

## CHAPTER 13

# LESSONS LEARNED IN THE MANAGEMENT OF CASUALTIES WITH GENITOURINARY SYSTEM INJURIES

### INTRODUCTION

Although accepted surgical principles and standards are applicable to military combat surgery, several differences existed between military (battlefield) and civilian surgery during the Vietnam War and until only recently<sup>1</sup>:

- increased frequency of high-velocity weapon wounds, which produce greater tissue destruction than the more-frequently seen low-velocity wounds, which are the ones seen in the civilian community;
- increased frequency of multiple fragment wounds (from artillery and mortar shells, bombs, booby traps, land mines);
- evacuation of casualties from the combat zone to multiple medical treatment facilities (MTFs) outside the theater of action—even to the continental United States—which precludes continuity of care by the same surgeon and house staff throughout all the phases of wound care; and
- greater incidence of mass casualties with high-velocity wounds in combat hospitals.

Accordingly, most surgeons and urologists arrived in the Republic of Vietnam (RVN) with little or no theoretical knowledge or practical experience of the type and magnitude of injuries (penetrating and blunt) incurred by the combat soldier, especially in mass casualty situations. Many of the lessons in surgical techniques and management, which had been learned from prior wars and were then relearned by these doctors, remain relevant now.

This never-ending process was eloquently described by Thomas J. Whelan, Jr.,<sup>1</sup> who was Chief of Surgery at Tripler General Hospital during the Vietnam War:

Through the bitter experiences in armed conflicts military surgeons have learned their lessons. With the exception of some new advances in resuscitation, monitoring, and physiologic support system[s], there have only been few changes over the years in the patching up of the horrible wounding potential of modern armament. The actual surgical principles and techniques remained the same. Unfortunately, lessons learned over and over again have to be relearned the hard way by civilian surgeons first exposed to wounds of war.<sup>1(p4)</sup>

The learning curve was steep, but fortunately these surgeons rapidly acquired the general surgical principles and techniques for the care of the wounded. As a result, the level of care for the wounded was extraordinarily high during the Vietnam War, reflected by the remarkably low hospital mortality of 2.6%. This hospital mortality would have been even lower if not for the efficiency and rapidity of the helicopter aeromedical evacuation system: patients who would in previous wars have been killed in action were evacuated with mortal wounds to MTFs. (The more-serious wounds that usually involve multiple organ systems and mortality were from nonurological wounds.)

The first revision of *Emergency War Surgery*,<sup>2</sup> which was published in 1975, is an excellent introduction to the problems of war surgery. The national and international consensus that the book contains for the recommended treatment of the combat casualty evolved from the experience of prior wars and the Vietnam War. The 1975 revision was superseded in 1988<sup>3</sup>; anyone doing battlefield surgery should consult both of these and the most recent version<sup>4</sup> of *Emergency War Surgery*.

## LESSONS LEARNED

Many of the surgical lessons learned from the care of the wounded soldier in RVN and Japan are reviewed in this chapter, first in a general sense, and then specifically related to urological wounds. Because of the frequency of more-severe injuries to nonurological organ systems that are associated with genitourinary tract wounds, urologists had to be familiar with both the overall triage and resuscitation and the wounded casualty and the general principles of treatment employed in the management of these nonurological wounds.

### Initial Treatment

#### *Casualty Evaluation and Resuscitation*

The ABCs of evaluating a trauma casualty include (a) ensuring an adequate airway, (b) controlling bleeding, and (c) restoring circulation. Breathing can rapidly be assessed by observation and physical examination; pneumothorax, hemopericardium, and flail chest can be defined and treated rapidly with thoracentesis, aspiration of pericardial blood, and insertion of chest tubes. In the severely injured patient, insertion of an endotracheal tube, with concentrated oxygen available for positive pressure breathing, is often necessary. During the Vietnam War, large-bore intravenous catheters originally intended for monitoring central venous pressure—or even sterile nasogastric tubes inserted through venous cutdowns—were used to rapidly administer large volumes of whole blood and crystalloid solutions (eg, Ringer's lactate). Immediate operation may be needed to control bleeding, and, to optimally time the procedure, the operating surgeon should participate in this phase of the resuscitative process.

### ***Assessment of Injuries***

For all suspected abdominal wounds, a nasogastric tube, urethral catheterization, and rectal examination quickly give valuable information. The presence or absence of blood in either tube or if found during the rectal examination indicates certain injuries and diagnostic and treatment pathways. In patients with hematuria, a high-dose infusion intravenous pyelogram should be performed and then followed by a flat plate X-ray examination of the abdomen, taken either on the way to or inside the operating room. For all suspected abdominal wounds, a midline laparotomy is performed while the patient is being resuscitated or a short time later.

Neither observation nor watchful waiting was employed during the Vietnam War, especially in mass casualty situations, to obviate “losing a patient in the shuffle” who needed laparotomy, as morbidity and mortality were (and still are) greatly increased when abdominal wounds are missed. In general, most urological wounds were diagnosed as part of the secondary survey or by findings at exploratory surgery, the presence of hematuria, and/or subsequent X-ray procedures.

### ***Antibiotics***

The virtues of perioperative antibiotics are well known. Broad-spectrum antibiotics were widely used during the Vietnam War, as nearly all wounds were contaminated on the battlefield prior to surgery. For colorectal and small-intestinal wounds, antibiotics effective against anaerobic rods and cocci (*Bacteroides*, clostridia, and anaerobic streptococci) as well as Gram-negative organisms were targeted for antibiotic coverage.

Patients with persistent fever, sepsis, or multiple organ failure should undergo reoperation in lieu of persistent antibiotic treatment. Antibiotics are no substitute for good surgical debridement and drainage of infection.

### ***Soft-Tissue Wound Debridement and Delayed Primary Closure***

Wounds of the soft tissues are the most common in warfare. Although the necessity and rules for “adequate” debridement and delayed primary closure of these high-velocity, tissue-destroying wounds are accepted by most professional military surgeons, these lessons must be relearned by every generation of combat military surgeon. Then as now, certain structures are to be aggressively debrided (muscle and fascia); others should be removed (completely detached pieces of bone, 2- to 3-mm rim of skin); and specific structures (nerves, blood vessels, tendons, and penile-corporal-erectile tissue) are debrided sparingly. All wounds are dressed open except maxillofacial and craniocerebral wounds, minor hand wounds, and scrotal–testicular wounds.

In general, delayed primary closure should be done in the operating room 4 to 10 days following debridement. Some wounds may need redebridement prior to primary closure.

## **Specific Urological Wounds**

### ***Renal Wounds***

During the Vietnam War, 33% of all battlefield urological trauma involved the kidney, and 80% of the injuries were penetrating (ie, wounds). The mortality in RVN from abdominal renal wounds was 7.5%. Most renal wounds were associated with multivisceral abdominal organ injuries, and the diagnoses were established at abdominal exploration. A high-dose infusion intravenous pyelogram and an X-ray examination (abdominal flat plate) were used to define the side of injury and the “normalcy” of the uninvolved kidney. The controlled approach to the renal pedicle was employed by urologists in exploring a retroperitoneal hematoma or flank mass, but the nephrectomy rate in-country was still high and variable (51%–84%). Many renal wounds were managed by general surgeons. Indications for nephrectomy were irreparably damaged kidney, uncontrolled hemostasis, or to facilitate the management of other wounds and patient resuscitation. Debridement, control of bleeding, and partial nephrectomy with flank drainage were other techniques used in managing these renal wounds.

In Japan, 1 patient died from generalized organ sepsis, and we (JNW and JWW) performed 10 delayed nephrectomies for various combinations of urinoma, nephrocutaneous fistulae, massive delayed hemorrhage (usually associated with perinephric abscess), pyelonephritis, and localized and generalized sepsis. An aggressive approach, namely nephrectomy, was often indicated and curative in resuscitating these patients and managing these complications.

### ***Ureteral Wounds***

Wounds of the ureter were uncommon during the Vietnam War, accounting for approximately 5% of urological wounds; however, their mortality (10.5%) was the highest of all abdominal cavity wounds in which the genitourinary tract was injured that were incurred in RVN. Roughly 20% of these wounds were unrecognized or “missed” in RVN (70% of these wounds were caused by gunshots, 30% by multiple fragments), and missed wounds were associated with a high incidence of intraabdominal visceral injuries, major vascular damage, and bladder wounds. Two thirds of the wounds involved the lower ureter. Ureteral wounds were generally managed by debridement and ureteroureterostomy or ureteroneocystostomy, depending on location of wound, and some attempt was made to accomplish ureteral stenting and wound drainage.

Complications of ureteral wounds that we saw in Japan were numerous: urinary fistulae (33% of patients), significant sepsis (41%), hydronephrosis, and urinary ascites. There were 2 deaths, 1 from sepsis and 1 from coagulopathy with uncontrolled hemorrhage. Seven patients required nephrectomy to manage these complications. Many reasons accounted for the complications:

- incomplete debridement and wound drainage,
- inadequate and uncontrolled urinary diversion and ureteral stenting,
- lack of appropriate ureteral stents,
- high incidence of contaminating associated organ injuries, and
- frequency of missed ureteral wounds.

The last point deserves special emphasis. Morbidity and mortality are greatly increased when a wound is missed at laparotomy. To avoid missing a ureteral wound, all retroperitoneal hematomas should be explored and the ureter should be examined. Wartime and civilian trauma surgeons in general should maintain a high index of suspicion when a missile creates extensive retroperitoneal damage. They should liberally use intravenous dye such as indigo carmine to define ureteral perforation.

### ***Bladder Wounds***

Although relatively uncommon in RVN (10%–15% of all urological wounds), bladder wounds accounted for 9.7% of deaths in abdominal cavity wounds. Wounds of the bladder were associated with a high incidence of contaminating wounds of the gastrointestinal tract (> 70%) and vascular system, resulting in overwhelming sepsis and uncontrolled hemorrhage. Several patients had massive pelvic soft-tissue and bladder wounds. The diagnosis was made at surgical exploration, and the principles of treatment were essentially unchanged from World War II: control of hemorrhage, debridement and primary repair of the bladder and associated injuries, suprapubic cystostomy, colostomy for colorectal injury, and pelvic drainage.

Major complications in Japan developed in 60% of patients; the most common complications were infection (abscess, peritonitis, sepsis), which resulted in 2 deaths from sepsis-induced coagulopathy and uncontrolled hemorrhage; urinary extravasation; and fistulae. Coccygectomy was performed on several patients to adequately debride and drain the pelvis. A lack of controlled urinary and pelvic drainage was a major problem and source of complication in many of these casualties.

### ***Blunt Pelvic Trauma with Posterior Urethral Disruption***

Blunt pelvic injuries with posterior urethral disruption were uncommon during the Vietnam War (only 15 [2.2%] of 692 urological war injuries); most often, they occurred from vehicular trauma. Two thirds of these casualties also had other organ injuries; bladder rupture occurred in one third, which was associated with more-severe injuries and bleeding. Preoperative retrograde urethrography should be done in the stable nonemergent patient with suspected posterior urethral injury before catheterization is attempted. The diagnosis in Vietnam in 80% of these patients was made at pelvic exploration. Initial treat-

ment in Vietnam generally included pelvic exploration; control of hemorrhage; celiotomy for suspected intraperitoneal injury; suprapubic cystostomy; bladder repair; urethral Foley catheter stenting; and attempts at direct suture apposition of the torn urethral ends, often with catheter traction and pelvic drainage.

In Japan, complications developed in 13 (87%) of these 15 patients: urethral stricture, pelvic abscess, urinary extravasation, and periurethral abscess were the most common and required 33 surgical procedures. The inability of anterior Penrose drains to adequately drain the pelvis; poor surveillance of drains in the evacuation process; and small, poorly positioned, often obstructing suprapubic catheters accounted for the frequency of urinary extravasation and pelvic abscesses. Suprapubic cystostomy only for urinary diversion is adequate initial treatment and is indicated when

- an unstable patient has multiple, severe, associated organ injuries;
- a massive pelvic hematoma or bleeding is present;
- urethral stenting is difficult; or
- the operator is inexperienced.

Urethral realignment can be accomplished several days later in MTFs in the evacuation chain under more-ideal conditions. Catheter traction and direct reconstitution and suturing of torn urethral ends are contraindicated.

### ***Wounds of the Posterior Urethra and Prostate***

Posterior urethral wounds were uncommon, occurring in only 20 (3%) of the 692 RVN urological injuries that we managed in Japan. By and large, the 3 puncture wounds and 3 penetrating fragment missile wounds in this group resulted in limited injury and were easily managed. In contrast, the 14 wounds caused by gunshot often resulted in extensive shattering, devitalizing, disruptive wounds of the posterior urethral prostatic membranous urethra and bladder with severe anatomic derangement and bleeding. The bladder was injured in 9 soldiers; of the associated nonurological organ wounds, the most common were injury to the rectum, which occurred in 65% of patients, to the bony pelvis in 40%, and to the small bowel in 35%.

Treatment in RVN was aimed at controlling hemorrhage and reestablishing bladder–posterior urethral continuity, most often over a stenting urethral Foley catheter with or without suture anastomosis of the opposing ends of the deranged or distracted tissue; primary repair of the bladder and suprapubic cystostomy was done in all patients. Severe disrupting wounds should be managed by “damage control”: control of bleeding and suprapubic cystostomy should be done in all; bladder repair should be done if feasible; and nephrocutaneous stenting should be done selectively in instances of massive bladder loss; reconstruction of the lower urinary tract can be delayed.

The major complications that we managed in Japan were primarily in wounds caused by gunshots: pelvic abscess, urethral stricture, massive urinary extrava-

sation and urethral fistulae, extensive tissue destruction of the bladder, and destruction of the urinary sphincter mechanism. These 21 complications in 10 patients required 15 anesthetic operative procedures, including 1 definitive urinary diversion.

Because posterior urethral wounds are uncommon (except for case reports from past wars), there are virtually no tabulated data defining the extent of initial wounds, treatment, complications, results, or long-term follow-up in the literature. However, most of the general principles of management outlined in this volume have not substantially changed since World War II, and they still apply to the management of these wounds.

### *Wounds of the External Genitalia*

Approximately two thirds of all genitourinary tract injuries in the Vietnam War were to the external genitalia. These were the most common of the injuries that we saw. Their overall incidence and organ distribution has not significantly changed since World War II: scrotal–testicular is the most common, followed by penile, and then urethral injuries. High-velocity penetrating missiles (fragments or gunshots) caused most of the 452 external genital wounds in 303 patients in this RVN–Japan experience during the Vietnam War. Nonurological-associated organ injuries occurred in 95% of these patients: to the extremity, soft tissue, and bony pelvis in 70%; intraabdominal, 23%; and intrathoracic, 4%.

In general, most urologists in Vietnam took a conservative approach to initial debridement of vital soft-tissue and organ injury, open wound dressing, and redebridement if needed before delayed primary closure. Early in the war, attempts made in RVN at meticulous reconstruction and skin coverage under tension in extensive soft-tissue penile and urethral wounds often resulted in tissue necrosis, secondary infection, and organ deformity in Japan. This practice was abandoned later in the war. Instead, localized, low-velocity, soft-tissue and urethral wounds were usually managed in RVN with careful debridement and primary repair, urethral catheterization, or proximal perineal urethrostomy. As the war progressed and with increased experience and feedback from Japan, high-velocity wounds of the deep penile soft tissue and urethra were initially treated in RVN with suture or pressure control of the bleeding, conservative debridement, open wound dressing, urethral marsupialization or proximal urethrostomy, and suprapubic cystostomy. Redebridement and delayed skin coverage (split-thickness skin graft or pedicle scrotal grafts) were performed in Japan. Major reconstruction and urethroplasty were performed in the continental United States.

Because of their excellent blood supply and elasticity, scrotal wounds were usually treated by aggressive debridement and primary closure with absorbable suture. The problem of frequent separation of scrotal skin incisions that we saw in Japan was resolved by using nonabsorbable nylon suture material to close these wounds in RVN. Limited and bilateral testicular wounds were treated conservatively with debridement (partial orchiectomy) in RVN, and several



patients with missed testicular wounds had successful partial orchiectomy in Japan. Orchiectomy was reserved primarily for destroyed testicles and to facilitate hemostasis in unstable patients.

### ***Anterior Urethral Injuries***

Anterior urethral injuries are uncommon and often are secondary to iatrogenic causes, blunt trauma, and straddle trauma. Penetrating missiles from gunshots or fragments are the leading cause of anterior urethral wounds in wartime; they were the cause of the wounds in 46 of the 48 patients with anterior urethral trauma in our series. Several other associated organ-system injuries were experienced in 45 of the 48 patients. The diagnosis of urethral injury was suspected by the cause and location of the injury and the presence of blood at the urethral meatus; the diagnosis was confirmed by the passage of a catheter, or at surgical wound inspection or exploration, at debridement, or, rarely, by endoscopy or urethrography. Important factors in the treatment of these penetrating missile injuries were the extent and agent of injury, the presence of associated injuries, the status of the soft tissue, and the time of diagnosis. Early in the war, most major lacerations were treated with debridement, attempts at partial repair of the urethra and soft tissues, and urinary diversion, often with Foley catheters.

Complications that we saw in Japan included urethritis and urethral stricture, soft-tissue and urethral ischemic necrosis, and urethrocutaneous fistulae. The high incidence of urethral stricture was attributed to the frequent use of indwelling Foley catheters and the infrequent use of suprapubic tubes. Several patients had extensive necrosis and infection of the urethral soft tissue and significant penile skin loss; these areas were debrided and dressed over several weeks with subsequent delayed skin coverage with split-thickness or scrotal pedicle grafts in Japan.

To profess that extensive defects of the soft tissue and skin of the penis must be covered by skin as part of the initial treatment of the injury is to perpetuate a myth. One of the more-important concepts of initial treatment of extensive high-velocity urethral and associated soft-tissue penile wounds that evolved during the later years of the Vietnam War included 2 parts, the first dealing with process and the second with place:

1. the usefulness of soft-tissue and urethral debridement, open wound dressing, urethrostomy or urethral marsupialization, and proximal urinary diversion, with
2. redebridement, skin coverage, and limited urethroplasty being performed in Japan and staged-delayed hypospadias repair being performed in the continental United States.



Limited, localized wounds that are usually caused by low-velocity projectiles should be debrided and repaired primarily. All major contaminating penetrating anterior urethral injuries should have proximal suprapubic urinary diversion. Wounds caused by high-velocity projectiles that have large urethral defects and extensive penile injuries should initially be treated by debridement, open wound dressing, urethrostomy or urethral marsupialization; delayed redebridement, skin grafting, and urethroplasty should be done after the patient has been evacuated to a noncombat-zone MTF.

## UNIQUE LESSONS LEARNED IN VIETNAM AND JAPAN

Several new lessons and techniques of management of urological wounds evolved from the RVN and Japan experience:

- initial “damage control” (eg, for severe pelvic hemorrhage) should be performed; repair and reconstruction of extensive wounds of the posterior urethra can be delayed;
- conservative debridement of extensive penile urethral wounds, urethral marsupialization and/or urethrostomy, and staged delayed reconstruction and urethroplasty should be done;
- large soft-tissue and skin defects of the penis can be left open and debrided for several weeks before skin coverage;
- nonabsorbable suture material can be used in the initial primary closure of scrotal wounds;
- early and late coccygectomy can be done to facilitate pelvic debridement and drainage; and
- aggressive debridement, including delayed nephrectomy, is efficacious in resuscitating the severely ill patient with sepsis, whose condition is usually associated with perinephric retroperitoneal infection and urinary extravasation.

These lessons and techniques remain applicable to contemporary management of urological wounds.

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