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SURGICAL EXPLORATION OF THE INJURED KIDNEY: CURRENT INDICATIONS AND TECHNIQUES

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ABSTRACT

When treating renal injuries, the goals of the urologic surgeon are preservation of maximal renal function with a minimal risk of complications. To meet these, accurate staging is essential. The combined use of clinical and radiologic findings, with intra-operative information where available, will enhance the practitioner's ability to detect, classify, and treat renal injuries appropriately. We discuss our current approach to renal trauma and current indications and techniques for surgical exploration of the injured kidney.

Key words: kidney; wounds and injuries; practice management; reconstructive surgical procedures
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CLASSIFICATION OF RENAL INJURIES

In patients sustaining abdominal trauma, approximately 10% will have an injury of the genitourinary tract. Of these injuries, one half will be to the kidney (1,2). Renal injuries traditionally have been classified by mechanism: blunt trauma (constituting 80 - 90%), occurring most commonly in falls, motor vehicle accidents, and assaults (3); and penetrating trauma, occurring most commonly from gunshot and stab wounds. The majority of blunt renal injuries are minor and can be managed conservatively (at our institution, only 2.5% have required exploration and surgical repair [2,4]), while penetrating injuries more often require operative intervention owing to the frequency of severe damage and associated intra-abdominal injuries (5).

Accurately determining the grade of renal injury is a key factor in deciding the mode of management. The Organ Injury Scaling Committee of the American Association for the Surgery of Trauma has classified five grades of traumatic renal injuries (6,7) (Table-1).

INDICATIONS FOR SURGICAL EXPLORATION

Before a renal injury can be selected for nonoperative management, it must be radiographically imaged and accurately staged (Figure-1). Incomplete staging mandates surgical exploration. Our indications for renal imaging have been well described (3,8). In adults, the presence of gross hematuria, microhematuria with shock, or microhematuria in patients with major deceleration injury warrants imaging with computed tomography (CT). In the pediatric population, any degree of hematuria, with or without shock, or a mechanism of injury to suggest a possible renal injury (e.g. deceleration injury or flank contusion) mandates imaging. The widespread use of CT and accumulated experience with the non-operative management of high-grade renal injuries have led to decreased rates of renal exploration.

Absolute Indications

The intraoperative finding of an expanding, pulsatile or uncontained retroperitoneal hematoma

Table 1 *- American Association for the Surgery of Trauma. Organ injury severity scale 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	< 1 cm parenchymal depth of renal cortex without urinary extravasation
III	Laceration	> 1 cm parenchymal depth of renal cortex without collecting system rupture or urinary extravasation
IV	Laceration	Parenchymal laceration extending through 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, devascularizing the kidney

* *Data drawn from reference 6; reprinted with permission from reference 7*

† *Advance one grade for bilateral injuries up to Grade III.*

indicates persistent bleeding, usually from major parenchymal or vascular injury, and exploration is mandated (9). In grade 5 injuries, for instance, the severity - either pedicle avulsion or extensive parenchymal destruction - will require intervention (see Vascular Injury, below).

If adequately staged, many major renal injuries can be managed expectantly. Expectant management is not necessarily nonoperative: it is a period of close observation (with repeat radiographic studies in some cases), which determines when the injury might require surgical intervention.

Incomplete Staging

Often the instability of associated injuries will hinder complete staging, and in these cases a more aggressive approach is warranted. When a suspected renal injury has not been adequately staged preoperatively, an intraoperative single-shot high-dose intravenous urogram should be obtained. Injection of 2 mL/kg of intravenous contrast is given as a bolus and a single film is obtained at 10 minutes (10). Any abnormal or incomplete finding warrants renal exploration.

Thus, exploration is indicated in patients with unstaged blunt renal trauma, a retroperitoneal hematoma, or equivocal findings on single-shot intravenous urography. In addition, all patients with penetrating renal trauma with a retroperitoneal hematoma in whom adequate preoperative staging is not possible should undergo exploration. This approach has resulted in a high rate of renal salvage and has not increased the rate of unnecessary nephrectomy (11).

Relative Indications

Both blunt and penetrating trauma can produce large areas of non-viable tissue, often best managed by early surgical debridement. When injuries with significant devitalized parenchyma are managed expectantly, short-term complications (such as persistent urinary extravasation and abscess formation) as well as long-term complications (such as hypertension) are more apt to occur. This has been demonstrated by Husmann & Morris (12), who reported that major renal lacerations associated with devitalized fragments constituting more than 25% of the unit resulted in an 80% complication rate (including peri-

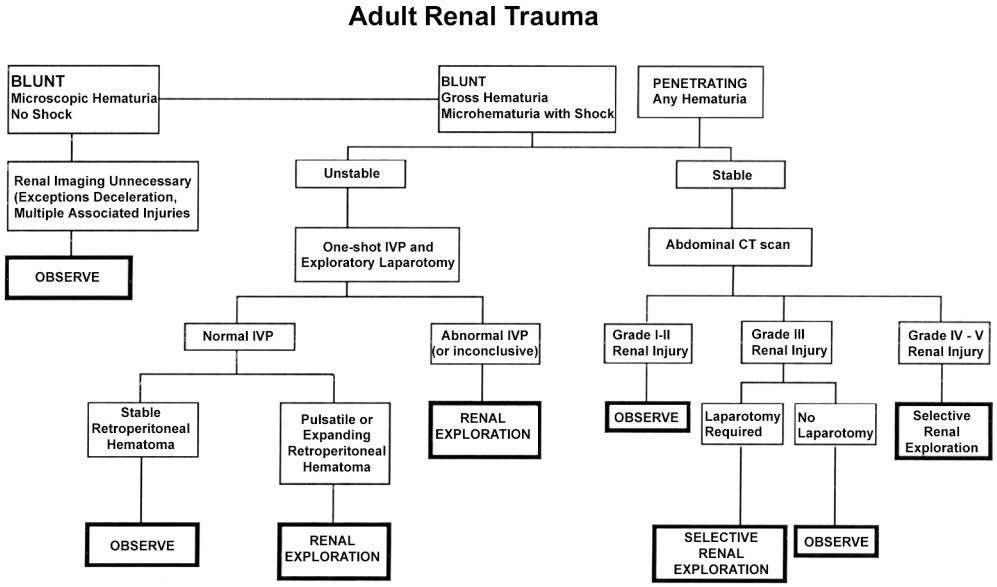

Figure 1 *- Algorithm for treating patients with renal trauma. (Reprinted with permission from: Meng MV, Brandes SB, McAninch JW. Renal trauma: indications and techniques for surgical exploration. World J Urol. 1999; 17: 71-7).*

nephric abscess, infected urinoma, and delayed hemorrhage), requiring open surgical management. When immediate exploration with renal repair was performed in similar patients with associated pancreatic or bowel injuries, morbidity was reduced to 23% (13). On this basis, grades 3 and 4 injuries with significant devitalized fragments and concomitant intraperitoneal organ injuries should undergo immediate surgical repair.

In our experience, patients with a large, nonviable fragment and urinary extravasation or retroperitoneal hemorrhage, even without significant intraperitoneal injury, may also benefit from early renal exploration. The intervention is usually partial nephrectomy, which minimizes potential post-traumatic complications.

Urinary extravasation alone does not necessitate surgical intervention, but it commonly reflects a major renal injury (grade 4) from either a laceration of the renal pelvis or parenchyma or an avulsion of the ureteropelvic junction (UPJ). If the latter, immediate exploration is indicated. Suspicion of UPJ avulsion is raised by nonvisualization of the ipsilateral ureter on CT or intravenous urography (IVU) and by the presence of significant contrast extravasation both medially and perirenally on the imaging study. These injuries are fairly rare and are more common in children with rapid deceleration injuries (14). They rarely heal spontaneously.

Blunt trauma can lead to forniceal rupture and significant urinary extravasation without associated parenchymal injury (15). When the degree of extravasation is small, most cases will resolve spontaneously. Larger degrees of extravasation may still subside without intervention, but monitoring with serial CT scans is indicated because of the risk of complication without spontaneous resolution. Intervention is indicated in persistent leakage, significant urinoma formation, or sepsis development.

Recent literature has shown more than 75% spontaneous resolution rate of urinary extravasation associated with grade 4 renal injuries. Percutaneous or endoscopic treatment was successful in most cases (16,17). Of 47 patients with major renal lacerations and urinary extravastion reported by Glenski & Husmann (16), 15% required endoscopic stenting for persistent leakage and only 9% of these required further intervention, i.e. exploration.

Gunshot wounds to the kidney often result in significant tissue damage and an increased risk of delayed complications, owing to the "blast effect" of the projectile's temporary and permanent cavities. High-velocity missiles or close-range shotgun blasts are particularly devastating. Thus, the threshold for exploration for urinary extravasation from gunshot wounds should be lower than that for stab wounds or blunt trauma (5).

Vascular Injury

In cases of renovascular injury, prompt diagnosis and immediate operative repair are mandatory for renal preservation. However, the detection of renal pedicle injuries is frequently delayed because associated life-threatening injuries take precedence. Over 50% of trauma victims with renal vascular injuries present in shock and the mortality rate ranges from 10 - 50% (18).

Renal pedicle injuries are seen more commonly in children because of their relatively larger kidneys and lower amount of perinephric fat and degree of musculoskeletal development. During deceleration injuries the inelastic intima of the artery can be disrupted, leading to thrombosis of a segmental or main renal artery with consequent parenchymal ischemia or infarction. Main renal artery injuries have the lowest rate of repair and salvage (19). If surgical repair is undertaken within 12 hours, the chance of salvage is greatest; nevertheless, revascularization has demonstrated only a modest 10 - 30% success rate in multiple reports (19-22). Even with intervention within 5 hours, Cass et al. (19) have reported significantly reduced function in the few kidneys appropriate for vascular repair. Such patients are always critically ill, and attempted repair subjects them to increased operative time and risks the complications of hypertension and delayed nephrectomy. Thus, renal preservation is best attempted within 12 hours of injury and in patients with bilateral injury or solitary renal units. Patients in whom the injury appears to be incomplete or perfusion seems intact intraoperatively can also be considered for reconstruction.

When the diagnosis of renal artery thrombosis is delayed or repair is not otherwise indicated, nephrectomy should be performed at exploration for associated injuries. Patients with isolated renal artery thrombosis who otherwise do not require exploration can be safely observed. The kidney can be allowed to atrophy slowly over time; complications of bleeding, infection and hypertension requiring nephrectomy are rare (23).

RENAL EXPLORATION

Although an in-depth description of specific renal reconstructive techniques is not within the purview of this article, principles regarding renal exposure must be borne in mind to ensure good salvage rates. When exploring an injured kidney, nephron preservation is the primary goal. Because uncontrolled hemorrhage is often the cause of total nephrectomy, we advocate preliminary proximal vascular control in all cases of renal trauma (24,25).

Early Vascular Control

Proximal vascular control was initially described by Scott & Selzman (26). A transabdominal midline incision from the xyphoid to the pubic symphysis provides the best access to the abdominal viscera and vasculature. The transverse colon is lifted from the abdomen and placed on the chest under moist laparotomy sponges. The root of the small bowel mesentery and the underlying retroperitoneum are exposed by lifting the bowel superiorly and to the right. A vertical incision is made over the aorta superior to the superior mesenteric artery and into the retroperitoneum, and this is extended upwards to the ligament of Treitz. Often, the aorta is difficult to palpate owing to the presence of retroperitoneal hematoma. In these cases, the inferior mesenteric vein is used as a guide: the incision is made just medial to it, and the dissection is carried down to the anterior surface of the aorta (Figure-2).

Upon identification of the aorta, dissection is continued superiorly until the left renal vein is identified crossing the aorta. This is the key landmark for the identification of the remaining renal vessels (Figure-3). Loops are placed around these vessels, which are left unoccluded unless heavy bleeding that cannot be controlled by direct manual compression of the renal parenchyma is encountered. The artery is

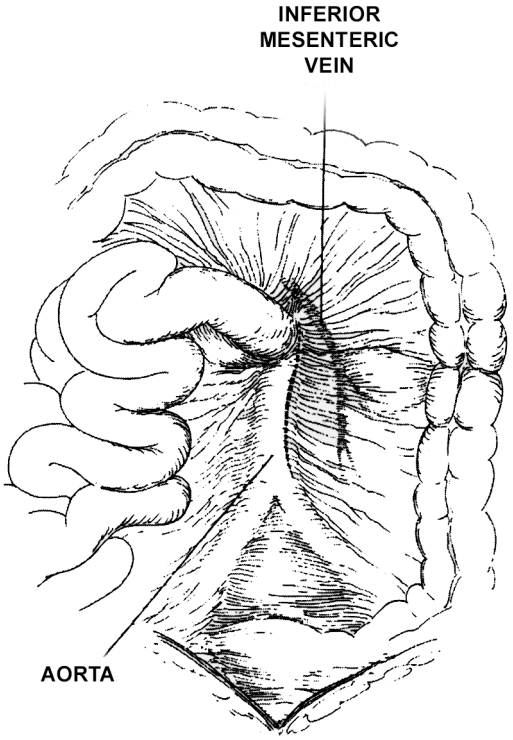

Figure 2 *- Surgical approach to the renal vessels and kidney. The retroperitoneal incision is made over the aorta medial to the inferior mesenteric vein. (Reprinted with permission from: McAninch JW: Surgery for Renal Trauma. In: Novick AC, Streem SB, Pontes JE (eds.), Stewart's Operative Urology. Baltimore, Williams & Wilkins. 1989; 234-9).*

first occluded and, if bleeding persists, the vein is clamped to reduce back bleeding. Warm ischemia time should be held to less than 30 minutes if possible (27). In our experience, occlusion of the renal vessels was required in only 17% of cases, but there is no reliable method for identifying such patients before exploration. On average it takes only 12 minutes to isolate the renal vessels.

Once vascular control has been achieved, the colon is reflected medially and the retroperitoneal hematoma is evacuated after Gerota's fascia is incised laterally (Figure-4). The kidney is then exposed and assessed for injuries. The entire kidney must be well exposed to examine the renal pelvis, parenchyma and vessels fully.

RECONSTRUCTIVE PRINCIPLES

The first step in reconstruction involves adequate debridement: all nonviable tissue should be sharply excised and removed. Preservation of one-third of one kidney provides sufficient renal function to avoid dialysis. The renal capsule should be preserved if at all possible, as it makes eventual closure more successful. Parenchymal vessels should be suture-ligated with 4-0 chromic sutures. Persistent, smaller venous bleeding will usually stop after the parenchymal defect is closed.

Lacerations in the collecting system should be closed in a watertight fashion with running 4-0 chromic suture. Careful injection of dilute methylene blue into the renal pelvis after gentle occlusion of the proximal ureter can aid identification of injuries and confirm adequate closure of the collecting system. Additional drainage by internal stent or nephrostomy tube is not routinely required.

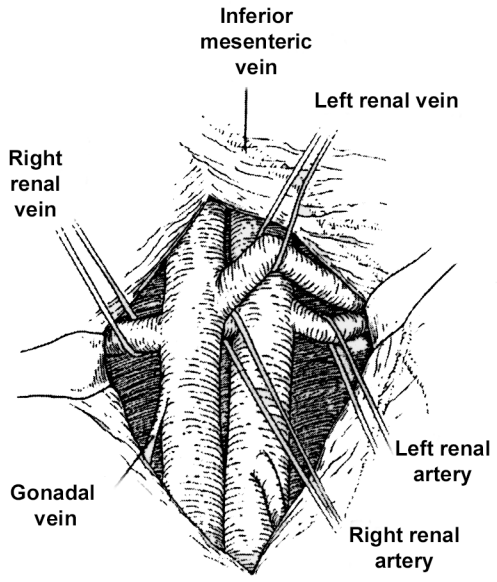

Figure 3 *- Anatomic relationship of the renal vessels. (Reprinted with permission from: McAninch JW: Surgery for Renal Trauma. In: Novick AC, Streem SB, Pontes JE (eds.), Stewart's Operative Urology. Baltimore, Williams & Wilkins. 1989; 234-9).*

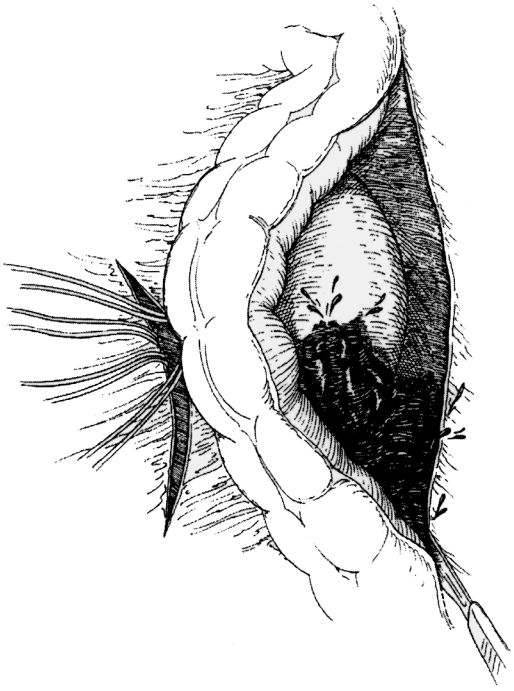

Figure 4 *- The retroperitoneal incision lateral to the colon, exposing the kidney. (Reprinted with permission from: McAninch JW: Surgery for Renal Trauma. In: Novick AC, Streem SB, Pontes JE (eds.), Stewart's Operative Urology. Baltimore, Williams & Wilkins. 1989; 234-9).*

After reconstruction, the defect should ideally be covered with renal capsule by reapproximation of the parenchymal edges. This is done with interrupted 3-0 vicryl sutures tied over gelfoam bolsters. This improves hemostasis and reduces the risk of urinary extravasation. We place titanium surgical clips on the sutures to aid identification of the suture line on postoperative CT scans. If the renal defect is significant, it can be packed with a hemostatic agent such as Avitene (microfibrillar collagen hemostat; Bard; Murray Hill, NJ) or with perinephric fat (Figure-5).

In rare cases, a devitalized polar segment will require partial nephrectomy with amputation and closure of the collecting system. Omentum is a good choice to cover the polar defect if renal capsule is not available. In all renorrhaphies, a one-inch Penrose drain is left dependently to drain the retroperitoneum. A suction drain should not be used as it can promote urinary leakage from the repaired collecting system. Vicryl mesh can be placed around the kidney to stabilize the renorrhaphy repair or when large or multiple parenchymal defects are difficult to cover.

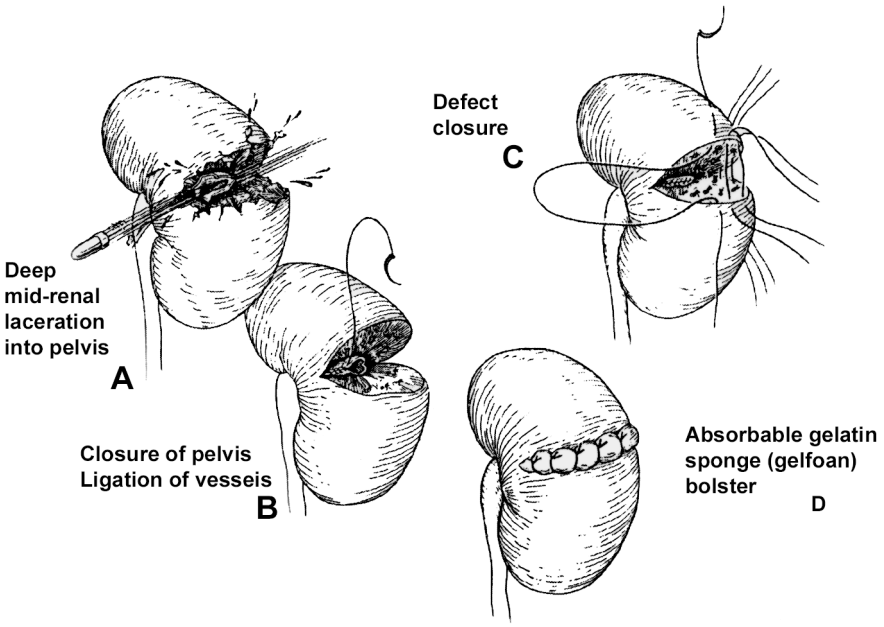

Figure 5 *- Technique of renorrhaphy after midpole grade IV injury. (Reprinted with permission from: McAninch JW: Surgery for Renal Trauma. In: Novick AC, Streem SB, Pontes JE (eds.), Stewart's Operative Urology. Baltimore, Williams & Wilkins. 1989; 234-9).*

CONCLUSIONS

Our treatment guidelines and algorithms for the management of renal trauma are based on our 25-year experience with more than 3150 renal injuries at San Francisco General Hospital as well as on the accumulated knowledge of other trauma centers. This experience has validated our approach and reconstructive techniques. Renal exploration is necessary in only 2% of blunt injuries and in 57% of penetrating injuries (42% of stab wounds and 76% of gunshot wounds [28]). Early vascular control yields a high rate of renal salvage, with only 11% of renal explorations requiring nephrectomy in our hands.

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