Radiologic percutaneous interventions for ureter disease

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Learning objectives

Radiologic percutaneous Interventions for ureter disease such as percutaneous nephrostomy and antegrade ureteral stenting are frequently performed minimally invasive, image-guided procedures. The recent increase in usage of ureteral stents in the management of a variety of urinary tract disease processes mandates familiarity with these devices, and their potential complications.

• To provide a basic understanding of the indications and various imaging-guided, nonvascular interventional techniques widely performed in the ureter.

Background

• With advances in imaging technologies and percutaneous instruments, percutaneous procedures under image guidance have become a well-established field of interventional radiology. Ureters can become injured as a result of various conditions. Percutaneous intervention for ureter disease such as ureteral stenting, embolization and nephrostomy, help restore urine flow through blocked ureters and reroute urine flow from its normal pathway, either temporarily or permanently.

• Technical advances 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).

• Although stent design has evolved in recent decades, none of the currently available models meets all requirements for an ideal stent (Table 2).

Images for this section:
### Table 2. Properties of the ideal ureteral stent

<table>
<thead>
<tr>
<th>Easy insertion from any access</th>
<th>Easy exchange and removal</th>
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<tr>
<td>Resistance to migration</td>
<td>Resistance to encrustation</td>
</tr>
<tr>
<td>Optimal flow characteristics</td>
<td>Nonreflux</td>
</tr>
<tr>
<td>Patient tolerability</td>
<td>Radiopacity</td>
</tr>
<tr>
<td>Biocompatibility</td>
<td>Biodurability</td>
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<tr>
<td>Versatile</td>
<td>Affordable</td>
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### Table 1. Indications for ureteral stent placement

| Relief of benign or malignant obstruction | obstructions
<table>
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<tr>
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<td>ureteral instrumentation</td>
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<td>stone visualization</td>
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<tr>
<td></td>
<td>Alignment of drainage elements</td>
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<td></td>
<td>Maintenance of luminal caliber</td>
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<tr>
<td></td>
<td>After ureteral intervention</td>
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<td>Identification of ureter(s)</td>
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<table>
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<th>Management of urine leak</th>
<th>trauma or surgery</th>
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<td>ureteral fistula</td>
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### Table 4

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Findings and procedure details

- Percutaneous intervention for ureter can be useful in patients with ureteral obstruction due to ureteral stones, ureteral or trigonal obstructive cancer, following ureteroscopy (endoscopy of the ureter), for post-operative ureteral anastomosis, ureteral tears, ureteral spasm, inflammation or lower urinary tract fistula.
- In addition, the presence of the ureteral stent may result in subsequent passive ureteral dilation to permit passage of previously obstructive stones, or allow passage of the flexible ureteroscope for appropriate ureteral intervention such as foreign body retrieval. This technique is currently routinely performed for ureterolith-induced obstructions, nephroliths or ureteroliths that are undergoing shockwave lithotripsy to aid in fragment passage following treatment. Stent placement in the ureter for bladder tumors causing obstruction is now being performed routinely as well.

1. Ureteral Stent

- Ureteral stents are used to bypass a blocked or injured segment of ureter, thus restoring continuity of flow.
- Ureter stent placement can be useful in patients with ureteral obstruction due to ureteral stones, ureteral or bladder tumor (Fig. 1), for post-operative ureteral anastomosis, ureteral tears (Fig. 2), ureteral stricture (Fig. 3), inflammation or lower urinary tract fistula.
- Currently, commonly used ureteral stents are composed of polymeric compounds including silicone, polyurethane, Silitek, C-flex, Percuflex or Tecoflex. The stents usually have a double pigtail design to prevent migration with side holes to improve drainage. They also require periodic exchange at 3- to 6-month intervals.
- Technique
  - For all antegrade ureter manipulations it is preferable to have access via a middle or upper calyx. Typically, antegrade ureter stent placement is performed two to 3 days after preliminary percutaneous nephrostomy (PCN). Antegrade ureter recanalization is performed with a hydrophilic guidewire.
  - The appropriate stent length is determined by using the "bent guide wire" technique. The distance between the two sharp bends of the guidewire marked at the renal pelvis and UVJ area corresponds exactly to the required length of the double-J catheter.
  - The stent is inserted with a pusher catheter, first deploying the bladder loop and then the renal pelvic loop. The correct position and proper function of the stent is checked with an antegrade pyelogram.

2. Metal Stent
• More recently, Stents made of biodegradable materials and metals are also used for management of malignant ureteral obstruction.
• Ureteral metal stenting serves as an important therapeutic option to alleviate malignant ureteral obstruction. The cause of obstruction may be invasion-infiltration of the ureters by tumor (cervical, bladder, prostate, or colorectal cancer), extrinsic compression by a retroperitoneal primary or metastatic neoplasia, or scarring, adhesions, and luminal ureteral strictures resulting from radiotherapy or chemotherapy.
• The theoretical advantages of metal stents over polymer ones include reduced encrustation, improved tensile strength and stability, prolonged stent indwell time, and better flow.
• A variety of metallic alloys, designs, lengths and configurations of metallic ureteral stents have been used (Table 1).
• Mesh or covered stent: Uventa (Fig 4, 5).
  - A nitinol mesh design is sandwiched between two layers of PTFE sheets. It is designed to stay in the ureter, with its distal end protruding in the bladder.
• Coiled stent: Resonance (Fig 6).
  - It is a solid JJ stent. As it has no lumen, it is delivered into the renal pelvis and ureter through the lumen of a wide ureteric catheter. The urine is expected to drain by the side of the stent.
• Technique

  - After percutaneous tract is established, a nephrostogram is performed in order to verify the exact length and position of the ureteral stricture. The stenosed ureteral segment is passed using a 0.035-inch guidewire and a balloon (8-10 mm diameter) is introduced to dilate any strictures not wide enough to accommodate the 9 Fr introducer sheaths of the metallic double-J ureteral stent (MS).
  - After dilator removal, a coaxial system including an inner 5 Fr ureteric catheter and an outer 9 Fr introducer sheath is introduced over the wire until the tip of the outer sheath protrudes into the bladder. The guidewire and inner ureteric catheter are removed and the MS is inserted through the introducer.
  - A specially designed plastic pusher is used to push the proximal end of the MS inside the introducer sheath until the MS's distal pigtail curl is formed in the bladder. The introducer sheath is removed while holding the plastic pusher in place. The formation of a pigtail at the proximal portion of the MS inside the ipsilateral collecting system confirms the appropriate positioning and the sheath is completely removed.

3. Complications with Ureteral Stent

• 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 complications associated with stents (Table 2).
Complications are divided by timing. Early complications in the immediate perioperative period include iatrogenic injury at the time of placement, stent migration or patient discomfort.

Late complications, developing weeks to months after initial stent placement, include infection, difficulties with stent exchange or hardware malfunction such as stent fracture.

Stent migration (Fig 7)
- It is related to JJ stent design and faulty technique of insertion. Double pigtail stents are less likely to migrate as opposed to J loop stent. Migration can occur either way but upward migration is more common. Upward migration is primarily due to placement of stent too short for the ureter. Other causes of migration are renal ureteric dynamics, peristalsis and incorrect size selection.

Encrustation (Fig 8)
- No current stent is inert within the urinary tract. The presence of the stent provides a framework for deposition of urine constituents and biofilm formation by the bacteria. Over time, this will occur with any stent. Prophylactic stent exchange is the only effective method of preventing encrustation.

Forgotten or overlooked stent
- Long-term complications are associated with prolonged indwelling times. With the passage of time all stents lose tensile strength, cracks are started at the holes resulting in fracture of the stents.

4. Balloon Dilation of Strictures

- The ureter has a rich blood supply that originates from multiple feeding vessels originating from the aorta, iliac, renal, and gonadal vessels. As there is extensive collateral flow throughout the ureteral adventitia, compromise of the vascular supply increases the risk of stricture formation.
- Balloon dilation of strictures is minimally invasive alternative interventions that lower cost, shorten hospital stay, and provide a safer treatment approach. The etiology and duration of stricture before intervention are key predictors of dilation success (Fig. 9). These are related to the disruption of blood supply after surgery and ischemic sequelae to the distal ureter. Benign, short-segment strictures tends to be successfully dilated (Fig 10).
- Balloon dilation is traditionally accomplished with sequential high-pressure dilatation using smooth walled balloons.

5. Percutaneous Foreign Body Removal

- Percutaneous antegrade removal of foreign bodies with a loop snare, basket or forceps via a nondilated nephrostomy route under fluoroscopic guidance is effective without major complications in patients with an available nephrostomy route or an inaccessible retrograde option.
• Ureteral stent is the most commonly encountered foreign body in the urinary tract (Fig. 11). Stones and fungus ball also can be removed percutaneously (Fig. 12).

6. Ureteric Embolization

• Lower urinary tract fistula and urinary incontinence occasionally complicate advanced pelvic malignancy or its treatment (Fig. 13).
• The success rate of the ureteric occlusion for treating refractory urinary tract fistula with gelfoam, glue, balloon, or coils is variable. Failures result from softening in urine for glue; incomplete occlusion, deflation, or migration for balloons; and migration for coils (Fig. 14).
• Ureteric embolization initiates an inflammatory response, resulting in obstruction due to mechanical obstruction and stricture formation within 2 to 3 days of the procedure.
• Transureteric embolization is the management option of choice for patients with refractory urinary fistula in whom management with simple diversion has failed.
• Technique
  - Using the preliminary percutaneous nephrostomy tube, ureter was catheterized with a coaxial delivery system. Through the delivery catheter placed in the distal ureter below the distal end of the outer sheath, embolization material was then delivered to the site of desired embolization to provide bulk for the embolus. After ureterogram, the coaxial sheath was removed over a guidewire and a nephrostomy drainage catheter inserted into the renal collecting system.

Images for this section:

Fig. 1: Percutaneous urinary stent placement due to ureter rupture after ureterorenoscopic removal of the ureter stone. A. IVP shows right ureteral obstruction in
the mid ureter. Note the vicarious contrast material excretion opacifying the gallbladder.

B. Percutaneous urogram shows extravasations of contrast medium around the right mid ureter. C. Conventional radiograph shows successful insertion of a stent with good position in the right ureter after superselective catheterization at the rupture site of the mid ureter. D. Photograph shows a double J polymeric ureteral stent used in this patient.

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Fig. 2: Percutaneous urinary stent placement due to ureter rupture after ureterorenoscopic removal of the ureter stone. A. IVP shows right ureteral obstruction in the mid ureter. Note the vicarious contrast material excretion opacifying the gallbladder. B. Percutaneous urogram shows extravasation of contrast medium around the right mid ureter. C. Conventional radiograph shows successful insertion of a stent with good position in the right ureter after superselective catheterization at the rupture site of the mid ureter. A safety PCN catheter was left in place to monitor the success of internal drainage with the stent and if continued antegrade access is desired. D. Photograph shows a double J polymeric ureteral stent used in this patient.

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Fig. 3: A 71-year-old women who had a ureteral stricture due to stomach cancer with periureteric metastasis. A. Nephrostogram shows severe tortuosity of the proximal ureter with strictures (arrows). B. A 5Fr catheter was exchanged for vascular sheath because it was considered that less pushing force could be applied via lower polar approach. C. The lesion was too tortuous for a guidewire to pass through it. The lesion could be negotiated with a 3 Fr microcatheter and a 0.016-in. floppy guidewire via the vascular sheath. D. An additional microcatheter was inserted to overcome the severe ureteric tortuosity. E. Once the tip of the microguidewire (arrows) was advanced into the urinary bladder, the tortuous ureter was straightened with meticulous torque control. F. A 5 Fr catheter was advanced into the ureter along the microcatheter system and then a 0.035-in. guidewire was inserted. G, H. After balloon dilatation (arrows) (G), a 6 Fr 26cm double J stent was introduced along the guidewire (H).

Table 3. Types of metal ureter stent

<table>
<thead>
<tr>
<th>Type</th>
<th>Brand</th>
<th>Length</th>
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<tr>
<td>Self expandable mesh stent</td>
<td>Wallstent™</td>
<td>Segmental</td>
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<tr>
<td>Thermo expandable shape memory stent</td>
<td>Memokath™</td>
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<tr>
<td>Balloon expandable stent</td>
<td>Strecker</td>
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<td>Covered metal stent</td>
<td>Passager™</td>
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<tr>
<td></td>
<td>Uventa™</td>
<td></td>
</tr>
<tr>
<td>Coiled stent</td>
<td>Resonance®</td>
<td>Full length</td>
</tr>
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</table>

Table 1

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Fig. 4: Percutaneous bilateral ureteral covered metal stent placement due to serial malfunctions of double-J stent in this patient who has ureter stricture after radiotherapy for advanced rectal cancer. A. Snare is introduced from preliminary nephrostomy tract and used to ensnare the proximal end of double J stent. Steady traction is used to remove the stent. Placement of metallic stents for malignant ureteral obstruction help restore urine flow through blocked ureters. B. The covered metal stent is positioned to encompass the entire length of the stricture with the ends of the stent extending at least 2-3cm proximal and distal to the stricture margins. C. Spot radiograph after bilateral stent replacement shows the stent position and patency by using contrast injection.

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Fig. 5: Percutaneous ureteral covered metal stent placement due to recurrent ureteric obstruction caused by ureter stones. A. Using antegrade pyelography, the length, shape, and level of stricture in the ureter are identified. B. The UVENTA stent is deployed through the delivery catheter with three radiopaque marker (arrowheads) via the outer sheath (arrow) after balloon dilatation for the obstructed ureter. C. Note that 3 stents are sequentially inserted with overlapping ends in order to cover a long stricture. D. Contrast injection through the delivery catheter shows the confirmation of the stent expansion and patency. E. Photograph shows a polytetrafluoroethylene membrane-covered self-expandable metallic (UventaTM ) stent used in this patient.

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Fig. 6: Percutaneous Resonance® ureteral coiled metal stent placement. A. Corronal reformatted CT image shows the right UVJ stricture with severe obstruction. B. Spot radiograph cast a doubt that the lower end of the stent might be extravesical in location during a retrograde ureteric stenting. C-E. After percutaneous antegrade double J coiled metal stent retrieval (C) by using a snare via a nondilated nephrostomy route, antegrade ureteric restenting (D) with the metallic stent (E) was done.

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<table>
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<th>Table 4. Complications with Ureteral Stent Placement</th>
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<tr>
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<td>Urinary tract infection / Pyuria</td>
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<td>Malposition</td>
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<td>Encrustation</td>
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<tr>
<td>Ureteral erosion or fistulization</td>
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<tr>
<td>Forgotten stent</td>
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<tr>
<td>Migration</td>
</tr>
<tr>
<td>Fracture</td>
</tr>
<tr>
<td>Inadequate relief of obstruction</td>
</tr>
</tbody>
</table>

Table 2

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**Fig. 7:** Inadequate relief of obstruction, stent malposition and migration

A. Post voiding IVP shows severe right ureteral obstruction caused by right UVJ stricture. B. Inadequate relief of obstruction and stent malposition. Simple radiograph demonstrates persistent obstruction of the right ureter and coiled metal stent of inadequate length selected for insertion. An appropriate stent length is critical for the prevention of irritative voiding symptoms and malpositioning of the stent during insertion. C. Distal stent migration. Conventional radiograph shows that the proximal portion of the stent lies at the level of iliac crests.

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Fig. 8: A 30-year-old woman with intrauterine pregnancy at 30 weeks and 6 days: One month follow-up of the nephrostomy catheter shows malfunction with encrustation. Note the whitish deposition of crystalline urine components arising from the catheter.

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Fig. 9: Balloon dilatation of obstructed ureter. A. Ureterogram after percutaneous ureteral catheterization shows narrowing of the right far distal ureter during robotic surgery for cervical cancer. B. After successfully traversing the stricture, obstruction was dilated with 6mm x 40mm conventional angioplasty balloon. Proper selection for balloon diameter, length, and inflation pressure is necessary. C. Ureteral patency was achieved after balloon dilatation and coaxial stent placement.

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Fig. 10: Balloon dilatation of ureter stricture. A. Preoperative coronal reformatted CT image shows the obstructed left distal ureter (arrow) in this patient who has undergone pelvic surgery for uterine adenomyosis. B-C. The injected contrast reveals a distal ureteral stricture via a nephrostomy tube(B) and a 5 Fr Kumpe catheter(C) that has been advanced into the distal ureter. D. Fluoroscopic spot image shows that the partially
inflated balloon with dilute contrast reveals the waist appearance corresponding to the stricture of the lesion. It is essential to choose appropriate balloon and to position catheter bridging lesion/stricture. E. Post procedure abdominal radiograph shows the typical course of double J stent and catheter patency.

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Fig. 11: Percutaneous retrieval of the malfunctioning ureteral stent. A. Puncture of the pelvocalyceal system, which is the basic step in the most interventional procedures of the urinary tract. A fine needle is inserted into the dilated pelvocalyceal system with the guidance of US or fluoroscopy. B. A loop snare via a sheath was introduced within the proximal loop of the double pigtail catheter. C,D. Ureteral stent was captured by the snare (C) and pulled into the sheath catheter (D).

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Fig. 12: Percutaneous ureter stone removal A. Preoperative coronal reformatted CT image shows left proximal ureter stone with obstructive uropathy. Note the combined renal parenchymal perfusion defects (arrows) suggesting acute pyelonephritis. B. Contrast injection of an indwelling nephrostomy tube demonstrates the impacted left proximal ureter stone as a filling defect (arrow). C. The trapped stone is pulled using
a stone basket (arrow) via an access sheath (arrowhead). D. Photograph shows the extracted ureter stone.

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**Fig. 13:** Ureteral embolization. Patients status post bilateral ureteral ligation and cystectomy for the failure to repair of the bladder rupture. A. Pyelogram through the coaxial delivery system in the left ureter shows contrast leakage along the surgical drainage catheter. B. A nest of stainless-steel coils was created using various sizes from 2 to 5mm in diameter. C. Histoacryl® glue was also sandwiched among the coil nests to hasten occlusion of the lumen. The delivery catheter was then rapidly and entirely removed through the coaxial sheath to prevent adhesion of the catheter to either the embolus or the ureteric wall. D. An antegrade ureterogram was taken to confirm occlusion of flow at the level of the coils.

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Fig. 14: Bilateral ureteral occlusion to dry urine leak in a 64-year-old man who underwent cystectomy and neobladder formation for bladder tumor A,B. Bilateral nephrostogram was performed in order to exactly recognize both anastomotic sites (arrows). C. Permanent transrenal ureteral occlusion with multiple coils and gelfoam pledget was done in the right ureter, proximal to the anastomosis. D. After initial coil and gelfoam embolization in the left ureter, a slight caudal migration of coils was noticed within the neobladder. Additional one or more coils were inserted in the left ureter, proximal to the previous coils.

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Conclusion

• Imaging-guided percutaneous interventions, which plays a major role in prolonging urinary excretory function, are widely performed in the management of ureter disease.

• The ideal ureteral stent is not yet available. The stent should be monitored while in place, promptly removed when no longer needed, and changed periodically if chronically indwelling.

Personal information

References


