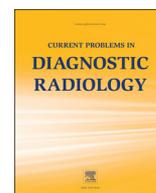




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## Comprehensive Imaging and Surgical Review of Urinary Diversions: What the Radiologist Needs to Know



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Urinary diversions are surgical procedures that reconstruct the lower urinary tract following cystectomy. The 2 common surgical approaches are based on the continence status of the urinary tract. Incontinent diversions have continuous urine drainage through a cutaneous stoma, whereas continent diversions offer the ability to self-void either via stoma catheterization or with the patient's own urethra. Given the large number of diversion procedures available, postsurgical anatomy may be complex. Multiple imaging modalities can be used to assess the postprocedural anatomy, potential complications, and for on-going oncologic monitoring. The purpose of this review is to describe the common surgical techniques and associated complications.

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### Introduction

Urinary diversions describe a group of urological procedures that function to redirect urine following the removal of the native bladder.<sup>1</sup> The most common indication for urinary diversion is following cystectomy for the treatment of muscle-invasive bladder cancer.<sup>2</sup> Urinary diversions are also performed as part of pelvic exenterations for advanced gynecological or gastrointestinal malignancies or refractory functional bladder pathologies.<sup>2–4</sup> Radiologists play a vital role in the monitoring of patients with urinary diversions to recognize postsurgical complications. However, the wide variety of urinary diversion surgeries alter the normal anatomy in different ways and make imaging interpretation challenging to the radiologist who is unfamiliar with these procedures. Furthermore, patients who undergo urinary diversion require frequent follow up and radiologists play a critical role in the evaluation of these patients to detect surgical complications and potential recurrence of disease. When evaluating patients for possible complications, it is important to have a robust understanding of the postsurgical imaging anatomy specific to the type of urinary diversion as well as to know specific complications that arise in each of these diversion procedures. The purpose of this review is to outline the surgical and imaging anatomy of

commonly performed urinary diversions as well as imaging techniques with a focus on imaging appearances of commonly encountered postsurgical complications.

### Selection of Urinary Diversion Procedure

Urinary diversions are classified based on the continence status of the reconstructed lower urinary tract; incontinent diversions continuously drain urine without continence mechanisms whereas continent diversions involve the creation of a control mechanism either through anatomical connections to the native urethra or through a surgically created stoma which allows for self-catheterization.<sup>5</sup> Continent diversions can further be subdivided into continent cutaneous diversions and orthotopic neobladders. Continent cutaneous diversions use detubularized bowel for the urine reservoir and include a catheterizable stoma.<sup>5,6</sup> Detubularization refers to any surgical alteration of the bowel to reduce peristalsis and to change its original shape into a urine reservoir.<sup>5</sup> This can be performed for both small and large bowel. Patients are required to perform clean intermittent self-catheterization of the stoma for voiding. Similar to continent cutaneous diversions, orthotopic neobladders are constructed from detubularized bowel; however, orthotopic neobladders are anastomosed to the patient's own lower urinary tract and allow patients to have normal urinary control via the patients' native sphincteric muscles.<sup>5,6</sup>

The choice of specific urinary diversion is unique to each patient and is based on a combination of oncologic and technical factors, as well as psychosocial factors.<sup>6</sup> In general, incontinent diversions are technically less challenging compared to continent diversions, however, they necessitate the use of an external

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**TABLE 1**  
Imaging techniques and indications of each in different urinary diversions

Indications for fluoroscopy	Indications for CT
<ul style="list-style-type: none"> <li>- Functional complications</li> <li>- Urine leaks</li> <li>- Strictures</li> </ul>	<ul style="list-style-type: none"> <li>- Postsurgical oncologic surveillance</li> <li>- Study the upper urinary tract</li> <li>- Postprocedural anatomy</li> <li>- Pouch leak</li> <li>- Anastomotic leaks</li> <li>- Gastrointestinal or extraurinary complications</li> </ul>
Type of diversion	Imaging technique of choice
Ileal conduit	Flouroscopy (pouchogram) and CT urogram
Indiana pouch	Flouroscopy (pouchogram)
Mitrofanoff	Flouroscopy (pouchogram)
Mainz II	CT pouch cystogram
Studer pouch	CT pouchogram cystogram
Orthotopic neobladders	CT urogram

appliance with a stoma, which may have negative effects for patients' body image and quality of life.<sup>6</sup> Orthotopic neobladders and continent cutaneous diversions allow for a normal body image, but also require the patient to have the capacity to either undergo self-catheterization or to learn self-voiding techniques with a neobladder.<sup>6</sup> With respect to oncologic factors, the primary goal is effective resection of the original tumor and to minimize the risk of recurrence. For example, in patients undergoing urinary diversion postcystectomy for bladder cancer, orthotopic neobladders are contraindicated in men with tumor involvement in the prostatic urethra, as well as women with bladder neck involvement due to the increased risk of urethral recurrence.<sup>6</sup> Patients with locally advanced or node-positive bladder cancer are contraindicated for orthotopic neobladder given the recurrence risks.<sup>6</sup> Furthermore, in patients with gynecologic or gastrointestinal malignancies requiring pelvic exenterations, orthotopic neobladders are not recommended due to the increased risk of disease recurrence and the need for additional adjuvant therapies.<sup>3,4</sup>

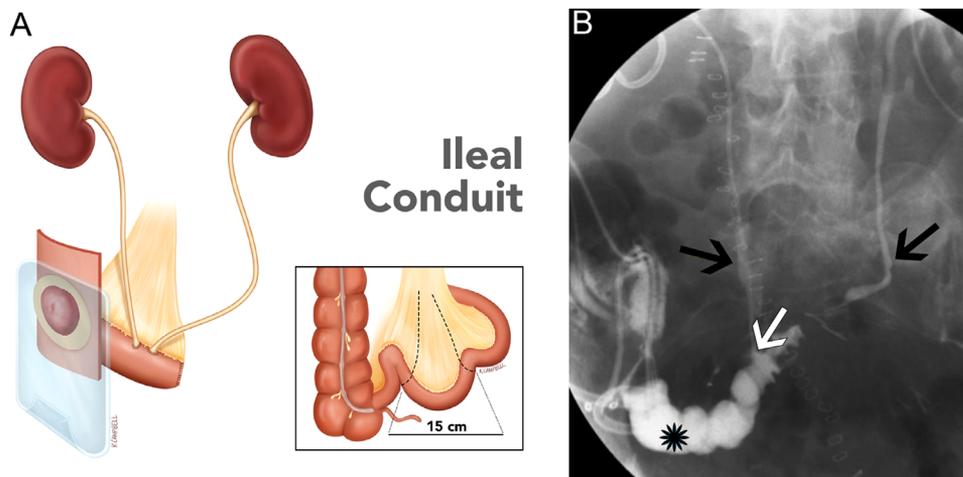
### Imaging Techniques

Fluoroscopic techniques and multiphasic computed tomography (CT) are the mainstays for imaging the urinary tract post-diversion surgeries (Table 1). Fluoroscopic techniques allow for dynamic assessment of the postoperative anatomy as well as

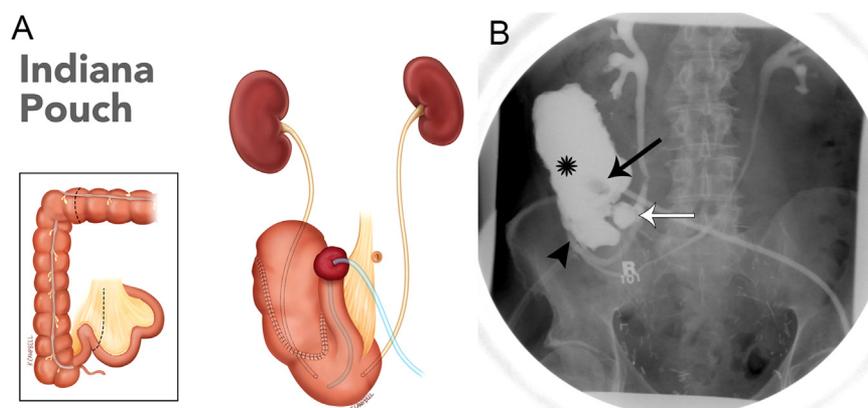
complications. Urinary pouchogram, also referred to as a loopogram, is a retrograde technique performed via insertion of an external catheter (14 French Foley catheter) and a 5 mL balloon through the conduit stoma.<sup>7</sup> Loopograms are particularly useful in the evaluation of the reservoir for ureteral leaks, and for assessment of presence and extent of strictures.<sup>7</sup> A scout image precedes the loopogram study as it helps assess for calculi in the ileal conduit, exact position of staple lines (common site for leak with staple line sometimes mimicking a subtle leak) and any preinjection high density material which may mimic a contrast leak. Our institutional loopogram protocol uses a gentle low-pressure hand injection where 150-300 cc of a dilute contrast solution (50 cc of water-soluble contrast diluted in 250 cc of saline) is injected into the urinary reservoir. Alternatively, contrast can be instilled into the urinary reservoir via gravity by hanging dilute contrast solution above the patient. Following contrast instillation, multiple fluoroscopic images in different projections (ie, anteroposterior, left and right anterior oblique) are obtained to assess the function of the conduit as well as to visualize specific areas of concern. This is followed by a post (ileal conduit) evacuation radiograph (in patients with ileal conduits) to assess for residual contrast (to look for conduit stomal stenosis) and to accentuate the presence of a subtle conduit leak.

Multiphasic CT of the abdomen and pelvis using a CT urogram protocol is the preferred first-line imaging modality for oncologic surveillance and evaluation of potential urinary diversion complications.<sup>8,9</sup> At our institution, we use a split-bolus protocol; this consists of a noncontrast CT followed by a contrast-enhanced study using initially 50 cc of nonionic iodinated IV contrast injected through a power injector at a rate of 3 cc per second. Approximately 5 minutes postinjection, the patient is rotated to facilitate contrast mixing with urine. Following this, an additional 80 cc (total 130 cc) of IV contrast is injected at a rate of 3 cc per second. Images are acquired at 100 seconds postsecond contrast bolus injection. This protocol will yield images demonstrating combined nephrographic and excretory phase (2,4).

CT urogram allows for the sensitive detection of postprocedural anatomy as well as assessing for potential gastrointestinal or genitourinary complications in the nephrographic and delayed phases. Additional imaging techniques may be useful for specific indications. For example, split-bolus portal venous phase dual-energy CT urography provides sufficient image quality with potential to reduce radiation exposure by eliminating the non-contrast phase of a conventional CT urogram and using a virtual noncontrast reconstruction.<sup>10</sup>



**FIG 1.** (A) Schematic diagram demonstrating surgical anatomy of the ileal conduit. (B) Loopogram of the ileal conduit. A balloon-inflated catheter is seen in the ileal conduit (\*). The ureters (black arrows) are anastomosed to the proximal end of conduit (white arrow). (Color version of figure is available online.)



**FIG 2.** (A) Schematic diagram demonstrating surgical anatomy of the Indiana pouch. (B) Fluoroscopic pouchogram image demonstrates right colonic reservoir (\*) with ileocecal valve and terminal ileal segment (white arrow) used as efferent limb and connected to abdominal wall. Foley bulb (black arrow) seen in colonic reservoir and contrast seen refluxing into bilateral collecting systems. Uretero-colic anastomosis denoted by arrowhead. (Color version of figure is available online.)

The CT pouch cystogram protocol includes injection of a small amount (100–200 cc) of dilute contrast into the new urinary reservoir through an external 14 French Foley catheter in addition to the intravenous contrast injection. CT pouch cystogram is useful in investigating suspected pouch leak as well as any complication involving the upper urinary tract.

Magnetic resonance imaging (MRI) is performed less commonly and only for specific indications, for example in younger patients with prior malignancy when radiation is a concern. It usually involves acquisition of high resolution T2-weighted sequences in the coronal, sagittal and axial planes, T1-weighted sequences, and contrast-enhanced images. Diffusion-weighted images can also be performed, but are not mandatory. MR urograms are not routinely performed for follow up of urinary diversions at our institution.<sup>11</sup>

## Incontinent Diversions

### Ileal Conduit

The ileal conduit uses the ileum to create a connection between the ureters and the anterior abdominal wall via a cutaneous stoma.



**FIG 3.** Contrast-enhanced coronal CT demonstrating Indiana pouch (\*) in the right lower quadrant, left ureter is denoted by black arrows. Multiple metallic surgical clips in bilateral common iliac regions are in keeping with lymph node dissection.

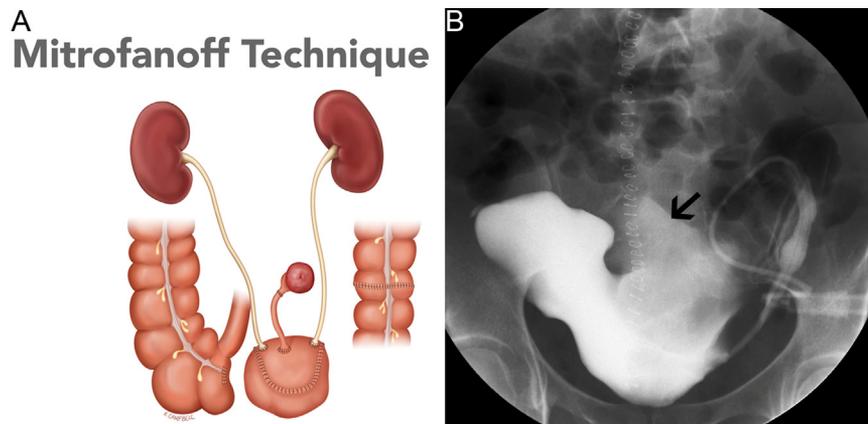
(Fig 1A). To create an ileal conduit, a 20 cm segment of distal ileum, taken approximately 15 cm proximal to the terminal ileum, is mobilized and isolated to be used as the diversion conduit.<sup>5,6,12</sup> The ureters are subsequently transected from the bladder and a ureteroileal anastomosis is created at the proximal limb of the conduit for each ureter. The ureteroileal anastomosis commonly results in reflux, as surgeries using antireflux mechanisms result in an increased risk of anastomotic stricture. The distal limb is brought out to the anterior abdominal wall in the right lower quadrant as a stoma. In the creation of the ileal conduit, the passive peristaltic action of the ileal segment from proximal to distal helps with passive urine flow, however, continence and urinary voiding are not possible.

Multidetector CT with CT urography protocol is used following ileal conduit reconstruction for routine oncologic surveillance as well as for investigation of diversion complications. Fluoroscopic examination such as loopograms are also used to assess functional complications such as urine leaks or strictures (Fig 1B). Normal postsurgical anatomy features the ileal conduit located in the right lower quadrant with connection to the cutaneous stoma.<sup>5</sup> Additionally, it is important to evaluate the ureteroileal anastomosis as this is often the site of stricture formation; the right ureter is often in anatomical position, whereas the left ureter often crosses the midline in connecting to the anastomosis.<sup>13</sup> Given that antireflux mechanisms are not incorporated in an ileal conduit, bilateral mild hydronephrosis is an expected postoperative finding.<sup>11</sup> Under fluoroscopic examination, peristaltic action of the ileal conduit can often be seen. Furthermore, given the lack of antireflux mechanisms, retrograde injection of contrast shows opacification of the ileal conduit with contrast refluxing into the renal pelvis.

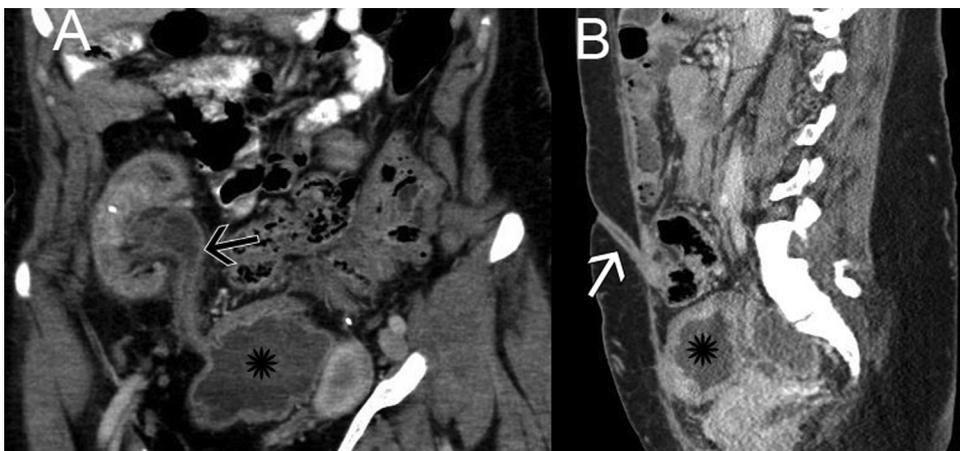
## Continent Diversions

### Indiana Pouch

The Indiana pouch is one of the common continent diversions with a catheterizable cutaneous stoma.<sup>14</sup> The technique involves creation of a urine reservoir which uses the ileocecal valve to create a continence mechanism<sup>15</sup> (Fig 2A). The pouch is created using 10 cm of terminal ileum, cecum, and ascending colon extending up to the hepatic flexure.<sup>15</sup> The ascending colon along with the cecum is detubularized via an incision through the tenia coli, reconfigured, and closed to serve as the urine reservoir.<sup>14,15</sup> An uretero-colic anastomosis is created connecting ureter to the neo-reservoir using a submucosal technique.<sup>15</sup> The ileocecal valve is subsequently



**FIG 4.** (A) Schematic diagram demonstrating surgical anatomy of Mitrofanoff technique. (B) Pouchogram of the Mitrofanoff technique demonstrates contrast opacified Mitrofanoff reservoir (black arrow). (Color version of figure is available online.)



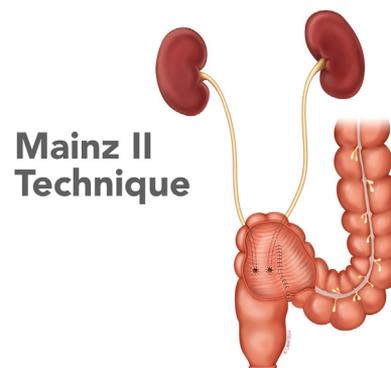
**FIG 5.** Coronal and sagittal CT images demonstrating Mitrofanoff technique. Detubularized colon which has been folded to form the reservoir (\*). (A) The coronal image demonstrates mild to moderate hydronephrosis proximal to the uretero-colic anastomosis (black arrow). (B) The sagittal image demonstrates appendix (white arrow) anastomosed to the reservoir at one end (with a cuff of cecum) and to the navel at the other.

doubly imbricated to create the continence mechanism.<sup>15</sup> The efferent limb is created from a segment of the terminal ileum which is tapered and led through the abdominal wall, typically in the right lower quadrant, to create a flush stoma. Patients self-catheterize via the stoma to empty the pouch.<sup>15</sup>

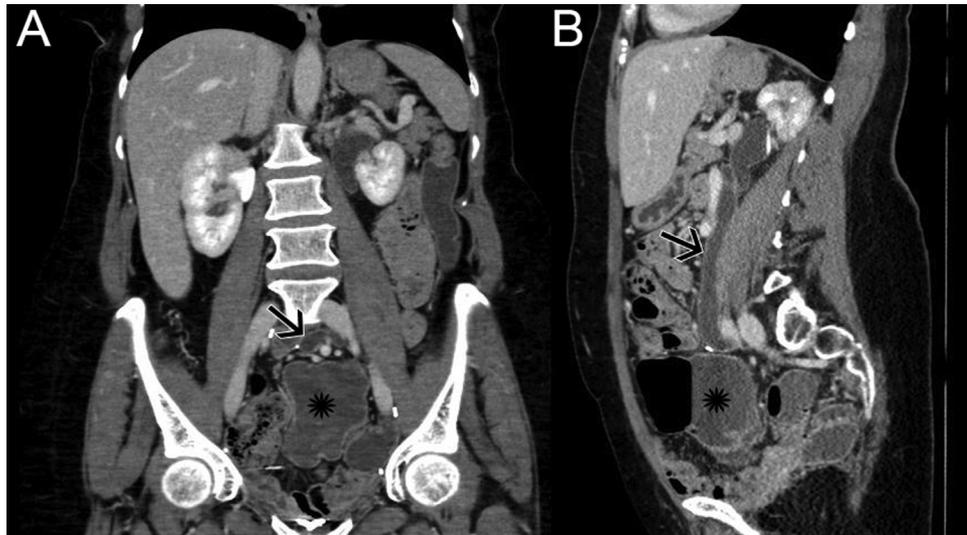
Multidetector CT of an Indiana pouch is demonstrated in Figure 3. In cross-sectional imaging, the urinary reservoir is typically found in the right lower quadrant and has an appearance of a fluid filled structure. The new reservoir may be easily distinguished from the functional gastrointestinal tract if positive oral contrast is administered. Additionally, residual cecal haustra may be visible in the reservoir as well as pockets of air due to self-catheterization.<sup>5,14</sup>

Like the ileal conduit, fluoroscopic examination with a pouchogram is useful to exclude leaks as well as to assess for ureteric strictures. A normal pouchogram of an Indiana pouch procedure is shown in Figure 2B. A Foley catheter is inserted through the stoma with retrograde injection of water-soluble contrast to visualize the upper and lower tracts. In assessing the function of the Indiana pouch, it is important to note that the course of the right and left ureter will differ given the location of the reservoir in the right lower quadrant. The left ureter will have a significantly longer course that crosses midline towards the uretero-colic anastomosis. Additionally, although the uretero-colic anastomosis does provide an antireflux mechanism, residual ureteric reflux is expected and mild bilateral hydronephrosis postoperative is considered normal.

Careful assessment of the reservoir, uretero-colic anastomosis, ureters, and calyces is required to exclude common complications. Acutely, urinary leak from the reservoir can be easily visualized on pouchography as an extravasation of contrast. Pouchography is also helpful in assessing late complications such as ureteric strictures, as this is often difficult to assess on CT. This is particularly



**FIG 6.** Schematic diagram demonstrating surgical anatomy of Mainz II (modified ureterosigmoidostomy). The Mainz II technique is characterized by creation of a low-pressure pouch for a remodeled and detubularized sigmoid colon. The ureters are implanted via a submucosal, antirefluxing tunnel. (Color version of figure is available online.)



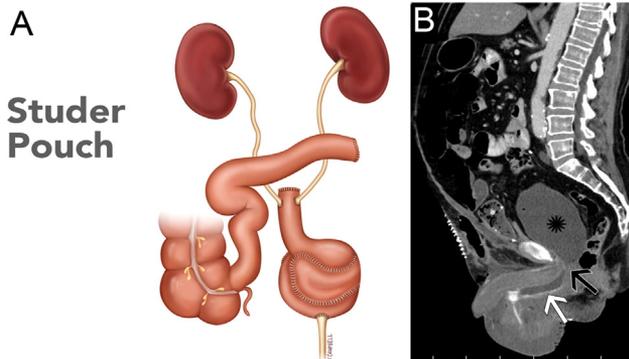
**FIG 7.** (A and B) Coronal and sagittal CT images of the modified ureterosigmoidostomy (Mainz II). CT images showing a detubularized sigmoid colon as the urinary reservoir (\*). Left ureter (black arrow) is markedly dilated concerning for a distal stricture.

important for patients with Indiana Pouch as the left ureter is at increased risk of stricture given its longer course.<sup>13</sup>

#### Mitrofanoff Technique

The Mitrofanoff technique is a variant of the continent urinary diversions and use the appendix as the catheterizable stoma (Fig 4).<sup>16</sup> A segment of the colon, typically the descending colon is remodeled, detubularized, closed, and folded to create a low-pressure reservoir. The appendix is isolated along with a cuff of cecum and is anastomosed to the newly created reservoir. The other end is then brought to the umbilicus to create a self-catheterizable stoma. The ureters are then individually anastomosed to the reservoir. Given its predictable vasculature and convenient and appropriate size, the Mitrofanoff technique is most commonly performed in younger patients with refractory bladder dysfunction or congenital urological abnormalities.<sup>17</sup> Other tubularized segments can be used as the catheterizable stoma if appendix is not available, including ileum (Yang-Monti technique), and less commonly, the ureter and fallopian tube.<sup>16,17</sup>

Common CT imaging appearance of the Mitrofanoff technique is demonstrated in Figure 5. The urine-filled colonic reservoir may contain locules of air due to self-catheterization as well as hypoattenuating material due to mucous secretions from bowel.<sup>5</sup>



**FIG 8.** (A) Schematic diagram demonstrating surgical anatomy of Studer pouch (B) Sagittal CT images demonstrate an orthotopic neobladder (\*) created from the ileum. The Studer pouch has been anastomosed (black arrow) to the native urethra (white arrow), and voluntary voiding preserved. A urethral voiding device is noted in-situ. (Color version of figure is available online.)

It is important to visualize key structures of the reservoir, including the uretero-colic anastomoses as well as the efferent appendix limb connecting the reservoir to the umbilicus. In a pouchogram view (Fig 4B), contrast can be visualized in the Mitrofanoff reservoir which can help detect the presence of leaks or strictures.

#### Mainz II (Modified Ureterosigmoidostomy)

Ureterosigmoidostomy was a surgical approach first described in the early 20th century, however, it was associated with high morbidity and mortality due to fecal reflux to the kidneys.<sup>18</sup> In the modified ureterosigmoidostomy (Mainz II) technique, ureteric reflux is significantly reduced via a low-pressure pouch created from detubularized segment of sigmoid colon (Fig 6).<sup>18</sup> The pouch is created from a side-to-side anastomosis of a 20 cm segment of distal sigmoid colon and closed posteriorly in an inverted “U” shape.<sup>18</sup> The ureters are implanted via a submucosal antireflux tunnel to further reduce the risk of fecal reflux. The resultant



**FIG 9.** Contrast-enhanced image of orthotopic neobladder. Status postoperative day 10 with fever and elevated white cell count. Coronal image demonstrates bilateral large hemipelvic collections containing air and fluid (black arrow) representing abscess formation secondary to neobladder leak. Left hemipelvic collection is seen communicating with the left lateral neobladder wall (white arrow).

**TABLE 2**  
Complications of urinary diversion surgeries<sup>19</sup>

Early (< 30 d)	Late (> 30 d)
Intestinal complications Anastomotic leak	Infection: Lithiasis: 10%
Collections: > Urinoma > Hematoma > Lymphocele > Abscess	Urinary obstruction
Urinary obstruction	Stoma complication Anastomotic stricture Renal failure Malacoplakia > Tumor recurrence

pouch is subsequently fixed in the promontory. This technique allows for a continence mechanism via the anal sphincter.

In imaging patients with a Mainz II diversion, CT is the imaging modality of choice. Fluoroscopic techniques are not helpful for ureterosigmoidostomy due to the antireflux mechanisms preventing retrograde flow of contrast beyond the pouch. The common postsurgical imaging anatomy is demonstrated in Figure 7 which shows the detubularized sigmoid reservoir to be typically distended with urine. Additionally, the ureters may be difficult to assess due to the antireflux mechanism. However, careful

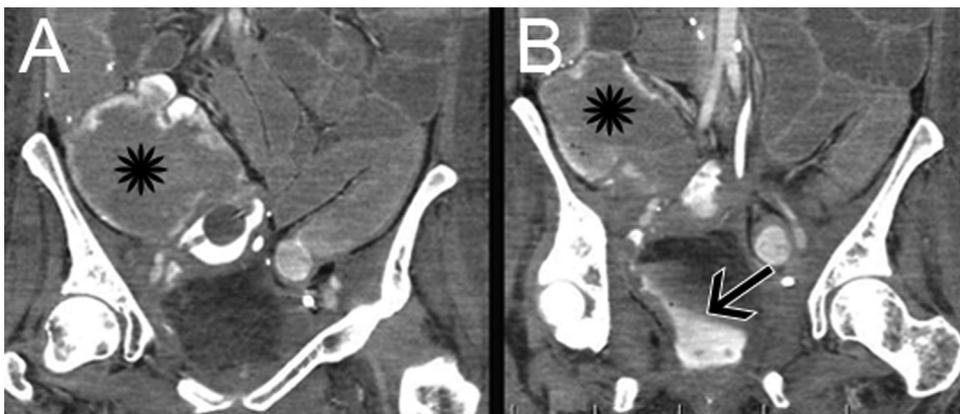
evaluation for segmental areas of mild ureteric dilatation must be made to exclude early small strictures.

### Orthotopic Neobladders

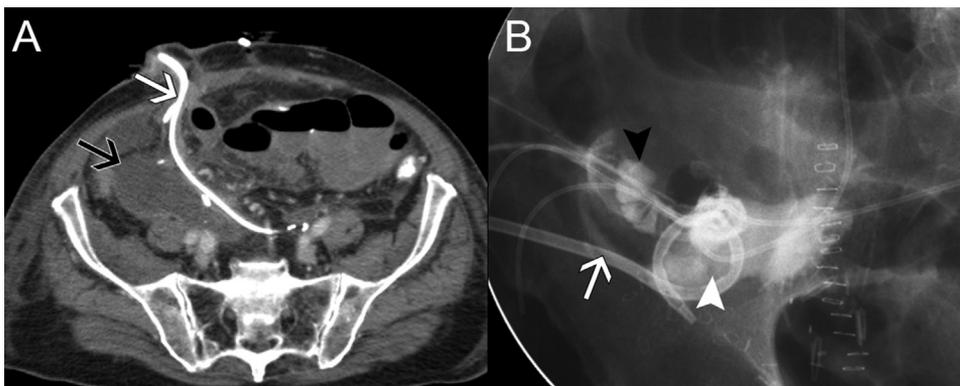
#### Studer Pouch

The Studer pouch is created from a 40–65 cm long segment of ileum, approximately 20 cm proximal to the ileocecal valve (Fig 8).<sup>7</sup> The selected segment is detubularized (by cutting the antimesenteric border), remodeled, and undergoes end-to-end or side-to-side anastomosis to create the urinary reservoir.<sup>5</sup> A 10 cm proximal end of the ileal segment is left intact and serves as the afferent limb of the Studer pouch.<sup>7</sup> The afferent limb is anastomosed to the ureters due to the isoperistaltic effect of the ileal segment, which acts as an antireflux mechanism.<sup>5,7</sup> The distal aspect of the pouch is anastomosed to the patient's native urethra to complete the lower urinary tract. Continence is maintained by the patient's own external urethral sphincter.

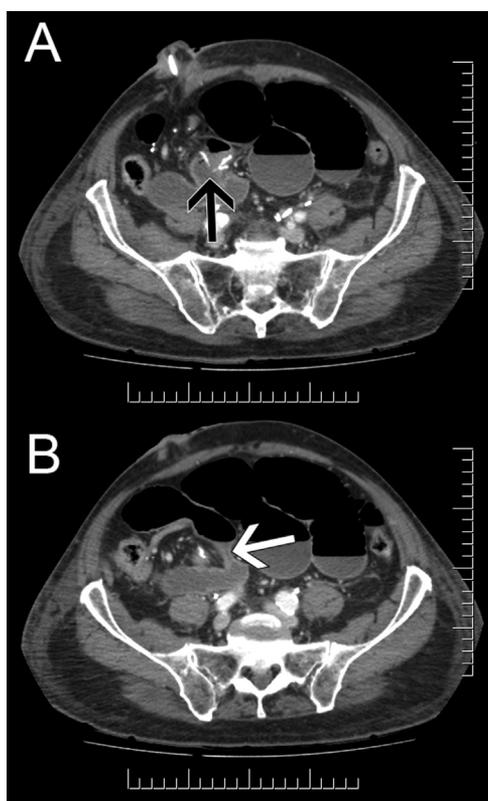
CT pouch cystogram can be used for routine investigations of the Studer pouch as it ensures adequate reservoir distention (Fig 8B and C). The neobladder is characterized by a round-shaped, urine filled reservoir. What distinguishes the neobladder from a native bladder is the presence of the afferent ileal limb that is connected to the ureters bilaterally. In cases of orthotopic neobladder, it is important to identify the neobladder as well as to evaluate both the uretero-afferent limb as well as the neobladder-urethral anastomosis to ensure patency and detect any evidence of contrast leak from either end.



**FIG 10.** Coronal (A and B) contrast-enhanced CT images of Indiana pouch urinary diversion. Extraluminal contrast admixed with fluid (black arrow) surrounding colonic reservoir (\*), consistent with leak.



**FIG 11.** (A) Axial contrast-enhanced CT image demonstrating urinoma postileal conduit procedure. A urinoma (black arrow) surrounding ureteric stent (white arrow) within the ileal conduit, concerning for a leak. (B) Posturinoma drainage study shows contrast leakage (white arrowhead) from ileal conduit (black arrowhead) into space around drainage catheter (white arrow).



**FIG 12.** Patient with history of increasing abdominal pain and obstipation for 7 days postileal conduit reconstruction. Axial (A and B) CT images with IV and oral contrast demonstrate multiple dilated small bowel loops leading up to the small bowel anastomosis (the donor site for ileal conduit) in the distal ileum which shows an abrupt change in caliber (white arrow) as it wraps around the ileal conduit (black arrow). This was proven to be an internal hernia leading to high-grade bowel obstruction on surgery.

## Complications

Surgical complications related to urinary diversions are categorized based on time as early (< 30 days) or late (> 30 days) complications.<sup>6,19</sup> Given the differences in technical complexity between procedures, large variability exists in the reported rates of postsurgical complications. The list of common early and late complications is shown in [Table 2](#).

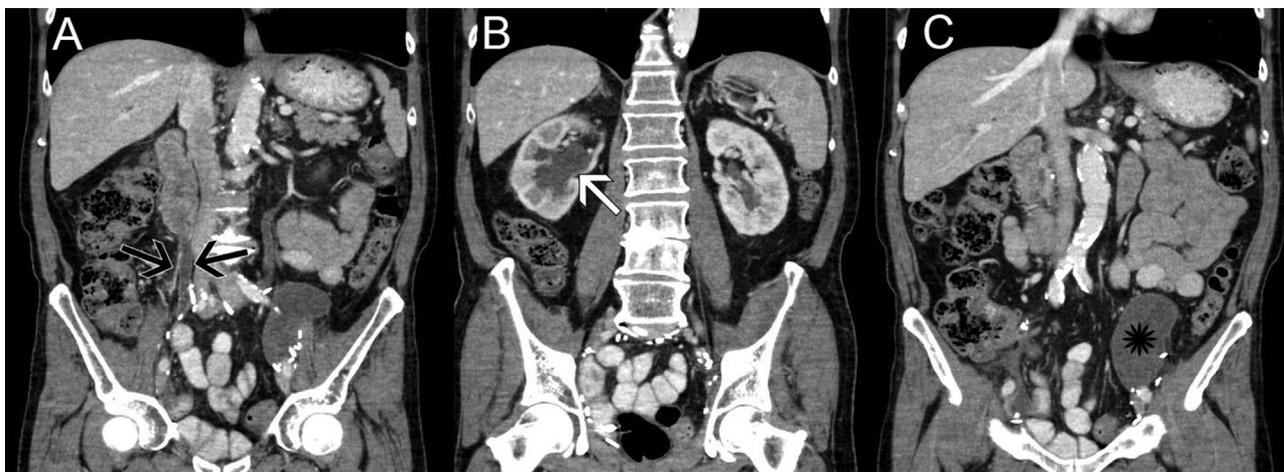
### Early Anastomotic Leaks & Collections

Postdiversion urine leaks occur in approximately 4% of patients and occur most commonly at the ureteroenteric anastomosis.<sup>20</sup> Clinically, these present in the early postoperative period with increased output from the wound or surgical drain and worsening clinical status. Imaging investigations with contrast-enhanced CT scan or loopogram are performed for these indications, and CT imaging can sometimes demonstrate a clear defect in the reservoir wall ([Fig 9](#)). CT cystograms on the other hand can demonstrate contrast extravasation from the ureteroenteric anastomosis or reservoir on the delayed phase ([Figs 10 and 11](#)). The detection of urine leakage is important as prolonged leakage may lead to periureteral fibrosis and scarring resulting in anastomotic stricture formation.<sup>20</sup>

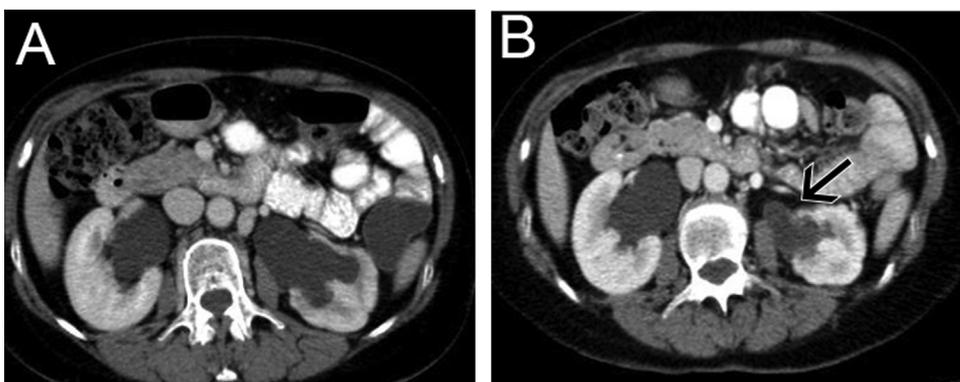
Undrained urine leaks may coalesce as an urinoma ([Fig 11](#)). The other differential diagnosis for postoperative fluid collections include hematoma, lymphocele, and abscess. A history of lymph node dissection increases the risk of postoperative lymphocele formation ([Fig 14C](#)). Urinoma can be distinguished from hematoma or lymphoceles as it fills with iodinated contrast on excretory or delayed phase of contrast-enhanced CT scans.<sup>11,20</sup> Any postoperative fluid collection may become secondarily infected and develop into abscess. Abscesses demonstrate rim enhancement on contrast-enhanced CT and may include pockets of air as well as associated secondary inflammatory fat thickening and stranding ([Fig 9](#)).



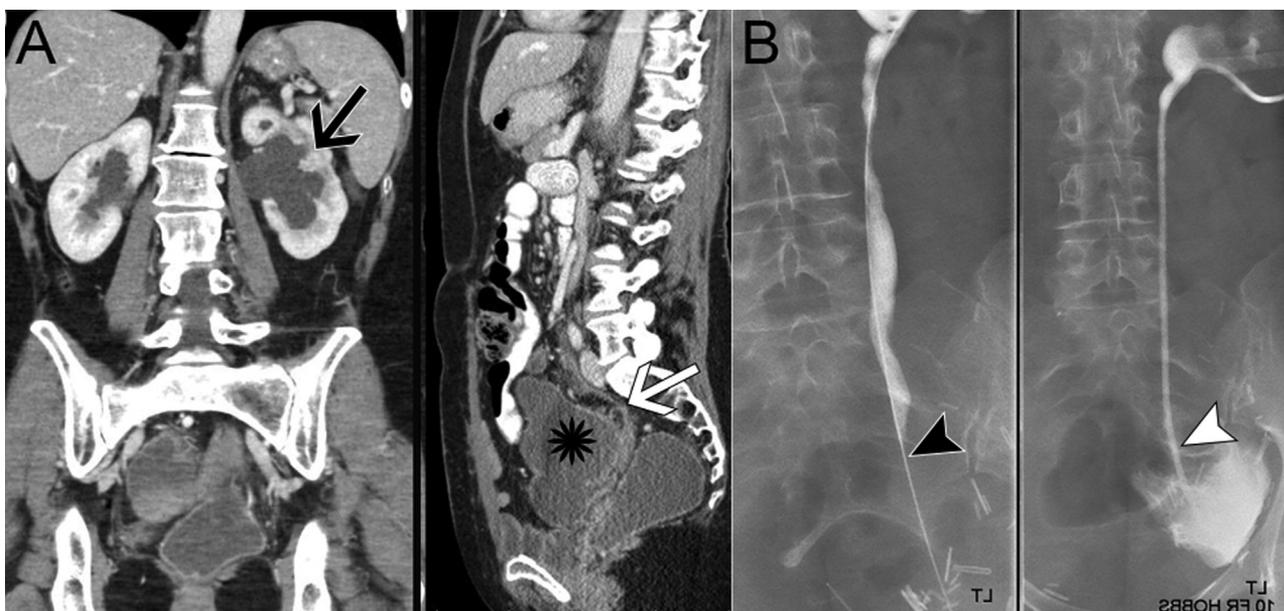
**FIG 13.** Axial (A) and coronal (B) noncontrast and contrast-enhanced CT images of a Mainz II (modified ureterosigmoidostomy) diversion with new fever and renal failure. There is moderate left sided hydronephrosis (black arrow), and dilated left ureter (black arrowheads) on contrast-enhanced scan. Worsening left hydronephrosis (white arrow) with left perinephric stranding and uroepithelial thickening (white arrowheads) and layering hyperdense material in left pelvis consistent with pyonephrosis.



**FIG 14.** Coronal contrast-enhanced CT images of patient with ileal conduit. (A) There is abnormal dilatation of the right ureter (black arrows) suspicious for distal right ureteric stricture. (B) Associated upstream hydronephrosis (white arrow) of the right kidney. (C) Cystic lesion (\*) anterior to the left iliopsoas muscle measuring 5.5 × 4.4 cm consistent with a lymphocele.



**FIG 15.** (A) Axial contrast-enhanced images of Mainz II diversion demonstrating moderate bilateral hydronephrosis. (B) Axial contrast-enhanced images of same patient demonstrating interval progression of atrophy involving the left kidney (black arrow) 1 year later with worsening renal function.



**FIG 16.** (A) Coronal and sagittal contrast-enhanced CT images in patient with a Mainz II urinary diversion. The images demonstrate bilateral hydronephrosis, left worse than right (black arrow), with narrowing of the distal left ureter close to the site of reimplantation into the colonic reservoir (\*). The features are concerning for stricture (white arrow). (B) Sequential fluoroscopic nephrostogram images of the same patient demonstrating a stricture (black arrowhead) at the left ureteric reimplantation site, undergoing balloon dilatation with subsequent improvement in ureter caliber (white arrowhead).

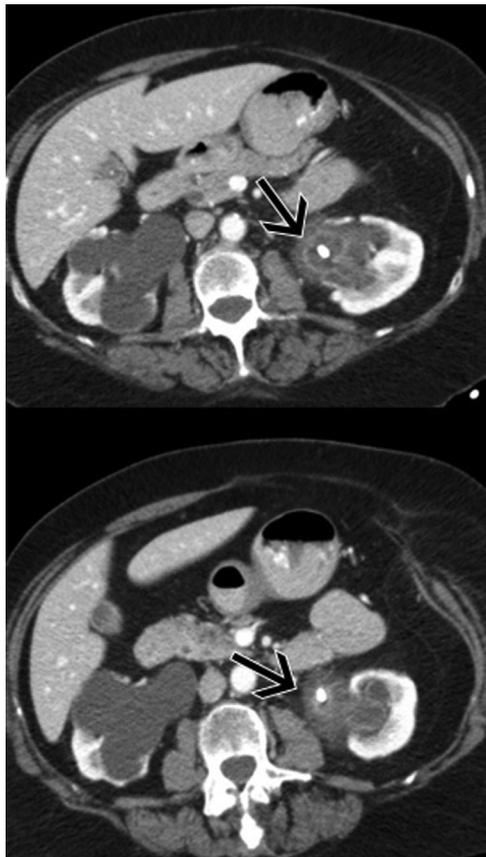
### Bowel-Associated Complications

Small bowel obstruction can occur both in the early and late postoperative period. Bowel obstruction can be caused by postoperative adhesions, most commonly at the site of the enteroenteric anastomosis, bowel ischemia, or internal herniation<sup>11</sup> (Fig 12). CT with IV and oral contrast typically demonstrates distended loops of small bowel and can help to identify the specific transition point indicating the location and degree of mechanical obstruction.<sup>21</sup> Although most partial-grade obstructions can be managed conservatively, high-grade obstruction with worsening clinical symptoms are usually treated with surgical intervention.

### Anastomotic Strictures and Associated Complications

Ureteroenteric anastomotic strictures are serious, late complications associated with significant morbidity.<sup>13</sup> Strictures are most commonly benign, related to periureteral scar formation and fibrosis due to ischemia or urine leakage, however, malignant strictures secondary to tumor recurrence can occur as well.<sup>13</sup> The left ureter is at a higher risk for strictures compared to the right due to increased mobilization and dissection of the left ureter to create the ureteroenteric anastomosis. The reported incidence of anastomotic stricture ranges between 4% and 7% and these most commonly occur within 24 months of surgery.<sup>13,19</sup>

Imaging evaluation for possible strictures is important as anastomotic strictures may be clinically subtle. CT is the most



**FIG 17.** Axial contrast-enhanced images of patient with ileal conduit, demonstrate dilated left renal pelvis with stent with associated uroepithelial thickening (black arrows), consistent with pyelitis secondary to stent malfunction. Stent was subsequently changed. Additionally, the right kidney shows significant hydronephrosis and cortical atrophy.



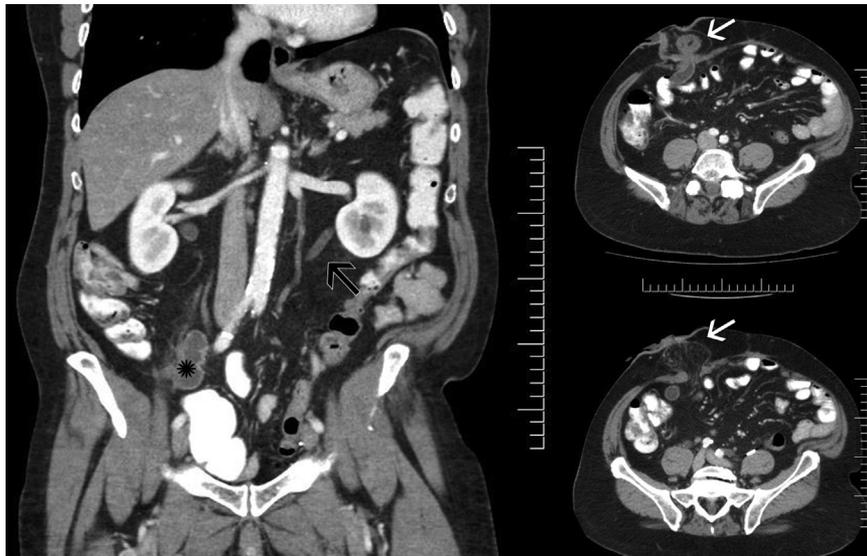
**FIG 18.** Coronal noncontrast-enhanced CT image of ileal conduit. Multiple radiopaque calculi (black arrow) seen within the ileal conduit.

useful imaging modality in the evaluation of strictures; the presence of new-onset or progressive proximal ureteric dilatation and hydronephrosis are the most common imaging findings. In patients with refluxing anastomoses, loopogram may be useful to evaluate the degree of reflux as the absence of reflux may indicate presence of stenosis or stricture (Figs 13A and 14). Upon identification of a potential stricture, a benign or malignant etiology should be differentiated. The presence of an enhancing soft-tissue mass surrounding the anastomosis on CT is concerning for tumor recurrence. The complications of benign strictures include infection, manifesting on imaging as hydronephrosis with uroepithelial thickening or hyperenhancement or both along with perinephric inflammatory stranding (Fig 13B). Chronically, benign strictures can lead to progressive renal parenchymal atrophy which should be noted on serial imaging (Fig 15A and B).

Minimally invasive techniques such as balloon dilatation as well as ureteric stenting are commonly used for treatment of ureteroenteric anastomotic strictures (Fig 16). Balloon dilatation is associated with high rates of stricture recurrence, with reported success rates ranging from 0%-70%.<sup>13</sup> The major disadvantage with stenting is related to obstruction secondary to stent malfunction. This may lead to infection of the upper urinary tract and worsening hydronephrosis with diminished renal function (Fig 17).

### Urinary Tract Calculi

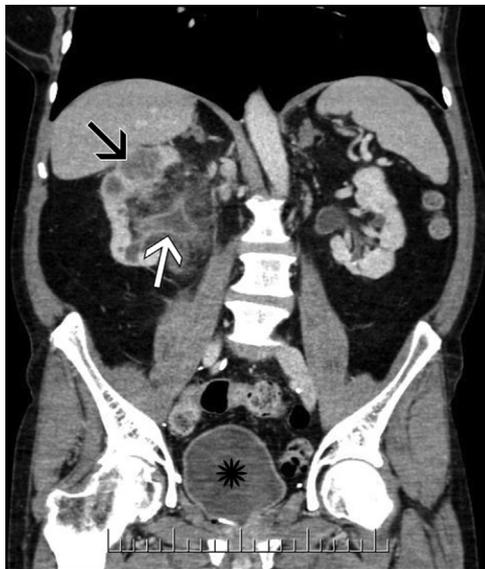
Urolithiasis is a common, long-term complication associated with both continent and incontinent urinary diversions with a reported rate of 10%.<sup>19,22</sup> Stones may form in both the upper urinary tract or within the reconstructed urinary reservoir. The risk of urolithiasis is multifactorial, but primarily relates to chronic bacterial colonization, urinary stasis, and metabolic abnormalities associated with bowel reservoirs and conduits.<sup>22</sup> Noncontrast CT remains the most sensitive imaging modality to detect and evaluate stone burden (Fig 18). Management includes shockwave lithotripsy, percutaneous nephrolithotomy, as well as ureteroscopic lithotripsy.<sup>22</sup> Medical management with increased fluid intake, correction of metabolic abnormalities, and antibiotic prophylaxis against urinary tract infections are important for chronic prevention of stones.<sup>22</sup>



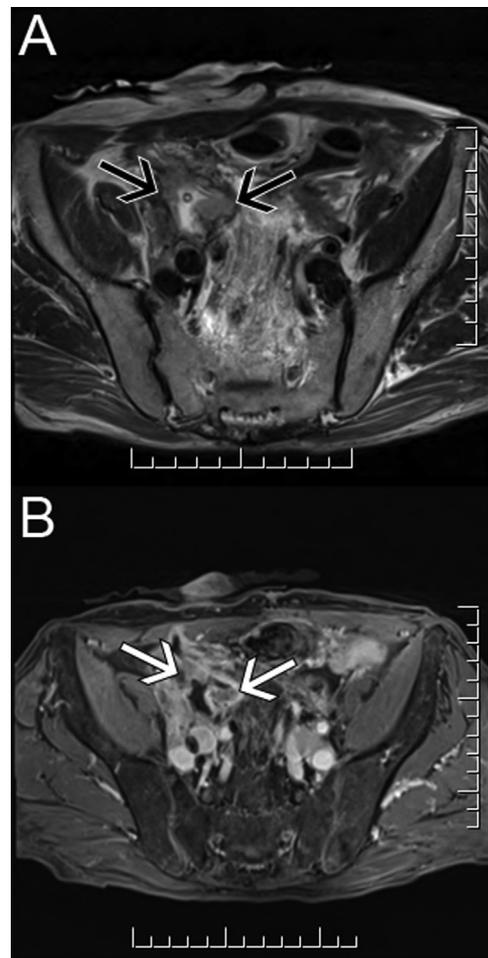
**FIG 19.** Coronal and axial contrast-enhanced CT images demonstrate ileal conduit (\*) in right lower quadrant with part of left ureter seen extending toward the right side (black arrow). There is a parastomal hernia (white arrows) containing mesenteric fat and a segment of the ileal conduit folded into itself, which demonstrates mild wall thickening and normal enhancement.

### Parastomal Hernias

Parastomal hernias are protrusions of the abdominal viscera through the incisional stoma wall defect most commonly associated with ileal conduits.<sup>23</sup> They are one of the most common long-term complications in patients with ileal conduits, with incidence reported as high as 65%.<sup>23</sup> Patients present with a stoma-site abdominal bulge which may or may not be painful; however, symptoms of bowel obstruction necessitate urgent imaging using CT scan for early diagnoses of serious complications including bowel incarceration or strangulation. CT typically shows loops of bowel as well as mesentery herniating through the stoma wall defect (Fig 19). Surgical repairs are reserved for acute



**FIG 20.** Coronal contrast-enhanced CT images of patient with history of bladder cancer treated with radical prostatectomy and cystectomy with neobladder creation (\*). There is a heterogeneously enhancing mass (black arrow) in the upper pole of right kidney with cystic components. Thickening of the right pelvic and ureteric walls (white arrow) with surrounding fatty proliferation/inflammation. Biopsy of soft tissue mass confirmed diagnosis of transitional cell carcinoma.



**FIG 21.** Axial T2-weighted (A) and contrast-enhanced fat-saturated T1-weighted sequence (B) MRI of a patient with prior ileal conduit. The T2-weighted image demonstrates irregular intermediate signal intensity thickening (black arrows) in the ileal conduit. On the fat-saturated T1-weighted image, the abnormal region of thickening demonstrates enhancement on the postgadolinium image (white arrows). This was diagnosed as cancer recurrence on biopsy.

complications (ie, bowel obstruction) or in patients with chronic symptoms that significantly affect quality of life.

### Disease Recurrence

Urothelial bladder carcinoma is associated with a high rate of recurrence locally, in the upper urinary tract, or can present with distant metastases. Cross-sectional imaging is crucial for accurate and potentially early detection of recurrence to initiate early treatment. Local recurrence occurs in approximately 5%–15% of patients with invasive urothelial cancer.<sup>24</sup> Imaging features are nonspecific and may include abnormal soft tissue thickening, presence of a new pelvic mass, and new onset malignant strictures (Fig 20) with or without pelvic lymphadenopathy. Although CT urography is often the first-line imaging modality to assess local recurrence, contrast-enhanced MRI can offer greater differentiation of local soft tissues (Fig 21). Positron emission tomography/CT is being increasingly used in surveillance of patients with treated bladder carcinoma as it allows for increased sensitivity to detect disease and facilitates a directed search when follow-up imaging such as MRI or CT is performed.<sup>25</sup> Patients with bladder cancer are also at increased risk of metachronous upper tract disease, occurring in approximately 0.75%–6% of patients,<sup>26</sup> manifesting as abnormal renal enhancement, urothelial thickening, and signs of obstruction (Fig 20).

### Conclusion

Urinary diversions are complex surgical procedures frequently performed following cystectomy. Radiologists must have a good knowledge and understanding of the surgical techniques and expected postsurgical anatomy to accurately evaluate and detect potential complications. Imaging with fluoroscopy and CT urography or pouch cystogram play a key role in the follow up of patients with urinary diversions for assessment of immediate and late complications. Interventional radiology techniques are helpful in the evaluation and treatment of urinary tract-related complications, especially ureteroenteric strictures. Serial imaging is key for the assessment of potential late complications such as progressive hydronephrosis, which may lead to renal failure. Ultimately, timely detection and diagnosis of complications and potential disease recurrence in this patient population is crucial for potential management, and to salvage renal function with early intervention.

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