Diagn Interv Radiol 2023; DOI: 10.5152/dir.2022.21640

ABDOMINAL IMAGING

REVIEW

Urethrocystography: a guide for urological surgery?

Patrícia S. Freitas
Ana S. Alves
Paulo S. Correia
João L. Dias

ABSTRACT

Urethrocystography remains the gold-standard technique for urethral pathology diagnosis. Nowadays, of the various indications for performing urethrocystography, the most common is due to a clinical suspicion of urethral stricture. Due to the high prevalence of strictures and their substantial impact on a patient's quality of life, the examination must allow the location, exclusion of multifocality, and assessment of the extent of the stricture to influence surgical planning. This article intends to demonstrate that the radiologist's role, by performing and interpreting the modality of urethrocystography, influences and is crucial for the urologic therapeutic decision and that the patients who were submitted to reconstruction by urethroplasty had a better success rate. The authors aim to review the radiological anatomy of the male urethra, discuss the modalities of choice for imaging the urethra (retrograde urethrography and voiding cystourethrography), provide an overview of the different indications for performing the study, examine the different etiologies for urethral strictures, understand the relevance of the different appearances of urethral pathology, and identify the surgical options, especially in the treatment of urethral strictures. Simultaneously, the study exposes cases of urethral trauma, fistulas, diverticulum, and congenital abnormalities.

KEYWORDS

Male urethra, radiology, surgery, urethral stenosis, urethrocystography, urology

Compared to the female urethra, the male urethra is more prone to develop pathology.[1,2] Urethral stricture is the most common pathological condition. Due to its high occurrence, radiologists must understand the urethral anatomy and typical clinical presentation of the underlying disease besides recognizing its imaging findings. Urethrogram techniques such as retrograde urethrocystography (RUG) and voiding cystourethrography (VCUG) are the modalities of choice for imaging the urethra. Given that most urethral strictures need urological intervention, it is also important to understand the most common surgical procedures and their possible complications. An adequate interpretation of the urethrogram, describing the stricture caliber, extension, and location, is crucial and largely influences the urological surgical approach.

Normal anatomy of the male urethra

The male urethra is a narrow fibromuscular tube that measures about 17.5–20 cm in length and is anatomically separated by the urogenital diaphragm into two sections: the anterior and posterior urethra.[3,4] The urethra begins at the internal urethral orifice in the trigone of the bladder and opens in the fossa navicularis at the external urethral meatus.

The anterior urethra is conventionally divided into the penile and bulbar urethra. The bulbar urethra, being entirely internal, originates at the inferior aspect of the urogenital diaphragm and terminates at the penoscrotal junction.[4] Proximal to the dilated portion, the bulbar urethra assumes a conical shape at the bulbomembranous junction. The penile (or pendulous) part is entirely external and extends from the penoscrotal junction to the external meatus at the penile glans.[3] The periurethral Littré glands lie parallel to the dorsal aspect of the anterior urethra.

From the Department of Radiology (P.S.F. ✉ patriciafreitas958@gmail.com, A.S.A., P.S.C., J.L.D.), Centro Hospitalar Universitário de Lisboa Central, Lisbon, Portugal; Department of Radiology (J.L.D.) Hospital CUF Tejo, Lisbon, Portugal.

Received 26 June 2021; revision requested 26 July 2021; last revision received 2 September 2021; accepted 4 October 2021.

Epub: 21.12.2022

Publication date: 31.01.2023

DOI: 10.5152/dir.2022.21640

You may cite this article as: Freitas PS, Alves AS, Correia PS, Dias JL. Urethrocystography: a guide for urological surgery? *Diagn Interv Radiol.* 2023;29(1):9-17.

The posterior urethra is also divided into two segments: the prostatic and membranous urethra. The prostatic urethra is approximately 3.5 cm long; in its posterior wall, the so-called urethral crest continues into the verumontanum, where the prostatic utricle lies.[3] Distal and lateral to the utricle, the orifices of the prostatic or ejaculatory ducts appear. The prostatic urethra then tapers toward the membranous urethra, the narrowest part of the urethra, which measures approximately 1–1.5 cm long, and ends in the inferior aspect of the urogenital diaphragm. The Cowper glands lie within the urogenital diaphragm, lateral to the membranous urethra, and their ducts empty into the bulbar urethra.[3]

The external sphincter is a striated voluntary muscle located within the urogenital diaphragm and is responsible for active continence.

Radiological anatomy of the male urethra

RUG is a diagnostic procedure based on the retrograde injection of iodinated contrast media through the urethral meatus. The anterior urethra is better evaluated in retrograde studies, which allows better repletion. In contrast, VCUG is useful for the posterior urethra study. In this technique, the bladder neck opens widely during urination, permitting the identification of normal permeability and distension of the posterior urethra (Figure 1). Additionally, VCUG can help detect bladder abnormalities and is also an indication for studying vesicoureteral reflux.

Technical procedure

Less invasive than urethroscopy, urethrocystography is frequently requested by urologists to evaluate strictures and decide the need for surgery and its appropriate approach. It is also requested as the follow-up to surgical procedures such as urethrotomy and urethroplasty.

Table 1 summarizes the material that should be used during the urethrocystography procedure. Although some authors preconized the use of a Foley catheter, it is also a valid option to inject the iodinated contrast directly into the urethral meatus.[3,5] During the procedure, five basic steps should be followed: patient preparation, RUG, cystography, VCUG, and a post-voiding study. Table 2 describes them in detail. Also, some tips and tricks to accomplish a successful examination when faced with RUG difficulties are listed in Table 3.

If the urethral meatus shows a severe stricture, meatotomy, or hypospadias, the conventional method with balloon filling in the tip of the catheter is not useful. Instead, a thinner cannula attached to the syringe should be used, or the contrast could be injected directly into the meatus.

Strictures that resist contrast progression may expel the Foley catheter, and excessive distension of the catheter balloon may tear the mucosa. This statement may be particularly important for patients medicated with anticoagulants or antiaggregants.

The clamp method is a new technique popular in some European hospitals and does not use syringes or the conventional Foley catheter with balloon inflation.[6] This method consists of drip infusion and external compression with a ring and uses a thin pre-lubricated catheter (6-Fr), which is described in more detail in Table 3.[6] A prospective study concluded that this is a simple, effective, and well-tolerated procedure.[6]

Indications, contraindications, and cautions

In accordance with the practice parameters of the American College of Radiology, the current indications for performing a RUG are urethral strictures (suspicion, follow-up, or pre- or post-surgery), pelvic trauma, urethral diverticula, bladder outlet or urethral obstruction, hematuria, recurrent urinary tract infection (UTI), diminished urinary stream, incomplete voiding, urethral foreign bodies, tumors, fistulae or false passages, post-operative urethral injury, and congenital abnormalities.[7] The indications for VCUG are the same, plus the vesicoureteral reflux; bladder morphology, capacity,

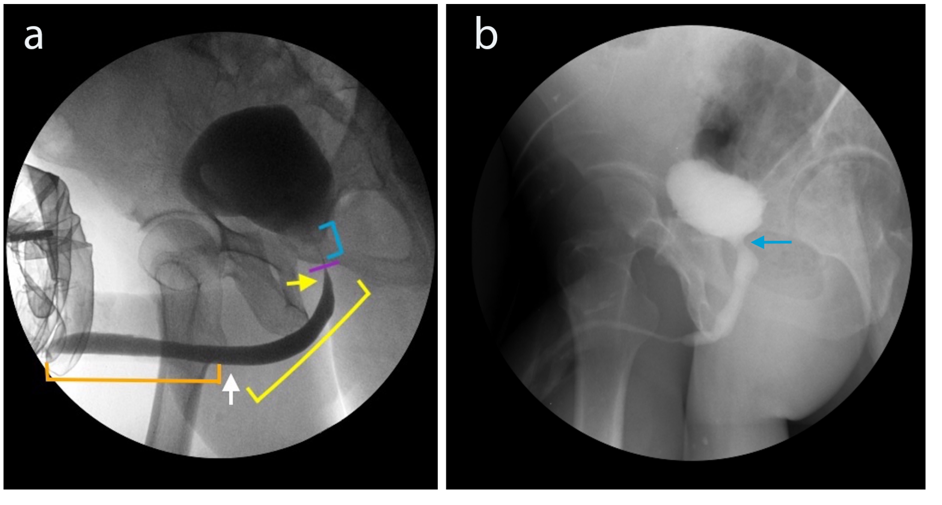

Figure 1. RUG **(a)** and VCUG **(b)** images show penile urethra (orange bracket, **a**); penoscrotal junction (white arrow, **a**); bulbar urethra (yellow bracket, **a**); bulbomembranous junction assuming conical shape (yellow arrow, **a**); membranous urethra (purple line, **a**); prostatic urethra (blue bracket, **a**) and bladder neck opening (blue arrow, **b**). RUG, retrograde urethrocystography; VCUG, voiding cystourethrography.

Table 1. List of the material needed in the radiology department to perform a urethrocystography

Sterile gloves	12-Fr / 14-Fr Foley catheter (100% silicone) (optional)
Lead gloves	Sterile field with a hole
Iodinated contrast water-soluble (ex. Iohexol)	Sterile cup
Physiological saline (NaCl)	Sterile compresses
Distilled water	Lidocaine 2% (ex: lidonostrum)
Bladder syringe 100 mL	Urinal
Syringe 5 mL (optional)	Catheter clamp (optional)

Main points

- Urethral stricture is a high-prevalence pathology and substantially impacts patients' quality of life.
- Urethrocystography remains the gold-standard technique for urethral pathology diagnosis.
- Urethral dilatation and internal urethrotomy have equivalent long-term success rates, which are significantly lower when compared to the urethroplasty surgical rates.
- The radiologist's role, by performing and interpreting the modality of urethrocystography, influences the urologic therapeutic decision.

and injury; incontinence; and unexplained intraperitoneal fluid after surgery or trauma.[7]

No absolute contraindications are found in the medical literature for these exams. However, a few relative contraindications are consensual: pregnancy, UTI (antibiotic prophylaxis should be considered in patients with a history of UTI; if an active infection exists, postponing the exam is advised), recent instrumentation, and iodinated contrast allergy, especially if there has been extravasation of contrast from the urethra or bladder.[7]

Complications due to contrast media are rare. Despite that, there might be complications related to the technique, like urethral trauma, intravasation of contrast, and hematuria.

Although it is rare, there might be a few indications for female urethrography. These generally include urethral diverticulum, urethral strictures, and urethral trauma.[1,8] The latter is one of the most common etiologies because of obstetrical complications.[1,2,8]

Artifacts and other pitfalls

Several artifacts may occur during the procedure. Radiologists should recognize these findings and not mistake them for pathology.

The kinking artifact occurs due to incorrect positioning by mild or incomplete traction of the penis gland (Figure 2). Filling defects

Table 2. Urethrocystography protocol. Description of the five basic steps that should be performed during the procedure

1. Patient preparation	- Explain the procedure and the potential discomfort/pain; - Ask the patient to micturate before the examination; - Take a preliminary radiograph (AP view with the center focused just below the pubic bone and also a supine oblique view); - Place the patient in a supine, right posterior oblique position (35º–45º), with the right knee flexed under the extended left leg; - Retract the foreskin for physiological saline cleaning; - Sterile field placement.
2. RUG	- Protect your hands with lead gloves and then put on sterilization gloves. - Prepare the bladder syringe with 100 mL of iodinated contrast diluted in physiological saline (60% + 40%, respectively); - Inject iodinated contrast directly into the urethral meatus. Use your left hand as a clamp by holding the penile gland. With your right hand, introduce the syringe tip into the urethral meatus and inject the contrast media until the patient achieves the voiding sensation. This less invasive method may prevent urethral trauma; however, it might occasionally cause significant contrast media extravasation and lead to more hand radiation exposure. Due to these reasons, you may opt for a different technique, such as the Foley catheter; - Put a small amount of local anesthetic (lidocaine 2%) at the tip of the catheter (some authors do not recommend lubricating the catheter, as it may increase the risk of expulsion); - Place the catheter tip in the fossa navicularis (approximately 2 cm); - Inflate the catheter balloon with 2 cc of distilled water or air; - Moderate traction is required to elongate the urethra, and pressure is applied over the glans to avoid expulsion of the catheter*; - Contrast material is instilled slowly; - Record the anterior urethra distension and the bladder filling; - Clamp the catheter and remove the syringe; then fill in the syringe again with contrast and adjust it to the catheter posteriorly; remove the clamp; - When the patient mentions the need to urinate, we clamp the system, deflate the balloon and remove the catheter.
3. Cystography	- AP and lateral projections radiographs (initial bladder volume).
4. VCUG	- Place the patient in the orthostatic and left-posterior-oblique position (35º–45º); - Fluoroscopy at the moment of voiding.
5. Post-voiding study	- AP and lateral radiographs to document post-void residue volume or a unique AP radiograph to document the absence of residue.

*Adequate distention and urethral traction are the keys to preventing overlap, foreshortening, or underestimating strictures; RUG, retrograde urethrocystography; VCUG, voiding cystourethrography; AP, anteroposterior.

Table 3. Tips and tricks

RUG and VCUG difficulty	Tips and tricks
Urethral meatus' stricture	- If you do not feel comfortable injecting iodinated contrast directly into the urethral meatus with a syringe or if the Foley catheter may be too large, use an infant feeding tube (usually 5-Fr, 8-Fr, or 10-Fr depending on the stenosis degree) or an HSG catheter (5-Fr or 7-Fr with balloon)
Catheter balloon slipping out	- You may use the clamp method: a clamp device connected to a balloon-less catheter and a drip infusion system. The catheter (6-Fr pre-lubricated) is coupled to the device and connected to the infusion system to be purged. The catheter is then inserted into the urethral meatus, and the device is moved in a more proximal direction. The clamp ring will surround the balanoprepucial sulcus, and you must tighten the band to apply external compression. After the preparation, you may open the infusion system and check that there is no extravasation of contrast material so that the RUG can begin.[6] - This can also be avoided by externally compressing the penile gland and the catheter balloon with the examiner's hand.
Female urethrography	Although it is very rarely necessary to evaluate the female urethra, in this case, you may use the: - Midori catheter - HSG catheter (5-Fr) - Rubber bulb of the Knutsson clamp (if available).

RUG, retrograde urethrocystography; VCUG, voiding cystourethrography; HSG, hysterosalpingography.

mostly happen when the Foley catheter is not correctly purged, and an air bubble enters the urethra, which may simulate a urethral stone (Figure 3); however, most of the time, these artifacts are transitory and disappear during the fluoroscopic study. A non-pathological filling defect can also be found in the prostatic urethra caused by a normal anatomical structure, like the verumontanum (Figure 4). The contraction of the constrictor nudae muscle may appear as an anterior indentation in the proximal bulbar urethra, which should not be reported as a focal stricture (Figure 4). The posterior urethra should not be seen as a pathological tapering in the RUG, since it only distends while voiding.

Some normal structures, like Littré glands and Cowper glands and ducts, may be opacified in the urethrogram (Figure 5). Despite being normal, their appearance can be related to pathologies, like strictures or inflammation. The other structures that can be opacified are prostatic ducts and seminal vesicles (Figure 5). It is important to recognize and be aware of the anatomic location of these structures since they may simulate a fistula pathway.

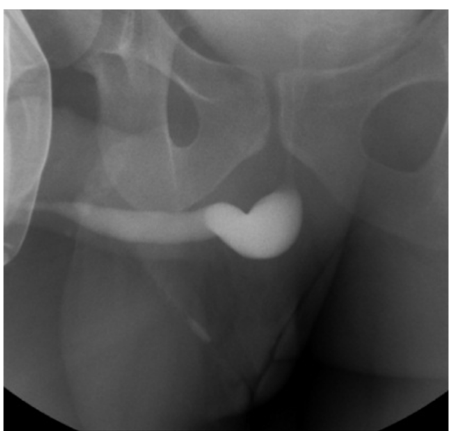

Figure 2. RUG demonstrating incomplete traction of the penis gland leading to a kinking artifact. RUG, retrograde urethrocystography.

Other artifacts may appear due to extracorporeal extravasation of the contrast material. Similar linear extra-urethral opacifications may be seen due to contrast intravasation into regional vessels (Figure 6). It may be understood as a complication due to high resistance during the contrast administration.

Urethral pathology

A. Strictures

Pathology of the male urethra is a common problem and can substantially affect patients' quality of life. It is more common in older adults (>50 years) and usually presents as strictures.[9]

Most patients with a urethral stricture usually show clinically chronic obstructive voiding symptoms. Some may relate the symptoms to a cause, such as a history of prior instrumentation, infection, or injury. However, the etiology of some strictures remains unknown due to the time delay between the symptoms and the causal event.[10]

A. 1- Stricture classification

A. 1.1- Based on etiology

The main etiologies of strictures are idiopathic, iatrogenic, inflammatory, traumatic, and tumoral.[11] **Iatrogenic strictures** are responsible for approximately 45% of all urethral strictures and usually involve a fixed and narrow location.[9,10,12] They occur mostly in the membranous urethra but also at the penoscrotal junction. The main iatrogenic causes are post-radiotherapy and instrumentation, such as trans-urethral resections, prolonged catheterization, cystoscopy, and hypospadias repair.[10,12] Regarding **idiopathic causes**, there are clinical features that point to strictures being triggered by unrecognized repetitive minor perineal trauma.[13] **Inflammatory stricture** usually involves the proximal bulbar urethra; it may result from infectious urethritis, non-specific urethritis, or Balanitis xerotica obliterans (BXO). **Traumatic strictures** generally involve the bulbomembranous junction and develop rapidly. Usually, they affect short segments and are related to pelvic trauma.[14] Despite the fact that urethral stricture disease may increase the risk of urethral neoplasia by more than 50%, tumoral stricture remains the rarest cause.[9]

However, the etiology varies by population and study. According to Verla et al.[15], the classification can also be presented as idiopathic, iatrogenic, external trauma, infection, and lichen sclerosus. A multicenter study published in 2013 showed that urethral strictures in the USA and Italy are more iatrogenic rather than caused by external trauma when compared to India (35% vs. 16% and 16% vs. 36%, respectively).[16] Additionally, developing countries face primarily infectious strictures, while in the Western world, one of the most important strictures is iatrogenic.[10,16,17] Concerning the pediatric population, the common causes of urethral stricture are traumatic (36.9%), iatrogenic (31.8%), and idiopathic (28.7%).[18] Congenital strictures, such as congenital bulbar stricture (Cobb's collar), are a very rare entity and are still a subject of controversy.[18]

A. 1.2- Based on location

The vast majority of strictures are anterior, especially at the bulbar urethra. They typically result from fibrous scarring due to the proliferation of fibroblasts and collagen, which reduces the urethral width, and are commonly related to spongiofibrosis.[3] On the other hand, the posterior urethra stricture usually results from an obliterative process caused by trauma, surgery, or other iatrogenic procedures such as pelvic radiation.[19]

The main etiologies of **penile urethral strictures** are inflammatory (40%) and iatrogenic (40%). Traumatic and idiopathic ori-

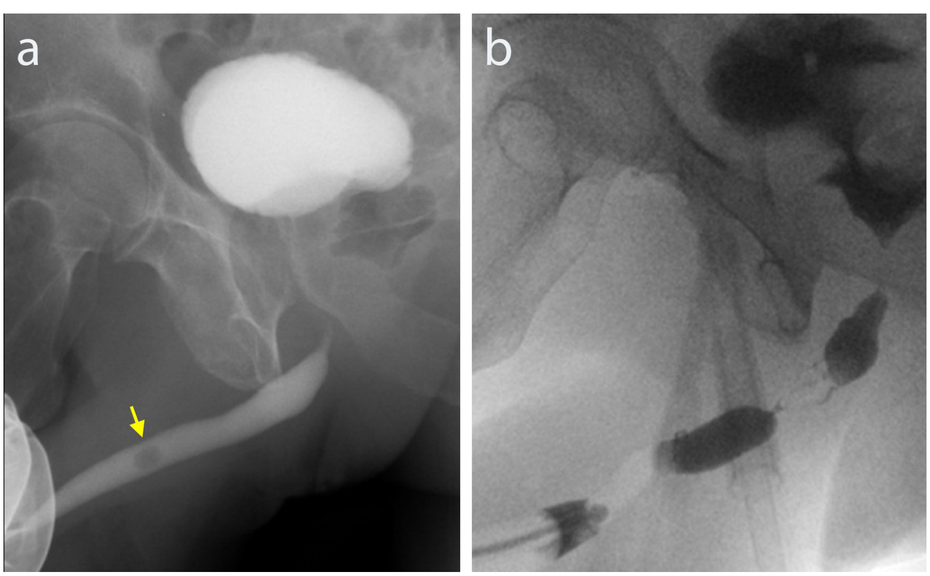

Figure 3. RUG **(a)** and inverted RUG **(b)** showing transitory filling defects caused by air bubbles artifacts due to an incorrectly purged Foley catheter, which may mimic a urethral stone (yellow arrow, **a**). RUG, retrograde urethrocystography.

gin account for less incidence (5% and 15%, respectively).[19,20] BXO is the genital form of lichen sclerosus. It usually presents as white plaques on the glans and the foreskin; it is a chronic inflammatory condition dominated by atrophic rather than proliferative fibrosis.[20] BXO can lead to the distal urethra and meatal stricture, being more severe when it reaches the penile urethra (Figure 7). Other infectious and inflammatory causes can be due to gonococcal urethritis, nongonococcal urethritis (*Chlamydia trachomatis*), and condyloma and tuberculosis, which are very rare. The iatrogenic causes usually result from post-reconstructive hypospadias surgery, post-urethral instrumentation, and traumatic catheter insertion.[10,11]

The etiology of **bulbar urethral stricture** is idiopathic (40%), iatrogenic (35%), post-traumatic (15%), and inflammatory (10%).[19,20] Generally, post-traumatic bulbar strictures are short in length and classically as a result of a straddle injury (Figure 8). Iatrogenic strictures are common; if occurring after traumatic catheter insertion or prolonged catheter exposure, the bulbar–penile transition is the most frequent site affected. However, if they happen after transurethral resection of the prostate (TURP), then the bulbomembranous transition is the most probable site to be injured. The idiopathic strictures are usually short and occur in young men, mostly at the proximal portion.[20] The infectious etiologies are rare; however, a classic etiological agent is *Gonococcal urethritis*, which is generally responsible for long-segment and irregular strictures (Figure 8).[3,20] It is important to recognize if the stricture extends to the membranous urethra, so the external urinary sphincter is not damaged during surgery.

One of the most common causes of **membranous urethral stricture** is iatrogenic, post-TURP. Due to its location, the associated fibrosis compromises the sphincter function. When there is significant pelvic trauma, the membranous urethral stricture may result from distraction injuries (obliterative stricture).[14]

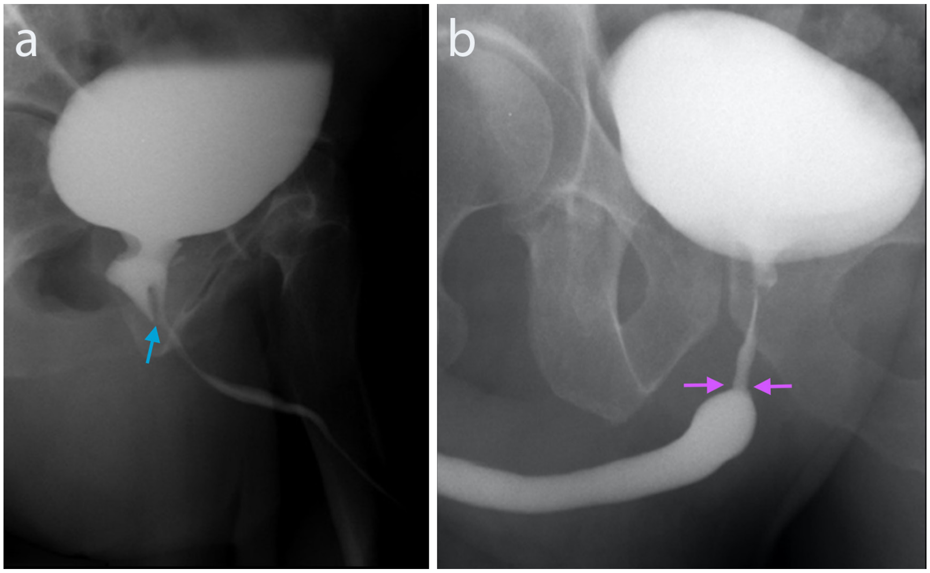

Figure 4. (a, b) RUG showing non-pathological filling defects in the prostatic urethra caused by a normal anatomical structure. Verumontanum as a filling defect (blue arrow, **a**) and normal tapering of the transition of the bulbar urethra to the posterior urethra due to the contraction of the constrictor nudae muscle (purple arrows, **b**). This must not be reported as a focal structure since the posterior urethra only distends properly in the VCUG. VCUG, voiding cystourethrography.

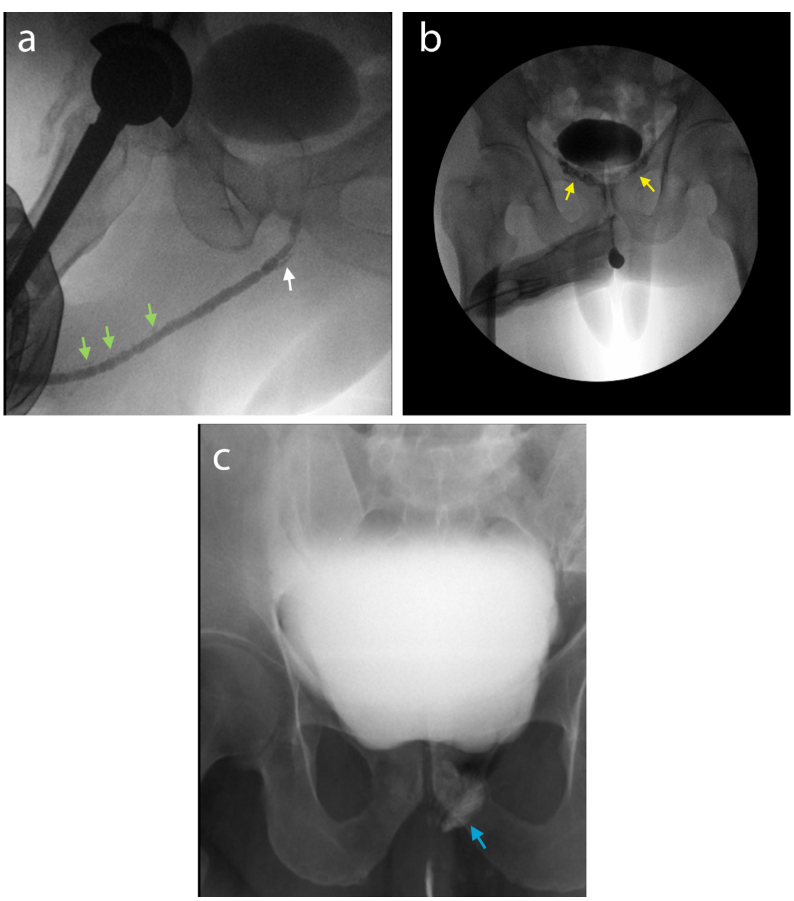

Figure 5. (a–c) RUG **(a, b)** and VCUG **(c)** show opacified Littré glands (green arrows, **a**) and opacified Cowper gland (white arrow **a**), contrast reflux to seminal vesicles (yellow arrows, **b**) and opacified left prostatic duct (blue arrow, **c**). RUG, retrograde urethrocystography; VCUG, voiding cystourethrography.

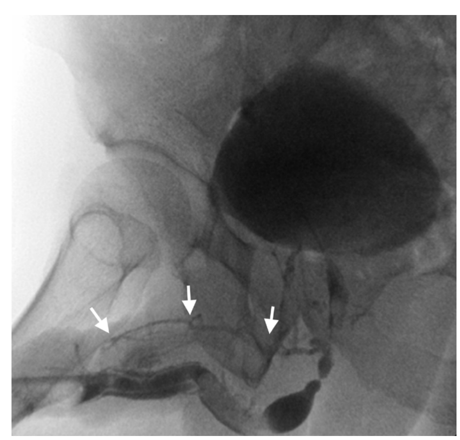

Figure 6. RUG shows opacification of the venous system due to high resistance during the urethrogram study (white arrows). RUG, retrograde urethrocystography.

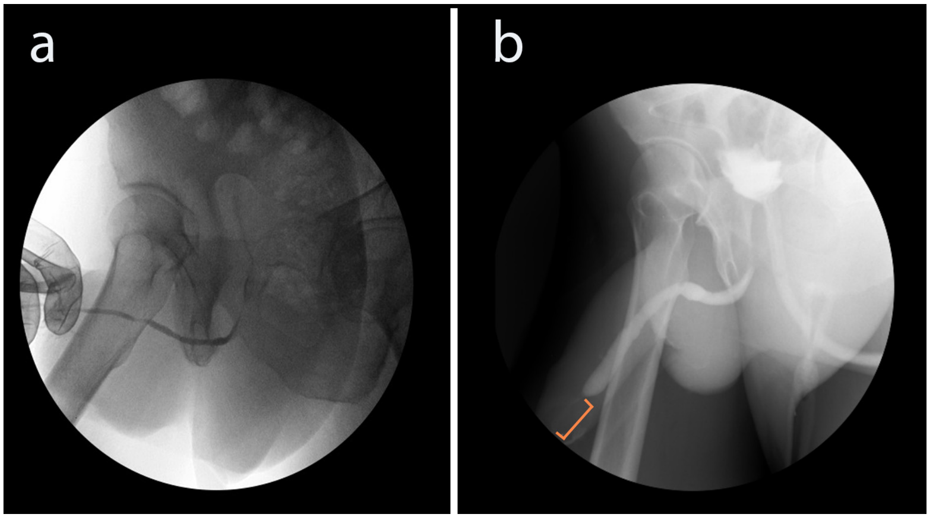

Figure 7. (a, b) Two different patients with balanitis xerotica obliterans. The urethrogram shows a filiform anterior urethra due to multiple strictures **(a)** and a long-segment penile urethra stricture (orange bracket, **b**). Both patients were proposed for BMG urethroplasty. BMG, buccal mucosal graft.

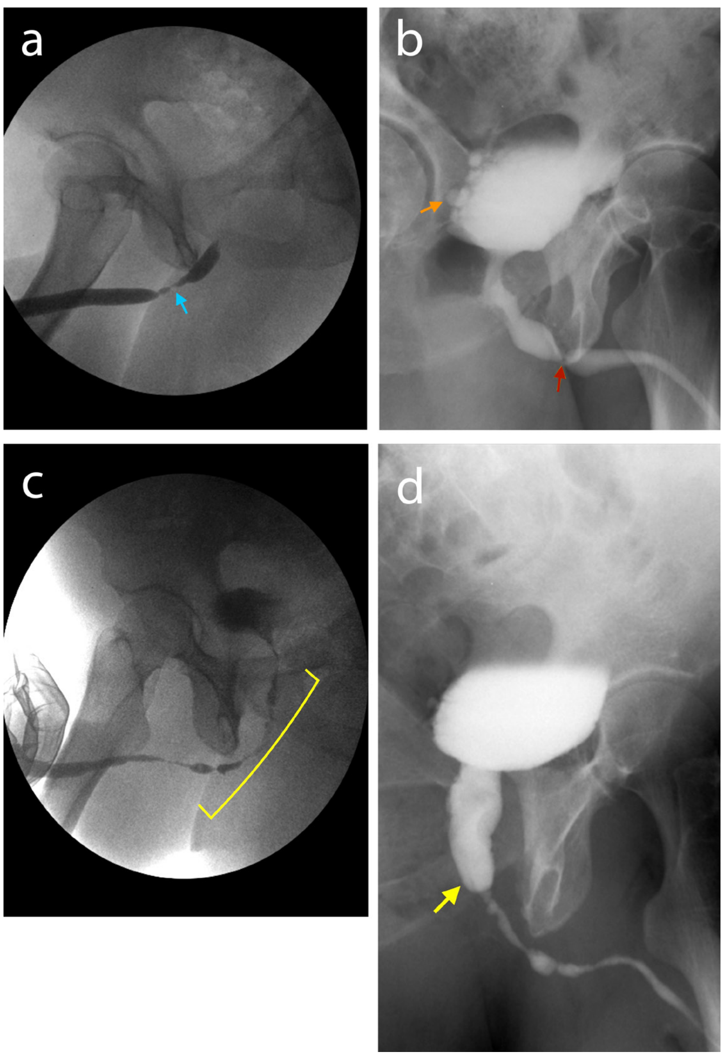

Figure 8. Bulbar urethral strictures demonstrated in RUG **(a, c)** and VCUG **(b, d)**. RUG shows proximal bulbar stricture resulting from a straddle injury in a 45-year-old patient with a post-pelvic trauma status (blue arrow, **a**). VCUG reveals ring stricture of the proximal bulbar urethra (red arrow, **b**), causing dilatation of the upstream segments in a patient with gonococcal urethritis. Bladder diverticula (orange arrow, **b**). Long-segment and irregular bulbar stricture in a 72-year-old patient with a clinical history of previous urethritis (yellow bracket, **c**). The enlarged caliber of the prostatic urethra (yellow arrow, **d**) due to the high pressure of the long-segment bulbar stricture. RUG, retrograde urethrocystography; VCUG, voiding cystourethrography.

Prostatic urethral strictures usually occur after prostatic treatment (prostatectomy, brachytherapy, or cryotherapy). Strictures of the bladder neck may occur post-TURP.[20]

A. 1.3- Based on length and caliber

Usually, there are short-segment strictures, long-segment strictures, multiple strictures, and obliterative strictures. Using Devine's method, urethral strictures can be classified by RUG and sonourethrogram (SUG) as mild, moderate, and severe according to the reduction in the caliber of the urethral lumen (<33%, 33%–50%, and >50%, respectively).[21,22] This is calculated by comparing the caliber of the maximum point of the stricture with the normal urethral lumen caliber outside the stenotic segment length. Focal strictures were also classified into three groups: short, intermediate, and long (<1 cm, 1–2.5 cm, and >2.5–6 cm, respectively).[21,22]

A. 2- Stricture complications

Studies have shown that the natural history of untreated urethral stricture disease can lead to complications such as a thick-walled trabeculated bladder (85%), acute urinary retention (60%), prostatitis (50%), epididymal-orchitis (25%), hydronephrosis (20%), peri-urethral abscess (15%), and stones (10%).[9,10] As previously stated, a permanent urethral stricture increases the risk of malignancy by 50%.[9]

A. 3- Stricture treatment options

Treatment options for strictures depend on multiple factors. This section explains the different surgical techniques and elucidates the best treatment options for each urethral stricture location.

A.3.1- Surgical techniques

A.3.1.1- Minimally invasive procedures

The minimally invasive procedures include **urethral dilatation** and **internal urethrotomy** (IU), the latter showing higher success rates for bulbar strictures <1.5 cm in length. Some studies, such as Steenkamp et al.[23,24], have shown no difference between these two procedures regarding recurrence rates. They also concluded that both methods are less effective with longer strictures. IU is performed by making a transurethral incision to release the scar tissue, which allows healing by secondary intention at a larger caliber (Figure 9); it has shown a success rate of 8%–80% and a long-term success rate of 20%–30%.[19,25,26]

The minimally invasive procedures show a high risk of recurrence, especially if there is a long segment stricture (80% chance of recurrence if the stricture segment is >4 cm) or multiple strictures.[19] The risk is also greatest at the penile or membranous urethra and if long-length spongiofibrosis is associated. A UTI at the time of the procedure and previous urethral procedures can also contribute to the recurrence.

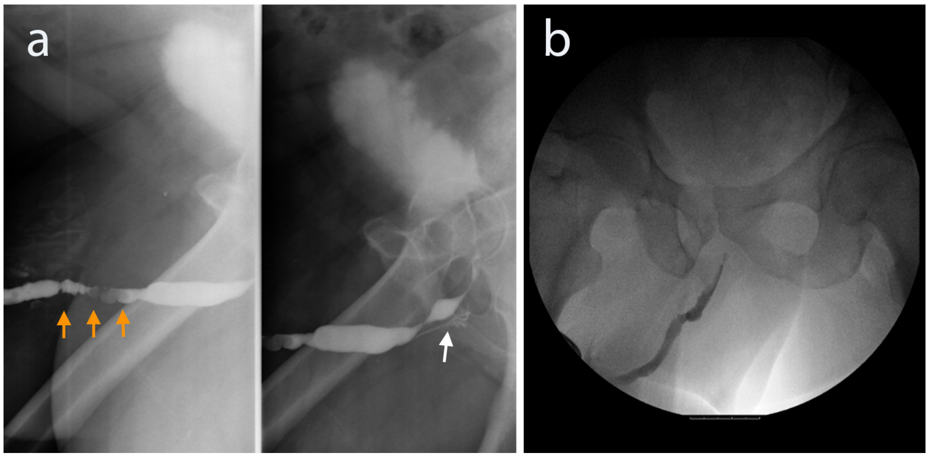

Figure 9. Anterior urethral strictures before **(a)** and after **(b)** treatment. The 72-year-old patient shows in the RUG multiple ring strictures of the anterior urethra (orange arrow, **a**) with a Cowper gland opacification due to high pressure (white arrow, **a**). Three years later, the patient underwent IU, and the RUG showed a favorable evolution of the previous strictures **(b)**. IU, internal urethrotomy; RUG, retrograde urethrocystography.

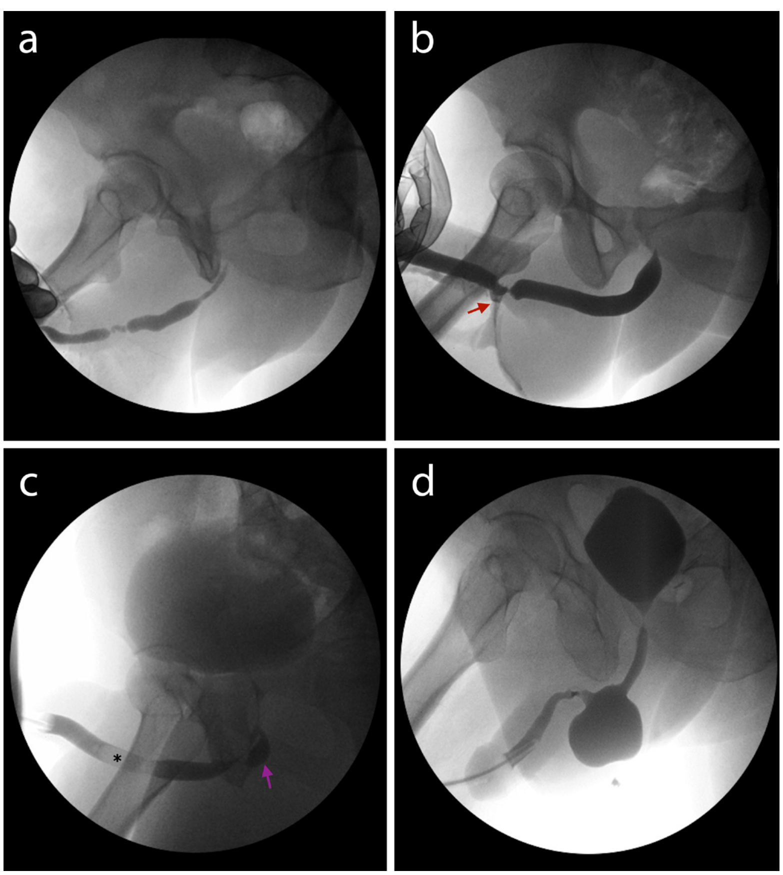

Figure 10. RUG showing post-operative complications in four different patients. Recurrent penile urethra stricture in a patient who has already undergone five IUs **(a)**. Penile urethral trauma already submitted to urethroplasty; as a post-surgery complication, a urethral fistula developed at the healing wound (red arrow, **b**). Post-urethroplasty diverticulum (purple arrow, **c**); air bubble artifact **(*, c)**. Status post-artificial urinary sphincter, showing a diverticular image upstream of the stenotic segment (29 × 30 mm), which communicates with the penile urethra, suggestive of a pre-stenotic diverticulum **(d)**. RUG, retrograde urethrocystography; IU, internal urethrotomy.

A. 3.1.2- Reconstructive surgery

Reconstructive surgery of the urethra shows better long-term success rates, estimated at 85%–90%, and is the most effective method for the definitive correction of urethral stricture.[27,28] It is mostly performed in two ways, end-to-end anastomotic urethroplasty and graft urethroplasties. However, a perineal urethrostomy can also be carried out if there are severe or panurethral strictures, primarily those with BXO or recurrent strictures after hypospadias repairs.[29]

End-to-end anastomotic urethroplasty consists of stricture excision followed by anastomotic suturing of the urethral ends; it usually has few complications and has been traditionally used for bulbar strictures <2 cm in length.[30] It is not recommended for penile strictures.

Moreover, **graft urethroplasty** is the gold standard for definitive correction; the procedure consists of a urethrotomy of the stricture with posterior defect closure with a buccal mucosal graft (BMG).[20] This is an effective procedure for strictures longer than two centimeters.

A. 3.2- Treatment options based on location

Depending on the urethral stricture location, there are specific indications for which treatment is selected. So, it is important to document the precise location of the stricture because it will influence the surgeon's decision.

Penile urethral stricture: Usually, it is treated with graft urethroplasty. The patch can be either a penile skin flap or BMG. However, if it is a complicated stricture with suspected lichen sclerosus, urethroplasty using penile skin as a graft should not be used because of the stricture's high recurrence rate.[29] Urethral dilatation or IU can be the initial treatment for meatus or fossa navicularis stricture.

Bulbar urethral stricture: For uncomplicated short-segment bulbar strictures, end-to-end anastomotic urethroplasty or minimally invasive procedures are the treatment options. However, if there are long-segment or recurrent short-segment strictures, the treatment of choice is graft urethroplasty.[29]

Posterior urethral stricture: In case of complete posterior urethral disruption by pelvic fracture, a bulbomembranous anastomotic urethroplasty should be carried out.[29] However, if the membranous stricture is secondary to TURP, a urethral dilatation is preferred to preserve the sphincter. Prostatic strictures are uncommon and technically very challenging to treat.

After reconstructive surgery, to allow adequate healing of the tissues without urine exposure, surgeons insert a transurethral catheter and remove it after 7–21 days.[31] Most urethroplasty centers use peri-catheter RUG to evaluate the appropriate time for catheter removal. This technique consists of placing a small-caliber tube (e.g., feeding tube 5-Fr) in the urethral meatus next to the transurethral catheter and injecting contrast alongside the catheter.[31] Although it is not a mandatory routine technique, it may have a crucial role in difficult cases, such as tension anastomoses or when redoing procedures. It will prevent the risk of infection, radiation exposure, and extra cost.[31]

A. 4- Post-operative complications

Post-urethroplasty complications are rare.[19] These include urine leaks, post-voiding dribble, UTIs, fistula development, urethral diverticulum, and stricture recurrence (Figure 10). The complications include incontinence, chordee, erectile and ejaculatory dysfunction, and necrosis of the penile skin. However, some studies have shown that after one year of surgical reconstruction, there is no difference in erectile function compared to that preoperatively.[32,33] Harvest site complications might also include pain, oral numbness, and mouth tightness. Recurrent strictures in patients who have already been submitted to urethroplasty are generally treated with IU alone, demonstrating better long-term success rates.[34,35]

B. Other urethral pathologies

The urethra is susceptible to trauma because of its relation to the pubic bones and puboprostatic ligaments. Injury to the posterior urethra occurs in 3%–25% of patients with pelvic fractures.[14,36] The posterior urethral trauma usually happens after a crushing force, and the anterior urethra injury generally occurs after a straddling injury.[37] Rarely there might be a penile fracture or a penetrating injury (Figure 11). The Goldman system proposes the classification of urethral injuries for urethrography.

There are also congenital urethral abnormalities (Figure 12). In this category, urethral duplication, megalourethra, posterior urethral valves, congenital urethral stenosis, urethral diverticulum, epispadias, and hypospadias stand out.[38]

Male urethral tumors are a rare condition and represent less than 1% of all urologic cancers in those aged >50 years.[3]

Complementary techniques

As an additional method, some authors believe that detecting an anterior urethral stricture in RUG indicates retrograde sonourethrography (RSUG).[39] This comes with the fact that RSUG visualizes the peri-urethral tissues and surrounding spongiofibrosis and measures the stenosis more accurately.[39] However, a study has also shown that by considering the radiographic magnification and the application of correct measurement methods, RUG does not underestimate stricture length.[21]

Computed tomography (CT) RUG may be useful in evaluating traumatic urethral injuries and periurethral fistulas.[40,41] A study published in 2021 on CT-RUG using the clamp method reported no pain in 81% of patients and showed that this technique had better diagnostic efficacy in cases of periurethral fistula, urethral stent, previous urethroplasty, and urethral lithiasis compared to RUG and RSUG.[42]

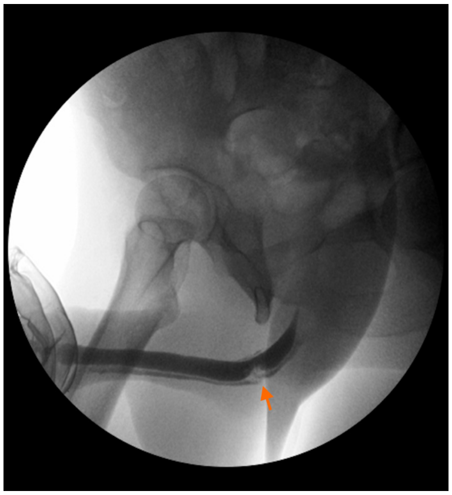

Figure 11. A 40-year-old man with a bulbar urethral fracture after trauma (orange arrow).

Recent articles have shown the utility of magnetic resonance imaging (MRI) in urethral stricture disease. This technique can detect spongiofibrosis, reducing the limitation of the subjective SUG examination and giving detailed information about periurethral tissue and anatomic relationships.[43]

Conclusion

Urethral stricture is a high-prevalence pathology that substantially impacts a patient's quality of life.

Urethrocystography is the standard technique to detect urethral pathology and influences therapeutic decisions. Sometimes the urethrogram study may be complemented with ultrasound, MRI, or CT, which better defines the peri-urethral and adjacent organs.

Urethral stricture treatment depends on multiple factors. Both minimally invasive procedures have equivalent long-term success rates that are significantly lower when compared to urethroplasty surgical rates.

The radiologist's involvement is crucial in the urethrocystography interpretation, initial description, and eventual need for additional diagnostic strategy, demonstrating a consequent impact on the decision of the proper urologic surgical approach.

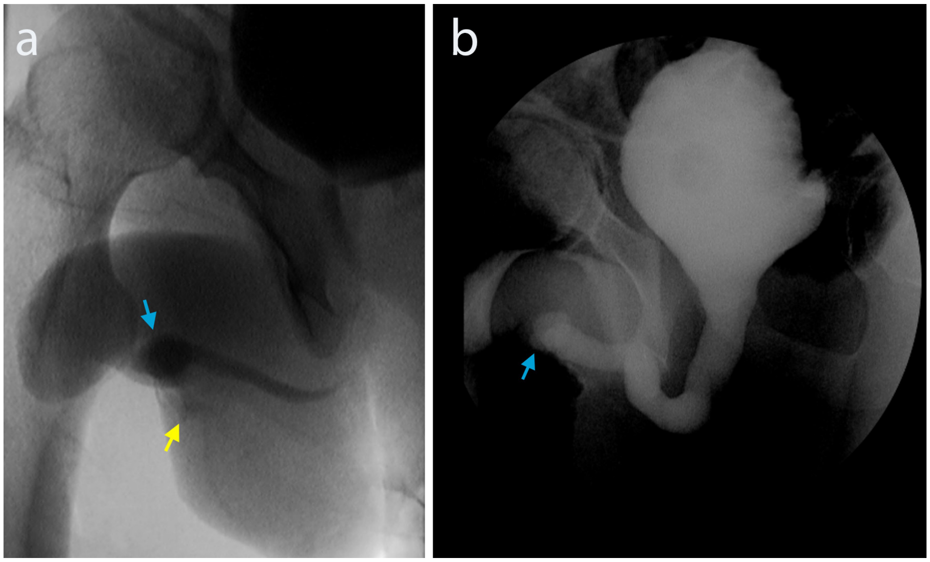

Figure 12. **(a, b)** Status post-hypospadias surgery. Dilatation of terminal urethra (blue arrow, **a** and **b**) and ventral penile fistula (yellow arrow, **a**).

Conflict of interest disclosure

The authors declared no conflicts of interest.

References

1. Patel DN, Fok CS, Webster GD, Anger JT. Female urethral injuries associated with pelvic fracture: a systematic review of the literature. *BJU Int.* 2017;120(6):766-773. [CrossRef]
2. Waterloos M, Verla W. Female urethroplasty: a practical guide emphasizing diagnosis and surgical treatment of female urethral stricture disease. *Biomed Res Int.* 2019;2019:6715257. [CrossRef]
3. Kawashima A, Sandler CM, Wasserman NF, LeRoy AJ, King BF Jr, Goldman SM. Imaging of urethral disease: a pictorial review. *Radiographics.* 2004;24 Suppl 1:S195-S216. [CrossRef]
4. Eaton J, Richenberg J. Imaging of the urethra: Current status. *Imaging.* 2005;17(2):139-149. [CrossRef]
5. Sandler CM, Corriere JN Jr. Urethrography in the diagnosis of acute urethral injuries. *Urol Clin North Am*. 1989;16(2):283-289. [CrossRef]
6. Berná-Mestre JD, Berná-Serna JD, Aparicio-Mesón M, Canteras-Jordana M. Urethrography in men: conventional technique versus clamp method. *Radiology.* 2009;252(1):240-246. [CrossRef]
7. American College of Radiology. ACR-SAR practice parameter for the performance of adult cystography and urethrography; 1992. Revised 2020. [CrossRef]
8. El-Nashar SA, Singh R, Bacon MM, et al. Female urethral diverticulum: presentation, diagnosis, and predictors of outcomes after Surgery. *Female Pelvic Med Reconstr Surg.* 2016;22(6):447-452. [CrossRef]
9. Flanagan JC, Batz R, Nordeck SM, Lemack GE, Brewington C. Urethrography for assessment of the Adult Male Urethra: RadioGraphics Fundamentals | Online Presentation. *Radiographics.* 2018;38(3):831-832. [CrossRef]
10. Lumen N, Hoebeke P, Willemsen P, De Troyer B, Pieters R, Oosterlinck W. Etiology of urethral stricture disease in the 21st century. *J Urol.* 2009;182(3):983-987. [CrossRef]
11. Wessells H, Angermeier KW, Elliott S, et al. Male urethral stricture: American Urological Association Guideline. *J Urol.* 2017;197(1):182-190. [CrossRef]
12. Fenton AS, Morey AF, Aviles R, Garcia CR. Anterior urethral strictures: etiology and characteristics. *Urology.* 2005;65(6):1055-1058. [CrossRef]
13. Viers BR, Pagliara TJ, Rew CA, et al. Characteristics of idiopathic urethral strictures: a link to remote perineal trauma? *Urology.* 2017;110:228-233. [CrossRef]
14. Ingram MD, Watson SG, Skippage PL, Patel U. Urethral injuries after pelvic trauma: evaluation with urethrography. *Radiographics.* 2008;28(6):1631-1643. [CrossRef]
15. Verla W, Oosterlinck W, Spinoit AF, Waterloos M. A comprehensive review emphasizing anatomy, etiology, diagnosis, and treatment of male urethral stricture disease. *Biomed Res Int.* 2019;2019:9046430. [CrossRef]
16. Stein DM, Thum DJ, Barbagli G, et al. A geographic analysis of male urethral stricture aetiology and location. *BJU Int.* 2013;112(6):830-834. [CrossRef]
17. Fall B, Sow Y, Mansouri I, et al. Etiology and current clinical characteristics of male urethral stricture disease: experience from a public teaching hospital in Senegal. *Int Urol Nephrol*. 2011;43(4):969-974. [CrossRef]
18. Ansari MS, Yadav P, Srivastava A, Kapoor R, Ashwin Shekar P. Etiology and characteristics of pediatric urethral strictures in a developing country in the 21st century. *J Pediatr Urol.* 2019;15(4):403.e1-403.e8. [CrossRef]
19. Hampson LA, McAninch JW, Breyer BN. Male urethral strictures and their management. *Nat Rev Urol.* 2014;11(1):43-50. [CrossRef]
20. Mundy AR, Andrich DE. Urethral strictures. *BJU Int.* 2011;107(1):6-26. [CrossRef]
21. Babnik Peskar D, Visnar Perovic A. Comparison of radiographic and sonographic urethrography for assessing urethral strictures. *Eur Radiol.* 2004;14(1):137-144. [CrossRef]
22. Devine CJ Jr. Surgery of the urethra. In: Wals PC, Gittes RF, Perlmutter AD, Stamey TA eds. Campbell's urology, 5th edn. Saunders, Philadelphia; 1986:2860–2863. [CrossRef]
23. Steenkamp JW, Heyns CF, de Kock ML. Internal urethrotomy versus dilation as treatment for male urethral strictures: a prospective, randomized comparison. *J Urol.* 1997;157(1):98-101. [CrossRef]
24. Steenkamp JW, Heyns CF, de Kock ML. Outpatient treatment for male urethral strictures--dilatation versus internal urethrotomy. *S Afr J Surg.* 1997;35(3):125-130. [CrossRef]
25. Pansadoro V, Emiliozzi P. Internal urethrotomy in the management of anterior urethral strictures: long-term followup. *J Urol.* 1996;156(1):73-75. [CrossRef]
26. Santucci RA, McAninch JW. Actuarial success rate of open urethral stricture repair in 369 patient open repairs, compared to 210 DIV or dilation. AUA meeting. 2001. [CrossRef]
27. Wong SS, Aboumarzouk OM, Narahari R, O'Riordan A, Pickard R. Simple urethral dilatation, endoscopic urethrotomy, and urethroplasty for urethral stricture disease in adult men. *Cochrane Database Syst Rev.* 2012;12:CD006934. [CrossRef]
28. Naudé AM, Heyns CF. What is the place of internal urethrotomy in the treatment of urethral stricture disease? *Nat Clin Pract Urol.* 2005;2(11):538-545. [CrossRef]
29. Dugi DD 3rd, Simhan J, Morey AF. Urethroplasty for stricture disease: contemporary techniques and outcomes. *Urology.* 2016;89:12-18. [CrossRef]
30. Jordan GH, McCammon KA. Surgery of the penis and urethra. Vol. 1, (Elsevier Saunders, Oxford, 2012;956–1000. [CrossRef]
31. Haider A, Mahmud SM. Pericatheter urethrogram after anastomotic urethroplasty: Is it a must? *Pak J Med Sci.* 2018;34(5):1191-1194. [CrossRef]
32. Erickson BA, Wysock JS, McVary KT, Gonzalez CM. Erectile function, sexual drive, and ejaculatory function after reconstructive surgery for anterior urethral stricture disease. *BJU Int.* 2007;99(3):607-611. [CrossRef]
33. Xie H, Xu YM, Xu XL, Sa YL, Wu DL, Zhang XC. Evaluation of erectile function after urethral reconstruction: a prospective study. *Asian J Androl.* 2009;11(2):209-214. [CrossRef]
34. Santucci RA, Mario LA, McAninch JW. Anastomotic urethroplasty for bulbar urethral stricture: analysis of 168 patients. *J Urol.* 2002;167(4):1715-1719. [CrossRef]
35. Morey AF, Kizer WS. Proximal bulbar urethroplasty via extended anastomotic approach--what are the limits? *J Urol.* 2006;175(6):2145-2149; discussion 2149. [CrossRef]
36. Patel U. Lower urinary tract trauma. In: Patel U, Rickards D, eds. Imaging and urodynamics of the lower urinary tract. London, England: Taylor & Francis, 2005:115–121. [CrossRef]
37. Goldman SM, Sandler CM, Corriere JN Jr, McGuire EJ. Blunt urethral trauma: a unified, anatomical mechanical classification. *J Urol.* 1997;157(1):85-89. [CrossRef]
38. Kim B, Kawashima A, LeRoy AJ. Imaging of the male urethra. *Semin Ultrasound CT MR.* 2007;28(4):258-273. [CrossRef]
39. Berná-Mestre JD, Balmaceda T, Martínez D, et al. Optimisation of sonourethrography: the clamp method. *Eur Radiol.* 2018;28(5):1961-1968. [CrossRef]
40. Theisen KM, Kadow BT, Rusilko PJ. Three-dimensional imaging of urethral stricture disease and urethral pathology for operative planning. *Curr Urol Rep.* 2016;17(8):54. [CrossRef]
41. Lv XG, Peng XF, Feng C, Xu YM, Shen YL. The application of CT voiding urethrography in the evaluation of urethral stricture associated with fistula: a preliminary report. *Int Urol Nephrol.* 2016;48(8):1267-1273. [CrossRef]
42. Berná-Mestre JDD, Guzmán-Aroca F, Puerta-Sales A, et al. A new technique for computed-tomography urethrography in males: the clamp method. *Appl Sci.* 2021;11(3):1006. [CrossRef]
43. Frankiewicz M, Markiet K, Krukowski J, Szurowska E, Matuszewski M. MRI in patients with urethral stricture: a systematic review. *Diagn Interv Radiol.* 2021;27(1):134-146. [CrossRef]