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European Association of Urology

Guidelines

Review of the Current Management of Upper Urinary Tract Injuries by the EAU Trauma Guidelines Panel

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Article info

Article history:
Accepted December 18, 2014

Keywords:
Kidney trauma/injury
Ureteral trauma/injury
Blunt trauma
Upper urinary tract trauma
Penetrating trauma
Conservative management
Surgical repair
Guidelines
European Association of Urology
EAU

Abstract

Context: The most recent European Association of Urology (EAU) guidelines on urological trauma were published in 2014.
Objective: To present a summary of the 2014 version of the EAU guidelines on upper urinary tract injuries with the emphasis upon diagnosis and treatment.
Evidence acquisition: The EAU trauma guidelines panel reviewed literature by a Medline search on upper urinary tract injuries; publication dates up to December 2013 were accepted. The focus was on newer publications and reviews, although older key references could be included.
Evidence synthesis: A full version of the guidelines is available in print and online. Blunt trauma is the main cause of renal injuries. The preferred diagnostic modality of renal trauma is computed tomography (CT) scan. Conservative management is the best approach in stable patients. Angiography and selective embolisation are the first-line treatments. Surgical exploration is primarily for the control of haemorrhage (which may necessitate nephrectomy) and renal salvage. Urinary extravasation is managed with endourologic or percutaneous techniques. Complications may require additional imaging or interventions. Follow-up is focused on renal function and blood pressure. Penetrating trauma is the main cause of noniatrogenic ureteral injuries. The diagnosis is often made by CT scanning or at laparotomy, and the mainstay of treatment is open repair. The type of repair depends upon the severity and location of the injury.
Conclusions: Renal injuries are best managed conservatively or with minimally invasive techniques. Preservation of renal units is feasible in most cases. This review, performed by the EAU trauma guidelines panel, summarises the current management of upper urinary tract injuries.
Patient summary: Patients with trauma benefit from being accurately diagnosed and treated appropriately, according to the nature and severity of their injury.

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http://dx.doi.org/10.1016/j.eururo.2014.12.034
0302-2838/

1. Introduction

This paper is a comprehensive review of the current methods of diagnosis and treatment of injuries to the upper urinary tract (kidney and ureter). Iatrogenic injuries were covered fully in a previous publication by this group [1] and thus are excluded from this paper.

2. Evidence acquisition

The panel reviewed the English-language literature via a Medline search (publication dates up to December 2013) with the focus on newer publications, although some older key references are included. A full version of the latest European Association of Urology (EAU) guidelines on the management of urologic trauma is available in print [1] and online (www.uroweb.org).

3. Evidence synthesis

3.1. Kidney

3.1.1. Incidence and aetiology

Renal injuries occur in 1–5% of all trauma cases and are classified as blunt (90–95% in rural settings) or penetrating (40% in urban settings) [2]. The kidney is the most commonly injured genitourinary organ at all ages, with a male:female ratio of 3:1 [3]. Mechanisms include road traffic accidents (about 50%), falls (16%), sports (direct blow to the flank or abdomen), and assault. Sudden deceleration or a crash injury may result in contusion and laceration of the parenchyma and/or collecting system or, more rarely, in a vascular injury. Penetrating injuries (eg, gunshot and stab wounds) produce direct tissue disruption and are usually more severe.

The classification system of the American Association for the Surgery of Trauma is recommended [4] (Table 1). It is based on abdominal computed tomography (CT) or direct exploration and is able to predict the need for intervention, morbidity after blunt or penetrating injury, and mortality after blunt injury [5].

Table 1 – American Association for the Surgery of Trauma renal injury grading scale

Grade *	Description of injury
1	Contusion or nonexpanding subcapsular haematoma No laceration
2	Nonexpanding perirenal haematoma Cortical laceration <1 cm deep without extravasation
3	Cortical laceration >1 cm without urinary extravasation
4	Laceration: through corticomedullary junction into collecting system or Vascular: segmental renal artery or vein injury with contained haematoma, or partial vessel laceration, or vessel thrombosis
5	Laceration: shattered kidney or Vascular: renal pedicle or avulsion

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

3.1.2. Diagnosis

Injury should be suspected in a rapid-deceleration event or a direct blow to the flank. Pre-existing disease (eg, hydronephrosis, calculi, cysts, tumours) makes injury more likely [6]. Haemodynamic stability is the basis for management, so vital signs should be monitored. Physical examination may reveal a wound to the lower thoracic back, flanks, and upper abdomen, or bullet entry or exit wounds. Blunt trauma to the back, flank, lower thorax, or upper abdomen with haematuria; pain; ecchymoses; abrasions; fractured ribs; abdominal distension; and/or mass and tenderness are strong indications of injury.

Urinalysis, haematocrit, and baseline creatinine level are necessary tests. Haematuria is an indicator of renal injury but may be due to trauma elsewhere in the urinary tract. Major injury (eg, disruption of the ureteropelvic junction, pedicle injuries, segmental arterial thrombosis, and stab wounds, in approximately 9% of patients) may occur without haematuria. Urine dipstick is a reliable and rapid test. Most patients are evaluated within 1 h of injury, so creatinine measurement reflects renal function prior to the injury [7].

Indications for radiographic evaluation are visible haematuria, nonvisible haematuria with hypotension, or major associated injuries [8]. Patients with a rapid-deceleration injury need immediate imaging to rule out ureteral avulsion or pedicle injury. Stable patients with nonvisible haematuria after blunt trauma have a low likelihood of significant injury [9]. Patients with penetrating trauma to the torso have a high incidence of significant injuries and imaging should be performed regardless of the degree of haematuria.

Ultrasound can identify who requires a more detailed investigation, and it is useful for the follow-up of parenchymal lesions, haematomas, and urinomas but cannot accurately assess renal lacerations [10].

Intravenous pyelography (IVP) is inferior to currently available CT imaging [11]. It may demonstrate nonfunction or extravasation. During emergency laparotomy, a one-shot IVP (bolus intravenous injection of 2 ml/kg contrast followed by a single plain film after 10 min) may provide information on the presence and function of the contralateral kidney [12].

CT scanning is recommended for the assessment of stable patients. It defines the location and severity of renal and associated injuries [11]. Central parahilar haematoma increases the possibility of pedicle injury even if the parenchyma is well enhanced. Excretory phase scans should be performed to rule out injuries to the collecting system. CT imaging is also valuable in patients with gunshot wounds (GSWs) who are being considered for nonoperative management [13].

3.1.3. Treatment

Hospitalisation or prolonged observation after a normal CT scan is unnecessary in most cases, as well as in grade 1 and 2 injuries, whether due to blunt or penetrating trauma. Expectant treatment of grade 3 injuries is strongly recommended [14]. Supportive care with bed rest and observation is the treatment of choice for stable patients and is associated with a lower rate of nephrectomy, without any increase in morbidity.

Although patients with grade 4 and 5 injuries and major associated injuries experience high exploration, nephrectomy, and complications rates, an initially conservative approach is feasible in stable patients [15]. Patients diagnosed with urinary extravasation in solitary injuries can be managed without major intervention, with a resolution rate of >90% [16]. Unilateral main arterial injuries will normally be managed nonoperatively in stable patients, with surgical repair reserved for bilateral injuries or a solitary functional kidney in which the whole functioning renal mass is endangered. Conservative management is also advised in unilateral, complete, blunt artery thrombosis, as well as in multiple-trauma patients [17].

Angiography with selective embolisation is the first-line option in the absence of other indications for immediate open surgery. The main indications for angiography are embolisation for active haemorrhage, pseudoaneurysm, and vascular fistulae [18]. Higher renal-injury grade is associated with an increased risk of failure for the first attempt and a need for repeat intervention [19]. However, initial and/or repeat embolisation for high-grade injuries prevents nephrectomy in >75% of these patients. Secondary open surgery after failed embolisation usually results in nephrectomy [20]. Embolisation is three times more likely to fail for penetrating trauma. However, with reports that conservative management of penetrating trauma is possible in selected cases, renal embolisation in the setting of failed conservative therapy for penetrating trauma must be critically considered [21]. In cases of severe polytrauma or high operative risk, the main artery may be embolised, either as a definitive treatment or to be followed by interval nephrectomy.

The goal of exploration is the control of haemorrhage and renal salvage. The overall exploration rate for blunt trauma is <10% [22]. Absolute indications are life-threatening haemorrhage from renovascular injury, ureteropelvic junction avulsion, and urinoma unresponsive to ureteral stenting or perinephric drainage. Relative indications are laparotomy for other abdominal injuries or large, devascularised segments of kidney.

Stable haematomas detected during exploration for associated injuries should not be opened, whereas central or expanding haematomas indicate injury of the big vessels and require immediate exploration with vascular expertise. The need for exploration can be predicted, considering the type and grade of injury, transfusion requirements, renal function, and management of associated abdominal injuries [23]. Unresponsive haemodynamic instability due to renal haemorrhage is an indication for exploration, regardless of the mode of injury, as well as inconclusive imaging and a pre-existing abnormality [24]. Persistent extravasation or urinoma are usually managed endourologically and/or percutaneously. Although a grade 5 renal injury has traditionally been regarded as an absolute indication for surgical exploration, successful conservative management of grade 5 parenchymal injuries has been reported [25]. Independent factors that increase the risk of surgical intervention are Injury Severity Score >16, increased transfusion needs, perirenal haematoma size >3.5 cm, intravascular contrast extravasation, and grade 4–5 injuries [26].

A brief period of controlled urinary extravasation is unlikely to result in a significant adverse event. In the following 3 d, CT scans can select patients for reconstruction [27]. Ureteral stenting or nephrostomy diversion is mandatory after delayed reconstruction. Patients with renal trauma are at a 64% risk for nephrectomy when renal injuries are explored, regardless of operative intent. The overall rate of nephrectomy is around 13%, usually in patients with penetrating injury, higher rates of transfusion requirements, haemodynamic instability, and higher injury severity scores [28]. Mortality is not often a consequence of the renal injury itself. In gunshot injuries caused by a high-velocity bullet, reconstruction can be difficult. Renorrhaphy is the most common reconstructive technique. Partial nephrectomy is required when nonviable tissue is detected. Watertight closure of the collecting system is desirable. If the capsule is not preserved, an omental pedicle flap or perirenal fat bolster may be used. The use of haemostatic agents and sealants can be helpful and drainage of the retroperitoneum is recommended. Following blunt trauma, repair of grade 5 vascular injuries should be attempted in patients with a solitary kidney or bilateral injuries [29]. Nephrectomy for main artery injury does not worsen post-treatment renal function in the short term.

Although penetrating wounds have traditionally been approached surgically, a systematic approach based on thorough evaluation minimises negative exploration without increasing morbidity from a missed injury [30]. Persistent bleeding represents the main indication for exploration and reconstruction [31]. Gunshot injuries should be explored only if they involve the hilum or are accompanied by signs of continued bleeding, ureteral injuries, or renal pelvis lacerations. Low-velocity gunshot and minor stab wounds may be managed conservatively with good outcome [32]. In contrast, tissue damage from high-velocity gunshot injuries can be more extensive and nephrectomy is required often. Nonoperative management in stable patients is associated with a successful outcome in approximately 50% of stab wounds and up to 40% of GSWs [33]. If the site of penetration by stab wound is posterior to the anterior axillary line, 88% of such injuries can be managed nonoperatively. Stab wounds producing injuries of grade ≥3 are associated with a higher rate of delayed complications if treated expectantly [34].

3.1.4. *Follow-up and complications*

Early complications are bleeding, infection, perinephric abscess, sepsis, urinary fistula, hypertension, urinary extravasation, and urinoma. Delayed complications include bleeding, hydronephrosis, calculus formation, chronic pyelonephritis, hypertension, arteriovenous fistula (AVF), hydronephrosis, and pseudoaneurysms.

The risk of complications following conservative management increases with grade. Repeat imaging minimises the risk of missed complications, especially in grade 3–5 blunt injuries, although the usefulness of frequent scanning has never been satisfactorily proven unless there is fever, decreasing haematocrit, or flank pain [35].

Follow-up should involve physical examination, urinalysis, individualised radiologic investigation, serial blood

pressure measurements, and serum determination of renal function. A decline in renal function directly correlates with injury grade and is independent of the mechanism of injury and the method of management [36]. Follow-up examinations should continue until healing is documented and laboratory findings have stabilised. Nuclear scans are useful for documenting and tracking functional recovery following reconstruction [37].

The post-traumatic hypertension rate is <5%. It may occur acutely due to compression from haematoma (Page kidney) or chronically because of scar formation, is renin dependent, and is associated with parenchymal injury. Over the long term, aetiologies include artery thrombosis or stenosis (Goldblatt kidney), devitalised fragments, and AVFs. If hypertension persists, medical management, excision of the ischaemic segment, vascular reconstruction, or nephrectomy is required [38].

Percutaneous management of complications may pose less risk of renal loss than re-operation. Urinary extravasation after reconstruction often subsides without intervention as long as ureteral obstruction and infection are not present. Ureteral retrograde stenting or percutaneous drainage may improve healing [39]. Arteriovenous fistulae present with delayed haematuria, most often after penetrating trauma. Percutaneous embolisation is effective; larger ones require surgery [40]. Postprocedural complications include infection, sepsis, urinary fistula, and infarction. Pseudoaneurysm is rare, and embolisation is recommended. Renal colic from a retained missile can be managed endoscopically [41]. Duodenal obstruction may result from retroperitoneal haematoma.

3.1.5. Algorithms

Figures 1 and 2 show the suggested treatment of blunt and penetrating renal injuries in adults.

3.2. Ureter

3.2.1. Incidence and aetiology

Trauma to the ureters is rare because they are protected from injury by their small size, mobility, and the adjacent vertebrae, bony pelvis, and muscles; however, any injury to the ureter may result in severe sequelae. Overall, it accounts for 1–2.5% of urinary tract trauma [42,43] and 2–3% in modern combat injuries [42,44]. Penetrating trauma, mainly caused by GSWs, dominates most of the modern series, both civilian and military [42,45]. About one-third of cases are caused by blunt trauma, mostly road traffic injuries [43].

Ureteral injury should be suspected in all cases of penetrating abdominal injury, especially GSWs. It should also be suspected in blunt trauma involving deceleration, as the renal pelvis can be torn away from the ureter [42]. The relative frequency of injury site in the ureter varies between series, but it is more common in the upper ureter [45].

3.2.2. Diagnosis

External ureteral trauma is rare and usually accompanies severe abdominal and pelvic injuries. A high index of suspicion should be maintained because it is often initially missed and recognised in a delayed fashion only when the clinical signs present. In penetrating trauma, diagnosis is commonly made intraoperatively during laparotomy for other injuries [46], but it is delayed in most blunt trauma [45]. Penetrating trauma is usually associated with vascular and intestinal injuries, while blunt trauma is associated with damage to the pelvic bones and lumbosacral spine [43].

Haematuria is unreliable, as it is present in only 50–75% of patients [42,45]. Flank pain, urinary incontinence, vaginal or drain urinary leakage, haematuria, fever, uraemia, or urinoma are characteristic of delayed diagnosis. When the diagnosis is missed, the complication rate increases [42,44]. Early recognition facilitates immediate repair and provides better outcome. Prolonged ureteral obstruction (>2 wk) predisposes the patient to pain and risk of infection [47]; it generally results in irreversible renal damage and almost doubles the risk of hypertension [48].

Extravasation of contrast medium on CT scans or in IVP is the hallmark sign of ureteral trauma. However, often, more subtle signs are noticed (eg, hydronephrosis, ascites, urinoma, mild ureteral dilation). In unclear cases, a retrograde or antegrade urography is the gold standard for confirmation [45]. With the increasing use of CT scanning in polytrauma patients, the diagnosis of ureteral trauma is increasingly made radiographically before the clinical signs.

3.2.3. Treatment

Management of ureteral trauma depends on the nature, severity, and location of the injury. Partial injuries can be repaired immediately with a stent or urine diversion by a nephrostomy tube. Stenting is recommended because it decreases the risk of stricture [45], although careful insertion is required to avoid aggravating the ureteral injury. Immediate repair of ureteral injury is recommended, however, in unstable trauma patients, a *damage control* approach is preferred with diversion of the urine and a delayed definitive repair [49]. Injuries that are diagnosed late are usually treated first by a nephrostomy tube with or without a stent [45]. Retrograde stenting is often unsuccessful in this setting.

The standard for external trauma is open surgical repair (Table 2). Endourologic, laparoscopic, and robotic repairs of the ureter are increasingly reported in the literature as options for iatrogenic ureteral injuries [50]. Proximal and midureteral injuries can often be managed by primary ureteroureterostomy, while a distal injury is usually treated with ureteral reimplantation (Table 3). Wide debridement is highly recommended for GSW injuries due to the blast effect of the injury.

Table 2 – Principles of surgical repair of ureteral injury

• Debridement of necrotic tissue
• Spatulation of ureteral ends
• Watertight mucosa-to-mucosa anastomosis with absorbable sutures
• Internal stenting
• External drain
• Isolation of injury with peritoneum or omentum

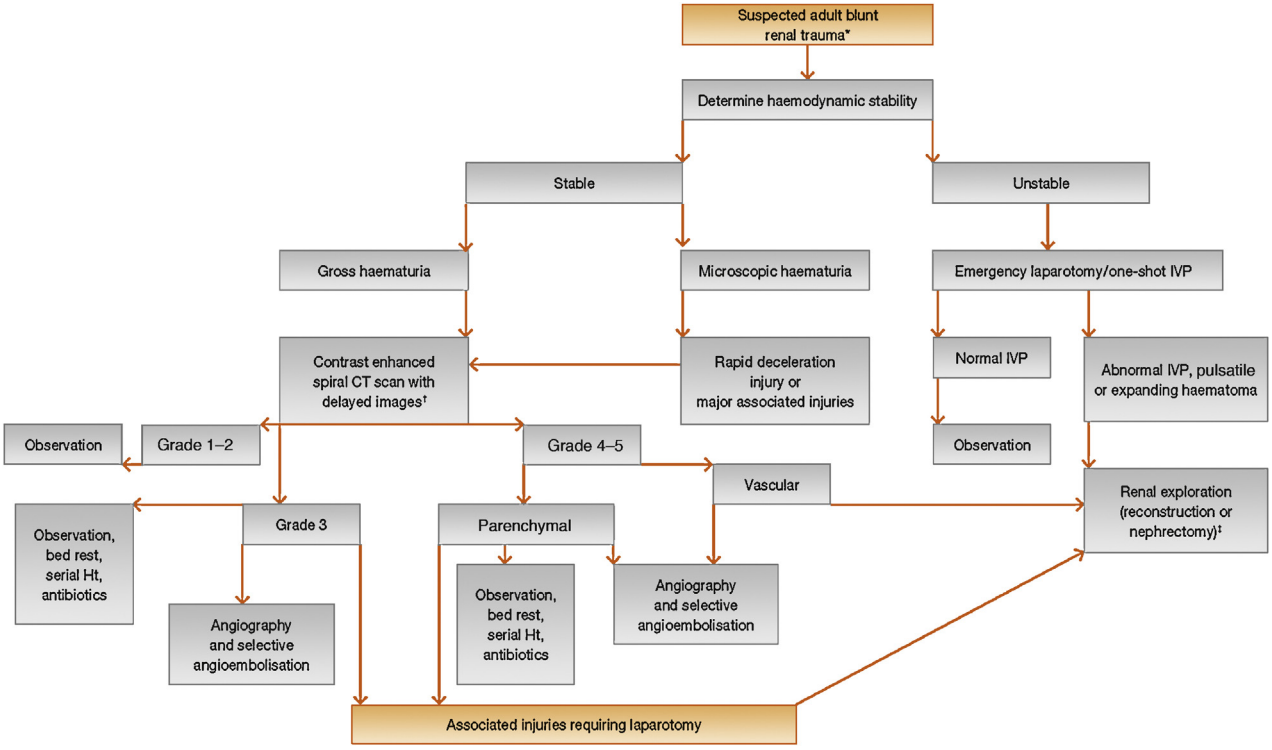

Fig. 1 – Evaluation of blunt renal trauma in adults. * Suspected renal trauma results from reported mechanism of injury and physical examination. † Renal imaging: Computed tomography scans are the gold standard for evaluating blunt and penetrating renal injuries in stable patients. In settings where the method is not available, the urologist should rely on other imaging modalities (intravenous pyelography, angiography, radiographic scintigraphy, magnetic resonance imaging). ‡ Renal exploration: Although renal salvage is a primary goal for the urologist, decisions concerning the viability of the organ and the type of reconstruction are made during the operation.
CT = computed tomography; Ht = haematocrit; IVP = intravenous pyelography.

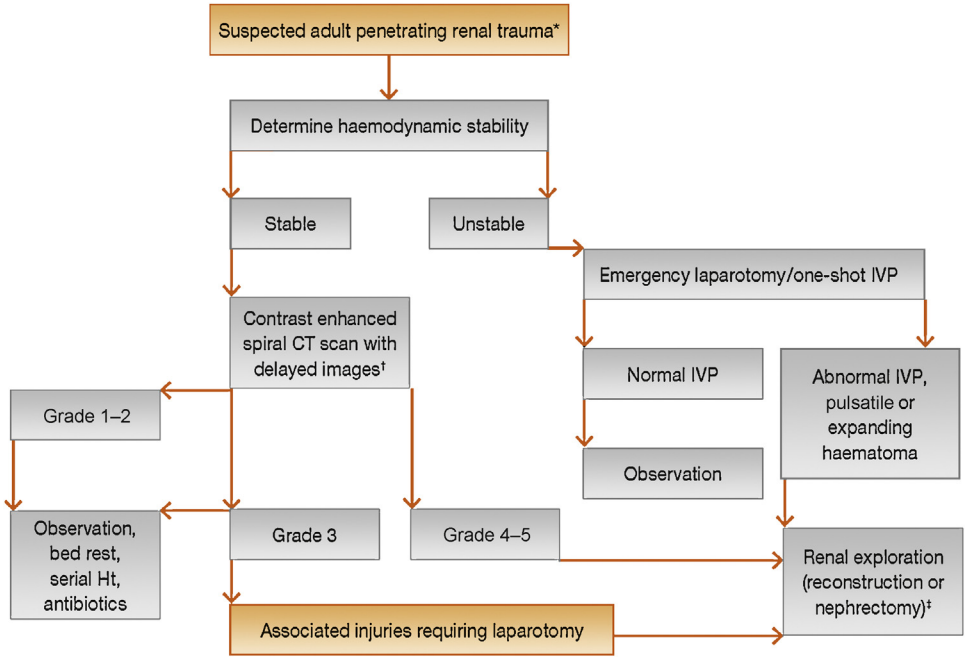

Fig. 2 – Evaluation of penetrating renal trauma in adults. * Suspected renal trauma results from reported mechanism of injury and physical examination. † Renal imaging: Computed tomography scans are the gold standard for evaluating blunt and penetrating renal injuries in stable patients. In settings where the method is not available, the urologist should rely on other imaging modalities (intravenous pyelography, angiography, radiographic scintigraphy, magnetic resonance imaging). ‡ Renal exploration: Although renal salvage is a primary goal for the urologist, decisions concerning the viability of the organ and the type of reconstruction are made during the operation.
CT = computed tomography; Ht = haematocrit; IVP = intravenous pyelography.

Table 3 – Reconstruction option by site of injury

Site of injury	Reconstruction options
Upper ureter	Ureteroureterostomy Transureteroureterostomy Ureterocalycostomy
Midureter	Ureteroureterostomy Transureteroureterostomy Ureteral reimplantation and a Boari flap
Lower ureter	Ureteral reimplantation Ureteral reimplantation with a psoas hitch
Complete	Ileal interposition graft Autotransplantation

3.2.3.1. Proximal and midureteral injury. Injuries <2–3 cm can usually be managed by a primary ureteroureterostomy [42]. When not feasible, a ureterocalycostomy should be considered. In extensive ureteral loss, a transureteroureterostomy is a valid option in which the proximal stump of the ureter is transposed across the midline and anastomosed to the contralateral ureter. The reported stenosis rate is 4%, and intervention or revision occurs in 10% of cases [51].

3.2.3.2. Distal ureteral injury. Distal injuries are best managed by ureteral reimplantation (ureteroneocystostomy) because the primary trauma usually jeopardises the blood supply to the distal ureter. The question of refluxing versus nonrefluxing ureteral reimplantation remains unresolved in the literature. The risk for clinically significant reflux should be weighed against the risk for ureteral obstruction.

A psoas hitch between the bladder and the ipsilateral psoas tendon is usually needed to bridge the gap and to protect the anastomosis from tension. The contralateral superior vesical pedicle may be divided to improve bladder mobility. The reported success rate is very high (97%) [51]. In extensive mid-lower ureteral injury, the large gap can be bridged with a tubularised L-shaped bladder flap (Boari flap). It is a time-consuming operation and not usually suitable in the acute setting. The success rate is reported to be 81–88% [52].

3.2.3.3. Complete ureteral injury. A longer ureteral injury can be replaced using a segment of the intestines, usually the ileum (ileal interposition graft). This should be avoided in patients with impaired renal function or known intestinal disease. Follow-up should include serum chemistry to diagnose hyperchloraemic metabolic acidosis [53]. The long-term complications include anastomotic stricture (3%) and fistulae (6%) [53]. In cases of extensive ureteral loss or after multiple attempts at ureteral repair, the kidney can be relocated to the pelvis (autotransplantation). The renal vessels are anastomosed to the iliac vessels and a ureteral reimplantation is performed [54].

4. Conclusions

It can be seen that the main cause of renal injury is blunt trauma, and the best method of diagnosing and classifying the extent of the injury is by CT scanning. In almost all renal injuries, the mainstay of treatment is conservative if the patient is stable. Selective angioembolisation is recommended as a technique to stop bleeding and achieve salvage of viable renal tissue, in the absence of any indications for immediate open exploration.

Noniatrogenic ureteral injuries are rare and are most commonly due to penetrating trauma. The diagnosis is usually made by CT scanning or at laparotomy. The prime method of treatment is open repair, dependent upon the nature, severity, and location of the injury.

Author contributions: Efraim Serafetinidis had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Serafetinidis, Kitrey, Djakovic, Kuehhas, Lumen, Sharma, Summerton.
Acquisition of data: Serafetinidis, Kitrey, Djakovic, Kuehhas, Lumen, Sharma, Summerton.
Analysis and interpretation of data: Serafetinidis, Kitrey, Djakovic, Kuehhas, Lumen, Sharma, Summerton.
Drafting of the manuscript: Serafetinidis.
Critical revision of the manuscript for important intellectual content: Serafetinidis, Kitrey, Djakovic, Kuehhas, Lumen, Sharma, Summerton.
Statistical analysis: Serafetinidis.
Obtaining funding: None.
Administrative, technical, or material support: Serafetinidis.
Supervision: Serafetinidis.
Other (specify): None.

Financial disclosures: Efraim Serafetinidis certifies that all conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript (eg, employment/affiliation, grants or funding, consultancies, honoraria, stock ownership or options, expert testimony, royalties, or patents filed, received, or pending), are the following: Duncan J. Summerton has received honoraria as a speaker for Lilly, AMS, Coloplast, GlaxoSmithKline, and Ipsen. The other authors have nothing to disclose.

Funding/Support and role of the sponsor: None.

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