Pelvic-fracture urethral injury in children

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SPECIAL ISSUES OF PFUI
REVIEW

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Abstract *Objective:* To review paediatric posterior urethral injuries and the current potential management options; because urethral injury due to pelvic fracture in children is rare and has a low incidence, the management of this type of trauma and its complications remains controversial.

Methods: We reviewed previous reports identified by searching the PubMed Medline electronic database for clinically relevant articles published in the past 25 years. The search was limited to the keywords 'pediatric', 'pelvic fracture', 'urethral injury', 'stricture', 'trauma' and 'reconstruction'.

Results: Most paediatric urethral injuries are a result of pelvic fractures after high-impact blunt trauma. After the diagnosis, immediate bladder drainage via a suprapubic cystotomy, or urethral realignment, are the initial management options, except for a possible immediate primary repair in girls. The common complications of pelvic fracture-associated urethral injury include urethral stricture formation, incontinence and erectile dysfunction. Excellent results can be achieved with delayed urethroplasty for pelvic fracture-associated urethral injuries.

Conclusion: Traumatic injury to the paediatric urethra is rare and calls for an immediate diagnosis and management. These devastating injuries have a high complication rate and therefore a close follow-up is warranted to assure adequate delayed repair by a reconstructive urologist.

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Epidemiology

Among the traumatic injuries to the genitourinary tract in children, urethral injuries account for only a few cases. As in adults, most of these occur in conjunction with a pelvic fracture after blunt trauma. Because

paediatric pelvic fracture-associated urethral injury (PFUI) is rare the available reports are limited to single-centre case series from centres of excellence.

The incidence of paediatric PFUI has been estimated to be 2.4–7.5% [1,2]. The orthopaedic reports show that the most common mechanism of injury is trauma associated with pedestrian impact by motor vehicles (71%), followed by passengers in motor vehicles (24%) [3,4]. The presence of a paediatric pelvic fracture is a strong indicator of serious trauma and carries a high likelihood of potentially life-threatening concomitant injuries. As such, the urologist should seek to obtain immediate bladder drainage and defer definitive urethral management until the patient is clinically stable.

The incidence of paediatric PFUI is <1–5% [4], but it has been reported to be as high as 30% [5]. In the largest series of 212 children with pelvic fractures, Tarman et al. [4] reported the incidence of urethral trauma to be <1%. Boys more commonly sustain a PFUI than girls, and the mean age of children presenting with a PFUI is 9 years [2,4,6].

Pathogenesis

The pelvic fractures that lead to urethral trauma are mostly those causing disruption of the pelvic ring. Specifically, the Malgaigne's fracture (vertical pelvic fractures through ipsilateral anterior and posterior pelvis, with fracture of the sacroiliac complex or sacrum and disruption of the inferior and superior pubic rami or pubic symphysis) and straddle fractures (disruption of all four ischiopubic rami) have a particularly high incidence of urethral injury [5]. These unstable fractures are more common in children and therefore the incidence of PFUI after these severe pelvic injuries is reported to be higher in children than in adults [5,7].

Anatomical differences also contribute to the higher incidence of PFUI in children, i.e., the delicate tissues of an immature pelvis, the relative intra-abdominal position of the bladder, and an underdeveloped prostate in boys. This latter difference can lead to a more proximal urethral injury, including the bladder neck and/or complete urethral disruption [7].

A lower incidence of PFUI is reported in girls than in boys [8]. This difference can be explained by the anatomical variation of the two genders, with the female urethra being shorter, more mobile and almost completely protected by the pubic bone.

Urethral injuries can vary from a minor contusion to partial or complete rupture. In girls, complete disruption of the urethra is most commonly associated with an anterior vaginal laceration. In boys the anterior portion is more susceptible to straddle injuries, causing bulbar urethral trauma due to its trapped anatomical position between the pubic symphysis and the blunt object. The incidence of bulbar urethral trauma

after straddle injuries in boys is 0.6–10% [6,9]. In comparison, the posterior urethra is most commonly injured by pelvic-ring fractures causing shearing forces that disrupt the puboprostatic ligaments and prostato-membranous junction [8]. The incidence of posterior urethral injury secondary to pelvic fracture in boys is 0.47–4.2% [2,6].

Diagnosis

A pelvic fracture in a child indicates that the patient has had a serious, high-impact trauma that is commonly associated with multiple concomitant injuries. In the presence of a pelvic fracture, especially unstable fractures, the clinician should have a high suspicion of a urethral injury. The location and displacement of anterior pelvic fractures might predict the risk of urethral injury, with each millimetre of displacement of the symphysis or inferomedial pubic bone being associated with a 10% higher risk of injury to the urethra [10].

After initial resuscitation and attention to life-threatening injuries, urologist consultation is warranted, particularly if the patient has gross haematuria, several associated injuries, or obvious lower urinary tract injuries on a physical examination (see below). Notably, it has been proposed that isolated microscopic haematuria in a child with a pelvic fracture should not automatically lead to lower urinary tract imaging and urology consultation, because the likelihood of a serious urethral injury is minimal [4]. In such circumstances, clinical suspicion should override any reservations to avoid an evaluation for a suspected PFUI.

Once consulted, the urologist should examine the abdomen and lower genitourinary tract. The most common initial clinical finding is blood at the meatus and/or gross haematuria, potentially resulting in urinary retention. Notably, DREs, especially in children with trauma, have been shown to have a poor sensitivity for the diagnosis of urethral injuries and can be omitted all together [11]. The high-riding prostate on a DRE remains a teaching point but has little clinical significance. Nevertheless, the examiner should consider that a concurrent rectal injury might be present in a child with a urethral injury from pelvic trauma, and which will need to be addressed to prevent severe pelvic infection.

Once the patient is stable, imaging studies aid in the diagnosis. For boys with a suspected urethral injury, the standard is retrograde urethrography (RUG). Depending on the age of the patient, a small feeding tube or 6–8 F urethral catheter is inserted into the fossa navicularis and 10–15 mL of undiluted contrast medium is injected while oblique-view plain radiographs are taken. The ideal position (if the injury permits) is a 45° oblique angle with a stretched penis, to avoid radiographic interference with the femur. RUG in girls is not a feasible option due to the short length of the urethra, and endoscopic evaluation

with cystoscopy and vaginoscopy under general anaesthesia is preferred to confirm the diagnosis.

CT, while not the standard for evaluating urethral injuries, is usually done as a first-line study in the acute setting in patients with high-impact trauma. In adults, CT findings associated with a urethral injury from pelvic fracture include elevation of the prostatic apex and extravasation of urinary contrast material above or below the urogenital diaphragm. However, these findings have not been verified in children [12].

In a non-acute setting, posterior urethral injuries can be assessed by antegrade voiding cysto-urethrography (VCUG) via a suprapubic catheter, in conjunction with RUG. These studies will identify the site, length and severity of the urethral trauma.

There is debate about the accuracy of VCUG/RUG in assessing the length of the disruption. Some have postulated that due to the loss of distensibility of the urethra or patient discomfort during the study, the proximal urethra might not fill with contrast medium, and thus might be misinterpreted as a long proximal urethral injury. Alternatively, a short disruption might be erroneously diagnosed if a urinoma cavity is present and in continuity with the proximal urethra, giving the appearance of an intact posterior urethral segment [7]. In any case, care must be taken in the performance and interpretation of these two diagnostic imaging methods.

In addition, for surgical planning, MRI has been proposed as a valuable method for urethral trauma [13]. MRI has the advantage of accurately defining the entire pelvic anatomy without exposure to ionising radiation, although in children it might require general anaesthesia or sedation due to the prolonged study time.

Another imaging method that is potentially useful in surgical planning is ultrasonography (US). US of the male urethra has not been studied specifically in children, but in adults can give detailed information about the soft tissue surrounding the injury, and is useful in evaluating post-traumatic anterior urethral strictures. For posterior urethral injuries, US can be challenging due to interference from the pelvic bones, and as such, its use is limited.

Treatment

Immediate management

The management of paediatric PFUI presents a challenge for urologists as no consensus or algorithm has yet been proposed or accepted. Significant controversy remains, as the relative infrequency of paediatric PFUI dictates that management is often guided by principles extrapolated from adult injuries.

Nevertheless, several important aspects are worth emphasising. First, the definitive management of a paediatric PFUI should be deferred until the patient is stabilised and the life-threatening injuries have been treated. Next, urethral manipulation should only be attempted after adequate imaging. If the patient needs immediate bladder drainage or urethral imaging is not immediately available, a suprapubic catheter should be placed and the urethral injury assessed after resuscitation. Finally, prophylactic antibiotics should be considered, to avoid infection from extravasation of urine and/or blood.

In the acute setting with a stable patient, there is controversy about the choice between suprapubic catheter drainage with delayed repair vs. immediate endoscopic realignment. Some authors suggest that endoscopic realignment can improve urethral mucosa relocation and possibly prevent urethral stricture formation, while others advise against it completely [7,8,14]. Podesta [15] reported a 100% failure rate for primary realignment for posterior urethral injuries in boys, but another study with twice as many patients (22) reported 65% urethral patency after realignment as the only treatment [16]. In adults primary realignment has been investigated and reported to have a high failure rate, with most patients developing a urethral stricture during the first year after the injury [17].

Despite the low definitive success rate of endoscopic realignment, advocates argue that it might decrease the length of the urethral defect, facilitating delayed urethroplasty [18]. If the decision is made to place a realigning catheter, it should remain in place for ⩾3 weeks for partial urethral injuries and for ⩾6 weeks for complete disruptions, at which time RUG/VCUG can determine if the patient has formed a stricture or has continued extravasation. A mandatory follow-up is recommended after removing the realigning catheter, as the timing of urethral stricture recurrence among realignment failures in one case series was a mean of 79 days after urethral catheter removal [17].

Immediate open repair should not be attempted due to a high risk of bleeding and possible disruption of the tamponade effect created by the pelvic haematoma, unless the injury is penetrating and involves the anterior urethra [8]. In the setting of rectal injury and/or bladder neck laceration, early surgical repair should be considered, to reduce the long-term complications of delayed surgery.

There is controversy about the management of acute urethral injuries in girls. A review showed that primary repair in an acute setting can result in a satisfactory outcome, with only a few patients requiring additional surgery [19]. Hence, some argue that the preferred approach to manage female PFUI is by primary repair of the urethra and vaginal wall, with urethral catheter drainage. However, primary repair in an acute setting can be technically challenging, requiring an experienced reconstructive surgeon. Furthermore, the low incidence

of these injuries precludes any ability to definitively recommend an algorithm-based treatment. Repair should be dictated by the severity of injury and the clinical experience of the surgeon. If the urethral injury is grossly displaced or complex, and no experienced urologist is available, urinary diversion with a suprapubic catheter is advised. Notably, with preliminary suprapubic cystotomy almost all female patients with a urethral injury will develop a stricture with dense scar around the urethral injury site, and at times involving the vaginal wall, leading to vaginal stenosis [20].

Deferred repair/sequelae

The ultimate goal in managing a urethral injury is to avoid long-term sequelae and achieve adequate voiding function, continence and sexual potency. Of the complications that can ensue from PFUI, urethral stricture is the most commonly reported, with an incidence of 25% [21]. The treatment of post-traumatic urethral strictures in children presents a challenge to the urologist. The management of the stricture depends on the location, length, bladder neck integrity and the gender of the patient.

Only a few series have examined the management of PFUI in girls, and as such, formal recommendations are not possible. In the rare event that the urethral stricture in female patients is particularly short, some authors suggest delayed direct-vision internal urethrotomy. Alternatively, if the stricture is distal with no involvement of the bladder neck, creation of a neomeatus with a simple incision has been reported [19]. In girls with complete urethral obstruction, a bladder-tube flap that creates a neourethra has been described, and has acceptable results. Due to the risk of stress urinary incontinence after this surgery, a bladder-neck suspension should be considered [19]. Complete excision of the scar tissue followed by end-to-end anastomosis with an omental flap wrapped around the bladder neck has also been described [22]. Only three of the seven girls in this small series had mild stress urinary incontinence that was managed with Kegel exercises and medical treatment.

Podesta and Jordan [20] reported a series of PFU strictures in girls who had a combined vaginal-transpubic approach, and had a high stricture-free rate of 100%. With this approach they were also able to address a urethro-vaginal fistula and vaginal stricture. They noted that injury to the bladder neck correlated with postoperative incontinence.

Among boys, stricture formation can be divided into the anterior and the posterior urethra, and each might need a different surgical approach. A 32-year experience by one surgeon showed that anterior urethral strictures in boys could be repaired via the perineal approach with either an excision and primary-anastomosis urethro-plasty, or with a ventral buccal mucosa graft onlay [6]. In that study, a buccal graft was used when the stricture length was >2 cm, but at times even longer strictures were repaired with a primary anastomosis. The success rate after anastomotic urethroplasty and ventral buccal graft urethroplasty was 100% and 80%, respectively. Among posterior urethral strictures in that study, a perineal primary anastomotic repair was possible, except for one patient who required a combined perineal-abdominal approach due to a long stricture. The overall success rate for the posterior stricture cohort was 88.9%. For the postoperative failures, endoscopic treatment with urethrotomy was a successful salvage manoeuvre. The success of endoscopic incision for recurrent stricture after post-traumatic anastomotic urethroplasty has been confirmed in a series of 22 boys [23]. The authors concluded that urethrotomy for strictures of <1 cm after urethroplasty is a sufficient treatment, with a high success rate (90%) and no urinary complications. Notably, multiple endoscopic treatments as a first-line treatment for post-traumatic urethral strictures in children should be avoided, as scarring and re-stricturing can occur, making a definitive repair more challenging.

Even though the perineal approach is generally appropriate for repairing a stricture in children, surgeons should be familiar with the transpubic and abdominal approaches, as the disruption can extend into the prostatomembranous junction and bladder neck [24,25]. Outcomes have been reported to be similar between the perineal (84%) and transpubic (100%) approaches [15]. In that series, the decision between them was based on the stricture length, with strictures of >3 cm being repaired with the abdomino-perineal approach for better exposure and a tension-free repair. In a series of 78 boys undergoing delayed repair there was a similarly high success rate of 93% for perineal and 91% for transpubic urethroplasty [26]. Notably, in that series, a few patients were treated with a urethro-scrotal inlay, with a high failure rate of 57%. Similarly high failure rates have been reported with substitution urethroplasty using a tubed penile fasciocutaneous flap [27].

Initial incontinence rates after a transpubic approach have been reported to be as high as 30%. This postoperative stress urinary incontinence is mostly transient, but if persistent, incontinence can be attributable to the bladder neck injury from the trauma itself and not to the surgical approach [28,29]. Other complications of transpubic urethroplasty are due to the removal of the pubic bone with ensuing bladder herniation and an abnormal gait. As an alternative to pubic bone resection, symphysiotomy has been described as an effective and less morbid approach [30].

For a long prostatomembranous stricture, a perineal transpubic technique with no need for abdominal expo-

sure was recently reported [29]. Twelve boys had a urethral gap of > 5 cm after excision of the scar tissue. The pubic bone was removed after complete separation and retraction of the two corporal bodies through the perineal exposure. This surgical technique has an acceptable urethral patency rate, but the penis was shortened in three-quarters of the boys, and the method needs further validation by reconstructive surgeons. An anterior sagittal trans-anorectal exposure is another alternative approach to avoid an abdominal incision for PFUIs [31]. With this technique the patient is placed prone with a bolster elevating the pelvis. The midline incision is made from the anterior margin of the anus to the scrotum, and the anterior rectal wall is opened to expose the bulbar urethra.

Urethral patency was established in all but one patient in this small series of 11 patients. There were no postoperative reports of recto-urethral fistula or faecal incontinence. Currently, the commonest operation for PFUI that has been reported by Webster and Ramon [32] in adults is an elaborate perineal approach which includes distal urethral mobilisation, corporeal body separation, inferior pubectomy, and supracrural urethral re-routing in a sequential manner to allow for a tension-free repair.

Only a few studies have investigated the effect of a PFUI on erectile function. The reported incidence of ED is up to 60–75% [33,34]. A recent study of 60 patients showed that a urethral gap length of > 2.5 cm and lateral prostatic displacement were independent predictors of ED after injury. Duplex US showed that the cause of ED was mostly arteriogenic, and the authors concluded that half of the children sustaining a traumatic urethral injury will have ED at puberty when assessed with the International Index of Erectile Function [35]. The pelvic fracture, not the ensuing urethral reconstruction, is the most likely cause of ED, and the highest rates of ED (75%) are due to injuries proximal to the prostatomembranous region [33].

Most studies have focused on managing the complications of PFUI, but little is known about the long-term psychological effects of severe physical trauma. A psychiatric evaluation was reported for 49 patients who had sustained a traumatic posterior urethral rupture as a child, and psychiatric disorders were diagnosed in 43% of these patients [36]. Psychological diseases included dysthymic disorder, social phobia, post-traumatic stress disorder, separation anxiety, major depression and generalised anxiety disorder, which correlated with the number of urological procedures required, the total number of hospitalisations, and presence of long-term hospitalisation. The latter also had a significant effect on the child's education. The authors recommended a multidisciplinary approach, including a child psychiatrist for those under long-term hospitalisation.

Conclusion

PFUI in children is uncommon and often secondary to high-impact trauma. If the child is diagnosed with an unstable pelvic fracture the suspicion for urethral injury should be high and evaluated with adequate imaging. Due to the rarity of the injury there is controversy about the choice of suprapubic tube placement and immediate realignment in the stable patient after trauma. Nevertheless, if the patient is unstable or no experienced urologist is available, a suprapubic catheter should be placed for bladder decompression. Complications after PFUI most commonly include urethral stricture formation, incontinence and ED. Last, delayed urethroplasty in the paediatric trauma patient has successful outcomes and can be managed with adult-based algorithms.

Conflict of interest

None.

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