RadioGraphics

Complications of Ureteral Stent Placement[1]

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CME FEATURE

See accompanying test at http://www.rsna.org/education/rg_cme.html

LEARNING OBJECTIVES FOR TEST 1

After reading this article and taking the test, the reader will be able to:

- Discuss the characteristics of the ideal ureteral stent.
- Recognize the imaging appearances of ureteral stents and the most common problems associated with them.
- Define the population of patients who are appropriate candidates for ureteral stent placement.

The recent increase in usage of ureteral stents in the management of a variety of urinary tract disease processes mandates familiarity with these devices, their consequences, and their potential complications, which at times can be devastating. Radiology plays an important role in the routine monitoring of stents and in the evaluation of these consequences and complications. It may also offer solutions for their correction. Stents should be monitored while in place, promptly removed when no longer needed, and changed periodically if chronically indwelling. Risk factors for complications should be minimized with high fluid intake, timely evaluation of clinical complaints, and aggressive treatment of documented infection. Certain patients may not be best served by indwelling stent placement, and urinary diversion by means of other mechanisms may be indicated. The implanting physician is responsible for informing the patient of the requirements, consequences, and complications associated with stent placement. Failure to do so has obvious management and potential medicolegal implications.

Abbreviation: ESWL = extracorporeal shockwave lithotripsy

Index terms: Stents and prostheses • Ureter, reflux, 82.85 • Ureter, stenosis or obstruction, 82.4617, 82.84 • Ureter, stents, 82.4611, 82.4617

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Table 1
Indications for Ureteral Stent Placement

Relief of benign or malignant obstruction
Adjunct to stone therapy
For obstruction
For ESWL
For intraluminal lithotripsy
For ureteral instrumentation
For stone visualization
Perioperative placement
Alignment of drainage elements
Maintenance of luminal caliber
After ureteral intervention
Identification of ureter(s)
Management of urine leak
Leak from trauma or surgery
Leak due to ureteral fistula

Source.—References 2–5.

Table 2
Characteristics of the Ideal Ureteral Stent

Easily inserted from any access
Resistant to migration
Optimal flow characteristics
Well tolerated by patient
Biocompatible
Biodurable
Resistant to encrustation
Nonrefluxing
Radiopaque or visible at US
Easily exchanged and removed
Versatile
Affordable

Source.—References 4–8.

Table 3
Consequences and Complications of Ureteral Stent Placement

Irritative voiding symptoms
Incontinence
Suprapubic or flank pain
Vesicorenal reflux
Hematuria
Pyuria
Urinary tract infection
Malposition
Migration
Inadequate relief of obstruction
Encrustation
Ureteral erosion or fistulization
Fracture
Forgotten stent

Source.—References 2–4, 7–12.

Introduction

Ureteral stents represent the most mature application of an indwelling endoluminal splint, having first been described by Zimskind et al (1) in 1967. As originally described, the intent of implantation was for the treatment of ureteral obstruction or fistula. Maturity of the technique paralleled development of extracorporeal shockwave lithotripsy (ESWL) and technical advances that allow endoluminal investigation and treatment of a variety of urinary tract diseases. As a result, the indications for ureteral stent placement have expanded significantly (Table 1) (2–5). Ureteral stent placement is now considered a standard and indispensable urologic tool.

As the technique has evolved, so has the design of the implanted device. It should be recognized, however, that no currently available device fulfills all of the criteria for the "ideal" stent (Table 2) (4–8). Certain consequences can be anticipated with implantation of a foreign object into the urinary tract. There can also be unexpected complications (Table 3) (2–4,7–11). Radiology plays an important role in the requisite monitoring of patients with indwelling stents as well as in evaluation of and potential therapy for the consequences and complications associated with stents. In this article, we review the evolution of stent design and then discuss and illustrate these consequences and complications, including urinary tract infection, malposition and migration, inadequate relief of obstruction, encrustation, stent fracture, ureteral erosion or fistulization, and the forgotten stent.

Evolution of Stent Design

In the original report of indwelling ureteral stent placement, a length of silicone rubber tubing was passed at cytoscopy over a ureteral catheter as an indwelling splint (1). Although this proved the feasibility of the technique, stent migration, stent encrustation, and stent obstruction occurred in

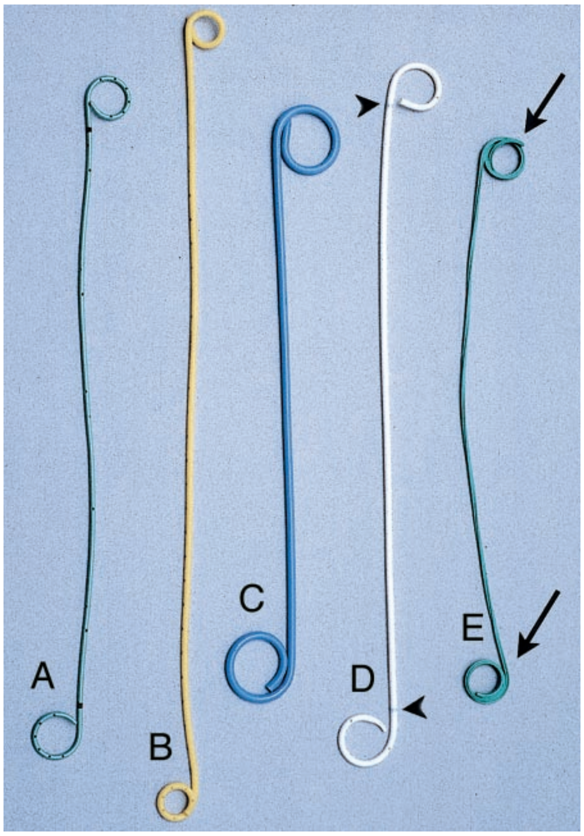

Figure 1. Some currently available ureteral stents. Stent *A* is a 6-F polyurethane stent with standard proximal and distal pigtail loops to prevent migration and fenestrations along the entire shaft length. Stent *B* is a 7-F silicone stent with holes in the loops only. (Stents *A* and *B* are manufactured by and shown courtesy of Cook Urological, Spencer, Ind.) Stent *C* is a Flexima ureteral stent (Boston Scientific). This 10-F stent has a hydrophilic coating and holes in the loops only. Stent *D* is an Ultrathane Amplatz ureteral stent (Cook, Bloomington, Ind). This 8.5-F polyurethane-latex stent has a hydrophilic coating and metal markers indicating shaft length (arrowheads). Stent *E* is a C-Flex Towers multilength stent (Cook Urological). This 6-F stent has a hydrophilic coating and ridges rather than fenestrations along its length to assist with urine flow. The internal lumen accommodates a .028-inch guide wire. Note the multiple coils on each end of the stent (arrows), which give a usable shaft length of 22–32 cm.

the small population of patients in the report. Irritative bladder symptoms were noted to be rare, and this was attributed to the softness of the silicone material. To address the issue of migration, McCullough (12) described the use of a curved catheter to prevent downward migration out of the kidney. Hepperlen et al (13) extended this concept by modifying a pigtail angiographic catheter that could be passed over a guide wire for ureteral placement. The pigtail loop was reconstituted in the renal collecting system, and side holes were placed along the length of the ureteral portion of the catheter to improve the drainage characteristics. A distal flange was added to prevent upward migration. Finney (14) further refined the design of the ureteral stent, describing a double-J catheter with oppositely directed loops at the renal and vesical ends to prevent migration. It was also thought that if the catheter were of the proper length and in the correct position, the prevalence of irritative bladder symptoms would be reduced.

The softness of silicone material continues to be the standard against which modern stents are judged; however, due to the high coefficient of friction of silicone, implantation of silicone stents is often difficult and sometimes impossible. This led to the use of polyethylene in the construction of stents to provide stiffness as an aid for insertion. This material proved to be unstable in the urinary environment, which made polyethylene stents prone to early fracture. Polyurethane was then substituted, and it continues to be used in stent construction today, either alone or in combination with other materials. More recently, copolymers such as C-Flex (Concept Polymer Technologies, Clearwater, Fla), Percuflex (Boston Scientific, Natick, Mass), and Flexima (Boston Scientific) have been used in the construction of double-J or double-pigtail catheters. Hydrophilic gel coatings have been added to assist with placement and to potentially reduce the prevalence of encrustation and complicating infection (Fig 1) (2,3,6,15). Stents made of biodegradable materials and metal are also under investigation (16–18).

The length of time a stent is left in place (indwelling time) is generally determined by the indication for placement and by physician experience. Indwelling times may range from a few days for relief of ureteral edema to the duration of the patient's life for maintenance of ureteral patency in obstruction from malignant disease. Regardless of the stent composition, manufacturers usually recommend exchange of stents at 3- to 6-month intervals, and studies have shown that the prevalence of complications increases with longer indwelling times (19).

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Figure 2. Appropriate stent placement. Abdominal radiograph demonstrates how a stent of appropriate length allows reconstitution of the proximal pigtail loop in the renal pelvis and the distal loop above the bladder base to prevent migration and reduce the occurrence of irritative bladder symptoms.

Figure 3. Urinary tract infection. Unenhanced (top) and contrast material–enhanced (bottom) computed tomographic (CT) scans were obtained in a patient who developed fever and flank pain 1 week after insertion of a stent for relief of ureteral obstruction from a distal stone. The urine was sterile at the time of stent insertion. The nephrographic defects seen on the contrast-enhanced scans reflect extensive renal involvement from acute pyelonephritis.

Consequences

Even with appropriate placement of modern stents (Fig 2), irritative bladder symptoms may occur in 80%–90% of patients (20–22). At times, these can be so intolerable as to require early stent removal (22).

Suprapubic and loin pain are common occurrences in patients with stents. If the stent is too long, allowing the distal loop to impinge on the bladder base, direct irritation with consequent symptoms may occur.

Vesicorenal reflux is inevitable with a patent stent in place. In a report of voiding cystourethrography performed in patients with stents, 80% of patients were shown to have reflux during the voiding stage of the examination (23). This is likely the cause of flank pain experienced during voiding by these patients. Despite improvements in biocompatible materials for stent construction, the epithelium of the renal collecting system, ureter, and bladder reacts to the presence of the foreign body (24). Microscopic hematuria can be seen in the majority of patients with a stent in place, and at times gross hematuria may develop. Pyuria as a response to the chronic irritation may also occur.

Complications

Urinary Tract Infection

Urinary tract infection may develop in the short term as a complication of instrumentation of a previously sterile urinary tract (Fig 3), or later as an extension of the underlying disease process. In most patients with ureteral obstruction, stent

Figure 4. Stent malposition. Urogram reveals that an overly long stent has passed beyond the collecting system into the renal parenchyma (arrows). Persistent flank pain prompted reassessment of the position of the stent.

a. b.

Figure 5. Stent malposition. **(a)** Conventional radiograph shows that a stent placed for ureteral obstruction from a stone (arrow) has pierced the renal parenchyma. The proximal portion of the pigtail loop lies in a subcapsular position. Gross hematuria that did not clear prompted repositioning of the stent. **(b)** Radiograph obtained after repositioning shows more optimal configuration of the renal pigtail loop.

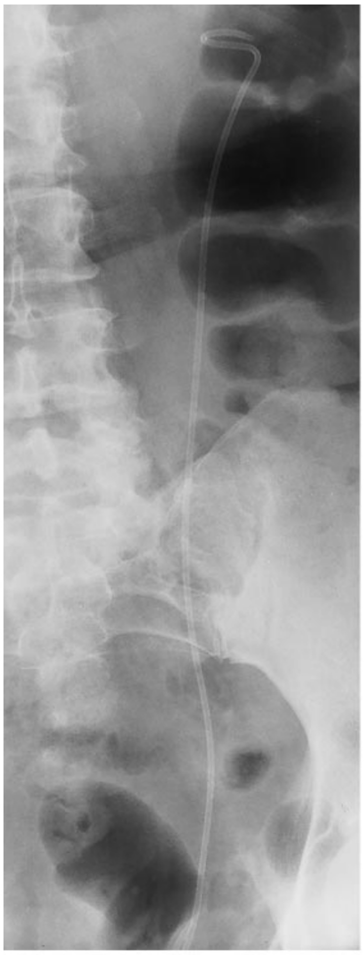
placement is performed with antibiotic prophylaxis, often as a single dose attendant to the procedure. In patients with a known urinary tract infection, stent insertion should be delayed if possible until appropriate treatment with culture-specific antibiotics allows urine sterilization (3). The presence of a foreign body may also lead to colonization of the urinary tract and, ultimately, of the stent itself. Eradication of these infections may eventually require exchange or removal of the stent.

Malposition

Malposition of a stent is defined as an incorrect position relative to initial placement (25). Stents made of stiffer materials may penetrate the ureter, collecting system, and kidney parenchyma during placement, resulting in urinoma or hematoma formation (Figs 4, 5).

Close observation of the configuration of the proximal stent loop may provide an indication of perforation of the renal pelvis (26).

Reconstitution of the proximal and distal loops or curves of the stent depends on inherent memory in the construction material, after the guide wire or other delivery system is removed. If a stent of inadequate length is selected for insertion and an inadequate distal curl is left in the bladder, reconstitution of the upper curl over



6a.

6b.

7.

Figures 6, 7. **(6)** Fish reeling. **(a)** Conventional radiograph obtained shortly after stent insertion reveals that the proximal pigtail loop of the stent is not completely reconstituted. Note the short distal curl. The stent could not be located at cystoscopy at the scheduled time of removal. **(b)** Conventional radiograph demonstrates reconstitution of the proximal loop with resultant retraction of the distal loop into the lower ureter. **(7)** Stent malposition. Persistent pericatheter leakage prompted evaluation of a recently placed stent. Conventional radiograph shows the distal stent tip in the proximal urethra adjacent to the bladder catheter (arrow).

time may retract the distal stent tip into the ureter ("fish reeling"), thereby complicating retrieval (Fig 6) (25).

An appropriate stent length is critical for the prevention of irritative voiding symptoms and malpositioning of the stent during insertion (25). Stent length may be based on operator experience, the measured length of the ureter as determined from imaging studies, the patient's body habitus, or use of the bent guide wire technique (3,25). Ideally, stents can be placed with fluoroscopic assistance and positioning problems identified and corrected at the time of insertion (27, 28). It should be recognized, however, that the stent is not static within the urinary tract, and if the patient develops unusual or persistent symptoms, evaluation with conventional radiography (supplemented with other imaging as indicated) may be warranted (Fig 7).

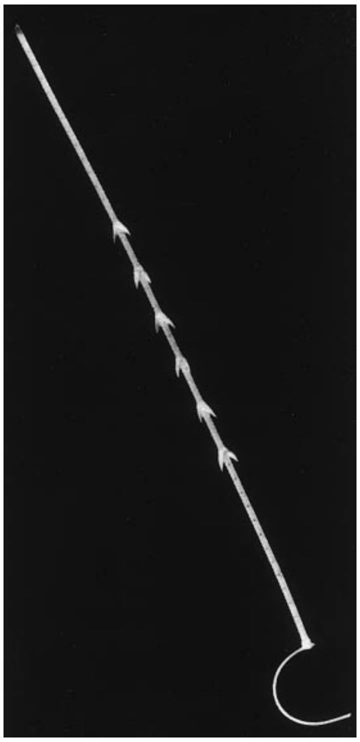


Figure 8. Gibbons stent. Barbs were added to the silicone tubing of the stent to prevent migration. Insertion was sometimes problematic, however, and this stent is no longer available. (Courtesy of American Heyer-Schulte, Goleta, Calif.)

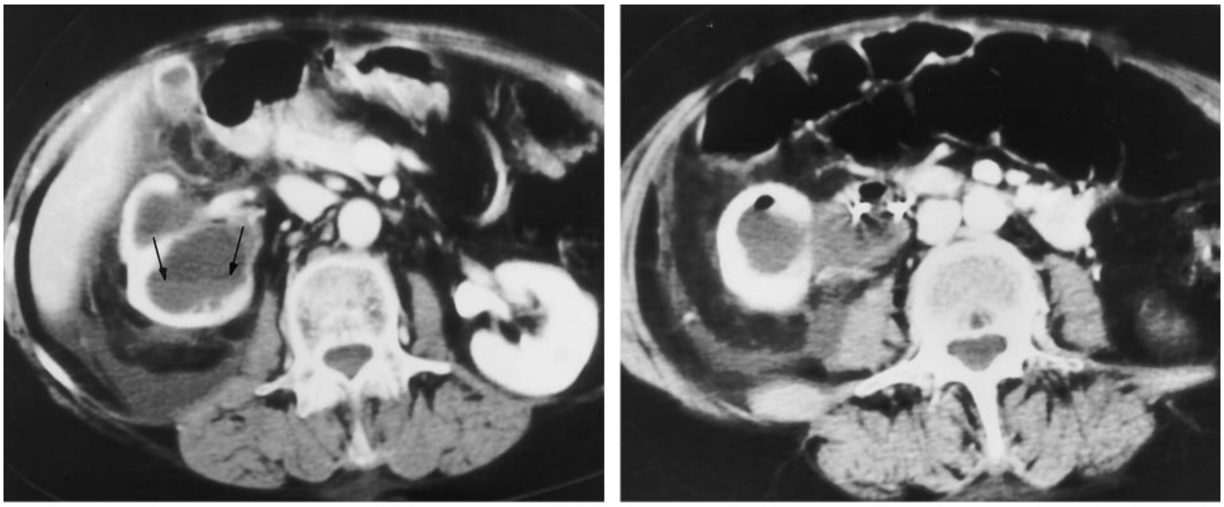
a.

b.

Figure 9. Distal stent migration. **(a)** Conventional radiograph shows a C-Flex stent coiled in the bladder after extrusion from the left ureter. **(b)** Left retrograde ureteropyelogram demonstrates a large amount of clot within the renal pelvis and ureter as a result of stent migration.

Migration

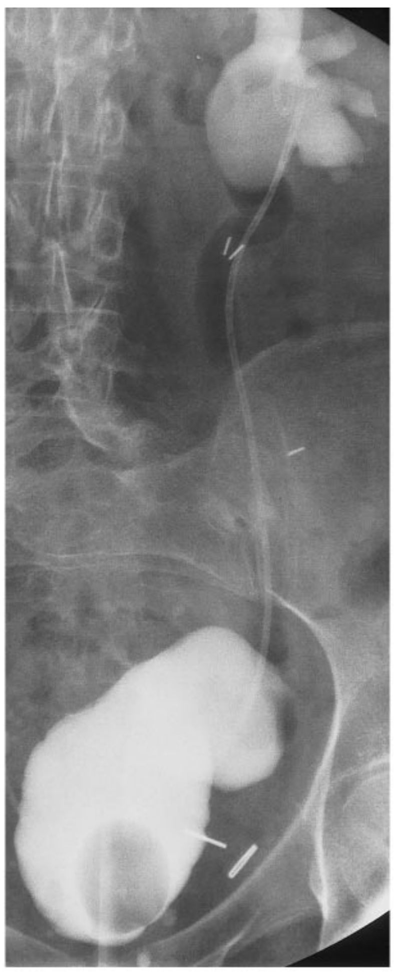
Migration of the stent within the urinary tract may also occur. Gibbons (29) initially addressed the problem of downward migration of soft silicone tubing by adding barbs along the shaft of the tube, a stent design that bears his name (Fig 8). All currently available, completely internalized stents combat migration with the presence of a proximal and distal J or pigtail. Nevertheless, peristalsis may discharge a stent (especially one constructed from softer materials) from the ureter. One can also speculate that the prevalence of this complication will increase with the use of stents coated with hydrophilic materials (Fig 9). Migration upward or downward can also occur as a result of late reconstitution of the retention curves as described earlier.



a. b.

Figure 10. Inadequate relief of obstruction. The patient underwent CT 1 week after insertion of a double-pigtail stent for relief of ureteral obstruction caused by extrinsic compression from colon carcinoma. **(a)** CT scan demonstrates persistent hydronephrosis in an atrophic right kidney. Note the fluid-debris level in the dependent portion of the collecting system (arrows), a finding that indicates pyonephrosis. There is also extensive perinephric inflammatory change. **(b)** CT scan shows a renal pelvic stent loop in the dilated renal pelvis. Note the air within the collecting system, which may be the result of the instrumentation or of active infection.

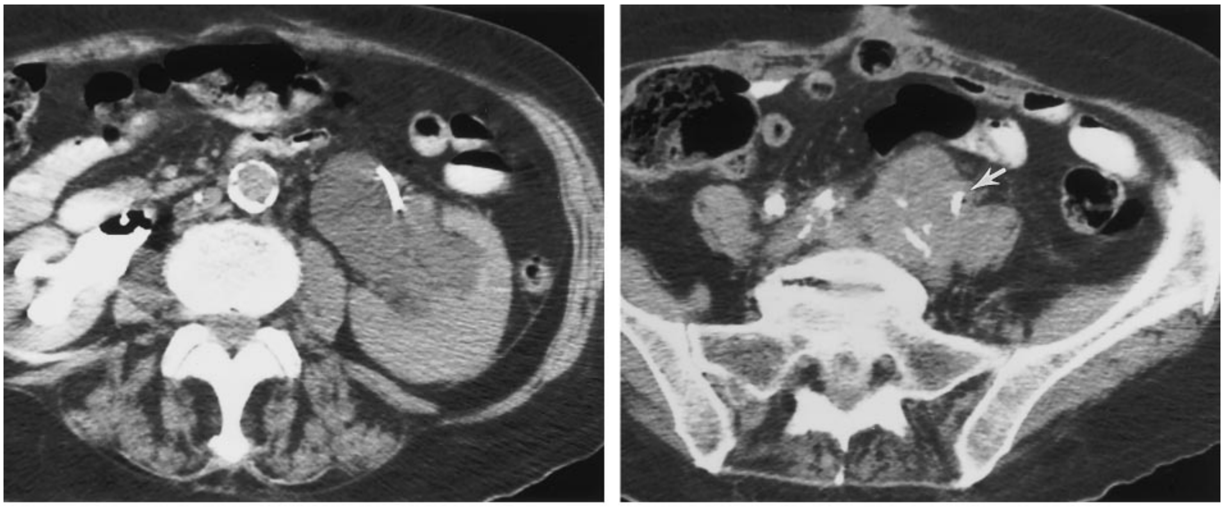
a.



b.

c.

Figure 12. Assessment of stent patency. **(a)** Preliminary radiograph shows a double-pigtail stent that was placed following ureteral reconstruction. **(b)** Cystogram reveals reflux of contrast material both through and around the left-sided stent. **(c)** Image from a postvoiding examination demonstrates significant decompression of the upper urinary tracts.



a. b.

Figure 11. Failure of obstruction relief due to long-segment ureteral encasement by tumor. **(a)** CT scan shows moderate left-sided hydronephrosis, despite the presence of a double-J stent that had been placed approximately 10 days earlier. Failure of improvement in renal function prompted reevaluation. Contrast material in the right collecting system is the residual from right-sided stent placement performed the same day as this CT study. **(b)** CT scan obtained at the level of the iliac artery bifurcation shows a large mass of lymph nodes. The mass surrounds the calcified left iliac artery and encases the ureter, which is defined by the stent (arrow).

Inadequate Relief of Obstruction

Occlusion of a stent lumen may occur at any time following insertion into the urinary tract. Short-term luminal obstruction, occurring within hours to days of insertion, may result from hematuria related to the technique or from increased urine viscosity and constituent debris associated with insertion in an infected system (3). This latter circumstance should be approached with caution and consideration given to nephrostomy drainage instead of internal stent placement (Fig 10) (30,31).

Relief of obstruction after stent insertion is a result of a complex interaction of hydrodynamic forces related to the specific cause of obstruction in the ureter, ureteral peristalsis, and stent characteristics (32,33). Despite the presence of an internal lumen as a conduit for urine flow, some authors suggest that a larger volume of urine flow occurs outside the stent (33,34). Docimo and DeWolf (32) noted a high failure rate (defined as clinical evidence of stent occlusion within 30 days of placement) in patients with extrinsic ureteral obstruction, most often from compression by tumor, when small (6-F) stents were used. It was also suggested that this problem could be overcome in some cases with the use of larger (7- or 8-F) stents (32). They postulated that in patients with long aperistaltic ureteral segments, flow outside the stent was limited, and more rapid occlusion of the stent lumen would occur (Fig 11). Even larger-diameter stents can be placed antegradely or retrogradely in these cases.

Although clinical findings of flank pain may suggest the possibility of stent obstruction, these symptoms can also be associated with a functioning stent. Assessment of renal function with blood chemistry studies may not reflect acute obstruction, especially if the obstruction is unilateral. Imaging studies that demonstrate hydronephrosis can also be misleading. It is well known that in patients with long-standing upper tract obstruction, placement of a stent may not return the renal collecting system to a normal appearance (33). Most patent stents will demonstrate reflux at the time of voiding cystography, and this can be used to assess patency (Fig 12). Color Doppler

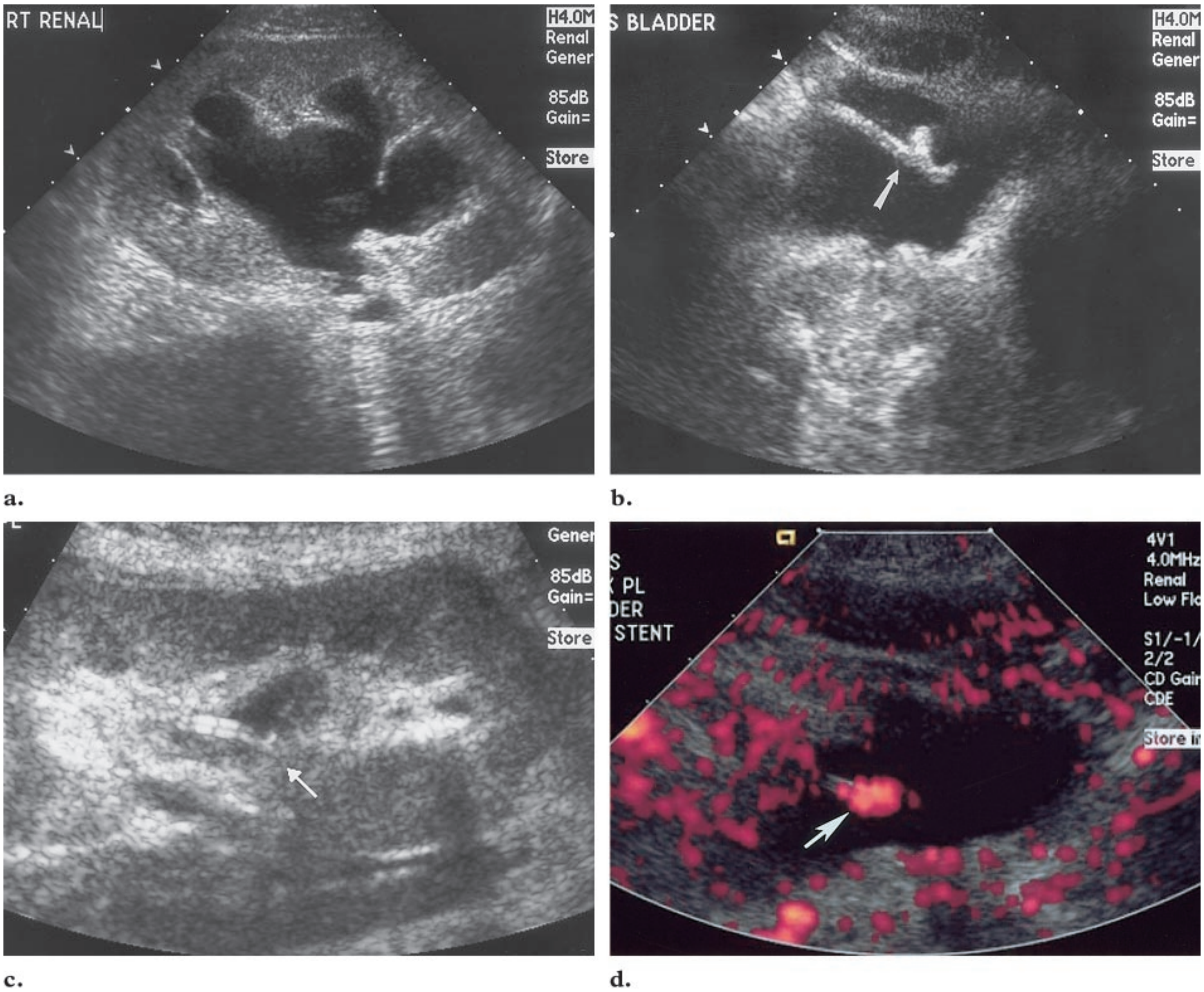


Figure 13. Assessment of stent jet patency in a patient with a transplanted kidney in the right iliac fossa who presented with deteriorating renal function. **(a)** US image shows moderate hydronephrosis. The upper end of the stent is difficult to identify. **(b)** US image shows the lower end of the stent (arrow) in the bladder. No jets emanating from the stent could be identified at color or power Doppler US. **(c)** Repeat US image obtained following stent replacement demonstrates resolution of the hydronephrosis. Note the stent (arrow) in place in the collecting system. **(d)** Power Doppler US image demonstrates a jet emanating from the bladder loop (arrow).

ultrasonography (US) for assessment of stent jets has also been used (Fig 13) (35). Diuretic renography has been reported to be the most sensitive test for determining ureteral stent patency (36).

There are other patient populations who may not be best served by implantation of a ureteral stent for relief of obstruction (31,32). When stents are placed for ureteral obstruction in a patient with a small irritable bladder or a bladder with a fistula, or in a patient with incontinence, the resultant symptoms may be intolerable. Patients with a high-pressure bladder as a result of a neurogenic bladder or outlet obstruction may not experience relief of upper tract obstruction due to improper antegrade drainage, and the presence of the stent may cause worsening of symptoms and

Figure 14. Bladder outlet obstruction heralding stent failure. Radiograph obtained after contrast material was instilled into the bladder in anticipation of antegrade stent placement shows marked trabeculation of the bladder, a finding that is consistent with bladder outlet obstruction. A balloon catheter is in place to assist with stricture dilation prior to attempted stent insertion. The high bladder pressure may negate antegrade flow through an internalized stent unless bladder catheter drainage is provided. Under these circumstances, external drainage via a nephrostomy tube may be more efficient. (Courtesy of Marc Banner, MD, Hospital of the University of Pennsylvania, Philadelphia.)

decreased renal function owing to reflux (Fig 14). In patients with bowel conduits, production of mucus by the enteric component of the conduit may rapidly occlude the lumen of a stent. These patients may be better served by creation of external urinary drainage by means of nephrostomy, or, in the case of patients with enteric conduits created with cutaneous ostomies, externalization of the stent in some other fashion.

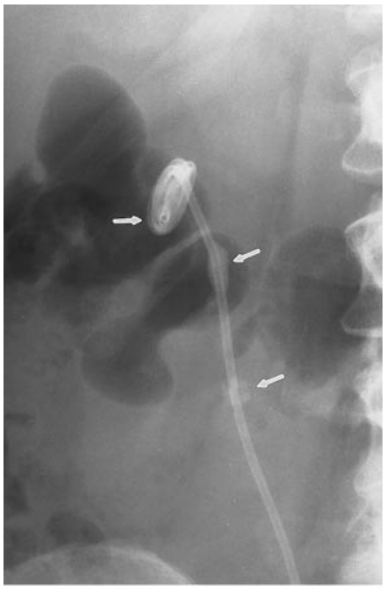
Encrustation

As alluded to previously, no current stent is inert within the urinary tract. The presence of the stent provides a framework for deposition of urine constituents. Over time, this will occur with any stent. To prevent encrustation, dilution of the urine with high fluid intake and aggressive treatment of any urinary tract infection should be undertaken (37). Prevention of encrustation and possible stent occlusion is also one of the major indications for prophylactic exchange of ureteral stents as recommended by the manufacturer.

The presence of lithogenic urine, coupled with prolonged indwelling stent times, clearly increases the risk of encrustation. El-Faqih et al (19), reporting on a population of patients in whom stents were placed to assist with treatment of urinary tract stones, found that encrustation occurred in 9.2% of stents retrieved before 6 weeks, 47.5% of stents left in place for 6 to 12 weeks, and 76.3% of stents left in place longer than 12 weeks. Associated morbidity was found to be minimal if indwelling times did not exceed 6 weeks (19). However, close follow-up and monitoring of these patients is mandatory (5).

Management of encrustation represents a continuum from therapeutic nuisance to major urologic intervention (37,38). Severe encrustation tends to preferentially deposit crystalline material at the renal or bladder end of the stent. This has been attributed to peristaltic “wiping” of the ureteral portion of the stent (37). Minimal stent encrustation may not prevent removal of the stent, and, if recognized, can be treated with ESWL (Fig 15) (38). Larger-volume encrustations must be dealt with before stent removal is attempted.

Figures 15–17. Encrustation. **(15a)** Conventional radiograph demonstrates minimal encrustation around the proximal portion of a ureteral stent (arrows), which was initially placed to assist with treatment of urinary tract stone disease. **(15b)** Conventional radiograph obtained after stent removal shows the encrusting shell that was left behind. The patient was successfully treated with ESWL. **(16)** Conventional radiograph shows encrustation about the vesical loop of a double-pigtail ureteral stent. Note the upper urinary tract stone disease. The distal encrustation was treated cystoscopically prior to stent removal. **(17a)** Conventional radiograph shows a stent with encrustation of both the proximal and distal loops. **(17b)** Urogram shows that the proximal encrustation has produced obstruction at the ureteropelvic junction. Several cystoscopic sessions were necessary for successful treatment of the vesical portion of the encrustation. The renal pelvic portion was addressed with percutaneous nephrostolithotomy. Stent removal was ultimately successful.



15a.

15b.

17a.

16.

17b.

Figure 18. Stent fracture in a patient with disseminated prostatic carcinoma. **(a)** Abdominal radiograph shows bilateral ureteral stents that were placed for relief of ureteral obstruction. No arrangements were made for follow-up given the patient's condition. **(b)** On a conventional radiograph obtained 18 months later when the patient presented with a complaint of recurrent urinary tract infections, the stents are fractured into multiple pieces. This necessitated percutaneous entry with cystoscopic and ureteroscopic manipulations for complete removal.

a. **b.**

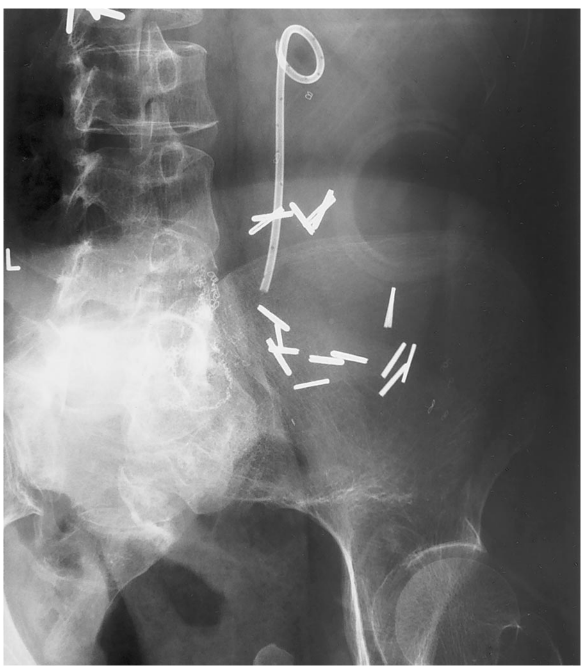
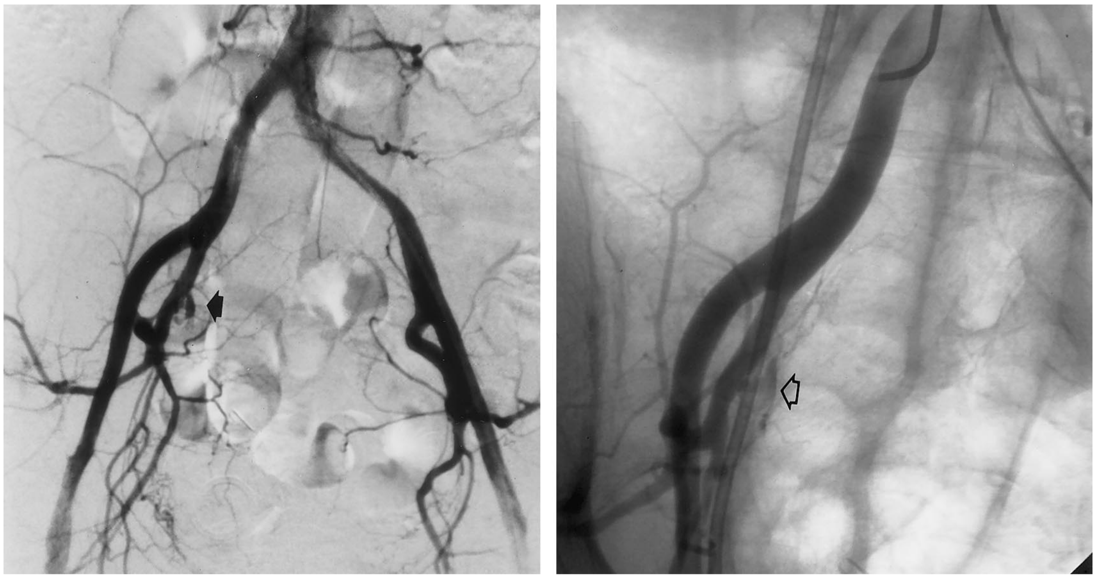


Figure 19. Stent fracture in a patient with exstrophy of the bladder. A stent was placed at the time of urinary reconstruction. Conventional radiograph obtained after attempted removal 10 weeks later demonstrates fracture of the midshaft of the stent. The proximal portion of the stent was removed percutaneously.

Blind traction of heavily encrusted stents may injure the urinary tract or fracture the stent. Combinations of ESWL, percutaneous lithotomy, cystoscopic lithopaxy, and open surgical techniques may be required in the most advanced cases (Figs 16, 17) (37).

Stent Fracture

Urine is a hostile environment. Polyethylene was abandoned as a construction material when it became evident that stents made of this material became brittle and fractured after relatively short indwelling times (15). Stent fracture has also been reported with newer materials (39,40). Most fractures occur at fenestration sites, but the fenestrations are thought to be an integral component for optimizing flow via the stent. Encrustation is also likely to play a role in stent fragmentation, with both of these complications increasing in prevalence in direct proportion to indwelling times (Figs 18, 19) (19,40).



a. b.

Figure 20. Ureteroarterial fistulization in a patient with cervical cancer who had undergone surgery and radiation therapy. A chronic indwelling stent was used to relieve recurrent ureteral obstruction. The patient was referred for arteriography after stent exchange produced pulsatile blood flow from the right ureter, which was seen at cystoscopy. **(a)** Nonselective pelvic arteriogram demonstrates an area of extravasation (arrow) that arises from the right internal iliac artery. **(b)** Selective right common iliac arteriogram confirms the extravasation from the proximal internal iliac artery, immediately adjacent to the stent (arrow). **(c)** Completion arteriogram obtained following coil embolization of the right internal iliac artery demonstrates no evidence of a residual fistula. The patient had no recurrent symptoms for the remaining 8 months of her life.

c.

Ureteral Erosion or Fistulization

The rarest, most feared complication of ureteral stent placement is erosion of the stent into adjacent structures, especially the arterial system. A high degree of clinical suspicion is necessary if mortality from this complication is to be avoided (41–46). Intermittent hematuria in a patient with a stent is the usual reason for presentation, but massive hematuria to the point of circulatory collapse may occur and may be provoked by ureteral stent manipulation (40). Extensive pelvic surgery and irradiation appear to be contributing factors to the development of this complication because both may lead to ureteral ischemia. The chronic presence of a plastic stent within a ureter at risk, adjacent to a pulsating vascular structure (normal vessel or graft or pseudoaneurysm at the site of vascular repair), appears to produce the circumstances that are necessary for erosion to occur (41).

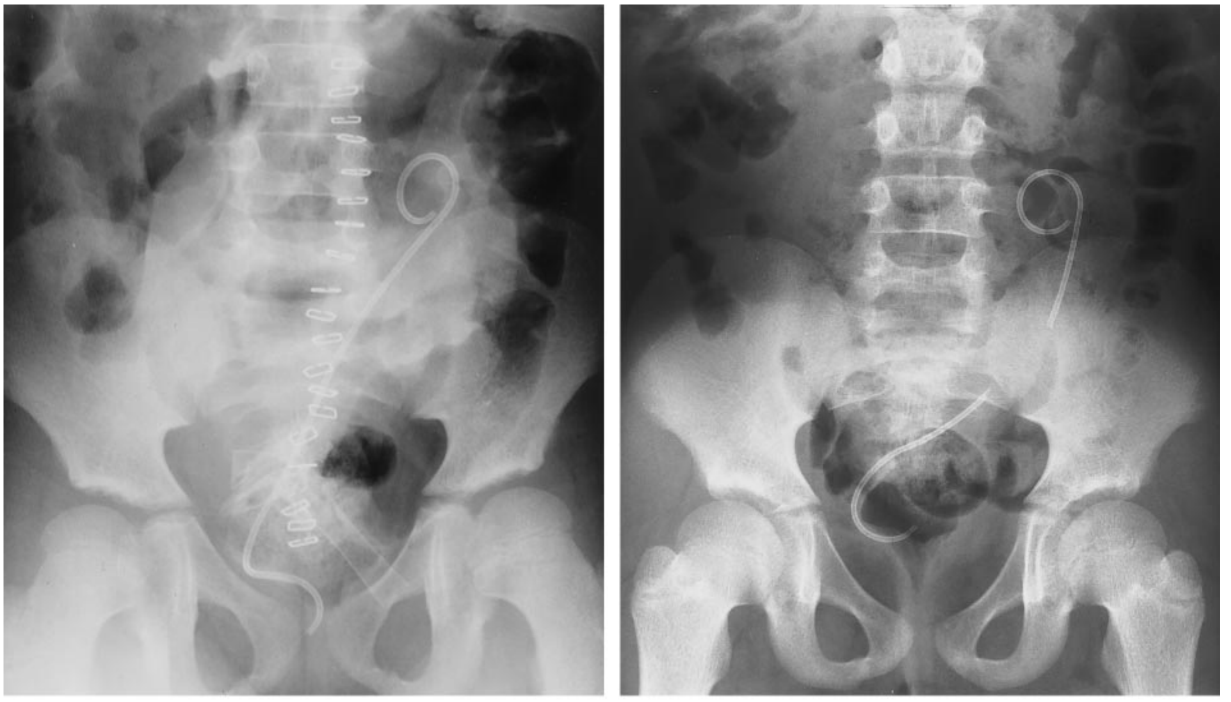
Diagnosis by means of clinical examination or any imaging procedure may be difficult. Angiographic evaluation may be misdirected if the diagnosis is not considered. Appropriate diagnosis is integral to therapy, which may include open surgical techniques, interventional radiologic techniques, or a combination of the two (Fig 20) (41).

a. b.

Figure 21. Forgotten stent in a patient who was being evaluated for recurrent urinary tract infections. Bilateral ureteral stents had been placed at the time of bladder augmentation surgery 9 years earlier. **(a)** Conventional abdominal radiograph obtained following US, which was reported to show "stones," demonstrates numerous fractured stent pieces. **(b)** Urogram shows reasonably good excretion from both kidneys, with several of the stent pieces within the augmented portion of the bladder. The pieces were removed with a combination of percutaneous and cystoscopic techniques.

Forgotten Stent

Neither the urinary environment nor the stent placed within it is stable for long periods of time. The prevalence of all consequences and complications increases the longer a stent remains in place (19). A stent requires monitoring while it is in place, removal at the earliest appropriate time, and periodic exchange if chronically indwelling. At times, these recommendations may need to be modified depending on patient characteristics (ie, in patients with urinary tract stone disease) (19,47). Because of these maintenance requirements, compilation of a registry of patients with indwelling stents, related to any practice, has been recommended. Occasionally, stents are "forgotten," adding medicolegal implications to those complications occurring as a result of the longer indwelling times (Figs 21–23) (48–50).



a. b.

Figure 22. Forgotten stent in a 7-year-old girl. The stent was inserted at the time of open surgical repair of a ureteropelvic junction obstruction in the low-lying left kidney. **(a)** Conventional radiograph reveals that the stent is slightly too long, with the tip projecting into the proximal urethra. **(b)** KUB (kidney, ureter, bladder) image obtained 18 months later when the patient presented with recurrent urinary tract infections demonstrates stent fracture. This probably resulted from the prolonged indwelling time, which likely produced catheter deterioration leading to brittleness and subsequent fracture. Note the maturation of the skeleton. In addition, the original stent length is likely now inadequate given the patient's growth.

Although generally considered a urologic procedure, stent placement is frequently performed with antegrade percutaneous access by interventional radiologists. An understanding of consequences and complications, requirements of monitoring and maintenance, and coordination of arrangements for follow-up or removal is the responsibility of the implanting physician.

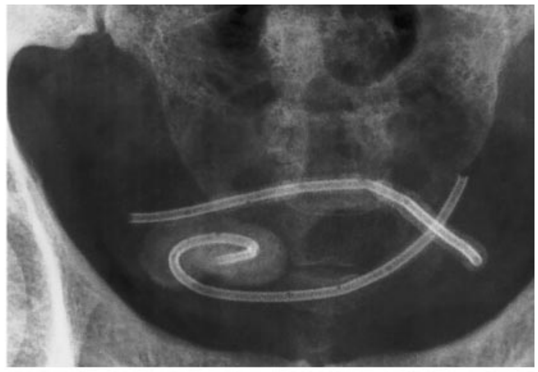
Conclusions

Placement of indwelling ureteral stents has become routine in the management of a variety of urinary tract disease processes. The ideal stent is not yet available. The majority of patients will experience consequences, and some patients will have complications, which at times can be devastating. The stent should be monitored while in place, promptly removed when no longer needed, and changed periodically if chronically indwelling. Risk factors for complications should be minimized with high fluid intake, prompt evaluation of clinical complaints, and aggressive treatment of documented infection.

Certain patients may not be best served by indwelling stent placement, and urinary diversion by means of other mechanisms may be indicated. These patients include those with infected obstruction, uncorrected bleeding disorders, small irritable bladders, bladders with fistulas, high-pressure bladders or bladder outlet obstruction, bladder incontinence, extrinsic ureteral obstruction that produces long aperistaltic segments, urinary reconstruction involving bowel segments, and conditions precluding cystoscopic maintenance of the stent.

The implanting physician bears responsibility for informing the patient of the requirements, consequences, and complications attendant to stent placement. Failure to do so has obvious management and potential medicolegal implications.

a.



b.

Figure 23. Forgotten stent in a patient who had undergone ureteral stent placement 18 months earlier as a temporizing measure in anticipation of treatment of a 1-cm right renal pelvic stone. **(a)** Abdominal radiograph shows a large encrustation around the proximal portion of the stent. Stent fragments are also seen in the bladder. **(b)** Pelvic radiograph shows encrustation around the stent fragments in the bladder. The patient had not been contacted regarding stent maintenance because it was anticipated that he would return for stone therapy.

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