Genitourinary trauma

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Abstract

Genitourinary (GU) organs are commonly injured in trauma patients. Although the kidney is the most commonly injured organ, other GU structures such as the bladder and urethra are also susceptible to injury. GU trauma is broadly divided into blunt and penetrative and based on the mechanism of injury. Prompt diagnosis and recognition of iatrogenic GU injury is also paramount. A delay in diagnosis and treatment can have significant consequences (e.g. abscess formation, fistulae and permanent renal impairment in the case of ureteric injury). Not all GU injuries require urgent surgery. Some can be managed with minimally invasive techniques (such as angiographic embolization), whereas others are managed entirely conservatively. The immediate management of these patients is geared towards haemodynamic stability. Haemodynamic shock that is resistant to the usual resuscitative measures often suggests ongoing bleeding and need for immediate intervention. The early management of most GU injuries with delayed presentation includes urinary diversion (through insertion of nephrostomy tube or suprapubic or urethral urinary catheter insertion) with delayed and definitive surgical reconstruction taking place at a later stage. Using the most up-to-date guidelines and published data we summarize the management of GU trauma by affected organ.

Keywords Bladder injury; renal trauma; trauma images; ureteral injury; urethral injury; urological injury

Background and epidemiology

Genitourinary (GU) trauma is seen in men and women of all ages. However, it is more common in young males. Urological organs are involved in about 10% of abdominal trauma patients.[1] GU trauma most frequently occurs in multi-trauma patients, with isolated GU injuries being uncommon. Following a systematic emergency assessment, the first priority in these patients is securing the airway, controlling external bleeding and managing haemodynamic shock. Physical examination, blood tests and radiological investigations are often carried out alongside haemodynamic resuscitation. GU trauma is broadly classified into blunt and penetrative injuries. Below we summarize the management of GU trauma by affected organ.

Renal trauma

The kidney is the most commonly injured urological organ, accounting for up to 5% of all trauma cases and are associated with young age and males.[2] The kidney is particularly susceptible to deceleration injuries due to its relatively fixed pelvis and vascular pedicle. Over 90% of injuries are due to blunt trauma, including road traffic collisions, falls, assaults and sport injuries. The majority of these patients can be managed conservatively as bleeding is usually self-limiting and controlled within the retroperitoneal space. Renal injury is seen in less than 5% of blunt abdominal trauma cases.[2,3] Gunshot and stab wound injuries are rarer mechanisms of trauma but are the most common forms of penetrating renal trauma. They tend to be more unpredictable and cause significant parenchymal destruction. They are often associated with multi-organ injury. Haematuria is present in most renal trauma patients but, gives little indication of the severity of injury. Patients with renal trauma are assessed and resuscitated according to Advanced Trauma Life Support (ATLS) principles, with the primary goal of haemodynamic stabilization.

The incidence of iatrogenic renal injuries depends on the original procedure, with <10% complication rate following renal allograft biopsies. The most common injuries are haematuria, arteriovenous malformations and pseudo aneurysm formation. The majority of injuries can be managed conservatively, and intervention is rare.

Classification of renal trauma

The most widely used and validated classification system for renal injury is the American Association for the Surgery of Trauma (AAST) scale (Table 1). This helps to predict morbidity and plan intervention. It is often based on Computer Tomography (CT) images but can also be determined using surgical explorative findings.

Initial assessment

A thorough history from conscious patients and any witnesses in the unconscious is crucial, as the mechanism of injury gives a good indication its severity. Sudden deceleration, such as falls and high-speed motor vehicle accidents suggest significant trauma. In penetrating injuries, a detailed history including the type of weapon and the velocity of the projectile such as a knife or a bullet, will help to predict the extent of injury. Details of any

AAST grading system for renal injury

Grade	Injury description
1	No laceration; contusion or non-expanding sub-capsular haematoma
2	Cortical laceration of <1 cm deep, no urinary extravasation; non-expanding peri-renal haematoma
3	Cortical laceration >1 cm deep; no urinary extravasation
4	Cortical laceration into collecting system *or* segmental renal artery or vein injury, partial vessel laceration, vessel thrombosis
5	Shattered kidney *or* avulsed vascular pedicle

NB: advance one grade for bilateral injuries up to grade 3.

Table 1

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pre-existing renal disease must be obtained early, as their co-existence can complicate the outcome of an otherwise minor renal assault. Renal diseases to be aware of include the presence of a solitary kidney, hydronephrosis, and renal cysts and tumours which can complicate otherwise minor injuries, as well as intrinsic medical diseases affecting the kidney.

Clinical examination in a trauma setting is usually carried out alongside obtaining the history. Vital signs are monitored throughout the clinical assessment. Early signs of shock include tachycardia and later, a drop in blood pressure. If shock is resistant to the usual resuscitative measures it could indicate ongoing bleeding requiring emergency intervention. Penetrating trauma to lower posterior thorax, flank and upper abdomen should raise the suspicion of renal injury. In blunt trauma, haematuria, flank bruising, fractured ribs, abdominal tenderness or the presence of a palpable mass may indicate underlying injury to the kidney.

Laboratory investigations

Urinalysis, haemoglobin, haematocrit estimation and creatinine levels are crucial early tests in patients with suspected renal injury. The presence of haematuria is not a sensitive test for the detection of renal injury. Pelvi-ureteric junction disruption or injury to the vascular pedicle can occur in the absence of haematuria. Urine dipstick performed at the bedside is rapid and sufficiently reliable for evaluation of haematuria. Serum creatinine level taken within an hour of the trauma often reflects renal function prior to the injury and therefore a raised creatinine level may indicate pre-existing renal impairment.

Serial haematocrit measurements and patient response to resuscitative measures along with need for blood transfusion are crucial in the decision-making process. In those with suspected ongoing bleeding, the source of haemorrhage should be radiologically investigated, assuming the patient is stable enough to do so.

Radiological investigations

All patients with penetrating renal injury, suspected clinically on the basis of an entry and/or exit wound, regardless of the presence of haematuria, should undergo renal imaging. In blunt trauma, the presence of any degree of haematuria and haemodynamic shock is associated with a 12.5% incidence of major renal injury. In contrast, this figure falls to 0.2% in those with only non-visible haematuria and absence of shock.[3] Therefore, patients with suspected blunt renal trauma require radiological imaging if they have visible haematuria, presence of major associated injuries or non-visible haematuria with hypotension (any recorded systolic pressure <90 mmHg). Exceptions to this rule includes deceleration injuries who require investigation regardless of haemodynamic status.

Computed tomography (CT): with intravenous contrast is the gold standard investigation of suspected renal injury (Figure 1). It is superior to ultrasonography, intravenous pyelography and angiography because as well as accurately defining the location of injury, it also detects contusions, segmental renal vascular injuries and shows the location, presence and to a degree the functional status of the contralateral kidney. It visualizes any retroperitoneal haematomas, associated abdominal and pelvic injuries, as well as showing a detailed anatomy of the kidney including the depth of any renal lacerations.[4] Without intravenous contrast administration, a full renal injury assessment cannot be made, as pedicle injury is classically diagnosed on a contrast CT when there is no renal contrast enhancement.[3] For an accurate assessment of the collecting system, urographic phase images at 10-15 minutes post injection of intravenous contrast are required.

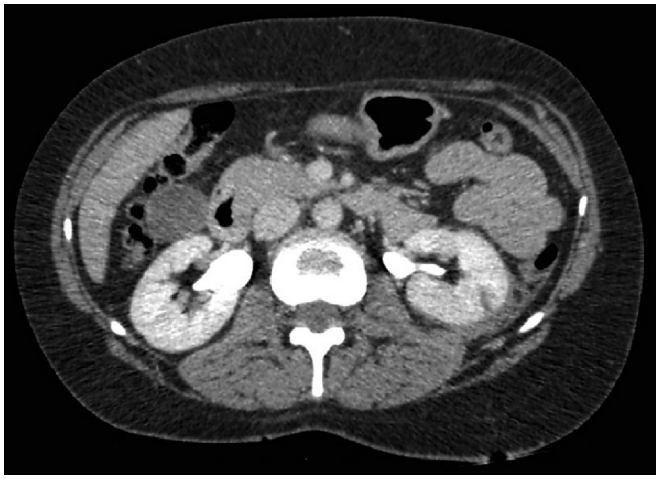

Figure 1 CT scan showing a left renal cortical laceration without contrast extravasation.

Other imaging modalities:

Ultrasonography (US) – is used in the initial assessment of trauma patients to look for intra-peritoneal free fluid and is often referred to as focused assessment with sonography for trauma or FAST scan. Its use in the assessment of renal injury is limited and although it can detect renal lacerations, it does not provide information about the depth of laceration, urinary excretion or leakage. Despite this, US scan has its place in the follow up of stable renal injuries. As the majority of renal injuries are minor parenchymal lesions, they can be followed up with serial US scans looking for resolution of parenchymal and perinephric haematomas and urinomas. Contrast sonography with air-bubbles is described but not routinely used,[5] not least because micro bubbles are not excreted into the urinary collecting system and cannot demonstrate renal pelvis or ureteric injuries.

Intravenous pyelography (IVP) – involves injection of 2 ml/kg of contrast medium, followed by a plain X-ray image at 10–15 minutes. It has been superseded by contrast CT as the gold standard imaging modality. Due to its lower specificity and sensitivity for renal injury and its inability to visualize associated intra-abdominal pathology, IVP is only recommended when CT and angiography are unavailable. As well as establishing the extent of injury of the affected kidney it also reveals the presence or absence of the contralateral kidney. IVP clearly visualizes the parenchyma and the collecting system when images are taken at various intervals. Therefore, a complete or partial non-visualization is highly indicative of a shattered kidney or pedicle injury. The other significant finding on IVP is extravasation of contrast, which implies injury to renal capsule, parenchyma or/and collecting system. Any of these findings on IVP should be further investigated with contrast CT scan. Patients

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who undergo emergency surgical exploration and have not undergone prior CT imaging, should have a one shot IVP on the operating table to ensure the presence of a functioning contralateral kidney. This will guide further surgical management of the injured kidney.

Magnetic resonance imaging (MRI) – although sufficiently sensitive, is not ideal in trauma patients, as it requires a longer time and access to patient during scanning is limited. It is therefore only appropriate in patients with contrast allergy, when CT scan is unavailable or in the rare cases when CT finding is indeterminate.

Management of renal injury

Conservative management: The main factor which influences the management of patients with renal trauma is haemodynamic stability. Conservative management has become the accepted treatment approach of the majority of these patients. The high rate of nephrectomy has been the main precursor for the move away from surgical exploration of haemodynamically stable patients.

Conservative management includes bed rest, fluid resuscitation, close monitoring of vital signs and administration of antibiotics when clinically indicated. This conservative approach to management has been shown to be associated with a lower rate of nephrectomy without an increase in the overall rate of morbidity.[6] The guidelines of the European Association of Urology (EAU) advise against routine prolonged hospitalization and observation of patients for possible renal injury with normal CT scans.[2]

Using the AAST grading system, all grade 1 and 2 injuries, which include contusions, sub-capsular or peri-renal non-expanding haematomas and lacerations of less than 1cm in depth can be managed conservatively. The same rule applies to both blunt and penetrating injuries. With emergence of good data from various studies, AAST grade 3 injuries are also being safely treated in a non-surgical manner in most centres in Europe and North America.[7]

Angiographic embolization: Selective arterial embolization is the treatment of choice for controlling renal haemorrhage when other indications for immediate surgical exploration do not exist (Figure 2). Indications for angiographic embolization include active haemorrhage, pseudo-aneurysm and vascular fistulae. Although the first attempt at embolization in high grade injuries may fail, repeat embolization prevents nephrectomy in over 75% of these patients.[6] The failure rate of embolization in penetrating injuries is significantly higher than in blunt trauma.

Surgical management: The indications for surgical exploration can be divided into absolute and relative. Absolute indications include haemodynamic instability, poor response to aggressive fluid resuscitation, expanding pulsatile retroperitoneal haematoma, which suggests pedicle injury (AAST grade 5 vascular injury). Relative indications include persistent urinary extravasation, although the majority can be managed endourologically. Pre-existing renal abnormalities, inconclusive imaging and incidental finding of a renal tumour are the other relative indicators for surgical exploration.

Traditionally, AAST grade 4 and 5 injuries have been managed surgically, often resulting in nephrectomy. However, more recently good quality data have emerged suggesting that an initial conservative approach to management of these injuries is feasible and acceptable.[8] It is important to be mindful that these high-grade injuries are associated with significant

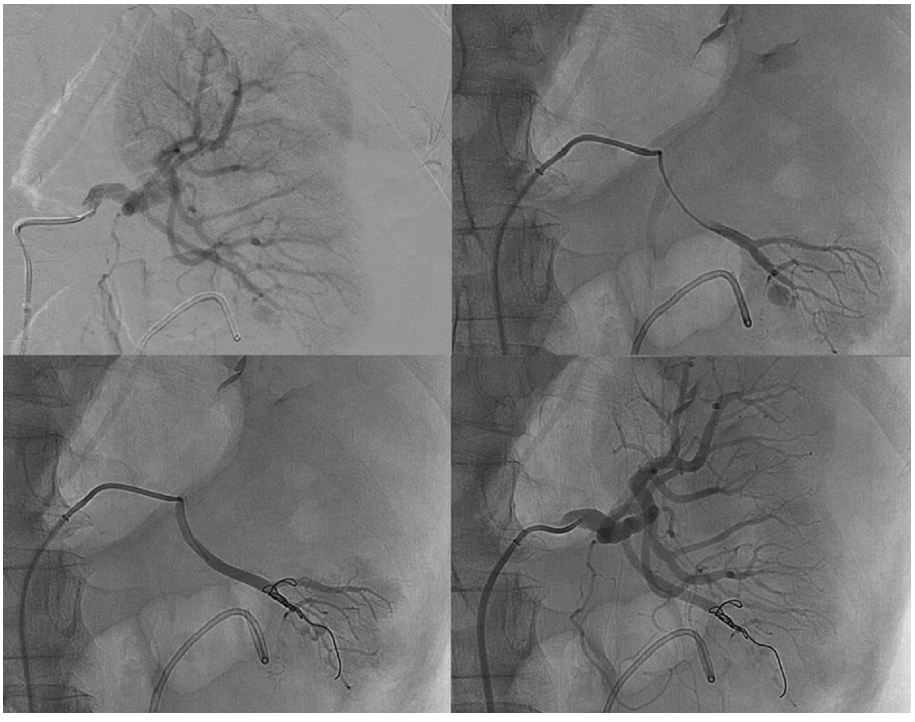

Figure 2 Angiographic selective renal arterial embolization for a post PCNL bleed.

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complications and some will end up requiring surgery despite an early expectant approach to treatment. It is therefore advisable to obtain repeat imaging after 48 hours in order to diagnose developing complications. This is particularly important in those with persistent flank pain, fever or falling haematocrit. AAST grade 4 injury of urinary extravasation can be managed non-surgically successfully with resolution of urinoma in over 90% of cases.[8] Persistent urine extravasation or urinoma is usually managed successfully with ureteric stenting or percutaneous nephrostomy insertion. Segmental arterial injuries (AAST grade 4) in a haemodynamically stable patient are also managed expectantly with the exception of bilateral arterial injuries and arterial injury in a solitary kidney. These require exploration and reconstruction.

In penetrating injuries, the standard approach has been surgical exploration. EAU guidelines state that a systematic approach using clinical, laboratory and radiological information must be taken in order to reduce the rate of negative laparotomies.[2] Generally, penetrative grade 3 and higher-grade injuries are unpredictable and have a higher rate of complications when treated in an expectant manner.[8]

Surgical exploration – The trans-abdominal approach to the injured kidney is usually adopted, because in addition to excellent renal access, it also allows inspection of other intra-abdominal organs. Some of the penetrating injury series report concomitant non-renal organ injuries of up to 94%.[9] The aims of surgical exploration for renal trauma include haemorrhage control and renal salvage by reconstruction. Either the kidney can be approached first and haemorrhage controlled after, or the vessels can be isolated and therefore ongoing or later haemorrhage managed before exploration of the kidney. Strong evidence exists which suggest a higher renal salvage rate with early vascular isolation before opening of Gerota's fascia. This is because haemorrhage after opening of Gerota's fascia is a major cause for nephrectomy and therefore control of the vessels reduces this risk. In a comparative series by McAninch et al. the nephrectomy rate was almost three times higher when vascular control was not obtained early.[9]

Access to vascular pedicle – In order to get vascular control, the small bowel is mobilized and an incision made in the retroperitoneum over the aorta, just medial to the inferior mesenteric vein. The exposed anterior surface of the aorta is explored superiorly until the left renal vein is reached. This can be identified relatively easily as it crosses the aorta anteriorly. Both the vein and artery are isolated and vessel loops placed around them. The right renal vein is sometimes difficult to secure through this incision. In a haemodynamically unstable patient, a vascular clamp can be placed directly over the renal hilum after making the incision already described or by blunt dissection along the plane of the psoas muscle alongside the aorta or cava.[9]

Access to kidney and reconstruction – The kidney is accessed by making a peritoneal incision lateral to the colon followed by incision and mobilization of the Gerota's fascia. A large bleed at this stage can be controlled with an already placed vessel loop or by placing a vascular clamp over the isolated vessels.

Renal reconstruction is often possible and only around 13% undergo nephrectomy during exploration.[10] The principles of renorrhaphy include adequate renal exposure, temporary vascular control, watertight closure of the injured collecting system and re-apposition of the parenchyma. Capsular defects can be closed with omental or Gerota's fascial flaps and finally good drainage of retroperitoneal space is obtained. These techniques are familiar to surgeons performing partial nephrectomy surgery.

Complications

Early complications within a month of the injury include bleeding, perinephric abscess, hypertension and urinoma development. Delayed complications include bleeding, urolithiasis, hydronephrosis, chronic pyelonephritis and arteriovenous fistulae. Bleeding can be managed angiographically with selective embolization. Arteriovenous fistulae which present with late onset of significant haematuria are also amenable to angiographic treatment. Hydronephrosis and persistent urinoma can usually be successfully managed by ureteric stenting. Perinephric abscess is managed with radiologically placed percutaneous drains.

Ureteric trauma

Ureteric injury is uncommon accounting for less than 5% of all genitourinary trauma. The ureter's small size, position and elasticity are protective against trauma. Iatrogenic ureteric trauma is the most common type accounting for 75% of all ureteric injuries with gynaecological surgery accounting for over half the cases. The remainder occur during colorectal, vascular and urological procedures. The distal ureter is the most commonly injured site. Gunshot and blunt deceleration trauma are other causes. The iatrogenic mechanism of injury can be anything from suture ligation, clamp crushing, to ischaemia as a result of thermal injury or devascularization. These various modes of injury can lead to either partial or complete disruption and can present either immediately or at a delayed stage.

Diagnosis of ureteric injury can be difficult as there are no specific signs and symptoms. The presence of flank pain, urinary leakage from the vagina or other wounds and drains, urinary incontinence, haematuria, ileus and fever raise the possibility of ureteric injury and should prompt radiological investigation. The majority of iatrogenic ureteric injuries come to light in a delayed fashion. Immediate repair has a better outcome and reduced morbidity.

The gold standard diagnostic modality for ureteric injury is retrograde pyelography (Figure 3(**a**)). However, the diagnosis is often made on CT with intravenous contrast. The classical sign of ureteric injury on CT is extravasation of contrast but, is not often seen, and the only findings suggestive of ureteric trauma may be hydronephrosis, proximal hydroureter, ascites or a urinoma.

Management

Management of ureteric trauma depends on the level and severity of injury. Iatrogenic trauma, which is noticed intra-operatively should be repaired immediately. Primary closure over a stent and tube drainage of the injury site is undertaken. In the case of an accidently ligated ureter, the stitch can simply be removed with or without ureteric stenting. Partial ureteric tears are usually managed with ureteric stenting if feasible (Figure 3(**b**)). Although stenting of a partially injured ureter may reduce the risk of stricture formation and urine extravasation, the

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Figure 3 (**a**) Nephrostogram showing contrast extravasation from an injured right distal ureter. (**b**) Fluoroscopic images of a rendez-vous procedure demonstrating both antegrade and retrograde access to the injured ureter in order to place a stent across the damaged ureteric segment.

risk of further damage during stent insertion must be considered. The stent is usually left in place for six weeks and a urethral catheter for a few days to minimize ureteric reflux.

Complete ureteric tears and injuries with delayed presentation, not amenable to ureteric stenting usually require open surgical repair after urinary diversion with nephrostomy insertion. The reconstructive technique varies dependent on the level of ureteric injury. The general principles for ureteric reconstruction include debridement of ureteric ends, spatulation of both ureteric ends, before watertight anastomosis and isolation of the injury with peritoneum or omentum. A ureteric stent and an external tube drain are placed. For lower-third injuries, direct bladder reimplantation, with or without a psoas hitch procedure, or direct end-to-end anastomosis, is required. For middle-third injuries, either direct uretero-ureterostomy or Boari flap reimplantation onto the bladder is required, or possibly trans-uretero-ureterostomy, but this has the disadvantage of violating the normal contralateral ureter. Upper-third injuries can often be repaired similarly to mid-third injuries, with the addition of uretero-calycostomy. For more severe ureteric injury such as avulsion, ileal chute interposition, renal autotransplantation onto the iliac vessels or extra-anatomical stenting are possible solutions. If the surgeon is unfamiliar with these techniques, a temporizing nephrostomy tube can be placed before referral to a tertiary centre. On occasion, endourological techniques may be used to salvage an injured ureter with combined retrograde

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ureteroscopic and antegrade ureteric access to bridge the ureteric injury with a stent. The long-term outcome of these techniques is uncertain.

Bladder trauma

Bladder trauma can be classified according to the mechanism of injury, into blunt, penetrating or iatrogenic. About three-quarters of bladder ruptures are as a result of blunt trauma, often road traffic collisions, followed by falls and industrial accidents. Bladder injury is seen in only 3% of patients with pelvic fracture. Conversely, around 80% of patients with bladder injury due to blunt trauma have associated pelvic fractures. Concomitant urethral injury is seen in around 10% of cases.[11] Bladder rupture can also be classified anatomically into intra-peritoneal, extra-peritoneal and combined, as proposed by AAST.

Intra-peritoneal rupture accounts for around 40% of all cases and is caused by a sudden rise in intra-vesical pressure following a blow to the lower abdomen or pelvis. The dome, being the weakest part of the bladder, is a common site of rupture which leads to extravasation of urine into the abdominal cavity. Extra-peritoneal rupture accounts for 60% of injuries and is almost always seen in the context of pelvic fractures. Injury is caused by either bone fragments or shearing forces following distortion of pelvic ring often resulting in an antero-lateral bladder wall tear.

Penetrating bladder injury is uncommon, whereas iatrogenic bladder trauma is relatively common and often seen with gynaecological surgery. In particular, complicated hysterectomy, caesarean section and transurethral resection of bladder tumour are the common culprits.

Diagnosis

Visible haematuria is almost always present in bladder injury. Additional clinical features include suprapubic pain, urinary retention and suprapubic tenderness. Intra-peritoneal bladder rupture is suspected when in addition to the above features, there is presence of ileus, abdominal distension and unexpectedly high serum urea or creatinine level. A small number of patients (5–15%) with bladder rupture will only have non-visible haematuria. The combination of visible haematuria and pelvic fracture are highly indicative for bladder injury and therefore immediate cystographic investigation is required. Trauma patients with visible haematuria without pelvic fracture, or with non-visible haematuria with pelvic fracture should undergo further imaging based on the history and clinical findings.[2]

External iatrogenic bladder injury must be suspected when there is extravasation of urine, presence of clear fluid in the surgical site, appearance of blood in the bladder catheter or gas in the urine bag during laparoscopic surgery. Internal iatrogenic injury during transurethral procedures must be suspected when fatty tissue or/and a dark space between detrusor muscle fibres is seen or when bowel is visualized. Inability to distend the bladder or a low return of irrigation fluid during transurethral surgery are suggestive of significant perforation.

Cystography: A number of studies have shown that passive bladder filling with clamping of the catheter and administration of intravenous contrast is not a reliable method for diagnosis of bladder perforation. A stress cystogram is therefore the accepted and established investigation of choice for suspected bladder perforation (Figure 4). Retrograde cystography is performed by filling the bladder to 350–450 ml of dilute contrast. Once filled, antero-posterior, oblique and post-drainage images are taken. As well as visualizing a perforation, it also shows whether the rupture is intra or extraperitoneal. Cystographic features of an intraperitoneal bladder rupture include outlining of abdominal organs and filling with contrast of the retrovesical space and the paracolic gutters. 'Flame-shaped' areas of contrast extravasation into the perivesical tissue and a 'teardrop deformity' caused by pelvic haematoma are features indicative of an extraperitoneal rupture of the bladder.

Computed tomography: CT cystography with retrograde instillation of contrast has a similar sensitivity as plain X-ray cystography. However, a CT urogram alone is not sufficiently reliable as the dilute contrast drains into a relaxed bladder. Ultrasound scan is not a reliable diagnostic modality for bladder rupture, though it can visualize free intra-peritoneal fluid.

Cystoscopy: is recommended when bladder injury is suspected intraoperatively. It can directly visualize and localize the injury and assess the ureteric orifices. If an intraperitoneal bladder defect is seen following trans-urethral surgery it is sometimes helpful to leave a ureteric catheter within the defect to aid location of the bladder injury at surgical exploration.

Management

Almost all extra-peritoneal ruptures including iatrogenic injuries can be managed conservatively with catheter drainage of the bladder. Small intra-peritoneal injuries caused during transurethral procedures and injuries caused by other pelvic and abdominal surgery that are not identified intraoperatively can also be managed conservatively with catheter drainage provided that there is no evidence of peritonitis or ileus.[12] Placement of an intraperitoneal drain can be considered when the defect is larger. Around 90% of extra-peritoneal injuries heal within ten days of continuous bladder drainage.

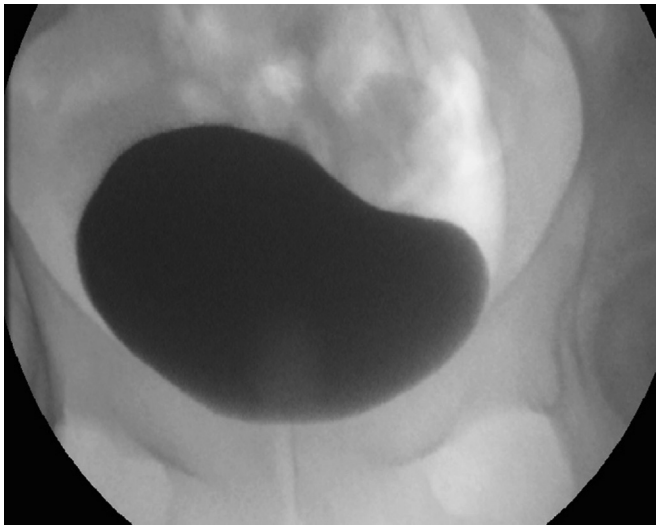

Figure 4 Cystogram showing an intact bladder.

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Surgical repair: The majority of intra-peritoneal ruptures and extraperitoneal ruptures with bladder neck injury, bladder wall entrapment, bone fragments in the bladder wall and associated rectal and vaginal injuries require formal exploration and repair. Iatrogenic injuries recognized intraoperatively are primarily closed and require bladder drainage. Penetrating non-iatrogenic trauma including gunshot injuries involving the bladder require emergency exploration, debridement and repair of injured bladder wall. Other organs are often involved and these should be inspected during laparotomy.

Bladder perforation repair is preferably done in two layers using absorbable suture to prevent stone formation. A cystogram at ten days post repair is often performed prior to removal of bladder catheter.

Urethral trauma

Urethral trauma is the second most common urogenital trauma after renal injuries. Blunt trauma accounts for approximately 90% of cases. The urogenital diaphragm divides the male urethra into anterior and posterior segments. The anterior urethra is subdivided into the penile and bulbar urethra at the peno-scrotal junction. The posterior urethra consists of membranous and prostatic sections. The female urethra is short and relatively mobile. It is therefore rarely injured and occurs in only 0–6% of pelvic fractures.

Anterior urethral injuries

Due to its relative exposed nature, the anterior urethra in the male is at particularly high risk of external injuries. Urethral instrumentation and catheterization are the most common causes of urethral injury and subsequent structure formation. Blunt urethral trauma occurs with blows to the pelvis and perineum in motor vehicle accidents and fall-astride or straddle injuries. Due to its relatively immobile nature the bulbar urethra is often crushed against the pubic symphysis. Penetrating trauma that can damage the urethra include stabbing, gunshot wounds and dog bites. Concomitant urethral injury in penile fracture is discussed later.

Posterior urethral injuries

Pelvic fractures, almost exclusively, cause most posterior urethral injuries and are seen in about 20% of pelvic fractures in men and up to 5% of women. Not all pelvic fractures carry the same risk of urethral injury. Unstable fractures, fractures of the pubic symphysis and bilateral ischiopubic rami fractures have the highest likelihood of urethral trauma. The injury site is often at the prostate–membranous junction and the severity of injury can vary from simple stretching to partial rupture and complete disruption. Penetrating urethral injuries are either caused by gunshot and stab trauma or by iatrogenic endoscopic and vaginal procedures.

Diagnosis

Blood at the urethral meatus is a classical sign of urethral injury and warrants radiological investigation. It is present in up to 75% of anterior and 90% of posterior urethral injuries. However, its absence does not exclude urethral trauma. In female urethral injury, blood at the vaginal introitus is often seen. Inability to void in the presence of a palpable bladder is highly suggestive of a complete urethral disruption. Haematuria and painful voiding are often present but the degree of haematuria does not correlate well with severity of injury. Bleeding and urinary extravasation can result in penile, scrotal and perineal bruising. Rectal examination in these patients is necessary to rule out associated rectal injuries and to assess the prostate gland. A high-riding prostate is a sign of urethral disruption at the prostato-membranous junction. A boggy mass may be all that is palpable in the presence of a pelvic haematoma.

Retrograde urethrography: is the investigation of choice in the assessment of suspected male urethral injury (Figure 5) and aids injury classification.[13] Urethrography visualizes the site and extent of injury. It does not distinguish between a partial tear and a complete disruption. Although time consuming, a urethrogram is easily performed by the insertion of a Foley catheter into the distal urethra and occlusion of the meatus by inflation of the catheter balloon in the navicular fossa with 2 ml of water. Between 20 and 30 ml of dilute contrast is injected through the catheter into the urethra and radiographs are taken ideally at 30^{o} angulation.

Urethroscopy: Flexible urethroscopy can be used to diagnose a urethral injury and in particular differentiate between a complete and partial injury. Urethroscopy is thought to be a superior option over urethrography in suspected female urethral injuries because the short urethra precludes adequate imaging. In addition, urethral injury secondary to penile fracture is best assessed with flexible urethroscopy. Urethroscopy also offers an opportunity to attempt catheterization over a guidewire.

Management

Anterior urethral injury: The recommendation for penetrating anterior urethral injuries is immediate exploration, debridement and repair.[2] Small lacerations can be primarily closed, while defects of up to 1.5 cm and 3 cm in the penile and bulbar urethra, respectively, can be closed with spatulation of both severed urethral ends. Larger defects need urethral marsupialization and

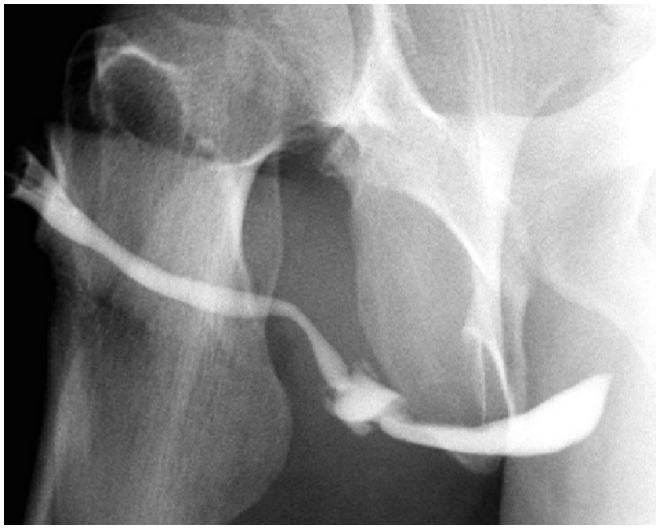

Figure 5 Retrograde urethrogram showing extravasation of contrast from the injured anterior urethra.

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staged repair. Two-staged urethral repair is also recommended in presence of infection during the initial exploration. Anterior urethral injury as a result of penile fracture must be repaired early during repair of the fracture and often requires simple closure of the tear.

In blunt anterior urethral injury, the extent of injury is difficult to assess in the acute setting and therefore the general consensus is against early exploration and repair. Urinary diversion is recommended in order to minimize urinary extravasation and associated complications including infection, abscess and fistulae formation. This can be achieved by insertion of a suprapubic catheter (SPC) or urethroscopic urethral realignment and catheterization. The catheter is maintained in place for four weeks and removed in the absence of urethral leak on urethrography. Subsequent stricture formation can be treated with endoscopic optical incision or with formal urethral reconstruction if the stricture is >1 cm or dense.

Posterior urethral injury: The management of posterior urethral injury is controversial. EAU recommendations which are based on the review of current literature are discussed here.[2]

Posterior urethral injuries can be surgically managed immediately within 48 hours of the injury, or by delayed primary treatment (48 hours–2 weeks), or by deferring treatment for ≥3 months. The choice of surgical intervention is between endoscopic urethral realignment and urethroplasty. It is also important to establish whether the urethral injury is complete or partial. When urological input is first sought the site of urethral injury is often not known but it is frequently in the posterior urethra. Although suprapubic catheter insertion is recommended, this can be associated with significant morbidity, especially in the presence of pelvic haematoma. It is therefore entirely reasonable for an experienced clinician to attempt a gentle urethral catheterization first.

Partial posterior urethral tears are managed with urinary diversion with SPC or a urethral catheter. Subsequent stricture formation can be managed with urethrotomy for short strictures and with urethroplasty if the stricture is longer and dense.

Complete disruption of the urethra can be managed immediately with urethroscopic realignment and urethral catheterization. Early realignment reduces the risk and severity of stricture formation and it simplifies later urethroplasty. Immediate urethroplasty is not recommended as accurate debridement cannot be undertaken in the presence of swelling and haematoma and risk of re-bleeding in the pelvis is high. Delayed primary urethroscopic realignment (no later than two weeks after the injury), following immediate suprapubic catheterization at the time of injury, can be undertaken before the urethral fibrotic process begins. This can reduce the length of time that suprapubic catheterization is required and may reduce the subsequent stricture rate. Delayed primary urethroplasty, may not be feasible in most pelvic fracture patients due to positioning and incomplete resolution of haematoma.

Deferred urethroplasty (after 3 months of SPC urinary diversion) is the treatment of choice in posterior urethral disruptions. These defects are often short and a tension free urethroplasty can be performed with spatulation of both urethral ends. For longer defects, urethroplasty with buccal mucosal grafting is undertaken.

External genital trauma

Testis trauma

The majority of scrotal injuries are due to blunt trauma, often sustained in sporting activity. Injuries vary from simple bruising to haematocele, testicular dislocation and even testis rupture. Testicular dislocation is rare but can be bilateral. Management relies upon manual replacement and secondary orchidopexy. For large haematoceles, defined as approximately three times larger than the contralateral testis, surgical drainage is usually required. Smaller haematoceles can often be left to settle conservatively. Testis rupture is defined as a tear of the tunica albuginea and patients often have severe pain and vomiting. Clinically the testis may be difficult to feel and USS has a sensitivity of around 95% in visualizing tears of the tunica albuginea. Early surgical exploration and repair is recommended.

Penile fracture

Penile fracture is uncommon and occurs when the penis is excessively bent, often during intercourse. The tunica albuginea of the corpus cavernosum is torn and this is frequently experienced as a cracking sound followed by immediate pain and detumescence during vigorous intercourse. Subsequently, swelling and bruising result in the so called 'aubergine sign' and the defect is sometimes palpable. The diagnosis is made clinically from history and examination but it can be diagnosed radiologically with MRI and USS in experienced hands. Immediate closure of the defect is recommended and allows for exploration of the urethra for concomitant injury, which happens in about 20% of cases.

Paediatric trauma

Paediatric trauma is usually managed by a combination of paediatric urologists, paediatricians and emergency physicians, in level one trauma centres. The urinary tract in children differs from adults in clinically relevant ways which affect the management of the paediatric trauma patient.

The paediatric kidney is more susceptible to trauma, when compared with adults. This is due to a more pliable thoracic cage, weaker abdominal musculature, less surrounding perirenal fat and a lower position in the abdomen. In addition, children with significant renal trauma are less likely to present with visible or non-visible haematuria[14] and are able to maintain their blood pressure for longer.[15] Therefore, the index of suspicion must be higher and significant mechanisms of injury and/or co-existing injuries should prompt further investigation with FAST scan, serial physical examinations for ≥24 hours and consideration of CT scanning. Management of paediatric trauma is often conservative with bed rest and intravenous fluids. Indications for surgery are haemodynamic instability or expanding retroperitoneal haematoma[15]

Ureteric injuries in the child are rare due to the close proximity of the kidney and bladder. CT scan with 10-minute phase following the injection of intravenous contrast improves diagnostic accuracy. Percutaneous methods of treatment are recommended when treatment is required.

Children are more likely to sustain bladder injuries than adults. Paediatric bladders are higher up in the abdomen, have weaker abdominal musculature and less surrounding fat when

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compared with adults. Cystogram/CT with cystogram are most likely to detect injuries. As in adults, extra-peritoneal injuries can be managed by bladder catheterization for 7–10 days. Intraperitoneal injuries are common in children due to its higher position and are treated with open surgical exploration and primary repair. ◆

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