Renal Gunshot Wounds: Clinical Management and Outcome

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Background: **To analyze our experience with renal gunshot wounds (GSW).**

Methods: **We analyzed our prospective trauma database for patients with renal GSW.**

Results: **Two hundred one patients (206 renal units) with renal GSW were collected from our database. Preoperative imaging (1-shot intravenous pyelogram, dedicated intravenous pyelogram, or computed tomography) was performed in 68.7% (n = 140). Gross or microscopic (>5 red blood cell/high power field) hematuria was present in 88.7%. Injury to other organs was present in 96.5% (194 of 201), with >1 organ involved in 74.6% (other than kidney). The liver was the most commonly injured organ. Using the American Association for the Surgery of Trauma grading system, there were 46 grade 1 (G1), 21 G2, 62 G3, 51 G4, and 26 G5 injuries. The trend to observe without renal exploration has not changed significantly during the past three decades (1978–1989 = 32.8%, 1990–1999 = 39%, 2000–2007 = 30.4%). Ninety-five renal units (excluding nephrectomy) underwent repair with associated small or large bowel injuries without any known complications, including 14 patients with mesh used during renal repair. The renal salvage rate was 85.4% (n = 176 of 206) with two delayed nephrectomy procedures for persistent bleeding after initial repair. The total number of nephrectomy procedures was 30 of 206 renal units. Postoperative imaging was obtained in 32.8% (55 of 201) patients, and there were no known cases of postinjury hypertension. Overall survival was 90.6% (182 of 201), with 2 intraoperative and 17 postoperative deaths. There were no postoperative infections related to renal reconstruction. Isolation of renal vessels was obtained in all patients before opening Gerota's fascia with no deaths secondary to urologic intervention.**

Conclusion: **Selective observation and various operative techniques can yield high renal salvage rates approximating 85% after GSW.**

Key Words: **Kidney, Penetrating trauma, Outcome, Management.**

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Renal gunshot wounds (GSW) are uncommon but create some of the most complex injuries seen in the urinary system. The blast effect from a bullet can produce significant tissue damage and fragmentation. As such, evaluation and operative management decisions differ from renal stab wounds and blunt renal trauma. In contrast to blunt renal trauma, which predominately presents as a low-grade injury that can be observed, penetrating renal GSW injuries predominately present with an advanced grade of injury leading to more complex management scenarios and higher rates of renal exploration. After abdominal GSW, the patient is often taken directly for emergent exploratory laparotomy. In such a setting, preoperative imaging is not performed, which will require the trauma surgeon and urologist to make intraoperative decisions regarding whether or not to explore and reconstruct an injured renal unit. The primary aim of this article is to evaluate our management of renal GSW in the acute setting and the eventual impact on patient outcome.

This article will frequently refer to the American Association for the Surgery of Trauma (AAST) Organ Severity Score for the kidney.[1] As such, a description and picture of the grading system has been provided for reference (Fig. 1, Table 1).

PATIENTS AND METHODS

Since 1978, over 105 variables pertaining to the admission, mechanism of injury, initial evaluation, management, and outcome have been prospectively entered into our renal trauma database. Permission to collect such data has been obtained by the Institutional Review Board at San Francisco General Hospital. We queried all patients who sustained penetrating renal trauma secondary to GSW and evaluated management and clinical outcomes from 1978 to the present.

All patients with penetrating renal trauma were admitted and managed at San Francisco General Hospital, a dedicated level one trauma center. To ascertain the presence of shock, the earliest vital signs after the GSW were recorded in our database. There was not a preference for the method of microscopic hematuria detection, as dipstick and formal urinalysis were both used for data collection. This decision is based upon a large study of patients after blunt renal trauma, which reported that dipstick analysis has a 97.5% specificity and sensitivity when compared with microscopic urinalysis.[2] If the patient's clinical condition was stable, radiographic imaging was obtained before exploratory laparotomy. If preoperative imaging was not possible before exploratory

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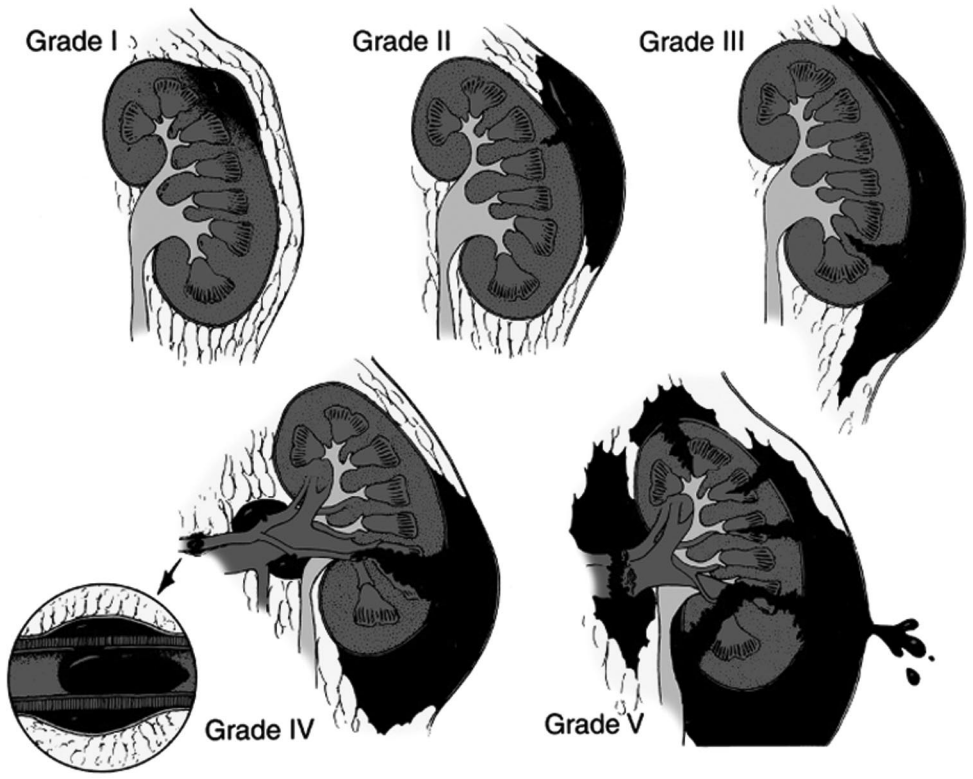

Fig. 1. *American Association for the Surgery of Trauma (AAST) organ Injury Severity Score for the kidney. Reprinted with permission from McAninch JW, Santucci RA. Renal and ureteral trauma.* Campbell-Walsh Urology. *9th ed. Philadelphia, PA: W. B. Saunders Company; 2007:1276.*

Table 1 American Association for the Surgery of Trauma Organ Injury Severity Score for the Kidney

Grade	Type	Description
I	Contusion	Microscopic or gross hematuria, urologic studies normal
	Hematoma	Subcapsular, nonexpanding without parenchymal laceration
II	Hematoma	Nonexpanding perirenal hematoma confined to renal retroperitoneum
	Laceration	Parenchymal depth of renal cortex <1.0 cm without urinary extravasation
III	Laceration	Parenchymal depth of renal cortex >1.0 cm without collecting system rupture or urinary extravasation
IV	Laceration	Parenchymal laceration extending through renal cortex, medulla, and collecting system (positive urine extravasation)
	Vascular	Main renal artery or vein injury with contained hemorrhage
V	Laceration	Completely shattered kidney
	Vascular	Avulsion of renal hilum that devascularizes kidney

* Advance one grade for bilateral injuries up to grade III. Described by Moore et al.[1]

laparotomy, every effort was made to perform one-shot intravenous pyelogram (IVP) before renal exploration to assess the viability of the contralateral renal unit. One-shot IVP was also used in select cases to assist with decisions to avoid renal exploration and reconstruction (low-velocity GSW, clinically stable patient, minor renal injury, absence of urine extravasation, and intraoperative absence of expanding or pulsatile renal hematoma). If performed, 2 mL/kg of iodinated contrast was administered intravenously based upon the weight of the injured patient with a subsequent abdominal radiograph taken 10 minutes later. If renal exploration was performed (Gerota's fascia opened), AAST renal grade was assigned based upon the findings at exploration.

Intervention for renal GSW consisted of observation/bed rest, retroperitoneal exploration alone (Gerota's fascia not surgically violated), nephrectomy, or renal reconstruction/repair. The decision not to perform renal exploration was based upon the patient's clinical situation, bullet velocity of GSW, quality of one-shot IVP, and intraoperative appearance of the retroperitoneum. The absence of an expanding or pulsatile retroperitoneal hematoma and absence of urine extravasation on a good quality one-shot IVP were important factors that helped to influence the decision to not perform renal exploration. If the kidney could not be reasonably staged by radiographic means, then renal exploration was performed.

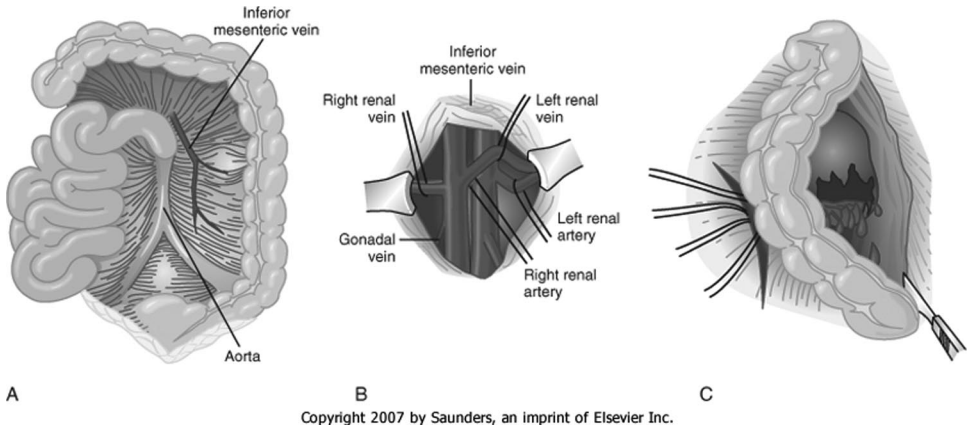

Fig. 2. (A) *Midline exploratory laparotomy provides ample exposure for renal exploration. The inferior mesenteric vein is a useful landmark if retroperitoneal hematoma obscures the aorta. (*B*) Renal artery and vein relations. (*C*) Opening Gerota's fascia after obtaining renal artery/vein control. Reprinted with permission from McAninch JW, Santucci RA. Renal and ureteral trauma.* Campbell-Walsh Urology. *9th ed. Philadelphia, PA: W. B. Saunders Company; 2007:1279.*

All renal explorations were performed after control of the renal artery and vein was obtained with vessel loops. We prefer to obtain vascular control of the main renal vessels via a midline approach, after making an incision over the aorta. A retroperitoneal hematoma can prevent localization of the aorta. In this scenario, the incision will be medial to the inferior mesenteric vein, which serves as a useful landmark (Fig. 2). After this maneuver, the lateral aspect of Gerota's fascia was incised sharply and the kidney was examined for injury. Debridement of devitalized parenchyma was performed before formal reconstruction of renal GSW injuries. The collecting system was reapproximated with running 4-0 polyglactin suture, whereas 4-0 chromic suture was used for parenchymal bleeding. If needed, retrograde injection of methylene blue into the proximal ureter with a 26-G needle while atraumatically obstructing the ureter distally was performed to rule out additional collecting system injury. Upper or lower pole injuries were treated by partial nephrectomy, whereas mid-pole injuries were closed over thrombin-soaked Gelfoam bolsters (Figs. 3 and 4). After repair, Gerota's fascia was reapproximated over the renal parenchyma to provide additional hemostasis for the reconstructed kidney. If Gerota's fascia was not present due to trauma from the GSW blast effect, an omental pedicle flap or woven polyglactin mesh was placed around the renal parenchyma. A clinical example of how we use the omental pedicle flap is provided in Figure 5. Lastly, we prefer to leave a drain in the region of the kidney after major renal reconstruction but avoid active drain suction to decrease the chance of fostering a leak from the collecting system.

Dedicated radiographic imaging of the kidney(s) was obtained after exploratory laparotomy to assess the stability of the repair or, if observational therapy was chosen, the significance/AAST renal grade of the nonreconstructed renal injury. IVP was used early in our series to assess for renal injury after GSW; however, we rarely use this type of imaging today, as computed tomography (CT) is the gold standard for abdominal imaging. CT with 10-minute delayed images allows for more accurate staging of the renal injury and provides the physician with vastly improved detail pertaining to the status of surrounding abdominal organs. Serial hematocrit determination, bed rest, and urethral catheterization

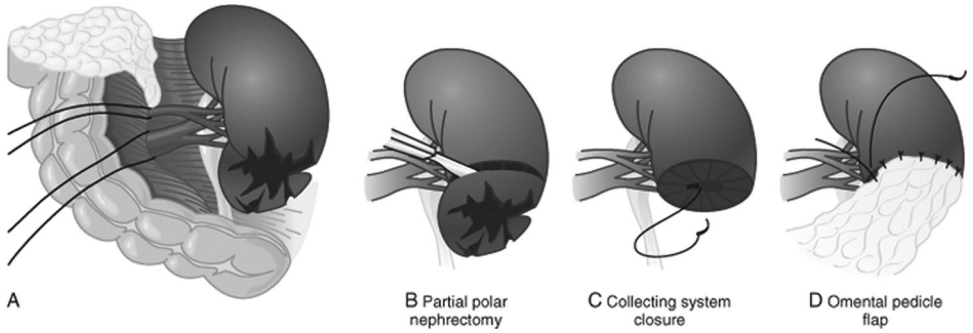

Fig. 3. (A–D) *Partial nephrectomy is useful to treat upper or lower pole parenchymal injuries. An omental pedicle flap is useful to cover the defect after collecting system closure. Reprinted with permission from McAninch JW, Santucci RA. Renal and ureteral trauma.* Campbell-Walsh Urology, *9th ed. Philadelphia, PA: W. B. Saunders Company; 2007:1280.*

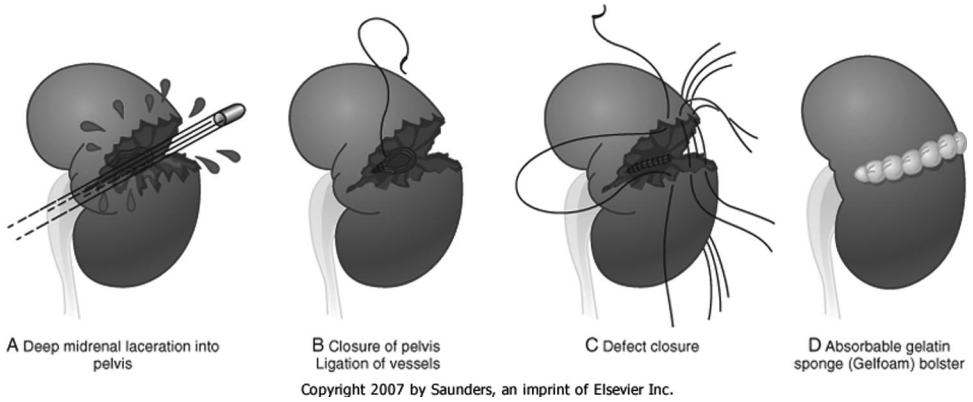

Fig. 4. *(A–D) Mid-pole injuries are best treated with collecting system closure and ligation of vessels. Thrombin-soaked Gelfoam can be inserted into the defect to provide additional compression while closing the outer renal capsule. Reprinted with permission from McAninch JW, Santucci RA. Renal and ureteral trauma.* Campbell-Walsh Urology*, 9th ed. Philadelphia, PA: W. B. Saunders Company; 2007:1280.*

were continued until the patient was deemed clinically stable and gross hematuria ceased. Patients were seen in our urology clinic with a Lasix renogram and abdominal CT 1 month after injury. Based upon the poor level of clinical follow-up after discharge from the hospital, we have since changed our policy to recommending Lasix renal scans before discharge. The blood pressure was also assessed at this visit to rule out postinjury hypertension (i.e., the presence of a Page kidney—hypertension secondary to perirenal hematoma that evolves to an encased scar around the kidney).

RESULTS

Two hundred one patients (206 renal units) with renal GSW were identified from our cohort of over 3,900 renal trauma patients since 1978. The average age of our cohort was 27.76 years old (median, 26.0; minimum age, 6; maximum age, 58), and the overwhelming majority of patients with renal GSW were male (91.3%). The earliest recorded systolic blood pressure indicated that shock (systolic blood pressure $<$90 mm Hg) was present in 87 of 210 patients (43.3%). Data pertaining to hematuria at initial evaluation were present in 193 of 201 patients. Gross hematuria was present in 52.3% of these patients, whereas gross or microscopic ($>$5 red blood cells/high power field) hematuria was present in 88.7% of our cohort.

Preoperative imaging (1 shot IVP, dedicated IVP, or CT) was performed in 68.7% (n = 140 patients). All one-shot IVP examinations were performed intraoperatively. The AAST renal grading system was used to stratify injuries after renal GSW among the 206 renal units (Table 2). Associated injury to other organs was highly correlated with 96.5% of patients (194 of 201) having concomitant abdominal, thoracic, vascular, or neurologic injuries. Of the associated injuries, 74.6% included multiple organs ($>$1 organ, other than kidney). The most commonly injured organs in association with the renal injury were the liver, large bowel, and small bowel (Table 3).

Observation/bed rest (n = 51), exploration only (n = 20), nephrectomy (n = 30), or renal reconstruction (n = 105) was used in the management of individual renal units after GSW (Table 4). Different reconstruction techniques were often used on the same kidney to achieve successful repair (i.e. renorrhaphy with omental pedicle flap to cover reconstructed location). The various reconstruction techniques for renal reconstruction are detailed in Table 4. Our trend to observe select renal GSW with renal exploration or repair has not changed during the past three decades (Table 5). There were 95 renal units that were reconstructed (excluding nephrectomy) in the setting of large or small bowel injuries or both. Of the 95 renal units, 14 patients had mesh used during reconstruction. There were no subsequent complications among these 95 renal units that we were aware of in the acute or outpatient setting.

The overall renal salvage rate after renal GSW was 85.4% (176 of 206 renal units). Nephrectomy in the delayed setting was performed in two patients because of persistent bleeding. One of these patients had bilateral AAST grade 4 renal injuries. The left renal injury was managed with partial upper pole nephrectomy and lower pole renorrhaphy and the right renal injury was observed in the acute setting. Subsequent bleeding after surgery prompted angiography to further delineate the location of bleeding. At that time, the left main renal artery was angioembolized secondary to active bleeding. Bleeding from a right segmental renal artery was also noticed during angiography, which was successfully angioembolized in a selective manner. Nephrectomy was later performed for continued bleeding from the left kidney. The other patient with delayed nephrectomy had persistent bleeding after attempted vascular repair.

Postoperative imaging in the form of CT, IVP, or Lasix renogram was performed in 32.8% (55 of 201) patients. Postinjury hypertension was not diagnosed in the acute or chronic setting; however, we readily admit that follow-up in this population of patients was not uniform. Lasix renogram was performed in 31 of 201 patients (15.4%) after renal reconstruction, with 3 of 31 having $<$20% renal function after initial reconstruction. All three patients had vascular

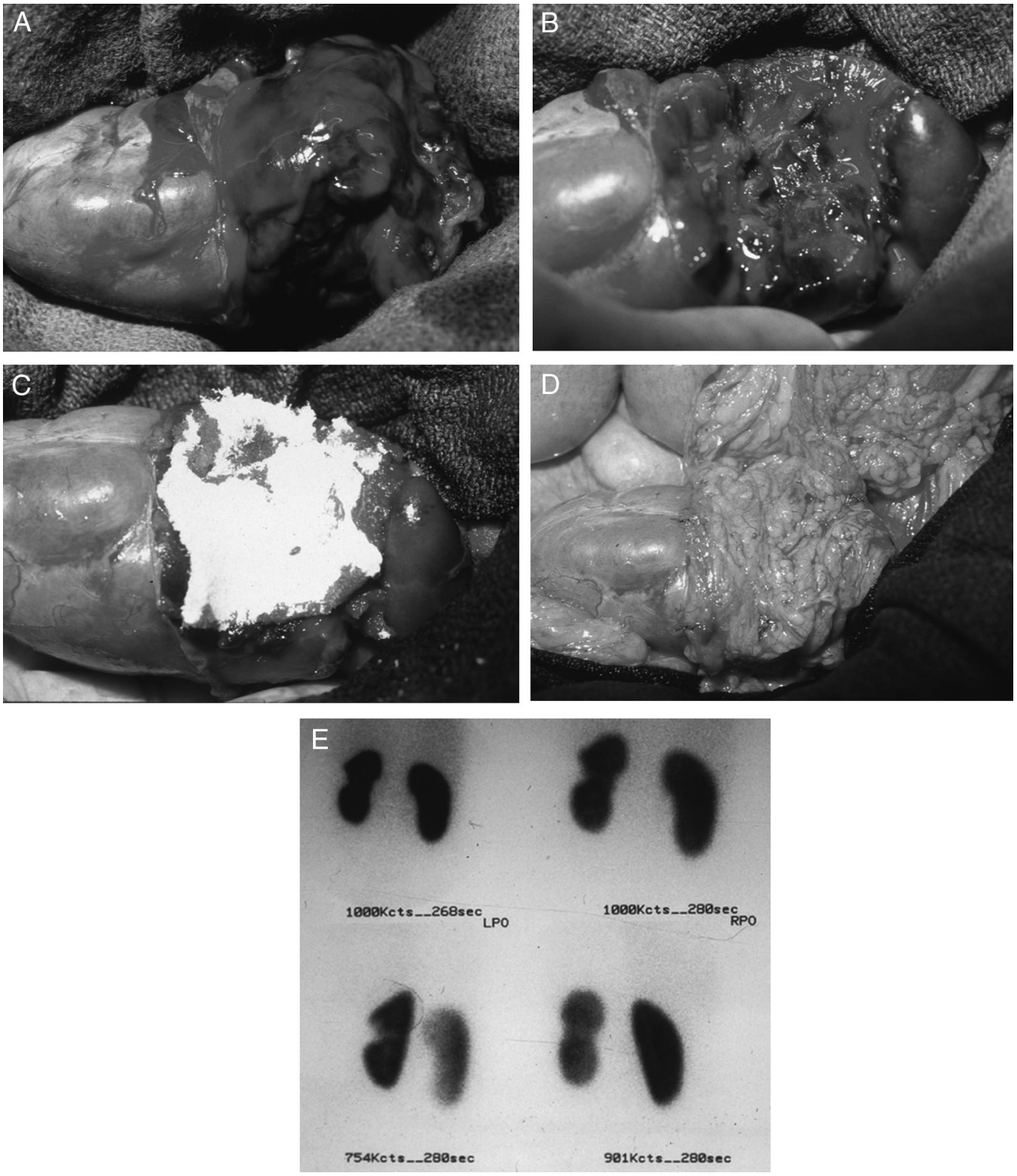

Fig. 5. (A–E) *Forty-eight-year old woman status post self-inflicted left upper quadrant GSW. Emergent exploratory laparotomy revealed a left colon injury and large left retroperitoneal hematoma. Single shot IVP documented a normal right kidney. In preparation for left renal exploration, the renal vessels were isolated and the left kidney explored. An AAST renal grade 4 injury was identified and repaired by closure of the urinary collecting system with absorbable suture. Individual bleeding vessels were ligated* (A *and* B). *Hemostatic agent was applied* (C) *and the defect covered with an omental pedicle flap* (D). *Renal scan 3 months postinjury revealed 38% left and 62% right renal function* (E).

Table 2 AAST Renal Grade of Renal GSW Patients (n = 206 Renal Units)

Renal GSW: AAST	Renal Grade (N = 206 Renal Units)
Grade 1	46
Grade 2	21
Grade 3	62
Grade 4	51
Grade 5	26

Table 3 Associated Injuries in Abdomen, Thorax, Cardiovascular, and CNS After Renal GSW

Organ	Number (%)
Liver	87 (43.3)
Large bowel	72 (35.8)
Small bowel	65 (32.3)
Stomach	45 (22.4)
Spleen	39 (19.4)
Diaphragm	38 (18.9)
Pancreas	31 (15.4)
CNS	28 (13.9)
Adrenal	13 (6.5)
Lungs	12 (6.0)
Cardiovascular	11 (5.0)
Ureter	5 (2.5)
Bladder/urethra	2 (1.0)

CNS, central nervous system.

Table 4 Renal GSW Intervention Stratified By AAST Renal Grade (n = 206 Renal Units)

Intervention	G1	G2	G3	G4	G5	Total
Observation/bed rest	31	9	9	3	0	52
Exploration only	15	4	1	0	0	20
Nephrectomy	0	0	4	7	19	30
Reconstruction/repair*	0	8	49	40	7	104
Mesh	0	1	10	11	1	23
Omental flap	0	0	23	19	1	43
Peritoneal patch	0	0	2	0	0	2
Renorraphy	0	7	25	16	2	50
Vascular repair	0	0	0	14	5	19
Partial nephrectomy	0	0	11	22	0	33

* Different repairs were often performed on the same kidney to achieve successful outcome.

grade 4 injuries that required vascular repair. Two of the three also required partial nephrectomy for additional parenchymal injury.

The overall survival rate was 90.6%, with 2 intraoperative and 17 postoperative deaths after renal/abdominal GSW. Of the deaths (n = 19), AAST renal grade injury was as follows: 1 G1, 5 G3, 3 G4, and 10 G5 injuries. All 19 patients suffered multiple injuries, with the median number of injuries among the deceased as three other organs/locations (average 3.6). The four most commonly injured organs in association with the kidney among the deceased were the liver (11 of 19), pancreas (7 of 19), small bowel (7 of 19), and large bowel (7 of 19). Of the 13 deceased patients who underwent reconstruction/nephrectomy, there were 10 damage control nephrectomy procedures, 1 vascular repair, 1 renorrhaphy with omental pedicle flap, and 1 partial nephrectomy with omental pedicle flap. Three patients were observed and three were explored only (including the 2 intraoperative deaths). Vessel control was obtained in the nephrectomy cohort. Isolation of the renal vessels was obtained in all 135 renal units that underwent renal reconstruction/repair with no deaths secondary to urologic intervention.

DISCUSSION

To date, this series is the largest to analyze the management and outcome after renal GSW. We were able to successfully salvage 85.4% of renal units after GSW. By salvaging as much renal parenchyma as possible via renorrhaphy, partial nephrectomy, or observation in select cases, our hope is that the remaining renal parenchyma in the injured renal unit can aid in avoiding the future need for dialysis. The overwhelming majority of nephrectomy procedures were performed in the acute setting (28 of 30), as there were only two delayed nephrectomy procedures. We attribute our success to the following maneuvers: an excellent working relationship with the trauma surgeons at San Francisco General Hospital, early control of the main renal vessels, debridement of surrounding parenchyma before reconstruction, and an aggressive attitude toward reconstruction.

It is our belief that early isolation of the main renal vessels has assisted in our low nephrectomy rate[3–5]; however, we acknowledge that others do not subscribe to this view.[6,7] The approach is easily reproducible and can be achieved in a timely manner. We did not analyze the number of renal units that required temporary vascular occlusion in this study; however, an earlier report from our institution reported 11 of 92 renal units (12%) to have required temporary vascular occlusion after renal injury.[4] As stated previously, we prefer

Table 5 Trends in Management of Renal GSW During the Past Three Decades (Renal Units)

Intervention	1978–1989 (%)	1990–1999 (%)	2000–Present (%)	Total (%)
Observation/bed rest	19 (26.0)	23 (26.4)	10 (21.7)	52 (25.2)
Exploration only	5 (6.8)	11 (12.6)	4 (8.7)	20 (9.7)
Reconstruction/repair	41 (56.2)	36 (41.4)	27 (58.7)	104 (50.5)
Nephrectomy	8 (11.0)	17 (19.5)	5 (10.9)	30 (14.6)
Total	73 (100)	87 (100)	46 (100)	206 (100)

to make our incision over the aorta to gain access to the main renal artery and vein. Instances in which timely access can be delayed can occur when there is a large retroperitoneal hematoma. If present, we would make our incision just medial to the inferior mesenteric vein to gain access. Some surgeons approach renal vasculature control by mobilizing the ascending or descending colon medially to gain access to the main renal vessels.

Because of concern about devascularization of surrounding structures from the GSW blast effect, debridement of surrounding parenchyma is a crucial step to ensure successful reconstruction after renal GSW. Without debridement, the fragile renal parenchyma and collecting system involved in the blast effect could lead to delayed bleeding or urine extravasation. This is one of the reasons that we use the omental pedicle flap after formal reconstruction. The well-vascularized omentum provides an excellent environment for healing by providing protection against delayed bleeding, urinary extravasation, and local infection.

Observation of penetrating stab wounds to the kidney has become more acceptable in the medical literature[8]; however, concern over the blast effect from GSW has prevented adoption of this sort of management to very select circumstances. Indeed, in a center renowned for aggressive nonoperative management of abdominal GSW, Velmahos and colleagues[9] at the University of Southern California were only able to observe 38% of abdominal GSW in a cohort of over 1,800 abdominal GSWs. In our cohort of 206 renal GSWs, the majority of observed renal units had sustained AAST renal grade 1–3 injuries (96.1%), with the only two remaining renal units AAST renal grade 4. Surprisingly, the majority of our observed cohort had >1 associated injury to other organs, with only five patients having no other injury than the renal GSW and 16 patients having one additional injury to the abdomen, thorax, vasculature, or central nervous system (21 of 51, 41.1%).

Some surgeons will argue that exploratory laparotomy should be pursued in all abdominal GSW patients. In our series, observation of renal GSW patients was pursued only if preoperative imaging of a clinically stable patient revealed the renal injury to be low grade without presence of urine extravasation. If preoperative imaging was not performed in lieu of emergent exploratory laparotomy, intraoperative one-shot IVP was performed to evaluate the presence of a functional contralateral renal unit (i.e., the observance of a pyelogram) and to evaluate the injured renal unit. If the one-shot IVP conclusively demonstrated absence of urine extravasation to the injured renal unit and the retroperitoneum was not expanding or pulsatile upon visual inspection, then observation was considered. As such, we want to stress that we do not advise to pursue observation of renal GSW without radiographic staging.

The utility of the intraoperative one-shot IVP is a controversial topic among urologists and trauma surgeons; however, we think it is a vital part of the initial evaluation when preoperative CT is contraindicated by the need for immediate laparotomy. The perceived delay in obtaining the one-shot IVP is a source of frustration to trauma surgeons. We have not found the one-shot IVP to delay operative exploration; however, our radiology service is knowledgeable on the technique (i.e., contrast is readily available, radiology technicians are efficient in inserting/removing their radiographic cassette without disrupting the surgical field). We do concede that in the setting of an unstable patient with evidence of acute renal bleeding, we have foregone a one-shot IVP in lieu of urgent damage control nephrectomy.

As above, the utility of the one-shot IVP is to identify a normal contralateral kidney before renal reconstruction. The incidence of a congenitally functioning solitary kidney after autopsy is quoted as 1 in 1,000[10]; however, despite this low number, one-shot IVP has aided our diagnosis and management of this scenario in rare instances. Select cases have also allowed us to use the one-shot IVP for intraoperative examination of the injured kidney to avoid renal exploration. In a retrospective review of 50 patients, the one-shot IVP allowed safe observation in 16 (32%) patients.[11] Important factors that can limit the appearance of a one-shot IVP include massive fluid resuscitation, peripheral edema, and significant hypotension.[12]

Astute readers will note that angiography with superselective embolization was not used in our database of renal GSW. We readily admit that our approach to renal trauma is aggressive toward surgical exploration and reconstruction; however, we have used superselective angioembolization for trauma. Smaller coaxial catheters are now available that will allow interventional radiologists to access segmental vessels for embolization, which aids in preserving ultimate renal function. Unfortunately, most series of superselective embolization involve small numbers with variable presentations making interpretation of specific indications difficult. Our own series of superselective angioembolization for renal hemorrhage, includes 26 patients with 16 of 26 secondary to trauma.[13] All AAST renal grade 4 injuries were successfully managed in this series; however, no grade 5 injury ($n = 5$) was amenable to embolization alone.

The question of whether or not to perform renal exploration/repair in the setting of concomitant gastrointestinal or pancreatic injury can arise in the setting of operative management of abdominal GSW. In our current study, there were no complications among the 95 renal units that were reconstructed (excluding nephrectomy) in the setting of gastrointestinal or pancreatic injury. Included in this cohort were 14 renal units that had mesh used in the repair, without subsequent consequence on outcome. Our own review of combined management of renal and gastrointestinal and pancreatic injuries in the setting of blunt or penetrating abdominal trauma did not find gastrointestinal or pancreatic injury to contraindicate renal reconstruction.[14,15]

Weakness of this article include the commonly quoted problem of poor long-term follow-up, which is an unfortunate problem in the setting of trauma. As such, we readily admit

that incomplete follow-up restricted our ability to capture the ultimate impact of reconstruction on renal function and the presence of postinjury hypertension. Furthermore, it is difficult to extrapolate the eventual effect of renal reconstruction given the low rate of postreconstruction Lasix renograms in our trauma population. Differentiation between low- and high-velocity GSW would have also been interesting in regards to AAST renal grade and management outcome; however, we did not collect this data in our database.

CONCLUSION

Renal GSW are strongly associated with concomitant neurologic, thoracic, vascular, and abdominal injuries and are associated with a more advanced AAST renal grade. Knowledge of various operative techniques is vital to ensure high renal salvage rates in this challenging trauma cohort. Observation of renal GSW should only be pursued after appropriate radiographic staging.

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DISCUSSION

Dr. Ajai Malhotra (Richmond, Virginia): The strengths of the paper lie in the numbers, the fairly uniform management plan, despite the long period over which the paper is, and the very high salvage rate of 86 percent of the renal units salvaged.

Furthermore, their secondary nephrectomy rates are low with no patient that was observed requiring a delayed nephrectomy. This suggests that their selection and choice of therapy were appropriate.

I have some questions and several, some comments and several questions. The authors support the role of perioperative imaging for grading and decisions about management.

Dr. Charles E. Lucas (Detroit, Michigan): Many years ago Dr. Michael McGonigal presented our findings on renal function in patients with major injuries undergoing operative repair which often led to nephrectomy as opposed to non-operative management. The patients without hypotension from renal bleeding and without extravasation beyond Glissen's capsule almost uniformly did well without exploration. The renal plasma flow and the glomerular filtration rate were significantly reduced in those patients who had exploration which often led to nephrectomy as opposed to those patients treated without exploration. Dr. McGonigal was taken to task for his presentation, since it went against many of the recommendations that Dr. McAninch and his team were recommending as it related to exploring major renal gunshot wounds.

Dr. McAninch was kind enough to send his protégé, Dr. Richard Santucci, to Detroit in order to teach us the proper interpretation of the Bible. Unfortunately, Dr. Santucci was contaminated and he is now publishing excellent results obtained with the non-operative management of Type III and Type IV renal gunshot wounds. It appears that we will have to send Dr. Santucci, the protégé, back to the west coast in order to teach Dr. McAninch, the master, the proper 21st Century interpretation of the Bible.

Dr. M. Margaret Knudson (San Francisco, California): My question has to do with the timing. How long would you say the average time to repair these kidneys is? Because that is certainly a concern that we all have when we have a patient with severe injuries.

And what should be the damage control approach to the injured kidney? If the trauma surgeons tell you that "we're in the damage control mode," how are you going to, what are you going to do with that kidney? Are you going to pack it or are you going to take it out?

Dr. David G. Jacobs (Charlotte, North Carolina): I just have a question about the role of the IVP. It's been alluded to in the previous discussion.

I wonder whether the authors can give us some information as to how frequently that changed their decision making either for surgery on that kidney or any anatomic injuries that may have been identified with the use of the IVP.

Dr. Allen Morey (Dallas, Texas): First of all, the oncologic literature as more renal lesions are being handled by partial nephrectomy the use of tissue sealants and hemostatic agents has been associated with a decreased rate of delayed bleeding and prolonged urinary leakage.

And so I would like the authors to comment on some of the hemostatic agents that they've been using, if they have any preferences or if they've seen any reduction of complications with any particular type of agent.

And then, secondly, their policy of routinely isolating and controlling the renal vessels, they do have a very high rate of renal salvage but this policy has been frequently challenged as being time consuming, technically demanding and often unnecessary.

Previously they have published a 12 percent rate of occlusion of the renal vessels during the reconstruction. And I would ask them, are they still occluding the vessels about 12 percent of the time? And, if so, does that justify the routine performance of that maneuver?

Dr. Jack McAninch (San Francisco, California): Thank you very much for your questions. I'll attempt to answer these and still challenge Dr. Lucas, again.

The question in reference to the 30 percent who did not get imaged, that was because these patients were emergently in the operating room and there was no opportunity to image because of the critical nature of the patient.

The importance of this single shot IVP, it gives us about a 30 percent chance of not exploring the hematoma because we've got an adequate study to demonstrate that there has been no significant injury to the kidney. If that study is not normal, we do explore the kidney.

There were no deaths related to the renal injuries in this case. And we did not have any AV fistulas or other complications related to the injury other than what was presented.

I would just say that obviously we don't know about AV fistulas completely since only 30 percent of these patients ultimately got postoperative imaging and so we can't be 100 percent sure of that.

Dr. Lucas, I would just say that there is a big difference, as you already know, between blunt and penetrating injuries. A penetrating injury to the kidney, if you follow these nonoperatively your risk of post-injury complications, in my opinion, would be significantly worse.

So avoiding getting any kind of imaging and just letting the hematoma sit, sure, you get by part of the time; but when you have a complication, you lose the kidney.

Dr. Knudson, I do believe that if we can't repair this kidney within an hour of the time we begin the operation then we shouldn't be probably doing it. So having a quick response to kidney repair is necessary because certainly a long repair time is dangerous to these patients.

I think the damage control nephrectomy we did – 30 percent of these nephrectomies that were done were damage control. And I think that will be pretty much what we will see in the future.

For Dr. Morey, yes, we use tissue sealants but primarily they are gel form or Avatine, that type. And we've not been using the other type sealants.

And, as you can see from our experience, we don't feel there is a need to change that since the complication rate from delayed bleeding, etc cetera, and extravasation is extremely low.

Vessel isolation, in my opinion we need vessel isolation since it decreases the instance of nephrectomy, mostly because we can control the bleeding. A 12 percent occlusion rate, that's true.

But I would say this, I probably personally operated on 85 percent of these patients that were presented today. And I don't occlude the vessels very often so I do tolerate more bleeding, perhaps, than other people might.

I thank everyone for their questions and the opportunity to present this material.