European Urology

European Urology 47 (2005) 1–15

EAU Guidelines on Urological Trauma

Thomas H. Lynch[a], Luis Martínez-Piñeiro[b], Eugen Plas[c], Efraim Serafetinides[d], Levent Türkeri[e], Richard A. Santucci[f], Markus Hohenfellner[g,*]

[a]*St. James's Hospital, Trinity College, Dublin, Ireland*
[b]*University Hospital La Paz, Madrid, Spain*
[c]*City Hospital Lainz, Vienna, Austria*
[d]*417 NIMTS, Athens, Greece*
[e]*Department of Urology, Marmara University School of Medicine, Instanbul, Turkey*
[f]*Detroit Receiving Hospital, Wayne State University School of Medicine, Detroit, MI, USA*
[g]*Department of Urology, University of Heidelberg, Im Neuenheimer Feld 110, 69120 Heidelberg, Germany*

Accepted 26 July 2004

Available online 20 August 2004

Abstract

Purpose: To determine the optimal evaluation and management of genitourinary (renal, ureteral, bladder, urethral and genital) injuries by review of the world's literature on the subject.

Methods: A consensus committee convened by the Health Care Office of the European Association of Urology (EAU) to summarize the literature concerning the diagnosis and treatment of genitourinary trauma.

Results: Findings of 350 citations are reviewed.

Conclusions: The genitourinary trauma literature still relies heavily on expert opinion and single-institution retrospective series. Future prospective trials of the most significant issues, when possible, might improve the quality of evidence that dictates practitioner behavior. This paper represents a 5000 word summary of the full 35,000 word report. Full text of this review is available online at http://www.europeanurology.com.

Keywords: Trauma; Renal injury; Bladder injury; Urethral injury; Ureteral injury; Genital injury

1. Introduction

Genitourinary injuries (GUI) can lead to significant morbidity and mortality, but the incidence, severity and optimal treatment of these injuries has not been established in population-based cross-sectional studies. To codify the appropriate evaluation and management of GUI, a committee was convened by the Health Care Office (HCO) of European Association of Urology (EAU). The committee was charged with reviewing the available literature on the subject of GUI and creating a consensus document on the appropriate diagnosis and treatment of renal, ureteral, bladder, urethral and genital injuries. This is a brief summarized report (<5000 words) of the full Urological Trauma report (35,000 words) which appears in full online at http://www.europeanurology.com.

2. Material and methods

2.1. Subcommittee composition

The HCO of the EAU selected trauma subcommittee members from 6 European countries and the US. Each member was a Urologist with special expertise in GUI based on training, experience, and research publications.

2.2. Search criteria

A Medline search using PubMed (http://www.ncbi.nlm.nih.gov/pubmed/) included articles from 1966 to November 2003. Retrievable articles numbered in the thousands. 350 pertinent peer reviewed articles were retrieved, and additional papers referenced

* Corresponding author. Tel. +49 6221 566 321; Fax: +49 6221 56 53 66.
E-mail address: markus_hohenfellner@med.uni-heidelberg.de (M. Hohenfellner).

0302-2838/$ – see front matter © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.eururo.2004.07.028

Table 1
AAST organ injury severity scale for the kidney

1	Contusion or non-expanding subcapsular haematoma. No laceration
2	Non-expanding 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
5	Laceration: shattered kidney Or Vascular: renal pedicle injury or avulsion

in bibliographies but not initially retrieved from Medline were also examined.

3. Renal trauma

Renal injury (RI) occurs in approximately 1–5% of all traumas [1], as the kidney is the most commonly injured genitourinary and abdominal organ [2]. Blunt trauma accounts for the largest percentage of RIs (90–95%) [3], while gunshot and stab wounds represent the most common causes of penetrating injuries. Penetrating injuries tend to be more severe, have a higher number of associated organ injuries, and usually result in a higher nephrectomy rate (25–33%) [4]. The Committee on Organ Injury Scaling of the American Association for the Surgery of Trauma (AAST) classified RIs as shown in Table 1 [5].

3.1. History and physical exam

Possible indicators of RI on history and physical examination are falls, high-speed motor vehicle accidents, or a direct blow to the flank. In penetrating injuries, information includes the size of the weapon in stabbings, and the type and calibre of weapon used in gunshot wounds. Special consideration should be given to pre-existing renal disease and the functioning renal mass of the trauma patient [6]. Pre-existing renal abnormality makes RI more likely following trauma.

3.2. Laboratory evaluation

Haematuria does not correlate with the degree of injury [7]. Disruption of the ureteropelvic junction, renal pedicle injuries, or segmental arterial thrombosis may occur without haematuria [8]. Haematuria out of proportion to the history of trauma suggests pre-existing renal pathology [9]. Interval haematocrit, and the requirements for blood transfusions is an indirect sign of the rate of blood loss and is crucial in the decision-making process (Fig. 1).

3.3. Imaging

Patients with blunt trauma and microscopic haematuria, but without shock or a deceleration mechanism have a low incidence of significant RIs, and do not require imaging (Fig. 2). In patients with penetrating trauma, if RI is clinically suspected, or when any degree of hematuria is present, renal evaluation should be performed [10]. The role of ultrasound in the radiographic evaluation is limited, although a possible role of ultrasound may be the serial evaluation of stable RIs and as a screening test to identify patients requiring radiological exploration [11].

When patients must go immediately to the operating room, intraoperative one shot IVP can be helpful, although some experts have questioned its value in cases of penetrating abdominal trauma [12]. The technique consists of a bolus intravenous injection of 2 ml/kg radiographic contrast followed by a single plain film taken after 10 minutes. This study provides important information for decision-making in the critical time of urgent laparotomy, and documents the presence of a functioning contralateral kidney [13].

CT is the gold standard method for the radiographic assessment of stable patients with RIs as it defines the location of injuries and pre-existing abnormalities, detects contusions and devitalized segments, visualizes the entire retroperitoneum, and provides a view of the other abdominal/pelvic viscera [14]. A lack of contrast enhancement of the kidney or a central parahilar haematoma suggest the possibility of pedicle injury [15]. The presence of a large haematoma medial to the kidney and displacing the renal vasculature suggests a venous injury.

Very fast ‘‘spiral’’ CT provides shorter scanning times, but injury to the renal collecting system may be initially missed, so delayed scans should be performed to rule out urinary extravasation [16]. Standard, formal IVP may be the study of choice in centers where timely CT scanning is not available.

MRI may be useful if CT is not available, in patients with iodine allergy, or in the very few cases where the findings on CT are equivocal. Angiography is specific for defining the exact location and degree of vascular injuries, and may be preferable when planning selective embolization for the management of persistent or delayed haemorrhage [8].

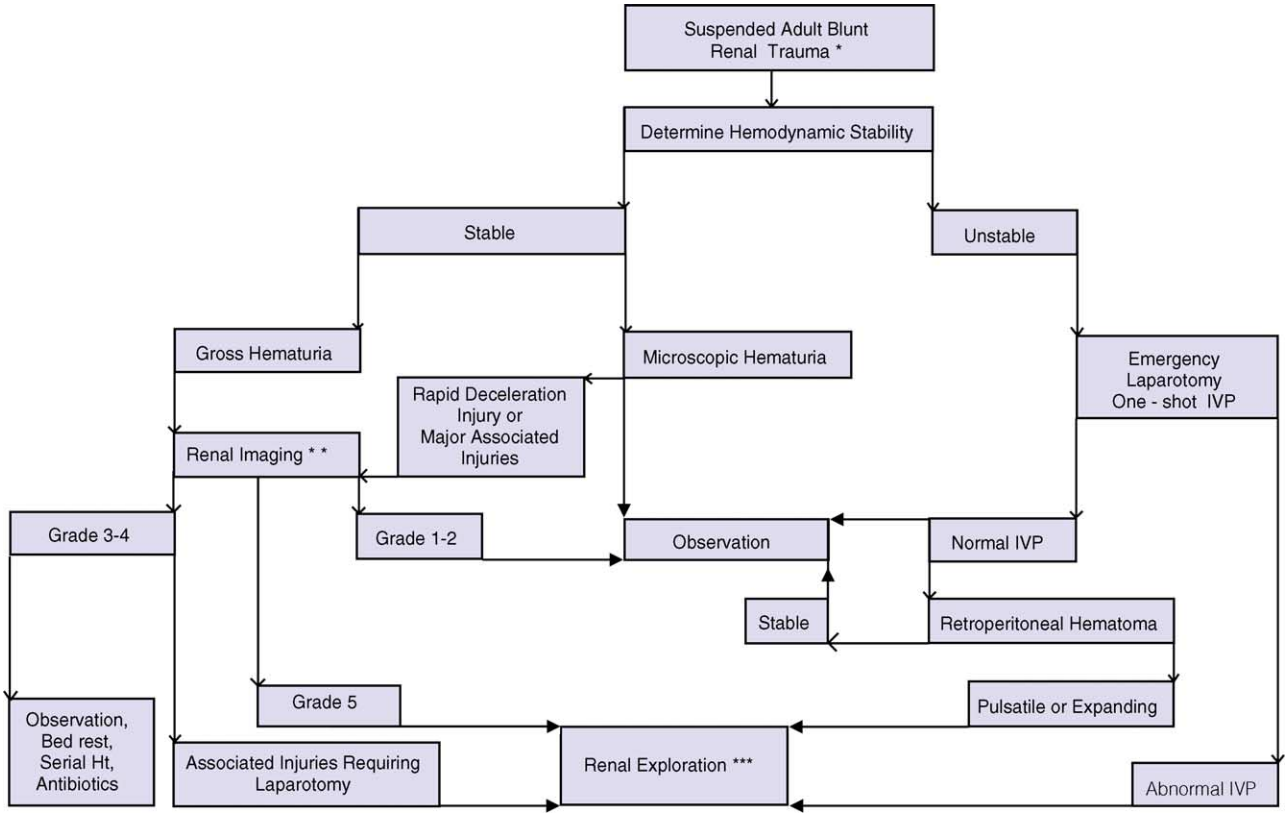

Fig. 1. Evaluation of blunt renal trauma in adults. *Suspected renal trauma results from reported mechanism of injury and physical examination. ** Renal imaging: CT scans are the gold standard for evaluating blunt and penetrating renal injuries in stable patients. In settings where the method is not available, the urologist should rely on other imaging modalities (IVP, angiography, radiographic scintigraphy, MRI). *** 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.

3.4. Indications for renal exploration

Absolute indications for surgery include life-threatening haemodynamic instability due to renal haemorrhage [17] and an expanding/pulsatile perirenal haematoma identified at exploratory laparotomy (which is usually a sign of Grade 5 vascular injury). Relative indications include persistent bleeding, suspected renal pelvis or ureteral injury. The management of RIs with urinary extravasation and devitalized fragments has been controversial, as some studies show increased rate of complications when they are managed nonoperatively [18].

A transperitoneal operative approach [17] with temporary vascular occlusion before opening of Gerota's fascia is recommended [19]. Renorrhaphy is the most common reconstructive technique, while partial nephrectomy may be required for polar injuries. Watertight closure of the collecting system either directly or by the oversewing of parenchyma is imperative. An omental pedicle flap may be used for coverage [20]. Drainage of the ipsilateral retroperitoneum is recommended.

In renovascular injuries, nephrectomy is the treatment of choice unless there is a solitary kidney or the patient has sustained bilateral injuries [21]. Arteriography with selective renal embolization for haemorrhage control is a reasonable alternative to laparotomy in selected patients [22].

3.5. Non-operative management

In stable patients, supportive care with bed-rest, hydration and antibiotics is the preferred initial approach and is associated with a lower rate of nephrectomy, without any increase in the immediate or long-term morbidity and a low (5%) failure rate [23].

All Grades 1 and 2 RIs can be managed non-operatively. Recent studies support expectant treatment of Grade 3 injuries [24]. The majority of patients with Grades 4 and 5 RIs present with major associated injuries, with a resultant higher rate of renal exploration [25].

Stable patients with penetrating wounds should undergo complete staging to define the full extent of the injury (Fig. 3). Renal gunshot injuries must be explored if they involve the hilum, are accompanied by signs of continued bleeding, or if ureteral/renal pelvis injury is suspected [26]. Low-velocity gunshot and stab wounds of minor degree may be managed conservatively [27]. If the site of penetration by stab wound is

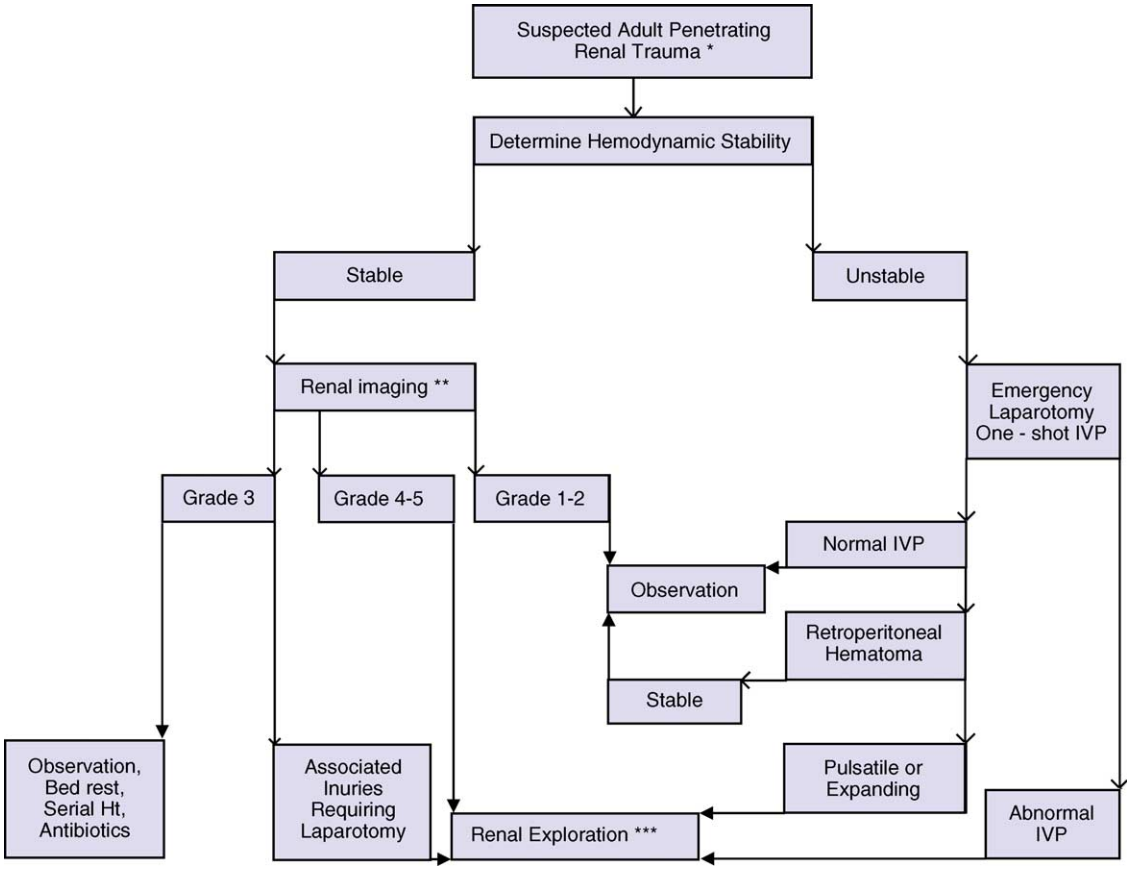

Fig. 2. Evaluation of penetrating renal trauma in adults. *Suspected renal trauma results from reported mechanism of injury and physical examination. ** Renal imaging: CT scans are the gold standard for evaluating blunt and penetrating renal injuries in stable patients. In settings where the method is not available, the urologist should rely on other imaging modalities (IVP, angiography, radiographic scintigraphy, MRI). *** 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.

posterior to the anterior axillary line, 88% of such RIs could be managed non-operatively [28].

3.6. Post-operative care

Patients should be monitored for bleeding episodes in the month after surgery. Renovascular hypertension should be monitored for at least a year, and potentially indefinitely. Requirements for follow-up CT scans are controversial. Patients should be rescanned if they develop fever, increasing flank pain or persistent bleeding, although requirements for rescanning are not standardized in the literature. Nuclear renal scans may be useful for documenting and tracking functional recovery in patients following reconstruction [29].

Early complications occur within 30 days after injury and include: bleeding, infection, perinephric abscess, sepsis, urinary fistula, hypertension, urinary extravasation and urinoma. Delayed complications include bleeding, hydronephrosis, calculus formation, chronic pyelonephritis, hypertension, arteriovenous fistula, hydronephrosis and pseudoaneurysms. Delayed bleeding may be life-threatening. Selective angiographic embolization is the preferred treatment [30]. Perinephric abscess formation is best managed by percutaneous drainage [24], but may require open exploration.

Hypertension may occur from renal artery thrombosis, segmental arterial thrombosis, devitalized fragments and arteriovenous fistulae with a frequency of less than 5% [31]. CT and arteriography is informative [32]. Treatment may include medical management or surgery.

Urinary extravasation after reconstruction often subsides without intervention as long as ureteral obstruction and infection are not present. Retrograde ureteral stenting improves drainage and often allows healing [33]. Arteriovenous fistulas present with delayed haematuria after penetrating trauma–percutaneous embolization or surgery are the therapeutic options [34]. Pseudoaneurysms are managed with transcatheter embolization [35]. Post injury duodenal obstruction, or acute renal colic from retained missiles are rare complications [36].

3.7. Paediatric renal trauma

Blunt renal trauma accounts for more than 90% of RIs in children [37]. Differences in anatomy, as well as

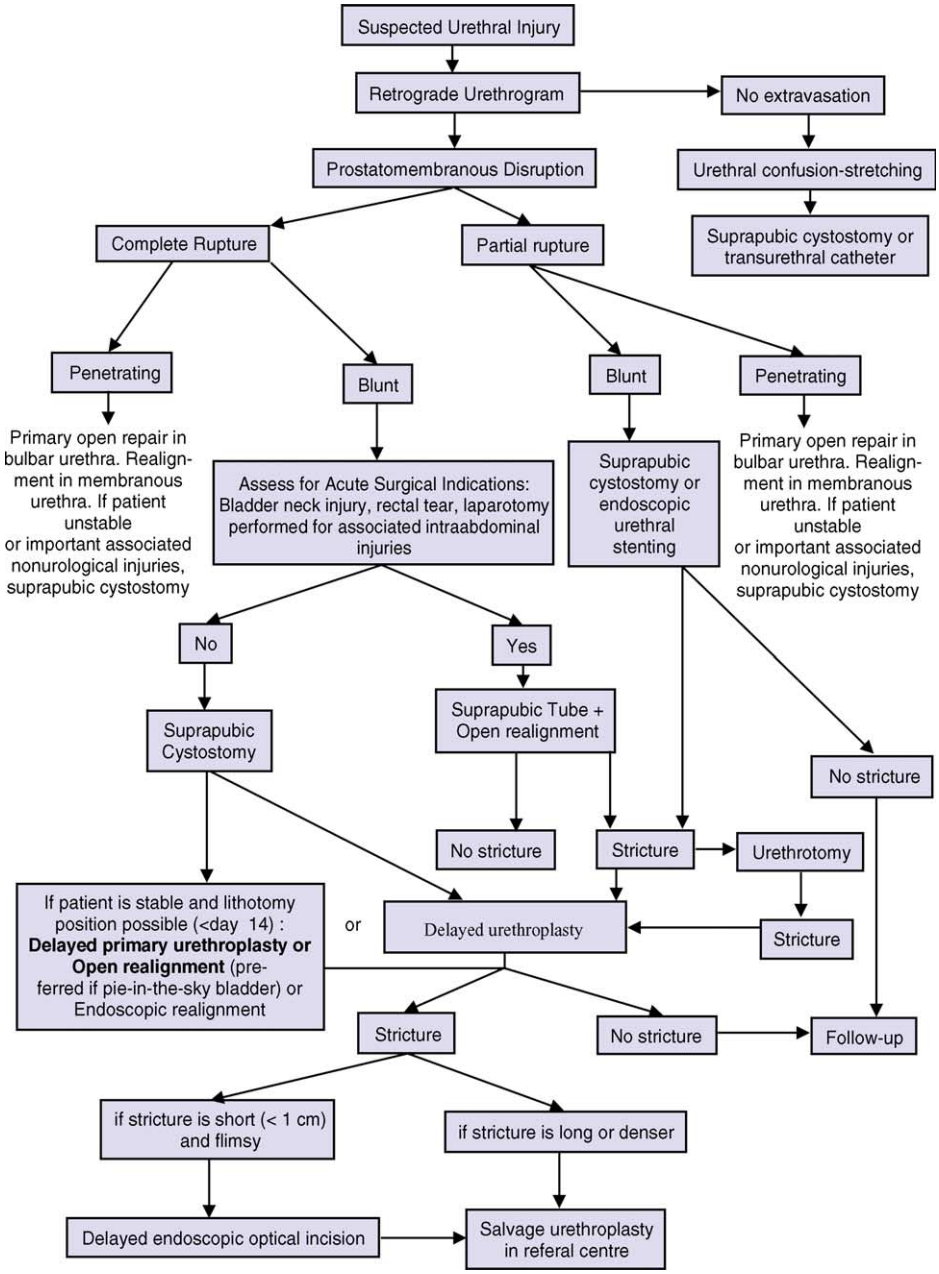

Fig. 3. Management of posterior urethral injuries in men.

the higher incidence of pre-existing renal disease, make children more likely to sustain RI [38].

Unlike in adults, hypotension is a rare and unreliable sign in children, as an outpouring of catecholamines can maintain blood pressure despite a significant volume of blood loss from an injury [39].

Some propose that all paediatric patients with any degree of haematuria should be evaluated for renal injury [40] while others conclude that significant injuries are unlikely in the absence of gross hematuria, or microhematuria plus shock/deceleration [41]. Ultrasound may be a reliable method for screening and following the course of RI [42], although CT is still the gold standard.

Conservative treatment for Grades 1–2 paediatric RIs is clearly supported in the literature [43] and non-operative management of even some severe paediatric RIs can result in an excellent long-term outcome. Haemodynamic instability or a diagnosed Grade 5 vascular injury remain absolute indications for operative management [44]. Stable patients with urinary extravasation can be managed expectantly. In cases where there is persistent leakage, percutaneous drainage or ureteral stenting is recommended.

Table 2
AAST organ injury severity scale for the ureter

Grade	Description of injury
I	Haematoma only
II	Laceration <50% of circumference
III	Laceration >50% of circumference
IV	Complete tear <2 cm of devascularization
V	Complete tear >2 cm of devascularization

4. Ureteral trauma

Because of its protected location, small size, and mobility, trauma to the ureter is relatively rare and accounts for only 1% of all GUI. In large studies of ureteral injuries (UIs), 75% are iatrogenic, 18% are from blunt trauma, and 7% were from penetrating trauma. Among iatrogenic injuries, 73% are gynaecological in origin, 14% are from general surgical cases and 14% are urological. The injury in the upper third is reported 13%, in the middle third 13%, and in the lower third 74% [45]. The AAST has classified UIs as shown in Table 2 [5].

The most common diagnostic investigation is IVP (57%), retrograde ureteropyelography (23%), ureteral catheterization (29%), and open surgery at the time of injury or when strong suspicion of UI obviates the need for imaging (in 24%). (2) There are no classic clinical symptoms and signs [46]. UI should be suspected in all cases of penetrating abdominal injury, and in cases of blunt deceleration trauma in which the kidney and renal pelvis can be torn away from the ureter. This deceleration injury is more likely to occur in children because of their hyperextensible vertebral column [47]. Haematuria is present in only half of those with UI.

UI may cause radiological signs of upper urinary tract obstruction but the sine qua non is extravasation of radiological contrast material [46]. The diagnosis is most often made with intraoperative one-shot IVP and CT scans. If a high suspicion of UI exists and the CT scan is non-diagnostic, then an IVP can be obtained. If this is also non-diagnostic and a suspicion still exists, then retrograde pyelography should be undertaken.

4.1. Management

Partial tears can be managed with ureteral stenting or by placement of a nephrostomy tube to divert urine [46]. If a Grade 2 or 3 injury is encountered during immediate surgical exploration of an iatrogenic injury, then primary closure of the ureteral ends over a stent may be recommended, with placement of an external, non suction drain adjacent to the injury.

Grades 3–5 ureteral injuries are repaired using the following principles:

- debridement of ureteral ends to fresh tissue,
- spatulation of ureteral ends,
- placement of internal stent,
- watertight closure of reconstructed ureter with absorbable suture,
- placement of external, non-suction drain,
- isolation of injury with peritoneum or omentum.

The type of reconstructive repair procedure depends on the nature and site of the injury [46]. The options are

1. upper third:
   - uretero-ureterostomy,
   - transuretero-ureterostomy,
   - ureterocalycostomy,
2. middle third:
   - uretero-ureterostomy,
   - transuretero-ureterostomy,
   - boari flap and reimplantation,
3. lower third:
   - direct reimplantation,
   - psoas hitch,
   - blandy cystoplasty,
4. complete ureteral loss:
   - ileal interposition (delayed),
   - autotransplantation (delayed).

Immediate nephrectomy should be undertaken, although it is controversial, only when UI complicates the repair of an abdominal aortic aneurysm or other vascular procedure in which a vascular prosthesis is to be implanted.

5. Bladder trauma

Among abdominal injuries that require surgical repair, 2% involve the bladder [48]. Blunt trauma accounts for 67–86% of bladder ruptures (BR), while penetrating trauma for 14–33% [49]. The most common cause (90%) of BR by blunt trauma is motor vehicle accidents [50]. BR in the setting of blunt trauma may be classified as extraperitoneal or intraperitoneal. About 70–97% of patients with BR from blunt trauma have associated pelvic fractures [51]. The AAST organ injury severity scale for the bladder appears in Table 3.

Few demographic risk factors for BR exist, but driving under the influence of alcohol predisposes to

Table 3
AAST organ injury severity scale for the bladder

I	Hematoma	Contusion, intramural hematoma
I	Laceration	Partial thickness
II	Laceration	Extraperitoneal bladder wall laceration <2 cm
III	Laceration	Extraperitoneal (>2 cm) or intraperitoneal (<2 cm) bladder wall laceration
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)

both accidents and to a distended bladder, so it is a risk factor [52]. The two most common sign and symptoms are gross haematuria (82%–100%) and abdominal tenderness (62%) [53]. Other findings may include the inability to void, bruises over the suprapubic region, and abdominal distension. Extravasation of urine may result in swelling in the perineum, scrotum, thighs, and anterior abdominal wall.

The classic combination of pelvic fracture and gross haematuria constitutes an absolute indication for immediate cystography in blunt trauma victims [54]. All patients with gross hematuria and a pelvic ring fracture should undergo radiologic examination of the bladder. Microscopic haematuria is only a relative indication of injury, and recommendations for radiologic exam are split in the literature. In patients with pelvic fracture and microhematuria, imaging should be reserved for those with anterior rami fractures (straddle fracture) or Malgaigne type severe ring disruption (Tile III). In paediatric patients, a threshold for radiological evaluation of greater than or equal to 20 rbc/hpf would miss 25% of cases with BR [55].

5.1. Imaging

Retrograde cystography in the evaluation of bladder trauma is considered the standard diagnostic procedure [50]. When adequate bladder filling and post-void images are obtained, cystography has an accuracy rate of 85–100% [50]. For the highest diagnostic accuracy, the bladder must be distended by the instillation of at least 350 ml of contrast media. BR may be identified only on the post-drainage film in approximately 10% of cases [50]. False-negative findings may result from improperly performed studies with less than 250 ml of contrast instillation, or omission of a post-drainage film [56].

Other imaging modalities such as IVP, angiography, MRI, and ultrasound are inadequate for evaluation of the bladder and urethra after trauma [57]. Additionally, standard CT is not reliable in the diagnosis of BR. CT cystography, however, when properly performed with 350 cc of dilute (2%) contrast is an excellent substitute for standard cystography [58].

5.2. Treatment

Most patients with blunt trauma resulting in extraperitoneal bladder rupture can be managed safely by catheter drainage only, even in the presence of extensive retroperitoneal or scrotal extravasation [56]. However, bladder neck involvement [49], the presence of bone fragments in the bladder wall, or entrapment of the bladder wall by bone should necessitate surgical intervention [52].

Intraperitoneal ruptures should always be managed by surgical exploration. Lacerations are usually large, with the potential risk of peritonitis due to urine leakage if left untreated [56]. Patients with penetrating bladder injuries should undergo emergency exploration and repair [56].

6. Urethral trauma

Unstable diametric pelvic fractures [59] and bilateral ischiopubic rami fractures have the highest likelihood of injuring the posterior urethra. In particular, the combination of straddle fractures with diastasis of the sacroiliac joint has the highest overall risk; the odds ratio is about 7 times higher for these types of fractures [60].

Multiple classifications for urethral injuries have been proposed, however the Committee on Organ Injury Scaling of the American Association for the Surgery of Trauma (AAST) has developed a urethral-injury scaling system (Tables 4 and 5) [61].

Clinical management can be advised according to this scale:

- Type I no treatment required.
- Types II and III can be managed conservatively with suprapubic cystostomy or urethral catheterisation.
- Types IV and V will require endoscopic realignment or delayed urethroplasty.

Penetrating injuries to the anterior urethra usually occur from gunshot wounds and involve the pendulous and bulbar urethral segments equally. These injuries are often found with penetrating penile or testicular trauma.

Table 4
AAST organ injury severity scale for the urethra

Type	Description	Appearance
I	Contusion	Blood at the urethral meatus; normal urethrogram
II	Stretch injury	Elongation of the urethra without extravasation on urethrography
III	Partial disruption	Extravasation of contrast at injury site with contrast visualized in the bladder
IV	Complete disruption	Extravasation of contrast 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

Table 5

Grade	Description of injury
(A) AAST organ injury severity scale for the vagina[a]	
I	Contusion or hematoma
II	Laceration, superficial (mucosa only)
III	Laceration, deep into fat or muscle
IV	Laceration, complex, into cervix or peritoneum
V	Injury into adjacent organs (anus, rectum, urethra, bladder)
(B) AAST organ injury severity scale for the vulva[a]	
I	Contusion or hematoma
II	Laceration, superficial (skin only)
III	Laceration, deep into fat or muscle
IV	Avulsion; skin, fat or muscle
V	Injury into adjacent organs (anus, rectum, urethra, bladder)
(C) AAST organ injury severity scale for the testis[b]	
I	Contusion or hematoma
II	Subclinical laceration of tunica albuginea
III	Laceration of tunica albuginea with <50% parenchymal loss
IV	Major laceration of tunica albuginea with ≥50% parenchymal loss
V	Total testicular destruction or avulsion
(D) AAST organ injury severity scale for the scrotum	
I	Contusion
II	Laceration <25% of scrotal diameter
III	Laceration ≥25% of scrotal diameter
IV	Avulsion <50%
V	Avulsion ≥50%
(E) AAST organ injury severity scale for the penis	
I	Cutaneous laceration/contusion
II	Bucks' fascia (cavernosum) laceration without tissue loss
III	Cutaneous avulsion/Laceration through glans/meatus/ cavernosal or urethral defect <2 cm
IV	Cavernosal or urethral defect ≥2 cm/partial penectomy
V	Total penectomy

[a] Advance one grade for multiple injuries up to grade III.
[b] Advance one grade for bilateral lesions up to grade V.

6.1. Clinical assessment

The initial management of all urethral injuries is resuscitation of the patient and the diagnosis of potentially life-threatening injuries. In the absence of blood at the meatus or haematoma, a urological injury is unlikely and will be rapidly excluded by bladder catheterization.

Blood at the meatus is present in 37–93% of patients with posterior urethral injury and at least 75% of patients with anterior urethral trauma [62]. Its presence should preclude any attempts at urethral instrumentation, until the entire urethra is adequately imaged. In an unstable patient, an attempt can be made to pass a urethral catheter, but if there is any difficulty a suprapubic catheter is inserted and a retrograde urethrogram performed when appropriate. There are no convincing data indicating a higher rate of infection or urethral stricture after a single attempt at catheterization [63]. However, if a urethral injury is suspected, urethrography prior to attempted catheterization is the most prudent approach.

Haematuria, although non-specific, may indicate urethral injury. The amount of urethral bleeding correlates poorly with the severity of injury, and total transection of the urethra may result in little bleeding [64]. Additionally, pain on urination or inability to void suggests urethral disruption. A high-riding prostate is a relatively unreliable finding in the acute phase, since the pelvic haematoma associated with pelvic fractures often precludes the adequate palpation of a small prostate, particularly in younger men [63]. In females, blood at the vaginal introitus is present in more than 80% of patients with pelvic fractures and co-existing urethral injuries [65].

6.2. Radiographic examination

Retrograde urethrography is considered the gold standard for the initial evaluation of urethral injury [66]. In cases of subsequent urethral stricture, simultaneous cystogram and urethrogram is necessary, although magnetic resonance imaging (MRI) [67] or endoscopy through the suprapubic tract can be used to define the anatomy. Ultrasonography is not a routine investigation in the initial assessment of urethral injuries.

6.3. Management: anterior urethra

Bunt injuries resulting in partial tears can be managed with a suprapubic catheter or urethral catheterization

[68]. Suprapubic cystostomy has the advantage that it not only diverts the urine away from the site of injury, but it avoids urethral manipulation [69]. Satisfactory urethral luminal recanalization occurs in approximately 50% of partial anterior urethral disruptions [70]. Short and flimsy strictures can be managed with optical urethrotomy or urethral dilation. Denser strictures require formal urethral reconstruction. Delayed anastomotic urethroplasty is indicated in strictures less than 1 cm in length.

Longer strictures of the anterior urethra should not be repaired by an end-to-end anastomosis to avoid chordee. In these cases, flap urethroplasty is indicated. If at the time of initial exploration, the urethra is found to be so extensively disrupted that primary anastomosis is not feasible - this occurs with defects over 1–1.5 cm length - the procedure should be aborted. The surgeon should marsupialize the urethra preparatory to a two-stage urethral repair with proximal suprapubic urinary diversion.

Most female urethral disruptions can be sutured primarily [71]. For proximal urethral injuries, urethral exposure is best obtained transvesically, permitting direct visualization of the bladder, bladder neck and proximal urethra.

6.4. Management: posterior urethra

Partial tears of the posterior urethra can be managed in most cases with a suprapubic or urethral catheter and repeat retrograde urethrography at 2-weekly intervals until healing has occurred [68]. They may heal without significant scarring or obstruction if managed by diversion alone [72]. Any residual or subsequent stricture can be managed with urethral dilation or optical urethrotomy, if short and flimsy or by anastomotic urethroplasty if denser [73].

Treatment options include primary open surgical exploration and realignment, primary endoscopic realignment, delayed primary urethroplasty, delayed endoscopic incision and delayed urethroplasty. In posterior urethral injuries associated with rectal injuries, immediate open exploration, rectal repair and urethral realignment is advisable [68].

Primary endoscopic realignment is encouraged in the peri-injury period if feasible. A great variation of techniques is used for primary endoscopic evaluation, including:

- simple passage of a catheter across the defect [74],
- endoscopically assisted catheter realignment using flexible, rigid endoscopes and biplanar fluoroscopy [75],
- use of interlocking sounds (‘railroading’) or magnetic catheters to place the catheter [76].

Primary OPEN realignment (with pelvic haematoma evacuation and dissection of the prostatic apex) is not recommended acutely. It is difficult, potentially dangerous, and is associated with unacceptably high impotence and incontinence rates [77].

The concept of early (7–21 days) primary urethroplasty has been advocated by a single center. It involves primary repair of the urethra in the early post injury period, often in conjunction with planned orthopedic procedures [78]. While single center results were promising, we do not recommend wide use of this technique until further studies have been reported [79]. In female urethral disruption, early primary urethroplasty has been advocated, although no large experience exists [80].

The most common result of a posterior urethral distraction is a relatively short prostatobulbar urethral gap. It can generally be resolved by a perineal approach anastomotic repair. The restricture rate after delayed anastomotic urethroplasty was less than 10% [81] and the risk of impotence caused by delayed urethroplasty is about 5% and the rate of incontinence is about 4% [82]. Recurrent urethral strictures after open urethroplasty, or special cases such as a previous rectal injury may require additional reconstructive procedures such as skin flaps, or a combined abdomino-perineal approach [83].

Some practitioners attempt endoscopic incision of the scar between the two normal urethral ends before open urethroplasty is contemplated [84]. This fails in the majority (80%) of patients [85] and urethral false passage and rectal perforation have been reported [86]. Stents are not currently recommended for patients with strictures following pelvic trauma, as fibrotic tissue tends to grow though into the lumen of the stent [87]. While intervention should be guided by the clinical circumstances, the following algorithms are suggested for the treatment of urethral injuries in males and females (Figs. 3–5).

7. Genital trauma

One-third to two-thirds of GUI are associated with the external genitalia [88]. Proper management of genital trauma requires gathering of information about the persons, animals or weapons involved in the accident. In males, a direct blow to the erect penis may cause penile fracture, frequently occurring during consensual intercourse, which accounts for approximately

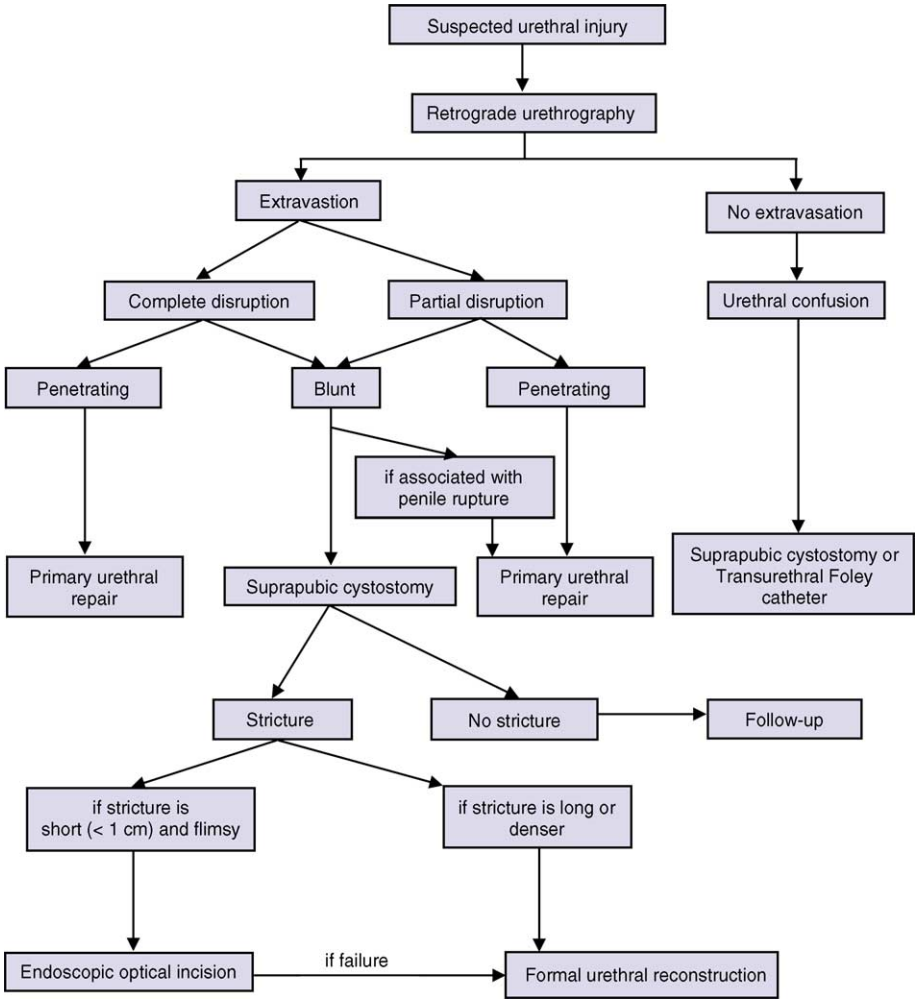

Fig. 4. Management of anterior urethral injuries in men.

60% of penile fractures [89] (Fig. 6). Penile fracture is caused by rupturing of the cavernosal tunica albuginea and may be associated with lesions of both the corpus spongiosum and urethra in 10–22% [90].

Blunt trauma to the scrotum can cause subcutaneous scrotal haematoma, hematoscrotum, testicular dislocation and/or testicular rupture. Traumatic dislocation of the testicle occurs rarely, usually in victims of car or motor cycle accidents, or in pedestrians run over by a vehicle [91]. When present, bilateral dislocation of the testes has been reported in up to 25% the cases [92]. Testicular rupture is found in approximately 50% of direct blunt traumas to the scrotum [93]. In females, blunt trauma to the vulva is rare.

Penetrating trauma to the external genitalia is frequently associated with complex injuries of other organs. In children, penetrating injuries are most frequently seen after straddle-type falls or laceration of genital skin due to falls on sharp objects [94].

Off-road bicycling and motorbike riding, accidents from in-line hockey skating and rugby footballers have been associated with blunt testicular trauma [95]. Self-mutilation of the external genitalia have been reported in psychotic patients and transsexuals [96].

7.1. Diagnosis

In females, an abusive assault may be related with genital injury, so investigation must consider this possibility (Fig. 7). In suspicious cases, vaginal smears should be taken for detection of spermatozoa [94]. In patients with genital injuries and blood at the vaginal introitus, complete vaginal inspection with speculum under sedation or general anaesthesia is recommended [97].

In males, the presence of hematuria suggests the need for retrograde urethrography. Patients with penile fracture report a sudden cracking or popping sound

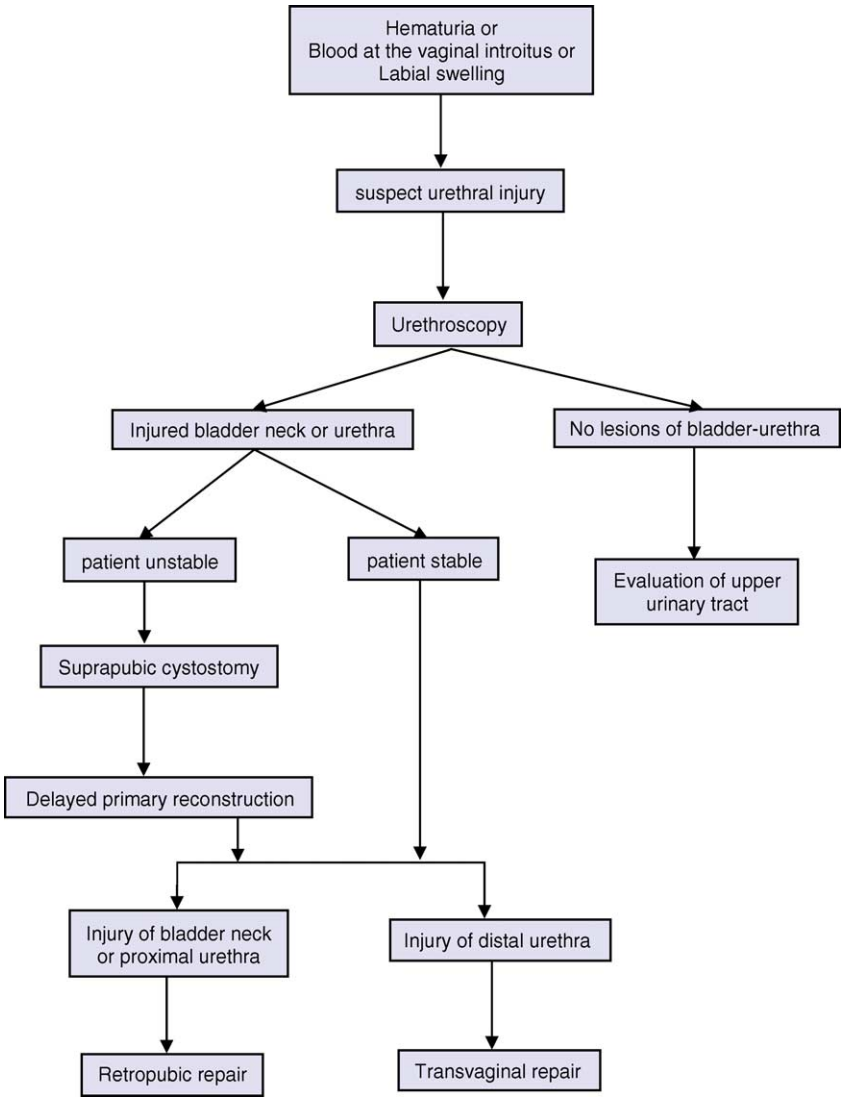

Fig. 5. Management of urethral injuries in women.

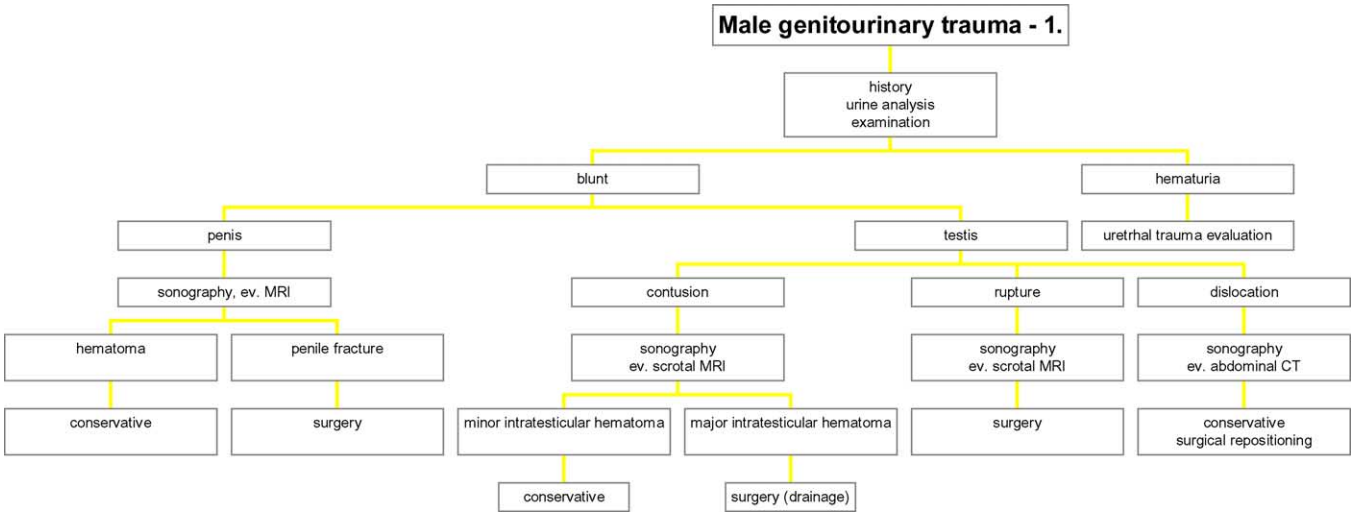

Fig. 6. Management of blunt male external genital trauma.

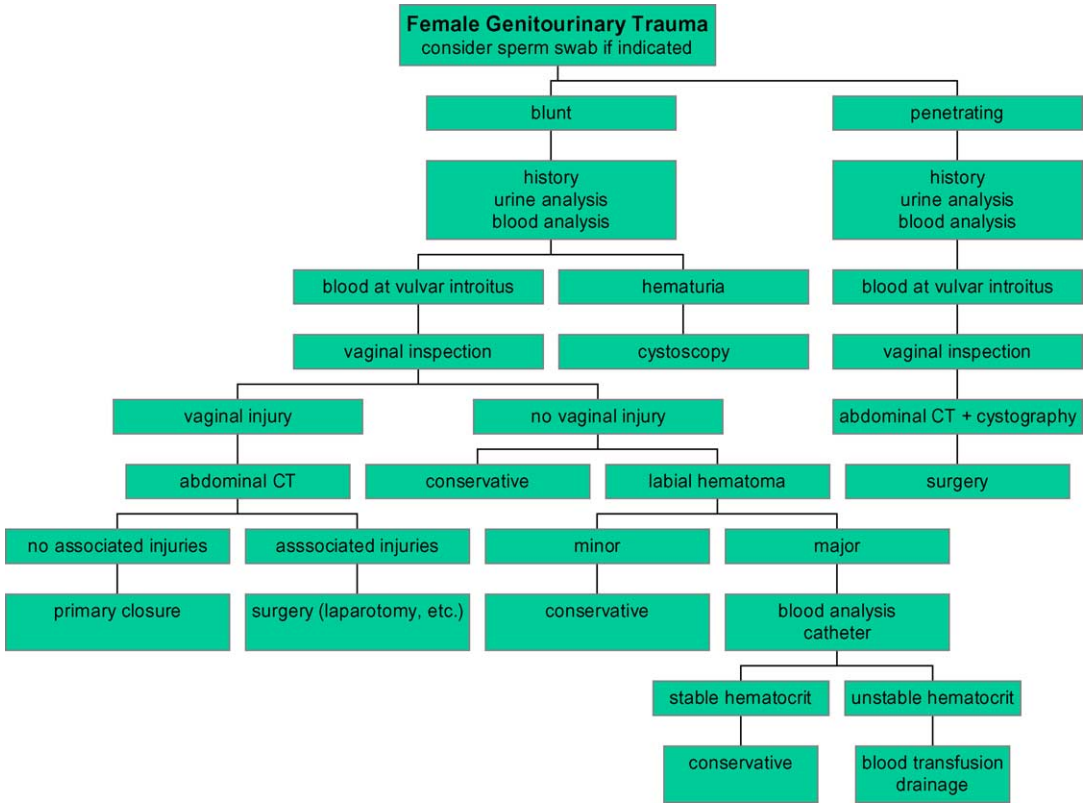

Fig. 7. Management of female external genital trauma.

associated with local pain and immediate detumescence [89]. Contradictory results have been presented regarding the usefulness of ultrasonography in testicular trauma [96,98–102]. If imaging cannot exclude testicular rupture, surgical exploration is recommended.

7.2. Treatment: penile trauma

After blunt trauma, the presence of subcutaneous haematoma without rupture of the cavernosal tunica albuginea and no immediate detumescence of the erect penis does not require surgical intervention. Non-steroidal analgesics and ice-packs are indicated. This injury can be distinguished from penile fracture by the absence of post-traumatic flaccidity. In the case of penile fracture, immediate surgical intervention with closure of the tunica albuginea is recommended.

In penetrating trauma of the external genital in men, urethrography is recommended. Surgical exploration, conservative debridement of necrotic tissue, and primary closure when possible is recommended [96].

7.3. Treatment: testicular trauma

After blunt trauma, subcutaneous hematoma without hematocele can be treated by non-steroidal analgesics. In case of small hematocele, conservative management is recommended with non-steroidal analgesics and ice-packs [102]. If hematocele is large, surgical exploration with extraction of hematoma is recommended [103]. In cases of testicular rupture, surgical exploration with excision of necrotic testicular tubules and closure of the tunica albuginea is mandatory. Traumatically dislocated testis can be manually replaced, but secondary surgical fixation of the ruptured tunica vaginalis is recommended. If manual reposition cannot be performed, surgical exploration and orchidopexy will be required.

Penetrating injuries to the scrotum need surgical exploration with conservative debridement of non-viable tissue (Fig. 8). In case of complete disruption of the spermatic cord, realignment without vaso-vasostomy can be performed if surgically feasible [104]. If there is extensive destruction of the tunica albuginea, mobilization of a tunica vaginalis flap can be obtained for testicular closure. Antibiotics and tetanus prophylaxis are recommended perioperatively.

Extended laceration of scrotal skin requires surgical intervention for skin closure. Due to the elasticity of the scrotum, most defects can be primarily closed [96].

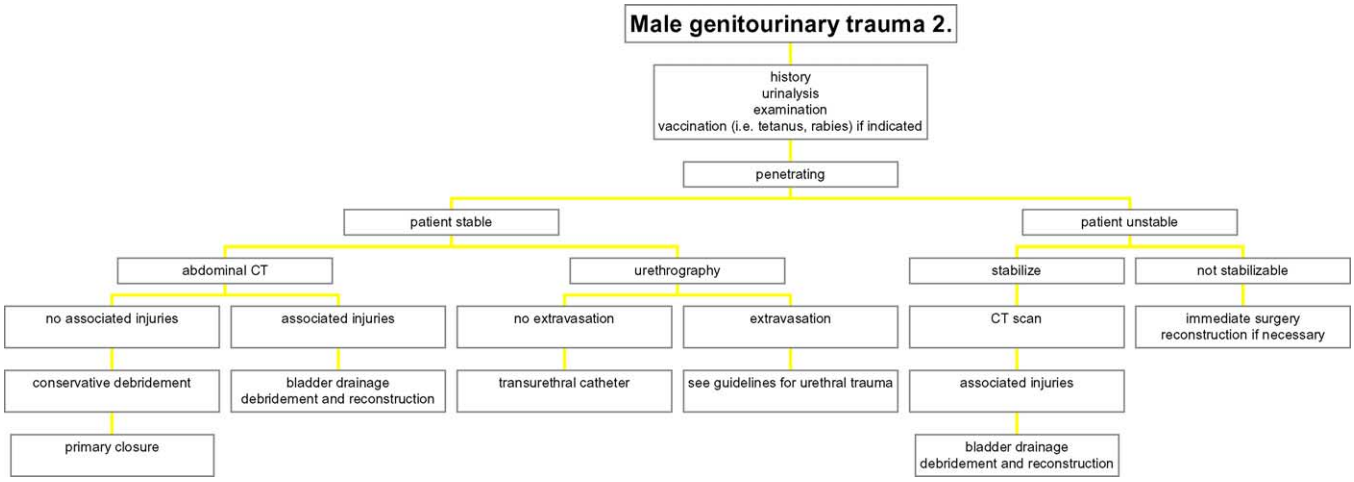

Fig. 8. Management of penetrating male external genital trauma.

7.4. Treatment: vulvar injuries

Blunt trauma to the vulva is rare and commonly present as haematomas. Non-steroidal antirheumatics and cold packs relieve pain, requiring no surgical intervention in most cases. In extended vulvar haematoma or haemodynamic unstable patients, surgical intervention and antibiotics may be indicated (Fig. 7). In case of vulvar laceration, realignment after conservative debridement is indicated.

References

[1] Baverstock R, Simons R, McLoughlin M. Severe blunt renal trauma: a 7-year retrospective review from a provincial trauma centre. Can J Urol 2001;8:1372.
[2] Kristjansson A, Pedersen J. Management of blunt renal trauma. Br J Urol 1993;72:692.
[3] Krieger JN, Algood CB, Mason JT, Copass MK, Ansell JS. Urological trauma in the Pacific Northwest: etiology, distribution, management and outcome. J Urol 1984;70:132.
[4] Ersay A, Akgun Y. Experience with renal gunshot injuries in a rural setting. Urology 1999;972:54.
[5] Moore EE, Shackford SR, Pachter HL, McAninch JW, Browner BD, Champion HR, et al. Organ injury scaling: spleen, liver, and kidney. J Trauma 1989;29:1664.
[6] Giannopoulos A, Serafetinides E, Alamanis C, Constantinides C, Anastasiou I, Dimopoulos C. Urogenital lesions diagnosed incidentally during evaluation for blunt renal injuries. Prog Urol 1999;9:464.
[7] Buchberger W, Penz T, Wicke K, Eberle J. Diagnosis and staging of blunt kidney trauma. A comparison of urinalysis, i.v. urography, sonography and computed tomography. Rofo Fortschr Geb Rontgenstr Neuen Bildgeb Verfahr 1993;158:507.
[8] Eastham JA, Wilson TG, Ahlering TE. Radiographic evaluation of adult patients with blunt renal trauma. J Urol 1992;148:266.
[9] Schmidlin FR, Iselin CE, Naimi A, Rohner S, Borst F, Farshad M, et al. The higher injury risk of abnormal kidneys in blunt renal trauma. Scand J Urol Nephrol 1998;32:388.
[10] Mee SL, McAninch JW, Robinson AL, Auerbach PS, Carroll PR. Radiographic assessment of renal trauma: a 10-year prospective study of patient selection. J Urol 1989;141:1095.
[11] McGahan JP, Richards JR, Jones CD, Gerscovich EO. Use of ultrasonography in the patient with acute renal trauma. J Ultrasound Med 1999;18:207.
[12] Nagy KK, Brenneman FD, Krosner SM, Fildes JJ, Roberts RR, Joseph KT, et al. Routine preoperative "one-shot" intravenous pyelography is not indicated in all patients with penetrating abdominal trauma. J Am Coll Surg 1997;185:530.
[13] Morey AF, McAninch JW, Tiller BK, Duckett CP, Carroll PR. Single shot intraoperative excretory urography for the immediate evaluation of renal trauma. J Urol 1999;161:1088.
[14] Kawashima A, Sandler CM, Corl FM, West OC, Tamm EP, Fishman EK, et al. Imaging of renal trauma: a comprehensive review. Radiographics 2001;21:557.
[15] Kawashima A, Sandler CM, Corriere Jr JN, Rodgers BM, Goldman SM. Ureteropelvic junction injuries secondary to blunt abdominal trauma. Radiology 1997;205:487.
[16] Brown SL, Hoffman DM, Spirnak JP. Limitations of routine spiral computerized tomography in the evaluation of blunt renal trauma. J Urol 1998;160:1979.
[17] McAninch JW, Carroll PR, Klosterman PW, Dixon CM, Greenblatt MN. Renal reconstruction after injury. J Urol 1991;145:932.
[18] Husmann DA, Morris JS. Attempted nonoperative management of blunt renal lacerations extending through the corticomedullary junction: the short-term and long-term sequelae. J Urol 1990;143:682.
[19] Gonzalez RP, Falimirski M, Holevar MR, Evankovich C. Surgical management of renal trauma: is vascular control necessary? J Trauma 1999;47:1039.
[20] McAninch JW, Dixon CM, Carroll PR. The surgical treatment of renal trauma. Vestn Khir Im I I Grek 1990;145:64.
[21] Tillou A, Romero J, Asensio JA, Best CD, Petrone P, Roldan G, et al. Renal vascular injuries. Surg Clin North Am 2001;81:1417.
[22] Hagiwara A, Sakaki S, Goto H, Takenega K, Fukushima H, Matuda H, et al. The role of interventional radiology in the management of blunt renal injury: a practical protocol. J Trauma 2001;51:526.

[23] Schmidlin FR, Rohner S, Hadaya K, Iselin CE, Vermeulen B, Khan H, et al. The conservative treatment of major kidney injuries. Ann Urol (Paris) 1997;31:246.
[24] el Khader K, Mhidia A, Ziade J, Patard JJ, Guille F, Lobel B. Conservative treatment of stage III kidney injuries. Acta Urol Belg 1998;66:25.
[25] Santucci RA, McAninch JM. Grade IV renal injuries: evaluation, treatment, and outcome. World J Surg 2001;25:1565.
[26] Velmahos GC, Demetriades D, Cornwell 3rd EE, Belzberg H, Murray J, Asensio J, et al. Selective management of renal gunshot wounds. Br J Surg 1998;85:1121.
[27] Baniel J, Schein M. The management of penetrating trauma to the urinary tract. J Am Coll Surg 1994;178:417.
[28] Bernath AS, Schutte H, Fernandez RR, Addonizio JC. Stab wounds of the kidney: conservative management in flank penetration. J Urol 1983;129:468.
[29] Wessells H, Deirmenjian J, McAninch JW. Preservation of renal function after reconstruction for trauma: quantitative assessment with radionuclide scintigraphy. J Urol 1997;157:1583.
[30] Heyns CF, Van Vollenhoven P. Selective surgical management of renal stab wounds. Br J Urol 1992;69:351.
[31] Lebech A, Strange-Vognsen HH. Hypertension following blunt kidney injury. Ugeskr Laeger 1990;152:994.
[32] Montgomery RC, Richardson JD, Harty JI. Posttraumatic renovascular hypertension after occult renal injury. J Trauma 1998;45:106.
[33] Haas CA, Reigle MD, Selzman AA, Elder JS, Spirnak JP. Use of ureteral stents in the management of major renal trauma with urinary extravasation: is there a role? J Endourol 1998;12:545.
[34] Wang KT, Hou CJ, Hsieh JJ, Chou YS, Tsai CH. Late development of renal arteriovenous fistula following gunshot traumaa case report. Angiology 1998;49:415.
[35] Miller DC, Forauer A, Faerber GJ. Successful angioembolization of renal artery pseudoaneurysms after blunt abdominal trauma. Urology 2002;59:444.
[36] Park JK, Yang SO, Park SC. Duodenal obstruction by retroperitoneal hematoma induced by severe blunt renal trauma. J Urol 2001;165:1993.
[37] McAleer IM, Kaplan GW, Scherz HC, Packer MG, Lynch FP. Genitourinary trauma in the pediatric patient. Urology 1993;42:563.
[38] Elshihabi I, Elshihabi S, Arar M. An overview of renal trauma. Curr Opin Pediatr 1998;10:162.
[39] Quinlan DM, Gearhart JP. Blunt renal trauma in childhood. Features indicating severe injury. Br J Urol 1990;66:526.
[40] Stein JP, Kaji DM, Eastham J, Freeman JA, Esrig D, Hardy BE. Blunt renal trauma in the pediatric population: indications for radiographic evaluation. Urology 1994;44:406.
[41] Santucci RA, Langenburg SE, Zachareas MJ. Traumatic hematuria in children can be evaluated as in adults. J Urol 2004;171:822.
[42] Wessel LM. Jester I. Scholz S. Arnold R. Lorenz C. Wirth H, et al. [Diagnostic and therapeutic consequences of kidney injuries in pediatric blunt abdominal trauma]. Urologe A 2000;39:425.
[43] Levy JB, Baskin LS, Ewalt DH, Zderic SA, Bellah R, Snyder 3rd HM, et al. Nonoperative management of blunt pediatric major renal trauma. Urology 1993;42:418.
[44] Baumann L, Greenfield SP, Aker J, Brody A, Karp M, Allen J, et al. Nonoperative management of major blunt renal trauma in children: in-hospital morbidity and long-term followup. J Urol 1992;148:691.
[45] Palmer LS, Rosenbaum RR, Gershbaum MD, Kreutzer ER. Penetrating ureteral trauma at an urban trauma center: 10-year experience. Urology 1999;54:34.
[46] Morey AF, Bruce JE, McAninch JW. Efficacy of radiographic imaging in pediatric blunt renal trauma. J Urol 1996;156:2014.
[47] Medina D, Lavery R, Ross SE, Livingston DH. Ureteral trauma: preoperative studies neither predict injury nor prevent missed injuries. J Am Coll Surg 1998;186:641.
[48] Carlin BI, Resnick MI. Indications and techniques for urologic evaluation of the trauma patient with suspected urologic injury. Semin Urol 1995;13:9.
[49] Corriere Jr JN, Sandler CM. Management of the ruptured bladder: seven years of experience with 111 cases. J Trauma 1986;26:830.
[50] Sandler CM, Goldman SM, Kawashima A. Lower urinary tract trauma. World J Urol 1998;16:69.
[51] Castle WN, Richardson Jr JR, Walton BJ. Unsuspected intraperitoneal rupture of bladder presenting with abdominal free air. Urology 1986;28:521.
[52] Dreitlein DA, Suner S, Basler J. Genitourinary trauma. Emerg Med Clin North Am 2001;19:569.
[53] Carroll PR, McAninch JW. Major bladder trauma: mechanisms of injury and a unified method of diagnosis and repair. J Urol 1984;132:254.
[54] Morey AF, Iverson AJ, Swan A, Harmon WJ, Spore SS, Bhayani S, et al. Bladder rupture after blunt trauma: guidelines for diagnostic imaging. J Trauma 2001;51:683.
[55] Abou-Jaoude WA, Sugarman JM, Fallat ME, Casale AJ. Indicators of genitourinary tract injury or anomaly in cases of pediatric blunt trauma. J Pediatr Surg 1996;31:86.
[56] Morey AF, Hernandez J, McAninch JW. Reconstructive surgery for trauma of the lower urinary tract. Urol Clin North Am 1999;26:49.
[57] Festini G, Gregorutti S, Reina G, Bellis GB. Isolated intraperitoneal bladder rupture in patients with alcohol intoxication and minor abdominal trauma. Ann Emerg Med 1991;20:1371.
[58] Deck AJ, Shaves S, Talner L, Porter JR. Computerized tomography cystography for the diagnosis of traumatic bladder rupture. J Urol 2000;164:43.
[59] Devine PC, Devine Jr CJ. Posterior urethral injuries associated with pelvic fractures. Urology 1982;20:467.
[60] Koraitim MM, Marzouk ME, Atta MA, Orabi SS. Risk factors and mechanism of urethral injury in pelvic fractures. Br J Urol 1996;77:876.
[61] Moore EE, Cogbill TH, Jurkovich GJ, McAninch JW, Champion HR, Gennarelli TA, et al. Organ injury scaling. III: Chest wall, abdominal vascular, ureter, bladder, and urethra. J Trauma 1992;33:337.
[62] Lim PH, Chng HC. Initial management of acute urethral injuries. Br J Urol 1989;64:165.
[63] Dixon MD. Diagnosis and acute management of posterior urethral disruptions. In: McAninch JW, editor. Traumatic and Reconstructive Urology. Philadelphia: W.B. Saunders; 1996. p. 347–55.
[64] Antoci JP, Schiff Jr M. Bladder and urethral injuries in patients with pelvic fractures. J Urol 1982;128:25.
[65] Perry MO, Husmann DA. Urethral injuries in female subjects following pelvic fractures. J Urol 1992;147:139.
[66] Nicolaisen GS, Melamud A, Williams RD, McAninch JW. Rupture of the corpus cavernosum: surgical management. J Urol 1983;130: 917.
[67] McAninch JW. Pubectomy in repair of membranous urethral strictures. In: McAninch JW, editor. Traumatic and Reconstructive Urology. Philadelphia: W.B. Saunders; 1996. p. 411–5.
[68] Koraitim MM. Pelvic fracture urethral injuries: the unresolved controversy. J Urol 1999;161:1433.
[69] Glassberg KI, Tolete-Velcek F, Ashley R, Waterhouse K. Partial tears of prostatomembranous urethra in children. Urology 1979;13:500.
[70] Cass AS, Godec CJ. Urethral injury due to external trauma. Urology 1978;11:607.
[71] Jackson DH, Williams JL. Urethral injury: a retrospective study. Br J Urol 1974;46:665.
[72] Turner-Warwick R. Prevention of complications resulting from pelvic fracture urethral injuriesand from their surgical management. Urol Clin North Am 1989;16:335.
[73] Chapple CR, Png D. Contemporary management of urethral trauma and the post-traumatic stricture. Curr Opin Urol 1999;9:253.

[74] Porter JR, Takayama TK, Defalco AJ. Traumatic posterior urethral injury and early realignment using magnetic urethral catheters. J Urol 1997;158:425.
[75] Gelbard MK, Heyman AM, Weintraub P. A technique for immediate realignment and catheterization of the disrupted prostatomembranous urethra. J Urol 1989;142:52.
[76] Guille F, Cipolla B, Leveque JM, Guirassy S, Olivo JF, Lobel B. Early endoscopic realignment of complete traumatic rupture of the posterior urethra. Br J Urol 1991;68:178.
[77] Webster GD, Mathes GL, Selli C. Prostatomembranous urethral injuries: a review of the literature and a rational approach to their management. J Urol 1983;130:898.
[78] Weems WL. Management of genitourinary injuries in patients with pelvic fractures. Ann Surg 1979;189:717.
[79] Venn SN, Mundy AR. Immediate management of major trauma to the urinary tract. Eur Urol 1998;33:1.
[80] Hemal AK, Dorairajan LN, Gupta NP. Posttraumatic complete and partial loss of urethra with pelvic fracture in girls: an appraisal of management. J Urol 2000;163:282.
[81] Martinez-Pineiro JA, Carcamo P, Garcia Matres MJ, Martinez-Pineiro L, Iglesias JR, Rodriguez Ledesma JM. Excision and anastomotic repair for urethral stricture disease: experience with 150 cases. Eur Urol 1997;32:433.
[82] Coffield KS, Weems WL. Experience with management of posterior urethral injury associated with pelvic fracture. J Urol 1977;117:722.
[83] MacDiarmid S, Rosario D, Chapple CR. The importance of accurate assessment and conservative management of the open bladder neck in patients with post-pelvic fracture membranous urethral distraction defects. Br J Urol 1995;75:65.
[84] Gupta NP, Gill IS. Core-through optical internal urethrotomy in management of impassable traumatic posterior urethral strictures. J Urol 1986;136:1018.
[85] Pansadoro V, Esmiliozzi P. Internal urethrotomy in the management of anterior urethral strictures: long-term followup. J Urol 1996;156:73.
[86] Yasuda K, Yamanishi T, Isaka S, Okano T, Masai M, Shimazaki J. Endoscopic re-establishment of membranous urethral disruption. J Urol 1991;145:977.
[87] Jordan GH. Management of membranous urethral distraction injuries via the perineal approach. In: McAninch JW, editor. Traumatic and Reconstructive Urology. Philadelphia: W.B. Saunders; 1996. p. 393–409.
[88] Brandes SB, Buckman RF, Chelsky MJ, Hanno PM. External genitalia gunshot wounds: a ten-year experience with fifty-six cases. J Trauma 1995;39:266.
[89] Haas CA, Brown SL, Spirnak JP. Penile fracture and testicular rupture. World J Urol 1999;17:101.
[90] Tsang T, Demby AM. Penile fracture with urethral injury. J Urol 1992;147:466.
[91] Shefi S, Mor Y, Dotan ZA, Ramon J. Traumatic testicular dislocation: a case report and review of published reports. Urology 1999;54:744.
[92] Nagarajan VP, Pranikoff K, Imahori SC, Rabinowitz R. Traumatic dislocation of testis. Urology 1983;22:521.
[93] Cass AS, Luxenberg M. Testicular injuries. Urology 1991;37:528.
[94] Okur H, Kucikaydin M, Kazez A, Turan C, Bozkurt A. Genitourinary tract injuries in girls. Br J Urol 1996;78:446.
[95] Herrmann B, Crawford J. Genital injuries in prepubertal girls from inline skating accidents. Pediatrics 2002;110:e16.
[96] McAninch JW, Kahn RI, Jeffrey RB, Laing FC, Krieger MJ. Major traumatic and septic genital injuries. J Trauma 1984;24:291.
[97] Husmann DA. Editorial comment. J Urol 1998;159:959.
[98] Pavlica P, Barozzi L. Imaging of the acute scrotum. Eur Radiol 2001;11:220.
[99] Corrales JG, Corbel L, Cipolla B, Staerman F, Darnault P, Guille F, et al. Accuracy of ultrasound diagnosis after blunt testicular trauma. J Urol 1993;150:1834.
[100] Patil MG, Onuora VC. The value of ultrasound in the evaluation of patients with blunt scrotal trauma. Injury 1994;25:177.
[101] Martinez-Pineiro Jr L, Cerezo E, Cozar JM, Avellana JA, Moreno JA, Martinez-Pineiro JA. Value of testicular ultrasound in the evaluation of blunt scrotal trauma without haematocele. Br J Urol 1992;69:286.
[102] Fournier Jr GR, Laing FC, McAninch JW. Scrotal ultrasonography and the management of testicular trauma. Urol Clin North Am 1989;16:377.
[103] Cass AS, Luxenberg M. Value of early operation in blunt testicular contusion with hematocele. J Urol 1988;139:746.
[104] Altarac S. A case of testicle replantation. J Urol 1993;150:1507.