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Renal Injury: 5-Year Experience and Literature Review

Key Words

Renal injury · Associated injuries · Mortality

Abstract

Introduction: Appropriate management of renal trauma is controversial. The purpose of this study is to present our 5-year experience in renal trauma and review the literature. ***Materials and Methods:*** From 1999 to 2003, 28 patients were identified with renal injuries. 25 (89.3%) of the injuries were caused by blunt trauma, 2 (7.1%) by stab wounds, and 1 (3.6%) by gunshot wound. Methods for diagnosis included ultrasonography (US), computed tomographic (CT) scan, diagnostic peritoneal lavage (DPL), combinations of more than one technique or no one of them. The English-language literature about renal trauma was also identified using Medline, and additional cited works not detected in the initial search obtained. ***Results:*** 18 patients underwent immediate or during 24 h operation; while 5 nephrectomies were performed. 11 patients with grade I to III injuries were selected for nonoperative management of renal injuries. All complications were noted and studied according to the initial therapeutic management and grade. Follow-up was clinical and radiological. 3 postoperative deaths were observed. ***Conclusion:*** The goals of treatment of renal injuries include accurate staging and minimal complications. Surgery can be avoided in most cases of blunt renal injury but there is also a trend towards conservative management of penetrating trauma. Nephrectomy is associated with high-grade renal injuries, while minor renal injuries can safely be managed conservatively.

Introduction

The topic of renal trauma has offered many substantial and poignant issues of debate over the years, such as classification schemes, management techniques, imaging and diagnostic preferences, and post-traumatic sequelae. Various classification structures have been proposed and utilized for over a century, while the traditional controversy between observation and invasive surgery with trauma patients still exists. Modern advances in imaging and diagnostic procedures have dramatically shifted the reliance on intravenous pyelogram to computed tomography, yet the question remains of how much imaging actually is needed in the average patient presenting with renal trauma.

In this study, we describe our 5-year experience with 28 cases of renal injuries and review the literature.

Materials and Methods

During the period from January 1999 to December 2003, a series of 28 patients with renal injury managed at our surgical department. The medical records were reviewed for patient age, mechanism of injury, side of injury, significant associated abdominal in-

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Table 1. Grading system of the American Association for the Surgery of Trauma [1]

Grade*	Criteria
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: <1.0 cm parenchymal depth of renal cortex laceration
III	laceration: >1.0 cm parenchymal depth of renal cortex, without collecting system rupture or urinary extravasation
IV	laceration: parenchymal laceration extending through the renal cortex, medulla, and collecting system vascular: main renal artery or vein injury with contained hemorrhage
V	laceration: completely shattered kidney vascular: avulsion of renal hilum which devascularizes kidney

*Advance one grade for bilateral injuries up to grade 3.

Table 2. Severity of renal injuries

Grade	Blunt injuries	Penetrating injuries	
		gunshot wounds	stab wounds
I	8	0	0
II	6	0	0
III	7	0	1
IV	3	0	1
V	1	1	0

juries, physical findings including degree of hematuria, laboratory findings, radiologic imaging, medical and surgical management and the development of major or minor complications.

There were 24 males (85.7%) and 4 females (14.3%). The median age of injured patients was 35.2 years (range 17–64). Of 28 renal injuries, 16 (57.1%) involved the right kidney and 12 (42.9%) the left kidney. Renal lacerations were graded based on the American Association for the Surgery of Trauma (AAST) renal injury grading scale (table 1) [1].

Of 28 patients injured, 22 (78.6%) were the result of a motor vehicle accident, 3 (10.7%) falls, 2 (7.1%) stab wounds and 1 (3.6%) gunshot wounds. 8 grade I (28.6%), 6 grade II (21.4%), 8 grade III (28.6%), 4 grade IV (14.3%), and 2 grade V (7.1%) renal injuries were identified. There were 25 blunt (89.3%) and 3 penetrating (10.7%) – included 2 stab wounds – renal injuries. The severity of renal injuries is shown in table 2.

Methods for diagnosis included ultrasonography (US), computed tomographic (CT) scan, diagnostic peritoneal lavage (DPL), combinations of more than one technique or none of the above techniques; neither intravenous pyelography (IVP) nor magnetic resonance imaging (MRI) was performed. US was done on 21 patients (75%) and was helpful in diagnosis for 19 patients (90.5%). CT scan with intravenous contrast was obtained in 15 patients (53.6%) and diagnostic in 15 (100%). DPL was done in 3 patients (10.7%) and was positive in all patients (100%). The 3 DPL-positive patients were taken immediately to the operating room because they were hemodynamically unstable. Emergency exploratory laparotomy was performed in 1 patient because of significant abdominal trauma after gunshot wounds. He was hemodynamically unstable (hemorrhagic shock) and was immediately taken to the operating room without preoperative diagnostic tests.

Generally, of patients with significant abdominal trauma, those who were hemodynamically unstable and had confirmation of intra-abdominal fluid by means of US or DPL were taken to the operating room immediately. Patients who were hemodynamically stable but had diffuse and significant abdominal tenderness were also usually taken directly to the operating room. All other patients with abdominal trauma underwent CT scanning of the abdomen and pelvis.

The presence of hematuria was also noted for each of these injuries. Of 28 patients, 27 (96.4%) presented with gross hematuria and 1 (3.6%) had no hematuria. No patient had a history of renal dysfunction.

Associated abdominal injuries were also identified on US, CT scans or at exploratory laparotomy in 18 patients (64.3%). Liver laceration, spleen laceration, long bones fractures and small bowel perforation were most common concomitant injuries in 6, 4, 3 and 1 patient, respectively. Mesenteric vessel bleeding, pelvic fracture, epidural hematoma and rib fracture-pneumothorax were concomitant injuries in 4 patients.

Results

Characteristic Features in This Series

A total of 5 nephrectomies was performed. They all had major renal injuries (grade IV and V), with 60% of these patients (n = 3) in shock at presentation. Two patients had stab wound renal injuries, while 3 patients had blunt renal injuries. Four of the nephrectomies were performed within 12 h of admission; these were performed at initial operation

because of patient instability secondary to exsanguinating hemorrhage, in concordance with a severely damaged kidney or for shattered kidneys that were felt to be unsalvageable. One nephrectomy was delayed and was performed 24 h after the admission because of hemodynamic instability, peritoneal signs and rapid decline of hematocrit. The nephrectomy rate was 17.8%. All patients who underwent nephrectomy also had other associated major intra-abdominal injuries. Not one nephrorrhaphy was performed, while the remaining 23 patients did not require nephrectomy.

In 3 (37.5%) of the 8 grade I patients renal explorations were performed in conjunction with exploratory laparotomy. Of the grade II injuries (n = 6), 4 renal explorations (66.6%) were performed with exploratory laparotomy, while 4 (50%) of the 8 grade III injuries required renal exploration in conjunction with exploratory laparotomy. All patients with grade IV (n = 4) and V trauma (n = 2) required renal exploration initially. Overall, a total of 17 patients (60.7%) required exploratory laparotomy.

Abdominal incision exploration was preferable for rapid opening and closing of the wound, maximum exposure, easy renal pedicle control and exploration of other organs. In all the operations we performed an abdominal incision. During the renal exploration procedure, the presence of bilateral kidneys was confirmed by palpation, Gerota's fascia was opened only in pulsating or expanding hematoma and nephrectomy was performed in the case of exsanguinating or shattered kidney.

The abdominal and nonabdominal injuries with their associated grade of renal injury are shown in table 3. For complicated injuries splenectomy was performed in 4 patients, hepatic repair in 5 patients (suture of liver parenchyma, hemostasis of the blood vessels, biologic fibrin glue and absorbable hemostatic gauze; the sixth patient with liver laceration was treated conservatively), intestinal repair in 1 patient and mesenteric vessels ligation in 1 patient.

Eleven patients (39.3%) with minor renal injuries (grade I to grade III) had no surgical treatment. They were hemodynamically stable, without peritoneal signs. They had no associated injuries requiring surgical treatment. Crystalloid fluids were used. Eight (72.7%) of these patients received packed red cell transfusions during resuscitation during the first 24 h after admission. The mean 24-hour transfusion requirements were 2.3 units. They were given bed rest and observed with serial urinalysis, serial hematocrit and follow-up CT scan for grade III injury and US for grade I and II injuries. All the patients under conservative treatment were followed-up for 3 months after their hospitalization with US and blood tests and were found to be completely well.

Table 3. Grade-specific associated injuries

Injury	Associated injuries by grade of renal injury					Total
	I	II	III	IV	V	
Spleen laceration			2	1	1	4
Liver laceration		2	1	1	2	6
Small bowel perforation	1					1
Mesentery vessels bleeding		1				1
Long bones fracture			1	2		3
Epidural hematoma		1				1
Pelvic fracture			1			1
Rib fracture-pneumothorax					1	1
Total	1	4	5	4	4	

In conservative management patients the complications were pneumonia (n = 2), intra-abdominal abscess requiring percutaneous drainage (n = 2) and late hematuria (n = 1). The median hospitalization was 10 days (range 3–16 days).

The postoperative complications for the patients in surgical management included pneumonia (n = 3), wound infection (n = 5), ARDS (n = 1) and intra-abdominal abscess requiring percutaneous drainage (n = 1). The median hospitalization was 21 days (range 13–34 days). 14 surgical treatment patients were followed up and their urine, blood and US results were normal. The median follow-up period was 2 months (range 1–4).

The total mortality rate was 10.7%; 3 patients. None of them was among the nonoperative management patients. A man with a gunshot wound renal injury died of severe liver injuries, spleen injuries and hemorrhagic shock and 1 patient died of severe liver injuries and hemorrhage; he had grade IV renal injury. This case represented the only patient in this study in whom the renal injury might have directly contributed to mortality. Both these patients died during the operation. The third patient who died was a 22-year-old woman who had undergone nephrectomy. From her history, she had α_1-antitrypsin deficiency and died in the Intensive Care Unit of lung contusion 11 days after the procedure.

Discussion

Mechanisms of Renal Trauma

The causes of renal trauma may be classified as: (1) blunt trauma: direct blow to the kidney; (2) penetrating

trauma: stab or gunshot injury, and (3) high-velocity deceleration: pedicle injury.

Despite their relatively favored location within the retroperitoneum, surrounded by perirenal fat and a resilient fascial sheath (Gerota's fascia), damage to the kidneys occurs quite commonly in the setting of direct blunt injury, multiple trauma, or penetrating trauma. A distinction is usually made between blunt and penetrating injury because of the increased occurrence of significant renal injury with a penetrating object and its effect on management [2–4].

Overall, 80–90% of renal injuries are due to blunt trauma, most often incurred in falls, motor vehicle accidents, and assault [5]. In the developed world the vast majority of renal injuries result from motor vehicles accidents. In Europe, 97% of renal injuries are blunt [6]. The majority of blunt renal injuries are minor and managed conservatively. In less than 10% of the cases, the injuries are serious enough to require surgery [7].

Penetrating injuries, most commonly the result of gunshot and stab wounds, have an increased incidence of major renal injury and associated intra-abdominal injury [8]. Penetrating injuries are more common in the United States where their incidence has been reported to be up to 16% in a large series of 6,231 patients [9].

Most renal injuries are minor but major renal injury has been reported in up to 25% of blunt, and in up to 70% of penetrating renal trauma cases. Penetrating mechanisms are much more likely to cause severe renal injuries requiring operative intervention and nephrectomy [10]. An abnormal kidney is also more likely to be injured, and pre-existing renal abnormalities (e.g. hydronephrosis, cyst, tumor) have been reported in up to 19% of adult blunt renal injuries [11].

High-velocity deceleration may cause avulsion of the major renal vessels or stretching of the renal artery, leading to arterial occlusion. Rapid-deceleration kidney injuries are explored more often because of the increased incidence of renal pedicle and ureteropelvic junction involvement [12].

Staging of renal trauma consists of clinical, radiological, and surgical information. Combined use of these modalities has improved the capacity for detection, classification and appropriate treatment of renal injury. The Committee on Organ Injury Scaling of the American Association for the Surgery of Trauma has classified renal injuries according to grade (table 1) [1].

Renal Imaging

A variety of imaging modalities exists for the evaluation and staging of patients with suspected renal trauma. The indications for imaging in renal trauma include penetrating trauma with any degree of hematuria, blunt trauma with gross hematuria or blunt trauma and microhematuria with shock or clinical suspicion of abdominal organ injury [13].

Abdominal CT with intravenous injection of contrast medium is the best diagnostic approach for the evaluation of renal trauma providing accurate staging of injury, recognition of pre-existing pathologies of the injured kidney, documentation of functioning of the contralateral kidney and identification of associated injuries to other organs [6, 14]. The diagnosis rate of CT is high, which can accurately reflect the injury situation such as subcapsular hematoma, contusion, location and degree of laceration, and urinary extravasation. Zeng et al. [15] reported that CT was superior to IVP and that the CT diagnosis rate was 100%.

Leppaniemi et al. [16, 17] pointed out that MRI was also one of the useful tools for evaluating renal trauma and could substitute for CT in patients with an iodine allergy. However, MRI provides excellent details of the renal anatomy but offers no clear advantage over CT.

US shows a high diagnosis value for severe renal trauma and free fluid usually indicates solid organ injuries [18]. It has a high negative predictive value (96–98%) and may limit the number of patients undergoing evaluation by CT [19]. US may also be especially useful for the diagnosis and follow-up of postoperative fluid collections and renal lacerations managed conservatively.

The reported accuracy of IVP in renal trauma varies from 65 to 95%, but the presence of an abnormality on IVP usually requires CT or angiography to delineate the precise extent of injury.

Indications for angiography include suspected renal arterial thrombosis or segmental arterial injuries for which embolization or stenting is considered [20].

Urinalysis

Urinalysis is the most important laboratory study used to assess a patient with suspected renal injury. It is a common sign of renal trauma, being present in 80–94% of the cases [21]. However, there is no absolute relationship between the presence, absence, or degree of hematuria and the severity of renal injury [6, 21, 22]. It should be noted that slight hematuria can be presented in severe renal injury or renovascular pedicle injury. In penetrating trauma the degree of hematuria correlates especially poorly with

the severity of renal injury, while in blunt trauma the distinction between gross and microscopic hematuria has a predictive value in determining the likelihood of a major injury [6].

Management

The treatment of renal trauma has been extensively discussed in the literature. While nonoperative management has become the standard in the majority of blunt renal trauma [23–26], the treatment of penetrating and high-grade blunt injuries is more controversial. However, it appears that nonoperative management has a dominant role in the conservative management of renal stab wounds [27], and a burgeoning role in the management of some renal gunshot wounds [28, 29]. The 'correct' rate at which surgery should be applied to renal trauma patients is unknown, but most authors agree that grade I renal injury requires no intervention and grade V injury nearly always requires operative intervention, usually nephrectomy [30, 31].

According to the blunt renal injuries, early evidence seemed to suggest that patients who had surgical management had lower complication rates [32–34], but many authors support the use of nonoperative treatment for the management of blunt renal injury due to the low rate of nephrectomy [10, 20, 24, 35–39]. Another argument is found in series that decrease the operative rate simply by changing institutional policy toward surgery. Centers that adopt a conservative approach have decreased their rates of renal exploration and their rates of nephrectomy, without any apparent increase in complications. Two studies of 38 and 24 patients showed a near twofold and sixfold decrease in the need for nephrectomy respectively, when a policy of nonoperative treatment of renal trauma was adopted [10, 26]. The general approach to patients with blunt renal trauma is not surgical, because 90% have minor injuries [6, 40, 41].

Nonoperative treatment of penetrating abdominal injury was once an unthinkable concept. In the past, all penetrating renal injuries mandated exploration. Improved imaging has allowed more accurate staging and, as a result, has increased the role of expectant management in select cases of penetrating renal injury. The safety of this approach is well documented [28, 42, 43]. In recent years, many authors support the nonoperative treatment of penetrating renal injuries while others suggest routine exploration of the injured kidney [44]. Overall nonoperative management of renal injuries, either blunt or penetrating, is feasible in patients who are hemodynamically stable and no other intra-abdominal injuries requiring surgery [24, 35, 45–47]. Nonoperative management must rely upon close monitoring, accurate staging and trained surgeons. The absolute and relative indications for surgical exploration of the kidney in trauma patients are shown in table 4 [6].

Table 4. Indications for renal exploration in trauma patients [6]

Absolute
Persistent life-threatening hemorrhage
Renal pedicle avulsion
Expanding, pulsatile or uncontained retroperitoneal hematoma (thought to indicate renal pedicle avulsion)
Relative
A large laceration of the renal pelvis
Coexisting bowel or pancreatic injuries
Persistent urinary leakage with failed percutaneous or endoscopic management
Abnormal intraoperative one-shot IVU
Devitalized parenchymal segment with associated urine leak
Complete renal artery thrombosis of both kidneys, or of a solitary kidney, or when renal perfusion appears to be preserved
Renal vascular injuries after failed angiographic management
Renovascular hypertension

Renal stab wound patients may be more treacherous to manage expectantly than blunt trauma patients. Some authors have reported that 54% of renal stab wounds are managed nonoperatively, even when a nonoperative stance is not necessarily embraced [45]. However, delayed bleeding rates in those treated conservatively ranged from 0 to 24% with several series confirming a delayed bleeding rate of about 20% [29, 45, 48].

According to the management of gunshot wounds, a general review of the available data suggest that a tendency toward more conservative treatment of even high velocity wounds may be possible [49]. Velmahos et al. [47] reported a nonoperative treatment rate of 38.5% in a series of 52 patients with gunshot wounds and concluded that mandatory exploration is not necessary for all cases of gunshot wounds. Other authors support expectant management for significant penetrating lacerations [25, 29, 45].

Renovascular injuries are quite rare, and this is reflected in the literature by numerous studies with small patient numbers and little consensus on management. In these injuries, conservative therapy probably means nephrectomy or observation with possible delayed nephrectomy in the case of unilateral thrombus with a functional contralateral kidney [50]. Some renovascular injuries – blunt, arterial, and grade IV – have a poor outcome [50] and high risk of renovascular hypertension [51].

Conclusions

Nephrectomy is associated with high-grade renal injury, penetrating trauma and the presence of other sources of life-threatening hemorrhage [52, 53]. On the basis of our analysis and the current literature, accurate staging of trauma is mandatory for the safe and effective management of renal injury. Close monitoring and trained surgeons also effect management while abandonment of routine exploration of renal injuries in hemodynamically stable patients with no other indications for surgery is safe and effective in selected cases of penetrating trauma and has resulted in lower nephrectomy rates.

Generally, minor injuries to the kidney are well tolerated and resolve without any intervention. Depending on the degree of injury and the stability of the patient, nephrectomy or a renal salvage procedure are both options for patients who require operation. Severely injured kidneys may not be salvaged at all.

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