Upper Urinary Tract Trauma

CHAPTER 94

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Epidemiology

- **The kidney is injured in up to 5% of all traumas and accounts for 24% of all solid organ injuries.**
- Isolated renal trauma occurs in a minority of patients after blunt injury and is more commonly associated with concomitant solid organ injuries (liver and spleen).
- The majority of renal injuries are **low to intermediate** grade (American Association for the Surgery of Trauma [AAST] grade **I–III**) and can be managed conservatively without significant long-term consequences.

- In a systematic review and National Trauma Databank (NTDB) registry studies, the distribution of renal injury grades were **I (22-28%), II (28-30%), III (20-26%), IV (15-18%), and V (6-7%).**
- Renal **vascular** injuries occur very **infrequently**:
- main renal artery injury : 0.05%
- Renal vein injuries : 0.04%

- The most common injuries are intimal injury with intraluminal thrombus, pseudoaneurysm with/without thrombus and intimal injury .

Presentation and History

- Perhaps the most important information to obtain in those with blunt renal injury is the **mechanism of injury**. Information about the speed of vehicle or height of fall is helpful.
- The kidney is vulnerable to **deceleration** injury:
- **renal hilum** and **ureteropelvic junction** (UPJ).
- Examples of deceleration injury are renal artery thrombosis, renal vein disruption, renal pedicle avulsion, and UPJ disruption.

- **Penetrating renal injuries** most often come from **gunshots** and **stab wounds**.
- **10-20%** of all abdominal penetrating injuries (associated with concomitant abdominal injuries) .
- Penetrating renal injuries have higher rates of **significant and persistent renal bleeding**, need for **renorrhaphy/ nephrectomy**, and higher rate of complications when managed nonoperatively.

- Low velocity gunshot wounds cause less damage and are not as devastating as high-velocity wounds, unless they penetrate the **renal hilum or collecting system.**
- **High-velocity** bullet wounds (>2000 ft/s or >610 m/s) cause **blast effect** with cavitation and are more often associated with delayed tissue necrosis.

- Stab wound entry sites that include the **upper abdomen**, **flank**, and **lower chest**, should raise suspicion for possible renal involvement.
- Trauma to the **anterior axillary line : renal hilum and pedicle injury**
- Trauma to the **posterior axillary line** : **parenchymal injury**.

- **Physical examination** of all body systems must be detailed and complete. In a conscious patient, a thorough history can be taken during the examination.
- **Rapid resuscitation**.
- **cervical spine immobilization**
- Examination of the **abdomen, chest, and back**

- **Indicators of possible renal injury on physical examination** :
- **flank ecchymoses, abdominal or flank tenderness, rib fractures(9 to 12), a significant blow to the flank, and penetrating injuries to the low thorax or flank.**
- **concurrent intra-abdominal injuries**, especially to the **liver, intestine, and spleen.**

- Gunshot injuries can be misleading in that small entrance wounds may underestimate larger tissue destruction within the body because of blast effect.

Hematuria

- **Gross hematuria** or **microhematuria (>5 RBC/hpf**]) with **hemodynamic instability** (SBP <90 mm Hg) are important indicators of **significant urinary tract injury**, particularly when associated with **acceleration/deceleration** injuries and **penetrating** trauma.
- However, the **degree of hematuria** does not necessarily correlate with the severity of renal injury and, similarly, the absence of hematuria does not exclude renal injury.

Classification

- The **AAST** Organ Injury Scaling Committee is the most widely used and accepted classification of renal injury.
- AAST grading is a predictive tool for **clinical outcomes**, such as the **need for surgical or angiographic intervention** or the rate of **nephrectomy**(contrast-enhanced CT)

TABLE 94.1 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

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

Data from Moore EE, Shackford SR, Pachter HL, et al.: Organ injury scaling: spleen, liver, and kidney, *J Trauma* 29:1664–1666, 1989.

- grade **IV** injuries include segmental vascular injuries, including arteriovenous malformations or pseudoaneurysms, as well as renal pelvis injuries/UPJ avulsions.
- Grade **V** now includes a devascularized kidney with active bleeding and a shattered kidney with loss of identifiable parenchymal renal anatomy

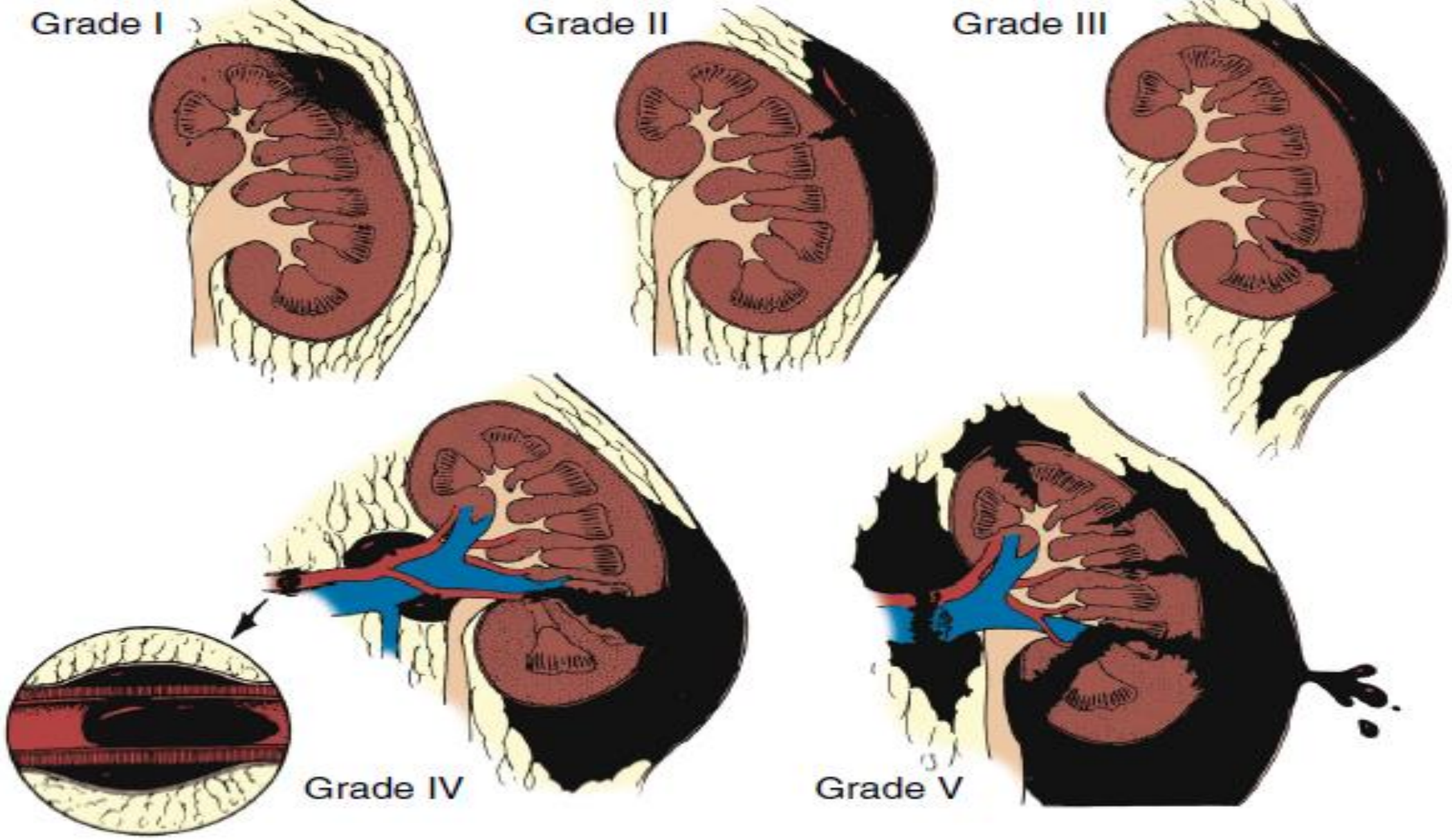
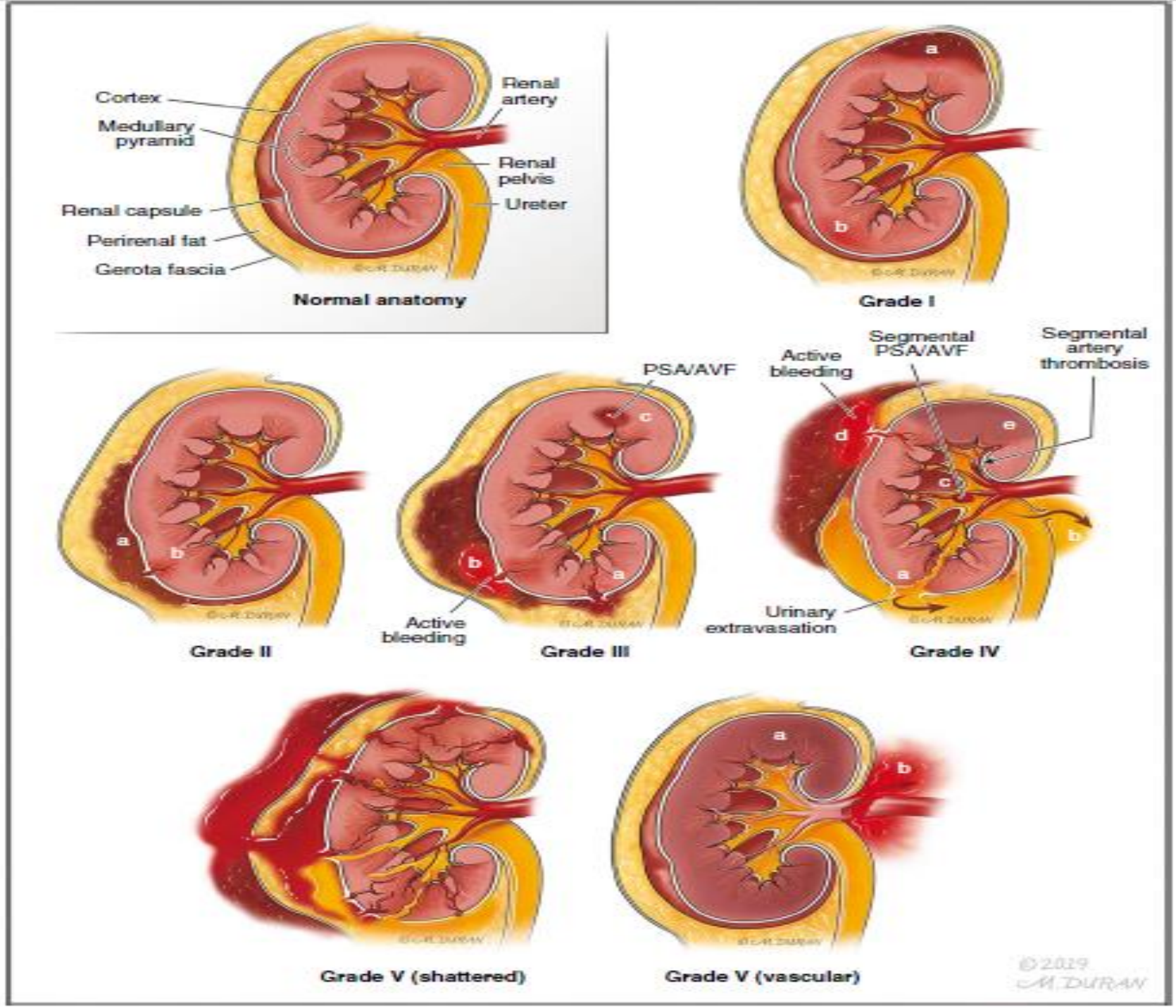


Fig. 94.1. Classification of renal injuries by grade. (Modified from the organ injury scale of the American Association for the Surgery of Trauma. Based on Moore EE, Shackford SR, Pachter HL, et al.: Organ injury scaling: spleen, liver, and kidney, *J Trauma* 29:1661–1664, 1989.)


Cortex
Medullary pyramid
Renal artery
Renal pelvis
Ureter
Renal capsule
Perirenal fat
Gerota fascia
Normal anatomy
Grade I
Grade II
PSA/AVF
Active bleeding
Grade III
Segmental PSA/AVF
Active bleeding
Segmental artery thrombosis
Urinary extravasation
Grade IV
Grade V (shattered)
Grade V (vascular)
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Indications for Renal Imaging

- 1. All patients with a **penetrating trauma** with a likelihood of renal injury (abdomen, flank, ipsilateral rib fracture, significant flank ecchymosis, or low chest entry/exit wound)
- 2. All patients with **blunt trauma** with significant **acceleration/deceleration** mechanism of injury **(vascular pedicle or ureteral pelvic junction injury.)**
- 3. All patients with blunt trauma and **gross hematuria**
- 4. All patients with blunt trauma with **microhematuria AND hypotension** (defined as a SBP <90 mm Hg at any time during evaluation and resuscitation)
- 5. All **pediatric patients** with shock and microhematuria (>5 RBCs/hpf)

- Patients with microscopic hematuria without hypotension or acceleration/deceleration injury can be observed clinically without imaging.
- However, if renal injury is suspected on the basis of history, mechanism of injury, examination, or the patient's subsequent clinical course, imaging should be performed.

- 1.Children have an up to 50% higher risk for renal trauma than adults after blunt abdominal injury, such as motor vehicle accidents and 33% higher risk for high-grade injury.
- larger comparative kidney size, less perirenal fat, nonossified bones, and less relative rib coverage over the kidneys in children.

- 2. **High catecholamine output** after trauma in children
- Importantly, children often do not become hypotensive with major blood loss, and in the absence of this sign can still have an exsanguinating renal injury. Liberal use of renal imaging is probably warranted.
- 3. Children have a higher proportion of **congenital renal abnormalities** such as **severe hydronephrosis or UPJ obstruction**, which may result in significant renal injury from seemingly minor trauma

Imaging

- **Contrast-enhanced CT with immediate and delayed images**
- CT provides the most definitive staging information (i.e., **parenchymal lacerations**, **extravasation** of urine)
- **Associated injuries** to the bowel, pancreas, liver, spleen, and other organs can be identified, and the **degree of retroperitoneal bleeding** can be assessed by the size of the retroperitoneal hematoma.
- **Lack of uptake of contrast** material in the parenchyma suggests **arterial thrombosis** or transection.

- **Findings on CT** that raise suspicion for **major injury** are:
- (1) **medial hematoma**, suggesting **vascular injury**;
- (2) **medial urinary extravasation**, suggesting renal pelvis or **UPJ avulsion injury**;
- (3) **global lack of contrast enhancement of the parenchyma**, suggesting renal **artery occlusion** (cortical rim sign); and
- (4) **the combination of 2 or more** of the following: axial CT perinephric hematoma rim distance >4 cm, medial renal laceration, and vascular contrast extravasation (suggesting brisk active bleeding), which constitute an AAST grade IV injury.

- A 4-cm perinephric hematoma is associated with an increased rate of bleeding interventions from 1.7-16.2%, and 31% for a 6-cm hematoma.
- **Active extravasation** of intravascular contrast seen on CT (i.e., the patients are bleeding so briskly as to be detectible on the vascular phase CT scan) is highly associated with the need for subsequent **AE**.

- One **major limitation of CT** is the inability to define a renal **venous injury** adequately. With normal arterial perfusion, the parenchyma appears normal and the collecting system may contain contrast material. A **medial hematoma** accompanying the preceding findings suggests a venous injury.

- In contemporary practice, there is a limited role for intraoperative "**one-shot" IVP**.
- The main purpose of the one-shot IVP is to assess the presence of a **functioning contralateral kidney**.
- It is vital to know if a patient has only 1 kidney, because urgent surgical exploration of renal injuries often leads to nephrectomy for the injured kidney.

- **Ultrasonography** is typically used in the immediate evaluation of abdominal injuries (focused assessment with sonography for trauma [FAST] examination) but has **poor specificity** in the adult renal patient for renal injuries.
- Ultrasound is **limited** by obesity, subcutaneous air and prior abdominal operations.
- It cannot differentiate between a hematoma and a urine leak.

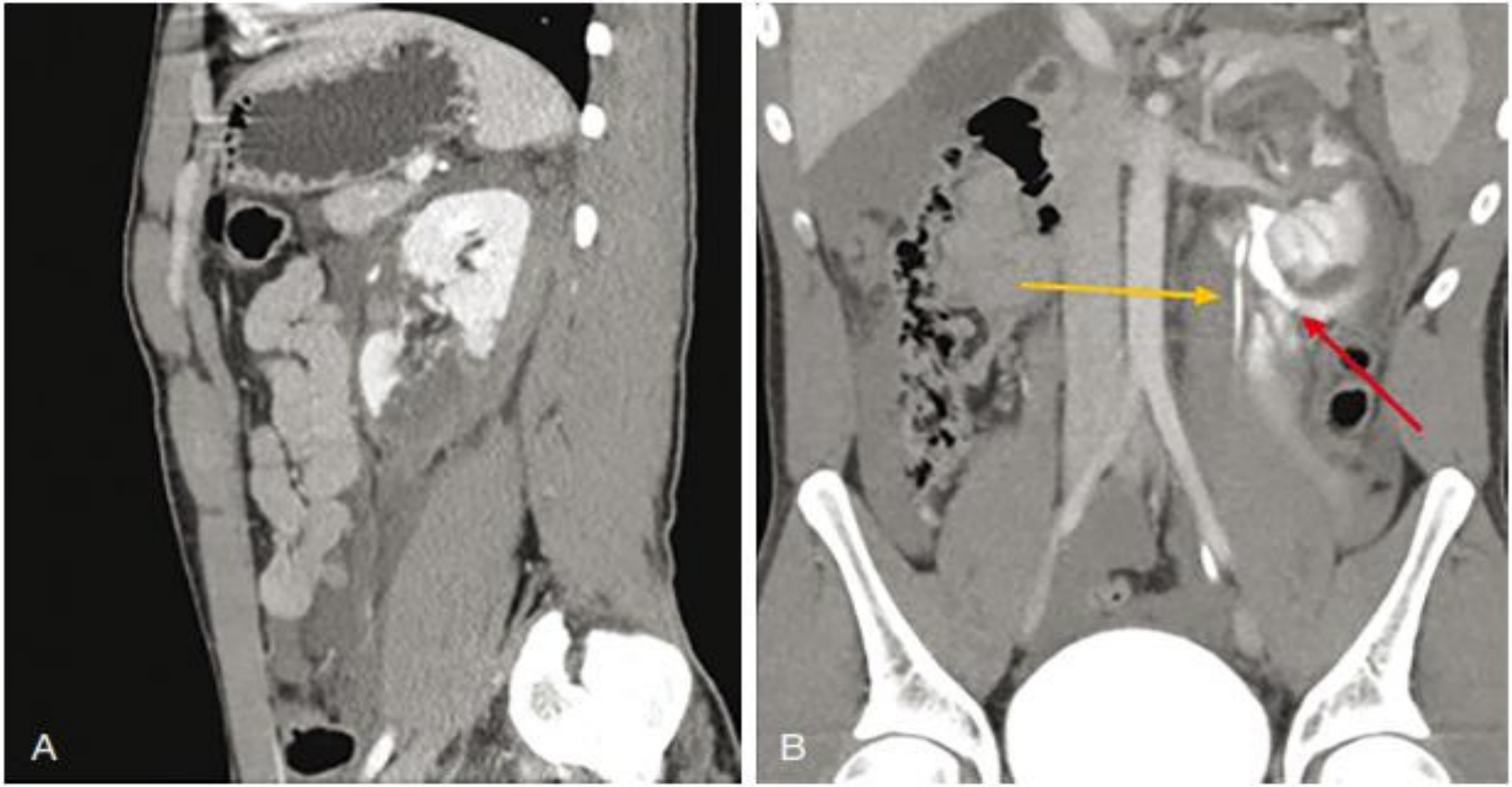

Fig. 94.4. CT scan of a left renal injury following an all-terrain vehicle accident. (A) The immediate contrast phase. (B) Delayed-phase imaging demonstrating a grade IV injury with a normal ureter *(yellow arrow)* and urinary extravasation *(red arrow)*.

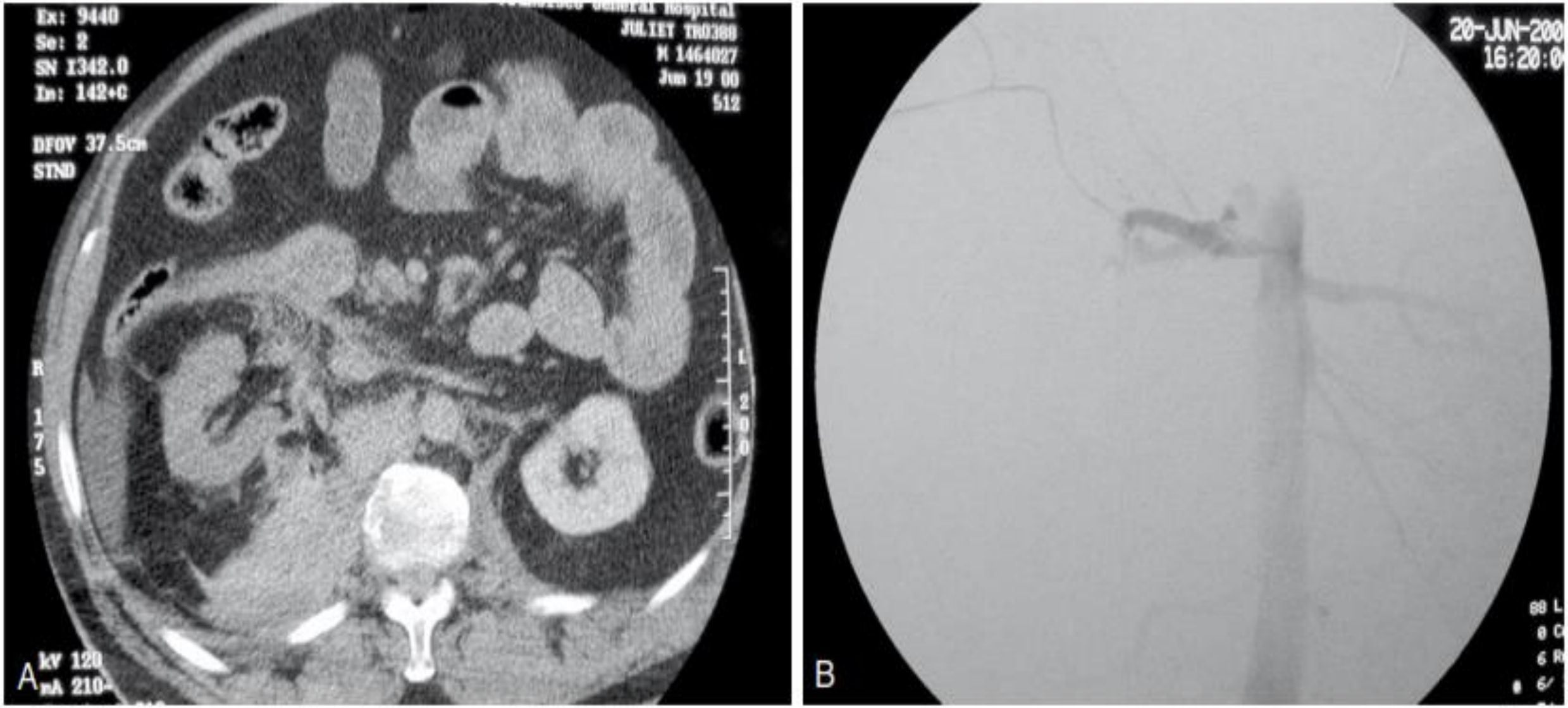

Fig. 94.5. (A) CT scan showing right renal artery thrombosis after crush injury. Note poor contrast uptake in right kidney compared with left and diffuse soft tissue injury medial to right kidney in the area of the renal artery. (B) Angiogram showing right renal artery thrombosis after crush injury.

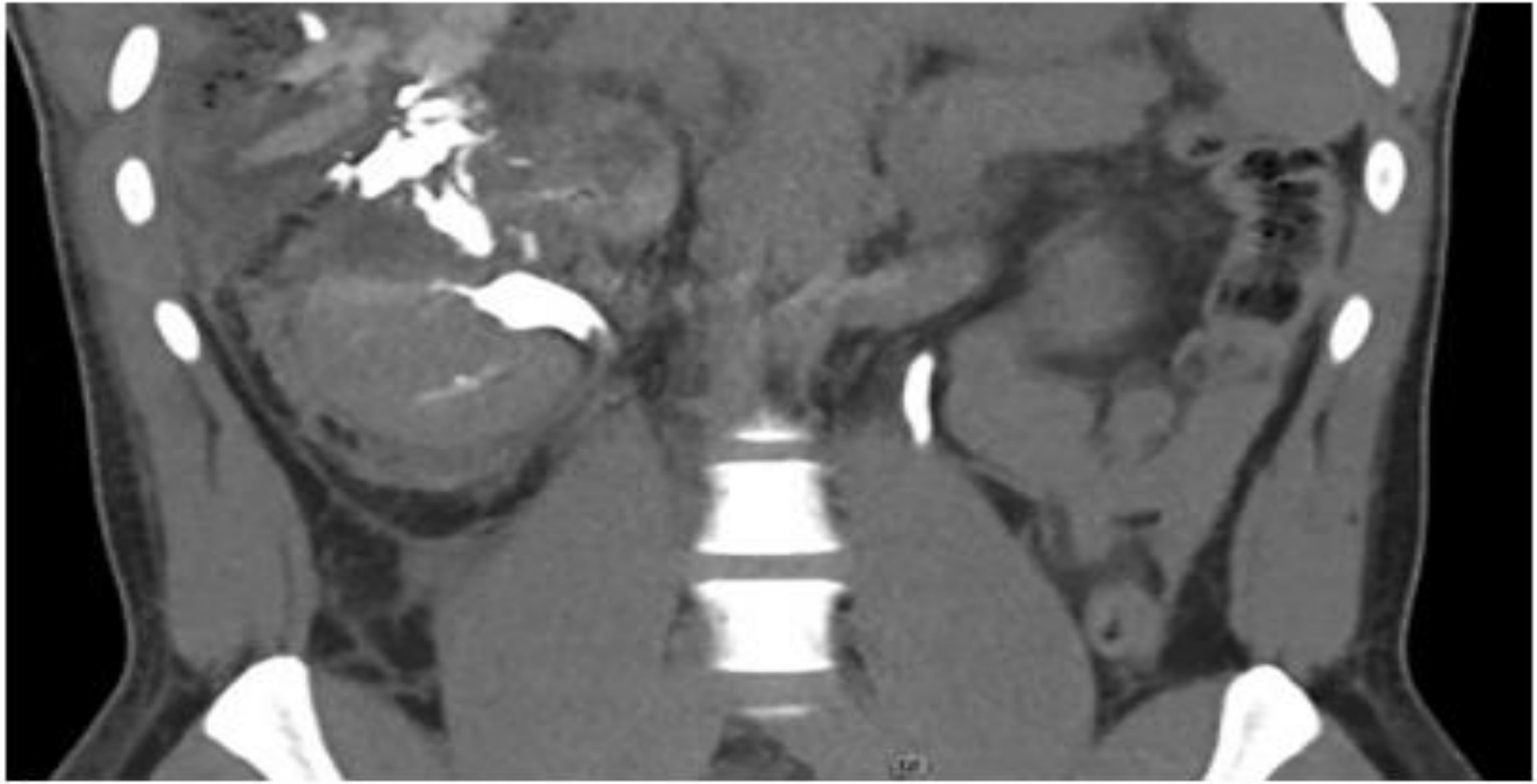

Fig. 94.6. In the same patient as Fig. 94.5, delayed phase CT scan, demonstrates urinary extravasation.

Principles of Renal Trauma Management

Nonoperative Management

- The **AUA** Urotrauma Guidelines are as follows:
- 1. In hemodynamically stable patients with renal injury, clinicians should use **noninvasive** management strategies.
- 2. Clinicians may initially **observe** patients with **renal parenchymal injury and urinary extravasation**.

- **Noninvasive management strategies:**
- **close observation** with **vital signs** monitoring,
- serial **hemoglobin/hematocrit** every 4 to 6 hours,
- and repeat **physical examination**.
- Classic teaching is to prescribe bed rest until gross hematuria resolves. However, this practice is empirical and early mobilization has been demonstrated to be safe in renal injury, as well as liver and spleen injuries.

- **Clinical triggers for failure of expectant nonoperative management :**
- **hemodynamic instability**,
- **declining hemoglobin/hematocrit** and **transfusion of 2 to 3 units** of packed RBCs,
- **change in physical examination findings** (flank pain/abdominal guarding).
- With respect to **urinary extravasation**,intervention is warranted with signs of enlarging urinoma on imaging with or without signs of flank pain, infection, fever/chills, and rising WBC count.

- **Significant renal injuries (5%):**
- hemodynamically stable with accurately staged: **expectant management** regardless of mechanism.
- grades IV and V injuries

Penetrating renal injury

- **Nonoperative management**
- Disrupt Gerota's fascia and loss of the natural **tamponade effect**
- **High-grade** penetrating injuries are more often **managed surgically** because of intervention for **associated intra-abdominal** injuries.

- Stab wounds **posterior to the posterior axillary line** are less likely to cause visceral injuries and may be successfully managed **without intervention**.
- close observation with serial exams and monitoring
- Patients who develop **new tenderness** or **abdominal guarding** warrant abdominal **exploration**.

- The only **absolute intraoperative indication** for kidney exploration :
- **pulsatile and expanding retroperitoneal hematoma**, which suggests a lifethreatening renal artery laceration.(laparotomy for associated traumatic injuries)

- **The AUA Urotrauma Guidelines** :
- **routine follow-up CT imaging** :
- **48 hours after** injury in high-grade renal injury (**grade IV–V**) with deep lacerations
- and/or those with **clinical signs** of complications (e.g., **fever, chills, flank pain, evidence of bleeding, abdominal distention**).

- There is mounting evidence that **significant complications** almost always present with symptoms, such as **fever, flank pain, dropping hematocrit, and increasing hematuria**.

Treatment After Failure of Conservative Management

- **Risk factors** for failure of conservative management:
- **renal injury grade**, **nonrenal abdominal injuries**, and **penetrating injuries**.
- ureteral stent, nephrostomy tube, or AE.
- **Delayed bleeding :** within **2 weeks after** injury.

- **conservative management** resulted in:
- lower complication rates,
- fewer transfusions,
- shorter intensive care unit (ICU) and hospital days,
- and reduced mortality compared to aggressive surgical management.

Urinary Extravasation

- Patients with high-grade renal injury and urinary extravasation: **Initial observation (**76-90% will heal without intervention).
- **significant renal pelvis or UPJ injury**:
- **Medial urinary contrast extravasation**,
- **medial urinoma**
- **absence of contrast in the distal ureter** on delayed urogram CT

- For such patients,**prompt intervention** is required(**endoscopically**, **percutaneously**,**or open**)

- Furthermore, the presence and increasing volume of devitalized parenchyma is associated with increase odds of intervention and surgical management.
- In the **absence of devitalized parenchyma**, UPJ injury, obstructed ureter with urinary extravasation in otherwise clinically stable patients, **expectant management with close observation** with initiation of prophylactic antibiotics (despite lack of evidence to support it) is reasonable.

- **Repeat imaging** to evaluate for enlarging and/or infected urinoma and/or intervention is required for patients with **worsening flank pain, fever, rising WBC count, ileus, and/or peritonitis**.
- Currently, the AUA Guidelines recommend considering repeat imaging **48 to 72 hours after initial imaging** to re-evaluate for **enlarging urinoma** and **continued urine leak**.

- In the case of a **symptomatic urine leak/enlarging urinoma** with/without signs of infection, urinary drainage with retrograde **ureteral stent placement**, **nephrostomy tube**, and/or **urinoma drain placement** is required and supported by the AUA Guidelines.

- In severe renal injuries with continued urinary extravasation, placement of an internal **ureteral stent alone** for drainage usually prevents prolonged urinary extravasation and decreases the chance of perirenal urinoma formation. It may be useful to also initially place a **Foley catheter** after ureteral stent placement to maintain maximal drainage.

- **Percutaneous nephrostomy drainage** with consideration for **antegrade ureteral stent** placement is a viable option in these situations:
- concomitant pelvic fracture with urethral distraction defects, severe genital trauma prohibiting urethral access, complete ureteral transection, and fractures prohibiting the dorsal lithotomy position.)

- When the perinephric fluid collection persists despite ureteral stenting or percutaneous nephrostomy drainage, placement of a **percutaneous drain** can facilitate healing and prevent or treat abscesses.

Interventions for Renal Trauma

Angioembolization

- Renal arteriography and AE are increasingly used in the management of high-grade renal injury.
- **Superselective AE** provides an effective and less invasive technique to successfully manage bleeding.
- **improved renal salvage rates** and **avoids** the need for exploration that would otherwise result in **nephrectomy**.

- **Traumatic pseudoaneurysms and arteriovenous fistulae** are the result of trauma and may occur in a **delayed** manner after a period of conservative management or prior interventions.
- These are often treated with **initial or repeat AE** with a high expected success rate.

Operative Management

- **Absolute indications include:**
- (1) hemodynamic instability with no or transient response to resuscitation,
- (2) expanding/pulsatile renal hematoma (usually indicating renal artery laceration),
- (3) suspected renal vascular pedicle avulsion, and
- (4) UPJ avulsion.

- **Relative indications are**:
- **(1)** urinary extravasation with significant renal parenchymal devascularization
- **(2)** renal injury together with colon/pancreatic injury
- **(3)** arterial thrombosis, and
- **(4)** urinary extravasation from parenchymal injury.(spontaneous resolution in up to 90%)

Renal Exploration

- Surgical exploration of the acutely injured kidney is best by a **transabdominal approach**, which allows complete inspection of intra-abdominal organs and bowel.
- Injuries to the great vessels, liver, spleen,pancreas, and bowel can be identified and stabilized, if necessary,before renal exploration.

Nephrectomy

- The decision to perform a nephrectomy rather than attempt reconstruction of an injured kidney depends on many factors:
- the **overall clinical status** of the patient, the **nature of the renal injury** (i.e., is it reconstructable, is it the cause of instability), **concomitant injuries**, the presence/absence of a functioning **contralateral kidney** (by imaging, palpation, and/or one-shot IVP), as well as the **experience** of the trauma and/or urology teams involved.

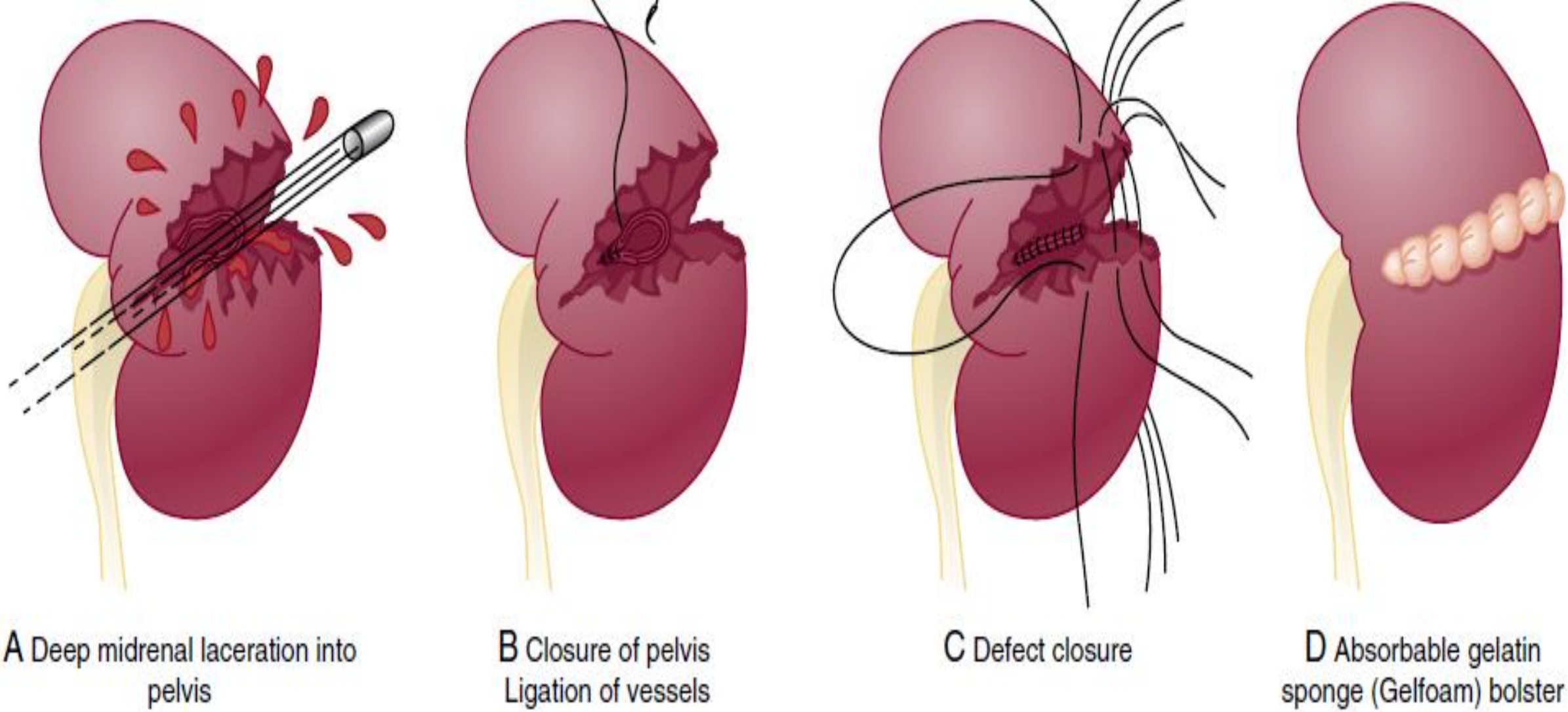

Fig. 94.13. Technique for renorrhaphy. (A) Typical injury in midportion of kidney. (B) Debridement, hemostasis, and collecting system closure. (C) Approximation of parenchymal margins. (D) Sutures tied over gelatin sponge bolster.

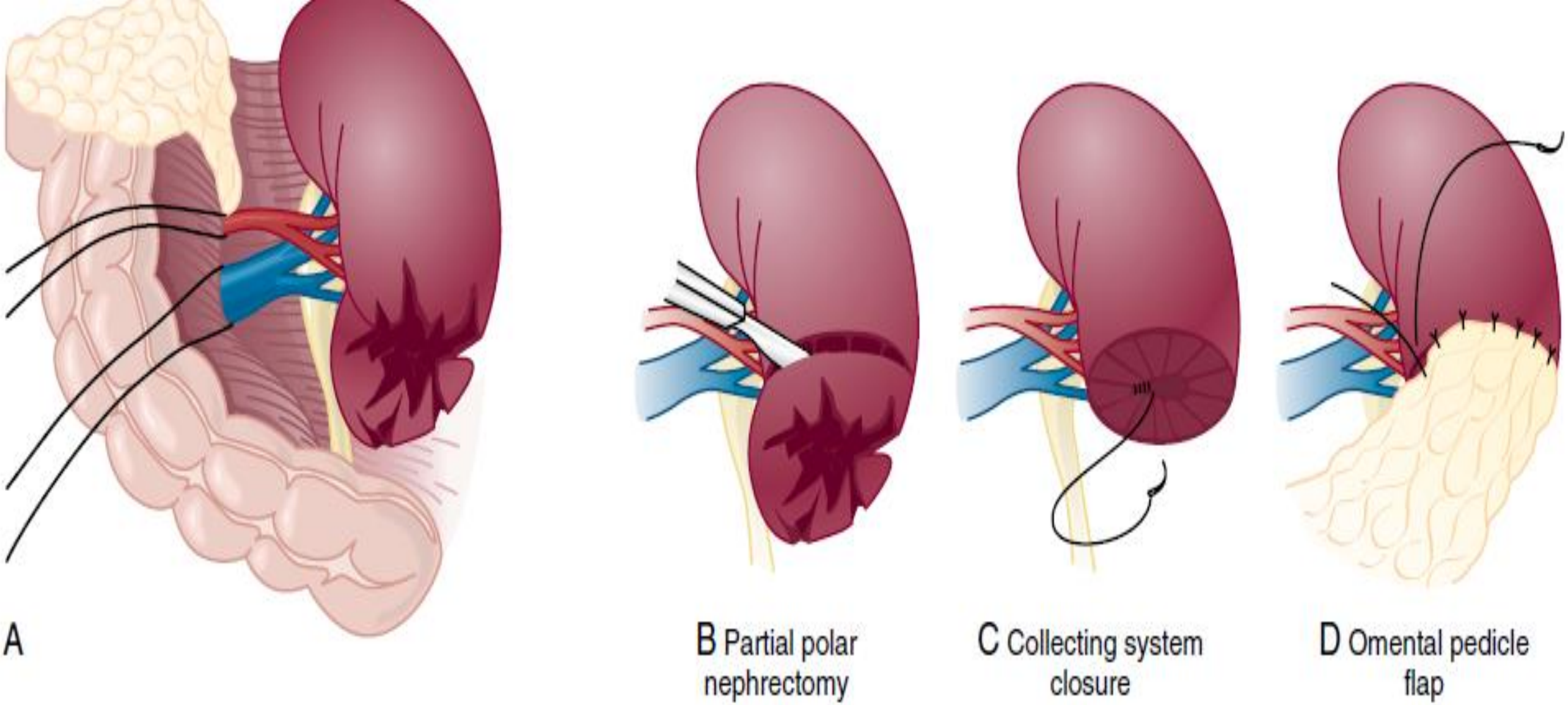

Fig. 94.12. Technique for partial nephrectomy. (A) Total renal exposure. (B) Sharp removal of nonviable tissue. (C) Hemostasis obtained and collecting system closed. (D) Defect covered.

Renovascular Injuries

- **Renovascular penetrating or avulsion injuries** after trauma are uncommon and often have associated injuries requiring operative intervention.
- **For major renovascular injuries** in patients with two kidneys, **prompt nephrectomy** is advocated.

- The **absolute indications** for attempted **revascularization** are **solitary functioning kidney** or **bilateral renal artery injuries**.
- The success of renal salvage is highly dependent on the length of **warm ischemia time**, which ideally should be **<120 minutes.**

Complications

- The **primary** goal of trauma management : survival
- **secondary** : renal salvage.
- **patient factors**, **injury mechanism**, AAST injury **grade** and **associated injuries**, and **management of the renal trauma** and associated injuries.

Mortality

- Mortality in patients with renal trauma is likely the result of the **nature of the trauma** and **associated injuries**, **initial trauma management, and subsequent complications**, rather than being directly related to the renal trauma itself.

Acute Kidney Injury

- Male sex,increasing transfusion requirement,AAST grade
- DMSA scan:2.9%
- It is difficult to discern the impact of renal trauma on long-term renal function because long-term follow-up and outcomes are often lacking.

Persistent Urinary Extravasation, Urinoma, and Perinephric Abscess

- Persistent urinary extravasation can result in **urinoma,perinephric infection, and, rarely, renal loss**.
- placement of an internal **ureteral stent** with/without a **Foley** catheter to maximize drainage.
- percutaneous **nephrostomy** or transcutaneously placed urinoma **drain**

- **Perinephric abscess** : persistent urinary extravasation and urinoma are the typical precursors.
- Urinary drainage with a **ureteral stent** with/without percutaneous **nephrostomy** followed by **percutaneous abscess drainage** offers a good initial method of management.
- **Open surgical** management in refractory cases is rarely necessary.

Delayed Bleeding

- Delayed renal bleeding can occur up to several weeks after injury but usually occurs **within 21 days**.
- The initial management is **bed rest** and **hydration**. Should the bleeding persist, **angiography and embolization** frequently can localize and control the bleeding vessel.

Hypertension

- The incidence of de novo hypertension following renal trauma appears to be low
- **early** after trauma or **late** complication.

- **The pathophysiology of hypertension**:
- **(1)** renal vascular injury, leading to stenosis or occlusion of the main renal artery or one of its branches (Goldblatt kidney);
- **(2)** compression of the renal parenchyma with extravasated blood or urine or scarring caused by the hematoma (Page kidney);
- **(3)** posttrauma arteriovenous fistula (AVF).
- In these instances, the **renin-angiotensin axis** is stimulated by partial renal **ischemia**, resulting in hypertension

- The management of hypertension depends on the clinical scenario and suspected etiology.
- In the setting of a **Page kidney**, if it occurs acutely, the management is largely medical with **ACEI** and **ARB** to control blood pressure and wait for reabsorption of the hematoma.
- refractory hypertension and/or renal dysfunction: intervention with **percutaneous drainage** or **open/laparoscopic subcapsular decortication.**

Other Complications

- Uncommon complications include :
- new **hydronephrosis/UPJO** (in absence of ureteral/UPJ injury) that may be related to fibrosis from urinary extravasation/hematoma, **chronic flank pain**, and **renocutaneous fistula**

Follow-up After Trauma

- Low-grade (grade **I and II**) injuries **do not require** imaging at follow-up; however.
- for **asymptomatic** patients after grade **III to V** injuries with renal salvage,**DMSA scan** may be used to document remaining function.
- periodic **monitoring of blood pressure, physical examination, urinalysis, and assessment of renal function** is prudent.
- The optimal timing to return to **normal activities or sports** after renal trauma is not known; however, expert opinion suggests **2 weeks to 3 months**, depending on AAST grade.

- Thanks for your attention