MINI-SYMPOSIUM: PELVIC FRACTURES

(iv) Pelvic fractures and genitourinary injuries

Jonathan Yerasimides, Craig S. Roberts*

Department of Orthopaedic Surgery, University of Louisville School of Medicine, 210 East Gray Street, Suite 1003, Louisville, Kentucky 40202, USA

KEYWORDS
Pelvis;
Fracture;
Genitourinary;
Urethral tears;
Dyspareunia

Summary
The association between pelvic fractures and genitourinary injuries, particularly bladder ruptures and posterior urethral tears, is well known. Sexual dysfunction (erectile dysfunction and dyspareunia) is also becoming a well-recognised frequent sequela of pelvic fractures. The management of combined genitourinary injuries and pelvic fractures is controversial, as there is evidence that the acute management of urethral tears may have a profound effect on future sexual function and continence. Currently, a trend exists toward more aggressive treatment of the bony injuries, genitourinary injuries, and sexual dysfunction with the hope of improving overall long-term functional outcomes.

Introduction

Although the association between pelvic fractures and genitourinary injuries is well known,1-6 there is increased recognition in the medical community of the morbidity of concomitant urogenital injury and its deleterious effects on sexual function. Harwood et al.7 reported that 42% of patients with a urethral injury had sexual dysfunction. Less common consequences of pelvic fractures include vaginal lacerations in women and erectile dysfunction from damage to the autonomic cavernosal supply in men.8,9 The management of concomitant pelvic fractures and genitourinary injuries is controversial. We present an overview of the anatomy, diagnosis, and treatment of genitourinary injuries associated with pelvic fractures.

Anatomy

The close proximity of the bladder, prostate, and urethra within the pelvic ring make these structures highly susceptible to injury when fractures occur to the bony pelvis. The bladder is an extraperitoneal sac that lies anterior and inferior to the peritoneal cavity and posterior to the pubic symphysis. In children, the bladder is an abdominal organ that lies above the pubic symphysis and does not fall into its adult position below the symphysis until about the sixth year of life.2 The empty bladder is rarely superior to the symphysis pubis in the adult, but as it fills with urine, it ascends into the abdominal cavity along the anterior abdominal wall. The urethral orifice in the most inferior portion of the bladder marks the neck. In men,
the neck is contiguous with the prostate which makes the urethra more vulnerable because the dense puboprostatic ligaments firmly fix the prostate (and therefore urethra) to the posterior surface of the symphysis pubis. Diastasis of the pubic symphysis has been reported to be associated with impaired sexual potency.7

In women, the bladder is directly attached to the pubic symphysis by the pubovesical ligaments.2 Because the female urethra is short and mobile compared to the long, well-fixed male urethra, it is injured less frequently that the male urethra. Support to the urethra is provided by the pelvic floor inferiorly and the rectum posteriorty. With the exception of the fixed bladder neck, the bladder is free to move. The superior portion, or dome, is the weakest and least supported portion of the bladder.2,10

The prostate divides the male urethra into anterior and posterior portions. The posterior portion is comprised of the prostatic and membranous segments and is the most commonly injured region. The prostatic segment is approximately 3 cm in length and lies between the bladder neck and verumontanum. The membranous segment is the portion of the urethra that traverses the urogenital diaphragm. It is firmly fixed and averages 2.0–2.5 cm in length.2 The urogenital diaphragm has traditionally been considered a separate anatomic structure consisting of two fascial layers with a thick layer of skeletal muscle in between these layers. However, anatomic and radiographic studies in cadavers by Colapinto and McCallum11 refuted this concept by demonstrating that the prostate and urogenital diaphragm are a single unit. In their investigation, the muscle in the urogenital diaphragm was shown to be contiguous with the substance of the prostate gland. These enveloping fibres formed the voluntary sphincter of the urethra. These authors found that the prostate, membranous urethra, and urogenital diaphragm worked as a fixed single unit during traumatic urethral avulsion. The weakest point was the inferior surface of the urogenital diaphragm or the bulbomembranous urethral junction, and not the prostatomembranous junction as was previously believed.11 This finding was supported by radiographic evidence of contrast extravasation into the perineum in patients with complete urethral disruption. Contrast would be expected to be contained in the pelvis if the urogenital diaphragm was intact.11,12

Mechanism of genitourinary injury

The most common injuries to the lower urinary tract associated with pelvic fractures are bladder rupture and urethral disruption as a result of motor vehicle collisions, an automobile striking a pedestrian, a fall from a significant height, and motorcycle collisions.6 Malgaigne’s fracture has been shown in multiple studies to be the predominant type of pelvic fracture associated with urethral injury.5,13,14

Bladder injury can occur in either the extraperitoneal or intraperitoneal regions; both regions are rarely injured simultaneously. Classically, intraperitoneal injury consists of a large, horizontal tear in the bladder dome which occurs as a result of a force applied to the abdomen or symphysis region associated with a full bladder. The intravesical and intra-abdominal pressure becomes acutely elevated and the bladder ruptures at its weakest point in the dome. This can occur without associated pelvic ring disruption as a result of a seatbelt injury in a motor vehicle accident.12

The incidence of extraperitoneal rupture is approximately 85% and most commonly involves the anterolateral wall near the neck.2,10 Extraperitoneal bladder rupture classically occurs from direct penetration by a sharp, bony spicule.15 In contrast, intraperitoneal ruptures occur 15% of the time. Nonetheless, there have been previously published reports disputing this classic concept. Carroll and McAninch16 noted only 35% of bladder injuries occurred on the same side as the pelvic fracture. This was corroborated by Cass and Luxenberg who proposed that severe lower abdominal trauma caused a rupture of the empty bladder similar to the known mechanism of intraperitoneal rupture.17

The incidence of injury to the male urethra associated with pelvic fractures ranges from 1.4% to 11%.2 Urethral injury in females is uncommon because of the relative mobility of the untethered urethra. The most common fracture pattern is an anterior ring disruption, especially with posterior involvement, such as Malgaigne’s fracture.5 The main mechanism is a shearing force against the points of fixation of the urethra. When a fracture of the pelvis occurs, either the symphysis is mobilised or the pelvic contents are compressed. In the former, the prostate is displaced with the symphysis, stretching the urethra. In some cases the displacement is not significant enough to cause complete disruption and a partial tear occurs. When the pelvic contents are significantly compressed, such as in a lateral compression fracture, the prostate is forced upwards, tearing the puboprostatic ligaments and subsequently the urethra.5 The disruption occurs at the inferior portion of the membranous urethra, or the bulbomembranous junction. Radiographically,
displacement of the pubic ramus relative to the ischium produces the classic urethral disruption.\textsuperscript{3}

Giannoudis et al.\textsuperscript{7} noted that damage to the delicate vascular structures and nerves to the genitalia can occur after fracture of the pelvis even in the absence of urological injury. Neurological injury usually involves the lumbosacral plexus. There is a lack of consensus about the precise vascular injury that can cause sexual dysfunction. Sharlip\textsuperscript{18} reported impotence in three patients in whom obliteration of both of the internal pudendal arteries occurred at the level of the urogenital diaphragm. Levine et al.\textsuperscript{19} investigated impotent patients and reported that all who had sustained a fracture had also suffered injury to the posterior urethra. These authors identified vascular lesions in both hypogastric-cavernous beds in all patients, and lesions of the pudendal or common penile arteries in 90% of patients with a fracture. Munarriz et al.\textsuperscript{20} reported that 80% of patients who had sustained trauma to the pelvis had an abnormality of venous outflow, and 70% had an abnormality of venous occlusion. Angiography most frequently detected abnormalities in the common penile and cavernous arteries. These investigators found pure arterial damage in 30% of patients. Others have stated that erectile dysfunction is unlikely to be caused by venous abnormalities, but probably represents inadequate smooth muscle function as a result of arterial or neural damage.\textsuperscript{7,21}

Diagnosis

There should be a heightened suspicion of urologic injury in any patient presenting with a pelvic ring injury. The classic clinical signs of urologic injury are blood at the urethral meatus, inability to void despite the sensation of a full bladder, and a high riding or ‘absent’ prostate on rectal examination.\textsuperscript{2–4} Blood and/or urine extravasate into the perineum producing the classic perineal butterfly hematoma is diagnostic of urethral injury.

If a urologic injury is suspected by initial clinical assessment, the Foley catheter should be placed by a urologist because of the significant risk of completing a partial tear or contaminating a retroperitoneal haematoma.\textsuperscript{2–4} A retrograde urethrogram should be performed first to assess the integrity of the urethra. This is usually performed with 30–40 ml of a water-soluble contrast medium which is gently instilled into the urethra. A film is obtained as the last 10 ml is instilled.\textsuperscript{4} Spirnak described a simple technique in which the tip of a 14-Fr or 16-Fr Foley catheter was inserted in the urethral meatus and advanced enough to inflate the balloon with several milliliters of saline.\textsuperscript{2} A syringe was used to administer the contrast medium through the catheter. If the urethra was normal, the balloon was deflated and the catheter advanced into the bladder where a cystogram could be performed.

When the posterior urethra is disrupted, the contrast medium can be seen extravasating into the perineum or above the urogenital diaphragm. Historically, a urethrogram in the presence of a urethral injury demonstrated spread of contrast material above the urogenital diaphragm. A review of 100 cases by Sandler et al. supported Colapinto and McCallum’s earlier studies that showed that the disrupted urethra occurred at the inferior border of the urogenital diaphragm.\textsuperscript{11,22} Sandler and associates demonstrated predominant extravasation into the perineum, indicative of a tear located below the level of the urogenital diaphragm.

Following retrograde urethrogram, the integrity of the bladder should be assessed. If the urethra is intact, the cystogram is performed retrograde through the urinary catheter. To avoid a false-negative result, the bladder must be overdistended to assure sufficient filling. Weyrauch and Peterfy experimentally demonstrated in dogs that bladder incisions as large as 2 cm could be missed if the bladder was not sufficiently distended.\textsuperscript{23} In the adult, 300–500 ml of contrast medium is administered with gravity and films are taken. A complete bladder study includes anteroposterior, oblique, lateral, and post-drainage films.\textsuperscript{2} Post-drainage films are important because some bladder wall defects can be obscured by a fully contrast filled bladder. When the contrast is emptied from the bladder, residual extravasated medium can be seen.

Cystographic findings of an extraperitoneal bladder rupture are a teardrop-shaped bladder and extravasation of contrast confined to the pelvis. It is easily contrasted to the intraperitoneal rupture where the contrast medium fills the peritoneal cavity with no distinct pattern.\textsuperscript{2}

Treatment of urologic injuries

The treatment of patients with combined urologic and pelvic fractures requires coordination between orthopaedic, urologic, and general surgeons. Abdominal organ injury occurs in 50% of patients with pelvic and urologic injury.\textsuperscript{3} These patients may require exploratory laparotomy at which time orthopaedic and urologic pathology can be...
addressed if the patient is stable. Many orthopaedic surgeons fear contamination from combined orthopaedic and urologic procedures. Routt et al. reported the results of a protocol in which 23 patients with unstable pelvic fractures with associated urologic injuries were treated with open reduction and internal fixation of the anterior pelvic ring injury using the same anesthetic and surgical exposure as the urethral realignment or bladder repair. Only one of 23 cases (4%) was complicated by late, deep infection. Zingg et al. also reported that infection occurred in only one of 10 patients treated with simultaneous urologic repair and open reduction and internal fixation of pelvic ring injuries.

Intraperitoneal bladder perforation requires surgical exploration, repair, and placement of a suprapubic catheter. Symphyseal plating can be done under the same anaesthetic and appears to have an acceptable risk of infection when performed within 48 h of placement of the suprapubic catheter. Beyond this point, alternative methods such as external fixation should be considered.

Prior to the 1970s, extraperitoneal bladder rupture was considered an injury that required surgical treatment. Currently, if patients with extraperitoneal bladder rupture are undergoing exploratory laparotomy for abdominal injuries, the bladder should be addressed at the same sitting. All other patients should be managed non-operatively unless a bony spicule perforating the bladder is suspected. Non-operative management requires urinary catheter placement and close observation. Broad spectrum antibiotics are given and a cystogram performed 7–10 days prior to catheter removal. Most ruptures heal by 10 days, and virtually all heal by 3 weeks with non-operative management.

Urethral tears are classified as complete or partial (35%). The incidence rate of these injuries is approximately 65%. The treatment of partial urethral injuries is relatively straightforward, as most are managed with a urinary catheter placed by a urologist. If the catheter cannot be advanced across the partial tear easily, a suprapubic cystostomy tube is placed to divert urine. The catheter is maintained for 2–3 weeks before radiographic evidence of healing is confirmed. A retrograde urethrogram is performed in patients managed with a urinary catheters. A voiding cystourethrogram is performed in patients who have a cystostomy tube. The catheter is removed when the urethra is healed.

Management of complete urethral disruption is controversial. There are three main treatment options: immediate surgical exploration and realignment over a urinary catheter, primary urethroplasty, and suprapubic cystostomy drainage with delayed urethroplasty. One of the most frequently cited studies is that of Webster and associates who reviewed more than 300 patients from 15 reported series in order to determine the incidence of complications associated with each treatment option. Of the patients who underwent primary realignment, 69% developed strictures, 44% had impotence, and 20% were incontinent. Those with suprapubic cystotomy and delayed reconstruction showed a decreased incidence of impotence (11.6%) and incontinence (1.7%), but had a urethral stricture rate of 100%. Routt et al. reported that urologic complications occurred in 30% of their patients treated with primary urologic repair at the same sitting as the orthopaedic fixation. These authors also reported that urethral stricture was present in 44% and impotence in 16.7%. The complications of impotence, stricture, and incontinence are not necessarily complications, but consequences of these severe injuries. Harwood et al. noted that primary suturing of urethral injuries was associated with high rates of incontinence and impotence at follow-up. Urethral realignment fell out of favour in the early 1970s. Currently, urologic reconstruction in the face of pelvic fracture remains an area of interest and development.

Acute management of urethral injury uses early suprapubic catheterisation. It has been noted that early urethral realignment is an alternative to suprapubic catheterisation if the patient is stable and institutional expertise is available. The ultimate goal of early and more aggressive treatment of urethral injury is the improved outcomes and genitourinary function at follow-up. Treatment involves urinary diversion either through a suprapubic catheter if there is a leak on the urethrogram, or a urethral catheter if no leak is found. Repair of the urethra when necessary is most commonly not performed acutely, but rather is done on a delayed basis. Routt et al. presented an alternative approach with combined early repair of the urethral injury and symphyseal disruption in a series of 28 patients; however, strictures and impotence were relatively frequent complications.

With new techniques involving fluoroscopic and endoscopic guidance, primary realignment techniques can be performed with delayed reconstruction. Simultaneous antegrade and retrograde urethroscopy can be used to pass urethral catheters with a reduced risk of iatrogenic injury to the periurethral tissues. Catheters remain in place for 6–8 weeks, at which time a repeat urethrogram is performed to assess stricture formation and the need for delayed reconstruction.
In summary, we propose a simple algorithm for the workup and management of suspected urologic injury in association with a pelvic fracture (Fig. 1). The main decision point after a retrograde urethrogram/cystogram is the diagnosis of either a urethral injury or a bladder injury. If it is determined that the urethra is injured, the next decision point is between a partial tear and a complete tear. If it is determined that the bladder is injured, the main decision point is between an extraperitoneal injury and an intraperitoneal injury.

**Sexual dysfunction in males after pelvic fracture**

Patients are often reluctant to discuss sexual dysfunction after pelvic injuries, and will only do so when the clinician questions them directly during a follow-up evaluation. The clinician needs to gather information about the temporal relationship between the pelvic ring injury and the sexual dysfunction, role of medications, diabetes, neurologic disease, vascular disease, and basic psychological profile. If the patient relates nocturnal or early morning erections, serious underlying organic pathology is thought to be unlikely, and the case is more likely to be psychogenic.²⁷  

King²⁸ reported sexual impotence in 16 (20%) of 90 male patients which was more likely to be associated with a urethral injury. Ellison et al.²⁹ reported on a series of 42 men with pelvic fractures and noted that at 20-month follow-up, persistent impotence was associated with vasculogenic trauma. Mark et al.³⁰ reported that 57 of 92 (62%) patients who had undergone delayed perineal repair following a pelvic fracture and urethral

![Figure 1](image-url)  
**Figure 1** A proposed algorithm for the diagnosis and management of suspected urologic injury in association with a displaced pelvic fracture.
injury remained impotent in the long term with a median follow-up of 4 years.

The pattern of the pelvic ring injury appears to affect the prognosis. Bellabarba et al.\(^4\) reported on the outcome of an uncommon variant of the anterior-posterior compression injury in which the posterior ring injury was a midline sagittal sacral fracture extending into the spinal canal. In their series of 10 patients followed an average of 31 months, there were no objective neurologic findings that could be attributed to sacral nerve root injury. Three patients had sexual dysfunction at final follow-up, but none had evidence of sacral root/plexus injury secondary to the fracture. One additional patient who sustained a urethral tear required a chronic suprapubic catheter because of a stricture. Six patients, including one who required a repair of a retroperitoneal bladder tear, had no urogenital sequelae. The authors concluded this Denis Zone III variant had a lower incidence of associated neurologic deficits (>50%), particularly compared to those reported in patients with transverse zone III sacral fractures. The midline sagittal fracture variant and simultaneous lateral displacement of both bony and neural elements through the midline may have protected the sacral nerve roots and plexi from injury.

Harwood et al.\(^4\) suggested an algorithm for management of post-traumatic erectile dysfunction. If appropriate basic screening tests show no underlying primary pathology, initial management should consist of pharmacologic agents. Phosphodiesterase inhibitors, such as Sildenafil Citrate or Viagra (Pfizer, New York, NY), have been successful in treating erectile dysfunction. The drug acts by inhibiting phosphodiesterase type 5 to facilitate normal erection in men with normal neurovascular status. Therefore, only men with intact nerve and vascular status will respond to this treatment.

Patients who fail oral agents can be tried on intracavernosal injections. The most commonly used agent is prostaglandin E1, which is injected directly into the corpora cavernosa to induce erection. It acts as a smooth muscle relaxant and has generally good results although some patients report penile pain or prolonged erection. Again, this treatment will be ineffective in those with neurologic damage. Failure of oral and injectible agents should be followed with further investigations such as Doppler scanning and arteriography. Treatment options beyond this point usually revolve around mechanical prostheses or vacuum devices. Micro-surgical revascularisation has been used with varying success but has limited indications.

There are many treatment options; however, no recommendation for preferred treatment are currently available.\(^7\) Mark et al.\(^30\) reported on 92 patients who underwent delayed perineal repair following a pelvic fracture and urethral injury. They found that 57 patients (62%) remained impotent in the long term with a median follow-up of 4 years. Self-injection with vasoactive agents was successful in 24 of 27 (89%), suggesting a neurogenic etiology. They concluded that disruption of the cavernosal nerves lateral to the prostatomembranous urethra behind the symphysis pubis was the most likely cause of impotence injury. Bilateral pubic rami fractures had a high incidence of associated impotence.

### Sexual dysfunction in females alter pelvic fracture

Female sexual dysfunction involves pain during sexual intercourse (dyspareunia) and future difficulty with vaginal childbirth with resultant need for Caesarean section. Kiely and Williams\(^32\) reported the results of a questionnaire sent to women who had sustained major pelvic fractures and sacro-iliac disruption. Seven of the 11 patients who were sexually active reported dyspareunia. Four of the 11 patients had given birth, and only one required a Caesarian section.

Copeland et al.\(^33\) reported the results of a study of the effect of trauma and pelvic fracture on genitourinary, sexual, and reproductive function. Urinary complaints occurred significantly more often in the study group (with pelvic fractures) than in controls (21% and 7%, respectively), in patients with residual pelvic fracture displacement >5 mm than in those without displacement (33% and 14%, respectively), and in patients with residual lateral (60%) or vertical (67%) displaced fractures than in those with medially displaced fractures (21.4%). Caesarian section rates were significantly more frequent in subjects with fractures initially displaced >5 mm than in those with fractures initially displaced <5 mm (80% and 15%, respectively). There was no difference in the incidence of infertility or miscarriage between groups. Dyspareunia was more common in subjects with fractures displaced >5 mm than in those with non-displaced fractures (43% and 25%, respectively). The authors concluded that pelvic trauma negatively affected the genitourinary and reproductive function of female patients.
Fallat et al.34 studied 31 women treated at a Level I trauma centre who had sustained reproductive tract injuries. The injuries were divided into coital (all of whom had vaginal lacerations) and non-coital injury groups. At follow-up, seven women in the combined group had subsequent pregnancies, and only two patients who had sustained pelvic fractures had dyspareunia. The authors concluded that even severe injuries do not preclude normal pregnancy and sexual function.

Treatment of female sexual dysfunction focuses mainly on the treatment of dyspareunia and maintenance of ability to bear children through the birth canal. Gynaecologic referral should be made in most cases of dyspareunia after a pelvic fracture. Dyspareunia may be relieved by excision of a bony exostosis in select cases.35 In addition, female patients who sustain a pelvic fracture should be counselled about the increased risk of a Caesarian section for childbirth.

Conclusion

Traditional understanding and treatment of urologic injuries associated with pelvic fractures has been coupled with an increased awareness of risk of future sexual dysfunction. Contemporary management continues to evolve, with an increased trend towards more aggressive treatment of the pelvic fractures and dislocations, urologic injuries, and sexual dysfunction with the hope of improved overall long-term functional outcome.

References


