The Urethrogram: How it Guides Urological Surgery

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Learning objectives

1. To understand normal urethral anatomy

2. To be able to perform a urethrogram

3. To appreciate the different indications for a study

4. To have an overview of the different aetiologies for urethral strictures

5. To have an understanding of strategies for difficult studies, such as trauma patients.

6. To have an understanding of the different surgical options available for stricture management.

7. To understand the relevance of the different urethrogram appearances and how these impact on the surgical management

Background

Urethral strictures have been well recognised since ancient times with reports in Greek and Egyptian literature. More recently, urethrography with antegrade passage of iodinated contrast was developed by Knutsson in the early 20th century. His eponymous clamp served 2 functions; to catheterise the distal penile urethra whilst the clamp element constricted the gland penis around the catheter. Retrograde injection of iodinated contrast was therefore obliged to pass proximally up the urethra.

Although a number of variations have been described, most radiologists utilise a more conventional method whereby a catheter is inserted into the distal urethra and gentle inflation of the catheter balloon in the fossa navicularis permits both anchorange and prevents contrast spillage.

There are a number of different indications for performing a urethrogram with assessment of potential urethral stricture disease being the most common. Given its relatively common occurrence in contemporary urological practice, it is a technique which most radiologists should be able to perform and interpret.
**Imaging findings OR Procedure details**

**Indications**

The majority of requests for urethrography are due to a clinical suspicion of urethral stricture. Typical symptoms are those of hesitancy, poor stream, terminal dribbling and most commonly the sense of incomplete bladder emptying\[1\]. A urinary flow rate trace typically shows a long slow protracted curve in a relatively young male patient. The urethrogram should demonstrate the anatomical site, multiplicity and length of any strictures, thereby allowing appropriate urological surgical intervention.

Many strictures are found at rigid cystoscopy. If short and in the bulbar urethra direct vision internal urethrotomy (DVIU) may be appropriate. If the stricture is recurrent, long and in other anatomical positions the chance of 'cure' are low and surgical management planning with urethrogram may be appropriate.

Pelvic trauma is a relatively common indication for urethrography. Pelvic fractures have a high association with disruption of the posterior urethra and a study is indicated to exclude such an injury prior to urethral catheterisation\[2\]. If the study has to be delayed due to urgent surgical need a suprapubic catheter can be sited with an antegrade study at a later occasion. Patients with blunt trauma to the perineum (so-called 'saddle injuries') are at risk of trauma to the bulbar urethra with subsequent stenosing.

Following open reconstructive urethral surgery it is standard urological procedure to leave a urethral catheter in-situ for a number of weeks whilst the repair heals. It is common in this situation to perform a urethrogram prior to catheter removal. This will identify any significant residual urethral stricturing at site of repair whilst identifying any potential leak of contrast from the operative site. In this situation the catheter can be left for a longer duration or reparative operative intervention considered.

Less common indications include pre-operative planning of complex hypospadias reconstructive surgery and to identify (and delineate the extent) of potential penile malignancy (such as urethral squamous cell carcinoma).

**Normal Urethral Anatomy (Figure 1)**

The urethra extends from the external urethral meatus to the bladder base and is divided anatomically into anterior and posterior divisions by the urogenital diaphragm
(the external urinary sphincter). The anterior urethra consists of the penile (or pendulous) and bulbar urethra whilst the posterior urethra consists of the membranous and prostatic urethra.

The penile urethra is entirely external and passes through the corpus spongiosum. The fossa navicularis represents a localised dilatation just proximal of the urethral meatus within the glans penis. It is lined by the glans of Littre that provide urethral lubrication. Occasionally these are opacified during urethrography and appear as small linear contrast collections parallel to the superior margin of the anterior urethra, the appearance often reflecting chronic infection or stricturing[3].

The bulbar urethra is surrounded by the bulbospongiosus muscle and commences at the penoscrotal junction and is entirely internal. The penile-bulbar 'junction' on urethrogram is identified by recognising an angle change at the proximal penile urethra (see diagram). The bulbar urethra typically demonstrates a 'U'-shaped curve and is the most inferior part of the urethra. The more proximal part is relatively capacious and referred to as the 'sump' whilst the distal part that tapers towards the penile urethra is known as the 'cone'. The accessory sex glands of Cowper drain via ducts that enter the proximal bulbar urethra and are occasionally seen to fill with contrast in a normal patient although they are often recognised with associated strictures due to the increased intraluminal pressure causing opacification.

The membranous urethra is only 1-1.5 cm in length and passes through the urogenital diaphragm. It is the least distensible portion of the urethra.

The prostatic urethra is approximately 3.5cm in length and begins at the bladder base, passing inferiorly through the prostate and demonstrating distal tapering as it passes towards the membranous urethra. The urethral crest is a longitudinal ridge of smooth muscle that lies on the posterior aspect of the prostatic urethra and extends from the bladder base to the membranous urethra. The verumontanum is a 1cm long ovoid soft-tissue projection on the posterior aspect of the prostatic urethra. This contains a small central depression that represents the remnant of the MÜllerian duct. Multiple small openings around the verumontanem represent the openings of the prostatic ducts. The openings of the paired ejaculatory ducts are just distal and lateral.

**The technique**

In order to optimally visualise both the anterior and posterior urethra, a standard urethrogram involves an ascending (retrograde) study to assess the anterior urethra and a subsequent descending (antegrade) study to assess the posterior urethra.
Due to the resting tone of the external urinary sphincter, an ascending study will distend the anterior urethra but only a relatively small volume of contrast will pass proximally and the posterior urethra is usually suboptimally distended (see Figure 1), with consequential reduced appreciation of posterior urethral stenoses. The descending study allows adequate distension of the posterior urethra (Figure 2).

With the patient supine, the urethral meatus is prepared in sterile fashion. A 6-8 Fr Foley catheter is inserted to the fossa navicularis and the balloon inflated with 1-2mls of saline. An option preferred by the author is to use a hysterosalpingogram catheter. Unlike a standard Foley catheter, this has an end hole with contrast being directed immediately proximally rather than laterally with a Foley catheter. This results in less patient discomfort and reduced risk of balloon/catheter expulsion during filling. Lubricating anaesthetic gels are not used due to the increased risk of catheter expulsion.

The patient is angled approximately 30 degrees left-side up (LAO) or the C-arm rotated to achieve the same result. This oblique projection is crucial as it allows visualisation of the entire length of the urethra[4].

The penis is positioned laterally over the thigh and slight traction applied whilst gentle injection of 20-30mL of iodinated contrast is injected under fluoroscopic guidance.

With a more relaxed patient, having distended the anterior urethra, contrast is seen to 'jet' beyond the external sphincter and fill the bladder. Often with more tense patients, spasm of the sphincter prevents proximal passage and gentle continuous injection should be applied until sphincter relaxation occurs. A single exposure with maximal anterior urethral distension is taken.

To permit a descending study the bladder must be filled with a 350-400mL of contrast. The catheter is removed and the patient asked to micturate into a bottle with the penis at a similar angle to the antegrade study. Angling the table approximately 45 degrees head-up can facilitate voiding. Again an exposure is taken during maximal urinary flow. Exposures are preferred to fluoroscopic 'grabs' due to the improved mucosal detail.

**Difficult situations**

Up to 24% of adult patients with pelvic fractures have associated urethral injuries[5]. Although rarely life-threatening they have significant long-term morbidity, such as stricturing, incontinence and impotence[6].
The most common site of urethral injury following pelvic fracture is the posterior urethra, with injuries occurring in 3-25% of cases[7]. The membranous urethra is at particular risk, with disruption threatening the active continence mechanism.

Clinical signs suggestive of a urethral injury include blood at the meatus, haematuria, voiding difficulty, perineal swelling/haematoma and a 'high-riding' prostate at rectal examination.

A urethrogram is indicated in haemodynamically stable patients if urethral injury is suspected prior to transurethral catheterisation to prevent 'blind' passage of the catheter through a urethral tear into a pelvic haematoma [4]. Furthermore, catheterisation may exacerbate haemorrhage and extend a partial tear into a complete tear together with potentially causing infection of a hitherto sterile pelvic haematoma[2]. If the study reveals an injury then suprapubic catheterisation is necessary for temporary urinary diversion (Figure 3).

If urethral injury becomes apparent subsequent to transurethral catheterisation, urethrography should be performed promptly with the study presenting a challenge with a urethral catheter in-situ.

Patients identified at initial presentation as having a urethral injury, treated with either suprapubic catheterisation or surgical repair should undergo a repeat study at a later date. The in-dwelling catheter can be removed if the urethrogram appearances are acceptable. Evidence of on-going contrast leak, complete urethral transaction or an evolving stricture should undergo appropriate urological management.

Post-traumatic urethrography should include both an ascending and descending study, although in the presence of a suprapubic catheter, contrast can be administered intravesically with the subsequent descending study usually being sufficient. Particular scrutiny should be directed at the bladder neck, junction of prostatic/membranous sections and the bulbar urethra - these areas being the most vulnerable.

Potential pain from pelvic/spinal injuries often significantly limits patient mobility making standard urethrogram positioning impossible. The patient should be assisted into a 30 degree position and supported with foam pads. If movement is contraindicated or impossible, C-arm angulation of 30 degrees LAO is necessary. Slight cranio-caudal angulation of the x-ray tube assists assessment of the bladder neck for subtle leaks from this area. If views are obscured by internal/external orthopaedic fixation devises (such as pelvic external fixators) significant tube angulation may be required.
A peri-catheter technique is necessary if a trans-urethral catheter is already in-situ[2]. A small gauge paediatric catheter can be inserted alongside the in-dwelling catheter and its balloon inflated in the fossa navicularis. Contrast is thereby instilled via the paediatric catheter and an ascending study performed. A second technique involves insertion of a fine bore feeding tube (i.e. without anchoring balloon) that is advanced proximally up the entire urethra under fluoroscopic guidance during continuous contrast injection. If distended images are necessary a gauze tie can be secured around the tip of the penis.

The descending study is performed with the patient micturating around the in-dwelling urethral catheter (having removed the paediatric catheter). In order to void, it may be necessary to push the in-dwelling catheter slightly proximally (thereby displacing the catheter balloon from the bladder neck) or by deflating the balloon. Angling the fluoroscopic couch and tube 'head-up' can facilitate voiding.

If ascending and descending studies fail to identify a leak the catheter can be removed following urological discussion. A standard second descending study may be performed.

Identification of a complete urethral transection on the ascending study necessitates assessment of the length of the injury as long segment transactions require more extensive reconstructive procedures. With the anterior urethra 'contrast-filled' to the level of the transection, the catheter is clamped thereby retaining the contrast within the urethra. A simultaneous descending study via the suprapubic catheter is performed with the patient voiding. Identification of the distal extent of the injury allows appreciation of the overall length and therefore appropriate surgical management.

If the patient has hypospadias or a meatal stricture, insertion of a fine-bore feeding catheter should be performed through the narrowing. A seal is created by tying ribbon around the distal penis.

**Urethral Strictures**

Urethral strictures represent a significant urological problem in modern practise. In the UK the prevalence is approximately 10 per 100,000 men, increasing to over 100 per 100,000 in the elderly[8].

Patients typically present with poor urinary stream, hesitancy, terminal dribbling and classically a sensation of incomplete bladder emptying. Although often difficult to distinguish from the symptoms of prostatic bladder outflow obstruction, a urinary flow rate
showing a long, slow protracted trace is highly suggestive, particularly if accompanied by a supportive history of aetiological factors.

Although historically strictures typically represented the sequelae of Gonococcal urethritis, in the modern urological world the aetiology is more diverse. Typical aetiologies include infectious/inflammatory causes such as Lichen sclerosis (LS) and non-specific urethritis (NSU) and post-traumatic strictures. Idiopathic and iatrogenic strictures are the main aetiological groups.

Although there is some overlap, the different anatomical urethral divisions are prone to strictures of different aetiologies and as such the aetiologies are best categorise as to their likely site of stricturing (stenosing by convention in the posterior urethra).

Penile Urethra

1. Inflammatory

Balantitis xerotica obliterans (BSO) is the genital form of Lichen sclerosis, a chronic inflammatory condition which typically involves the prepuce and glans with itchy white plaques evident. Typically causing meatal strictures, in more severe cases the condition can extend up the penile urethra, causing inflammatory constriction and stricturing. The condition has become increasingly common in recent years and now is the commonest identifiable cause of penile strictures in young and middle-aged adults[1].

Other inflammatory conditions include the sequelae of poor penile hygiene.

2. Iatrogenic

Reconstructive surgery for hypospadias is increasingly common and post-reconstructive strictures can range from a relatively simple meatal stricture to a full-length stricture of the anterior urethra with development of urethrocutaneous fistula.

Other iatrogenic causes include strictures following urethral instrumentation and traumatic catheterisation (typically at the penile-bulbar junction - see later).

Bulbar Urethra
1. **Post-traumatic** (Figure 4)

Post-traumatic strictures are usually short in length and the consequence of a 'straddle' injury, occurring almost exclusively in the bulbar urethra[9].

2. **Iatrogenic**

Iatrogenic causes of bulbar urethral strictures are common and include endoscopic/catheter trauma and prolonged urethral catheterisation. The penile-bulbar junction is the usual site of a post traumatic catheterisation stricture, the proximal bulbar urethra (often involving the membranous urethra/sphincter mechanism) being the common site of post-TURP strictures ('sphincter-strictures')[10].

3. **Idiopathic/Congenital**

Also a common group, idiopathic strictures typically occur in young/adolescent men at the junction of the proximal and middle thirds of the bulbar urethra. The aetiology is debated and usually considered congenital. As with the above groups, the strictures tend to be short. Embryologically, this region represents the site of fusion of the urethra from 2 separate origins and a slight narrowing can be identified on urethrography in 'normal' subjects and does not always indicate a pathological stricture.

4. **Infective** (Figure 5)

Although rare as a cause of urethral strictures in the developed world, Gonococcal urethritis is the classical aetiological agent causing anterior urethral strictures. Likely a consequence of chronic or recurrent infection, a delay of over 20 years between initial infection and stricture presentation is typical[11]. The typical urethrogram appearance is that of a long-segment, irregular stricture of the bulbar urethra[4]. Of critical urological importance is the recognition of potential extension proximally into the membranous urethra. This is suggested if the proximal bulbar urethra appears narrowed, elongated, asymmetric, irregular or absent[12]. If the proximal extent is not appreciated urological cutting of scar tissue may involve the external urinary sphincter with ensuing incontinence. Today non-specific urethritis is more common than Gonococcal-related urethritis [REF].

**Membranous urethra**

1. **Iatrogenic** (Figure 6)
The most common cause of a stricture of the membranous urethra is a result of transurethral resection of the prostate (TURP). In these cases the lumen remains in continuity with the stricture being relatively superficial in depth and sphincter function being compromised by associated fibrosis.

2. **Trauma**

Injuries to the membranous urethra sustained during significant pelvic trauma are commonly complete transections with no luminal continuity present. As such, these injuries are distraction injuries than true 'strictures'.

**Prostatic urethra and Bladder neck**

1. **Iatrogenic**

Structures of the prostatic urethra can be difficult to treat but are unusual and may occur following contemporary prostatic treatments such as laser prostatectomy or cryotherapy.

Bladder neck strictures typically are a consequence of open radical prostatectomy or TURP. It has been suggested that stricturing occurs when the original cause of the BOO was dyssynergic bladder neck obstruction with the subsequent surgery adding fibrotic stricturing[13].

**Treatment options**

In general, surgery should be carried out in specialist centres with individual cases discussed in a uro-radiology meeting. Treatment options depend on a number of factors including anatomical site, aetiology, multiplicity and length. Treatment strategies should also consider patient co-morbidity and appropriateness for complex surgery.

**Direct vision internal urethrotomy (DVIU)** - Figure 7

Also known as 'optical urethrotomy' this involves endoscopic visualisation with a rigid cystoscope, passing a guide-wire across the stricture then internal 'cutting' of the urethra. This procedure is rarely curative and has been shown to have no advantage over simple stricture dilatation. It is only suitable for short (<1cm) bulbar strictures with only a 60% success rate achieved. Penile, multiple and longer strictures rarely respond [14, 15].
**Urethral stenting**

Has been used to supplement urethrotomy but results have been generally poor with recurrent stricturing often necessitating a difficult salvage urethroplasty[16].

**Urethroplasty**

These involve either surgical excision of the stricture followed by anastamotic suturing of the urethral ends or opening the stricture (stricturotomy) and closing the opened defect with a ‘patch’ of either a graft or flap.

Anastamotic urethroplasty has the best success rate and lowest complication rate therefore is performed when possible. It is not suitable for the penile urethra as the consequential shortening interferes with erection.

Graft/flap urethroplasties typically use vascularised pedicles of local genital skin or free grafts - typically buccal mucosal grafts (BMGs) as a patch to close the urethral defect following stricturotomy.

Urethroplasty is the only curative option for treatment of recurrent bulbar strictures and all anterior urethral strictures regardless of previous treatment.

**Treatment by location/stricture appearance**

**Penile Urethral Strictures** (Figures 8 & 9)

Complicated strictures secondary to failed hypospadias surgery and BXO are problematic and although BMGs may be feasible more complex cases often require specialist staged repairs. Genital skin should not be used for strictures due to lichen sclerosis

More straightforward penile strictures are often treated with a stricturotomy and patch with either penile skin flap or BMG.

**Bulbar urethral strictures** (Figures 10 & 11)

Urethroplasty is the only curative option for the treatment of recurrent bulbar strictures.

An uncomplicated short stricture is best treated by excision and end-to-end anastomosis. Longer strictures undergo stricturotomy and BMG patch to close the defect.
Membranous urethral strictures (Figure 12)

If secondary to TURP then urethral dilatation is preferred to preserve sphincter function.[10]. Those strictures secondary to pelvic fractures usually undergo suprapubic catheterisation with a delayed urethroplasty. Another option is an immediate endoscopic realignment procedure.

Prostatic Urethral Strictures (Figure 13)

These strictures are uncommon, typically following modern prostatic treatment such as brachytherapy and cryotherapy. These are notoriously difficult to treat and excision of scarred tissue is required with anastamosis of bladder neck onto urethra below with likely incontinence. Other options include urinary diversion.

Images for this section:
**Fig. 1:** Normal Urethral anatomy (ascending urethrography) The Urethra is divided into anterior (penile & bulbar) and posterior (membranous and prostatic) divisions. Note the angle change (arrow) indicating the transition from penile to bulbar urethra. Pe: Penile, B: Bulbar, M: Membranous, Pr: Prostatic.

**Fig. 2:** Normal descending (antegrade) appearances. Note the distension of the posterior urethra (arrow) not achieved in an ascending (retrograde) study. A full study should typically include both an ascending and descending study.
Fig. 3: Young male trauma patient (pedestrian vs car) who sustained multiple pelvic fractures (not shown) Urethrogram performed as blood at urethral meatus. Study demonstrates leak of contrast from membranous urethra. Suprapubic catheter inserted in operating theatre and delayed urethral repair performed.
Fig. 4: Post-traumatic bulbar stricture Ascending (left image) and descending (right image) studies, showing short-segment post-traumatic bulbar stricture (black arrow). Note the excessive dilatation of the posterior urethra on the descending study (white arrow). Classically the result of a 'straddle' injury, these are almost exclusively found in the bulbar urethra.
Fig. 5: Multiple strictures of the anterior urethra as a consequence of pan-urethral urethritis. Note filling of Cowper's duct (white arrow)
**Fig. 6:** Stricture of the membranous urethra. Ascending and descending study following TURP and prostatic radiotherapy (external beam). The stricture becomes apparent on the descending study (arrow). Note the wide opening of the bladder neck post-TURP.

**Fig. 7:** Cystoscopic appearance of an anterior urethral stricture (white arrow) before and after optical urethrotomy and dilatation. These strictures are seldom 'cured' by the procedure and recurrence is the normal situation.
Fig. 8: Proximal penile urethral stricture due to gunshot injury. Ascending study demonstrates a short-segment stricture of the penile urethra (arrow). The patient underwent subsequent buccal mucosal graft (BMG)urethroplasty.
Fig. 9: Descending urethrogram showing long segment penile stricture (arrow) Note the distension of the bulbar and posterior urethra. Note the consequential bladder wall thickening and trabeculation. These are finding that should be documented.
**Fig. 10:** Long-segment bulbar urethral stricture. Both ascending and descending studies show a tight proximal bulbar stricture (arrow). Urethrotomy/dilation would be inappropriate due to the length and the patient requires open urethroplasty. The segment is too long for anastamotic urethroplasty and substitution urethroplasty with BMG is the likely outcome.

![Image of urethra with stricture](image1.png)

**Fig. 11:** Long-segment bulbar stricture (arrows). The long segment of stricture suggests urethroplasty is the likely surgical intervention.
**Fig. 12:** Post-traumatic stricture of the membranous urethra. Descending study showing dilatation of the prostatic urethra due to a tight stricture of the membranous urethra (arrow). Treatment is with interval urethroplasty.
Fig. 13: Post-brachytherapy (radiotherapy) severe stricture of prostatic urethra. Note the multitude of radio-opaque brachytherapy 'seeds' implanted into the prostate. The treatment of such strictures is extremely difficult (see text)
Conclusion

A urethrogram is an essential tool for the contemporary radiologist and careful interpretation of a good quality study is essential for appropriate surgical management.

Personal Information

References


