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Diagnosis and Management of Pediatric Urethral Injuries

Key Words

Reconstruction · Urethral injury · Urethral stricture ·
Trauma · Diagnosis · Therapy

Abstract

Objective: The incidence of urethral injuries in children is rare due to the fact that the urethra is short, mobile and protected by the pubic bone. The management of urethral trauma in childhood remains controversial because of the limited expertise of most urologists. **Material and Methods:** We performed a literature review by searching the Medline database for articles published between 1975 and 2010 based on clinical relevance. Electronic searches were limited to the keywords 'pediatric', 'urethral injury', 'trauma' and 'reconstruction'. **Results:** Retrograde urethrography is considered the gold standard for diagnosis of urethral injuries. The initial management should ensure drainage of the bladder either by suprapubic cystostomy or urethral realignment if possible: in complete anterior urethral disruption as well as in children with life-threatening pelvic and intra-abdominal injuries after posterior urethral injuries, a deferred repair after 3 months is necessary. Immediate primary suturing of disrupted and dislocated urethral ends should be avoided because of high complication rates. Primary repair, however, of the defect is possible in girls avoiding a 2-stage approach. **Conclusion:** The aim of therapy is minimizing remote dam-

ages such as urethrocutaneous fistulae, periurethral diverticulae, strictures, incontinence and impotence with different therapeutic management depending on classification of the injury and the presence of life-threatening injuries.

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Introduction

Traumatic injury to the pediatric urethra is a relatively rare but possibly serious event in children [1]. Straddle injuries caused by a blow to the perineum as a result of striking an exterior object with the power of one's own body weight and significant trauma to the urethra resulting from a pelvic fracture occurs in both sexes. Urethral injuries in girls are rare because of the short mobile urethra and the well-protected localization behind the pubic bone. Injuries occur mainly with pelvic fractures and are associated with laceration of the anterior vaginal wall due to the intimate contact of these two structures.

Basis for Etiological Considerations

In males the urethra is divided into the anterior and posterior segments by the urogenital diaphragm. The posterior urethra consists of the membranous urethra

Fig. 1. Sagittal view of the pelvis and external genitalia in a newborn boy (arrow: prostate; asterisk: symphysis). Plastination: Department of Anatomy, Histology and Embryology (EB, HF), Prof. H. Fritsch, MD.

enclosed in the urogenital diaphragm, and the prostatic urethra. The anterior part is formed by the bulbar and penile urethra. The pelvic diaphragm closes the pelvic outlet and supports the pelvic contents, including the uterus and vagina in females and the bladder and rectum in both males and females. In both sexes the pelvic floor forms the basic boundary between the posterior and anterior urethra. The perineal membrane, which represents the fascia of the urogenital diaphragm, is a significant landmark adjudicating upon the degree and/or classification of urethral injury, as reflected by the amount of contrast material extravasation above or below this membrane during a retrograde urethrogram.

Classification of Urethral Injuries

Anterior urethral injuries originate from blunt trauma such as vehicular accidents such as falling astraddle on the crossbar of a bike or blows to the perineum from bicycle handlebars, tops of fences or kicks to the perineum. Characteristically, these traumas are straddle-type injuries infrequently associated with pelvic fractures. Predominantly, the bulbar urethra is concerned, as due to the trapped anatomical position, the bulbous urethra is compressed between the blunt objects and the concave inferior surface area of the symphysis pubis. The injury of the anterior urethra represents the predominant lesion type in boys [2].

Posterior urethral injuries are linked with pelvic fractures, most commonly caused by road traffic accidents, crush injuries and falls from height. In contrast to adults, the intra-abdominal location of the bladder and the pre-pubescent smaller as well as more cranially placed prostate predispose to complete posterior urethral rupture in boys [3] (fig. 1).

Due to the fact that the prostatomembranous urethra is entirely encircled by the rigid ischiatic arch, it is obvious that a pelvic injury with straddle fractures involves the posterior urethra. A disruption of the prostatomembranous urethra occurs at the two fixation points of the posterior urethra. The first of these is at the urogenital diaphragm which adheres to the ischiopubic rami. Secondly, injuries occur at the puboprostatic ligaments, the fixation point of the prostatic urethra to the anterior pubic arch. Fractures of the infant pelvis can be categorized, e.g. according to Torode and Zieg [4], from I to IV. Types I, II and III are stable fractures classified as avulsions, iliac wing fractures or plain pelvic ring fractures, respectively. Especially high-energy vertical forces transmitted to the pelvis via extended femurs produce Malignant fractures (type IV fractures), which are characterized by anterior fractures through the rami or pubic symphysis coupled with posterior fractures of the ipsilateral ilium, sacrum or sacroiliac joint [5]. The consequence of these major shearing forces is the rupture of the puboprostatic ligaments and the prostatomembranous junction. Mobilization of the prostate and the blad-

Fig. 2. Retrograde urethrogram in a 14-year-old boy. Extravasations of contrast agent proximal to the urogenital diaphragm indicating a type II injury according to Goldman.

Fig. 3. Contrast medium within the extraperitoneal pelvis as a result of posterior urethral injury proximal to the urogenital diaphragm.

Fig. 4. Contrast medium within the borders of the dartos (Colles') fascia as a result of anterior urethral injury distal to the urogenital diaphragm.

der usually takes place. In addition to the disruption of the dorsal venous complex, a hematoma develops and the prostate is displaced consequently (high-riding prostate) [6] (fig. 2).

Goldman Classification

Even though many classifications have been proposed for urethral traumatic injuries, the most accepted scheme based on the results of retrograde urethrography is the Goldman classification [7]. The scheme is divided into five types:

Type I: Rupture of the puboprostatic ligament, the posterior urethra is intact, but stretched by the movement of the prostate and the neck of the bladder superiorly; therefore, no extravasation of contrast material is seen.

Type II: Partial or complete posterior urethral injury in which the tear of the membranous urethra is found above the urogenital diaphragm; contrast-agent extravasation is seen within the extraperitoneal pelvis (fig. 3).

Type III: Partial or complete posterior urethral injury with disruption of the urogenital diaphragm including the proximal bulbous urethra leading to an extravasation not only within the extraperitoneal pelvis, but also within the perineum.

Type IV: Bladder neck injury with extension into the proximal urethra; the contrast-agent extravasation is found in the extraperitoneal pelvis just about the bladder neck and periurethrally. If only the bladder base without extension into the urethra is injured, a type IVA can be distinguished.

Type V: Partial or complete injury confined to the anterior urethra, hence extravasation is present inferior to the urogenital diaphragm. Only after disruption of the deep layer of the penile fascia, contrast agent is issued within the borders of the dartos fascia (fig. 4).

Incidence

Urethral injuries account for 3.4% of the children admitted with traumatic injuries of the genitourinary tract [8]. The reported frequency of urethral injury in pelvic traumas of boys range from 7.4 to 13.5%, urethral injury in girls have reported incidences of about 4–6% [9, 10]. Nevertheless, one should also pay attention to minor lesions of the pelvis which can result in urologic problems in the pediatric age group, as these urogenital injuries, particularly urethral contusion in girls, tend to be underdiagnosed [11].

Diagnosis

Clinical Assessment

In the presence of pelvic fracture of every type, straddle injuries or penetrating trauma close to the urethra, one should investigate the infant urethra. The most common clinical feature is blood at the meatus and/or hematuria followed by perineal, scrotal and labial hematoma. A typical butterfly configuration of the hematoma at the superficial perineum is found in children with injuries to the urethra distal of the urogenital diaphragm ('butterfly' bruising) [12]. In boys, scrotal enlargement is the consequence of extravasated fluids after rupture of Scarpa's fascia and its continuation into the perineum, i.e. the dartos fascia. Moreover, an inability to void with severe residual urine and a high-riding prostate on rectal examination is suspicious for a traumatic involvement of the urethra [13]. In girls with severe pelvic fractures, the presence of labial swelling may indicate urethral injury with extravasation of urine.

Computed Tomography

Because an extensive trauma as the underlying mechanism of urethral injury can generally be assumed, CT scanning is the preferred primary diagnostic device. Although it will not directly show the urethral trauma, a complex analysis of the entire involved bone structure as well as soft tissue organs of the pelvis and retroperitoneum is possible. Classification of pelvic fracture with concomitant hematoma development should be performed initially. In experienced hands, it is also possible to use CT as an initial screening method for urethral injuries [14].

Magnetic Resonance Imaging

Particularly in evaluating posterior urethral injuries and estimating the length of the urethral obliteration as well as the degree of fibrosis of the external sphincter complex, MRI provides considerable advantages when delayed reconstruction is performed [15]. MRI represents an image modality with less overall exposure to ionizing radiation for children, but general anesthesia or sedation is necessary in small infants.

Retrograde Urethrography

Retrograde urethrography is considered the gold standard in diagnosing urethral injuries. The plain radiographs of the pelvis taken during the exam are not only able to reveal a fractured pubic ramus and diastasis of the pubic symphysis, but also foreign bodies, such as bullets or stones. Depending on the age, a 6- to 8-Fr Foley catheter is

placed to the fossa navicularis in boys. Ten to 15 ml of undiluted contrast material is injected and films are taken during the injection. As soon as the general condition of the child permits, the patient should be positioned at a 45° oblique angle with a stretched penis and a cephalad meatus to avoid radiographic interference with the femur.

Anterograde Cystourethrogram

In posterior urethral injuries a simultaneous retrograde urethrography and antegrade cystogram via a suprapubic catheter is performed initially or at a later date to assess the site, severity and length of the urethral injury.

Ultrasonography

Because retrograde urethrography does not provide more detailed information on the adjoining soft tissue injury, sonourethrography combined with insufflation of saline solution distending the lumen is suggested [16]. In the follow-up or rather before second-stage surgery, an evaluation of the length of strictures as well as reactive spongiofibrosis and false tracts using sonourethrography is achievable [17].

Cystoscopy

After suprapubic drainage of the bladder and radiographic demonstration of the site of the urethral trauma and extravasation, subsequent cystoscopy (combined with guidewire placement) within the scope of therapeutic transurethral splinting is advantageous. Due to the shortness of the female urethra, girls in particular benefit from this endoscopic examination [18].

Therapy

The management of the urethral trauma remains controversial because of the limited expertise of most pediatric urologists due to the infrequency of these injuries. If any urethral injury is suspected, no attempts at urethral instrumentation should be made until the entire urethra is imaged as described above. To avoid infections as a result of urine or blood extravasation, which may cause an inflammatory reaction, antibiotics should be administered. Definitive management can be considered as soon as the patient is stabilized and life-threatening injuries have been treated. The aim of the therapy is minimizing remote damages, in particular urethrocutaneous fistulae, periurethral diverticulae, stricture formation, incontinence and impotence. Except for some partial type V (an-

terior) injuries, the initial management is to obtain drainage of the bladder by a suprapubic cystostomy, which assures not only a safe urinary diversion, but also prevents urine extravasation at the site of injury.

Anterior Urethral Injuries (Type V, Partial or Complete)

In partial anterior urethral injuries, the suprapubic tube should remain in situ for 4 weeks. After a normal VCUG without signs of contrast extravasation or stricture, the cystostomy can be removed. In stabilized patients with non-life-threatening urethral injuries, a catheter placed over an endoscopically inserted guidewire is useful to allow for improved urethral mucosa relocation. Immediate surgical repair could be performed for complete disruption of the urethra in penetrating or open anterior traumas. Surgery should keep in mind the principles of hypospadias repair to avoid strictures or urethrocutaneous fistulas [19]. If complete disruption associated with longer defects or dislocation of the distracted two ends of the urethra requires complex reconstruction, a deferred treatment after 3 months is necessary.

Posterior Urethral Injuries (Types I–IV)

The majority of partial posterior urethral injuries are managed by the placement of a suprapubic tube; a combined retrograde and antegrade urethrogram is performed when appropriate. Complete posterior urethral ruptures (types II–III) are managed with a suprapubic diversion followed by a delayed repair after 1–2 weeks. By this time the pelvic hematoma has resolved, while formation of periurethral or pelvic fibrosis is nascent [20]. Suprapubic cystostomy combined with postponing repair after months is necessary in unstable patients with life-threatening pelvic and intra-abdominal injuries. The complete urethral disruption results in a bulboprostatic urethral gap replaced by an organized hematoma showing angiogenesis and fibrosis [21]. As an alternative to a cystostomy, a temporary continent urinary diversion in terms of an appendicovesicostomy (Mitrofanoff principle) may be used [22]. This catheterizable stoma provides continence and perpetuates a low-pressure urine reservoir while allowing postponement of surgical repair.

Immediate primary suturing of disrupted urethral ends is associated with high complication rates of strictures, restenosis, incontinence and impotence [23]. Although these complications seem to be related to the severity of the primary injury of the pelvic trauma and associated bladder neck rupture [24], prompt surgical repair cannot be recommended due to the often critical general

state and associated injuries of the child. Immediate open repair may remove the tamponade effect caused by the pelvic hematoma and thus carries the potential for hemorrhage. Primary open realignment bridging the urethral gap under direct vision using two sounds or one punched sound combined with a retrograde cystoscopy permitting guidewire placement allows correction of the proximal displaced prostate and apposition of distinct dehiscent urethral stumps [25]. This method, however, results in an increase of impotence rates when compared to delayed repair (36 vs. 19%) on account of the periprostatic exploration and/or dissection [2].

In partial proximal urethral injuries or in a marginal urethral dehiscence, a simple endoscopic realignment pushing forward a guidewire is feasible. This may be assisted by means of vital dyes injected via the suprapubic tube. Because pediatric trauma patients may receive multiple CT scans, time-consuming radiological realignment should be avoided in children to minimize radiation exposure [26]. Endourological repair should not enhance the resulting impotence rate as no periprostatic surgery is required. Consequently, endoscopic realignment should be the therapeutic goal in children if appropriate pediatric endoscopic equipment is available. Adequate infant and pediatric cystoscopic equipment should be combined with a video camera system to allow magnification of the infant's demanding anatomy. The discussion about the initial treatment of posterior urethral injuries as well as the recommendation of primary endoscopic alignment is still ongoing; accurate statistics focusing on the pediatric population are not yet available [27].

Deferred Repair

In case of the development of a posterior urethral distraction with strictures, experience of a wide-range of surgical procedures considering the specific infant anatomy is necessary. The extent and depth of the traumatic posterior urethral distraction defect, with or without involvement of the external sphincter complex, is frequently difficult to predict before surgical intervention. Because of the more abdominally located bladder and small prostate in boys, urethral injury frequently comprises both the membranous and supraprostatic regions [28]. However, it is controversial whether injuries of the mid-prostatic urethra ever result in transverse cuts or strictures rather than anterior longitudinal tears without stricture formations [3]. Mainly because of the incomplete filling of the prostatic urethra, the accurate distance of the distraction de-

fect is frequently misjudged; therefore, a priori transpubic urethroplasty is often preferred [3]. MRI can resolve this problem not only because the required general anesthesia in infants results in ideal examination conditions, but also because MRI provides anatomic detail of the periurethral tissues and the orientation of the lesion in three dimensions [29]. Most surgeons prefer the perineal approach to perform a bulboprostatic anastomotic repair, which is also the technique used in adulthood to treat injuries of the membranous urethra [30]. Nevertheless, if a prostatic displacement and/or a long distance of the urethral stumps are diagnosed preoperatively, a transpubic procedure is advisable. The disadvantage of this transpubic approach lies in the partial or complete pubectomy needed, which leads to a ventral gap and thus implies an increased risk for hernia and an abnormal foot position [31]. Symphysiotomy, in which the pubic cartilage is transected and forced apart by a retractor, represents an excellent alternative to pubic resection [32]. Deferred treatment should consider the golden triad assuring successful outcome, i.e. complete excision of scarred tissues, lateral fixation of healthy mucosa of the urethral endings and creation of a tension-free anastomosis [33].

As opposed to the decision-making in urethral injuries, the treatment of urethral injuries in girls should aim at a primary repair of the defect [34]. A 2-stage approach performing a suprapubic cystostomy to postpone definitive repair should be avoided, as the formation of scar tissue at the site of obliteration tends to result not only in urethral stricture, but also in dense adhesion and scarring of the vaginal wall, which in turn can cause vaginal stenosis [35]. The primary repair of the female urethra consequently includes the care of the lacerated vaginal wall to ensure an adequate vaginal opening allowing menses and subsequent cohabitation [36]. Primary repair and reconstruction of the vaginal wall not only prevent vaginal stenosis, but also facilitate the approximation of the urethral stumps. For patients with widely separated urethral ends requiring sutures under tension, for those patients in whom it proves impossible to identify the urethral stumps, and for patients with widely displaced pelvic fractures, a preliminary urinary diversion with suprapubic cystostomy followed by a definitive repair after several weeks is indicated. In life-threatening clinical conditions it is inadvisable to perform immediate surgical repair. In these cases, early cystostomy drainage with deferred surgical reconstruction is recommended [37]. According to the degree of the urethral and vaginal injury, a transvaginal, abdominal-vaginal, retropubic or transpubic approach with symphysiotomy is advisable.

After complete or partial loss of the urethra as a result of pelvic fracture, a flipped anterior or oblique bladder-wall tube may be suggested [38, 39]. Hosseini et al. [40] reported on 7 girls (median age: 6 years) with a complete urethral disruption after pelvic fracture. All of them underwent delayed retropubic urethroplasty with end-to-end anastomosis of the urethra 6 months after the trauma. After a median follow-up of 36 months, 3 girls developed mild stress urinary incontinence. Continence is achieved by the detrusor tonus of this tubularized bladder flap as well as by additionally performing bladder neck suspension.

Iatrogenic Urethral Trauma Caused by Catheterization

In adults the majority of iatrogenic lesions are the result of improper or prolonged catheterization and account for 32% of urethral strictures. Of these, 52% affect the bulbar and/or prostatic urethra [41]. In children data published on this matter are rare. D'Cruz et al. [42] reviewed urethral injuries arising from incorrect balloon insertion in children undergoing urinary catheterization from 1995 to 2006. Only 6 boys (aged 1 month to 16 years) were identified over the 11-year period. All injuries were confirmed by urethrogram. The bulbar and prostatic urethra were affected in 3 (50%) and 3 (50%) children, respectively. Three boys needed suprapubic catheters, but follow-up imaging revealed healing without stricture in all patients with no long-term complications. Alcázar García et al. [43] evaluated retrospectively the incidence of possible complications after urinary catheter insertion (performing MCUG) in 181 children: 96.7% of the children who underwent this technique did not manifest any type of complication nor urinary discomfort. In children undergoing cardiac surgery, the urinary catheter should be removed as soon as possible postoperatively. The risk of postcatheterization urethral strictures in this patient group is higher because of poor tissue perfusion concomitant with serious congenital cardiac anomalies together with secondary urine infection in the presence of a urethral catheter [44]. Balloon-related urethral trauma, especially in children, can be avoided by the implementation of educational programs and educating health-care professionals on proper placement and confirmation of the position of the catheter to decrease the exposure of children to catheter-related risk factors (such as prolonged and/or improper catheterization).

Conclusion

Urethral injuries in children are rare. The management of the urethral trauma remains controversial largely because of the limited expertise of most pediatric urol-

ogists. The aim of therapy should be to minimize remote damages such as urethrocutaneous fistula, periurethral diverticula, urethral stricture, incontinence and impotence.

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