2 Access, Stents, and Urinary Drainage

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SUMMARY

Ureteral access is necessary in many endourological procedures including ureteroscopy and ureteral stenting. Technologies such as ureteral access sheaths, balloon dilators, and coaxial dilators may be helpful in facilitating ureteral access in difficult cases. This chapter describes a stenting technique that relies on fluoroscopic guidance once the initial guidewire is placed and the cystoscope is removed.

Key Words: Ureter; stent; calculi; ureteroscopy; nephrostomy tube; shockwave lithotripsy.

INTRODUCTION

Ureteral stents are a mainstay in the urological armamentarium and are utilized in the treatment of urolithiasis including postureteroscopy, preshockwave lithotripsy, and to relieve symptomatic renal colic. Routine stenting postureteroscopy and intracorporeal lithotripsy, once the standard of care, have been shown to be unnecessary following uncomplicated ureteroscopy and stone manipulation. Advances such as laser lithotripsy and smaller ureteroscopes have minimized the potential morbidity of ureteroscopy to the point that the indwelling stent has become the most morbid part of the procedure. Ureteral stents may cause considerable side effects ranging from dysuria, urgency and frequency to hematuria

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and suprapubic pain. There is an emerging body of literature that routine stenting postureteroscopy is not necessary and that the need for stenting should be determined on a case by case basis.

Stents are also used to provide urinary drainage in nongenitourinary causes of ureteral obstruction, such as pregnancy and malignant ureteral obstruction. An alternative and effective method of urinary drainage is the percutaneous nephrostomy tube which is easily placed in patients with significant hydronephrosis and may be even more successful than retrograde ureteral stenting when urinary drainage is required as a result of obstruction of the distal ureter. Incompressible stents incorporating metal into the stent material have been used to provide urinary drainage to patients with malignant ureteral obstruction. Conversely, biodegradable stents have been developed to provide ureteral drainage temporarily following an endourological procedure before degrading and being excreted in the urine, thus obviating the need for cystoscopic stent removal. Other stent advancements will see coatings, new materials, and drugs loaded directly into the stent material or coated on the stent surface to improve comfort and reduce biofilm formation, infection, and encrustation.

Access to the ureter is required any time closed endoscopic ureteral procedures are to be carried out including during ureteral stenting and in association with diagnostic and therapeutic ureteroscopy for urolithiasis. More detail will be provided in other chapters regarding procedure specific aspects of ureteroscopy and percutaneous procedures; this chapter will focus on initially gaining retrograde access to the ureter, aspects related to ureteral stenting and a comparative analysis of alternative methods of urinary drainage. A brief summary of new stent technologies and biomaterials will also be presented.

Indications to Access the Ureter

Achievement of ureteral access is necessary for performing retrograde endoscopic procedures such as ureteroscopy, or for placing a ureteral stent. Table 1 lists common indications for ureteral stent placement.

Stones

Urolithiasis represents one of the more common reasons to insert a ureteral stent. Clinical indications for stenting include patients with intractable pain, those with infected pyonephrosis, or patients with impaired renal function from obstruction. In addition, ureteral stenting is often employed as an adjunct to shockwave lithotripsy or endoscopic procedures in patients requiring surgical stone management.

Ureteral Stones: Retrograde Ureteral Stenting vs Nephrostomy Tube Drainage

Pyonephrosis with an obstructing stone requires urgent decompression using either retrograde ureteral stent placement or antegrade percutaneous nephrostomy tube drainage *(1)*. Whether urinary drainage to bypass the obstruction is best accomplished via a ureteral stent or a nephrostomy tube is a subject of debate. The first randomized clinical trial to compare these two methods in obstructed, infected patients was performed by Pearle et al. *(2)* in 42 patients with obstructing urolithiasis and pyonephrosis. The time to defervescence, length of stay in hospital, pain symptoms, and normalization of leukocytosis did not differ between these two groups suggesting that urinary decompression by either retrograde ureteral stenting or antegrade percutaneous nephrostomy tube insertion are both equally effective in treating obstructed pyonephrosis. However, patients had significantly less fluoroscopy exposure (2.6 minutes less) when they were stented in a retrograde fashion.

Table 1
Indications for Ureteric Stent Insertion

- Stones—intractable pain, infection, hydronephrosis, acute renal failure, solitary kidney
- Postureteroscopy
- Pretreatment (pre-SWL)
  - Solitary kidney, stone >15 mm in diameter,
- Steinstrasse post-SWL
- Pyonephrosis (infection)
- Stricture (endoureterotomy)
- Trauma
- Fistula
- Ureteropelvic junction obstruction
  - To relieve symptoms
  - Post endopyelotomy/pyeloplasty
- Hydronephrosis/calculi of pregnancy
- Post reconstruction
  - Renal transplant
  - Ureteroneocystotomy
  - Ureteroureterostomy
  - Cystectomy and urinary diversion
- Extrinsic ureteral obstruction

SWL, shockwave lithotripsy.

A similar study was performed by Mokhmalji and colleagues *(3),* who also found no difference in relief of the presenting symptoms between patients randomized to nephrostomy tube insertion and ureteral stent placement. Percutaneous nephrostomy tube placement was successful in all of the 20 patients randomized to that group, but only 80% of the 20 patients randomized to retrograde ureteral stent placement were successfully stented. Although not statistically significant, there was a trend towards an improved quality of life in the nephrostomy tube group when pain, dysuria, frequency, and hematuria were taken into consideration.

From the standpoint of infection and the requirement for urinary decompression, it appears that nephrostomy tube drainage and ureteral stents offer equal drainage of the upper urinary tract. Symptoms of pain and irritation are also similar. Placement of a nephrostomy tube or ureteral stent depends on availability of good interventional radiologists and the urologist's access to the cystoscopy suite or operating room. At some hospitals, the radiology suite may be more accessible than the operating room or cystoscopy suite or vice versa. Subsequent procedures should also be taken into account. For instance, in patients who will require a percutaneous nephrolithotomy, a percutaneous nephrostomy tube is the preferred intervention and in patients with stones amenable to shockwave lithotripsy (SWL), a ureteral stent is often preferable. Many variables must be taken into account to determine whether a percutaneous nephrostomy tube or ureteral stent should be placed in patients with obstructing stones.

Ureteral Stenting Effects on Ureteral Physiology and Stone Passage

Animal studies have demonstrated that ureteral stents decrease the frequency and amplitude of ureteral contraction in animals. In an animal model of ureteral stones causing obstruction, ureteral dilatation was observed proximal to the obstruction in the stented group whereas a nephrostomy tube group had no dilatation *(4)*. Stents also impeded spontaneous stone passage and reduced ureteral contractility when compared to the nephrostomy group *(4)*. This is controversial, however, as others have shown that ureteral stents facilitate spontaneous passage of distal ureteric stones less than 10 mm in diameter in 83% of patients studied *(5)*. The ureter and ureteral orifice are theorized to passively dilate from the stent, thus facilitating stone passage. Although stents may affect ureteral peristalsis, the dilation of the ureter and orifice do facilitate spontaneous passage of smaller stones.

Stent Comfort and Quality of Life

There is an increasing awareness that stents impact patients' quality of life. Stents may cause morbidity in up to 80% of patients with symptoms ranging from irritative voiding symptoms, hematuria, flank pain, suprapubic pain, infection, and stent migration to the "forgotten" encrusted stent *(6–8)*. As a consequence of these concerns, the use of routine stent placement is being more thoroughly considered on a case-by-case basis when utilized as an adjunct to SWL or ureteroscopy.

In order to quantify patient morbidity from stents, Joshi et al. *(7,8)* have developed and validated the first questionnaire of stent symptoms, the Ureteral Stent Symptom Questionnaire, which consists of 48 items spanning five criteria: pain, voiding symptoms, work performance, sexual health, and overall general health. Results indicate that 76% of stented patients experienced negative symptoms, 70% required analgesic, and 42% had to reduce their activity by half *(8)*. This validated tool should become a standard evaluation technique of new stent technologies.

Stones: Stenting as an Adjunct to Shockwave Lithotripsy

Stenting prior to SWL is thought to preclude renal obstruction from stone fragments following SWL *(9)*. More recently, the prophylactic efficiency of pre-SWL stenting has been called into question and is now a debated topic where some believe that stents in SWL patients not only lack efficacy to prevent renal obstruction, but may, in fact, impede the passage of stones fragments following SWL *(10)*.

Steinstrasse, or the "street of stone" occurs with an overall rate of 3 to 6% of patients undergoing SWL *(11)* and in 13 to 26% of nonstented patients with stone burdens greater than 25 mm in diameter *(12,13)*. Placing stents prior to SWL in patients with stones greater than 20 to 30 mm in diameter significantly decreased the rate of steinstrasse to 3 to 7% *(11,14–16)*. In patients with stones smaller than 25 mm, the rates of steinstrasse and infection were unaffected by stenting *(9,17–20)*. The reason for this latter finding is likely the result of a significant risk decrease of steinstrasse in patients with stones less than 20 mm *(21)*. A retrospective review by Madbouly et al. *(21)* has shown that there are four variables that are significantly correlated with an increased risk of steinstrasse: stone size greater than 20 mm, stones located in the renal pelvis, a dilated renal pelvis, and shock wave energy greater than 22 kV. The risk of steinstrasse was 3.7 times less in stones smaller than 20 mm compared with stones greater than that 20 mm. Stone location was also a factor because dilation of the collecting system would lead to decreased amplitude of each contraction and lower intrapelvic pressures and propulsive power. Stone fragments in the ureter and a nondilated renal pelvis are subjected to a higher force and rate of peristalsis which would lead to propulsion through the system. The risk of steinstrasse was reduced by two times for energies delivered at 18 to 22 kV and reduced by three times at energies of 14 to 18 kV *(21)*. High-energy shock waves have been shown to produce larger stone fragments compared with more frequent lower powered shocks which result in finer stone fragments *(22)*.

These studies suggest that ureteral stents should be placed prior to SWL for large stones (>20-mm diameter). Some studies, particularly those treating large stones with SWL, must be considered with caution as percutaneous nephrolithotomy is usually the treatment of choice in stones greater than 20 or 25 mm. For patients with stones less than 20 mm who are to be treated with SWL, there is little evidence that stenting prior to SWL reduces the rate of steinstrasse or infection.

Stones: Stenting Postureteroscopy

The principle of avoiding ureteral obstruction secondary to ureteral edema and stone fragments is the main driving force for routinely leaving a stent post ureteroscopy and has traditionally been regarded as the standard of care. Technical advances including miniaturization of ureteroscopes, utilization of the holmium:YAG laser, and softer stone baskets have made ureteroscopy relatively atraumatic and the main morbidity following ureteroscopy originates from the use of ureteric stents. Furthermore, stents add to the cost of patient care and require an additional cystoscopy for removal unless a pull string is used. Reducing stent use following ureteroscopy should improve patient care and satisfaction (*see* Table 2).

Hosking *(23)* was the first to report a large series of nonstented ureteroscopy patients who had minimal complications. Approximately half of the patients had no discomfort and the majority of those with discomfort described it as mild and easily resolved by oral analgesics. Although this report was a case series and did not have a stented control group, it was the first series to suggest that ureteroscopy did not routinely require stenting. Denstedt et al. *(24)* randomized 58 patients to receive either a stent or no stent after ureteroscopy. The results demonstrate that there were no differences in rehospitalization rate, analgesic use or stone free rates. At 1 week, the stented group had significantly more pain and irritative voiding symptoms than the nonstented group. None of these patients underwent ureteral dilation, the holmium:YAG laser was used for intracorporeal lithotripsy, and all stones were less than 2 cm. The holmium:YAG laser is safe and has minimal effects on surrounding tissue which makes it an ideal modality to preclude the need for a stent postoperatively *(25)*. In addition, a randomized study using intracorporeal electrohydraulic lithotripsy also demonstrated that these patients can be safely left unstented *(26)*. Other randomized studies have found similar results suggesting that following uncomplicated ureteroscopy without ureteric dilation, stenting is not routinely required *(24,26–28)*. Even in patients who underwent ureteral dilation at the time of ureteroscopy, nonstented patients had results and complication rates similar to stented patients *(23,29)*. In the series by Hosking and associates *(23)*, ureteral dilation was performed in 88% of patients who suffered minimal complications postoperatively. Borboroglu et al. *(29)* performed a study in 107 patients, which also included 83 patients who underwent ureteral balloon dilatation, and found that stented patients had more pain and analgesic requirements, but no difference in stone free or rehospitalization rates. These studies provide evidence that stenting after uncomplicated ureteroscopy is not routinely necessary, but rather should be determined on a case-by-case basis.

Hydronephrosis/Calculi in Pregnancy

Upwards of 90% of women have hydronephrosis by the third trimester of pregnancy *(30)*, but only 0.2–25% will become symptomatic and require medical attention

Table 2
Summary of Stent vs No-Stent Trials Following Ureteroscopy

Authors (ref)	*Year*	*Number of patients stented/not stented*	*Balloon dilation of ureter?*	*Difference in stone-free rates?*	*Method of intracorporeal lithotripsy*	*Significant difference in major complications? (fever, rehospitalization, obstruction)*	*Significant difference in minor complications? in minor complications? (pain, irritative voiding symptoms)*
Hosking et al. *(23)*	1999	0/93	Yes 82/93 (15-Fr balloon)	No	Electrohydraulic (3 pts.) Pneumatic lithotripsy (17 pts.) Basket extraction (73 pts.)	N/A	85% had no pain or pain controlled by oral analgesics
Denstedt et al. *(24)*	2001	29/29	No	No	HO:YAG Laser	No	More irritative symptoms in stented patients
Chen et al. *(26)*	2002	30/30	No	No	Electrohydraulic	No	No
Hollenbeck et al. *(27)*	2001	51/51	Yes (15-Fr balloon)	No	HO:YAG Laser	No	More pain in stented patients
Byrne et al. *(28)*	2002	38/22	No	No	HO:YAG Laser Pneumatic Lithotripter	No	Suprapubic discomfort on POD no. 1 was worse in non-stented patients, but by POD no. 6, was worse in stented patients.
Borboroglu et al. *(29)*	2001	53/54	Yes 83/107 (15- or 18-Fr balloon)	No	HO:YAG Laser Electrohydraulic	No	Stented patients has significantly more flank and bladder pain, urinary symptoms and required more narcotic analgesia.
Netto et al. *(29a)*	2001	133/162	No	No	Basket extraction Ultrasonic lithotripsy	No	No

HO:YAG, holmium: YAG.

(30–32). The vast majority of patients respond to conservative treatment (70–93%) and few will require ureteral stenting or nephrostomy tube insertion. Indications for stenting include: rising creatinine, pyelonephritis (febrile infection), and intractable pain *(30–32)*. Although ultrasonography may be used to confirm the position of the stent during the procedure *(33–36)*, limited fluoroscopy, which most urologists are more familiar with, can be used safely and effectively, especially in the later stages of pregnancy *(37,38)*. Shielding of the uterus and brief pulses of fluoroscopy should minimize the risks of radiation, but fluoroscopy should be avoided during the early stages of pregnancy *(37,39)*.

The incidence of urolithiasis ranges from 1 in 200 to 1 in 2500 pregnancies *(40)*. The majority of calculi presenting during pregnancy will pass spontaneously with conservative management *(41–44)*. If an obstructing calculus fails spontaneous passage, the options are to decompress the kidney and treat the stone after delivery, or to definitively treat the stone during pregnancy. Prolonged indwelling stents or nephrostomy tubes may lead to encrustation, biofilm formation, and infection as pregnant women have physiologic hyperuricosuria and hypercalciuria *(45,46)*; therefore, some studies suggest that ureteral stents should only be placed after 22 weeks gestational age to avoid the need for multiple stent changes *(44)*. In pregnant women less than 22 weeks gestational age, a percutaneous nephrostomy tube can be inserted and changed multiple times with relative ease *(44,47)*. If conservative management fails, ureteroscopy and intracorporeal lithotripsy is a reasonable treatment option and have proven to be safe in the treatment of urinary calculi in pregnant patients *(41,46,48–50)*. Utilization of intracorporeal methods of lithotripsy, such as the pulsed-dye laser, pneumatic lithotripsy, and the holmium: YAG laser, have been shown to be safe with success rates greater than 90% *(38,41,44,46,49)*. Advances in anesthesia and ureteroscopic equipment have made intracorporeal lithotripsy safe and effective in pregnancy when conservative management fails.

Stenting Postureteropelvic Junction Obstruction Reconstruction

Endopyelotomy for ureteropelvic junction obstruction was initially described by Wickham and Kellett in 1983 *(51)*. A standard procedure following endopyelotomy is to leave a tapered 14/7-Fr endopyelotomy stent to traverse and splint the incised ureteropelvic junction. The size of endopyelotomy stent remains controversial with one study suggesting that a larger diameter stent (27 Fr) improves results at 2 years *(52)*, whereas other studies in animal models find no difference between 7 and 12–14-Fr stents *(53,54)*. Stent indwelling time is also controversial: in two studies comparing 2 vs 4 weeks of stenting postendopyelotomy, 2 weeks were shown to have similar results to 4 weeks *(55,56)*. Patency rates were similar between 2 and 4 weeks of stenting (92 vs 90%, respectively) and patients stented for the longer period of time had significantly higher rates of infection *(56)*. There is also further evidence in an animal model that a longer duration of stenting results in more ureteral fibrosis and thus, a higher rate of failure *(57)*.

These studies demonstrate that 2 and 4 weeks of stenting with a 14/7-Fr endopyelotomy stent result in the same success rates following endopyelotomy. Likewise, the ideal stent diameter is still a matter of debate as sizes from 7- to 27-Fr have been shown to produce equal results.

Malignant Ureteric Obstruction

Malignant extramural compression of the ureter causing hydronephrosis and renal compromise may be a consequence of many nongenitourinary cancers. When faced with this situation, the urologist must decide if the patient needs decompression and if so, whether it is urgent and if a stent or antegrade nephrostomy tube should be placed *(58)*. If a stent is to be placed, what type of stent should it be and how often should it be changed? In the decision algorithm, the patient's entire clinical picture must be taken into account including the overall prognosis, symptoms such as flank pain, presence of infection, renal function, and intention for further treatment, such as chemotherapy *(59)*. For instance, a terminally ill patient with bilateral hydronephrosis who is asymptomatic and free of infection may only suffer from the addition of urinary drainage tubes *(60)*. The symptomatic patient (infection, flank pain, fluid overload from renal failure) should be diverted. Patients with renal compromise from obstruction and who are about to undergo chemotherapy (palliative or curative) should have their renal function optimized by urinary drainage.

Park et al. *(58)* reported on patients who initially had bilateral ureteral stents that failed to lower serum creatinine or relieve ureteral obstruction and subsequently required percutaneous nephrostomy tube insertion. They suggested that percutaneous nephrostomy tubes are advantageous over ureteral stents in relieving malignant ureteral obstruction and lowering serum creatinine *(58)*. Pappas et al. *(61)* evaluated 206 patients with malignant ureteral obstruction treated with percutaneous nephrostomy tubes and found that it was a safe and effective procedure that returned normal renal function to 66% of obstructed patients. One theory of why nephrostomy tubes are more efficient at relieving obstruction is that because urine drains around a stent rather than through the lumen, extraluminal compression from cancer prevents ureteral peristalsis and precludes peristent urinary drainage *(58,62)*. Lastly, because stents often cause significant bladder and flank symptoms, nephrostomy tubes may offer a better quality of life than stents in cancer patients *(60)*.

The percentage of successful retrograde stent placements is lower than nephrostomy tube insertion which is nearly always successful in a dilated system *(3,63)*. With very distal ureteral obstruction owing to advanced pelvic malignancies, retrograde stenting may be difficult because of the lack of "purchase" required to advance a guidewire or stent up the ureter *(3,63)*.

Recently, a third method of diversion involving a silicone polytetrafluorethylene coated tube that connects the renal pelvis to the bladder via a tunneled subcutaneous route has been described *(64–66)*. Metal, noncollapsible stents have also been attempted in malignant ureteric obstruction, but the main limiting factors have been blockage of the stent with hyperplastic tissue and infection *(67–70)*.

Percutaneous nephrostomy tubes offer easy placement, exchange, and good drainage of the upper urinary tract in this difficult group of patients *(71)*. Improvements in stent materials and technology will increase the use of indwelling ureteral stents in managing malignant ureteral obstruction *(72)*.

ACCESS TECHNIQUES

Ureteral Access: Step 1—The Urethra

Retrograde approaches to the urinary tract begin at the urethra and face the potential challenges that are encountered in the lower urinary tract such as meatal stenosis, urethral stricture, false passage, prostatic hyperplasia, and priapism. Good urological principles guide the management of each situation: meatotomy for stenosis, visual internal urethrotomy or dilation for strictures, insertion of a safety guidewire to circumvent false passages, use of flexible cystoscopy as an adjunct when an enlarged prostate is encountered, and intracorporal α-agonist injection for priapism.

Table 3
List of Instruments Required to Obtain Access to the Ureter

1. Flexible cystoscope (or rigid cystoscope)
2. Guidewires
   a) 0.038-in. floppy-tipped wire,
   b) hydrophilic coated wire straight or angled
3. Open-ended retrograde catheters, angled catheters
4. 8/10-Fr coaxial dilators
5. Radiocontrast and syringe
6. Ureteral access sheath
7. Balloon dilator
8. Amplatz dilators

Ureteral Access: Step 2—Advancing a Guidewire Into the Ureter

Table 3 lists the equipment necessary for ureteral access. Cystoscopy is initially carried out to identify the ureteral orifices. Either a flexible or rigid cystoscope may be used, but flexible cystoscopes are less traumatic, offer more patient comfort, and provide the surgeon with greater range of motion, particularly in patients with an enlarged prostate gland. A floppy-tipped guidewire 0.038 in. in diameter is inserted into the ureter, advanced, and coiled into the renal pelvis under fluoroscopy. Once the guidewire is secure in the ureter, the scope is removed leaving the guidewire in place. If there is doubt about the position of the wire or the anatomy of the collecting system, an open-ended ureteral catheter can be placed over the guidewire to perform a retrograde pyelogram using dilute contrast.

After the guidewire is placed, the next step is dependent on the procedure at hand: rigid ureteroscopy can be carried out by inserting the semirigid ureteroscope alongside the guidewire, whereas flexible ureteroscopy requires placement of a second guidewire which will be removed after enabling advancement of the flexible ureteroscope over the wire *(73)*. Placement of a secondary wire can be achieved by placing a double lumen wire introducer or an 8/10-Fr ureteral dilator sheath set. The flexible ureteroscope is back-loaded over one guidewire and advanced into the renal pelvis. Some advocate using a “double-floppy” guidewire, which reduces the potential for damage to the working channel of the ureteroscope *(74)*. The second wire must remain as a “safety” for access and identification of the ureteral lumen. Ureteral perforation, false passage, or any other difficulties can be salvaged by simply placing a stent over the safety wire and deferring the definitive procedure to a later date.

Ureteral Access: Step 3—Difficulties With the Ureteral Orifice

Once two guidewires are advanced into the renal pelvis, difficulty may be encountered at the ureteral orifice when introducing a flexible ureteroscope. This can be counteracted by gently rotating the scope over the guidewire while advancing it into the ureter. Ureteral dilation is not routinely necessary for ureteroscopy *(75)*, but if a truly stenotic orifice is encountered, balloon or coaxial dilatation may be necessary *(76)*. An alternative technique is to place an indwelling stent for 7 to 10 days to passively dilate the ureter and resume ureteroscopy at that time. Balloon dilators come in 5- to 7-Fr diameter catheters with balloons ranging from 4 to 7 mm in diameter that can exert up to 220 psi (15 atm). Experimental animal studies suggest that overzealous dilation to 15 Fr at 10 atm can cause

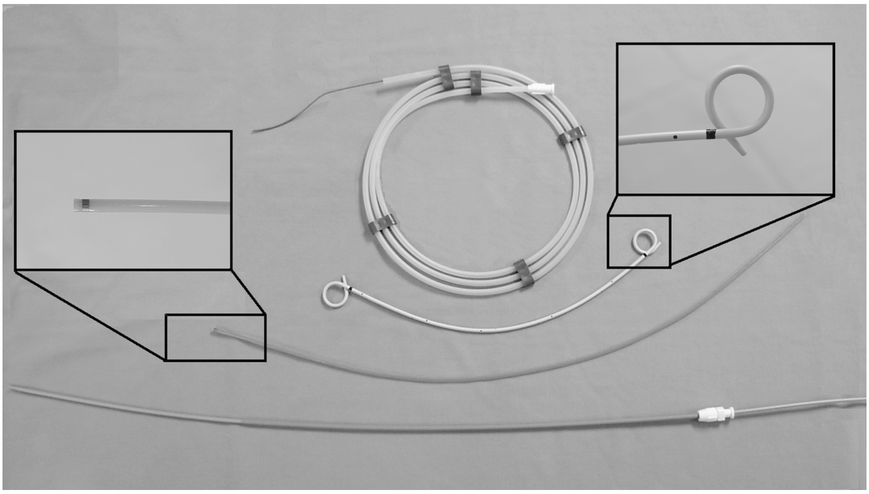

Fig. 1. Materials required for ureteral stenting. (From top to bottom) Floppy tipped guide wire, Double-J stent (curl magnified), metal-tipped stent pusher (radiopaque metal tip magnified), 8/10 coaxial sheath dilator set.

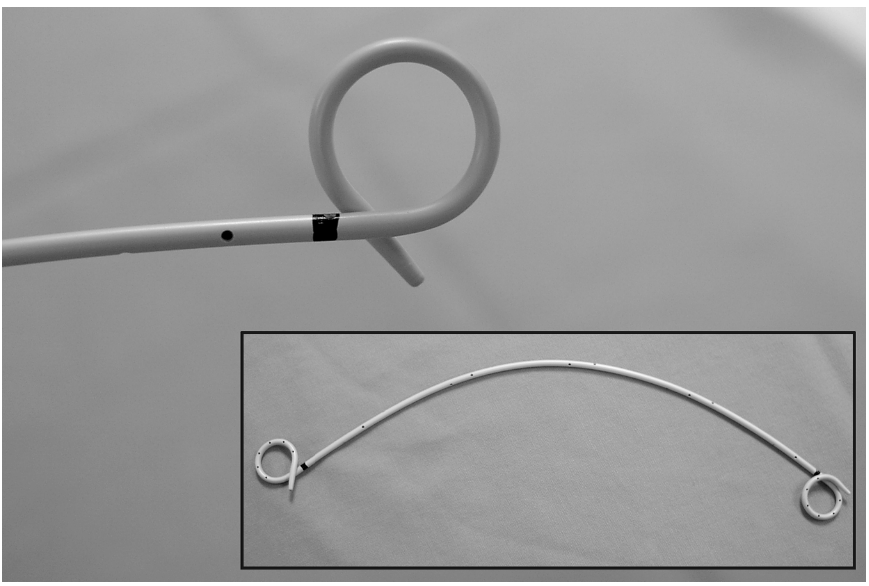

Fig. 2. Double-J stent. (Curl magnified) Sideholes aid in drainage and the black mark on either end of the stent facilitate visualization of the curl when placing a stent visually through the cystoscope.

ureteral aperistalsis, vesicoureteric reflux, increased pressure and hydronephrosis proximal to the area of dilation, and diminished ureteral contractility *(77,78)*. Only after 6 to 7 weeks of dilatation did the ureteral physiology and histology return to normal in these animals *(77–79)*. The safety and efficacy of balloon dilators in ureteroscopy have been confirmed in humans and are in routine use *(80,81)*. Sequential polyethylene coaxial dilators range from 6 Fr and up and are more cost effective than balloon dilators *(82)*. Care must be taken not to damage the urethra, ureteral orifice, or ureteral lumen. Applying the correct amount of tension to the guidewire while advancing the dilators will reduce the

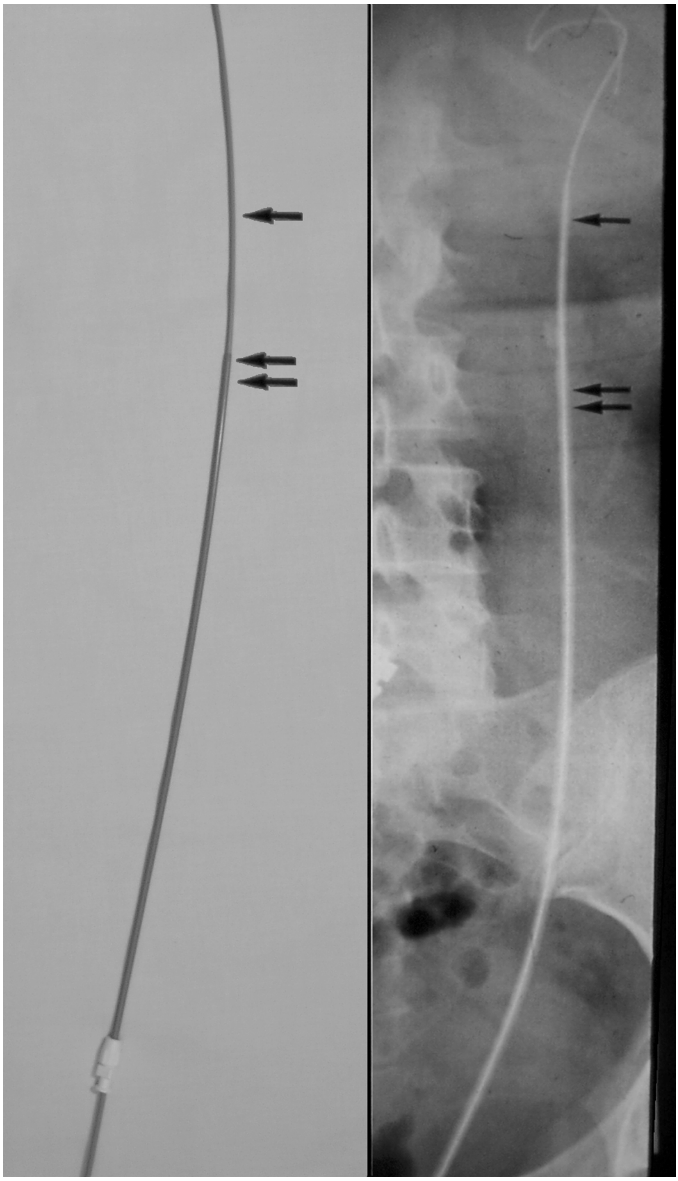

Fig. 3. Table-top and corresponding radiograph of the 8/10 coaxial dilator set. After advancement of the guidewire into the renal pelvis, the cystoscope is removed and the remainder of the procedure is performed under fluoroscopy. The 8/10 dilator set is advanced over the guidewire. The double arrows correspond to the end of the 10-Fr sheath. The single arrow delineates the end of the 8-Fr dilator which is almost in the renal pelvis. The 10-Fr sheath is advanced up to the hub of the patient's urethral meatus and the proximal end reaches the midureter in this case since the patient is female. In males, the 10-Fr sheath reaches just above the iliac vessels.

likelihood of ureteral or guidewire damage. Shearing forces can damage the ureter or guidewire, which will either prevent advancement of the ureteroscope or damage the working channel during advancement of a flexible ureteroscope. If resistance is met during scope advancement over the guidewire, the scope should be removed and the

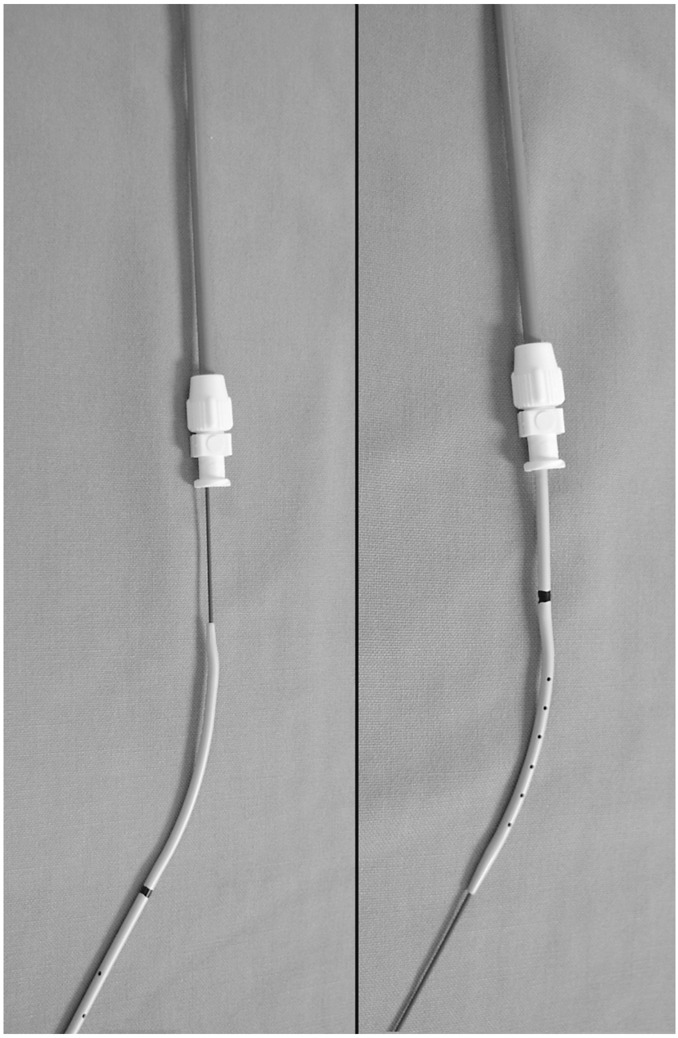

Fig. 4. The 8-Fr dilator has been removed and the stent is being advanced over the guidewire into the 10-Fr sheath. The 10-Fr sheath acts as a conduit to prevent buckling of the stent in the urethra, bladder, or ureter. Tension must be placed on the guidewire while the stent is advanced.

guidewire should be replaced through a ureteral catheter. Although balloon dilators are more expensive, they are less traumatic to the ureter than coaxial dilators.

Ureteral Access Sheath

Ureteral access sheaths were first developed in the 1970s to aid in difficult access to ureters for ureteroscopy *(83)*. The peel-away sheath became used in the 1980s which required sequential rigid dilators and several steps before the ureteroscope could be inserted, but was associated with a high rate of ureteral perforation (15–30%) *(84)*. Today's access sheaths consist of a two-piece hydrophilic, lubricious outer sheath and inner introducer which is removed after advancement over the guidewire. Sheaths come in various lengths (20–55 cm) and diameters (10–16 Fr) depending on patient size and gender. The access sheath acts as a dilator and a conduit that prevents buckling of the

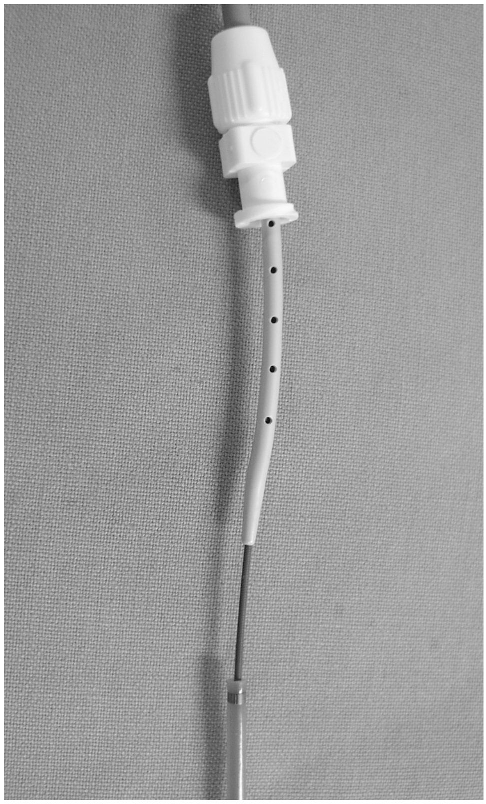

Fig. 5. The stent is advanced into the 10-Fr sheath as far as possible and the metal-tipped stent pusher is then advanced over the guidewire to push the stent.

flexible ureteroscope within the bladder. Operating room times and costs are also decreased by use of the access sheath *(85)*.

With these devices, the flexible ureteroscope is not inserted over a guidewire, but is advanced directly up the lumen of the access sheath. Ureteral access sheaths offer the advantages of better flow of irrigation, and thus visualization, concomitant intra-operative drainage of the bladder, and ease of access for repeated removal and reinsertion of the flexible ureteroscope *(74)*. This last benefit is particularly useful if basketing of multiple stones is desired. At the end of the procedure, the access sheath can facilitate the insertion of a ureteral stent if necessary *(86)*.

Pressure on the tip of ureteroscopes may be partially responsible for damage to the fibreoptics resulting in costly scope repair. The use of access sheaths has been shown to prevent and delay scope damage by reducing the stress on the tip of the scope during advancement, as well as preventing damage to the working channel by obviating the need for advancement over a guidewire *(87)*. One theoretical complication of access sheaths is prolonged pressure on the ureteral wall and ischemia resulting in a ureteral stricture. However, this has not been substantiated and the stricture rate is low as demonstrated in a retrospective review by Delvecchio et al. *(87a)* where only 1 of 71 patients developed a stricture.

Ureteral access sheaths have been shown to be a safe method for obtaining ureteral access for ureteroscopy with a low rate of stricture or ureteral perforation. Furthermore, operating room times and such postoperative symptoms as frequency, urgency, dysuria,

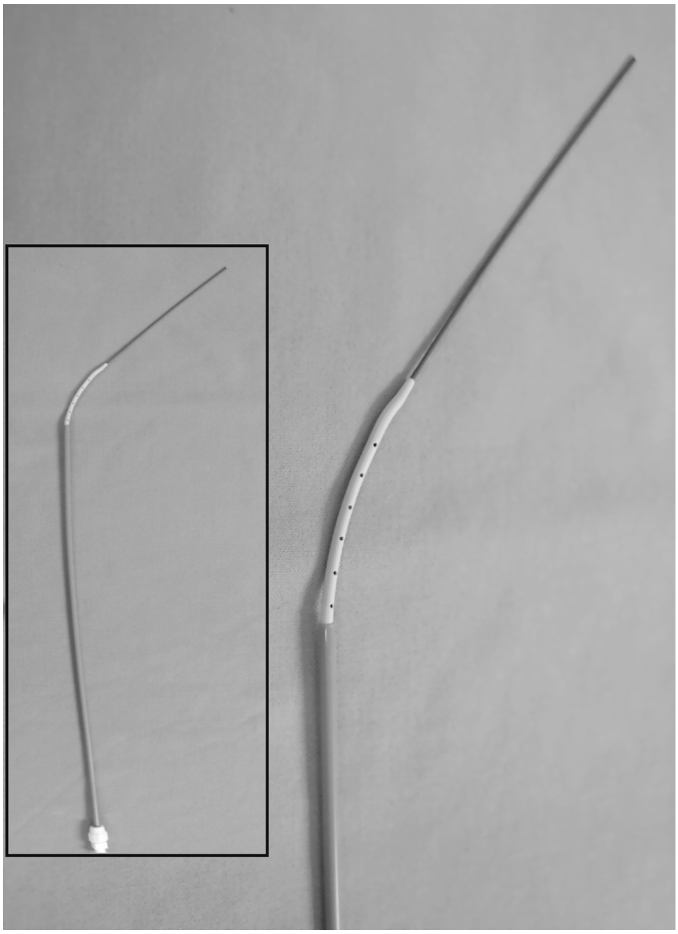

Fig. 6. As the stent is advanced, it will exit the 10-Fr sheath and enter into the renal pelvis. Pulling the guidewire slightly back will result in the curling of the proximal part of the stent.

and hematuria were significantly less in patients who were randomized to undergo ureteroscopy with a ureteral access sheath. Surgeon frustration is also diminished as multiple withdrawals and introduction of the scope can be performed easily and operative visualization is improved with the higher flow of irrigation through the sheath.

STENTING TECHNIQUE

The technique of stenting is outlined in Figs. 1 to 11. After a guidewire is placed into the renal pelvis, the cystoscope is removed and the procedure is visualized using only fluoroscopy, a technique used by radiologists. Instead of a single view of the inside of the bladder using cystoscopy, fluoroscopy allows the urologist to monitor both the distal and proximal ends of the guidewire and stent during the procedure. This technique is also more comfortable for the patient if they are only under light sedation because the cystoscope has been removed. An 8/10-Fr dilator is placed over the guidewire into the ureter by first advancing the 8-Fr portion. Once inside the ureter, the 10-Fr sheath is advanced over the 8-Fr portion into the ureter and confirmed by fluoroscopy. The 10-Fr sheath is advanced so that the hub is at the level of the urethral meatus. The 8-Fr dilator is removed

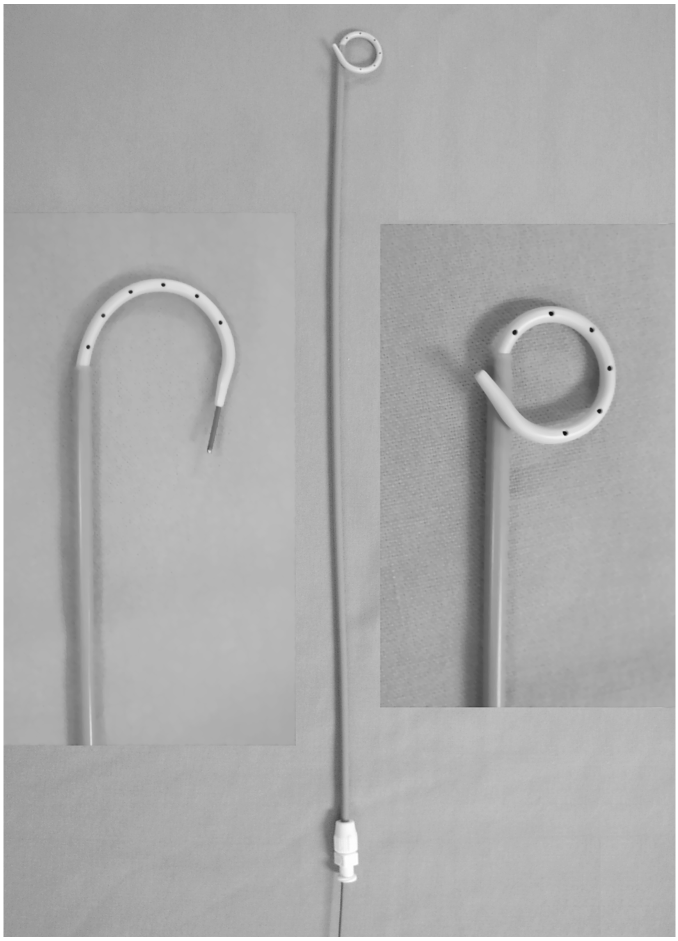

Fig. 7. Fluoroscopy is used to follow the stent into the renal pelvis. Once within the renal pelvis, the guidewire is withdrawn slightly so that the upper stent curls in the renal pelvis.

leaving the 10-Fr sheath which acts as a conduit for the stent and prevents buckling or coiling of the stent within the urethra, bladder, or ureter. The stent is advanced through the 10-Fr sheath and the pusher is advanced until its radiopaque marker is at the lower level of the pubic symphysis in females, and midway between the upper and lower level of the symphysis in males. The kidney is viewed on fluoroscopy and the guidewire is slightly retracted until the upper loop is seen to curl in the renal pelvis. With fluoroscopy on the pubic symphysis, the pusher is held with the radiopaque marker at the correct level and the 10-Fr sheath is withdrawn from the urethra. As the guidewire is removed the lower loop of the stent will curl in the bladder; however, if it remains in the urethra, it can be advanced by inserting a foley catheter or applying manual suprapubic pressure to the bladder which will displace the bladder cephalad and pull the stent into the bladder. This technique of stenting is demonstrated in the companion DVD, that accompanies this volume and a similar technique utilizing a ureteral access sheath has also been described *(86)*.

A potential complication of this technique of ureteral stenting is inadvertent advancement of the distal end of the stent into the ureter. The best way to avoid this

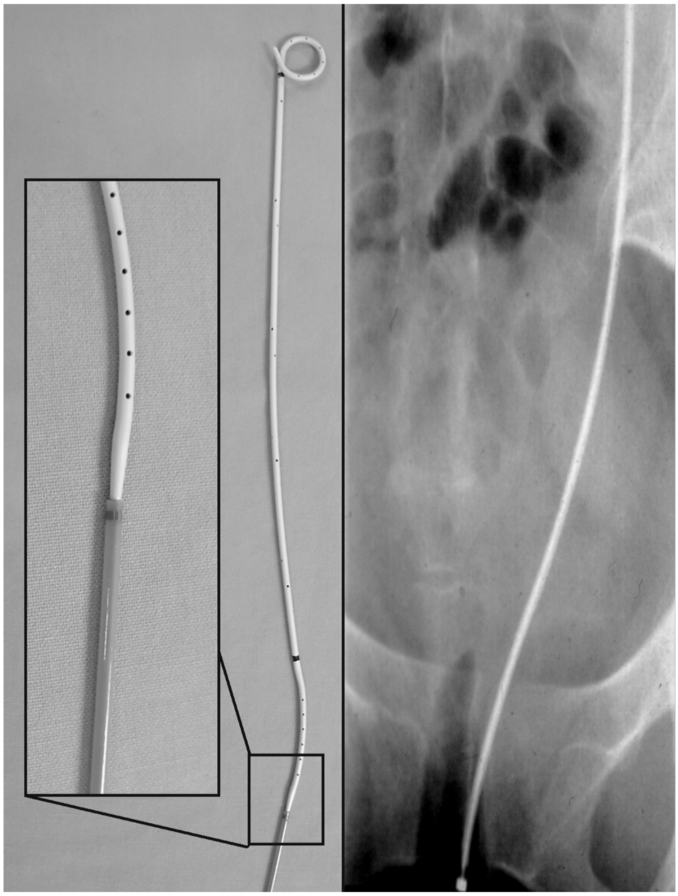

Fig. 8. Radiographically, the metal-tipped pusher is at the correct level of the symphysis for a female patient and the 10-Fr sheath has been withdrawn. The metal-tipped pusher is positioned at the lower border of the pubic symphysis in women and at the level of the mid pubic symphysis in men. Once the metal-tipped pusher is in the correct position, the 10-Fr sheath is backed-up over the guidewire.

complication is to prevent it by ensuring that the radiopaque marker on the stent pusher during the procedure does not go above the bottom of the pubic symphysis in females or above the middle of the symphysis in males. If a stent is advanced too proximal into the ureter, cystoscopy should be carried out and a grasper should be used to pull the stent into the bladder if the end of the stent is visible in the bladder. If the tether is still attached to the stent, this can be used to pull the stent back into the bladder. If the stent is well within the ureter, a guidewire should be advanced into the ureter, and a semirigid ureteroscope inserted to attempt removal of the stent using a stone basket or graspers. An alternative method is to place a ureteral dilating balloon alongside the stent, partially inflate it and deflate it causing the stent to adhere to the deflated balloon. The stent is removed as the deflated balloon is slowly withdrawn under close fluoroscopic observation taking special care to avoid ureteral avulsion or damage to the ureteral orifice *(88,89)*. These maneuvers are best performed with the patient under neuroleptic or general anesthesia. There are also reports that stents may migrate distally or even retrogradely into the kidney *(88,90,91)*.

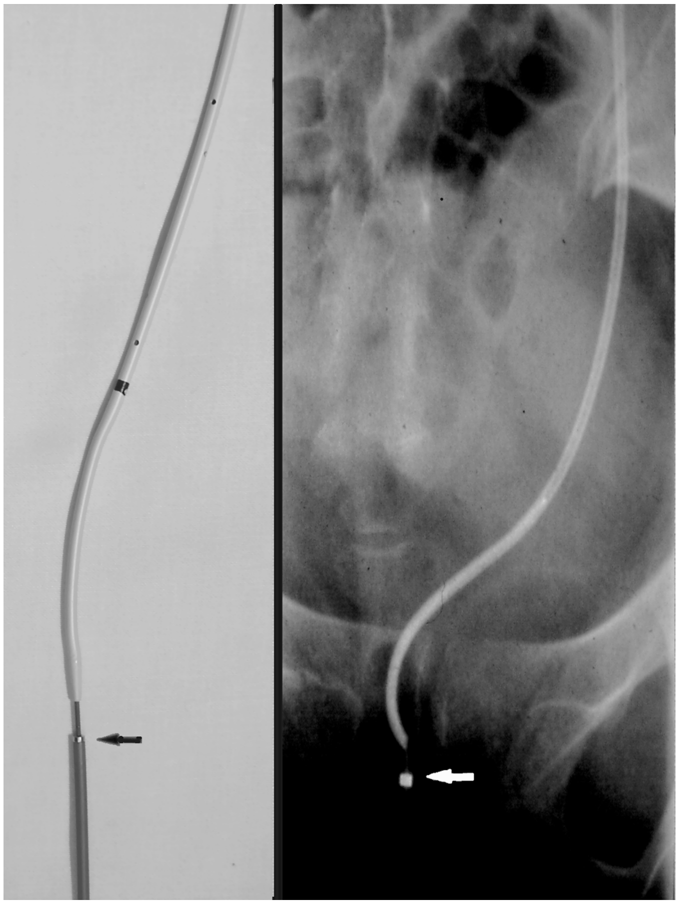

Fig. 9. The pusher is held in place at the correct level with the radiopaque marker (arrow) at the pubic symphysis.

STENT COMFORT, INFECTION, AND ENCRUSTATION: THE ROLE OF NEW BIOMATERIALS AND COATINGS

Ureteral stents may cause considerable morbidity, thus limiting their clinical tolerability and effectiveness *(6)*. It is only recently that a validated questionnaire to examine the morbidity of stents has been developed and showed that stented patients suffer substantial morbidity *(7,8)*. Without question, the major obstacles that limit stent use are the fact that they are uncomfortable, may cause infection, and provide a surface for crystals to bind and aggregate. The use of new biomaterials and stent technology are reviewed in detail elsewhere and highlight the recent advances in stent technology to improve stent comfort and decrease encrustation and infection rates *(92–96)*.

Risk factors for stent-associated infection include female sex, diabetes, chronic renal failure, and indwelling stent time greater than 90 days *(97)*. Oral antibiotics are often administered after stent insertion and have been found to prevent or delay both biofilm formation and infection *(98)*. Oral ciprofloxacin has been found to adhere to a ureteral stent at high enough concentrations to inhibit bacterial growth *(98)*. Even 2 to 3 days of oral antibiotics following stent insertion has been shown to delay biofilm formation and urine infection for up to 2 weeks *(99)*.

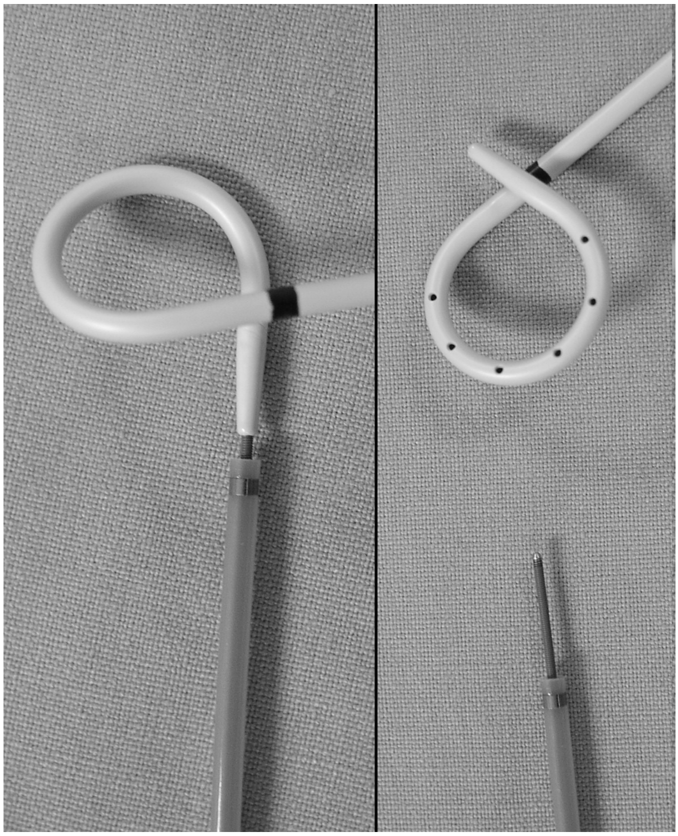

Fig. 10. The guidewire is withdrawn and the distal end of the stent is seen to curl in the bladder.

In an effort to improve comfort, prevent short-term postoperative ureteral edema and preclude cystoscopic stent removal, temporary ureteral drainage stents have been developed and shown to have little or no inflammation on porcine ureters *(100)*. Novel stent coatings, such as the enzyme oxalate decarboxylase, which breaks down oxalate, have been shown to decrease encrustation in an animal model *(101)*, whereas silver coatings have been shown to decrease bacterial adherence *(102)*. Other agents, such as intravesical anti-inflammatories, have also been employed to decrease stent symptoms and may prove to be a useful stent coating *(103)*.

A potential advance in stent technology utilizes metal in the stent material resulting in a crush resistant stent *(67–70)*. It has been used almost exclusively in malignant ureteral obstruction because of its rigidity and crush resistance. The clinical and animal trials utilizing the metal stent all point to stent failure secondary to lumen narrowing from tissue hyperplasia *(68)*. In addition, the surface of the stent is vulnerable to biofilm formation, as well as encrustation leading to infection and possible difficulty removing the stent *(68)*. Metal stents should be used sparingly and perhaps only in patients who have not tolerated regular double-J stents. Further development of more rigid, uncompressible stents may make this modality more effective in the future.

TIPS AND TRICKS

During stenting or ureteroscopy, a large or impacted stone can often impede passage of the guidewire into the renal pelvis. Table 4 outlines a treatment algorithm for advancing

Fig. 11. Radiographic appearance as the guidewire is withdrawn and the stent curls in the bladder.

Table 4
Algorithm for Passing a Guidewire Past an Obstructing Stone

1. Attempt passage with a hydrophilic guidewire.
2. Attempt passage using a retrograde ureteral catheter, or use to push stone into renal pelvis.
3. Pull ureteral catheter back, re-insert guidewire using the catheter to buttress the guidewire and give it support (***Note***: careful of ureteral perforation, only soft-tipped guidewires should be used in this situation).
4. Remove guidewire, and perform retrograde pyelogram to push stone back into renal pelvis (ureteral perforation will also be detected at this point, if present).
5. If the stone is very distal, leave the wire at the level of the stone, insert semirigid ureteroscope and treat the stone with intracorporeal lithotripsy (ensure the safety wire is visible at all times). A second guidewire should be placed into the renal pelvis as soon as it is possible.
6. If above fails, ensure there is no extravasation (perforation) by retrograde pyelogram, remove all instruments, and end the procedure. Patient may require a percutaneous nephrostomy tube if indicated (infection, symptomatic, compromised renal function, solitary kidney). Alternative therapies should be considered (antegrade ureteroscopy, open ureterolithotomy, or a second attempt ureteroscopy in 7 to 10 days).
   a. There is evidence that percutaneous nephrostomy tubes actually facilitate stone passage *(4)*. Furthermore, there is also evidence that ureteral stents impede the passage of stones *(4)* and may even be ‘jacked’ up to the kidney by a stent during shockwave lithotripsy *(90)*.

a guidewire past an obstructing stone. If a regular floppy tipped guidewire cannot be inserted, a ureteral catheter can be used to exchange it for a hydrophilic guidewire. The hydrophilic property of these wires reduces friction and allows them to slide between the stone and the ureteral lumen. Hydrophilic guidewires come in both angled and straight tips; the angled tips are often easier to manipulate around the stone. If this is unsuccessful, the next step is to reinsert the ureteral catheter over the wire and attempt to advance this past the stone. Owing to its blunt tip and greater rigidity, the ureteral catheter will slide past the stone or push it up into the renal pelvis where it can be easily treated. The ureteral catheter can also be used to perform a retrograde pyelogram which may propel the stone backwards into the renal pelvis. The retrograde pyelogram will also detect any extravasation of contrast which indicates a ureteral perforation, a potential risk in inflamed ureters with impacted stones.

When faced with difficulty advancing the guidewire past a distal ureteral stone, an alternative is to leave the guidewire at the level of the stone, insert the semirigid ureteroscope and treat the stone. The guidewire should remain visible at all times and as soon as it is possible, the guidewire should be advanced into the renal pelvis beyond the obstructing lesion. The last resort is to remove all instruments and abandon the surgical procedure, particularly if ureteral perforation has occurred. Patients will usually require urinary drainage via a percutaneous nephrostomy if there is infection, symptomatic pain, compromised renal function, solitary kidney, or ureteral perforation. Rarely, patients may be treated conservatively and alternative methods, such as SWL, open ureterolithotomy, or a second attempt at ureteroscopy in 7 to 14 days may be considered.

CONCLUSION

Retrograde access to the urinary system is the first step in many endourologic procedures and all urologists should be adept at dealing with the nuances of achieving access. Ureteral stents are a vital part of the urological armamentarium and play a role in the treatment of stones, reconstructive urology, ureteropelvic junction obstruction, hydronephrosis of pregnancy, and ureteral obstruction. Development of novel ureteral stent coatings, new stent materials, and compounds loaded directly into the stent should improve patient comfort and reduce the risks of infection and stent encrustation.

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