Kidney and Urotrauma

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Learning Goals

- Know that the hemodynamic status and the injury grade drive the decisional algorithm and the management of kidney and urologic trauma.
- Choose the most appropriate diagnostic-therapeutic strategy in case of kidney or urinary tract trauma.
- Know that nonoperative management may rely on some adjuncts as interventional radiology, endoscopic stenting, and percutaneous drainage, also useful in treating eventual complications.
- Nonoperative management may be the first phase inside a step-up treatment, with a planned delayed surgery.

98.1 Introduction

The incidence of genitourinary trauma is approximately 10%, and it usually involves males more frequently than females (3:1) [1–3]. Over the last decades, there has been a move toward a minimally invasive approach in the treatment of traumatic lesions. Across the years, nonoperative management (NOM) allowed trauma physicians to successfully treat an increasing number of traumatic injuries achieving good results in terms of outcomes, also thanks to the progressive introduction and development of new technologies as interventional endovascular procedures. The majority of genitourinary injuries, especially those caused by blunt trauma, can be managed nonoperative. As for other intra-abdominal organs, the decision process is based on the physiological status of the patient as well as on the anatomic grade of the injury and associated injuries [4]. A multidisciplinary approach (especially involving trauma surgeons and urologist) is cardinal to improve outcomes when dealing with urinary tract injuries.

98.1.1 Epidemiology and Mechanism of Injury

98.1.1.1 Kidney

The kidney is the most frequently injured genitourinary organ after trauma. Renal trauma occurs in 1–3% of all trauma cases and in up to 10% of abdominal trauma [1, 3, 5]. Kidney injuries are often consequences of blunt trauma, that is, the predominant mechanism of injury (>90%), while penetrating injuries such as stab and gunshot wounds are a less common mechanism of injury [2, 4]. However, these percent-

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ages vary between different geographic areas and healthcare systems.

The kidney is located deeply in the retroperitoneum, enclosed in a fibrous capsule that plays a key role in effectively containing bleeding and urinary leaks and should be preserved as much as possible during kidney mobilization and dissection. The renal capsule is surrounded by adipose tissue or perirenal fat, wrapped by the anterior (Gerota's fascia) and posterior (Zuckerkandl's fascia) leaves of the renal fascia. The kidney is kept in place only by the fibro-adipose fascia and the vascular pedicles and hence is vulnerable to blunt mechanism, especially associated with rapid deceleration.

- *Blunt trauma* may cause renal damage by direct blow to the organ or in case of rapid deceleration from high velocity. This specific mechanism is usually responsible of vascular pedicle and ureteropelvic junction injuries [2]. Rapid deceleration can stretch the renal vessels hence hesitating in a rare type of lesion: an isolated renal artery transection or divulsion [4]. Other common blunt mechanisms are fall from height, assault, skiing, and traffic accidents. Blunt injuries are often minor (75% of cases) and can be successfully managed with NOM in most of cases. Operative treatment (OM) is required in only 10% of blunt renal trauma.
- *Penetrating trauma*, either by stab and gunshot wounds, is related to higher incidence of major renal injuries than blunt mechanism (up to 70%) [2]. Renal injuries due to penetrating trauma tend to be associated with lesions of other intra-abdominal organs and are more likely to require surgical intervention [2, 4].

Pediatric kidneys are more vulnerable to injury when compared to adults for several anatomical reasons: relatively larger size of the organ in relation to the abdominal volume and lack of perinephric fat, thinner abdominal muscles, and lack of ossification of the rib cage [4–6]. According to some authors, the kidney is the most frequently injured intra-abdominal organ in the pediatric population [5]. Some injuries, like laceration of the renal pelvis or the ureteropelvic junction avulsion, are more frequent in children, but almost 85% of all pediatric kidney injuries due to blunt trauma are minor and are successfully treated with NOM.

98.1.1.2 Ureter

Ureteral injuries are rare, and the most common mechanism of injury is penetrating trauma (around 80% of cases). A damage to the ureter, in fact, occurs in less than 1% of blunt trauma and in approximately 4% of penetrating abdominal trauma [5]. Being caused most commonly by penetrating trauma (especially gunshot wounds), ureteral injuries are often associated with other intra-abdominal organ lesions [4]. Blunt trauma may cause damage to the ureter with high velocity deceleration mechanism: the most frequently injured area is the ureteropelvic junction [7, 8]. In general, injuries occur more commonly in the upper third of the ureter than in the middle or in the lower third [9].

98.1.1.3 Bladder

Blunt trauma is the most common cause of bladder injuries (65–80%). Common blunt mechanisms are sudden compression of a full bladder, shear forces, or, lastly, bone fragments in case of pelvic fracture. Considering the high amount of energy necessary to damage the bladder, it is not unexpected that the majority of bladder injuries (60–90%) are associated with pelvic fractures; nevertheless, patients with pelvic fracture present a bladder injury in 6–8% of cases [4, 8]. Bladder injuries may be *intraperitoneal* or *extraperitoneal* (see the paragraph "Classification") considering the involved portion of the organ. Intraperitoneal rupture is less frequent (around 15–40% of cases), and it usually occurs after direct application of blunt forces over a distended urinary bladder that cause a sudden increase in the intraluminal pressure and a rupture of the weakest part, the dome [7, 8]. Extraperitoneal rupture is the most common type, presenting in 60–90% of cases, and is seen almost exclusively associated with pelvic fractures [8]. When a pelvic ring fracture occurs, the shearing forces of the disruption may tear the bladder by stretching its

ligamentous attachments [8, 10]. The bladder can also be injured by a sharp bony fragment of the fractured pelvic ring. Combined intra-extraperitoneal bladder ruptures (CBR) are found in 5–12% of all bladder ruptures [4, 8, 10].

98.1.1.4 Urethra

Injuries to the urethra are uncommon, are more frequent in males, and are due to blunt trauma in 90% of cases [7, 11]. Urethral injuries can be divided in *anterior* or *posterior* ones (see the paragraph "Classification"). Anterior injuries involve the penile and the bulbar urethra. Posterior injuries instead involve the membranous and the prostatic urethra, those proximal to the perineal membrane.

Posterior urethral injuries are usually related to pelvic fracture and may be present in up to 5–10% of pelvic fractures [5]. The mechanism beneath consist of a shear of the puboprostatic ligaments: the consequent hematoma of the retropubic and peri-vesical space can be documented at the CT scan and is highly predictive of urethral injuries [8]. The site and type of pelvic fracture predicts the risk of urethral injury: in case of pubic symphysis involvement, every 1 mm of diastasis increase by 10% the risk of urethral injuries [12]. The anterior urethra is more commonly injured in case of straddle trauma by direct compression of the urethra itself against the inferior pubic arch. Penetrating trauma is a rare cause of injury both for anterior and posterior urethra [4].

Female urethral injuries are extremely rare due to its short size and commonly associated with pelvic injuries and rectal/vaginal lesions [4].

98.1.2 Classification

As for traumatic injuries to other organs, the AAST-OIS (American Association of Surgery of Trauma—Organ Injury Scale) classification and its revisions describe the anatomical aspect and extent of different types of damage to the kidney, ureter, bladder, and urethra [13–15] (Table 98.1). This classification represented a cornerstone of trauma injuries management and, since its introduction in 1989, has been effectively used in the treatment decision-process of several organs damaged, including the kidney. For other organs, such as the ureter, bladder, and urethra, the AAST system has been less utilized. Injuries to these organs are, in fact, difficult to be graded using available imaging approaches that often do not provide the necessary data to stratify the damage [5].

98.1.2.1 Kidney

The AAST classification describes different types of renal injuries and their extent, ranging from hematoma or subcapsular hematoma (grade I) to completely shattered kidney (Grade V; Table 98.1). As for other organs in the last decade (i.e., liver, spleen), NOM has presented progressively increasing success rates in patients who presented severe traumatic renal injuries but were hemodynamically stable. These results, along with significant advances in minimally invasive technologies, showed how physiology as well as anatomy is important. The World Society of Emergency Surgery (WSES) proposed a classification system based not only on the anatomical aspect of the injury but also on the physiologic status of the patient [4].

Kidney injuries can be divided into four classes according to the WSES classification that considers the AAST-OIS classification and the hemodynamic status (Table 98.2):

- Minor (WSES class I).
- Moderate (WSES class II).
- Severe (WSES class III and IV).

98.1.2.2 Urinary Tract

Ureteral injuries are graded by the AAST system considering the extent of contusion/laceration. Determining the grade is important in planning the treatment.

The AAST-OIS classification describes five grades of **bladder injuries**, ranging from bladder contusion to bladder neck avulsion (Table 98.1). Another classification system [10] does not take into account the size of the laceration but only its

Table 98.1 AAST-OIS injury scale

Grade	Injury type	Injury description
Kidney injury scale		
I	Contusion	Microscopic or gross hematuria, urologic studies normal
	Hematoma	Subcapsular, non-expanding without parenchymal laceration
II	Hematoma	Non-expanding peri-renal 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 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 that devascularizes kidney
Ureter injury scale		
I	Hematoma	Contusion or hematoma without devascularization
II	Laceration	≤50% transection
III	Laceration	>50% transection
IV	Laceration	Complete transection with 2 cm devascularization
V	Laceration	Avulsion of renal hilum that devascularizes kidney
Bladder injury scale		
I	Hematoma	Contusion, intramural hematoma
	Laceration	Partial thickness
II	Laceration	Extraperitoneal bladder wall laceration ≤2 cm
III	Laceration	Extraperitoneal (>2 cm) or intraperitoneal (≤2 cm) bladder wall lacerations
IV	Laceration	Intraperitoneal bladder wall laceration >2 cm
V	Laceration	Intraperitoneal or extraperitoneal bladder wall laceration extending into the bladder neck or ureteral orifice (trigone)
Urethral injury scale		
I	Contusion	Blood at urethral meatus; urethrography normal
II	Stretch injury	Elongation of urethra without extravasation on urethrography
III	Partial disruption	Extravasation of urethrographic contrast medium at injury site, with contrast visualized in the bladder
IV	Complete disruption	Extravasation of urethrographic contrast medium at injury site without visualization in the bladder; <2 cm of urethral separation
V	Complete disruption	Complete transection with >2 cm urethral separation or extension into the prostate or vagina

Advance one grade for multiple injuries up to grade III
From: Moore E.E., et al. "Scaling System for Organ-Specific Injuries." p. Table 19–22, 2007, [Online]. Available: http://www.aast.org

Table 98.2 WSES kidney trauma classification

	WSES grade	AAST	Hemodynamic
Minor	WSES grade I	I–II	Stable
Moderate	WSES grade II	III or segmental vascular injuries	Stable
Severe	WSES grade III	IV–V or any grade parenchymal lesion with main vessel dissection/occlusion	Stable
	WSES grade IV	Any	Unstable

WSES World Society of Emergency Surgery, *AAST* American Association for the Surgery of Trauma
F. Coccolini et al., "Kidney and urotrauma: WSES-AAST guidelines," World J. Emerg. Surg., vol. 14, no. 1, 2019

site, being more suitable and easier to be determined using radiological imaging techniques. This classification identifies four types:

- Bladder contusion.
- Intraperitoneal bladder rupture (IBR).
- Extraperitoneal bladder rupture (EBR).
- Combined bladder rupture (CBR).

The EBR can be further classified into two groups, simple and complex [16]:

- In the simple EBR, the urinary extravasation is confined to the extraperitoneal pelvic region.
- In complex EBR, the urinary extravasation can widely extend into the abdominal wall, the penis, the scrotum, and the perineum due to the disruption of fascial planes.

Several classifications systems exist to describe **urethral injuries:** the Colapinto and McCallum classification [17] has been used per years, but it only addresses posterior urethral injuries. The new Goldman classification [18] describes both anterior and posterior injuries, discerns between partial or complete lesions, and also addresses combined injuries of urethra and bladder, determining five types of damage. The imperative aspect that needs to be assessed is whether the injury is a partial or complete disruption of the anterior or the posterior urethra and if the damage involves the bladder neck or the rectum. All of these classifications are based on the aspect of the urethra at the retrograde urethrography [16].

98.2 Diagnosis

98.2.1 Clinical Presentation

The initial evaluation of a trauma patient follows the ATLS principles. The hemodynamic status is the key aspect that should drive the first management choices and diagnostic procedures. During the evaluation of a hemodynamically stable trauma patient, several factors should be investigated: mechanism of injury; an accurate abdominal, pelvic, and perineal examination; anamnestic data (solitary kidney, previous renal injuries or surgery; ureteropelvic obstruction; and kidney diseases like tumor or calculi). Preexisting renal abnormalities may increase the risk of injury, making the kidney more susceptible to trauma damage [11]. Furthermore, a solitary kidney should always be recognized before performing a nephrectomy in a trauma laparotomy.

Hematuria, gross or micro (defined as >3 red blood cells [RBC] per high-power field [HPF]), is an indicator of renal and urinary tract trauma, being frequently present (88–95%), but it does not predict the grade of injury [4, 19]. In fact, hematuria may be absent in case of renal pedicle avulsion or thrombosis of renal arteries, while renal contusion can present with macro-hematuria [6, 19].

Clinical examination should also investigate other findings that are suggestive of renal trauma: flank/abdominal pain, tenderness, contusion (ecchymosis or abrasions), or palpable mass.

Ureteral injuries may be subtle in presentation, thus a high index of suspicion is critical: hematuria is a common finding but may be absent in up to 45% of cases [5]. Bladder injuries frequently present with gross hematuria (95%), and the combination of pelvic fracture and macrohematuria is a strong predictor of bladder rupture [5, 11]. Bladder rupture may also present with suprapubic or perineal ecchymosis, inability to void, and abdominal pain/distension [5]. These same symptoms, associated with blood from the meatus, scrotal hematoma, and superiorly displaced prostate on rectal examination, also suggest a possible urethral injury.

98.2.2 Diagnostic Procedures

The diagnostic procedures performed on a trauma patient upon admission are strictly planned according to the hemodynamic status of the patient itself [4].

The **E-FAST** (extended-focused assessment with sonography for trauma) is highly sensitive in rapidly detecting free intra-abdominal fluid,

but its sensitivity and specificity decrease in diagnosing specific organ injuries, especially renal and urinary ones [4]. Ultrasonography may be used for follow-up evaluation of stable injuries, urinoma, and retroperitoneal hematomas [11].

The following patients should be investigated with appropriate urological imaging (i.e., CT scan with delayed urographic phase), in the suspect of renal or urinary tract trauma [5, 11]:

1. Blunt trauma and gross hematuria (always remember possible bladder lesions by pelvic trauma).
2. Blunt trauma with micro-hematuria and shock.
3. Major deceleration mechanism.
4. Penetrating trauma in the flank, back, or abdomen regardless the presence or degree of hematuria.
5. Other signs/symptoms that suggest a lower urinary tract injury (see above).

Over the years, **CT scan** with intravenous contrast became the gold standard in the evaluation of stable or stabilized trauma patients and, more specifically, replaced intravenous pyelography (IVP) in the primary diagnosis of renal and urinary tract injuries [4, 5, 11]. The standard execution of a CT scan, during the arterial and venous phases (20–30 s and 70–80 s of delayed images acquisition, respectively), allows to identify renal parenchymal injuries and vascular lesions. Usually, the kidney excretive phase (>80 s) is needed to properly complete the evaluation and staging of renal injuries [6]. The delayed excretory phase (urographic phase at 5–10 min of delay) is viable in diagnosing urinary tract injuries and detecting urinary extravasation [6, 19, 20].

Nevertheless, kidney and ureter are usually evaluated with CT scan, while lower urinary tract is better assessed with retrograde cystography/urethrography. Hence, different diagnostic procedures may be used according to the suspected injury site (Table 98.3).

Table 98.3 Imaging techniques in kidney and urotrauma

Organ	Imaging modalities of choice
Kidney	CT scan with urographic phase
	IVU
Ureter	CT scan with urographic phase
	Retrograde pyelography/IVU
Bladder	Retrograde cystography
	CT scan with urographic phase
Urethra	Retrograde urethrography
	Urethroscopy

98.2.2.1 Kidney

E-FAST has low sensitivity in diagnosing kidney injuries, due to the anatomical location of the organ [11]. Other ultrasonography imaging modalities, such as contrast-enhanced ultrasound (CEUS) and eco-Doppler, are not routinely used during primary evaluation of a trauma patient but, in case of hemodynamic stability, can be performed as an alternative to CT scan in *pregnant women* or in the *pediatric population* [4]. Several studies have shown good results and effectiveness of CEUS in detecting extravasation, thrombosis, pseudoaneurysm (PSA), and post-traumatic arteriovenous fistulas [4, 21, 22]. CEUS also seems to increase the accuracy of E-FAST in hemodynamically stable patients with suspected renal injury [4, 21, 23].

CT scan has become, over the years, the gold standard for precise evaluation and grading of renal injuries in stable patients [5, 11]. CT imaging, with its *arterial, venous, and nephrogenic phases*, is both sensitive and specific for demonstrating parenchymal contusion or lacerations (also defining the depth and the extension), devitalized segments, subcapsular hematoma, contrast extravasation (Fig. 98.1), and other vascular injuries (arterial or venous) such as lacerations or thrombosis. A lack of contrast enhancement of the kidney or a central para-hilar hematoma may suggest a pedicle injury; the "rim sign" (a thin rim of subcapsular cortex) indicates a renal vascular compromise as an arterial occlusion (also suggested by the "cut off sign": sudden stop of a contrast-opacified renal artery) and consequent infarction [24]. The *delayed excretory phase*

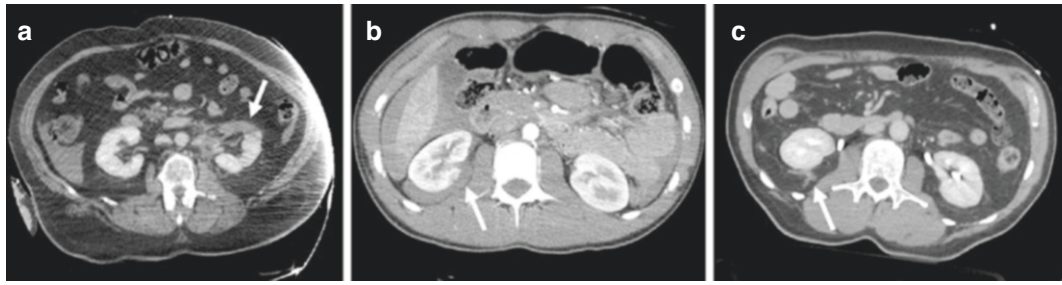

Fig. 98.1 CT scan imaging of renal trauma: (**a**) renal contusion (AAST Grade I, white arrow); (**b**) renal laceration (AAST Grade II, white arrow) with peri-renal hematoma; (**c**) urinary extravasation (white arrow)

(urographic) allows visualization of the renal collecting system, the pelvis, and the ureter detecting urinary extravasation. CT scan is also viable in evaluating the perinephric space (i.e., perinephric hematomas that need to be distinguished from subcapsular hematoma [25]) and the retroperitoneum and in diagnosing possible associated intra-abdominal injuries (liver, spleen, etc.).

Intravenous urography (IVU) or pyelography (IVP), consisting in an intravenous injection of ionic or nonionic contrast followed by an serial abdominal radiograph 2–15 min later, has been largely replaced by CT scan in most clinical settings [4, 5, 11]. Nevertheless, IVU is still used in some low-resources areas or infrastructure or when CT scan is not available, but a urinary tract injury is suspected. IVU can document the presence of both kidneys, gives general information of parenchymal injuries, and outlines the collecting system detecting eventual urinary extravasation. Finally, a one shot intraoperative IVU may be useful in unstable patients directly taken to the OR, when a kidney injury is discovered or suspected.

On the other hand, IVU is not able to provide precise staging, and its findings are nonspecific: false negative ranges between 37 and 75%, and up to 20% of patients with severe renal injuries may have a normal IVP [5, 26]. Retrograde ureteropyelogram plays a limited role but may be performed aiming to evaluate and treat concomitant ureteral injuries [5].

98.2.2.2 Pediatric Kidney Trauma

Kidney injuries in the pediatric population deserve special mention. As for adults, the degree of hematuria does not correlate with the grade of kidney injury, but macro-hematuria seems to be more related to major renal injuries [4, 27]. An aggressive imaging approach in children is emphasized by their ability to maintain a normal systolic pressure despite significant blood loss: according to some studies, signs of shock will present only in around 5% of pediatric patients with a severe renal damage [5]. On the other hand, to decrease the radiological exposition of children, it is important to select appropriate factors that demand a CT scan imaging. Traditionally, all pediatric patients with any degree of hematuria after blunt trauma were scanned [19], but nowadays the criteria changed: most authors suggest to perform a CT scan in all children that sustained a blunt trauma and present micro-hematuria >50 RBC/HPF regardless of hemodynamic parameters [6, 27]. Other factors, such as mechanism of injury, its energy, and other physical findings (flank hematoma, ribs fractures, drop in the hematocrit associated with hematuria), should be considered when planning the imaging technique [4, 6, 27, 28]. Hemodynamically stable children that present mild symptoms, micro-hematuria <50 RBC/HPF, and no other indications for CT scan may be evaluated with ultrasound and/or CEUS and/or Doppler [4].

98.2.2.3 Ureter

In diagnosing a suspected ureteral injury, ultrasound plays no role. Again, CT scan with delayed excretory phase is the imaging method of choice when investigating a ureteral injury [9, 11, 29]. Suggestive radiological signs of an injury to the ureter or to the ureteropelvic junc-

tion are low density retroperitoneal fluid, perirenal hematoma with extravasation of contrast in the peri-nephric space, peri-ureteral hematoma, partial or complete obstruction of the ureteral lumen, lack of contrast in the distal ureter, and extravasation of contrast [5, 29]. An important distinction that must be made with imaging is between transection and lacerations: in case of transection, distal ureter will not be opacified; otherwise, contrast will be present in the distal ureter [8]. Transections require surgical operations, whereas some lacerations can be treated with ureteral stenting. If the CT scan provides equivocal findings, an ascending urography (retrograde pyelogram) or an IVP may be considered as next imaging modalities [4, 9].

Delayed diagnosis of ureteral damage is related to increased morbidity and mortality, hence the importance of an early diagnosis in order to avoid missed injuries [9].

A direct inspection of the ureter is indicated in case of a trauma laparotomy performed in patients with suspected ureteral injuries without preoperative imaging: the aid of a single shot IVU or the extravasation of a renally excreted intravenous dye (methylene blue or indigo carmine) may help identify the site of the damage [11].

98.2.2.4 Bladder

Retrograde cystography (RC), either with conventional plain films or CT technique**,** represents the gold standard imaging for the diagnosis of bladder injuries [4, 5, 11, 16]. The procedure consists in filling the bladder with a minimum of 350–400 ml of contrast via a Foley catheter, and it usually requires a plain film before (as a scout radiograph), a full-bladder film, and a post-emptying film in order to obtain the highest diagnostic accuracy. In case of a suspected urethral injury, a retrograde urethrogram with contrast should be performed before placing a Foley catheter. The post-drainage image, showing a contrast extravasation behind an empty bladder, may be the diagnostic scout in about 10% of cases [16]. The CT scan cystography is equally effective and accurate in detecting and staging a bladder injury, showing a sensitivity and specificity of 95% and 100%, respectively [4, 5, 11]. If possible, CT scan cystography should be preferred, considering its accuracy, the speed of execution, and the absence of need of post-emptying scout [4, 5].

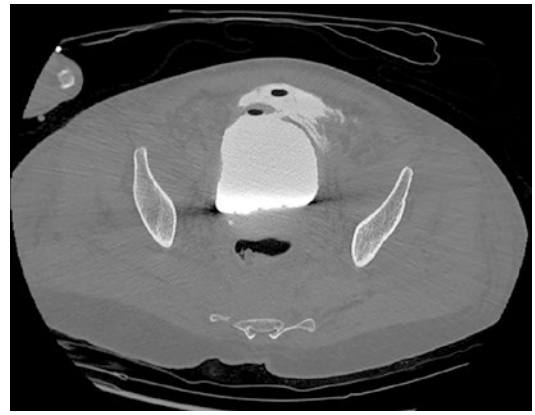

Fig. 98.2 SEQ Figure * ARABIC 2. Extraperitoneal bladder rupture with contrast extravasation

Intravenous contrast-enhanced CT scan with urographic phase may be diagnostic, especially in trauma patients undergone CT to investigate other intra-abdominal injuries. This imaging technique is, however, less sensitive and specific than RC in detecting bladder injuries, due to the low intravesical pressure obtained with passive bladder filling with contrast-opacified urine by clamping the Foley catheter [4, 5, 8].

If the suspected bladder injury is associated to a pelvic bleeding amenable to angiography/angioembolization (AG/AE), the RC should be postponed; hence, the AG/AE may be completed without being affected in accuracy [4] (Fig. 98.2).

As for the ureter, direct inspection of the bladder is indicated in case of a trauma laparotomy performed in patients with suspected bladder injuries without preoperative imaging: the aid of a single shot IVU or the extravasation of a renally excreted intravenous dye (methylene blue or indigo carmine) may help identify the site of the damage [11].

98.2.2.5 Urethra

In case the trauma patients present the above-mentioned symptoms, suggesting a urethral injury (i.e., blood from the meatus), two imaging techniques may be used in order to investigate it:

Fig. 98.3 SEQ Figure * ARABIC 3. Anterior urethral injury with extravasation of contrast, in a patient with severe pelvic fracture

retrograde urethrography (RUG) and **selective urethroscopy**. The first one is the procedure of choice if a urethral injury is suspected. Selective urethroscopy may be preferred in case of a penile lesion [4, 8, 11, 16] (Fig. 98.3).

RUG is performed instilling 10 ml of iodine contrast via a catheter inserted just at the urethral meatus, to avoid maneuvers that can further complicate the injury itself. Then, a radiograph of the lower abdomen is obtained, and it allows the physician not only to diagnose a damage to the urethra but also to distinguish between a complete and an incomplete rupture. An incomplete lesion is seen as an extravasation of contrast that also fills the bladder; complete injuries are associated with no presence of contrast inside the bladder [4]. In case of suspected urethral injuries, no bladder catheter should be positioned until a negative RUG is obtained: otherwise, positioning a suprapubic catheter should be considered (i.e., hemodynamic unstable patients directly taken to the OR) [4]. Considering that 10–15% of patients with an urethral injury due to a pelvic fracture also have an associated bladder damage, a retrograde cystography should be performed after a RUG via a Foley catheter (if the RUG was negative) or via a suprapubic catheter (if RUG showed an urethral rupture) [5]. The cystogram may be also obtained using the CT modality during an abdominal CT scan (CT cystogram) instead of the standard oblique X-rays [5].

98.3 Kidney Trauma: Management

98.3.1 Kidney: Nonoperative Management (NOM)

The management of renal trauma, as for other injured intra-abdominal organs, underwent a progressive shift toward nonoperative management (NOM) during the last few decades. Thanks to the increasing progress showed by technologies and minimally invasive procedures, NOM gained more and more consent showing good results even in high-grade injuries [3].

The majority of ***blunt injuries*** can be approached with NOM since these lesions are minor in most cases: several studies documented how NOM led to a lower rate of nephrectomies and a lower length of hospital stay without any apparent increase in complications rate [2, 30, 31].

NOM of ***penetrating injuries*** was once an unthinkable concept: isolated penetrating renal injuries are rare, being usually associated with other intra-abdominal injuries and hemodynamic instability. Recently, due to the improved imaging techniques that have allowed a proper staging, NOM is now considered as a safe treatment option in selected patients with renal trauma, with good outcomes and higher renal preservation rates [2, 4, 32, 33]. Hence, a significant proportion of penetrating renal trauma can be safely managed with NOM [34]: reported success rates of NOM in penetrating injuries are, respectively, around 50% and 40% in stab wounds (SWs) and gunshot wounds [2, 4, 35, 36]. The site of penetration can also be considered in the management decision: conservative treatment can be the successful strategy in around 88% of SWs posterior to anterior axillary line [11].

The hemodynamic status of the patient alongside the anatomic aspect of the injury are key factors in driving the management decision. WSES-AAST guidelines combined these two aspects in their classification (Table 98.2) and provided an algorithm for the management of renal and urological trauma (Figs. 98.4 and 98.6): NOM should be the first-line treatment in all hemodynamically stable patients with no other indications

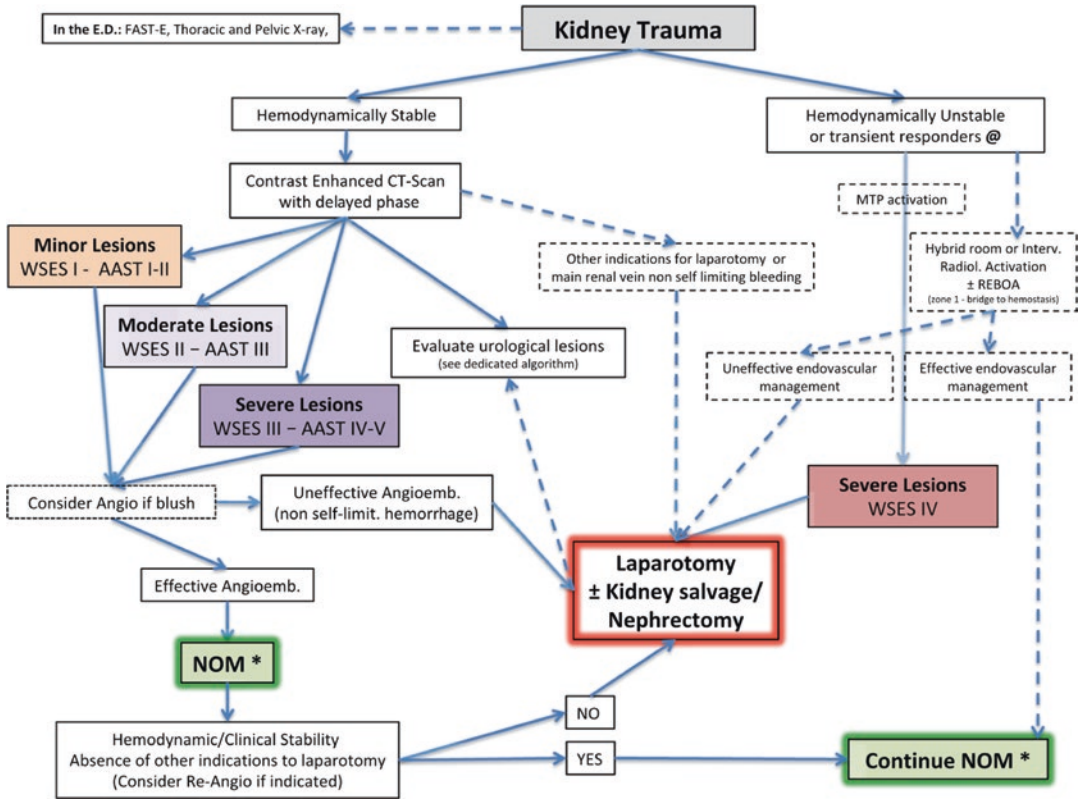

Fig. 98.4 WSES, World Society of Emergency Surgery; AAST, American Association for the Surgery of Trauma. F. Coccolini et al., "Kidney and urotrauma: WSES-AAST guidelines," World J. Emerg. Surg., vol. 14, no. 1, 2019

for surgery, regardless the severity of the renal injury (AAST grade I to V) [4, 5, 37, 38]. Even patients with urinary extravasation or a shattered kidney, if hemodynamically stable, may be effectively managed with conservative treatment.

In stable patients, an accurate staging of the damage extent with **CT scan** with intravenous contrast and delayed urographic phase is fundamental in order to properly grade the injury and plan the treatment modalities [35, 37, 39]. Since several authors consider inaccurate staging a relative indication to surgery [4, 6, 36, 40], CT scan with urographic phase plays a key role in selecting stable patients for NOM and in identifying patients at high risk for NOM failure [4].

In case of moderate/severe injuries, the presence of at least two of the following criteria suggests high risk of **NOM failure**:

1. Contrast blush.
2. Perirenal hematoma >3.5 cm.
3. Medial laceration with medial urinary extravasation.
4. Lack of contrast in the ureter (suggesting a complete ureteropelvic junction avulsion).

Conservative management relies on close monitoring, clinical observation, repeated examinations, and trained surgeons that are essential factors. In fact, NOM can be considered as treatment in severe injuries or in transient responder patients only in selected settings, where adequate resuscitation, ICU monitoring, operative room, surgical and interventional expertise are rapidly available [4]. Patients treated nonoperatively need to be monitored due to the risk of bleeding or complications.

Considering that urinary extravasation usually resolves spontaneously in around 80–90% of patients and that Gerota's fascia plays a key role containing bleeding and urinary leak, a

conservative treatment is a reasonable strategy if the hemodynamical stability is maintained. A nonoperative strategy can also comprehend *minimally invasive techniques as adjuncts*:

- Angiography/angioembolization.
- Endoscopic stent.
- Percutaneous drainage.

These adjunctive procedures can be used as first-line treatment in the acute setting, inside a conservative strategy, or as management options in case of complications (i.e., delayed pseudo-aneurism). Conservative management, for example, may result in non-resolving urinomas that can be treated with ureteral stenting or percutaneous drainage [37, 39] (Fig. 98.5).

Summarizing, *in the absence of other indications for laparotomy* and *in hemodynamically stable patients*, **NOM is feasible** in some specific situations that are not "per se" contraindications of a conservative approach [35, 41]:

- Isolated urinary extravasation.
- Prerenal hematoma.
- Renal fragmentation or a shattered kidney (Fig. 98.6b).
- Damage to the renal pelvis and ureteropelvic junction injuries.
- Penetrating lateral kidney injury.

Fig. 98.5 SEQ Figure * ARABIC 5. AAST grade V renal injury ("shattered kidney")

In a hemodynamically stable patient, a shattered kidney or even a total avulsion of the ureteropelvic junction are not indications for an urgent operation [35]. These two and other conditions may require a delayed planned treatment, either with minimally invasive technique (i.e., endoscopic stenting, percutaneous drainage) or open repair that definitively treat the damage or some eventual complications, outside the acute setting [37, 39]. Whenever the damage is not amenable of repairing, the kidney should be removed. In some situations, in fact, NOM should be considered as an *intermediate treatment or part of a planned step-up approach* (Table 98.4).

98.3.1.1 Angiography and/or Angioembolization (AG/AE)

Angiography and angioembolization play an important role as extensions of conservative management, showing lower complication rates than surgical approach [42]. In hemodynamically stable patients, *indications* to AG and eventual AE in case of renal trauma are the following [4, 43]:

- Segmental arterial injuries and other vascular anomalies detected at the CT scan (i.e., active contrast extravasation, pseudo-aneurism, arteriovenous fistula).
- Gross non-self-limiting hematuria.
- Extended perirenal hematoma.

Rates of AE success in blunt renal trauma reported in the literature range between 63 and 100% [4, 42], [43]. Conditions that have been described as *risk factors for AE failure* are the following [4, 44]:

- Age.
- Volume of blood products transfused in the first 24 h.
- Expertise of the center.
- Penetrating trauma.

Others, such as ISS or low hemoglobin level, are not associated with higher failure

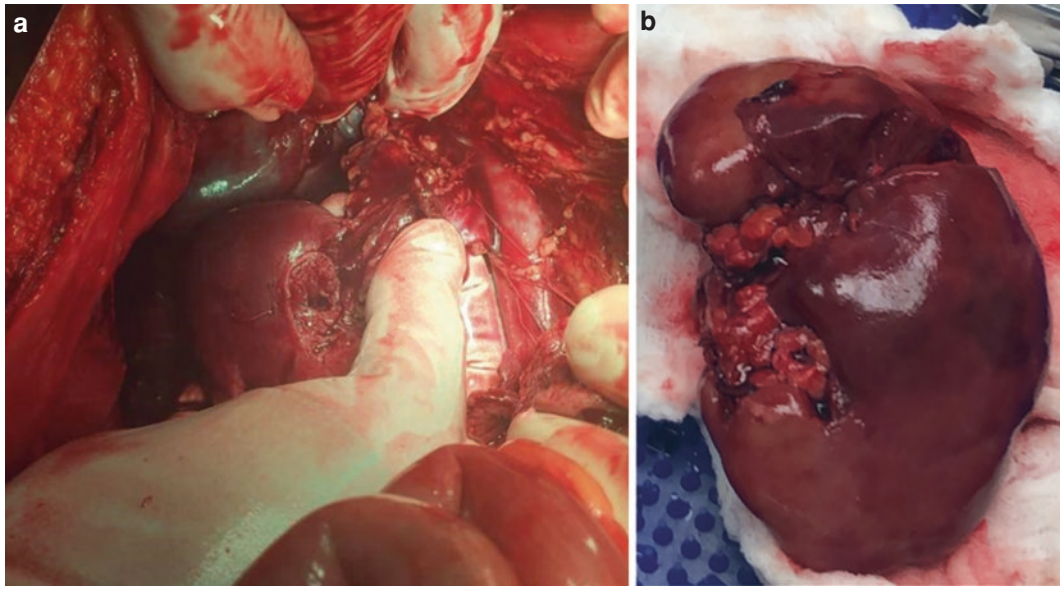

Fig. 98.6 (**a**) Renal laceration with associated renal vein injury (fingers are clamping the vein to attempt a repair); (**b**) renal laceration due to penetrating trauma

Table 98.4 Indications to surgical exploration in renal trauma

Absolute	Relative
1. Uncontrollable life-threatening hemorrhage	1. Ureteropelvic junction injuries
2. Pulsating/expanding retroperitoneal hematoma identified intraoperatively	2. Extensive tissue damage (high proportion of devascularized parenchyma)
3. Renal vein lesion with non-self-limiting hemorrhage (usually delayed interventions)	3. Shattered kidney
	4. Urinary extravasation

rate of AE. Nevertheless, anatomical grade of damage seems related to a higher need of repeating AE but not to an overall AE failure [44]. A repeated AE can be considered as treatment in case of rebleeding or failure of first AE in patients that remains hemodynamically stable [4].

When indicated, angioembolization should be performed as *super-selectively* as possible, in order to limit the extension of devascularized parenchymal tissue and preserve renal function [37].

Angiography may be negative after detection of a contrast extravasation at the CT scan in around 30% of blunt renal trauma [45]: in these cases prophylactic angioembolization is not indicated [4].

Angiography also finds indication in the treatment of hemodynamically stable patients with severe blunt trauma (i.e., shattered kidney) and main renal artery injuries (i.e., dissection or occlusion): embolization or endovascular stenting may be adopted as strategies in order to treat these injury patterns in selected centers and patients [4]. Percutaneous revascularization with stents showed better results than surgical operation on renal function [46], when warm ischemia time is less than 120 min.

Renal hilum avulsion and especially main renal vein injuries requires surgical management [4].

98.3.2 Kidney Trauma: Operative Management

Operative management (OM) should be adopted as treatment of choice in all hemodynamically unstable or nonresponder patients (WSES IV) and

in case of other indications to surgery (i.e., hollow viscous injury, see Liver chapter, Table 98.3).

Table 98.4 summarizes absolute and relative indications to surgical renal exploration.

Due to the lack of consensus in the literature regarding the relative indications presented in Table 98.4, the approved general trend is to approach these situations conservatively, if the hemodynamic status remains within the normality range and other viable solution to the anatomical damage exist. As already mentioned above, most of the situations considered as relative indications to surgery heal spontaneously and may be successfully treated with NOM and associated minimally invasive techniques (AE, percutaneous drainage, or endoscopic procedures).

Sometimes there is the need of ***late planned surgery*** in case of failure of conservative strategies, if the injury is not amenable to endovascular/endoscopic/percutaneous techniques or due to some complications [4, 11]. For example, devascularized renal tissue is not an indication for OM itself but can cause hypertension due to a high renin-angiotensin-aldosterone cascade activation. In case of hypertension nonresponsive to medical treatment and functional contralateral kidney, nephrectomy may be indicated [4, 11].

Retroperitoneal hematomas intra-operatively discovered and not adequately studied require surgical exploration if [4, 5, 11, 34]:

1. They are expanding or pulsatile.
2. They seem to be the only cause of hemodynamic instability.
3. Caused by penetrating trauma.

Renal exploration should not be performed routinely during a laparotomy carried out for other traumatic abdominal injuries in patients with associated renal injuries that do not require surgery, as opening the renal fascia increases the probabilities of nephrectomy [34]. An intraoperative IVP may also be considered in case of a suspected renal injury in patients without preoperative scanning.

Some surgical tips:

1. In unstable patients directly taken to the OR, a rapid palpatory assessment of the presence and dimension of the contralateral kidney is fundamental when suspecting a major renal injury probably requiring a nephrectomy.
2. Major renal artery laceration or severe parenchymal disruption that cause hemodynamical instability often require nephrectomy as surgical treatment (10% of cases, [34]). Some arterial injuries may be amenable to surgical repair, with success rate of 25–35%, and this strategy should be attempted especially in patients with solitary kidney or in those with bilateral renal injuries [4].
3. During exploratory laparotomy for renal trauma, two approaches have been described [5, 34]:
   - Exposing the kidney, its pelvis, and blood supply through a medial visceral rotation (Cattle-Braash or Mattox maneuver, right and left, respectively) and with direct incision of Gerota's fascia. This approach is the preferred one in case the patients are unstable and the renal damage appears to be too extensive.
   - Achieve a vascular control firstly, before opening Gerota's fascia, through an incision of the peritoneum above the aorta. This approach may be used in case of stable patients with injuries amenable to kidney-sparing operations but must be performed with caution.
4. Surgical steps to follow to repair renal injuries [5, 11, 34]:
   - Control the bleeding with electrocautery, suture ligation, or large transfix stitches.
   - Remove sharply any devitalized tissue.
   - Close collecting system injuries with watertight absorbable monofilament suture.
   - If possible, close the renal capsule above the injury, with a pledgeted not-absorbable suture. If it's not possible to repair the capsule due to a large damage, consider closing it with the interposition of hemostatic bolsters or an omental flap.
5. Some polar injuries not amenable of repair may be treated with partial nephrectomy.

6. An intraoperative injection of methylene blue inside the renal pelvis helps to check for eventual persistent urinary leak that need to be repaired.
7. At the end of the operation, in case of other intra-abdominal associated injuries, an omental flap over the kidney should be placed in order to separate it from the surrounding structures and to eventually protect other sutures/anastomosis from the urinary leak that increases the possibility of disruption [34].

Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) may be considered as a bridge to more definitive treatment (as surgical repair) in hemodynamically unstable patients, as for other intra-abdominal injuries [4].

98.3.3 Renal Trauma Complications

Complications after renal trauma may be divided in early and late according to the timing of presentation (within or after 1 month later to the trauma). Minor injuries (AAST grade 1 ore 2) usually heal without sequelae [8].

- **Urinomas** are the most common complication after renal trauma and they usually occur in case of not-self-resolving urinary extravasation (10–20% of cases [8]). They can be managed with conservative treatment consisting in ureteral stenting with or without percutaneous drainage [34]. Same strategy can be followed in case of infected urinomas or peri-nephric abscess [11].
- Vascular anomalies such as **pseudo-aneurism (PSA) or arteriovenous fistula** are amenable to angiographic treatment (embolization) [4, 34].
- **Delayed bleeding** may occur within 2 weeks, is usually caused by PSA or fistula rupture, and can be treated with angioembolization [11].
- **Hypertension** occurs in around 5% of cases [1, 11]. Significant devascularization and consequent scaring of renal parenchyma, renal compression by a subcapsular hematoma (Page kidney), and chronic occlusion or constriction of the renal artery (Goldblatt kidney) are all mechanism of post-traumatic hypertension. The decreased blood flow following these mechanisms cause an important activation of the renin-angiotensin-aldosterone cascade. The consequent hypertension may be medically treated in the majority of cases; in case of hypertension not responsive to medical treatment, a delayed nephrectomy may be considered [4, 34].
- **Other complications** that can follow renal trauma are hydroureteronephrosis, renal lithiasis, and chronic pyelonephritis [1].

98.4 Urinary Tract Injuries: Management

98.4.1 Ureteral Trauma

Several factors influence the management decision process in case of ureteral trauma: AAST grade and site of the injury, associated injuries, and whether the ureteral lesion is discovered during a CT scan, a trauma laparotomy performed in an unstable patient or in a delayed setting (i.e., late presentation) [9]. The main goal of ureteral injury management is preserving the renal function allowing urinary flow and preventing urinoma formation (Fig. 98.7).

Considering only stable patients with no other indications for laparotomy, AAST grade I and II (contusion and partial laceration) can be successfully managed with nonoperative treatment and/or ureteral stenting in most cases [4, 9, 11]. A nephrostomy tube may be necessary in case the stenting procedure is unsuccessful.

A direct inspection of the ureter is indicated in case of a trauma laparotomy performed in patients with suspected ureteral injuries without preoperative imaging: the aid of a single shot IVU or the extravasation of a renally excreted intravenous dye (methylene blue or indigo carmine) may help identify the site of the damage [11].

Once diagnosed, a ureteral injury should be repaired whenever possible. Ureteral injury repair depends on the hemodynamic status of the

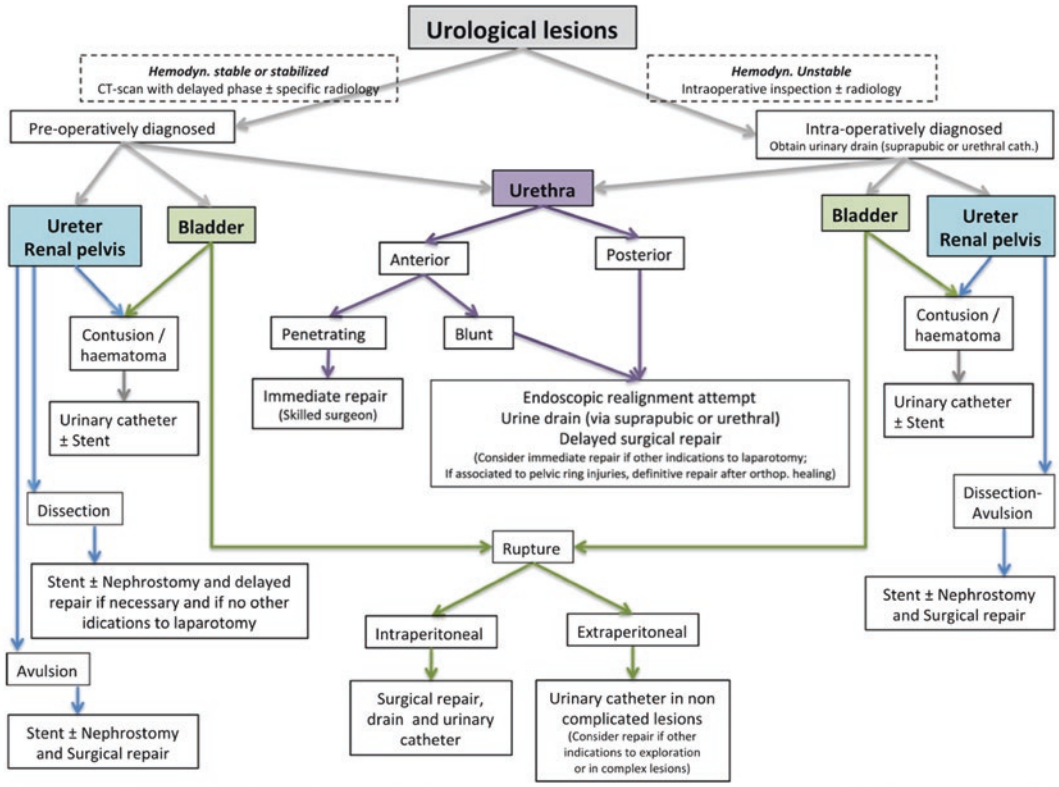

Fig. 98.7 WSES World Society of Emergency Surgery, AAST American Association for the Surgery of Trauma. F. Coccolini et al., "Kidney and urotrauma: WSES-AAST guidelines," World J. Emerg. Surg., vol. 14, no. 1, 2019

patient, on the site of injury and on the extent of damage [11, 34]. Anyway, there are some general principles that need to be remembered:

- Debridement of devitalized tissue in order to have vital margins but paying attention to not waste tissue and consequently to impair potential repair.
- Avoiding excessive dissection of the tissue surrounding the ureter during mobilization since this can cause a reduction of the blood supply and consequent ischemia.
- Spatulation of ureteral ends to reduce the risk of strictures.
- Performing a tension free, watertight, absorbable suture over a double J stent, which also helps in reducing the risk of stenosis.
- Eventual separation of the ureteral anastomosis from the surrounding tissues with the interposition of omentum.

In case of hemodynamical instability and damage control surgery need, a temporary strategy must be adopted: ligate the damaged ureter (both ends in case of transection), proceed with resuscitation, and delay definitive repair. Urinary diversion may be obtained through a temporary percutaneous nephrostomy tube.

Finally, different type of repair may be attempted according to the location (Table 98.5).

Ureteral reimplant with Boari flap or "psoas hitch" are useful techniques that can be used in case of injuries of the lower and middle (more rarely) third of the ureter when the tissue loss makes impossible to perform a direct anastomosis or reimplant into the bladder without tension [5, 9, 11, 34].

In the postoperative period, the bladder catheter should be removed first, followed 2–3 days later by the abdominal drain if the output is low, and there are no urinary leaks. Ureteral stents

Table 98.5 Surgical repair options, based on location and tissue loss

Upper third	Ureteroureterostomy (preferred)
	Ureteropyelostomy
Middle third	Ureteroureterostomy (preferred)
	(Ureteral reimplant with Boari flap or "psoas hitch")
Lower third	Direct reimplantation of the ureter (ureteroneocystostomy)
	Ureteral reimplant with "psoas hitch"
	Ureteral reimplant with Boari flap

should be left in place for 4–6 weeks after the repair, followed by an IVP or a retrograde pyelography to check the patency of the anastomosis or for urinary leak. An IVP or a RP should be repeated after 3 months [11, 34].

In case of delayed diagnosis or presentation of an incomplete ureteral injury, a stent placement should be attempted; if unsuccessful, a planned surgical repair should be considered [4].

98.4.1.1 Ureteral Trauma Complications

Common complications that can rise after ureteral trauma are urinary leak and consequent urinomas, periureteral abscess, and ureteral strictures. Most of this complication is preventable with proper early diagnosis, stenting, eventual nephrostomy tube, or surgical repair [9]. These complications are also treatable with the same techniques abovementioned.

98.4.2 Bladder Trauma

Bladder contusion can be managed with observation and conservative management without any specific treatment. For other types of damage, the injury location and the extent of damage influence the type of treatment required:

- All *penetrating injuries* and *intraperitoneal bladder rupture* (IBR) require surgical exploration and operative repair; the most common injury site of IBR is the dome. The repair can be performed with a single- or double-layer absorbable suture [5, 34]. In case of an isolated IBR, the repair may be attempted with laparoscopic technique [4]. Combined bladder rupture (CBR) usually needs to be surgically repaired [34].
- Extraperitoneal bladder rupture (EBR) can usually be managed with bladder catheter left in place for 7–10 days; hence, in case of no other indications for surgery, EBR is amenable to NOM, with clinical observation, laboratory exams, and antibiotic therapy. If urinary leak persist, another 10 days of catheter and a repeated cystogram are recommended [5]. The success rate in such cases is around 90% with most patients completely healed within 3 weeks [11]. In some cases, conservative management may be unsuccessful, and if urinary extravasation persists, surgical repair can be considered.
- In case of *complex EBR* (i.e., injuries to the bladder neck) and *EBR associated with other injuries* requiring surgery (rectal/vaginal lesions or pelvic ring fractures that need fixation), operative repair is indicated.

Postoperative care of the patients usually requires maintenance of the Foley catheter for 7–10 days, and abdominal drain should be removed first. Retrograde cystography can be performed in order to exclude urinary leakage before urinary catheter removal [34]. In the pediatric population, positioning of a suprapubic catheter after bladder repair is recommended [4].

In case of hemodynamic instability and need of damage control strategies, the bladder repair can be delayed and a bladder or suprapubic catheter can be placed as a temporary strategy to divert urinary flow [4].

A suprapubic catheter can replace a urethral catheter if the patient presents suspected associated injuries to the perineum or to the urethra [4].

98.4.3 Urethral Trauma

Management of urethral trauma requires taking into account several factors [5]:

- Hemodynamic stability of the patient.
- Mechanism of injury (penetrating vs. blunt).

- Site of injury (anterior, posterior, combined; see Goldman classification).
- Extent of damage (partial, complete, grade of tissue loss).
- Associated injuries.

In case of perineal trauma or suspected urethral injuries, urinary drainage should be obtained as soon as possible. A retrograde urethrography (RU) should be performed in order to detect such injuries and to decide between a transurethral and a suprapubic catheter: the latter one is indicated in case of contrast extravasation at the urethrogram or in case of hemodynamically unstable patients with suspect perineal damage directly taken to the OR [4]. Positioning a suprapubic catheter may not be easy, especially in case of associated hematoma or hypotension with consequent poor bladder filling: in such cases, it may be placed in an ultrasound-guided fashion way [47] or in alternative with open technique during surgical exploration.

Another treatment option of an injured urethra consists in primary realignment of the urethra with endoscopic approach (i.e., flexible cystoscope) [5].

In case of NOM, standard care comprehends maintenance of the transurethral or suprapubic catheter for at least 2 weeks and a retrograde urethrography prior to eventual catheter removal.

Blunt Injuries

- *Incomplete anterior urethral injuries:* may be managed conservatively with the placement of a transurethral catheter or supra-pubic diversion. Endoscopic realignment and catheterization should be considered before surgery. If NOM and these techniques fail, a delayed surgical repair (urethroplasty) should be planned [4, 5].
- *Complete anterior urethral injuries:* data are somehow contradictory, with suprapubic catheter and endoscopic realignment being the two most adopted strategies in the acute setting, followed by planned urethroplasty (usually after 3 months). Acute attempts of repair are not recommended. The definitive surgical repair rely on the necessity of an accurate evaluation of damage extension [4, 5, 48].
- *Incomplete posterior urethral injuries:* may be initially treated with conservative management (urinary diversion or endoscopic realignment), and delaying surgical definitive repair after 14 days, if there are no other indications for laparotomy.
- *Complete posterior urethral injuries:* immediate endoscopic realignment is the preferred option of treatment, since it is associated with good outcomes and results [4, 5]. If unsuccessful, positioning of a suprapubic catheter is another viable option, whereas surgical definitive urethroplasty should be delayed at least 14 days after the injury time.
- *Blunt posterior injuries*, in a hemodynamically unstable patient or in case of other abdominal injuries requiring surgery, should be treated as already described, with immediate urinary diversion and delayed planned surgical repair [4].
- *Posterior urethral injuries* associated to pelvic fractures should be treated with definitive surgical repair after the pelvic damage has healed [4].

98.4.3.1 Penetrating Injuries

Penetrating injuries of the urethra, either anterior or posterior, usually require operative management. In both cases (anterior and posterior), the management decision is primarily taken considering the hemodynamic status of the patient and the rapid availability of an experienced urologist.

In case of hemodynamic stability and if an expert urologist is available, a prompt operative repair is recommended. Otherwise, if patient's condition is unstable, there is the necessity of damage control procedures, or if the surgical repair is not feasible due to extensive tissue damage, the surgeon should adopt the following strategy [4, 11]:

- Temporary urinary diversion via suprapubic catheter.
- Eventual marsupialization of the urethra (in case of large anatomic defect).
- Delayed urethroplasty or reconstruction with graft if needed (usually 3 months after the injury).

Urethral Trauma Complications

A *multidisciplinary approach* of urethral trauma management is imperative to combine different expertise and obtain good outcomes: the aim is to proper select strategies that minimize adverse events such as urethral strictures, incontinence, and impotence.

Primary open realignment or primary open anastomosis showed higher rates of the above-mentioned complications [4], whereas endoscopic realignment and suprapubic catheterization showed good results [5, 11, 37]. Strictures may be treated with endoscopic procedures or planned urethroplasty.

Dos and Don'ts

Renal Trauma:

- Always consider NOM as a first strategy in hemodynamically stable patients and in transient responder if treated in a level I trauma center.
- *Do not* base the management decision only on the anatomical severity of the injury.
- Consider AG/AE, endoscopic stenting, and percutaneous drainage as precious adjuncts to NOM.

Urinary Tract Trauma:

- Remember to consider minimally invasive techniques (endoscopic or drainage) as nonoperative strategies to treat or to temporary manage certain injuries.
- Consider a step-up strategy with planned delayed surgical treatment;
- *Do not* forget that the treatment of urinary tract trauma needs to be multidisciplinary.

98.5 Follow-Up

Follow up varies according to injury grade and clinical conditions of the patient.

Minor injuries (AAST grade I and II) rarely are followed by clinical sequelae and do not require follow-up imaging [4]. In moderate and severe lesions, imaging follow-up is tailored on patient injury pattern and clinical status; contrast-enhanced CT scan with excretory phase is recommended in patients with severe renal injuries within 48 h after trauma or in patients with moderate injuries without urinary extravasation but with a worsening clinical status [49]. Ultrasound with or without contrast may be a valid alternative and represent the first choice in the pediatric patient.

CT scan with urographic phase is also indicated in case of ureteral and bladder injuries, whereas urethroscopy or urethrogram are the recommended imaging methods in case of urethral trauma [4].

Return to normal physical activity and sports is not recommended until microscopic hematuria is resolved. While minor/moderate injuries may require 2–6 weeks of rest, severe trauma may necessitate of 6–12 months away from sport activity [4].

Take-Home Messages

- Kidney is the most common injured genitourinary organ in case of abdominal trauma; the majority of injuries can be managed nonoperatively.
- Ureteral trauma occurs more frequently after penetrating trauma, requiring high index of suspicion, with a grade- and site-dependent repair.
- Injuries to the bladder may be associated with pelvic fractures; intraperitoneal lesions require a surgical repair, extraperitoneal ones may be treated conservatively.
- Urethral lesions may be managed with conservative treatment and realignment (with catheter or endoscopic technique), delaying the eventual urethroplasty.
- Adjunctive techniques like endoscopic stenting or percutaneous drainage may be used inside a nonoperative strategy.

Multiple Choice Questions

1. Kidney trauma:
   A. Is the most frequent type of genitourinary trauma and is usually due to blunt mechanism.
   B. May be caused by direct blow to the organ or in case of rapid deceleration.
   C. Is better diagnosed with contrast enhanced CT scan in hemodynamically stable patients.
   D. **All of the above.**
2. Post-traumatic bladder injuries:
   A. **Can be classified according to the rupture site in intraperitoneal, extraperitoneal, and combined.**
   B. Are rarely associated to pelvic fracture.
   C. Are most frequently intraperitoneal.
   D. Needs to be diagnosed with CT scan (urographic phase), which is the most sensitive method for these injuries.
3. Hematuria.
   A. Is not a reliable indicator of kidney or urinary tract trauma being frequently absent.
   B. **Is a common clinical finding in case of genitourinary trauma being present in up to 90% of cases.**
   C. Accurately predict the grade of renal injury.
   D. Is usually due to ureteral injuries.
4. In which of the following cases genitourinary tract must be suspected?
   A. Blunt trauma and gross hematuria.
   B. Major deceleration mechanism.
   C. Penetrating trauma in the flank, back, or abdomen regardless the presence or degree of hematuria.
   D. **All of the above.**
5. Retrograde urethrography-cystography.
   A. Plays no role in the acute setting in case of suspected genitourinary trauma.
   B. Has too low sensitivity and specificity to detect bladder injuries.
   C. **Is the imaging of choice if an urethral or a bladder injury is suspected.**
   D. Is useless if the aim is to distinguish between a complete and an incomplete urethral rupture.
6. Select the wrong sentence:
   A. Most renal injuries, even severe ones, may be managed conservatively with NOM.
   B. NOM should be the first line treatment in all hemodynamically stable patients with no other indications for surgery, regardless the severity of the renal injury (AAST grade I to V).
   C. **All penetrating injuries need to be operatively managed, being frequently associated with other intra-abdominal organ injuries.**
   D. NOM may be a first strategy in case of a shattered kidney or a ureteropelvic junction injury, in a hemodynamically stable patient.
7. Angiography and angioembolization (select the wrong one):
   A. **Are rarely indicated in case of renal trauma and has been replaced by innovative operative techniques.**
   B. Play an important role as extensions of conservative management, showing lower complication rates than surgical approach.
   C. When indicated, angioembolization should be performed as *sub-selectively* as possible, in order to limit the extension of devascularized parenchymal tissue.
   D. Allow to treat renal artery injury such as thrombosis or dissection with minimally invasive technique (endovascular stenting).
8. In case of operative management of renal trauma:
   A. Renal exploration should be performed routinely during a laparotomy carried out for other traumatic abdominal injuries in patients with associated renal injuries that do not require surgery.
   B. Expanding or pulsatile retroperitoneal hematomas intraoperatively

discovered and not adequately studied do not require surgical exploration.

C. **When attempting a kidney injury repair, follow the step of debridement of necrotic tissue, watertight absorbable suture, and closure the capsule above it.**

D. The most common surgical procedure performed is nephrectomy (90% of cases).

9. Select the correct sentence:
   A. The site of the ureteral injury does not affect the choice of the surgical procedure.
   B. **Extraperitoneal bladder rupture (EBR) can usually be managed with bladder catheter left in place for 10 days.**
   C. Penetrating bladder injuries and intraperitoneal ones should be managed with nonoperative management, drainage, or endoscopic treatment.
   D. Perform extensive dissection of the tissue surrounding the ureter during mobilization.
10. In case of urethral injuries:
   A. Their management requires taking consideration of several factors including hemodynamic status of the patient, site, and mechanism of injury, extent of damage, and associated injuries.
   B. A treatment option consists in primary realignment of the urethra with endoscopic instrumentation and eventual delayed definitive repair.
   C. A multidisciplinary approach of urethral trauma management is imperative in order to combine different expertise and obtain good outcomes.
   D. **All of the above.**

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