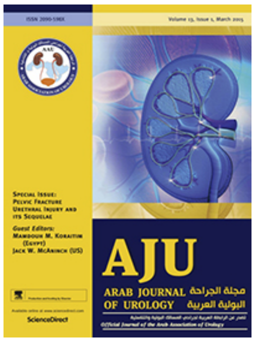

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EPIDEMIOLOGY AND DIAGNOSIS OF PFUI
REVIEW

The incidence, causes, mechanism, risk factors, classification, and diagnosis of pelvic fracture urethral injury

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KEYWORDS

Pelvic fracture;
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ABBREVIATIONS

PFUI, pelvic fracture urethral injury;
PFUDD, pelvic fracture urethral distraction defect;
MVC, motor vehicle collision;
BN, bladder neck;

Abstract ***Background:*** Pelvic fracture urethral injury (PFUI) is an uncommon but potentially devastating result of pelvic fracture. It ranges in severity based on the cause and the mechanism of injury.

Methods: We reviewed previous reports to identify the incidence, causes, mechanisms of injury and risk factors of PFUI. In addition, we reviewed the current classification systems and diagnostic methods that have been described to assess the severity of PFUI, to identify optimal management strategies and evaluate outcomes.

Results: PFUI occurs more commonly in men, but is more likely to be severe in children. The most common cause is motor vehicle collisions, and the mechanism is typically a ligament rupture at the attachment to the urethra. There is no reliable classification system to differentiate partial and complete PFUI. Retrograde urethrography is the standard imaging method but it has its limitations.

Conclusions: Despite many reports describing this injury, there is still a need to further clarify the incidence, aetiology and mechanism of injury to better determine optimal management strategies and evaluate outcomes. Consensus in the diagnosis

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RUG, retrograde urethrography

of PFUI is lacking, and outcomes of primary realignment and the role of flexible cystoscopy as a diagnostic method are still to be determined.

Introduction

Pelvic fracture urethral injuries (PFUIs) often result from high-velocity injuries that are associated with disruption of the pelvic ring. Depending on the severity of the injury they can be isolated, or more likely, associated with non-urological injuries that often are more pressing [1]. Urethral injuries associated with PFUIs were initially termed pelvic fracture urethral distraction defects (PFUDDs) by Turner-Warwick [2] based on the assumption that they were usually complete injuries. However, the International Consultation on Urological Diseases recommended replacing PFUDD with PFUI, because these injuries are not complete disruptions in most cases, and that even when they are complete, they are not necessarily distracted [1]. Here we review previous reports on PFUI and summarise the available data on its incidence, causes, mechanisms, risk factors, classifications and diagnostic strategies.

Incidence

Pelvic fractures occur in ≈9.3% of all blunt trauma cases presenting to the emergency department [3]. The reported incidence of PFUIs varies greatly, at 5–25% of pelvic fractures [1,3]. This variation is probably due to the heterogeneous nature of available prospective and retrospective reports [4,5]. Rapidly increasing populations in developing countries are more likely to have a greater incidence of vehicular accidents, leading to a higher prevalence of PFUIs. Stein et al. [6] reported vehicular accidents as a cause for nearly 36% of urethral strictures in India, vs. 15% in a cohort from the USA and Italy. PFUI is much more common in men than women (25% vs. 4.9%) due to a shorter urethra and lack of urethral attachments to the pubis in females [7]. Children suffering from falls sustain PFUIs that are often more severe than in adults because their pelvic fractures are often more severe [8]. Also, paediatric urethral injuries are more likely to be complete than in adults (69% vs. 42%) [8]. PFUI in children results in a higher incidence of stricture formation, is more likely to be proximal [8], and has a higher incidence of urinary incontinence [9,10].

Causes

Nearly half of pelvic fractures are considered mild to moderate in severity, and 95% of those fractures have minor associated injuries [11]. More severe pelvic fractures are associated with a higher risk of and more severe urethral injury [5]. Motor vehicle collisions (MVCs) are the most common cause of pelvic fracture (68–84%). MVCs are four times more likely to cause a PFUI than the second most common cause, falling from a height (6–25%) [8,12–15]. Typically, pedestrians involved in MVCs are more likely than the occupants of the motor vehicle to sustain a severe pelvic fracture and PFUI [8,16]. Less common causes of pelvic fracture include slipping and falling, being thrown or hit by an animal such as a horse, or being injured by machinery [9]. Industrial and mining accidents were previously major causes of pelvic fractures but are now less common, given the increasing automation of machinery and safety standards in the work environment [17].

In 2002, Demetriades et al. [3] retrospectively reviewed 1545 patients with a pelvic fracture who presented to a major trauma centre. The leading causes of pelvic fractures were motorcycle accidents (15.5%), pedestrian injuries (13.8%), falls from heights of > 5 m (12.9%), and automobile occupants in a MVC (10.2%). Pedestrian and motorcycle accidents were associated with more severe pelvic fractures relative to occupants of the automobile in MVCs.

Mechanism of injury

The bulbar urethra lies distal to the perineal membrane. Contrary to the initial thought that most PFUIs are prostatomembranous disruptions [4,18], most injuries occur at the bulbomembranous junction [8,19,20]. Most pelvic fractures by themselves do not cause urethral injuries, but urethral injuries result from the rupture of ligamentous attachments during pelvic-ring disruption. A PFUI occurs when the ligament ruptures at its urethral attachment [20]. In complete urethral injuries, the periprostatic venous plexus can be injured, with subsequent large haematoma formation, displacing the prostate cephalad and posterior [21]. A less common mechanism of injury involves direct injury to the urethra by a bony fragment, which is more likely to occur in women [7]. In children, PFUIs are more likely to be proximal in location and commonly involve the prostate and the bladder neck (BN), because the prostate is underdeveloped and poorly supported in children. In adults, urethral injuries are more commonly longitudinal, whereas they tend to be transverse in children [1].

Risk factors

Pelvic fractures are typically classified by the mechanism of injury or the stability (or instability) of the fracture. In the Tile's classification scheme [22], the most extensively used classification system, a type A fracture is a pelvic-ring fracture that is stable. Type B is a rotationally unstable fracture that is vertically stable. An example of this type of fracture is an 'open-book' and lateral compression fracture. Type C is both rotationally and vertically unstable, such as Malgaigne's fracture [20,23]. Table 1 provides a detailed description of the Tile classification for pelvic fractures. Aihara et al. [24] retrospectively assessed 362 pelvic fractures and showed that a widened symphysis with a sacroiliac joint involvement was predictive of bladder injury, while a widened symphysis and an inferior pubic ramus fracture was predictive of a urethral injury. Although these results were statistically significant, their predictive value was low. Another study by Koraitim et al. [8] reported that straddle fractures combined with sacroiliac joint diastasis were far more likely associated with urethral injury than either a straddle fracture alone, or even less commonly, a Malgaigne's fracture. PFUIs were consistently associated with the combination of a pubic arch fracture with disruption of the posterior pelvic ring. In 2006, Basta et al. [25] studied 25 patients with PFUIs and found that all of them had an anterior pelvic fracture. Multivariate regression analysis showed that independent factors predictive for PFUI were a displaced inferior medial pubic bone fracture and symphysis pubis diastasis.

Classification

An ideal classification system for PFUI assists in establishing appropriate management strategies and evaluating outcomes. Several classifications have been proposed for PFUI, some of which have not achieved widespread usage because they either are not comprehensive or not clinically useful. The main difficulty encountered with these classification systems is related to their lack of accuracy in differentiating partial from complete urethral transection. In practice, many patients are catheterised in the emergency department with no retrograde urethrography (RUG) because of other more pressing injuries. The RUG is often only used when catheterisation is difficult or resistance is met [1].

Colapinto and McCallum [26] were the first to classify PFUI with a system based on contrast extravasation on RUG (Table 2) [26–29]. Unfortunately, this lacks a proper assessment of the BN and prostatic urethral injuries. In addition, despite describing three types of injuries, 85% of their reported injuries fell under type 3 and they had no reported type 2 injuries, limiting the clinical value of their classification. Goldman et al. [27] attempted to modify Colapinto and McCallum's classification to make it more clinically applicable (Table 2). However, this failed to reliably distinguish partial from complete PFUIs.

The American Association for the Surgery of Trauma classification focuses on the degree of injury rather than the anatomical location [28]. Similar to previous systems, its limitations included differentiating partial from complete injuries. Consequently, there is a wide variation among different reports of partial vs. complete injuries, with the incidence of complete injuries ranging from 6% [30] to 97% [31]. Webster et al. [32] summarised the different available reports and identified an average incidence of 34% for partial injuries and 65% for complete injuries.

More recently, the European Association of Urology [29] developed a classification system for urethral injuries. Although all these classifications suffer from the inherent weakness of differentiating partial and complete PFUIs, they can offer a general guide to the appropriate management. In women, partial rupture is the most common type of injury, and usually

Table 1 Tile's classification of pelvic fractures.

Class	Description
A: stable	A1: fracture not involving the ring (avulsion or iliac wing fracture)
	A2: stable or minimally displaced fracture of the ring
	A3: transverse sacral fracture (Denis zone III sacral fracture)
B: rotationally unstable, vertically stable	B1: open book injury (external rotation)
	B2: lateral compression injury (internal rotation)
	B2–1: with anterior ring rotation/displacement through ipsilateral rami
	B2–2-with anterior ring rotation/displacement through contralateral rami (bucket-handle injury)
	B3: bilateral
C: rotationally and vertically unstable	C1: unilateral
	C1–1: iliac fracture
	C1–2: sacroiliac fracture-dislocation
	C1–3: sacral fracture
	C2: bilateral with one side type B and one side type C
	C3: bilateral with both sides type C

Table 2 Different classification systems for pelvic fracture urethral injury.

References	Classification
[26]	Type 1: the prostate or urogenital diaphragm is dislocated but the membranous urethra is merely stretched and not severed Type 2: the membranous urethra is ruptured above the urogenital diaphragm at the apex of the prostate Type 3: the membranous urethra is ruptured above and below the urogenital diaphragm
[27]	I – posterior urethra intact but stretched II – partial or complete pure posterior injury with tear of membranous urethra above the urogenital diaphragm III – partial or complete combined anterior/posterior urethral injury with disruption of the urogenital diaphragm IV – BN injury with extension into the urethra IV A – injury of the base of the bladder with periurethral extravasation simulating a true type IV urethral injury V – partial or complete pure anterior urethral injury
[28]	I – contusion: Blood at urethral meatus; urethrography normal II – Stretch injury: Elongation of urethra without extravasation on urethrography III – partial disruption: Extravasation of urethrography contrast at injury site with visualisation in the bladder IV – complete disruption: Extravasation of urethrography contrast at injury site without visualisation in the bladder; <2 cm of urethra separation V – complete disruption: Complete transaction with >2 cm urethral separation, or extension into the prostate or vagina
[29]	I – stretch injury: elongation of the urethra without extravasation on urethrography II – contusion: blood at the urethral meatus; no extravasation on urethrography III – partial disruption: extravasation of contrast at injury site with contrast visualised in the proximal urethra or bladder IV – complete disruption: extravasation of contrast at injury site without visualisation of proximal urethra or anterior urethra or bladder V – complete or partial disruption of posterior urethra with associated tear of the BN, rectum or vagina: extravasation of contrast at urethral injury site $\pm$ presence of blood in the vaginal introitus in women. Extravasation of contrast at BN during suprapubic cystography $\pm$ rectal or vaginal filling with contrast material

occurs at the 12 o'clock position, with varying lengths of urethral involvement. Complete transection is uncommon, and when present, typically involves the proximal urethra and BN [7,33]. Table 2 provides a summary of the classification systems available for PFUIs.

Diagnosis

A PFUI should be suspected in all patients presenting with pelvic fracture, especially if the fracture is associated with rotational instability (open and externally rotated, or compressed and internally rotated) or vertical instability (vertical shear fracture with significant posterior pelvic disruption) [1]. The classic signs for the clinical diagnosis of a PFUI in men are blood at the meatus (which occurs in 20–100% of cases) [1], inability to pass a urethral catheter, and a distended bladder. The inability to void can indicate a PFUI, but can also result from pain or shock. With a partial urethral injury the patient might be able to void with gross haematuria [4,5,34,35]. Other clinical signs are time-related and include scrotal or perineal haematoma and high-riding prostate on a DRE. The DRE is considered a good test to detect anorectal injuries, which are commonly associated with PFUIs. However, a DRE is of little or no value in detecting PFUIs [36–38].

All patients suspected of having a PFUI should undergo RUG to look for and evaluate the severity of the PFUI. RUG is considered the standard imaging method, with a high sensitivity and specificity for detecting urethral injuries when performed correctly. Practically, this is not always done as patients commonly have other more severe injuries that require urgent attention. In haemodynamically stable patients, CT is typically used first, followed by RUG, which can also be done using oblique views or by tilting the X-ray machine instead of the patient when there is a concern about other systemic or spinal injuries [39,40]. Haemodynamically unstable patients often undergo an emergency laparotomy, during which catheterisation or flexible cystoscopy can be attempted. 'Blind' catheterisation is associated with the theoretical risk of making the PFUI worse, although this has not been proven [24]. The use of flexible cystoscopy for the diagnosis and management of PFUIs has increased recently, because of the increased use of primary realignment in the acute setting. The superiority of this approach over RUG as a diagnostic method for PFUI has never been studied [41].

Conclusion

PFUI is an uncommon but potentially devastating complication of pelvic fracture. Despite many reports describing this injury, there is still a need to further clarify the incidence, aetiology and mechanism of injury to better determine optimal management strategies and evaluate outcomes. Many attempts have been made to classify PFUIs, but they all lack the ability to reliably differentiate partial and complete injuries. Consensus in the diagnosis of PFUI is lacking. The outcomes of primary realignment and the role of flexible cystoscopy as a diagnostic method remain to be determined.

Conflict of interest

None.

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