SIU/ICUD Consultation on Urethral Strictures: Epidemiology, Etiology, Anatomy, and Nomenclature of Urethral Stenoses, Strictures, and Pelvic Fracture Urethral Disruption Injuries

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This committee reviewed and evaluated published data, and recommended standardized terminology relating to the epidemiology, etiology, anatomy, and nomenclature of urethral stenoses, urethral strictures, and pelvic fracture urethral disruption injuries, as well as their surgical management. A literature search using Medline, PubMed (U.S. National Library of Medicine and the National Institutes of Health), Embase, online acronym databases, and abstracts from scientific meetings was performed from 1980-2010. Articles were evaluated using the Levels of Evidence adapted by the International Consultation on Urological Diseases (ICUD) from the Oxford Centre for Evidence-Based Medicine. Recommendations were based on the level of evidence and discussed among the committee to reach a consensus. There is expert opinion to support standards regarding the epidemiology, anatomy, and nomenclature of urethral stenoses, urethral strictures, and pelvic fracture urethral disruption injuries. There is level 3 evidence regarding the epidemiology and etiology of urethral stenoses, urethral strictures, and pelvic fracture urethral injuries. The literature regarding the epidemiology, anatomy, and nomenclature of urethral stenoses, urethral strictures, and pelvic fracture urethral disruption injuries are sparse and generally of a low level of evidence. The proposed ICUD system does not readily apply to these areas. Further research is needed so that stronger levels of evidence can be developed leading to recommendations regarding the accuracy of the data. To improve future research and promote effective scientific progress and communication, a standardized nomenclature and anatomy regarding the urethra and urethral surgery is detailed herein. UROLOGY 83: S1–S7, 2014. © 2014 Elsevier Inc.

This committee was charged with the responsibility of reviewing and evaluating published data, and standardizing terminology relating to the epidemiology, etiology, anatomy, and nomenclature of urethral stenoses, urethral strictures, and pelvic fracture urethral disruption injuries, as well as their surgical management.

MATERIAL AND METHODS

A literature search using Medline, PubMed (U.S. National Library of Medicine and the National Institutes of Health), Embase, online acronym databases, and abstracts from scientific meetings was performed for documents published from 1980-2010. Articles were evaluated using the Levels of Evidence adapted by the International Consultation on Urological Diseases (ICUD) from the Oxford Centre for Evidence-Based Medicine. Recommendations were based on the level of evidence and discussed among the committee members to reach a consensus.

RESULTS

The nomenclature pertinent to urethral stenoses, urethral strictures, and pelvic fracture urethral injuries, as well as their surgical management, is presented in this chapter. There is expert opinion to support standards regarding the epidemiology, anatomy, and nomenclature of urethral stenoses, urethral strictures, and pelvic fracture urethral disruption injuries.

The etiology of anterior urethral stricture disease may be broadly subcategorized into iatrogenic, traumatic, inflammatory, and idiopathic causes. There is level 3 evidence regarding the epidemiology and etiology of urethral stenoses, urethral strictures, and pelvic fracture urethral injuries. The gross and histologic anatomy of these conditions is presented in this chapter.

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CONCLUSIONS

The literature regarding the epidemiology, anatomy, and nomenclature of urethral stenoses, urethral strictures, and pelvic fracture urethral disruption injuries are sparse and generally of a low level of evidence. The proposed ICUD system does not readily apply to the areas of epidemiology, anatomy, and nomenclature.

Further research is needed so that stronger levels of evidence can be developed that can lead to recommendations regarding the accuracy of the data. To improve future research and promote effective scientific progress and communication, a standardized nomenclature and anatomy as to the urethra and urethral surgery was formulated and is detailed herein. Further research is needed to elucidate the mechanisms and etiology of certain urethral strictures and stenoses.

Introduction and Statement of the Problem

This committee was charged with the responsibility of reviewing and evaluating published data, and standardizing terminology relating to the epidemiology, etiology, and anatomy of urethral stenoses, urethral strictures, and pelvic fracture urethral disruption injuries, as well as their surgical management.

Relevant genitourinary anatomy related to the evaluation and management of these conditions is presented. A standardized nomenclature for urethral anatomy, urethral strictures, urethral stenoses, urethral injuries, and urethral surgery was formulated and is detailed herein.

Adoption of this standardized nomenclature from this point on should improve future research and promote effective scientific progress and communication among urologists and reconstructive specialists involved in the evaluation and management of men with urethral stenoses, urethral strictures, and pelvic fracture urethral injuries.

Methods/Identification of References

A literature search using Medline, PubMed, Embase, online acronym databases, and abstracts from scientific meetings from 1980-2010 was the basis of this review. The online electronic literature search involved unrestricted, fully exploded Medical Subject Headings (MeSH) using terms related to urethral stenoses, urethral strictures, and pelvic fracture urethral disruption injuries in men. Four online acronym databases—the Acronym Resolving General Heuristics (ARGH) program, the Stanford Biomedical Abbreviation Server, AroMed, and the Simple and Robust Abbreviation Dictionary (SaRAD)—were identified and queried regarding urethral surgery.

Articles were evaluated using the Levels of Evidence adapted by the ICUD from the Oxford Centre for Evidence-Based Medicine. Recommendations were based on the level of evidence and discussed among the committee members to reach consensus. Recommendations for future research are also presented.

Quality of the References.

Level 1. Meta-analyses of randomized controlled trials (RCTs) or good-quality prospective RCTs (Oxford 1a, 1b [0 references]).

Level 2. Clinical studies in which the data were collected prospectively and retrospective analyses based on clearly reliable data. Types of studies so classified include: observational studies, cohort studies, prevalence studies, low-quality RCTs, and case-control studies (Oxford 2a, 2b, 2c [0 references]).

Level 3. Studies based on retrospectively collected data. Evidence in this class includes case-control studies, clinical case series, and database or registry reviews (Oxford 3a, 3b,3c [~50 references]).

Level 4. Expert opinion (Oxford 4).

Recommendations

There is insufficient Level 1 and 2 evidence/data to support any grade A or B recommendations, but there is Level 3 evidence to support grade C recommendations regarding the epidemiology, anatomy, and nomenclature of urethral stenoses, urethral strictures, and pelvic fracture urethral injuries.

Scientific Foundations

Nomenclature Pertinent to Urethral Stenoses, Strictures, and Pelvic Fracture Urethral Injuries. Urethral "stricture" is the preferred term to describe an abnormal narrowing of any segment of the urethra surrounded by corpus spongiosum, and specifically implies varying degrees of spongiofibrosis. The term "spongiofibrosis" refers to scarring of the corpus spongiosum of varying degrees. Urethral "stricture disease" implies the underlying etiology. The Consultation Committee recommends that urethral terminology should be anatomical; therefore, the preferred term to describe urethral narrowing/obliteration is urethral "stricture." The term "stricture disease" should be reserved as a second-tier term. The term "stenosis" is reserved for narrowing of the membranous urethra (not secondary to pelvic fracture urethral injury), the prostatic urethra, and the bladder neck, as they are not invested by corpus spongiosum. Importantly, the term "stenosis" does not imply spongiofibrosis.

Urethral "calibration" refers to the measurement of the caliber (diameter) of the urethral lumen by various techniques. Urethral "dilation" refers to the stretching or enlargement of the urethral lumen by various techniques. The Consultation Committee recognizes that the term "dilatation" is used interchangeably. "Urethrotomy" is the general term to describe the incision of urethral epithelium and underlying spongiosum by either endoscopic or open techniques. "Internal urethrotomy" refers to an endoscopic urethrotomy performed with or without visual guidance. "Direct vision internal urethrotomy" (DVIU) refers to an endoscopic, visually guided incision of the scarred urethra using various techniques and is the preferred term. Second-tier terms are "optical internal urethrotomy" (OIU) and "visual internal urethrotomy" (VIU).

Regarding urethroplasty techniques, the term "onlay" refers to expanding the caliber of the urethra with a tissue graft or flap. The term "inlay" is not descriptive and not acceptable. "Excision and primary anastomosis (EPA) urethroplasty/urethral reconstruction" refers to when a narrowed urethral segment and its corresponding spongiofibrosis are excised with reapproximation of the two healthy ends of the urethra. This is the most descriptive, accurate, and appropriate term for this type of urethroplasty. The term "anastomotic urethroplasty/urethral reconstruction" should be reserved as a second-tier term, and "end-to-end urethroplasty" as a third-tier term. "Posterior" urethral reconstruction refers to reconstruction of the membranous urethra or prostatic urethra by various techniques and includes the subcategory of anastomotic repair for pelvic fracture urethral injuries.

The term "graft" refers to a tissue transfer technique where healthy tissue is harvested from one part of the body and transferred to another in order to replace diseased or injured tissue. A graft is without its own blood supply and relies on diffusion from its host bed for initial survival and subsequent re-establishment of the blood supply. "Flap" refers to a tissue transfer technique where healthy tissue is transferred on a vascular pedicle from one part of the body to another in order to replace/augment diseased or injured tissue. It is recognized that the continuity of the pedicle for microvascular free transfer flaps is surgically re-established at the time of surgery. Specific further description of tissue grafts and flaps is based on their anatomic donor site of origin and structure, and will not be described herein. The term "augmented urethroplasty/urethral reconstruction" describes urethral reconstruction with a tissue graft or flap, whereas the term "substitution urethroplasty/urethral reconstruction" describes urethral reconstruction with a tubularized tissue graft or flap. "Augmented anastomotic urethroplasty/urethral reconstruction" is a procedure in which the stricture is excised, a portion of the urethra is anastomosed (either ventrally or dorsally), and a graft or flap is placed on the contralateral side to complete the urethroplasty/urethral reconstruction.

Level of Evidence: 4

Recommendation: C

Epidemiology and Etiology of Urethral Stenoses, Strictures, and Pelvic Fracture Urethral Injuries. Urethral stricture disease results from a number of different etiologies. An understanding of the underlying cause of a particular stricture is helpful in determining the most appropriate type of repair. It may also impact the outcome and sequelae of the treatment options. Whereas inflammatory causes once accounted for the majority of urethral strictures, these have now become infrequent in the developed world. Iatrogenic injury to the urethra now accounts for most strictures, largely as a result of urethral catheterization or traumatic instrumentation. Further causes include external violence, which may result in blunt or penetrating trauma; ischemic urethral injury; and congenital strictures—the rarest type. This section classifies the most common etiologies of urethral strictures.

Mechanism of Injury to the Urethra. Injury to the anterior urethra results in scarring of the corpus spongiosum, or spongiofibrosis. This injury occurs outside the spongiosum as a result of blunt or penetrating injury, or results from internal disruption of the fragile urethral epithelium via instrumentation or inflammatory disease. The partial loss of the epithelial lining is the initiating factor in anterior urethral stricture disease. This typically results in a narrowing of the urethral caliber because the remaining epithelium is re-approximated by natural urethral closure pressure. The underlying de-epithelialized regions expose the underlying vascular spongy tissue, which heals by cross-adhesion and subsequent spongiofibrosis. Passage of urine through these defects during voiding results in further inflammation and subsequent spongiofibrosis.[1] The degree of spongiofibrosis underlying a stricture depends on both the degree of injury and the underlying etiology. These factors have important implications regarding treatment choice and expected outcome.

Devine et al[2] proposed a standardized classification system for urethral strictures based on degree of spongiofibrosis in 1983. Based on this classification, Jordan et al[3] have proposed an anatomic approach to the management of strictures, with patients being offered only those procedures that have resulted in high success rates in strictures of similar anatomic type. Adherence to this approach has resulted in success rates of 90%-93% in nearly all stages of anterior urethral strictures.[4]

Epidemiology and Incidence of Urethral Stricture Disease. There are no direct measures of the true incidence of urethral stricture disease. A recent publication by Santucci et al[5] reviewed the available data from 10 public and private databases in the United States in order to estimate the incidence and cost of this condition to the health care system. The incidence was estimated to be approximately 0.6% in susceptible populations, with 1.5 million office visits recorded between 1992 and 2000. In a follow-up publication, Anger et al[6] found that the incidence of urethral stricture diagnoses among Medicare beneficiaries dropped from 1.4% in 1992 to 0.9% in 2001.

Level of Evidence: 3

Recommendation: N/A

Etiology of Urethral Stricture Disease.

Overview. The etiology of anterior urethral stricture disease may be broadly subcategorized into iatrogenic, traumatic, inflammatory, and idiopathic causes. A recent meta-analysis of etiology in 732 stricture patients found that idiopathic and iatrogenic subtypes were by far the most common,[7] accounting for 33% and 33% of all cases, respectively. Inflammatory and post-traumatic etiologies were found in only 15% and 19% of patients, respectively.

Iatrogenic: Urethral Instrumentation. Urethral strictures can manifest following various transurethral procedures.

Diagnostic cystoscopy and urethral dilation are frequent causes of distal anterior urethral strictures. The frequency of post-transurethral resection of the prostate (TURP) urethral stricture ranges from 1.9%-9%. The Agency for Health Care Policy and Research (AHCPR) found a stricture rate of 3.1% in their review for the benign prostatic hyperplasia (BPH) guideline report.[8]

The etiology of post-TURP strictures remains controversial. In a retrospective analysis of etiologic factors in post-TURP stricture disease, Jørgensen et al[9] found a correlation between preoperative indwelling catheters and postoperative stricture formation, possibly as a result of mechanical trauma to an acutely inflamed urethra. This group observed no significant correlation between stricture and urinary tract infection or prostatic carcinoma, or mechanical disproportion between urethral and resectoscope sheath diameter.

Prostatic urethral stenoses have also been reported after minimally invasive procedures for benign prostatic enlargement/hyperplasia.

Long-term indwelling catheters are closely associated with urethral stricture development. The mechanism of injury may be due to pressure necrosis of the fragile epithelium, as well as chronic inflammation from infection perpetuated by the catheter. Changes in catheter design (eg, substitution of silicone for latex) have helped to reduce stricture incidence. Clean intermittent catheterization is a widely applied technique for facilitation of bladder emptying in various conditions. Hydrophilic catheters may be used for intermittent catheterization without catheter jelly.[10] Urethral strictures arise after prolonged periods of intermittent catheterization.[11]

Iatrogenic urethral strictures arise secondary to various ablative and reconstructive surgeries of the genitourinary tract. In the pediatric population, urethral stricture after posterior urethral valve ablation has been reported. Children undergoing surgical correction of anorectal malformations are also at high risk of iatrogenic urethral stricture development. Urethral strictures are also a recognized complication of hypospadias repair, occurring in up to 10% of cases.

Meatal stenosis is a common complication after circumcision, although the exact incidence is unclear. The etiology in this setting may result from nonspecific meatitis secondary to friction/trauma or from meatal ischemia due to circumcision-induced injury to the frenular artery.[12]

An uncommon group of patients with urethral strictures is those who have undergone total phallic construction—typically as a result of gender dysphoria, severe congenital deformity, or penile loss later in life. In this subset of patients, strictures typically develop at the native-neourethral anastomosis. These may develop secondary to relative ischemia at the anastomotic site or by kinking of the base of the phallus.

Posterior urethral stenosis may arise from treatment for prostate cancer. A recent review found the incidence of stenosis treatment to be 5.2%, whereas the actual incidence of stenosis occurrence may be somewhat higher.[13] Stenosis rates were highest with radical prostatectomy, followed by combination external beam plus brachytherapy.

Trauma. Anterior urethral injury can result from external trauma that is either blunt or penetrating in nature. Blunt urethral trauma results from straddle- or deceleration-type injuries, in which the relatively immobile bulbar urethra is compressed against the pubic bone. These injuries are rarely associated with pelvic fractures (unlike posterior urethral disruptions), and may present after a prolonged period if the initial injury went unrecognized. Rarely, the anterior urethra may be injured secondary to the buckling trauma related to a penile fracture. The frequency of urethral injury associated with penile fracture ranges from 3%-20%, depending on the study cited. The mechanism of injury is usually a direct blow or buckling force applied to the erect penis, resulting in a tear of the tunica albuginea of the corpus cavernosum with sudden detumescence.[14] If the tear extends into the corpus spongiosum, a urethral injury may result.

Penetrating injuries of the anterior urethra usually result from gunshot wounds, which rarely involve the urethra in isolation. Less common causes of penetrating injury include stab wounds and penile amputation injuries.

As with anterior urethral injuries leading to stricture, posterior urethral injuries can be associated with significant traumatic mechanisms. Posterior urethral injuries commonly occur in association with pelvic fractures. Shear mechanisms resulting in pelvic fracture may tear through the urethra at the bulbomembranous junction. The incidence of this injury ranges from 3%-25%, depending on the study and the specific type of pelvic fracture. The recent Société Internationale d'Urologie (SIU) consensus statement makes the important distinction between strictures of the anterior urethra and disruptions of the posterior urethra, which usually follow pelvic fracture injuries.[15] Pelvic fracture urethral disruption (distraction) injuries are addressed in great detail in another section of this Consultation. By consensus of the Consultation Committee, Pelvic Fracture Urethral Distraction Defects represent a subset of the larger Pelvic Fracture Urethral Injuries subcategory.

Inflammatory. Lichen sclerosus (LS) is a progressive sclerosing process, which can involve the penile shaft skin, glans, meatus, or anterior urethra. It is currently the most common inflammatory cause of glanular urethral strictures and acquired meatal strictures.

The exact cause of LS remains elusive, but trauma, autoimmune disorders, and infectious agents (most recently the spirochete *Borrelia burgdorferi*) have been implicated as causative.[16] Clinically, LS may present as phimosis in an uncircumcised man, or it may appear as typically whitish sclerotic plaques on the glans. LS may also present with obstructive voiding symptoms, as the disease progressively involves the meatus and fossa

navicularis. The damaging effects of high-pressure voiding against an obstructed meatus compound this process and the injury caused by repeated instrumentation in many cases.[17] The clinician must maintain a high index of suspicion for urethral involvement in the setting of LS and meatal stenosis. LS is most common in white subjects, with a female-to-male prevalence of between 6:1 and 10:1.[18] Notably, the first-tier term for this process should be "lichen sclerosus" or "lichen sclerosis" (LS). The term "balanitis xerotica obliterans" (BXO) is antiquated and not acceptable.

Reiter's syndrome is an unusual cause of inflammatory urethral stricture disease. The classic triad of urethritis, arthritis, and conjunctivitis may present to varying degrees. A specific agent in a susceptible host may trigger these symptoms.

Vitiligo is an uncommon disorder of localized hypopigmentation, which may involve the genital skin.[19] Urethral involvement arising from vitiligo is rare, but an inflammatory variant of the disease localized to the glans results in meatal stricture.[20]

Bulbar urethritis is a common urologic problem in prepubertal and adolescent boys, and may be associated with dysuria, meatal blood spotting, and microscopic hematuria. This has also been called idiopathic urethrorrhagia. In severe cases, bulbar urethral strictures may be associated with this condition. The exact etiology for this condition remains elusive, but it is suggested that stricture formation may result from inflammation rather than instrumentation.

Postinfectious. Recurrent gonococcal urethritis once accounted for the majority of anterior urethral strictures. The advent of effective antibiotic treatment has made such progression to stricture uncommon in North America, but post-gonococcal strictures still account for the majority of strictures in the developing world.

The role of non-gonococcal urethritis (NGU) in stricture development remains unclear. It has been postulated that chronic post-chlamydial urethral inflammation may be mediated by delayed hypersensitivity mechanisms.[21] *Ureaplasma urealyticum* and *Mycoplasma genitalium* were recently shown to be unlikely to be causative of clinically significant epithelial disease.[22] More uncommon infectious diseases may also result in urethral stricture disease. These include tuberculosis, schistosomiasis, and others.[23] In endemic areas, consideration should be given to these etiologies.

Congenital. Congenital urethral strictures are the least common subcategory. It is a diagnosis that can be reasonably made only in the absence of inflammation, trauma, infection, and urethral manipulation. Cobb et al[24] originally described a congenital narrowing of the bulbar urethra believed to be embryologically related to the rupture of the cloacal membrane or urogenital diaphragm. There is some dispute regarding whether this narrowing represents a variant of Young's type 3 posterior urethral valve.

Summary. Urethral stricture disease represents the final common pathway of a variety of different insults to the urethra. In the developed world, iatrogenic and traumatic injuries now account for the majority of urethral strictures, while postinfectious and congenital etiologies are less frequently encountered.

Inflammatory disease-related strictures (eg, LS) often present a particular reconstructive challenge and seem to be becoming more common. Thus, an understanding of each of the basic etiologies outlined here will help the reconstructive surgeon to determine the most appropriate treatment course.

Level of Evidence: 2b
Recommendation: N/A

Anatomy of Urethral Stenoses, Strictures, and Pelvic Fracture Urethral Disruption Injuries. A thorough understanding of the pertinent anatomy and its nomenclature is crucially important to improve future research and promote effective scientific progress and communication among urologists and reconstructive specialists involved in the evaluation and management of men with urethral stenoses, urethral strictures, and pelvic fracture urethral disruption injuries. An extensive review of the anatomy of the penis, urethra, and male pelvis is beyond the scope of this article but we refer the reader to various comprehensive reviews.[25-27]

Anatomy and Nomenclature of the Male Urethra. The corpus spongiosum lies in the ventral groove beneath the 2 corpora cavernosa, and contains the urethra. The distal end of the corpus spongiosum expands to form the glans penis, a broad cap of erectile tissue covering the distal ends of the corpora cavernosa. The 2 corpora cavernosa diverge, and the corpus spongiosum broadens between the 2 crura to form the bulbospongiosus (bulb of the urethra).

The urethra is the lumen of an epithelialized tube for the passage of urine and semen that extends from the distal bladder neck to the meatus. The "anterior" urethra extends from the meatus to the proximal bulbar urethra (or distal membranous urethra) and is entirely surrounded by the corpus spongiosum. The "posterior" urethra extends from the distal bladder neck to the distal membranous urethra (or proximal bulbar urethra). The consensus opinion of a World Health Organization (WHO) conference convened in Stockholm in 2002 is that the terms "anterior" and "posterior" urethra should be discarded. This International Consultation agrees and the recommended nomenclature reflects the fact that the urethra is subdivided into the following segments:

1. The urethral meatus is a slit-like opening located at the tip of the glans penis slightly ventrally, with its long axis oriented vertically. It is the termination of the urethra at the distal end of the penis. The term "external meatus" is redundant and thus it is recommended that the accepted term be "meatus" only.
2. The fossa navicularis is the distal portion of the penile urethra located within the erectile tissue of the glans

penis proximal to the meatus. It ends at the junction of the urethral epithelium with the skin of the glans. The fossa navicularis is lined with stratified squamous epithelium. The term "glanular urethra" is confusing, as the fossa navicularis is part of the penile urethra. It is therefore recommended that the term "glanular urethra" is no longer acceptable.

3. The penile urethra extends from the meatus to the distal edge of the bulbocavernosus muscle. It is completely surrounded by the corpus spongiosum and maintains a constant lumen size, generally centered in the corpus spongiosum. The penile urethra is lined with simple squamous epithelium. The term "pendulous urethra" is confusing and not descriptive, so it is recommended that the correct term be "penile urethra."
4. The bulbar urethra extends from the proximal penile urethra to the distal membranous urethra. It is surrounded by the bulbospongiosus of the corpus spongiosum and covered by the midline fusion of the ischiobulbocavernosus muscle. It becomes larger and lies closer to the dorsal aspect of the corpus spongiosum as it extends proximally. The bulbar urethra is lined with squamous epithelium distally, which progressively changes to transitional epithelium in the membranous urethra.
5. The membranous urethra extends from the proximal bulbar urethra to the distal verumontanum. It is surrounded by the voluntary external sphincter mechanism, both the smooth muscle external sphincter and the striated/rhabdosphincter. The membranous urethra is unattached to any fixed structure and is the only segment of the male urethra not surrounded by any other structure. It is lined with transitional epithelium.
6. The prostatic urethra extends from the proximal edge of the membranous urethra or the proximal verumontanum to the distal bladder neck. It is surrounded by the prostate. The transitional epithelium of the prostatic urethra is continuous with the trigone and bladder.
7. The bladder neck is surrounded by the fibers of the detrusor muscle and variably by any intravesical extension of the prostate. The transitional epithelium of the bladder neck is continuous with the trigone and bladder. When the bladder neck is affected by scarring, the term "bladder neck stricture" is not descriptive or correct because there is no corpus spongiosum located at the bladder neck, and by definition a "stricture" involves scarring of the corpus spongiosum, or spongiofibrosis. The term "bladder neck contracture" is also not descriptive and is confusing. It is recommended that the preferred term be "bladder neck stenosis" when the prostate is in situ or "vesico-urethral anastomotic stenosis" after radical/total prostatectomy. Therefore, the terms "bladder neck stricture" and "bladder neck contracture" are no longer acceptable.

The normal anatomic description of the urethra is with the penis in the erect state. Therefore, the dorsal urethra is that aspect of the urethra closest to the corpora cavernosa. The ventral urethra is the contralateral aspect of the urethra, farthest from the corpora cavernosa.

In terms of urethral injury that occurs with a pelvic fracture, it is recommended that "pelvic fracture urethral injury" (PFUI) be the preferred term. This terminology reflects the fact that various injury mechanisms may be involved, each resulting in fibrosis. This includes entities such as injury to the proximal bulbar urethra, which may result in spongiofibrosis and proximal bulbar urethral stricture. This also includes entities such as complete urethral disruption with loss of urethral continuity, which, by definition, is not a urethral "stricture" because it does not involve spongiofibrosis. In these cases of urethral disruption with loss of urethral continuity, "pelvic fracture urethral distraction defect" (PFUDD), as discussed previously, is the preferred term, and "posterior urethral stricture" is not acceptable. It is recognized that "urethral disruption defect" is an alternative, second-tier term.

A detailed description of the venous, arterial, lymphatic, and nervous anatomy of the penis is beyond the scope of this article.

References

1. Turner-Warwick R. Principles of urethral reconstruction. In: Webster GD, Kirby R, King L, et al., eds. *Reconstructive urology*. Oxford, UK: Blackwell Scientific Publications; 1993:609-642.
2. Devine CJ, Devine PC, Felderman TP, et al. Classification and standardization of urethral strictures [abstract #325]. Presented at: The 78th American Urologic Association Annual Meeting; April 17-21, 1983; Las Vegas, NV.
3. Jordan GH, Devine CJ, Devine PC. An anatomical approach to urethral stricture disease [abstract]. *J Urol*. 1986;135:210A.
4. Jordan GH. Management of anterior urethral stricture disease. In: Webster GD, Kirby R, King L, et al., eds. *Reconstructive urology*. Oxford, UK: Blackwell Scientific Publications; 1993:703-723.
5. Santucci RA, Joyce GF, Wise M. Male urethral stricture disease. *J Urol*. 2007;177:1667-1674.
6. Anger JT, Santucci R, Grossberg AL, Saigal CS. The morbidity of urethral stricture disease among male Medicare beneficiaries. *BMC Urol*. 2010;10:3.
7. Fenton AS, Morey AF, Aviles R, Garcia CR. Anterior urethral strictures: etiology and characteristics. *Urology*. 2005;65:1055-1058.
8. McConnell JD, Barry MJ, Bruskewitz RC. Benign prostatic hyperplasia: Diagnosis and treatment (Quick reference guide for clinicians). Rockville, MD: Agency for Health Care Policy and Research, Public Health Service, US Department of Health and Human Services; 1994; Publication No.: AHCPR 94-0583:1-17.
9. Jørgensen PE, Weis N, Bruun E. Etiology of urethral stricture following transurethral prostatectomy. A retrospective study. *Scand J Urol Nephrol*. 1986;20:253-255.
10. Biering-Sørensen F, Nielsen K, Hansen HV. Urethral epithelial cells on the surface of hydrophilic catheters after intermittent catheterization: cross-over study with two catheters. *Spinal Cord*. 1999;37:299-300.
11. Wyndaele JJ, Maes D. Clean intermittent self-catheterization: a 12-year followup. *J Urol*. 1990;143:906-908.
12. Persad R, Sharma S, McTavish J, et al. Clinical presentation and pathophysiology of meatal stenosis following circumcision. *Br J Urol*. 1995;75:91-93.
13. Elliott SP, Meng MV, Elkin EP, et al. Incidence of urethral stricture after primary treatment for prostate cancer: data from CaPSURE. *J Urol*. 2007;178:529-534 [discussion: 534].

14. Uygur MC, Gülerkaya B, Altuğ U, et al. 13 years' experience of penile fracture. *Scand J Urol Nephrol*. 1997;31:265-266.
15. Chapple C, Barbagli G, Jordan G, et al. Consensus statement on urethral trauma. *BJU Int*. 2004;93:1195-1202.
16. Akporiaye LE, Jordan GH, Devine CJ Jr. Balanitis xerotica obliterans (BXO). *AUA Update Series*. 1997;16:162-167.
17. Hall SJ, Wagner JR, Edelstein RA, Carpinito GA. Management of gunshot injuries to the penis and anterior urethra. *J Trauma*. 1995; 38:439-443.
18. Pugliese JM, Morey AF, Peterson AC. Lichen sclerosis: review of the literature and current recommendations for management. *J Urol*. 2007;178:2268-2276.
19. Bolognia J, Braverman I. Skin manifestations of internal disease. In: Harrison TR, Wilson JD, Isselbacher KJ, et al., eds. *Harrison's principles of internal medicine*. 12th ed. New York, NY: McGraw-Hill Professional; 1991:322-338.
20. Armenakas NA, McAninch JW. Fossa navicularis and meatal stricture penile flap reconstruction. In: McAninch JW, ed. *Traumatic and reconstructive urology*. Philadelphia, PA: WB Saunders; 1996:615-622.
21. Murphy GF, Mihm MC. The skin. In: Cotran RS, ed. *Robbins' pathologic basis of disease*. 4th ed. Philadelphia, PA: WB Saunders; 1989:1277-1313.
22. Martinelli F, Garrafa E, Turano A, Caruso A. Increased frequency of detection of Ureaplasma urealyticum and Mycoplasma genitalium in AIDS patients without urethral symptoms. *J Clin Microbiol*. 1999;37: 2042-2044.
23. García-Rodríguez JA, García Sánchez JE, Muñoz Bellido JL, et al. Genitourinary tuberculosis in Spain: review of 81 cases. *Clin Infect Dis*. 1994;18:557-561.
24. Cobb BG, Wolf JA Jr, Ansell JS. Congenital stricture of the proximal urethral bulb. *J Urol*. 1968;99:629-631.
25. Jordan GH, Schossberg SM. Surgery of the penis and urethra. In: Wein AJ, Kavoussi LR, Novick AC, et al., eds. *Wein: Campbell-Walsh Urology*. 9th ed. Philadelphia, PA: Saunders Elsevier; 2007:1025-1040.
26. Quartey JKM. Anatomy and blood supply of the urethra and penis. In: Schreiter F, Jordan GH, eds. *Urethral reconstructive surgery*. Heidelberg, Germany: Springer Medizin Verlag; 2006:11-17.
27. Wood DN, Nethercliffe J, Andrich DE, et al. Peritoneal and perineal anatomy and surgical approaches. *BJU Int*. 2004;94:719-737.