENTS MANAGED IN JAPAN

Complication	Number	
	Complications	Patients*
Abscess in Abdomen and/or Pelvis		23†
Sepsis		15
Gram-negative septicemia		5
GI hemorrhage, coagulopathy, death		2
Acute pyelonephritis, vesicorenal reflux		5
Peritonitis		3
Urinary Tract Fistulae	25‡	16
Vesicocutaneous	16	
Vesicorectal	3	
Vesicoperitoneal	1	
Posterior urethral cutaneous	2	
Ureterocutaneous	2	
Ureteroperitoneal (urinary ascites)	1§	
Osteomyelitis Bony Pelvis		8
Small Bowel Fistula		2
Small Bowel Obstruction		2
Fecal Fistula		2
Urethral Stricture		4
Hydronephrosis	3	2
Epididymo-Orchitis		3
GI Hemorrhage (“Stress Ulcer”)		1
Renal Failure		1
Periurethral Abscess		1

*33 complications in 57 total patients, for 58% complications
†Many patients had > 1 abscess
‡25 fistulae occurred in 16 patients
§See Chapter 3, Ureteral Trauma, Case 3-1
GI: gastrointestinal

2 developed sepsis-induced refractory coagulopathy, massive GI and systemic hemorrhage, and death.

Twenty-five urinary tract fistulae occurred in 16 patients: all 16 had vesicocutaneous fistulae; 3 also had vesicorectal; 1 had vesicoperitoneal; 2 had posterior urethral cutaneous; 2 had ureterocutaneous; and 1 had ureteral peritoneal, which resulted in massive urinary ascites, eventually complicated by sepsis, renal failure, coagulopathy, massive GI hemorrhage, and death (see Chapter 3, Ureteral Trauma, Case 3-1). None of these fistulae closed without further debridement and improved drainage, and even these procedures were no guarantee of closure. Osteomyelitis of the bony pelvis associated with urinary fistulae was present in 8 patients; this complication often required multiple debridement and removal of infected tissue and bone.

Two patients had small bowel fistulae: one had an ileal leak; the other, a missed duodenal perforation, which contributed to 1 of the deaths from peritonitis, sepsis, renal failure, coagulopathy, and refractory bleeding. The 2 fecal fistulae resulted in pelvic abscesses. Significant urethral strictures requiring treatment in Japan developed in 4 patients. Hydroureteronephrosis, secondary to distal ureteral obstruction, occurred in 2 patients (1 bilateral). One of the 3 patients with epididymo-orchitis required orchiectomy; and 1 patient developed sepsis secondary to a periurethral abscess, which responded to incision and drainage.

Some of the complications did not necessarily directly result from the type of injury, and they may not be unique to the modes of management. However, these complications can significantly add to the patient morbidity; they include

- catheter-induced urethritis, bacterial cystitis, reflux, acute pyelonephritis, Gram-negative sepsis, epididymo-orchitis, periurethral abscess, and urethral strictures;
- intestinal obstruction; and
- colostomy retraction.

Not all of these complications are tabulated.

Additionally, the great majority of these patients' urine was infected with Gram-negative bacteria (*Escherichia coli* and species of *Klebsiella-Aerobacter, Pseudomonas,* and *Proteus*) due to indwelling urethral catheters and suprapubic tubes. Often, these organisms were resistant to the antibiotics. Several episodes of Gram-negative sepsis followed urethral instrumentation (catheter change, urethral dilation for stricture, or both).

SURGERY AND TREATMENT OF COMPLICATIONS

Twenty-one of 33 (64%) patients with complications of their bladder wounds required a variety of general anesthetic operative procedures in Japan (Table 4-12). (Routine colostomy closure and minor procedures such as nonanesthetic debridement, wound irrigation, replacement of drains and tubes, panendoscopy, proc-

TABLE 4-12
SURGICAL PROCEDURES IN JAPAN IN PATIENTS WITH MAJOR COMPLICATIONS OF BLADDER WOUNDS

Surgical Procedure	No. Patients*
I&D, Debridement of Wounds in the Abdomen and/or Pelvis	18†
Fistulectomy-Urinary Tract	13†
Suprapubic Cystostomy	9
Coccygectomy	5
Celiotomy	5†
Repair GI fistula	4
Gastrostomy	3
I&D abscesses and hematoma	3
Lysis of small-bowel adhesions (internal observation)	2
Ligation of bleeding vessels	2
Vagotomy and pyloroplasty	1
Nephrostomy	2
Nephroureterectomy	2
Ureteral Reimplantation	1
Ileal Conduit Urinary Diversion	1
Internal Urethrotomy	1
I&D Periurethral Abscess	1
Orchiectomy	1

*21 of 33 patients had surgery for complications in Japan
†Some patients had > 1 procedure
I&D: incision and drainage
GI: gastrointestinal

toscopy, urethral dilation, and DPCs of wounds are not included in Table 4-12.) Eighteen patients had 1 or more explorations of their wounds and drainage sites with debridement and redebridement of necrotic tissue, and drainage of abscesses and sites of urinary extravasation and injured organs. Debridement of the urinary fistula tracts was performed 1 or more times in 13 of the 16 patients who had 25 urinary tract fistulae. We found that managing vesical fistulae with debridement and drainage alone was often insufficient for healing and frequently contributed to prolonged morbidity. Preferably, the necrotic, infected, usually fibrotic bladder tissue should be excised and the fistulous defect closed with suture.[12] Standard surgical techniques were used to repair the 4 GI fistulae.

Nine suprapubic cystostomies were performed in Japan: 3 for inadequate Foley urethral catheter bladder drainage as primary treatment in Vietnam of extensive bladder perforations with subsequent fistulae; 2 to replace small,

eccentrically positioned, poorly functioning suprapubic tubes; 2 to reestablish adequate bladder drainage after premature removal of suprapubic tubes in Vietnam without X-ray studies to ensure healing of fistulae; and 2 to enhance bladder drainage and facilitate the bladder debridement and fistula repair. Suprapubic cystostomy, using large caliber suprapubic catheters (26F–32F Malecot) brought through the bladder dome and exiting the incision in the midline in a cephalad course, should be used to drain penetrating bladder wounds. Foley catheter bladder drainage only in such wounds is contraindicated.

Five patients had coccygectomy to establish adequate pelvic drainage and to facilitate debridement of the retrovesical, perirectal, presacral, and sacral regions (see Case 4-1 through Case 4-4 and their discussions). This is a quick, simply performed, safe surgical procedure to enhance drainage and debridement of the deep posterior pelvis without significant morbidity or sequellae.[12,13]

Five patients had multiple intraperitoneal explorations (celiotomy) and surgical procedures including gastrostomy in 3 patients; excision and repair of 4 small- and large-bowel fistulae; drainage of abscesses in 3; lysis of small bowel adhesions for intestinal obstruction in 2; ligation of bleeding vessels in 2; and vagotomy and pyloroplasty in 1. One patient had 4 separate abdominal explorations and multiple intraabdominal procedures in Japan (see Case 4-12).

A nephrostomy was done in 2 patients: the first for distal ureteral obstruction, and the second for a distal ureteral wound with fistulae. In addition, nephroureterectomy was done in 2 other patients: the first for recurrent bacterial *Pseudomonas* urosepsis that had caused acute pyelonephritis, which was associated with his postureteral reimplant. The implant had refluxed urine into his upper urinary tract. The second nephroureterectomy was for a missed right ureteral injury and a fistula associated with urosepsis, a poorly functioning nephrostomy, and pelvic abscess in a patient with a prolonged hospital course and multiple complications (see Chapter 3, Ureteral Trauma, Case 3-4).

An ileal conduit urinary diversion was required in 1 patient who had almost complete destruction of his anterior bladder wall, posterior urethra, and pubis from multiple GSWs with massive, uncontrolled urinary extravasation (see Chapter 7, Wounds of the Posterior Urethra and Prostate, Case 7-7). In other patients, a severe urethral stricture responded to an internal urethrotomy, a periurethral abscess with sepsis was treated by incision and drainage, and 1 patient had an orchiectomy for a destroyed testis from epididymo-orchitis.

CASE STUDIES

The following case studies illustrate the complexity of bladder wounds. This is reflected in the high incidence of associated "contaminating" organ injuries and complications: primarily sepsis, urinary extravasation, and fistulae. The utility of coccygectomy in enhancing pelvic drainage and debridement is presented in several case reports.

Complicated Wounds Treated With Coccygectomy in Japan

Case 4-1

A. D., a 22-year-old first lieutenant, sustained a GSW to the right buttock; the bullet exited from the left groin with resulting fractures of the right iliac bone and sacrum and perforations of the terminal ileum, bladder, and sigmoid colon. As initial treatment, the soft-tissue wounds were debrided, the ileum primarily repaired, the bladder closed and drained with a Foley catheter only, and a sigmoid colostomy performed. One month later, A. D. arrived at US Army Hospital, Camp Zama, Japan, septic with purulent urinary drainage from the buttock and left groin. He presented with a poorly healing abdominal wound, a colostomy, a left groin fistula tract, and right buttock fistula tract.

An intravenous pyelogram (IVP) demonstrated a contracted bladder with urinary extravasation. A fistulogram demonstrated the extent of the fistulae. At surgery, the patient had debridement of the right iliac bone and pelvis, suprapubic cystostomy, and placement of a perineal sump, which functioned poorly.

He rapidly became afebrile but continued to intermittently drain urine and pus from the right buttock. Six weeks later, cystography demonstrated a persistent bladder fistula; subsequently, he had removal of the coccyx, extensive pelvic and iliac bone debridement, and excision and closure of the bladder fistulous opening. He manifested no further urinary leakage and was evacuated to the continental United States (CONUS) 1 month later (5-mo postinjury) with all tubes out, but with persistence of the right iliac osteomyelitis.

Comment on Case 4-1

This case demonstrates the importance of thorough initial debridement including removal of devitalized bony fragments. With more adequate initial urinary drainage (suprapubic cystostomy) and bladder debridement, the bladder fistula may well have been avoided. Because of the unpredictability of bladder fistula closure even following the establishment of seemingly adequate bladder and perivesical drainage, these defects should be excised and primary closed when feasible. Coccygectomy was done to facilitate adequate pelvic drainage and debridement, especially to the posterior bladder, rectal, pararectal, and sacral regions.

Case 4-2

B. O., a 20-year-old soldier, sustained a gunshot wound of entry to the right groin just lateral to the scrotum. The bullet entered the pelvis and exited through the mid sacrum with anterior and posterior perforations of the bladder and rectum. The preoperative IVP was normal. The anterior bladder perforation was closed and the bladder was drained with a suprapubic and urethral catheter. The rectal perforations were sutured and a sigmoid colostomy was performed. Anterior pelvic drains were inserted.

He arrived at Camp Zama 15 days later with the postoperative injury course being marked by daily febrile spikes and profuse pelvic and presacral urinary drainage with poorly functioning catheters. The nonfunctioning suprapubic catheter and obstructing anterior Penrose drains were removed. A cystogram demonstrated defuse pelvic and rectal extravasation. The upper urinary tracts were intact on excretory urography. Sump drainage controlled the urinary leakage, but the patient remained septic.

At pelvic exploration 5 days later, large defects in the anterior and posterior bladder wall were closed after debridement, and suprapubic drainage was reestablished. The infected bony fragments of sacral bone were removed, and the retrovesicular, perirectal, and parasacral areas were debrided and drained after removal of the coccyx. The patient manifested no further urinary leakage and soon was afebrile. A severe penile urethral stricture was noted 1 month after this surgery and required frequent dilations and subsequent interior urethrotomy. Cystography done 6 weeks after the surgery revealed an intact bladder without reflux.

At the time of evacuation, 7 weeks after surgery in Japan, the coccygectomy site and sacral defect were closed and the area covered with granulation and immature skin. Except for slight soreness on prolonged pressure from sitting, B. O. was without symptoms in this area.

Comment on Case 4-2

This case demonstrates the importance of thorough initial debridement and the need for redebridement. Bony fragments bathed in stool and urine provide a poor setting for primary healing. Coccygectomy is an ideal way of debriding and establishing suitable dependent pelvic drainage in some of these complicated injuries especially with sacral bone and rectal involvement.

Case 4-3

J. W., a 19-year-old soldier, incurred a gunshot wound of entry of the right buttock with multiple perforations of the small bowel, rectosigmoid colon, and bladder. At exploration of the abdomen and pelvis, the perforations in the small bowel and 3 holes in the rectosigmoid colon were closed, a sigmoid colostomy performed, a large tear in the left bladder base and trigone primarily closed with a questionable injury to the terminal left ureter untreated, the buttock wound debrided, the pelvis drained anteriorly, and suprapubic cystotomy with Foley catheter drainage of the bladder.

On evacuation to Camp Zama, Japan, 3 days later, the patient was febrile with purulent urinary drainage from the right buttock and had obstructing anterior Penrose drains. A preoperative IVP revealed no obstruction, and cystography demonstrated anterior, posterior, and lateral bladder pelvic extravasation. Five days later he had a coccygectomy, DPC of the buttock wound, debridement, repair of the vesicopelvic fistula, reimplantation of the transected left intramural ureter, and suprapubic cystostomy. The pelvic abscess and urinary drainage ceased after secondary closure of the suprapubic cystotomy.

Following a normal IVP, the patient was evacuated to CONUS.

Comment on Case 4-3

Again, this case demonstrates the problems of incomplete initial debridement and dependent pelvic urinary drainage. Coccygectomy provided adequate debridement of the pelvic structures, including the bladder. The terminal ureteral injury was handled in a standard fashion with reimplantation, which might have been accomplished at the treatment of the patient's original injury.

Case 4-4

G. D., a 34-year-old infantry officer, was wounded by gunshot, receiving several wounds to the right chest wall and thigh and extensive, penetrating, low abdominal, through-and-through bladder, rectal, and sacral injury. He had the anterior and posterior

bladder perforations repaired, suprapubic cystostomy, left sigmoid colostomy and mucus fistula with primary repair of the exit wound of the rectum. His postoperative course in Vietnam was one of continuing sepsis and septicemia (*Escherichia coli*).

His suprapubic tube was removed, and on arrival 17 days later in Japan, he was septic with an open midline suprapubic incision with purulent urinary drainage and a nonfunctioning Foley catheter, and purulent urinary drainage through the exit wound of the sacrum. Cystography revealed marked anterior and posterior urinary extravasation. Coccygectomy with debridement of the sacrum, anterior and posterior pelvis, and pubic symphysis with placement of anterior and posterior pelvic sumps were accomplished. The bladder was minimally debrided and left wide open anteriorly and posteriorly because of the extent of ischemia and sepsis (Figure 4-1).

The patient rapidly became afebrile, the posterior bladder wound closed, the sacral defect granulated and closed, and, because he was unable to tolerate a Foley catheter, the patient was evacuated to CONUS with a progressively closing suprapubic fistula.

Fig. 4-1. Coccygectomy for pelvic debridement: bladder fistula, soft tissues, and necrotic sacral bone; and dependent drainage of the retrovesical, pararectal, presacral areas. Note the 3 large-bore, soft-rubber tubes for irrigation and drainage that exit through the coccygectomy site (the two thin-walled tubes are Penrose drains). The lower end of the sacral wound defect (top of picture) has been closed with granulation tissue.

Comment on Case 4-4

This case again demonstrates the problems of incomplete initial debridement and pelvic drainage as well as repair of the urinary tract. Generally, we found in Japan that chronic bladder defects associated with fistulae are better managed with debridement and repair. However, in this case, because of the marked inflammatory and ischemic changes as well as perivesical pelvic sepsis, secondary closure of the bladder was not accomplished. In extensive wounds of the sacrum, coccygectomy permits dependent pelvic drainage away from the sacral defect, enhancing sacral healing by secondary intention.

Complicated Bladder Wounds With Ureteral Injury and Sepsis

Case 4-5

R. A., a 23-year-old soldier, sustained a GSW of the right buttock. The bullet exited at the pubic symphysis with perforation of the small bowel, rectum, posterior and anterior bladder, and transection of the terminal right ureter. On initial treatment in Vietnam, a segment of the patient's small bowel was resected, the right ureter was reimplanted, the bladder was sutured in 2 layers and drained with a suprapubic tube, a sigmoid loop colostomy was performed in the left lower quadrant of the abdominal wall, and the wound of entry was debrided and drained anteriorly and posteriorly.

The patient arrived at Camp Zama 10 days postoperatively, having run a septic course and was experiencing extensive pelvic pain. His Penrose drains were found to be obstructed anteriorly at the wound of exit; when the drains were manipulated, purulent urinary drainage was found. Several bony fragments could be palpated in the wound of entry. A cystogram confirmed the vesicopelvic cutaneous fistula with reflux on the right side. The Penrose drains were removed because they were obstructing, and the patient was maintained on suprapubic drainage with debridement of the iliac wound, which closed after 4 weeks. Repeat cystography confirmed the consistent vesicopelvic urinary extravasation and right reflux with closure of the cutaneous fistula (Figure 4-2. a,b,c,d,e).

Approximately 6 weeks after admission at Camp Zama, the suprapubic catheter plugged, and the patient developed an antibiotic-resistant *Pseudomonas* septicemia and shock. Three months later, with continuing pelvic extravasation, pain, and right reflux with recurrent acute right pyelonephritis, panendoscopy revealed a well-epithelialized

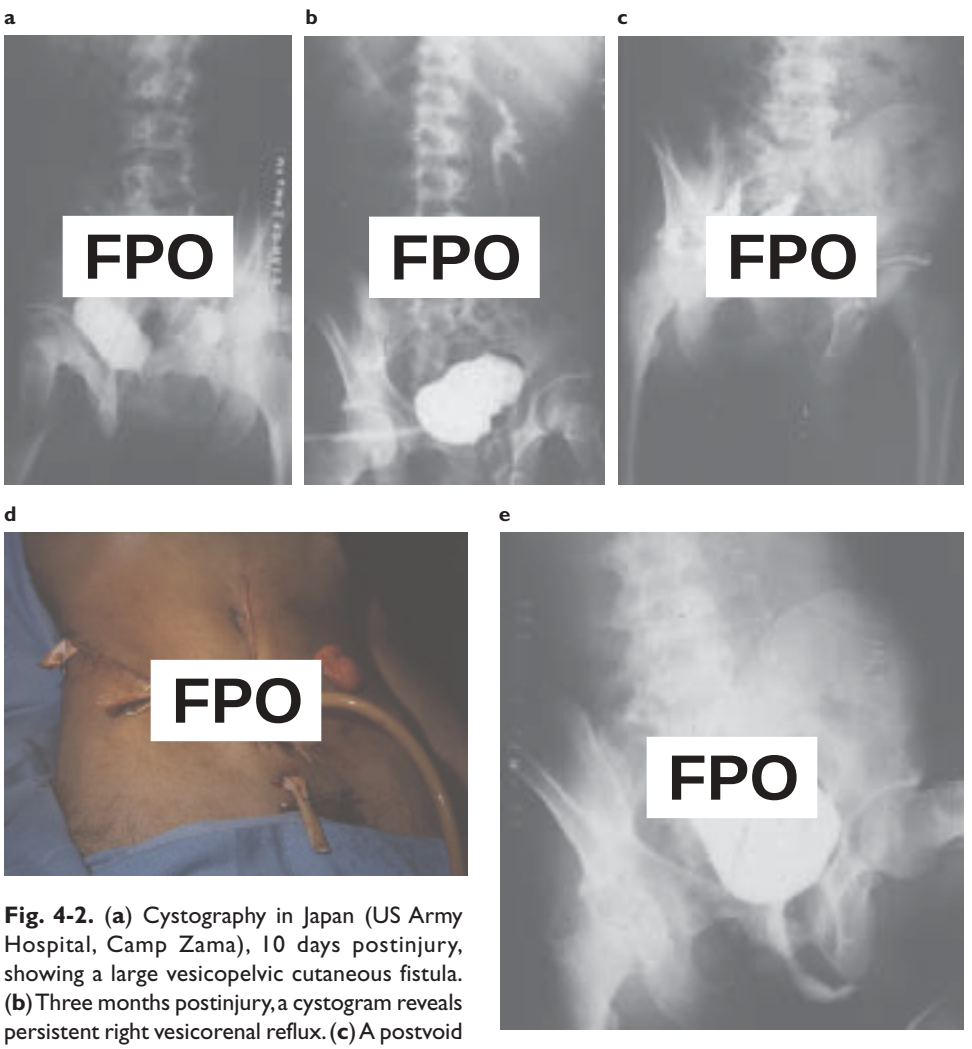

Fig. 4-2. (**a**) Cystography in Japan (US Army Hospital, Camp Zama), 10 days postinjury, showing a large vesicopelvic cutaneous fistula. (**b**) Three months postinjury, a cystogram reveals persistent right vesicorenal reflux. (**c**) A postvoid cystogram reveals the persistent vesicopelvic fistula and osteomyelitis of the symphysis pubis. (**d**) The patient immediately after surgery: debridement of the necrotic pelvic bone and fistulous tract, closure of the bladder, and right nephroureterectomy. (**e**) Five months (27 weeks) after the patient's admission to the hospital, cystography defines an intact bladder without reflux. Following colostomy closure, the patient was evacuated to the continental United States.

vesicopelvic sinus tract and a wide-open, gaping, poorly healing right ureteral orifice. At pelvic exploration, the sinus tract was found to communicate with the cavity of necrotic bone under the symphysis. The patient underwent debridement of the bone and necrotic tissue, closure of the bladder, and nephroureterectomy on the right side. Five days postoperatively, he developed an extensive *Pseudomonas* wound infection followed by several days of urinary leakage from the wound. Four-and-a-half months after admission, a cystogram revealed a small, right-sided bladder defect without fistulae. After the patient underwent colostomy revisions for intraabdominal retraction, his suprapubic catheter was removed and the urine sterilized. Cystography 6 weeks later revealed an intact bladder without reflux.

After colostomy closure, the patient had only mild chronic pain. He was evacuated to CONUS 27 weeks after admission.

Comment on Case 4-5

This case demonstrates the importance of thorough initial debridement and properly functioning tubes and drains, and the close relation between sepsis and fistulae formation. In retrospect, pelvic redebridement with removal of bony fragments should have been performed much sooner in Japan. Nephroureterectomy was done on the right side for persistent antibiotic-resistant *Pseudomonas* pyelonephritis. Reflux and recurring systemic sepsis were potentiated by the infection.

Case 4-6

R. L., a 20-year-old soldier, suffered a GSW to the left buttock; the bullet perforated the sigmoid colon and bladder trigone and anterior wall and exited through the lower anterior abdomen. The rectum was debrided and closed, the distal sigmoid colon exteriorized as an end colostomy, and the wound of entry debrided and the perivesical space drained. The wounds of the bladder were debrided and closed primarily, and suprapubic cystostomy drainage was established. A postoperative IVP done in Vietnam revealed mild hydroureteronephrosis to the level of the left sacroiliac region.

Two weeks later, on evacuation to Japan, the patient's wounds were found to be healing well, but an IVP revealed moderate asymptomatic left hydroureteronephrosis. Two weeks later on repeat IVP, the hydroureteronephrosis was found to have progressed, but it resolved several weeks later after a left nephrostomy drainage was established, and the left pelvic inflammation secondary to fecal contamination from a rectal stump fistula resolved. This fistula closed after daily irrigations with 1% neomycin sulfate, the colon was reanastomosed to the rectum, a cecostomy was performed, and a *Proteus* pyelonephritis responded to antibiotics.

The patient was evacuated to CONUS 4 months after being wounded, voiding per urethra.

Comment on Case 4-6

Medical personnel should maintain a high index of suspicion for ureteral injury in all transpelvic wounds, especially injuries to the bladder base, pelvic vessels, and the colorectum. Because of the nonavailability of suitable ureteral stents and an inability to pass a ureteral catheter, nephrostomy was employed to treat the progressive hydroureteronephrosis. Fecal contamination from the distal colon and rectal stump fistula can be prevented by a completely separated diverting colostomy and antibiotic irrigation of the distal defunctionalized large bowel and rectum.

Case 4-7

B. O., a 21-year-old infantryman, was shot by an AK-47 and sustained open fractures of the right acetabulum and hip joint, small bowel and rectal contusions, multiple perforations of the right side of the bladder, and generalized contusions of the distal right ureter. In Vietnam, he had segmental resection and anastomosis for the perforations of the ileum, a left descending loop colostomy, right ureteral catheter stenting, minimal bladder debridement, and suprapubic cystostomy. The pelvis was drained anteriorly and the buttock wound debrided and drained. His postoperative course in Vietnam was characterized by continued fever, persistent urinary drainage from anterior Penrose drains, and constant right hip pain.

On evacuation to Japan 3 weeks after the injury, the patient had purulent urinary drainage around his nonfunctioning, anteriorly placed Penrose drains, a normal cystogram, a distal right ureterocutaneous fistula without ureteral obstruction, and mixed Gram-negative bacterial infections from the pelvic drainage and bladder. He received organism-specific antibiotics, the obstructing Penrose drains were replaced with pelvic sump catheters, and the right ureterocutaneous fistula healed after placement of external catheter drainage to the fistula site and pelvic cavity.

With all catheters and drains removed, the patient was evacuated to CONUS for colostomy closure and further treatment for the right hip osteomyelitis.

Comment on Case 4-7

This case demonstrates that with bladder pelvic injuries, the ureter is clearly at risk and not uncommonly damaged. We found in Japan that terminal ureteral fistulae not associated with obstruction frequently responded to external fistula-tract drainage with small catheters. Internal ureteral stenting was a problem because of lack of appropriate equipment in Japan.

Missed Bladder Wound and Inadequate Urinary Diversion

Case 4-8

R. C., a 21-year-old soldier, suffered a gunshot wound of entry of the lower abdomen; the bullet exited through the anus. At transabdominal pelvic exploration, multiple perforations of the small bowel were closed and the wound of entry in the anterior bladder wall repaired with no mention of any exit wound of the bladder. In addition, the anterior rectal wall was repaired and a diverting transverse colostomy was done. A Foley catheter only was used to drain the bladder. The skin of the abdominal incision and wound site was dressed open. The patient was evacuated to the surgical service in Japan 4 days later and scheduled for DPC of the abdominal incision, however, cystography revealed a urinary leak at the bladder base into the pelvis and retrovesical region. An IVP was normal. At transabdominal pelvic exploration a large posterior wall intraperitoneal pelvic fistula was repaired, evacuation of an intraperitoneal hematoma, and suprapubic cystostomy and dependent pelvic drainage established. Convalescence was without sequelae.

Comment on Case 4-8

The wounds of entry and exit in all through-and-through wounds of the bladder should be explored both intravesically and extravesically, debrided, and

primarily closed with suprapubic cystostomy bladder drainage. Use of a Foley catheter alone for bladder drainage is contraindicated in the management of these wounds. Cystography should be accomplished postoperatively to access bladder healing and rationally manage these patients.

Inadequate Pelvic Wound Debridement and Pelvic and Bladder Drainage

Case 4-9

A. B., a 20-year-old infantryman, sustained MFWs of the right arm, right leg, left knee, right groin, symphysis pubis, and abdomen with perforation of the bladder, cecum, and right hernial sac, and laceration of the vas deferens. The perforated cecum was exteriorized as a cecostomy, the hernia was repaired, the transected vas deferens was anastomosed, and the lower extremity wounds were debrided and put in casts. Perforating wounds of the anterior bladder wall and right bladder neck were managed with suprapubic cystostomy and Foley catheter urethral stenting. Ten days postoperatively in Vietnam, the suprapubic tube was removed without benefit of a cystogram. The extremity wounds were treated with DPC.

The patient was evacuated to Japan 16 days postinjury, and cystography revealed a vesicopelvic cutaneous fistula. On continued catheter drainage this fistula persisted; he developed profuse urinary leakage from the right lower quadrant, chills and fever, and a penoscrotal periurethral abscess. A suprapubic cystostomy was performed along with debridement of the fistulous tract in the right lower quadrant and pelvis, removal of several bone fragments from the pubis, and incision and drainage of the periurethral abscess, which cultured *E coli* and *Pseudomonas* species. The patient's overall condition rapidly improved with complete healing of the vesicopelvic cutaneous fistula. He subsequently voided with an intact urinary tract.

After cecostomy closure, the patient was evacuated to CONUS for further treatment of his orthopedic wounds.

Comment on Case 4-9

Spermatic cord injuries are relatively uncommon, and this transection was repaired primarily. However, in the extensively wounded patient, just marking the transected ends of the vas deferens with sutures or clips would be more appropriate. Clearly, the suprapubic tubes should have been maintained on this patient, and cystography is mandatory before they are removed. Additionally, continued sepsis involving bony fragments and urine mandate that redebridement be accomplished.

Case 4-10

J. M., a 20-year-old soldier, sustained multiple soft-tissue fragment wounds of the thorax and upper extremities. He had a laparotomy for a pelvic fragment wound; the wound of entry was in the right buttock. There were no intraabdominal wounds; however, an anterior bladder perforation was closed in 2 layers after an intravesical missile fragment was removed, and the bladder was drained with a small, eccentrically placed suprapubic cystostomy tube. The perivesical space was drained with an anteriorly placed Penrose drain. The right buttock was debrided, and the transected right superior gluteal artery was ligated. He had a febrile postoperative course in Vietnam.

Ten days postinjury, he was evacuated to the US Army Hospital, Camp Zama, Japan. Following his admission, the patient had a febrile-abscess course with purulent drainage from the right buttock and sanguinopurulent urinary suprapubic drainage that cultured *Klebsiella-Aerobacter* and *Pseudomonas* species. The bladder drained poorly because of the small-caliber, eccentrically located suprapubic catheter, which became totally occluded. At bladder exploration, the catheter was removed and replaced with a large-caliber suprapubic tube located in the anterior dome and brought out cephalad through the midline. An extensive retrosymphysial perivesical abscess was also drained. The patient rapidly became afebrile and the buttock wound completely healed. After the suprapubic tube was removed, he voided without difficulty.

Comment on Case 4-10

Inadequate pelvic drainage is a persistent problem in these cases. It was difficult to drain the pelvis anteriorly, and these drains often became obstructed and contributed to the continued sepsis. Small and eccentrically placed suprapubic catheters have *no* role in the management of these bladder pelvic injuries. Suprapubic tubes should be brought out through the dome of the bladder, preferably in the midline in a cephalad course.

Case 4-11

P. S., a 20-year-old soldier, incurred a GSW made by an AK-47. The wound of entry was in the right buttock and hip; the bullet perforated the rectum and bladder. On exploration of the abdomen and pelvis, the severely lacerated bladder was found to be full of feces; the ureters were intact, and their integrity was ensured by intraoperative intravesical passage of ureteral catheters; the bladder was debrided and repaired, and suprapubic and Foley urethral drainage established; and the retropubic space was drained after sigmoid colostomy. The patient received penicillin and chloromycetin.

On evacuation to Japan 2 weeks postinjury, the patient was febrile and found to have purulent urinary drainage from the buttock wound. Digital exploration of the wound revealed a large collection of undrained urine and pus; sump tube suction drainage was established, and his generalized sepsis resolved.

The patient was evacuated, with progressive resolution and healing of his wounds.

Comment on Case 4-11

This case demonstrates the extensive devitalizing and contaminating effect of high-velocity transpelvic GSWs, especially when they are associated with rectal injury. The urinary extravasation, pelvic fistulae, abscesses, and systemic sepsis due to inadequate dependent pelvic drainage were the most commonly encountered complications in patients with bladder wounds that we managed in Japan.

Death From Septic Complications: Multiple Organ Failure and Coagulopathy

Case 4-12

S. K., a 25-year-old soldier, sustained shrapnel wounds to the right thigh and the right lower quadrant of the abdomen. One hour later, on admission to the USS *Repose,* examination revealed abdominal pain and diffuse abdominal tenderness and guarding. Other findings included a 2-cm wound of entry just superior to the right pubic tubercle, a superficial wound of the right thigh, and grossly bloody urine in the Foley catheter drainage bag. Surgical exploration

revealed a laceration of the posterior bladder wall and sigmoid colon, 3 perforations of the distal ileum, and a laceration of the left common iliac vein. Intraoperative treatment involved suture of the bladder and suprapubic cystostomy, sigmoid colostomy and creation of a mucus fistula, partial resection of the ileum and end-to-end anastomosis, repair of the common iliac vein, and debridement of the thigh wound. However, abdominal reexploration done 48 hours later because of marked abdominal pain and guarding revealed diffuse peritonitis and partial small bowel obstruction but no demonstrable intestinal anastomotic leak. On the 9th hospital day, the patient developed diffuse bleeding from his colostomy stoma, which was refractory to suture ligation and secondary to a coagulopathy. The bleeding initially responded to transfusions of fresh whole blood, but on surgical reexploration the following day for GI and wound bleeding, no specific bleeding points were found. The patient's diffuse oozing of blood was resistant to the usual hemostatic methods. Later that day, he was reoperated for a large hematoma in the right upper quadrant, which was evacuated, and a small bowel perforation was identified and closed. He continued to receive fresh whole blood transfusions, and slowly the bleeding subsided. During this period, jaundice developed with a total bilirubin rising to 26 mg%, which was believed to be secondary to hemolysis and sepsis. Five days later a fecal fistula spontaneously developed and drained through the right upper quadrant incision, and more wound bleeding required additional fresh whole blood. He then developed purulent drainage from all his incisions, which cultured *Pseudomonas* species. On 2 separate occasions, 2,000 mL of infected hematomas were drained from the right upper quadrant, right upper abdomen, and several attempts at suture closure of the small bowel fistula failed to heal.

On evacuation to the US Army Hospital, Camp Zama, Japan, 34 days postinjury, the patient was found to be malnourished and had a large midline skin incision, a right upper quadrant incision was open with a leaking small bowel fistula and excoriation of the abdominal wall skin; he also had a functional suprapubic catheter, end colostomy, and mucus fistula in the left lower abdomen. The patient's hospital course in Japan was marked by continued sepsis, refractory coagulopathy, massive GI bleeding, multiple intraabdominal abscesses, and a gastric-duodenal fistula. Over 4 weeks, he had 4 separate, major, anesthetic operative procedures in attempts to control his bleeding and intraabdominal sepsis including resection of a duodenal ileal fistula, ileostomy, drainage of multiple intraabdominal abscesses, gastrostomy, evacuation of gastric and extraperitoneal hematomas, and a vagotomy and pyeloroplasty. The patient continued to bleed from his urinary tract, GI tract, and from his incisions. His peritoneal cavity was continually contaminated by his gastric-duodenal fistula. He expired from uncontrolled sepsis and coagulopathy 6 weeks after admission to the US Army Hospital, Camp Zama, Japan. While hospitalized there, he had received 55 units of whole blood, 89 units of fresh frozen plasma, and 3 units of packed red cells in attempts to control his bleeding.

Comment on Case 4-12

This patient developed a severe uncontrolled coagulopathy resulting in multiple organ hemorrhage, presumably from sepsis secondary to uncontrolled peritonitis. The missed small bowel perforation triggered the series of catastrophic events. Thorough initial, complete, intraabdominal exploration, with recognition of the extent of organ injury and with definitive repair, diversion if indicated, and drainage of all visceral and other organ wounds, is vital to minimize postwound complications.

DISCUSSION

There is no significant difference between the low incidence of bladder injuries in the Vietnam War and World War II: they comprise approximately 15% of all urological injuries and their prevalence is only half that of bladder injuries in World War I (see Table 4-1). This stable incidence of bladder injuries results from combat soldiers' greater mobility in the latter 2 wars and the "protected" deep

location of the bladder within the bony pelvis. As in other wars, most bladder injuries were penetrating wounds. Of the 72 bladder injuries experienced in Vietnam and managed in Japan, 56 (78%) were caused by penetrating trauma: GSWs, 29; MFWS, 26; and impalement, 2; whereas the other 15 (22%) were blunt injuries (see chapters 5, Pelvic Fractures and Crush Injuries of the Bladder, and 6, Blunt Pelvic Trauma With Posterior Urethral Disruption).

Anatomical Considerations and Mortality

The deep pelvic position of the bladder and the complex anatomy of the region, with the presence of highly contaminated organs in a relatively small area, increase the likelihood of multiple associated-organ injury—serious complications including hemorrhage and death. The mortality with bladder wounds in Vietnam was 9.7% of all patients who died from abdominal organ wounds. This was the second-highest organ mortality rate in abdominal cavity wounds, reflecting the serious nature of other associated major injuries.[1]

Initial Management

Accordingly, during the Vietnam War, the battle casualty with penetrating pelvic wound or wounds and likely bladder injury, judged by the location and cause of the wound, and bloody urine, urinary extravasation, or both, had prompt transabdominal pelvic exploration to define and treat the bladder and associated injuries. For military combat casualties today, early mandatory exploration of all penetrating pelvic wounds is routine practice. Many civilian trauma surgeons and centers recommend mandatory surgical exploration for all penetrating missile wounds of the pelvis, regardless of the clinical presentation.[9,15]

The general principles of initial management of these complex bladder pelvic wounds, which evolved from a consensus of the urological experience from World War II, were used by urologists in Vietnam (discussed earlier in this chapter) and currently meet recommended standards of treatment for such injuries. Based on our experience in Japan, later in this section we emphasize some refinements in the management of these wounds.

Associated Injuries

The high incidence of injuries to extravesical organs in the abdomen and pelvis (47 of 57 [82%] patients with bladder wounds that were managed in Japan) reflects both (1) the unique proximity of the bladder to multiple organs in the abdomen and pelvis and (2) the penetrating explosive forces of the wounding agents (see Table 4-7). Twenty-one (45%) of the 47 patients with associated-organ wounds had 2 or more other organ injuries, excluding wounds to the soft tissue and long bones of the extremities.

The GI tract was the most common associated–organ system injured: 41 of 57 (72%) patients, with a total of 61 injuries to the small bowel, colon, and rectum. Injury to the small bowel was the most common (37% of patients),

with the colon (35%) and the rectum (19 of 57, or 33% of patients), indicating that a high percentage of these wounds were contaminated.

Thirty-two percent (18 of 57) of patients had 1 or more wounds to the bony pelvis. The ureter was injured in 13 of 57 (23%) patients, and the posterior urethra in 9 of 57 (16%). Twenty-seven of 57 (47%) patients had 1 or more injuries to the GU tract, with ureteral and posterior urethral injury most common. Three patients had liver injuries, 3 had vascular damage, and 1 had gallbladder pancreatic injury; these injuries were all uncomplicated. Both the frequency of multiple associated-organ injuries and the high percentage of contaminated wounds account for their complexity in management and the frequency of complications.

Complications and Management

Some form of localized infection (abscess) and/or sepsis (peritonitis, pyelonephritis, Gram-negative bacteremia and/or shock) and urinary extravasation from fistulae accounted for the most prevalent complications and need for surgery. Of the 23 patients with localized abscesses, 18 required 1 or more general anesthetic debridement and drainage procedures. Two of the 15 patients with sepsis died from peritonitis secondary multiple organ failure, uncontrolled coagulopathy, and massive GI and systemic hemorrhage; and 2 of the 5 with vesicorenal reflux–induced pyelonephritis were cured with nephroureterectomy.

Most of the 25 urinary tract fistulae in 16 patients required 1 or more debridements, surgical closure, and improved drainage (Figure 4-3). One patient, whose bladder and posterior urethra were destroyed, required a conduit urinary diversion in Japan (see Chapter 7, Wounds of the Prostate and Posterior Urethra, Case 7-7). One patient with a distal ureteral fistula was cured with ureteral reimplantation (see Chapter 3, Ureteral Trauma, Case 3-1). Several patients with osteomyelitis of the bony pelvis—often associated with urinary fistulae and purulent pelvic drainage—required redebridement.

In Japan, we performed coccygectomy in 5 patients to establish much-needed pelvic drainage and to adequately debride the retrovesical perirectal presacral and sacral regions (Exhibit 4-1). All 5 of these patients had complicating injuries and presented with sepsis and urinary fistulae. All had various combinations of bladder and colorectal perforations, and osteomyelitis of the pelvic bones (see Figure 4-2 c). The sacrum was fractured in 4. These patients' wounds were healed or healing without further complications on evacuation to CONUS. None had significant local morbidity or fecal incon-

Fig. 4-3. Two weeks after a soldier received a penetrating bladder-pelvic wound, a cystogram (done in Japan) demonstrates a vesicocolorectal fistula, which healed after debridement and closure of the bladder and rectal fistula. A diverting colostomy had been performed in Vietnam.

Exhibit 4-1
Procedure For Coccygectomy In Japan

When we performed coccygectomy in Japan, the procedure was as follows:

- The patient is in the prone position and a midline incision is carried down to the bone over the most inferior aspect of the sacrum and the entire coccyx.
- The coccyx is freed—posteriorly, laterally, and anteriorly—from its periosteal and ligamentous attachments by sharp dissection and a periosteal elevator.
- The tip of the coccyx is grasped and deflected upward, and the tissues are sharply cut from its deep surface while the surgeon stays close to the bone, avoiding the rectum.
- The coccyx is then excised sharply at or just below the sacral–coccygeal joint.
- After the coccyx is removed, the mid posterior wall of the rectum is exposed and may be retracted to either side to enter the pelvis and establish drainage and access to debridement.

Sources: (1) Wettlaufer JN. Coccygectomy in the management of genitourinary pelvic trauma. In: *Proceedings of the Kimbrough Urological Seminar, 27–30 Oct 1969*. 17th Annual Meeting. Eaton Laboratories, Division of the Norwich Pharmacal Co; Norwich, NY: 1969;3:54–59. (2) Commander in Chief Pacific. General surgery: Colorectal injuries. In: *Fourth Conference on War Surgery*. Tokyo, Japan: 16–19 Feb 1970: 32.

tinence from the procedure.[12,13] Our Japan experience resulted in urologists and surgeons in Vietnam performing coccygectomy as part of the initial wound treatment in patients with more-severely contaminated injuries to facilitate debridement and drainage.[14]

Forty-four (77%) of the 57 patients with transpelvic penetrating bladder wounds had complete management of their genitourinary wounds and complications in Japan. These 44 patients left the hospital without catheters, tubes, stents, or drains; and with an intact, functional urinary tract. The other 13 patients (23%) had incomplete treatment of the GU tract wounds: many of these patients had multiple long-term complex problems, most of them nonurological, which were better served by evacuation to CONUS.

Mortality

To restate, the mortality in Vietnam from a large series of patients with surgical exploration of their abdominal cavity wounds was 9.7% from bladder wounds.[1] Several urologists reported no mortality from bladder wounds in their casualties managed in Vietnam.[4,5] F. A. Leary, a urologist working at the US Air Force Clark Field Hospital, Philippines, reported his 2-year experience with 33 bladder-wounded casualties from Vietnam.[16] Twenty-eight (85%) of his 33 patients had completely uncomplicated courses and were promptly evacuated to CONUS, whereas 5 (15%) of the 33 had serious complications and died of massive wounds, poor wound drainage, uncontrolled urinary extravasation, overwhelming infection, and/or sepsis. Leary stressed that anterior exiting pel-

vic Penrose drains provided inadequate nondependent drainage. He encouraged dependent gravity drainage of the perirectal perivesical pelvis through the ischiorectal fossae.

Our experience was similar to that reported by Leary: most patients evacuated to Japan had inadequate pelvic drainage from anteriorly located Penrose drains, urinary extravasation, abscess formation, and sepsis. Two of our 57 patients, who both had bladder wounds that we managed in Japan, died of complications that included highly contaminated wounds, poor control of urinary and bladder drainage, peritonitis, sepsis-induced uncontrolled coagulopathy, and massive hemorrhage.

Recommended Treatment

Based on the Vietnam and Japan experience and current practice in major trauma centers, the following recommendations are reemphasized for the management of the battle casualty with transpelvic penetrating missile wounds of the bladder:

1. prompt mandatory transabdominal pelvic exploration;
2. control of bleeding (packing, ligation, suture);
3. meticulous initial debridement and redebridement of injured tissue;
4. selected primary repair of GU- and GI-tract injuries;
5. complete and adequate fecal (divided-separated colostomy) and urinary diversion (suprapubic cystostomy); and
6. dependent pelvic, perirectal, and perivesical drainage.

These recommendations are aimed at reducing the high complication rate from these complex injuries. Coccygectomy is recommended for extensive, contaminated, destructive wounds to facilitate debridement, repair, and dependent drainage.

All stable patients should have a preoperative digital rectal examination. The medical officer should be alert to the presence of blood, which could be evidence of colorectal injury, and be prepared to perform a proctosigmoidoscopy if the digital rectal examination is negative for blood but if the medical officer still has a high suspicion of colorectal injury (eg, GSWs of the buttocks. A proximal divided colostomy should be performed. Complete fecal washout of the distal colorectal segment should follow the colostomy.[8,14]

SUMMARY

Although bladder wounds were relatively uncommon in the Vietnam War (10.4%–14.7% of all urological wounds), they coexisted with a high incidence of associated injuries to organs in the abdomen and pelvis and other extravesical urological (ureteral and posterior urethral) injuries in 57 (82%) patients that we managed in Japan. Contaminated wounds (of the small bowel, colon, or

rectum) were the most common, and occurred in 72% of patients. These combination bladder–transpelvic wounds resulted in major complications in 58% of patients, with some form of infection (abscess, peritonitis, sepsis) and/or urinary fistulae the most common. Two patients died, and 64% of patients with these complications required 1 or more major anesthetic surgical procedures.

Many of the septic complications and fistulae were related to incomplete initial debridement and drainage and inadequate urinary tract diversion. Patients with complications frequently arrived in Japan septic with large pools of pus and urine behind obstructing, anteriorly exiting Penrose drains. Today's wider use of sump catheters and large-bore, soft tubes in place of Penrose drains is encouraged. The difficulty in achieving adequate anterior drainage of the pelvis mandates the use of presacral, pararectal, perivesical drains exiting the dependent perineum, especially in perforating wounds of the bladder base and rectosigmoid colon with or without bone involvement.

In our hands, coccygectomy was extremely valuable in the management of some of these complicated, complex injuries to the bladder and nearby organs in the abdomen and pelvis. This procedure permitted superb exposure to the retrovesical, perirectal, and presacral areas and the sacrum for debridement, drainage, and periodic wound irrigation. It is especially useful for drainage of the presacral region after debridement of contaminated sacral fractures (see Exhibit 4-1). This procedure is not only recommended for the management of some of these complicated, combined bladder–pelvic wounds, but it should also be considered in the initial management of more-severe complex contaminated wounds.

The prompt deployment and management of tubes is vital to establish and maintain adequate urinary drainage and diversion. Foley catheters are inadequate and contraindicated for primary bladder drainage in bladder-disrupting wounds. Appropriately positioned (26F-32F) Malecot suprapubic tubes should be used in all penetrating missile wounds of the bladder.

A "zone of injury" surrounds the site of tissue wounded by a high-velocity missile. This zone may be difficult to measure visually but will subsequently necrose, thus requiring wide initial debridement. The bladder is a suitable organ on which to perform wide debridement. Accordingly, more-extensive initial debridement will reduce the incidence of necrosis, tissue slough, and fistulae formation.

We recognize that "adequate debridement" can be a problem in an unstable patient with injuries to multiple organ systems, stool contamination, bony fragments, and devitalized tissue masked with blood and extravasated urine. However, in addition to the debridement of grossly devitalized tissue, all "expendable" bony fragments should be removed, which may require redebridement. In several cases in Japan, we found that infected, residual, incompletely debrided, bony fragments resulted in prolonged contamination, sepsis, and fistula formation, which only resolved after all devitalized infected bone was removed.

REFERENCES

1. Hardaway RM III. Viet Nam wound analysis. *J Trauma*. 1978;9(18):635–643.
2. Michels LM. Wounds of the urinary bladder: An analysis of 155 cases. *Ann Surg*. 1946;123:999–1002.
3. Clarke BG, Leadbetter WF. Management of wounds and injuries of genitourinary tract: A review of reported experience in World War II. *J Urol*. 1952;67(5):719–739.
4. Selikowitz SM. Penetrating high velocity genitourinary injuries, I: Statistics, mechanisms, and renal wounds. *Urology*. 1977;9(4):371–376.
5. Salvatierra O Jr, Ridgon WO, Norris DM, Brady JW. Vietnam experience with 252 urological war injuries. *J Urol*. 1969;101:615–620.
6. Hamm FC. Bladder injuries. In: Patton JF, ed. *Urology*. In: *Medical Department, United States Army: Surgery in World War II*. Washington, DC: US Department of the Army, Office of The Surgeon General, and Center of Military History. 1987: 385–405.
7. Young HH. Wounds of the urogenital tract in modern warfare. *J Urol*. 1942;47:59–108.
8. Duncan AO, Phillips TF, Scalea TM, Maltz SB, Atweh NA, Sclafani SJA. Management of transpelvic gunshot wounds. *J Trauma*. 1989;29(10):1335–1340.
9. Theodorakis SP, Baffes TG. Penetrating wounds of the pelvis. *South Med J*. 1985;78(7):782–783.
10. Kimbrough JC. War wounds of the urogenital tract. *J Urol*. 1946;55:179–189.
11. Lewis LG. Treatment of wounds of bladder and urethra. *Surg Clin North Am*. 1944;24:1402–1409.
12. Wettlaufer JN. Experience with Vietnam GU tract war wounds in Japan. In: *Proceedings of the Kimbrough Urological Seminar, 28–31 Oct 1968*. 16th Annual Meeting. Eaton Laboratories, Division of the Norwich Pharmacal Co, Norwich, NY: 1968;2:50–58.
13. Wettlaufer JN. Coccygectomy in the management of genitourinary pelvic trauma. In: *Proceedings of the Kimbrough Urological Seminar, 27–30 Oct 1969*. 17th Annual Meeting. Eaton Laboratories, Division of the Norwich Pharmacal Co, Norwich, NY: 1969;3:54–59.
14. Commander in Chief Pacific. General surgery: Colorectal injuries. In: *Fourth Conference on War Surgery, 16–19 Feb 1970*. Tokyo, Japan; 1970: 32.
15. McAninch JW. Professor and Vice Chair of Urology, University of California, San Francisco; and Chief of Urology, San Francisco General Hospital, San Francisco, Calif. Personal communication, 2003.
16. Leary FJ. Vietnam genitourinary casualties seen at USAF Clark Hospital, Philippines: A two-year experience. Presented at the 16th Annual James C. Kimbrough Seminar, 28–31 Oct 1968; Walter Reed Army Medical Center, Washington, DC; 1968.