SCANDINAVIAN JOURNAL OF UROLOGY
2023, VOL. 57, NOS. 1–6, 102–109
https://doi.org/10.1080/21681805.2022.2141311

ARTICLE

Lower urinary tract injuries in patients with pelvic fractures at a level 1 trauma center – an 11-year experience

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ABSTRACT

Background: Urological injuries can occur in patients with pelvic fractures. Treatment recommendations lack solid evidence and is often pragmatical. There is a continuous need to describe short- and long-term morbidity following lower urinary tract trauma.

Objective: To describe incidence, diagnosis, treatment, and morbidity following lower urinary tract injuries in pelvic fractures.

Patients and methods: Retrospective study including patients with pelvic, including acetabular, fractures admitted to a Level I Trauma Centre covering 2.8 million citizens between 2009 and 2020. Outcome measurements comprised primary management, treatment trajectory, short- and long-term complications and outcomes.

Results: A total of 39 (5%) patients with pelvic fractures had concomitant urethral and/or bladder injuries, and one patient with an acetabular fracture had a bladder injury. The management of urethral injuries varied vastly, and complete urethral ruptures were associated with severe short- and long-term complications. Only one patient with bladder injury experienced severe long-term complications.

Conclusions: Management of lower urinary tract injuries in patients with major pelvic fractures remains a major challenge. Special attention should be focused on urethral injuries where we uncovered an unsystematic treatment and follow-up even in a highly experienced centre, although this is also attributed to complicated multidisciplinary patient trajectories. There is a continuous need to reduce long-term complications following urethral trauma which should be addressed in multicenter studies.

ARTICLE HISTORY
Received 30 August 2022
Revised 19 October 2022
Accepted 25 October 2022

KEYWORDS
Pelvic fracture; trauma; urethra; bladder; lower urinary tract

Introduction

Pelvic fractures are the most life-threatening and severe orthopedic injuries accounting for 3–8% of all fractures, and usually occurs in major trauma cases (Injury severity score (ISS) $\geq$15) [1,2]. There are multiple factors associated with the risk of adverse outcomes and mortality which is reported to range from 5% to 50% [3]. Risk factors for adverse outcomes include fracture type, associated injuries, and the traumatic effect on physiological parameters such as derangement and hemodynamic stability following the trauma [4].

Urological injuries occur in 3–16% of patients with pelvic fractures and are most common in males [5,6]. Due to the protected anatomical location of the bladder, blunt bladder injuries can be associated with pelvic fractures. Bladder rupture can either be extraperitoneal (60%), intraperitoneal (30%) or a combination (10%) [6]. The lower risk of concomitant urethral injuries to pelvic fractures in females is due to the short length, limited mobility and lack of insertions to the pubic symphysis [7]. The risk for urethral injury is highest for major, instable and displaced pelvic fractures, and are rare in single and ipsilateral ramus fractures. Urethral injuries have not been reported in isolated fractures of the acetabulum, ileum and sacrum [8]. Genitourinary injuries are associated with morbidity and mortality following major pelvic trauma due to the risk of septicemia, uroplania, hematuria, prolonged catheter treatment and voiding problems [5,9]. Importantly, urological trauma may result in long-term complications such as urethral or bladder neck stenosis, incontinence, erectile dysfunction (ED) or use of permanent indwelling catheter that severely impair quality of life [8,10–15]. The specific management of urological injuries in pelvic trauma patients has limited support in evidence.

Aim of the present study was to describe incidence, diagnosis, treatment, and short- and long-term outcomes following urethral and bladder injuries in pelvic fracture patients at a level 1 Trauma Centre over an 11-year period.

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Methods

Data source and population

All trauma patients admitted (primary or secondary) to the Trauma Centre, Rigshospitalet, Copenhagen University Hospital, from 1 January 2009 to 31 December 2020 were included. The Trauma Center covers a population of 2.7 million people. Traumatic pelvic, acetabular and urological surgery is centralized to Rigshospitalet. Patients with pelvic and acetabular fractures were identified in our prospective Trauma Registry. Patient charts were manually reviewed for concomitant urological trauma. The following variables were extracted: age, sex, date of trauma, trauma mechanism, date of urological injury, diagnostic, date of surgery, fracture characteristics, and ISS. An experienced orthopedic trauma surgeon classified pelvic fractures according to Young-Burgess classification system: Anteroposterior compression (APC) I–III, Lateral compression (LC) I–III, Vertical shear (VS), or Combined fractures.

Urological injuries

Urethral injuries were classified as partial *vs.* complete rupture, and bladder injuries as extraperitoneal *vs.* intraperitoneal according to the European Urological Association (EUA) guidelines [16]. An experienced consultant urologist classified urological injuries. Primary management, treatment trajectory, short- and long-term complications, and long-term outcome were registered. Follow-up ended in January 2022.

Results

A total of 1061 patients with pelvic, including acetabular, fractures were admitted to our Level 1 Trauma Centre. A total of 39 (5%) with pelvic fractures had concomitant urethral and/or bladder injuries. A total of 259 patients had isolated acetabular fractures without pelvic involvement of which one patient (0.4%) had a bladder injury. Urological injuries were identified or suspected clinically, e.g. in case of hematuria or catheter problems, or in combination with trauma CT. If necessary, additional urological diagnostic investigations, such as cystoscopy and urography, were performed. Two subjects (14 and 20) had combined urethral/bladder injury and are included as *urethral injury*. All patients suffered from blunt trauma. Patient and trauma characteristics are listed in Tables 1 and 2.

Urethral injury

Twenty subjects (2% of total population) sustained urethral injuries of which 18 (90%) were men. Median age was 53 years (*IQR*: 45–63) and median ISS score was 29 (*IQR*: 24–39). The fractures were distributed as eight APC (two accompanied by acetabulum fracture), six LC, five Combined, and one VS. All patients had at least one ramus fracture and/or symphysis diastasis or rupture (Table 3).

Eleven patients (55% of urethral population) had *partial rupture*. Of these, five patients received Catheter à demeure (CAD) (45%), three suprapubic catheter (SPC) (27%), and three a combination of CAD and SPC (27%). There was no clear indication for the use of combined catheterization. Short- and long-term complications are listed in Table 1. Open realignment after initial SPC solved the trauma in 11% of cases. However, delayed urethroplasty (33%), stent (22%), Sachse's urethrotomy (11%) or permanent CAD (11%) was used as final treatment for the rest of the population. Six patients (55%) had no long-term voiding complications, but the remaining five (45%) suffered from severe long-term urological problems. Four (36%) patients reported ED at end of follow-up.

Nine patients (45% of urethral population) had *complete rupture*. All patients, except a multi-traumatized female, received SPC as primary treatment: four patients received SPC alone (44%), two combined with open realignment (22%), one patient combined with open secondary realignment (11%), and one patient combined with cystoscopic realignment (11%). Six of the patients subsequently underwent urological correction procedures: three urethroplasties (33%), one open realignment (11%), one stent placement (11%), and one Sachse with clean intermittent dilatation (CID) (11%). For one patient urethroplasty was not possible leading to permanent SPC. There were severe short- and long-term urological complications and all patients were still in urological care at the time of follow-up. Three (33%) had permanent CAD/SPC. Five (55%) had severe ED. Two patients died during follow up: one due to disseminated renal cancer and one because of multiple traumatic lesions.

Urethral injuries in females were rare and accounted for 0.3% of the total population. Both cases (11 and 20) were multi-traumatized with severe pelvic fractures: Combined and VS. For both cases the lesions were not confirmed with diagnostic imaging due to fatal lesions and treatment with SPC. For a detailed overview of injuries, see Table 1.

Bladder injury

Twenty-two subjects (2% of total population) sustained bladder injuries of which 12 (60%) were female. Two of these had urethral injuries and are included in that group (case 14 and 20). Median age was 48 years (*IQR*: 28–61) and median ISS score 25 (*IQR*: 18–29) (Table 2). Fractures were classified as 10 LC (one accompanied by acetabulum fracture), six APC, two VS (one accompanied by acetabulum fracture), one Combined fracture, and remarkably one patient had an isolated acetabulum fracture. All patients had at least one ramus fracture and/or symphysis diastasis except for the acetabulum fracture without pelvic ring involvement (Table 4).

A total of 17 (75%) patients had extraperitoneal lesion or rupture. All 17 patients received CAD as primary treatment. Six patients received CAD alone (35%), three combined with bladder lavage (18%), and eight combined with open suture of the bladder during pelvic surgery or explorative laparotomy (47%). One patient also received nephrostomy due to a ureter injury. Nine of 17 patients (53%) with extraperitoneal bladder lesions had no long-term complications, six (35%)

Table 1. Patient characteristics for patients with either partial or complete urethral injuries.

Subject, sex, age at trauma	Urethral injury	Trauma Mechanism	Primary treatment	Complications	Final treatment	Late complications	Final solution	
1. Male, 66 years	Injuries near prostate, possible *via* falsa	Bicyclist hit by motor vehicle	CAD + SPC	Stricture, retention	Sachse, CID	None	Resolved	Partial rupture
2. Male, 51 years	Unspecified	Hit by train	CAD	LUTS with urge	Conservative/none	None	Resolved	
3. Male, 53 years	Urethral injury, pars prostatica	Crushed under wall, ~2 ton	SPC	None	CAD	None	Resolved	
4. Male, 63 years	Unspecified, possible *via* falsa	Crushed between car and worktable	CAD + SPC	None	CAD	None	Resolved	
5. Male, 73 years	Urethral injury, pars prostatica	Pedestrian hit by car	CAD	UTI	CAD	None	Resolved	
6. Male, 65 years	Unspecified	Slip in level	CAD + SPC	Several UTIs	CIC	Retention	Resolved	
7. Male, 36 years	Injury with stricture, pars membranacea	Crushed under tree, ~250 kg	CAD, CIC, Sachse	Stricture recurrence, LUTS, ED	Urethroplasty	ED	Resolved, *via*gra	
8. Male, 42 years	Partial tear, pars membranacea	Motorcycle crash	SPC, realignment not possible	Multiple UTIs, penile and scrotal edema with fungal infection	SPC	ED	Resolved, *via*gra	
9. Male, 54 years	Injuries, pars prostatica	Motorcycle hit by motor vehicle	CAD	Retention	CAD	UTI, urosepsis, ED	Resolved, *via*gra	
10. Male, 46 years	Urethral injury, pars membranacea	Motor vehicle collision	CAD	Stricture, LUTS with urge, ED, UTI	Sachse	Stricture, ED	Lifelong CID	
11. Female, 89 years	Unspecified	Fall from second floor, ~7 m	SPC	SPC fall out, retention	CAD	None	Resolved	
12. Male, 52 years	Prostate torn off bladder, complete rupture	Crushed under machine, ~2 ton	SPC, realignment not possible (infection risk)	SPC fall outs, ED	Urethroplasty not possible	Total stricture pars prostate, stricture in distal urethra, ED	Permanent SPC	Complete rupture
13. Male, 29 years	Complete rupture near prostate	Crushed under forklift	SPC	Total stricture, UTI, intraabdominal SPC, pain	Urethroplasty + CAD	Re-stricture, anastomosis leakage, perineal abscess, penile/ scrotal pain, bladder concrements, LUTS, ED	Dilatation with success, Cialis	
14. Male 55 years	Prostate torn off bladder, complete rupture + bladder	Crushed under backhoe, ~40 ton	SPC + open realignment	Stricture, scrotal + penile edema, uroplania, UTI, CAD fall outs	Urethroplasty	Anastomosis diverticulum, urosepsis, UTIs, bladder concrement, retention, incontinence, ED	Multiple UTIs, Impotence	
15. Male, 35 years	Complete rupture, pars membranacea	Motorcycle crash	SPC	Ano-urethral fistel, suprapubic cicatrix infection, incontinence	Open realignment	Ano-urethral fistula, perineal abscess, ED	Abscesses, reference to surgery, *via*gra	
16. Male, 64 years	Complete rupture, pars membranacea	Pedestrian hit by truck	SPC + open secondary realignment	Stricture (partial in sphincter), multiple UTIs, retention, rectal pain	Stent (removed due to incontinence)	Total stricture, incontinence, urethral pain, UTI, SPC infections and fall outs	Permanent SPC	
17. Male, 61 years	Complete rupture, unspecified segment	Bicycle crash	SPC + open realignment	Lost to follow-up: Died of complications to disseminated renal cancer	CAD	Lost to follow-up: Died of complications to disseminated renal cancer	–	
18. Male, 54 years	Complete rupture, pars bulbosa	Crushed under metal plate, ~1.5 ton	SPC	Total obstruction/stricture, pars bulbosa	Urethroplasty, stent	Re-stricture, dysuria, UTIs, urge, retention, incontinence	SPC + new stent	
19. Male, 26 years	Complete rupture near prostate	Motor vehicle collision	SPC, cystoscopic realignment	Stricture (in sphincter). stranguria, urinary retention, ED	Sachse, CID, *via*gra	Re-stricture, dysuria, ED	CID, Endocrinologist	
20. Female, 52 years	Complete rupture + bladder rupture	Pedestrian hit by truck	CAD not possible	n/a	n/a	Lost to follow-up: Died from traumatic lesions	–	

All patients underwent pelvic fracture surgery at Copenhagen University Hospital, Denmark, in the period 2009–2020.
CAD: Catheter à demeure; CIC: clean intermittent catheterization; CID: Clean intermittent dilatation; ED: erectile dysfunction; LUTS: lower urinary tract symptoms; SPC: suprapubic catheter; UTI: urinary tract infection '+' indicates two treatments combined.

Table 2. Patient characteristics for with either extra- or intraperitoneal bladder injuries.

Subject, sex, age at trauma	Bladder injury	Trauma Mechanism	Primary treatment	Complications	Final treatment	Late complications	Final solution	
21. F, 41 years	Wall injury	Motor vehicle crash	CAD	None	None	None	Resolved	Extraperitoneal
22. F, 51 years	Wall injury	Pedestrian hit by motor vehicle	CAD	UTI, retention, urge	CAD + Tolterodin, Betmiga	Retention, urge	Physiotherapy, CIC	
23. M, 26 years	Contusion	Crushed under wall, ~2.5 ton	CAD with bladder lavage	CAD blockage, clots	CAD	None	Resolved	
24. F, 60 years	Small rupture, extraperitoneal	Motor vehicle vs motor vehicle, side	Open suture of bladder + CAD	None	None	None	Resolved	
25. F, 66 years	Rupture, extraperitoneal	Motor vehicle vs motor vehicle, frontal	Open suture of bladder + CAD	UTI	CAD	None	Resolved	
26. F, 44 years	Rupture, extraperitoneal	Motorcycle crash	Open suture of bladder + CAD	Uroplania (pelvic drain)	CAD	Hyperesthesia and hypesthesia genital area, decreased libido	Resolved Referral to a sexology	
27. F, 70 years	Rupture, extraperitoneal	Jump from building, ~8 m	CAD	Uroplania (pelvic drain)	CAD	UTIs, retention, CAD leakage	CAD	
28. F, 32 years	Rupture, extraperitoneal	Jump from building, ~9 m	CAD with bladder lavage	None	None	None	Resolved	
29. F, 70 years	Rupture, extraperitoneal	Fall from horse	Open suture of bladder + CAD	Urine leak from CAD, UTIs, urge incontinence	Incontinence ring, bulking, TVT-O, SPC, TVT	Severe urge incontinence, pain, UTIs	TVT and TVT-O remove	
30. F, 58 years	Rupture, extraperitoneal	Pedestrian run over by truck	Open suture of bladder + CAD	Re-rupture, wall necrosis	Open suture of bladder + CAD	Lost to follow-up: Died of multiple traumatic lesions	–	
31. M, 19 years	Rupture, extraperitoneal	Motor vehicle vs motor vehicle, side	CAD	Hematuria episodes, UTIs	None	Symphysis fistula	Lost to follow-up	
32. M, 24 years	Rupture, extraperitoneal	Motorcycle collision with motor vehicle	Open suture of bladder + CAD	UTIs	None	None	Resolved	
33. M, 51 years	Rupture, extraperitoneal	Motorcycle hit by motor vehicle	Open suture of bladder + CAD	None	CAD	ED	Resolved	
34. M, 29 years	Rupture, extraperitoneal	Pedestrian hit by motor vehicle	CAD	Urine leak from CAD	CAD	None	Resolved	
35. M, 35 years	Rupture, extraperitoneal	Crushed under chimney	CAD	None	CAD	None	Resolved	
36. M, 55 years	Rupture, bilat. extraperitoneal	Pedestrian hit by excavator	CAD with bladder lavage	Uroplania (pelvic drain) and cicatrice, drain fall out, scrotal-penile edema, pelvic infection	Double J-stent + CAD	Incontinence, ED	Physiotherapy Potency agents	
37. F, 13 years	Rupture, extraperitoneal + ureter	Cyclist run over by truck	Open suture of bladder + CAD + nephrostomy	UTI, kidney abscess, sepsis	Ureter suture + double J-stent	ATIN, UTIs, incorrect treatment of ureter injury	Kidney dx 15 % function	
38. F, 17 years	Rupture, intraperitoneal	Motor vehicle vs motor vehicle, side	Open suture of bladder + CAD	UTI	CAD	None	Resolved	Intraperitoneal
39. F, 65 years	Rupture, intraperitoneal	Jump from 1st floor, ~3 m	Open suture of bladder + CAD	UTI	None	None	Resolved	
40. M, 74 years	Rupture, intraperitoneal	Motor vehicle vs motor vehicle, frontal	Open suture of bladder + CAD	Urosepsis, retention, UTI	TUR-P SPC	Sclerosed bladder neck, retention, UTIs, bladder concrements, SPC fall outs	Permanent SPC	

All patients underwent pelvic fracture surgery at Copenhagen University Hospital, Denmark, in the period 2009–2020.
CAD: Catheter à demeure; CIC: clean intermittent catheterization; CID; clean intermittent dilatation; ED: erectile dysfunction; SPC: suprapubic catheter; TUR-P: trans urethral resection of prostate; TVT: tensionfee vaginal tape; TVT-O: tensionfree vaginal transoburator tape; UTI: urinary tract infection; '+' indicates two treatments combined.

Table 3. Description of pelvic fractures for patients with concomitant urethral injuries.

Subject, sex, age at trauma	YB Classification	Pelvic fractures	ISS
1. Male, 66 years	LC2	Bilateral dislocated ramus sup et inf + sacroiliac joint dx	29
2. Male, 51 years	APC2 + acetabulum	Bilateral ramus inf + ramus sup dx + bilateral sacral + acetabulum sin	41
3. Male, 53 years	APC3	Dislocated ramus sup et inf dx + luxated sacroiliac joint sin	20
4. Male, 63 years	APC2	Symphysis diastasis + luxated sacroiliac joint sin	25
5. Male, 73years	APC2 + acetabulum	Bilateral ramus sup inf et sup + sacroiliac luxation sin + acetabulum dx	25
6. Male, 65 years	LC3	Instable bilateral fracture of ramus sup et inf + sacrum	16
7. Male, 36 years	LC2	Bilateral ramus sup inf + sacrum sin	25
8. Male, 42 years	Combined	Bilateral ramus sup inf et sup + dislocated sacroiliac joint sin + bilateral acetabulum	41
9. Male, 54 years	APC3	Bilateral dislocated ramus sup et inf + symphysis diastasis + sacroiliac rupture and fracture dx	29
10. Male, 46 years	LC2	Ramus sup et inf sin + sacrum sin	–
11. Female, 89 years	Combined	Rasmus inf sin + ala sin + sacroiliac sin + acetabulum sin	22
12. Male, 52 years	APC3	Ramus sup et inf + symphysis diastasis + sacrum (massa lateralis) sin	29
13. Male, 29 years	LC2	Bilateral ramus sup et inf + sacrum dx	–
14. Male, 55 years	APC2	Comminute ramus sup sin + symphysis diastasis + sacroiliac sin + sacrum dx	–
15. Male, 35 years	APC3	Symphysis diastasis + sacrum dx + sacroiliac luxation dx	36
16. Male, 64 years	Combined	Bilateral comminute ramus sup + symphysis diastasis + ramus inf sin + bilateral sacrum + ala dx + acetabulum dx	17
17. Male, 61 years	Combined	Bilateral ramus inf + ramus sup dx + sacroiliac dx + bilateral comminut acetabulum	–
18. Male, 54 years	Combined, severe	Symphysis diastasis (20 cm) + sacroiliac joint dx + ileum sin + acetabulum sin	59
19. Male, 26 years	LC2	Bilateral ramus sup et inf + ilium sin + acetabulum sin + sacrum dx	–
20. Female, 52 years	VS	Bilateral ramus sup inf et sup + os pubis dx + bilateral sacrum + sacroiliac dx	54
			Median: 29 (IQR: 24–39)

APC: anteroposterior compression; LC: lateral compression; VS: vertical shear; YB: Young-Burgess.
Combined: Complex fracture, including a combination of APC, LC and/or VS.

Table 4. Description of pelvic fractures for patients with concomitant bladder injuries.

Subject, sex, age at trauma	YB Classification	Pelvic fractures	ISS
21. F, 41	VS	Ramus sup sin + sacrum (massa lateralis) dx	20
22. F, 51	LC2 + acetabulum	Bilateral ramus sup et inf + bilateral sacrum + sacroiliac dx + S2 + acetabulum	38
23. M, 26	LC2/3	Bilateral ramus sup + ramus inf sin + sacrum dx	–
24. F, 60	LC2	Ramus sup dx + scarum (massa lateralis) sin	13
25. F, 66	APC3	Ramus sup et inf sin + symphysis rupture + sacrum sin	50
26. F, 44	VS + acetabulum	Symphysis rupture + sacrum (massa lateralis) sin + acetabulum	25
27. F, 70	LC2/3	Bilateral ramus sup et inf + comminute sacrum (massa lateralis) sin	41
28. F, 32	LC3	Bilateral ramus communit sup et inf + bilateral pars lateralis sacrum + sacroiliac sin	29
29. F, 70	LC2	Symphysis rupture + sacrum sin	29
30. F, 58	APC3, bilat.	Bilateral ramus sup et inf + bilateral comminute sacrum + bilateral sacroiliac + bilateral ileum	42
31. M, 19	APC1	Bilateral ramus sup + symphysis rupture + sacrum dx	24
32. M, 24	APC3	Symphysis rupture + sacroiliac rupture sin	–
33. M, 51	APC3	Ramus sup dx + symphysis rupture + sacroiliac dx	16
34. M, 29	APC2	Ramus sup et inf dx + symphysis rupture + sacrum (massa lateralis) sin	20
35. M, 35	LC2/3	Bilateral ramus sup et inf + ala dx + sacroiliac luxation dx	25
36. M, 55	LC3, severe	Bilateral ramus sup et inf + bilateral sacroiliac + bilateral ileum + displaced S3, 4 and 5	29
37. F, 13	Combination	Ramus sup sin + sacroiliac sin + ileum sin + S1 sin + comminute acetabulum sin + acetabulum dx	17
38. F, 17	LC3	Bilateral ramus sup et inf + symphysis diastasis + sacroiliac sin	13
39. F, 65	LC2	Ramus sup et inf dx + comminute ileum dx	8
40. M, 74	–	Acetabulum sin, posterior wall	29
			Median: 25 (IQR: 18–29)

APC: anteroposterior compression; LC: lateral compression; VS: vertical shear; YB: Young-Burgess.
Combined: complex fracture, including a combination of APC, LC and/or V.

suffered from severe urological problems, and two (12%) patients were lost to follow up due to death and absence from hospital appointment.

Three patients (15%) had intraperitoneal ruptures and were treated with CAD and open suture of the rupture. Two patients (66%) with intraperitoneal bladder lesions had no long-term complications, but one patient (33%) had severe urological problems, including urinary retention and total bladder neck sclerosis, leading to permanent SPC. Short- and long-term complications are listed in Table 2.

Discussion

Traumatic urological injuries in major pelvic trauma often have low priority in the primary management of the trauma patient. The management of urological injuries is to a large extent pragmatic in each individual case and there is little evidence to support one treatment over the other [17,18]. In here, we have presented 40 cases with urological injuries in a large consecutive cohort of patients with major pelvic fractures. The incidence of 5% at our Trauma Center seems to be in concordance with the reported literature [5,6]. Overall,

we observed that the individual patient management and trajectory varied tremendously and was affected by many factors related to the trauma and concomitant injuries. Whereas bladder injuries were found to have a low risk of long-term complications, we observed that urethral injuries were associated with a combination of severe short- and long-term complications.

There are several issues related to diagnosis and management of urethral injury. Clinically, urethral injury is suspected if bloody discharge is observed at the meatus, or if urethral catheter placement is difficult or even impossible. However, partial ruptures may never be recognized in the heat of the trauma, and the true incidence of urethral injury may be underreported. On the other hand, unrecognized partial urethral ruptures may be of little clinical relevance both short- and long-term. It remains unknown if a clinically suspected urethral injury should be radiologically confirmed if placement of catheter is uncomplicated. Retrograde urethrography remains the gold diagnostic standard and is recommended by both European and American guidelines [16,19]. Only 5% of patients in this cohort underwent retrograde urethrography in the initial phase which may have impaired correct classification of the urethral injury. Also, precise anatomical classification of the injury was not always possible. Primary realignment is still recommended as best initial management and was achieved in 45% of cases here with CAD. We observed a use of combined SPC and CAD in patients with partial injury, but unfortunately the clinical indication was not clear and there is no literature to support this strategy. In patients with complete rupture and floating prostate, SPC was the primary treatment with secondary realignment. In cases where early re-alignment is suitable, endoscopic re-alignment is preferred, but in complete ruptures, the aim of re-alignment is to correct severe distraction injuries rather than to prevent stricture [16,17,20]. Three large systematic reviews showed an advantage of endoscopic re-alignment according to observational data [17,21,22]. When endoscopic re-alignment is possible, stricture formation is reduced to 44–49% compared to 89–94% stricture rate with suprapubic diversion. Furthermore, early re-alignment does not increase the risk of urinary incontinence or ED [17,21,22]. Several factors such as patient selection: severe *vs.* milder trauma and partial *vs.* complete ruptures, and differences in follow-up duration complicates comparison with other techniques, especially urethroplasty. These differences could also explain discrepancies in rates of incontinence, ED and re-stricture [17]. According to EAU guidelines, treatment of complete ruptures remains SPC with deferred urethroplasty, which ensures time for treatment of associated injuries, but also for pelvic hematoma resolution, prostate descend, and for scar tissue and patient to stabilize [23]. Deferred urethroplasty has an overall success rate of 86%, a low rate of incontinence (approximately 5%), and does not significantly affect erectile function itself [24,25].

ED constituted a frequent and severe complication in our cohort. Different mechanisms can lead to ED in the aftermath of a pelvic fracture, including traumatic neurogenic, vascular, or direct crural or tunica albuginea injury leading to intracorporal fibrosis or venous leakage [24,26]. A meta-analysis of 24 retrospective studies and case series estimated the risk of ED following pelvic fractures to 34%. Another 3% had de novo ED after delayed urethroplasty unrelated to the initial pelvic fracture injury. Patients undergoing primary endoscopic alignment suffered from ED in 16% of all cases, compared to 34% in patients before, and 37% after delayed urethroplasty repair. 37%, but the authors concluded this was due to lack of assessment of ED after injury and before realignment and bias whereby patients with less severe urethral injury undergo primary realignment [27]. Another meta-analysis found no difference in risk of developing ED for primary realignment *vs* SPC with the anticipation of delayed urethroplasty, indicating development of ED is related to trauma rather than the choice of initial management [22]. For both meta-analyses included studies were of low quality because of poor study design containing no randomized trials, and lack of validated tools for ED assessment. In our study, 45% of patients with urethral injury suffered from ED. The higher incidence could be related to the management, but also fracture types [28], and the severity of the injuries as ED seems to be related to the pelvic fractures to a greater extent than the management [29]. This could be partially explained by the fact that all included patients in this study were multi-traumatized and treated at a level 1 Trauma Center.

Stricture formation following urethral trauma is a known complication and occurred in 40% of our patients with urethral injury. Management of stricture formation is complicated as strictures can occur both as an early and late complication [24]. Delayed urethroplasty is the preferred treatment to prevent stricture formation with a reported 86% stricture free success rate [16,19,24]. Nevertheless, due to heterogeneity of the population and the complexity of (concomitant) injuries, choosing and implementing the correct treatment option for the individual patient remains a challenge. Lastly, 15% of the patients with urethral injury suffered from long-term incontinence of which all had complete rupture. Incontinence can occur secondary to sacral nerve or concomitant bladder neck damages [24]. In our study these patients suffered from multiple complications and received no specific treatment, such as bladder neck reconstruction, for the urinary incontinence.

Of 20 patients, 12 (60%) were classified as resolved and sustained no long-term complications. For evaluation of bladder injuries related to pelvic fractures, AUA and EAU recommends cystography (standard AP projection or CT). In case of visible hematuria, cystography is absolute indicated. AUA and EAU guidelines both recommend conservative treatment with CAD in uncomplicated extraperitoneal bladder injuries based on expert opinion [16,19]. Extraperitoneal lesions can be managed with continuous bladder drainage to prevent rise in intravesical pressure which thereby promotes the disruption to heal [30]. Most ruptures heal by 3 weeks, and AUA guidelines recommend surgical repair if healing is not achieved by 4 weeks [19]. As observed in this cohort, patient who are scheduled for open pelvic surgery, any bladder rupture should be surgically repaired to reduce the risk of infection according to guidelines. Surgical repair in intraperitoneal

ruptures is always recommended to prevent urine extravasation and consequently peritonitis and abdominal sepsis. In case of complex extraperitoneal bladder injuries, follow-up cystography should be performed to confirm healing, according to AUA and EAU [16,19]. In our cohort, primary treatment of bladder injuries adhered to guidelines. Nevertheless, we observed that no formalized urological follow-up program was scheduled, and 11 (55%) patients had cystography done at different times and indications. Despite inconsistent follow-up strategies, overall severe long-term urinary complications were rare.

Strengths and limitations

Strengths include the fact that data was derived from a large institutional database with detailed access to health care data using the national electronic medical journal system that made long-term follow-up available. Also, the data derives from a large population uptake area as pelvic trauma treatment is centralized to Rigshospitalet for 2.2 million people. Limitations include that the data derive from a single institution with its inherited biases. Also, urological trauma is rare, and this data must be considered as extended case report.

Conclusion

Lower urinary tract injuries in patients with major pelvic fractures remain a multidisciplinary challenge. Complete urethral ruptures are associated with severe short- and long-term complications and should receive special attention both in the initial assessment and in the follow-up. Initial treatment of urological injuries remains pragmatic and there is a continuous need for high-quality studies that compare treatment strategies to improve quality of recommendations.

Ethical approval

All data collected about the patient health status and personal information were subject to secrecy. The data collected was stored in a database in anonymized form, according to Danish law regulations. Ethical approval for this study was obtained from Danish data protection agency.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the The Rigshospitalet Research Council.

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References

[1] Coccolini F, Stahel PF, Montori G, et al. Pelvic trauma: WSES classification and guidelines. World J Emerg Surg. 2017;12:5.
[2] Hauschild O, Strohm PC, Culemann U, et al. Mortality in patients with pelvic fractures: results from the German pelvic injury register. J Trauma. 2008;64(2):449–455.
[3] Pohlemann T, Stengel D, Tosounidis G, et al. Survival trends and predictors of mortality in severe pelvic trauma: estimates from the German Pelvic Trauma Registry Initiative. Injury. 2011;42(10):997–1002.
[4] Giannoudis PV, Grotz MRW, Tzioupis C, et al. Prevalence of pelvic fractures, associated injuries, and mortality: the United Kingdom perspective. J Trauma. 2007;63(4):875–883.
[5] Bjurlin MA, Fantus RJ, Mellett MM, et al. Genitourinary injuries in pelvic fracture morbidity and mortality using the National Trauma Data Bank. J Trauma. 2009;67(5):1033–1039.
[6] Brandes S, Borrelli JJ. Pelvic fracture and associated urologic injuries. World J Surg. 2001;25(12):1578–1587.
[7] Pokorny M, Pontes JE, Pierce JMJ. Urological injuries associated with pelvic trauma. J Urol. 1979;121(4):455–457.
[8] Koraitim MM, Marzouk ME, Atta MA, et al. Risk factors and mechanism of urethral injury in pelvic fractures. Br J Urol. 1996;77(6):876–880.
[9] Velazquez N, Fantus RJ, Fantus RJ, et al. Blunt trauma pelvic fracture-associated genitourinary and concomitant lower gastrointestinal injury: incidence, morbidity, and mortality. World J Urol. 2020;38(1):231–238.
[10] Chung PH, Gehring C, Firoozabadi R, et al. Risk stratification for erectile dysfunction after pelvic fracture urethral injuries. Urology. 2018;115:174–178.
[11] Johnsen NV, Kaufman MR, Dmochowski RR, et al. Erectile dysfunction following pelvic fracture urethral injury. Sex Med Rev. 2018;6(1):114–123.
[12] Gómez RG, Mundy T, Dubey D, et al. SIU/ICUD consultation on urethral strictures: pelvic fracture urethral injuries. Urology. 2014;83(3 Suppl):S48–S58.
[13] Mundy AR, Andrich DE. Urethral trauma. Part I: introduction, history, anatomy, pathology, assessment and emergency management. BJU Int. 2011;108(3):310–327.
[14] Chung PH, Wessells H, Voelzke BB. Updated outcomes of early endoscopic realignment for pelvic fracture urethral injuries at a level 1 trauma center. Urology. 2018;112:191–197.
[15] Flynn BJ, Delvecchio FC, Webster GD. Perineal repair of pelvic fracture urethral distraction defects: experience in 120 patients during the last 10 years. J Urol. 2003;170(5):1877–1880.
[16] Lynch TH, Martínez-Piñeiro L, Plas E, et al. EAU guidelines on urological trauma. Eur Urol. 2005;47(1):1–15.
[17] Elshout PJ, Veskimae E, MacLennan S, et al. Outcomes of early endoscopic realignment versus suprapubic cystostomy and delayed urethroplasty for pelvic fracture-related posterior urethral injuries: a systematic review. Eur Urol Focus. 2017;3(6):545–553.
[18] Kitrey ND, Djakovic N, Gonsalves M, et al. EAU guidelines on urological trauma. Arnhem: European Association of Urology.
[19] Morey AF, Brandes S, Dugi DD, 3rd, et al. Urotrauma: AUA guideline. J Urol. 2014;192(2):327–335.
[20] Zhang Y, Zhang K, Fu Q. Emergency treatment of male blunt urethral trauma in China: outcome of different methods in comparison with other countries. Asian J Urol. 2018;5(2):78–87.
[21] Warner JN, Santucci RA. The management of the acute setting of pelvic fracture urethral injury (realignment vs. suprapubic cystostomy alone). Arab J Urol. 2015;13(1):7–12.
[22] Barrett K, Braga LH, Farrokhyar F, et al. Primary realignment vs suprapubic cystostomy for the management of pelvic fracture-associated urethral injuries: a systematic review and meta-analysis. Urology. 2014;83(4):924–929.
[23] Lumen N, Hoebeke P, Troyer BD, et al. Perineal anastomotic urethroplasty for posttraumatic urethral stricture with or without previous urethral manipulations: a review of 61 cases with long-term followup. J Urol. 2009;181(3):1196–1200.

[24] Barratt RC, Bernard J, Mundy AR, et al. Pelvic fracture urethral injury in males-mechanisms of injury, management options and outcomes. Transl Androl Urol. 2018;7(Suppl 1):S29–S62.
[25] Hosseini J, Soleimanzadeh Ardebili F, Fadavi B, et al. Effects of anastomotic posterior urethroplasty (simple or complex) on erectile function: a prospective study. Urol J. 2018;15(2):33–37.
[26] Shenfeld OZ, Kiselgorf D, Gofrit ON, et al. The incidence and causes of erectile dysfunction after pelvic fractures associated with posterior urethral disruption. J Urol. 2003;169(6):2173–2176.
[27] Blaschko SD, Sanford MT, Schlomer BJ, et al. The incidence of erectile dysfunction after pelvic fracture urethral injury: a systematic review and meta-analysis. Arab J Urol. 2015;13(1):68–74.
[28] Wright JL, Nathens AB, Rivara FP, et al. Specific fracture configurations predict sexual and excretory dysfunction in men and women 1 year after pelvic fracture. J Urol. 2006;176(4 Pt 1):1540–1545; discussion 1545.
[29] Kotkin L, Koch MO. Impotence and incontinence after immediate realignment of posterior urethral trauma: result of injury or management? J Urol. 1996;155(5):1600–1603.
[30] Inaba K, Okoye OT, Browder T, et al. Prospective evaluation of the utility of routine postoperative cystogram after traumatic bladder injury. J Trauma Acute Care Surg. 2013;75(6):1019–1023.