CHAPTER 3

URETERAL TRAUMA

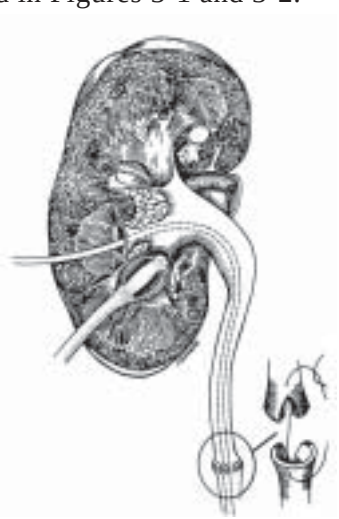
GU Tract Structure	Ch 2 Kidney	Ch 3 Ureter	Ch 4,5 Bladder	Ch 6,7,8,11 Urethra	Ch 8,9 Scrotum Testis	Ch 8,9 Spermatic Cord	Ch 8,10 Penis
No. Patients With Injury to Structure	132	36	72	83	199	14	128
% of Total GU Injuries	19.1	5.2	10.4	12.0	32.8	2.0	18.5

GU: genitourinary

INTRODUCTION

From February 1966 through March 1971, working primarily at the US Army Hospital, Camp Zama, Japan, we authors (JNW and JWW) treated 36 Vietnam War casualties who had ureteral trauma. The initial management of the casualties' injuries had been in Vietnam. Ureteral trauma occurred in 7.2% of 503 patients with urological injuries and accounted for 36 (5.2%) of all 692 genitourinary injuries (see Table 2-1 in Chapter 2, Renal Injuries: Penetrating and Blunt).

In Robinson et al's series[1] of 25 ureteral injuries published after World War II, more than two thirds of ureteral injuries were unrecognized initially. In our group, only 7 (19.4%) of the 36 patients had missed ureteral wounds. There is probably no area in the body in which the diagnosis is more frequently missed, and certainly no injury is subject to a greater diversity of methods of treatment.[1–8] Key technical points in the management of ureteral wounds are illustrated in Figures 3-1 and 3-2.



WOUND ANALYSIS

Nearly 70% of these wounds were secondary to bullets and about 30% were due to fragments (Table 3-1). All of these wounds involved other organ

Fig. 3-1. Technique of combining nephrostomy (proximal urinary diversion), ureteroureterostomy, and ureteral stenting. Reproduced with permission from Stutzman RE. Ballistics and the management of ureteral injuries from high velocity missiles. *J Urol.* 1977;118:948. Internet permission, Lippincott Williams & Wilkins home page: http://www.lww.com.

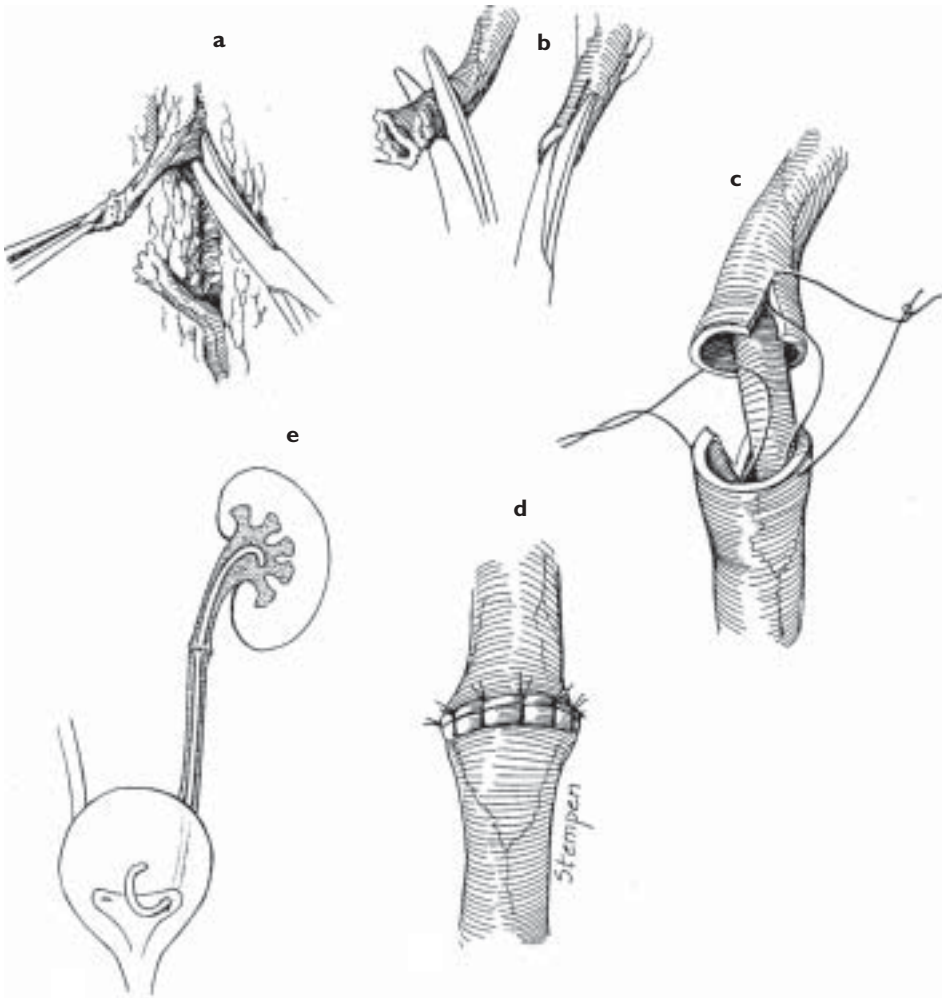


Fig. 3-2. Technique of ureteroureterostomy after traumatic disruption. (**a**) Defining the injury site with uretetral mobilization. (**b**) Debridement of the margins. (**c**) Spatulation. (**d**) Approximation with 5-0 absorbable sutures. (**e**) Placement of internal stent. Reproduced with permission from McAninch JW, Santucci RA. Genitourinary trauma. In: Walsh PC, Retik AB, Vaughan ED Jr, Wein AJ, eds. *Campbell's Urology.* Vol 4. 8th ed. Philadelphia, Pa: Saunders; 2002: 3719.

TABLE 3-1
URETERAL WOUNDS,*
FEBRUARY 1966–MARCH 1971

	Patients	
Agents of Injury	**No.**	**%**
Gunshot Wounds	25	69.4
Multiple Fragment Wounds	11	30.6
Totals:	**36**	**100.0**

*Treated at US Army Hospital, Camp Zama, Japan

systems; the associated injuries are detailed in Table 3-2. The small bowel was the organ most commonly injured, followed by the colon and the bladder. Nearly half of the colon injuries involved the sigmoid or rectum. Of the entire group of 36 patients, 8 (22.2%) had major vascular injuries, but only 1 had an associated renal injury. Two patients had ureteral contusions sec-

TABLE 3-2
ASSOCIATED ORGAN WOUNDS

	GSW		MFW		Total Wounded Organs	
Organ	**n**	**%**	**n**	**%**	**N**	**%**
Small Intestine	21	31.8	8	33.3	29	32.2
Colon, Total	18	27.3	6	25.0	24	26.7
Sigmoid and Rectum	8	12.1	1	4.2	9	10.0
Bladder	9	13.6	4	16.7	13	14.4
Iliac Vessels	3	4.5	2	8.3	5	5.5
Vena Cava	1	1.5	2	8.3	3	3.3
Liver	1	1.5	1	4.2	2	2.2
Pancreas	2	3.0	0	0.0	2	2.2
Kidney	1	1.5	0	0.0	1	1.1
Prostate	1	1.5	0	0.0	1	1.1
Penis	1	1.5	0	0.0	1	1.1
Totals:	**66**		**24**		**90**	

GSW: gunshot wound
MFW: multiple fragment wound

ondary to blast injury from gunshot wounds of the abdomen, and 1 had a superficial laceration. All 3 of this latter group were treated conservatively without drainage, none developed complications, and the results were satisfactory in all of these patients.

For purposes of this study, wounds were divided into those involving the upper two thirds and those involving the lower one third of the ureter (Figures 3-3 and 3-4). Complete data as to the location of the ureteral injury

Fig. 3-3. Upper ureteral trauma with massive urinary extravasation.

Fig. 3-4. Lower ureteral trauma with moderate urinary extravasation.

could be retrieved in 29 (80.5%) of the 36 cases (Table 3-3). Of 29 patients with adequate data, 11 (37.9%) had injuries to the upper two thirds of the ureter and 18 (62.1%) had injuries to the lower. Major complications requiring secondary surgical procedures occurred in 8 (73%) of the 11 with upper- and middle-third ureteral injuries, and 14 (79%) of the 18 with lower-third injuries. These complications included

TABLE 3-3
URETERAL WOUNDS, BY LOCATION AND WOUNDING AGENT

Portion of Ureter Wounded	GSW		MFW	
	n	%	n	%
Upper Third	7	35	1	11
Middle Third	2	10	1	11
Lower Third	11	55	7	78
Totals, Location Specified:	**20**		**9**	

- systemic evidence of sepsis,
- local formation of abscesses,
- infected urinomas,
- extravasation with urinoma formation or fistula,
- severe hemorrhage, and
- reflux.

Of patients with upper and middle ureteral injuries, 7 (67%) of the 11 had a satisfactory result; that is, the renal unit was preserved without significant renal damage. There was a 33% nephrectomy rate. Of patients with lower ureteral injuries, 68% had satisfactory results; 32% required nephrectomy.

When ranked by the location of the wound, no significant difference was seen in either complication rates or final results. We cannot speculate from these data as to the initial fatality rates following ureteral and associated wounds, as our analysis includes only those patients who survived their initial injuries and entered into the evacuation system.

Of our 36 patients with ureteral trauma, 25 (70%) had gunshot wounds (GSWs), and 11 (30%) had multiple fragment wounds (MFWs). Of the 25 patients with gunshot wounds, 20 (80%) developed complications from the injury and initial therapy, which were managed in Japan. All 11 of the patients with MFWs had major complications (Table 3-4). The incidence of minor complications in this group is unknown. Urinary fistula was the most common major complication occurring in 12 (33%) of the patients (Table 3-5). Ten patients had ureterocutaneous fistulae, and 2 developed ureterocolic fistula. Forty-two percent of the patients had severe sepsis, caused by either abscesses or generalized infections. Six patients (17%) developed urinary extravasation. This was manifested by fistula, urinoma formation, or by uri-

TABLE 3-4
COMPLICATIONS IN PATIENTS WITH URETERAL TRAUMA

Wounding Agent	Total Patients	Patients With Complications	
		No.	%
GSW	25	20	80
MFW	11	11	100

GSW: gunshot wound
MFW: multiple fragment wound

TABLE 3-5
COMPLICATIONS IN GUNSHOT AND FRAGMENT WOUNDS

Complication	Type of Wound		Patients	
	GSW	MFW	No.* With Complication	% With Complication
Fistula	8	4	12	33.3
Ureterocutaneous	6	4	10	27.8
Ureterocolic	2	0	2	5.5
Sepsis	8	7	15	41.7
Extravasation	5	1	6	16.7
Delayed Hemorrhage	0	3	3	8.3
Nephrectomy	3	5	8	22.2
Death	1	1	2	5.5
Total Patients*:	**25**	**21**		

*Total patients = 36; all had complications GSW: gunshot wound MFW: multiple fragment wound

nary ascites (1 case). Eight patients (23%) eventually required nephrectomy, and there were 2 deaths in this series (fatality rate = 6%). Both patients who died had an emergency nephrectomy as part of their treatment. We believe that, overall, the results were good; that is, the patient's involved renal unity was preserved with no apparent residual renal problems on the side of injury in 26 (72%) patients (Table 3-6). Case reports and comments on complications will appear later in this chapter.

Of the 7 patients (19%) whose ureteral wounds were initially missed, all developed symptoms or signs of urinary leakage, and 1 required a nephrectomy. There were no fatalities in this group (Table 3-7), but convalescence was prolonged.

TABLE 3-6
RESULTS OF TREATMENT AT TIME OF EVACUATION TO CONUS

Results	Patients	
	No.	%
Kidney Preserved With Good Results on IVP	26	72.2
Nephrectomy*	8	22.2
Death	2	5.6
Total Patients:	**36**	**100.0**

*1 patient who received a nephrectomy later died in CONUS: continental United States
IVP: intravenous pyelogram

TABLE 3-7
COMPLICATIONS IN PATIENTS WITH INITIALLY MISSED URETERAL WOUNDS

Total Ureteral Wounds	36
Wounds Missed on Initial Evaluation	7
Complications	**No.**
Fistula	5
Ureterocutaneous	3
Ureterocolic	2
Urinary Ascites	1
Abscess	2
Unreconstructible Ureteral Wound Necessitated Nephrectomy	1

We analyzed all the 36 patients according to the methods of treatment employed. Six patients were treated with nephrostomy drainage and debridement of the wound; 5 of the 6 underwent primary ureteral repair (Table 3-8). The remaining patient was treated in the Republic of Vietnam (RVN) with distal ureteral ligation. Four of the nephrostomies were done as part of the initial treatment, and 2 were done in Japan during delayed treatment for complications. Three (50%) of the 6 patients who received nephrostomies developed major complications; these included infections (2), fistula (2), hemorrhage (1), and urinoma (1), all of which required secondary surgical drainage, repair, or instrumentation that necessitated the use of an anesthetic in Japan. One patient treated with delayed nephrostomy died of nonurological causes with massive sepsis. We have not listed the minor complications, which responded to simple wound care, antibiotics, and the like.

Of the 6 patients who received tube nephrostomies, 2 (33%) had good results (ie, the renal unit was preserved without significant abnormality) and 4 (67%) had unsatisfactory results. Two patients required nephrectomy, and 1 patient had recurrent staghorn calculus disease secondary to *Proteus* infection associated with nephrostomy tube drainage.

Five (13.8%) of the 36 patients were treated with ureteral reimplantation into the bladder (Table 3-9). Four of these were stented, and 1 was treated without a ureteral stent. All bladders were drained and wounds debrided. Of the patients treated with reimplantation plus a stent, 3 (75%) developed major complications. Two patients had fistula, and the other

TABLE 3-8
COMPLICATIONS AND RESULTS: URETERAL TRAUMA PATIENTS* TREATED WITH NEPHROSTOMY

Complications and Results	Patients No.	Patients %
Complications Related to Wound	3	50
Infection	2	
Fistula	2	
Hemorrhage	1	
Urinoma	1	
None	1	
Final Results		
Satisfactory	2	33
Unsatisfactory	4	67
Death	1	
Nephrectomy	2	
Staghorn calculus	1	

*Total = 6 patients: 4 received initial treatment, 2 received delayed treatment

TABLE 3-9
PATIENTS* WITH URETERAL TRAUMA TREATED WITH URETERAL REIMPLANTATION

Technique	Patients No.	Patients %
Stented	4	
Wound-related complications	3	75
Infection	1	
Fistula	2	
Reflux	1	
Results		
Satisfactory	3	75
Unsatisfactory	1	25
Nephrectomy	1	
Unstented	1	
Wound-related complications		
Infection	1	
Fistula	1	
Results		
Satisfactory	1	100
Overall Results:		
Satisfactory	4	80

*N = 5

reflux and sepsis. Three (75%) of these stented patients had satisfactory results, but 1 had an unsatisfactory outcome requiring a delayed nephrectomy. The single patient with reimplantation without stenting developed complications of fistula and sepsis but ended up with a satisfactory result. The overall result from this method of treatment could be classified as satisfactory in 80% of the cases.

Ureteral Debridement, Ureteroureterostomy, and Drainage

Sixteen (44%) of the 36 patients were initially treated with ureteral debridement, ureteroureterostomy, and drainage (Table 3-10). Fourteen of 16 (88%) had stented anastamoses. Ten (71%) of the 14 stented patients developed major complications. Six patients developed infection; 4 a fistula; and others developed extravasation, obstruction, urinoma formation, and/or hemorrhage. The results were satisfactory in 9 (64%) of the stented group (ie, they had normally functioning renal units after healing had occurred) (Table 3-11). Five patients (36%) had unsatisfactory results. All of these required nephrectomy in Japan; 2 of these patients eventually died of multiple complications from various organ system wounds. The 2 patients treated with debridement and ureteroureterostomy who were unstented developed major complications. One developed a fistula and the other a significant infection, for a complication rate of 100%. Both eventually healed. Eleven of the 16 (62%) of the ureteroureterostomy patients had satisfactory end results.

Three patients were treated with stents only. These tended to be the less-severe wounds. One of these patients developed a urinary fistula and sepsis. All 3 eventually healed without apparent residual ureteral damage.

TABLE 3-10
COMPLICATIONS: URETERAL TRAUMA PATIENTS* TREATED WITH DEBRIDEMENT, URETEROURETEROSTOMY, DRAINAGE

Technique	Patients With Complication No.	%
Stented	14	
Complications	10	71.4
Infection	6	
Fistula	4	
Hemorrhage	1	
Urinoma	1	
Obstruction	1	
Extravasation	1	
Unstented	2	
Complications	2	100
Infection	1	
Fistula	1	

*N = 16

TABLE 3-11
RESULTS: PATIENTS* WITH URETERAL TRAUMA TREATED WITH DEBRIDEMENT, URETEROURETEROSTOMY, DRAINAGE

Technique	Patients No.	%
Stented		
Satisfactory	9	64.3
Unsatisfactory	5	35.7
Nephrectomy	5	—
Totals:	**14**	**100.0**
Unstented		
Satisfactory	2	100.0
Unsatisfactory	0	
Totals:	**2**	**100.0**

*N = 16

Ureteral Fistulae

The treatment and results of the 12 patients with ureterocutaneous fistulae are summarized in Table 3-12. It is impossible to ascertain the onset of fistulous drainage in these cases, as many of them arrived in Japan with urinary drainage in their dressings. Two of these patients had initially missed ureteral injuries. These wounds had initially been treated by a variety of methods. Primary repair or ureteroureterostomy was initially performed in 6 patients. Three patients had ureteroneocystostomies. Two of these patients were later treated with a nephrostomy, 1 of whom eventually required nephrectomy while in Japan. Two other patients required delayed nephrectomy.

The other fistulae were handled in a conservative fashion by use of ureteral catheters and enhanced external drainage of the fistula site. The results were good in 9 (75%) patients. Three of the patients with fistula had poor end results: 1 required surgery for staghorn calculus and 2 underwent nephrectomy. Four patients had noncutaneous fistula formation (Table 3-13); in all of them, the ureteral injury was initially missed. Two patients had ureterocolic fistulae and 2 had ureteroperitoneal. One of the latter died of complications from combined organ

TABLE 3-12
TREATMENT OF PATIENTS* WITH URETERAL WOUNDS THAT DEVELOPED URETEROCUTANEOUS FISTULAE

Patient With Ureterocutaneous Fistula	Treatment		Result
	Primary	Delayed	
J.C.	UU, stent	Conservative	S
K.S.	UU, stent	Conservative	S
S.C.	Ureteral reimplantation	Nephrostomy	P (staghorn calculus)
J.T.	Ureteral reimplantation	Fistula repair	S
J.J.	— (missed injury)	Nephrostomy, nephrectomy	F
R.D.	UU, stent	Nephrectomy	F
T.M.	UU, intubated ureterostomy	Conservative	S
J.S.	Repair, stent	Conservative	S
E.R.	— (missed injury)	Nephrectomy	F
F.C.	Repair, stent	Conservative	S
B.O.	(Contusion) stent	Conservative	S
J.W.	— (missed injury)	Reimplantation	S

*N = 12 F: failure P: poor S: satisfactory UU: ipsilateral ureteroureterostomy

TABLE 3-13
TREATMENT OF PATIENTS* WITH URETERAL WOUNDS THAT DEVELOPED NONCUTANEOUS URETERAL FISTULA

Patient	Treatment		Result
	Primary	Delayed	
L. M.†	— (missed)	Conservative ureteral catheterization	S
G. S.†	— (missed)	Conservative ureteral catheterization	S
T. S.‡	— (missed)	UU, stent: redebrided, reanastomosis, nephrectomy	F (death from sepsis)
R. H.‡	— (missed)	UU, stent	S

*N = 4
†Patient with ureterocolic fistula
‡Patient with ureteroperitoneal fistula
F: failure
S: satisfactory
UU: ipsilateral ureteroureterostomy

injuries and sepsis. This patient was treated with ureteroureterostomy and a stent, later required redebridement and reanastomosis, and finally nephrostomy drainage. The second patient with ureteroperitoneal fistula had prolonged urinary ascites. This was not diagnosed until 33 days postinjury. He was then treated with ureteroureterostomy and a stent and had good results. The 2 patients with ureterocolic fistulae healed completely with ureteral stenting.

Poor Results

Ten (28%) of the 36 patients in the total group had poor results (Table 3-14). This group includes 8 patients in whom nephrectomy was done. Two patients died: 1 had a nephrectomy and the other a nephrostomy. Both were septic, and both had multiple organ wounds. In neither case was the urological wound the primary cause of death. One patient treated with a nephrostomy developed a staghorn calculus, which required surgery and continued to require therapy for chronic urinary tract infection and potential stone reformation.

Infection and sepsis were the overwhelming causes of major complications leading to nephrectomy or to poor results. Infection was a major factor in 9 (90%)of the 10 patients. One patient required a nephrectomy because of bleeding through a nephrostomy tube. Poorly functioning tubes and/or stents with ureterorenal obstruction were factors in at least 4 of the complications.

CASE REPORTS

The following case reports and comments may help the reader grasp the complexity of problems that arise from the need for ureteral reconstruction. Not all the

TABLE 3-14
PATIENTS* WITH POOR RESULTS

Patient	Treatment in RVN	Complications	Result
T. S.	Repair, stent, drain	Sepsis, bleeding, MOWs	Nephrostomy, death
J. S.	Repair, stent, drain	Sepsis, abscesses, pyonephrosis obstructed stent, MOWs	Nephrectomy, death (septicemia, hepatic failure)
T. M.	Repair, stent, drain	Extravasation, abscess, sepsis, retinitis, deafness	Nephrectomy
J. J.	— (Missed diagnosis); nephrostomy 9 d after wound	Sepsis, extravasation, nonfunction of tube	Nephrectomy
D. B.	Nephrostomy, ureteral ligation	Bleeding through nephrostomy	Nephrectomy
R. D.	Repair, stent	Sepsis, fistula, ruptured bladder, periurethral abcess	Nephrectomy
E. R.	— (Missed diagnosis)	Extravasation, obstruction	Nephrectomy
R. A.	Reimplant, stent	Sepsis, reflux, fistula	Nephrectomy
S. C.	Ureteral reimplant	Fistula, sepsis (nephrostomy)	Staghorn calculus
J. R.	Repair, stent, drain	Obstruction, sepsis, extravasation, hemorrhage	Nephrectomy

*N = 10
MOWs: multiple organ wounds
RVN: Republic of Vietnam

patients discussed here would have received the same treatment today, as treatments and philosophies change over time. But the basic principles of management of these wounds has not changed significantly over the last several decades, and these are emphasized in the comment section that follows each case presentation and in the discussion section near the end of this chapter.

Cases With Fatal Outcomes

The 2 cases with fatal outcomes in Japan (from generalized sepsis, multiorgan failure, and metabolic imbalance) had complications from the initial management of their massive abdominal organ wounds and from primary repair of the ureteral wound. There is little margin for surgical error in the management of the battlefield casualty with extensive abdominal organ and ureteral wounds.

Case 3-1

T. S., a 20-year-old man, received MFWs caused by a booby trap explosion on 19 November 1969. He incurred injuries of the liver, gallbladder, head of the pancreas, transection of the third portion of the duodenum, laceration of the second

portion of the duodenum, a destructive lesion of the right colon, laceration of the distal left ureter, and multiple lacerations of the bladder. He was treated in Vietnam with a gastrostomy, duodenostomy, and jejunostomy, and all of these had been placed on tube-type drainage. An ileostomy was done with mucous fistula of the transverse colon. His ureteral injury was repaired over a stent and no further details were noted concerning this aspect of his wounds. A suprapubic mushroom catheter was put in place. His wounds had been debrided.

Following his initial hospitalization at the 12th Evacuation Hospital, RVN, he was evacuated to the US Army Hospital (USAH), Camp Zama, Japan, 12 days after his injury. Four days before he arrived in Japan, he had had an adequate urinary output and a blood urea nitrogen (BUN) of 20 mg/dL. This patient presented as an acutely ill man who appeared dehydrated with severe oliguria, a markedly distended abdomen with a fluid wave, and deep jaundice. Hydration was achieved and the patient was maintained on cephalosporin. There was no increase in urinary response to hydration. Oliguria progressed to total anuria. Laboratory studies showed a BUN of 107 mg/dL and creatinine of 5.6 mg/dL. Genitourinary consultation was obtained the day after admission, and the patient was given mannitol challenge with no increase in urinary output. His suprapubic tube and indwelling catheter were patent. His ureteral stent was no longer present, and there was no information as to when it had been removed.

An intravenous pyelogram (IVP) was done with high-dose contrast, with no visualization of either upper tract. It was felt clinically that the patient probably had massive urinary extravasation and might indeed have sufficient increase in intraabdominal pressure to obstruct his opposite ureter. He was examined endoscopically under a light anesthetic and both orifices were identified. A retrograde urogram on the left showed urinary extravasation at the point of the ureteral injury several centimeters above the ureterovesical junction. A retrograde study was attempted on the right; initially, resistance was met but later a catheter could be advanced up into the right renal pelvis. There was a hydronephrotic drip of urine with rather massive outflow through the ureteral catheter. It was apparent that the right upper tract was under considerable back pressure, although no specific point of obstruction was seen or demonstrated. This catheter was initially left in place.

A repeat left retrograde urogram demonstrated disruption of the ureteral anastomosis. The abdomen was then explored through a midline incision with aspiration of 3,500 mL of extravasated urine.

Appropriate cultures were done. The ureteral injury was identified, debrided, and repaired with fine chromic catgut over a stent. Adequate drainage was established. It was noted that there had been no apparent healing in the 12 days since this patient's injury. His duodenostomy tube was found to have been pulled out and was lying free; new, adequate drainage was then established.The patient deteriorated steadily from this point. He developed massive intraperitoneal bleeding on the 6th postoperative day and required reoperation with ligation of a branch of the pancreatoduodenal artery. At this time the duodenum was closed, the duodenostomy tube removed, and a posterior hole in the duodenum was discovered and closed. The patient had had extensive electrolyte losses during his hospital course. He had received 40 units of blood in Vietnam and 31 units in Japan. He developed severe pneumonia terminally and died 19 days after his injury.

Comment on Case 3-1

This patient obviously had massive wounds. Severe upper-gastrointestinal injuries with electrolyte and fluid losses and urinary extravasation were instrumental in his downhill course. It is not certain what factors were involved in the break-

down of the ureteral anastomosis, and we can only conjecture that more-adequate stent placement and drainage and possibly more-thorough debridement might have prevented the breakdown. He might have had a fatal outcome regardless of the handling of the ureteral wound, however. His postoperative potassium and calcium losses were extremely difficult to manage. He had terminal hepatic failure, probably due to sepsis.

Case 3-2

J. S., the second patient whose case resulted in a fatality, was a 22-year-old white man who sustained a GSW of the abdomen on 10 May 1970 near the Cambodian border in RVN. The entry site of his wound was the left flank, and he had multiple perforations of small bowel and descending colon. The perforations were closed and a colostomy was done. He was evacuated to the 3rd Field Hospital in RVN and developed a stormy postoperative course with high fever. Reexploration of the abdomen revealed a subdiaphragmatic abscess. At that time, splenectomy, drainage of the abscess, and revision of the colostomy were carried out. He had received an initial repair of a laceration of the left ureter, which had been repaired using only a ureteral stent for drainage.

His septic course continued and reexploration revealed obstruction of a hydronephrotic left kidney from a nonfunctioning ureteral stent. An emergency left nephrectomy was done. Papillary necrosis was present in the specimen. Following this, he developed abscess formation in the abdominal wall and a very septic course.

He was medically evacuated to USAH, Camp Zama, Japan. His course was progressively downhill with recurrent problems including gastrointestinal bleeding, progressive hepatic failure, sepsis, and anuria. He was treated with dialysis in Japan. He died with *Pseudomonas* septicemia 22 days following his injury.

Comment on Case 3-2

This patient's wounds were massive. First, in the presence of multiple bowel injuries and a ureteral injury, he might have been better treated with a left nephrectomy, rather than an attempted ureteral repair. His right kidney was apparently normal. Second, the patient's ureteral stent had become obstructed. In the face of sepsis, this poses a severe threat. Third, this patient had fecal drainage adjacent to an abdominal drain site, allowing ongoing contamination into the peritoneal space. This could have contributed to his problems with sepsis and abdominal wall abscess. And fourth, it is entirely possible that his initial abdominal wall debridement was inadequate. These factors emphasize several vitally important principles that must not be violated in the treatment and management of abdominal trauma.

Nephrectomies

Several patients required nephrectomy. Some of these will be analyzed in some detail in an effort to extract meaningful information.

Case 3-3

T. M., a 20-year-old man, sustained a GSW that entered the right low back area and exited through the epigastrium on 9 May 1970. Laparotomy revealed psoas muscle

damage, a divided right ureter, a laceration of the second portion of the duodenum and the right lobe of the liver, and massive damage to the ascending colon. The right spermatic vein was lacerated. The duodenal laceration was repaired, a right ureteroureterostomy was done over a 6 French (F) ureteral catheter stent, and the stent was brought down through the inferior ureter. A right hemicolectomy was done with ileostomy and a matured mucous fistula. The spermatic vein was ligated. Penrose drains were used. The patient was given antibiotics and was transferred to the 3rd Field Hospital in Saigon, RVN, on 10 May 1970, and subsequently to USAH, Camp Zama, Japan.

This patient initially had a high duodenostomy output. He had abdominal tenderness, became febrile, and old blood was noted in his ileostomy drainage. He was treated conservatively for stress ulcer. On 19 May 1970, digital examination of the drain sites resulted in evacuation of abscess material from the right perinephric and left subphrenic areas. He developed active gastrointestinal bleeding that could not be controlled conservatively, and abdominal exploration was done 21 May 1970. This revealed an abscess adjacent to the duodenal injury with leakage of duodenal contents. In addition, there was an abscess in the right flank adjacent to the site of the ureterostomy, and the anastomosis was found to have disrupted. The patient's right kidney appeared edematous, pale, and with punctate hemorrhages. A vagotomy and pyloroplasty and a right nephrectomy were performed.

Postoperatively, intestinal drainage occurred from the right flank drain sites; reexploration was done on 23 May 1970. A small hole was found in the lateral portion of the duodenum; a catheter was inserted, which exited out of the right abdomen. A tube jejunostomy was done. He continued to have a febrile course. A high-output fistula persisted. The patient developed significant electrolyte problems. He was started on hyperalimentation on 2 June 1970 to supplement his tube feedings. He was maintained on antibiotics throughout. He continued to have a very stormy course, with reoperation on 29 June 1970 for persistent fistula and high-intestinal obstruction. At this time, a gastrostomy was done in addition to a gastrojejunostomy, closure of a duodenal fistula, and drainage of small abscesses in the right upper quadrant.

Immediately postoperative to the reoperation, fluid was found to be draining from the right flank sump drainage site. It was felt that intestinal perforation possibly existed and exploration was done, which revealed a laceration of the gallbladder. A cholecystectomy was performed, after which the patient developed a recurrent left pneumothorax that required chest tube drainage. He was maintained on intravenous (IV) hyperalimentation. He developed seizures and sepsis and then was found to have bilateral severe retinitis secondary to septic emboli. His continuing electrolyte problems, disorientation, hallucinations, and irrational behavior finally improved. He developed severe bilateral hearing loss, which was noted 9 July 1970 [presumed secondary to antibiotics—DEL, ed]. He was eventually transferred to the continental United States (CONUS) for further convalescence and reanastomosis of his ileum to transverse colon.

Comment on Case 3-3

This case illustrates several problems. At initial surgery, the patient's wounds of the gastrointestinal tract had been missed, which resulted in devastating complications. His ureteral repair broke down, which required an emergency nephrectomy.

We found that in the presence of a normal opposite kidney and with multiple, complicated wounds of the abdomen and its contents, and with sepsis, patients who develop breakdowns of their primary ureteral injuries often are best treated with nephrectomy. Additionally, in the primary management of ureteral wounds in patients whose opposite kidney is normal but with massive other injuries including wounds of the abdominal and intestinal organs, often with severe hemorrhagic

shock and uncontrolled intraoperative bleeding, it may be more judicious to perform a nephrectomy than to attempt a primary ureteral repair. Another approach might be to delay initial repair of the ureteral injury by marking the upper side of the ureteral transection or injury with a silk suture, and then perform nephrostomy and consider a staged repair when the patient's overall condition allows. Some have performed a staged repair after intubating the transected ureter and bringing the ureteral catheter to the skin, so as to identify the ureter at the time of the staged secondary repair.[9]

The fluid and electrolyte problems secondary to high-bowel injuries and fistula formation are severe, and the difficulty controlling this patient's calcium and magnesium levels resulted in convulsions and tetany. Hyperalimentation was essential in this patient, as in many others. His septic emboli with subsequent retinitis demonstrate a rare but severe complication. [Although the patient's deafness was presumed at the time to be a permanent side-effect of the antibiotic, in retrospect, this conclusion is recognized to be false.—DEL, ed]

Case 3-4

J. J., a 21-year-old man, sustained MFWs to both buttocks and flank with perforations of the cecum, contusion of the dome of the bladder, and a missed laceration of the right ureter. These injuries occurred from a satchel charge. A laparotomy done on 28 March 1971 revealed numerous bone fragments in addition to the injuries noted above. A cecostomy was done. His bladder wound was thought to be a contusion and not a perforation.

On 2 April 1971, a delayed primary closure of soft-tissue wounds was done in RVN, and several days later the patient was noted to have clear liquid draining from his wounds. Methylene blue studies were done and were said to be negative.

On 6 April 1971, extravasation of urine from the wounds became apparent and a wound of the right lower ureter was discovered on IVP. A right nephrostomy was done using a 24F Foley catheter. Transection of the right ureter was noted and primarily repaired. A pelvic abscess was found and was drained with Penrose drains and sumps.

The patient became septic the next day. He had been on antibiotics. Five days later, he developed hypotension, tachycardia, and was believed to have Gram-negative bacteremic shock. He was given digitalis. He became psychotic with suicidal attempts the following day. Blood cultures were positive for *Escherichia coli*. On 14 April 1971, a right hip and flank abscess was incised and drained. All drains were out by 19 April 1971, and the patient was transferred to USAH, Camp Zama, Japan.

He then began to leak urine around his nephrostomy tube, and the tube became nonfunctional. In addition, he developed bleeding around the tube. Examination of X-ray films from RVN showed that a pyelostomy rather than a nephrostomy had been done. Attempts were made to handle the tube conservatively with irrigation and slight changes in position, but these were unsuccessful. The pyelostomy tube was removed and attempts to replace the tube were unsuccessful. A sump drain was used, but increasing amounts of urine appeared in the sump and there was no evidence of ureteral patency.

In view of this patient's extremely serious psychiatric condition, his recent sepsis, Gram-negative shock, continued uncontrolled urinary drainage, and with a normal opposite upper tract, nephrectomy was done on 26 April 1971. His course was benign following this, and eventually he was transferred to CONUS.

Comment on Case 3-4

This patient developed multiple complications secondary to a missed ureteral injury. Once the injury was recognized, attempts at ureteral repair failed. In this case, the poorly functioning pyelostomy tube clearly did not provide adequate and controlled proximal urinary diversion of the upper urinary tract. Nephrostomy and not pyelostomy should be employed for proximal diversion of the upper urinary tract in these injuries.

It is difficult to explain why methylene blue did not define the ureteral wound initially. In retrospect, an earlier IVP might have altered the course of this man's treatment and subsequent clinical course. No information concerning the status of the injured ureter was available from the patient's initial management in RVN. The principles of adequate debridement, ureteral spatulation, using fine absorbable sutures, using a stent when indicated, appropriate diversion, closure without tension, and using adequate antibiotics are all reemphasized with this case.

Case 3-5

D. B., a 23-year-old man, suffered MFWs of the buttocks and retroperitoneal area on 1 April 1971. He had received massive vascular damage with laceration of the vena cava at its bifurcation, damage to both common iliac veins, and transection of the right common iliac artery. A left iliac artery injury was also present. A vena caval ligation was done with repair of both iliac veins. The lacerations to both iliac arteries were repaired. The right ureter was found to be transected.

It was believed that the vascular wounds would be compromised by potential leakage from a ureteroureterostomy. Accordingly, the ureteral wound was handled with ligation of both transected ends of the ureter and insertion of a right nephrostomy tube. This patient required 32 units of whole blood initially. He was first treated at the 18th Surgical Hospital in RVN and later evacuated to the USS *Sanctuary* on 3 April 1971. He had a stormy febrile course and developed bleeding through the nephrostomy tube, a pleural effusion, and pulmonary emboli. A right nephrectomy was done on 20 April 1971 at USAH, Camp Zama, Japan. He had no further complications and eventually was evacuated to CONUS.

Comment on Case 3-5

In retrospect, it might have been best to have done a nephrectomy in view of the patient's normal opposite kidney and the fact that simple ligation of the ureters would necessitate a second operation in the area of vascular repair. However, delayed initial repair of ureteral wounds has been successful in a more-controlled setting in major trauma centers.[9] The key to success of this approach is adequate and complete proximal urinary diversion.

Case 3-6

R. D., a 21-year-old man, sustained MFWs of the pelvis and both lower extremities secondary to rocket fire. He incurred injuries of the left hypogastric vein and the right hypogastric artery. The right hypogastric artery and the vein on the left were ligated.

Small-bowel perforations were repaired, and a left ureteral injury was discovered and repaired over a 6F ureteral catheter secured to a suprapubic catheter. The patient's extremity injuries were debrided. He later required an amputation of his left foot and redebridement of the other extremity wounds. He had further amputation and care of his massive orthopedic wounds after evacuation to Japan, and had a persistent left ureterocutaneous fistula. This did not respond to conservative measures with sump drains and ureteral stenting.

The patient developed severe electrolyte problems and it was felt that he had renal tubular damage secondary to aminoglycoside antibiotics. His general condition gradually deteriorated with febrile episodes. It was felt that his continued urinary extravasation was a contributing factor. In view of this, a nephrectomy was done more than 1 month after his initial injury. He did well for a few days postoperatively but again developed a septic course. Periodically, areas of dead bone required redebridement. This patient was placed on intravenous hyperalimentation, and while on this regimen, problems resulted from hyperglycemia. He required massive electrolyte replacement, particularly potassium.

About 1 week later, the patient developed a periurethral abscess thought to be secondary to his Foley catheter. The catheter was removed and the abscess could easily be emptied by manual compression. The next day he developed a surgical abdomen, and there had been no urinary output for several hours. Surgical exploration revealed a ruptured bladder with a necrotic area in the dome of the bladder, apparently secondary to erosion and necrosis from long-term Foley catheterization. The bladder was debrided, repaired, and drained with a suprapubic cystostomy.

The patient developed pulmonary complications, which cleared with conservative therapy. His periurethral abscess did not recur. He eventually improved, although he did require further debridement of his extremity wounds before evacuation to CONUS.

Comment on Case 3-6

This patient had incredible wound problems and complications. Healing of his ureter was markedly impaired owing to sepsis and a generalized catabolic state. His urinary extravasation unquestionably contributed to his sepsis, and in retrospect, it might have been better to do a nephrectomy at an earlier date.

The method of handling his ureteral wound was compounded by inadequate proximal urinary diversion and controlled ureteral stenting. We can only conjecture that further complications were secondary to occlusion of the stent. Ureteral stenting should be used when primary ureteroureterostomy is done for high-velocity missile wounds, and it should be accompanied by proximal urinary diversion, preferably a nephrostomy.[10] The patient's severe electrolyte problems undoubtedly were made worse by aminoglycosides. (This occurred in more than 1 of our patients.) His potassium loss was a significant problem therapeutically.

This was 1 of the earlier patients that we treated with hyperalimentation. We encountered numerous problems in the management of this modality, and eventually abandoned it in this patient. Later refinements in hyperalimentation administration and management techniques allowed it to be done in a more satisfactory manner in other patients.

Development of a periurethral abscess is 1 of the complications of Foley catheter drainage and must be attributed to inadequate catheter care in Japan on

the part of all of us involved with his treatment. His ruptured bladder occurred secondary to urethral obstruction from his abscess and followed development of a necrotic area in the dome of the bladder, which had occurred from his indwelling catheter. We have seen this in debilitated patients under other circumstances.

Case 3-7

E. R., a 20-year-old man, suffered GSWs of the abdomen with injuries to the duodenum, jejunum, and lower pole of the kidney. He required 12 units of blood at the time of his initial surgery. Two weeks postinjury, the patient was found to have had a missed ureteral injury on the right. This was manifested by a ureterocutaneous fistula. Attempts were made to repair this in Japan, but (1) the distal end of the ureter could not be identified, as it was encased in severe scar and inflammatory tissue, and (2) there was a great deal of bleeding involved in dissection about the kidney. In view of these difficulties, a right nephrectomy was done.

Comment on Case 3-7

Severe complications almost invariably arise when a ureteral injury is missed: various forms of urinary leakage including urinoma, urinary ascites, and urinary fistulae; sepsis; hydronephrosis; renal failure; and ureteral stricture. These complications can often lead to nephrectomy.[11] It is easy to criticize the original surgeons, but it is also easy to miss these injuries—as all of us know who have dealt with trauma of this type. The use of methylene blue, careful exposure of the ureter to look for an injury, and excretory urography are the mainstays in diagnosing these injuries when they are not apparent.[11]

The injury to the lower pole of the kidney probably misled the surgeons in RVN, as their attention was undoubtedly focused solely on the kidney, rather than also on the ureter. The patient's adjacent bowel wounds were, of course, of paramount importance regarding treatment and repair. Sometimes it is simply not technically possible to reconstruct the ureter after an injury such as this in the face of severe infection, tissue reaction, and fibrosis. In circumstances like this, the presence of a normal opposite kidney may make nephrectomy more attractive.

Case 3-8

Information on this case is somewhat sketchy. R. A. suffered a GSW of the abdomen and pelvis. The patient was found to have a lower-third ureteral injury, which was repaired with the use of a stent, followed by ureteral reimplantation into the bladder and drainage. The bladder perforation was debrided and repaired and a suprapubic cystotomy performed. Wounds of the colon and small bowel were treated by repair and colostomy. The pelvis was drained with anterior-exiting Penrose drains.

Following evacuation to Japan, the patient had purulent urinary drainage around the obstructing Penrose drains. On evaluation, he was found to have a ureterocutaneous fistula and vesical renal reflux. He developed antibacterial-resistant *Pseudomonas* septicemia. He recovered after right nephrectomy and redebridement of infected bony pelvic fragments.

Comment on Case 3-8

This patient had multiple severe wounds, which undoubtedly contributed to his lack of healing, breakdown of his ureteral reimplant, urinary extravasation, and eventual loss of the kidney. Frequently, the nature of the wound precludes an uncomplicated postoperative course. Adequate debridement and the use of drains other than simple Penrose drains exiting anteriorly must be emphasized.

We found that Penrose drains did not provide good drainage in many cases, particularly when air evacuation was used with the patient in a supine position for long periods. On many occasions after manipulating or advancing Penrose drains, we were greeted with large amounts of pus and liquefied hematoma. Healing does not occur under these circumstances. Tubular drains, dependent pararectal and perivesical drains brought through the pelvic floor or coccygectomy site, and suction drains are all important in this respect and are emphasized elsewhere in this text.

Case 3-9

S. C., a 20-year-old man, suffered GSWs that destroyed his femoral head, injured the acetabulum, the rectum, the left ureter, the terminal ileum, and left a wound of exit in the right buttock. His wounds were debrided in RVN with resection of the terminal ileum and repair of the rectum. A left ureteroneocystotomy was done, as his ureter had been severed near the bladder. This was stented with a 10F red rubber catheter, and a large suprapubic tube was placed in his bladder. Delayed primary closure of his wounds was done along with drainage of a pararectal abscess.

His ureteral stent was obstructed at the time of his arrival in Japan. Urine and purulent drainage were found in his dressings. A coccygectomy was done, and large drains were inserted. His cystogram appeared to be normal. His ureteral stent continued to malfunction and it was removed on the 15th day postinjury. He developed urinary drainage that appeared in the left hip wound, and he had a urinary fistula through his coccygectomy site, as well. He had massive edema around the left ureteral orifice endoscopically. These wounds did not heal with sump drainage through the coccygectomy site. After left nephrostomy, the ureteral fistula closed and wound drainage ceased. He was later evacuated to CONUS.

Comment on Case 3-9

One of us (JNW) treated this patient later, in CONUS, and by then the patient had developed bilateral staghorn calculi and numerous other complications. In retrospect, it would have been far better to have done a high urinary diversion and restenting of the ureter early after his wounding, and his fistula might possibly have been prevented. His eventual staghorn calculi were probably the result of infection associated with his nephrostomy tubes and wounds.

Case 3-10

J. R., a 21-year-old man, sustained fragment wounds in RVN, which perforated the right colon, mid ileum, tore the right hypogastric vein, and lacerated the right ureter. Ileocecostomy was done with ileostomy and mucous fistula. The iliac and hypogastric veins were repaired, and the right ureteral injury was repaired over an indwelling stent. Penrose drains were used for drainage. Three days postoperatively, the patient developed evisceration of his wounds with

extrusion of small bowel. The herniation was reduced, the intestinal fistula closed, and the superficial wound was left open. His ureteral stent was removed about 1 week postinjury in RVN.

He developed thrombophlebitis in the right leg on the 15th postinjury day. He was treated with heparin and dextran. He developed gross hematuria with sepsis and fever up to 104.6° F. His IVP showed urinary extravasation and obstruction. Heparin was stopped, and he was placed on massive antibiotic therapy. An emergency nephrectomy was done in Japan and enhanced wound drainage was established. The pathology specimen showed an acute generalized pyelonephritis.

Comment on Case 3-10

Patients with massive, high-velocity wounds with multiple organ system injury and contamination with urinary and intestinal contents are at high risk for infection, sepsis, and poor healing. Even in the most ideal circumstances, ureteral healing may take several days to weeks to be complete after debridement, primary repair, and stenting.[11,12]

For most of these wounds, proximal urinary diversion primarily by nephrostomy with separate urinary stenting allows for a more optimal situation to allow time for healing.[10] Obviously, the ureteral catheter used in this case for stenting and drainage was not adequate. The integrity of the ureter should be evaluated radiographically when stents are removed. Adequate external drainage at the site of ureteral injury and repair should be maintained until complete healing is demonstrated.

Additional Ureteral Wounds

We managed 2 patients with ureterocolic fistula secondary to high-velocity missile trauma. Both of these were managed conservatively by ureteral stenting with complete healing (Figure 3-5).

One patient who had a missed ureteral wound arrived in Japan with massive urinary ascites without sepsis. Aspiration yielded 7,400 mL of intraperitoneal urine (Figure 3-6). Repair of the ureter was done 33 days postinjury with complete healing.

Figure 3-7 depicts a GSW in the second patient. Scattered fragments of the bullet can be seen along the missile tract. The transected left ureter was repaired and stented.

Fig. 3-5. Ureterocolic fistula.

Fig. 3-6. Massive urinary ascites.

Fig. 3-7. Gunshot wound involving the left ureter; metallic fragments are seen along the missile tract.

DISCUSSION AND SUMMARY

Although ureteral war wounds were relatively uncommon in the Vietnam War,[3–6] the mortality rate, 10.5%, was the highest of all abdominal cavity wounds explored.[13] We managed 36 patients with such wounds (7.1% of all of our patients with urological trauma, and accounting for 5.2% of all genitourinary war wounds). Virtually all of these wounds were caused by high-velocity missiles (GSW, 70%; MFW, 30%). Approximately two thirds of all ureteral wounds involved the lower third of the ureter and all of these wounds involved many other major organ systems. There was a high incidence of major complications (90%), morbidity, and nephrectomy (33%). The original ureteral wound was missed in 7 (19%) of our 36 patients.

We believe that patients with ureteral injuries in wartime situations are much more vulnerable to complications and poor results than are those in the civilian sector in general. This is due to the nature of the wounds and frequently to the nonavailability of facilities and personnel for urological evaluation and treatment of these patients. Many patients had massive injuries involving other organs, which frequently take precedence and often make it difficult to treat or even recognize the urological wounds. The nature of the injuries to other organs may compromise the options for urological repair. Many patients had been operated on by nonurologists; urological expertise is not always available in emergency situations in wartime.

However, it must be stressed that many of the complications that we and others[10] encountered were from incomplete debridement and lack of adequate ureteral stenting, proximal urinary diversion, and wound drainage. Ureteral stents are generally recommended when ureteroureteostomy or ureteroneocystostomy is used in the treatment of high-velocity missile wounds of the ureter. These stents should have been accompanied by proximal urinary diversion, preferably a nephrostomy.[10] The ureteral stents available during the Vietnam War were not adequate for proximal urinary drainage. Often these stents were left curled within the bladder, frequently became dislodged, and occasionally were placed through abdominal wall stab wounds from a distal ureterotomy. All of the above techniques frequently resulted in increased obstruction, urinary extravasation, sepsis, poor healing, and subsequent nephrectomy. Careful postoperative management of tubes, stents, and drains is extremely important. Penrose drains frequently are inadequate and often obstruct, whereas tubular sump–type suction drainage was ideal when available.

Several currently recommended principles in the management of these ureteral traumatic injuries should be reemphasized. In the acutely traumatized wounded patient, if a high-dose preoperative IVP was not accomplished or does not adequately define the ureters, the diagnosis of ureteral injury is best accomplished intraoperatively, through a transperitoneal approach. The surgical team must have a high index of suspicion, employing

- intraoperative, high-dose, one-shot IVP (see Chapter 2, Renal Injuries: Penetrating and Blunt);
- thorough exploration of the ureteral bed when indicated by location of the hematoma or other organ injuries and the missile pathway; and
- either IV indigo carmine or direct injection of methylene blue into the renal pelvis, followed by close observation for dye leakage from the site of the ureteral wound.

Such increased vigilance is often necessary to define a ureteral injury. Missed ureteral injury should be suspected in incidences of unexplained fever, leukocytosis, peritoneal signs, and urinary wound drainage. Delayed recognition of ureteral injury is best defined by retrograde urography.[11]

Ureteroureterostomy is the primary preferred technique to repair ureteral traumatic wounds of the upper two thirds of the ureter, including severe or large areas of contusion. Several key aspects of the repair of these high-velocity wounds include the following[11]:

1. wide mobilization of the ureter, sparing the ureteral adventitia;
2. liberal debridement of the ureter until the edges bleed freshly;
3. a water-tight, tension-free anastomosis created from spatulated ureteral ends, using interrupted fine absorbable suture;
4. controlled ureteral stenting;
5. proximal urinary diversion with nephrostomy (or by an adequate, well-positioned ureteral catheter); and
6. adequate external drainage from the anastomotic site.

Nephrectomy is indicated selectively: in instances of massive wounds in unstable patients, often with uncontrolled intraoperative hemorrhage, and in those with extensive ureteral wounds. A staged repair—in unstable patients and in the rare instance of a solitary kidney—might be considered by experienced urologists. Ureteral debridement and reimplantation into the bladder with a psoas hitch, if needed, and ureteral stenting are preferred treatments for distal ureteral wounds. In the postsurgical patient with complications (especially sepsis, urinary obstruction, and/or extravasation) and other organ and systemic problems, nephrectomy is often preferred over attempts at ureteral repair or reconstruction.

The appropriate intraoperative selections—the use and positioning of stents, urinary diversionary techniques, and drains—are key to a successful outcome with minimal complications in these patients. Most nonurological surgeons are not experienced in these techniques. Currently, a large variety of indwelling, inert self-contained ureteral stents and nephrotubes, which were not available in Vietnam, are available for stenting the ureter and providing proximal urinary diversion. Definitive interval follow-up urography is needed to rationally treat patients with high-velocity ureteral wounds and manage and make adjustments in tubes, stents, and drains, if necessary. Antibiotics should be used liberally.

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