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SPECIAL SECTION: UROTHELIAL DISEASE

Urinary diversions: a primer of the surgical techniques and imaging findings

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Abstract

Objective The article attempts to describe the indications, classification, and surgical anatomy of the commonly performed urinary diversion procedures, followed by the imaging protocol and radiological appearances of the normal postoperative anatomy and complications related to these procedures.

Contents Diversion procedures are used to reroute urine after cystectomy and in patients with refractory neurogenic or outlet obstruction of the urinary bladder. Broadly, these can be classified as continent and incontinent diversions. Patients with urinary diversions frequently undergo radiological investigations for the detection of complications. Commonly, a loopogram or pouchogram is performed few weeks after the surgery to look for leak, whereas CT or MRI is used for long-term follow-up. Postoperative complications can be early (within 30 days of the surgery) or delayed and include leaks, collections, strictures, calculi, parastomal hernia, small bowel obstruction, and oncologic recurrence.

Conclusion A variety of urinary diversion procedures are commonly performed and interpretation of the postsurgical anatomy can be overwhelming for the general radiologist. This article provides a basic understanding of the normal anatomy as well as a thorough discussion on the imaging protocol and radiological appearances of the potential complications associated with these procedures.

Keywords Cystectomy · Urinary diversion · Colonic pouches

Introduction

Urinary diversion procedures are used to reroute the flow of urine away from the bladder and urethra. With advances in surgical expertise, these procedures are widely performed for a number of advanced bladder and pelvic malignancies. The most common indication for urinary diversion is following radical cystectomy for muscle-invasive bladder cancer. Other indications include pelvic exenteration for advanced malignancies as well as treatment-refractory functional and neurogenic disorders of the bladder.

Patients with urinary diversion frequently undergo imaging to look for complications such as leaks, strictures, collections related to surgery and as a part of surveillance or diagnostic assessment for oncologic recurrence. For radiologists, it is important to be familiar with the surgical and radiological anatomy of the various diversion procedures and the potential complications which could develop after these procedures.

Types of urinary diversions and basic surgical principles

Urinary diversion procedures are broadly divided into incontinent and continent diversions. Incontinent diversions are more commonly performed since they are easier to perform. These procedures do not incorporate intrinsic continence mechanisms and require placement of a colostomy bag to collect the continuously draining urine. On the other hand,

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continent diversions are technically more difficult to perform, but provide a better quality of life [1]. Continent diversions include cutaneous diversions and orthotopic neobladders. In continent cutaneous diversions, the urine is diverted through a bowel loop which is detubularized (slit open longitudinally to reduce the peristalsis) and refashioned into a low-pressure reservoir, which is then connected to the cutaneous stoma through an efferent bowel loop. Reservoirs are created from the ileocolic segment or from other segments of the ileum and colon. The low pressure of the reservoir enables adequate urine storage, provides reasonable continence, and prevents reflux into the ureters. Continence is mainly achieved through the use of a tunneled 'flap' valve or nipple valve [2]. Often, additional antireflux mechanisms are incorporated at the site of the ureterointestinal anastomosis; however these should not be too tight to produce stenosis. The need for antireflux mechanism is controversial and several surgeons still choose direct, reflux-permitting anastomosis (the buttonhole technique) to the isoperistaltic ileal conduit or low-pressure reservoir. Although ureteric reflux is seen when contrast is injected with positive pressure into the loop, under physiologic conditions, the amount of reflux is much less and stable renal function has been reported [3]. For antireflux anastomosis, usually a submucosal tunnel technique is used, wherein the ureter along with the periureteric cuff of vessels and soft tissue is mobilized and pulled through a submucosal tunnel along one of the tenia coli to create a tension-free anastomosis [4]. This technique has a higher risk of developing stenosis later.

Continent cutaneous diversions require the patient to self-catheterize the stoma every 4–6 h. Failure to catheterize can result in renal failure from obstruction, infection, and perforation of the pouch [5]. In orthotopic neobladder reconstruction, a new reservoir is fashioned in the place of the surgically removed bladder. This procedure avoids a stoma as the neobladder is connected to the native urethra which enables continence through the external urethral sphincter.

Patient selection

Incontinent diversions are the most common diversion procedures performed worldwide since they are technically easier to perform. When expertise is available, oncologic factors, functional status of the patient as well as patient preferences govern the type of continent procedure performed.

Orthotopic bladder reconstruction enables voluntary per-urethral micturition, however is avoided in bladder cancers involving the urethra, and in patients having liver and renal dysfunction. In such patients, continent cutaneous diversions are preferred. These diversions are easier to catheterize, however require clean intermittent self catheterization (CISC) every 4–6 h and are better avoided in older patients and quadriplegics, in whom incontinent diversions are preferred. The various incontinent as well as continent diversion procedures are detailed below (Table 1).

Incontinent diversions

Cutaneous ureterostomy

The ureters are directly anastomosed to the skin to form two continuously draining stomas. However, in view of the high risk of strictures and renal failure, these procedures are no longer preferred for long-term urinary diversion.

Ileal conduit (Bricker procedure)

Ileal conduit is the most frequently performed diversion procedure worldwide. Here the distal ureters are anastomosed to an ileal segment resected 15 cm proximal to the ileocaecal valve (Fig. 1) [6]. Ureterointestinal anastomosis is achieved through the Wallace technique, wherein the two ureters are spatulated and joined together before anastomosing them to the proximal end of the isoperistaltic ileal loop. The distal end of the ileal segment is brought out through a cutaneous stoma, usually in the right iliac fossa. Since the ileal loop is not detubularized, peristalsis helps propel urine towards the cutaneous stoma. Usually, no antireflux mechanisms are incorporated at the ureteroileal anastomosis for the fear of development of stenosis and since the isoperistaltic nature of the ileal segment is sufficient to prevent significant reflux.

Table 1 Types of urinary diversions

Incontinent diversions	Continent diversions	
	Cutaneous diversions	Orthotopic neobladders
Cutaneous ureterostomy Ileal conduit Sigmoid conduit	Ileocolic reservoirs – Indiana pouch – Mainz I pouch – Florida pouch – Miami pouch – Charleston pouch Other colic reservoirs – Mainz II pouch – Mainz III pouch Ileal reservoirs – Koch pouch – T-pouch Miscellaneous – Mitrofanoff	Hautmann pouch Studer pouch

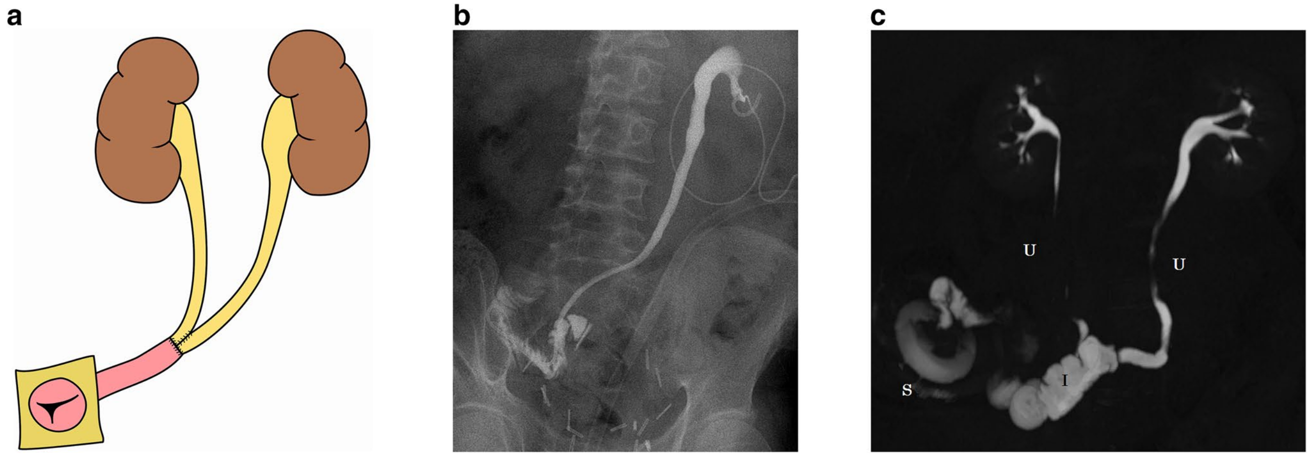

Fig. 1 **a** Pictorial representation of ileal conduit diversion. A short segment of distal ileum is used to divert urine into a cutaneous stoma. The ureters are anastomosed to the butt end of the conduit using the Wallace technique. **b** Nephrostogram images delineating a normal caliber left ureter and ileal conduit with free passage of contrast across the ureteroileal anastomosis. Note the surgical clips from radical cystectomy. **c** Excretory phase CECT, maximum intensity projection of the coronal image, showing normal anatomy of the conduit. (*U ureters*, *I ileal conduit*, *S stoma*)

Sigmoid conduit

Sigmoid conduit has higher risk of metabolic complications and is used only if the distal ileum is diseased or of the patient has short bowel syndrome. Here a segment of sigmoid colon is isolated and used as a conduit with the stoma opening in the left iliac fossa. Submucosal tunneling at the tenia (ureteral-tenial anastomosis) is used to prevent reflux.

Continent cutaneous diversions

Ileocolic reservoirs

Indiana pouch

Indiana pouch is the most common continent diversion performed worldwide. Here, the distal 15 cm of ileum, ileocaecal junction, caecum, and the ascending colon (up to the hepatic flexure) are resected in-toto with their vascularity (Fig. 2a). The colon is then detubularized and refashioned to form a 'pouch'-like reservoir (Fig. 2b). The ureters are anastomosed to this pouch using submucosal tunneling to

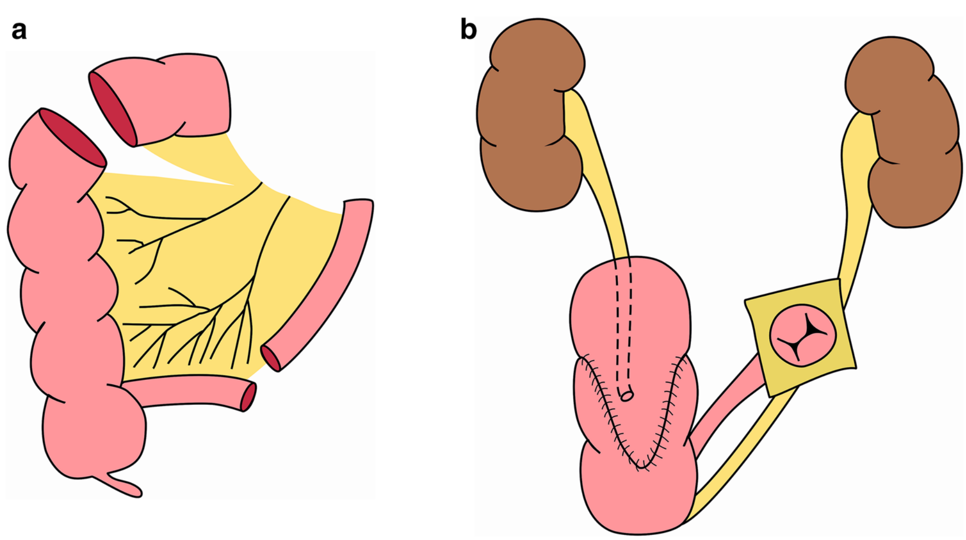

Fig. 2 The surgical technique of Indiana pouch. **a** Distal ileum and ascending colon up to hepatic flexure are isolated, preserving their supplying vessels. **b** A continent reservoir is made after detubularizing the colon and refashioning it into a pouch. The imbricated ileocaecal valve serves as the continence mechanism and the tapered distal ileum, brought out as the stoma, serves as the efferent limb

minimize the amount of reflux. The doubly imbricated ileocaecal valve forms the continent mechanism and the distal ileum forms the efferent limb, which is tapered and tunneled through the abdominal wall to open as a flush stoma in the right iliac fossa. The stoma can be catheterized every 4–6 h to drain the urine.

Mainz I pouch

The initially described Mainz I pouch involved creation of a reservoir from the distal ileum and the proximal ascending colon, with an ileal intussusception nipple serving as the continence mechanism [7]. Ureters are tunneled into the reservoir submucosally, usually along the tenia. The distal ileum is then brought out as a stoma. More recently, the appendix embedded submucosally over the caecal pole has been used as the efferent channel.

Other ileocolic reservoirs

Several other ileocolic reservoirs have been used, but are mostly of historical importance and rarely performed. However, it is important for radiologists to be familiar with their surgical anatomy, since they are likely to encounter these patients in follow-up.

The Florida pouch uses the caecum, ascending colon, hepatic flexure, and the proximal transverse colon to form an inverted "U-shaped" reservoir. The distal ileum formed the afferent limb, with the doubly imbricated ileocaecal valve forming the continence mechanism. The Miami pouch uses a similar technique, except that the efferent ileal loop is tapered and reinforced with sutures close to the ileocaecal valve [8]. The tapered ileum is brought out through the umbilicus as a catheterizable stoma. In the Charleston pouch, the reservoir is created using the distal ileum, caecum, and the ascending colon up to the hepatic flexure. The appendix brought out through the umbilicus serves as the catheterizable efferent channel [4].

Other colic reservoirs

Mainz II (modified ureterosigmoidostomy or the sigma rectum pouch) procedure

In this procedure, the distal sigmoid colon and proximal rectum are detubularized by longitudinally incising the antimesenteric border. An inverted "V-shaped" low-pressure reservoir is created by folding over the detubularized segments and creating a side-to-side anastomosis (Fig. 3) [9]. Submucosal tunnel implantation of the distal ureters helps prevent fecal reflux and reduces the risk of pyelonephritis. The major advantage of the Mainz II procedure is that it enables continence through the natural anal sphincter and requires no stoma. In addition, the colonic continuity is maintained. However, these reservoirs carry risk of adenocarcinoma and are not frequently performed anymore.

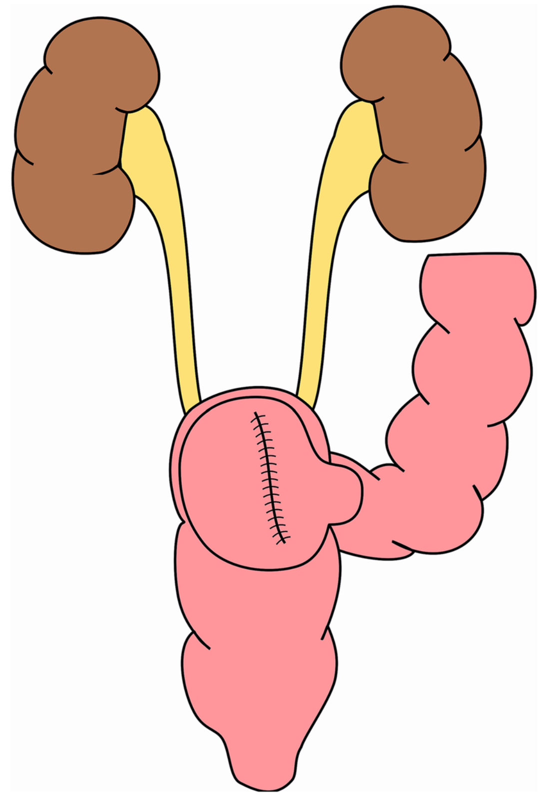

Fig. 3 The sigma rectum (Mainz II) pouch. The reservoir is created by detubularizing and refashioning the sigmoid colon, followed by anastomosing the ureters using an antireflux anastomosis. The bowel continuity is preserved

Mainz III pouch

This pouch is used in patients who have received pelvic irradiation, where the usage of ileocaecal or sigmoid segment is associated with higher incidence of leakage, ureteric stenosis, and poor healing. Here, a segment of colon around the hepatic or splenic flexure is used to create an inverted "U"-shaped pouch [10]. The proximal ureters are anastomosed to this pouch using a direct, refluxing technique. The tapered proximal end of the colon is used as the efferent channel which is brought out as a stoma after resecting the umbilicus.

Ileal reservoirs

The most commonly performed ileal reservoir is the Koch pouch. Here the distal 40 cm of the ileum is detubularized and refashioned to form a low-pressure spherical reservoir. The ureters are anastomosed to a short afferent ileal segment using an intussusception nipple valve which serves as the antireflux mechanism [8]. Another short ileal segment using an intussusception nipple valve as the continent mechanism serves as the efferent limb which is brought out as a stoma. However, the usage of nipple valve is more likely to result in complications like stenosis, prolapse of the ileal nipple and calculi.

To avoid the complications of the nipple valve, the T-pouch was created. Here, the distal 40 cm of the ileal segment is used to create a "V"-shaped pouch to which the remaining 10 cm ileal segment is tapered and anchored. This tapered segment serves as the afferent limb [11].

Ileal reservoirs carry increased risk of metabolic abnormalities as well as complications of malabsorption resulting from the isolation of a significant length of the ileum from the contiguous bowel [12].

Mitrofanoff technique (appendicovesicostomy)

This technique has been widely used since the 1980s in patients with refractory neurogenic bladder, idiopathic bladder dysfunction, outlet obstruction from severe urethral strictures, and as an adjunct to bladder augmentation in congenital urogenital abnormalities like extrophy and epispadias [13]. Here, the appendix along with its vessels is used as a continent channel connecting the bladder to a cutaneous stoma, usually at the umbilicus (Fig. 4). The appendix connected to the apex of the native or augmented bladder through a submucosal tunnel acts as a flap valve which collapses when the bladder distends, thereby providing continence.

In patients with neurogenic bladder, CISC of the appendicovesicostomy channel is a better alternative to continuous or recurrent urethral catheterization since the latter is associated with higher patient discomfort, technical difficulty of catheterization as well as complications like urethritis, urethral strictures, catheter blockage, and pericatheter leak.

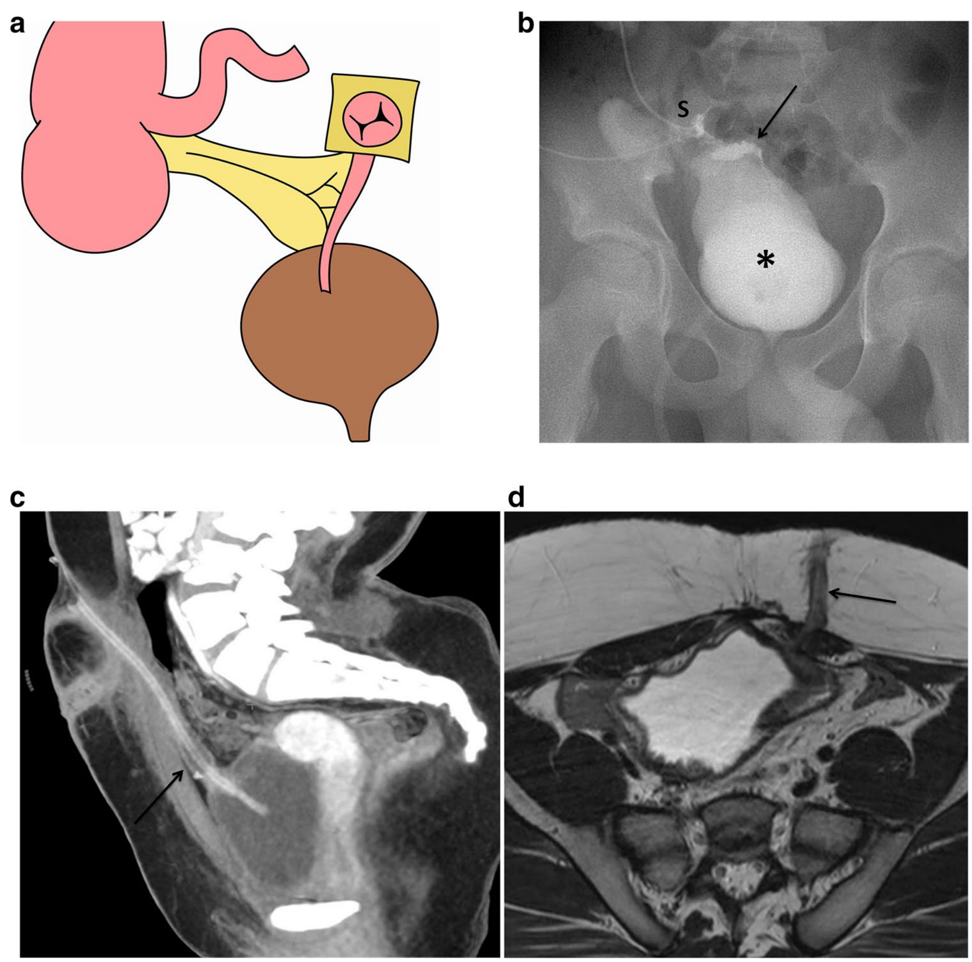

Fig. 4 The Mitrofanoff technique. **a** Pictorial representation of the surgical technique, where the appendix is used as a continent 'flap' valve connecting the bladder apex to the umbilical stoma. **b** Contrast study with the dye injected through the stoma. The appendix (*arrow*) is visualized as a narrow midline channel connecting the stoma (*S*) and the urinary bladder (*asterisk*). **c** Sagittal CECT and **d** axial T2-weighted MR images showing the appendix (*arrows*) tunneled through the abdominal wall. An infant feeding tube is seen within the appendix in **c**

In comparison to continent pouches, appendicovesicostomy avoids the need for intraperitoneal surgery and preserves bowel contiguity, thereby avoiding complications related to malabsorption. The main disadvantage is the higher risk of stomal stenosis [14].

Orthotopic neobladder

Orthotopic neobladders use fully detubularized ileal reservoirs which are anastomosed to the urethra. These neobladders enable per-urethral voiding and obviates the need for stoma. Voiding is achieved through the Valsalva manouver and relaxation of the external urethral sphincter. In a few cases, particularly females, CISC will ultimately be required for complete voiding. The two most popular types of orthotopic neobladder reconstruction are the Hautmann and Studer pouches. Orthotopic neobladders using the ileum are susceptible to complications of malabsorption similar to other ileal reservoirs.

Hautmann pouch

This large-capacity pouch is made using the distal 70 cm segment of the ileum, sparing a short segment immediately proximal to the ileocaecal valve. The ileal folds are arranged in a "W"-configuration and then detubularized using an incision along the antimesenteric border (Fig. 5). The flaps are then sutured together to form the low-pressure reservoir. Ureters are anastomosed to the non-detubularized segments of ileum at both ends of the neobladder using the reflux-permitting chimney technique. A small button of tissue is removed at the base of the neobladder and this area is then anastomosed to the urethra [5].

Studer pouch

This technique uses a 60 cm-long ileal segment, 20 cm proximal to the ileocaecal valve. The proximal end of this segment is rotated and brought over to the right iliac fossa. The distal 40 cm are then arranged in a "U"-configuration,

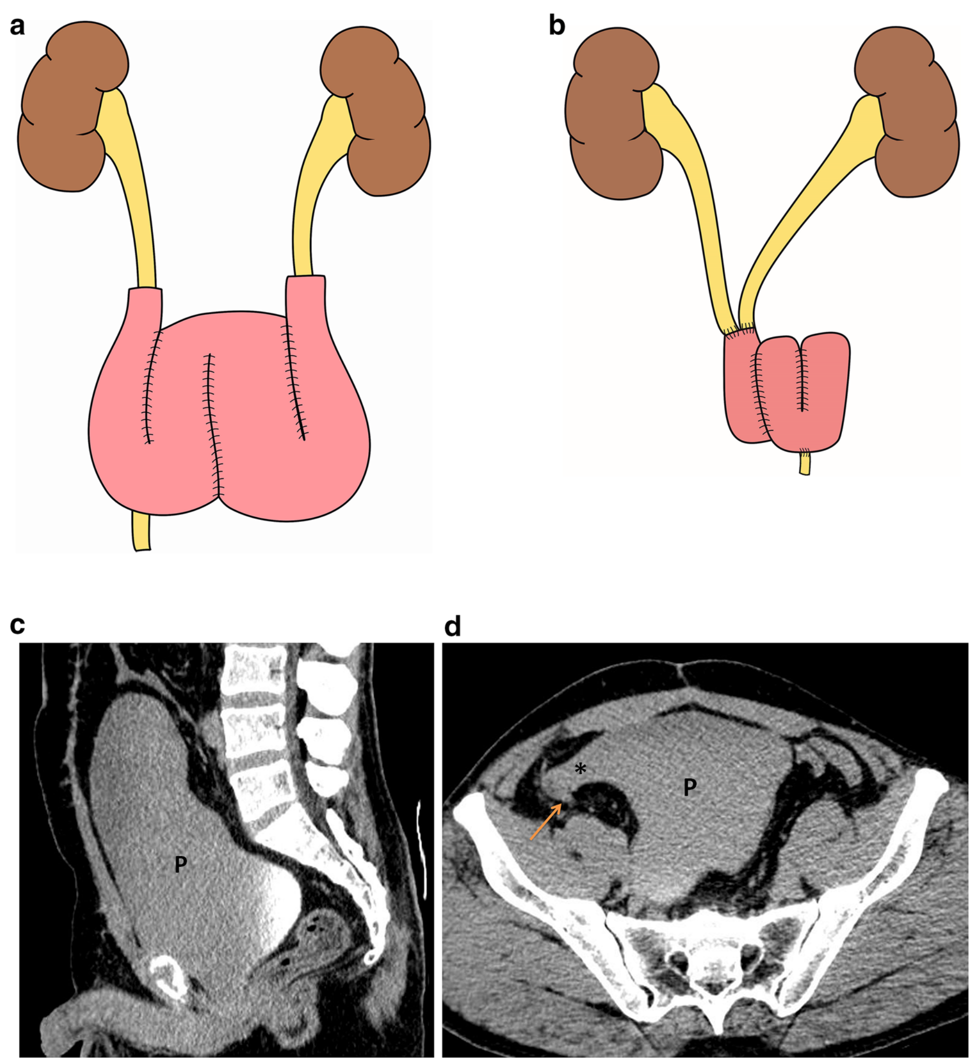

Fig. 5 **a** Pictorial representation of the Hautmann neobladder. The distal ileum is detubularized and fashioned in a "W" configuration to form the pouch. The ureters are anastomosed with the non-detubularized proximal and distal ileal limbs using a reflux-permitting chimney technique. Urethroneovesical anastomosis is performed. **b** The surgical anatomy of the Studer pouch. The distal ileum is partly detubularized to form the pouch and the proximal non-detubularized limb is used as the isoperistaltic loop to which the ureters are anastomosed. **c** Sagittal and **d** axial CECT images in the excretory phase showing the Hautmann neobladder. The right ureter (*arrow*) is seen anastomosed to the non-detubularized distal ileal limb (*asterisk*) of the capacious pouch (*P*)

detubularized and sutured together to form the neobladder [5]. The proximal 20 cm is left unaltered and forms the isoperistaltic loop into which the ureters are anastomosed (Fig. 5b). As with the Hautmann pouch, a small button of tissue is resected form the base of the neobladder and ileourethral anastomosis is performed.

Imaging protocol

After creation of urinary diversion, imaging is usually performed frequently to look for complications related either to surgical factors or to screen for oncologic recurrence. In all uncomplicated diversions, a loopogram or pouchogram is usually performed at 3–4 weeks to look for any leak prior to removal of the in situ draining catheter [6]. Subsequently, the frequency of follow-up imaging generally depends on the preferences of the referring urologist [15]. A reasonable imaging protocol would be a six-monthly CT or MRI for the first 2 years, followed by yearly once thereafter [16]. It is important to tailor the imaging and contrast administration protocol to suit the complication that is to be looked for. Surgical factors of concern in the immediate postoperative period include anastomotic site leaks and associated collections. Loopogram or pouchogram under fluoroscopic guidance are the most commonly performed procedures for assessing leak. After a scout radiograph is performed to look for calculi, staples, or other high density objects that may mimic a contrast leak, the stoma is catheterized using an appropriate-sized Foley's catheter and water-soluble contrast agent is injected to demonstrate the efferent loop and the pouch. Approximately 100–300 mL of diluted water-soluble contrast agent (1:4 dilution in saline) is injected using gravity-aided drip infusion technique or with low-pressure hand injection. Standard projections (anteroposterior, lateral, and bilateral oblique) are performed along with additional ones to look for areas of concern (ureterointestinal anastomosis and staple lines) [17]. Post-evacuation radiographs are used to look for residual contrast and subtle leaks. Cross-sectional modalities like CT or MRI are more sensitive in picking up subtle leaks and also help in looking for associated collections. CT performed with contrast injected into the loop and pouch usually suffices when leak and collections are to be looked for. MRI can be performed without intravenous contrast and is better than CT for assessing collections [18]. It is free from radiation and is preferred in children, patients undergoing frequent follow-up and in those with renal failure where intravenous contrast administration is to be avoided. However, MRI may miss small leaks since they may not open up without the generation of positive pressure as with contrast loopogram and pouchogram.

For assessing delayed surgical complications—strictures and parastomal herniation, cross-sectional imaging is performed. Strictures can occur at the ureteric anastomosis, within the pouch or at the stoma. Strictures of the ureteric anastomosis are best assessed in the delayed (excretory or urographic) phase after intravenous contrast administration. Usage of dual-energy CT (obviates the need for unenhanced CT) and split-bolus technique (combines nephrographic and excretory phases) reduces the radiation exposure [19]. Strictures can be partial or complete depending on the amount of contrast which passes across the ureter and hence it is better not to perform a concurrent CT loopogram when ureteric strictures are to be looked at. Intravenous urogram (IVU) may also be used to assess strictures and is particularly helpful in cases where the lower ureter is not well distended on CT due to peristalsis. However, when using IVU for patients post-diversion, abdominal compression should not be applied.

When parastomal herniation is suspected, CT has to be performed with intravenous as well as per-oral contrast administration unless the patient has acute intestinal obstruction or contraindications to contrast injection. This helps in assessing bowel viability, the level of obstruction and in differentiating the pouch and efferent loop from the bowel loops.

For assessing oncologic recurrence, a CT urography needs to be done with intravenous contrast. In patients with contraindications to contrast administration, non-contrast MRI would be appropriate. The excretory system has to be carefully evaluated in the urographic phase on CT or the T2-weighted, diffusion-weighted and post-contrast images on the MRI to look for other synchronous tumors. An assessment for lymph node or distal metastasis also needs to be done.

Imaging anatomy of uncomplicated urinary diversions

On imaging, the ileal conduit is seen as an isoperistaltic loop with the ureters anastomosed to the proximal end. Since the stoma is often placed in the right iliac fossa, the left ureter crosses the midline prior to the anastomosis. The conduit should be of uniform caliber without any focal narrowing. Since no antireflux mechanism is incorporated, it is common to see ureteric reflux and mild hydronephrosis in loopograms when contrast is injected into the conduit, generating a positive pressure. Reflux is also seen in the excretory phase of IVU and CECT since contrast-induced diuresis overwhelms the emptying capacity of the isoperistaltic loop. However, in physiologic conditions, the reflux is much lesser and stable renal function has been reported [3]. Fluoroscopy may be used to demonstrate peristalsis within the ileal segment.

In cases of continent cutaneous diversions using a pouch, the latter can be appreciated as an intraabdominal cystic structure on imaging (pouchogram or CT). The pouch is located in the right lower quadrant in case of ileocolic reservoirs, left lower quadrant in Mainz II pouch and lower central abdomen for the ileal reservoirs. Mainz III pouches are located in the subhepatic space or left hypochondrium depending on whether the ascending or descending colon has been used along with the transverse colon for the pouch creation. Residual haustrations from the parent colon are seen with colonic pouches and folds in case of ileal reservoirs; however, both tend to be less prominent with time as the pouch matures. Blood clots may be apparent in the immediate postoperative period and move with changing patient position. Air foci from catheterization as well as hypodense contents consistent with inspissated mucous secretions may be appreciated on CT. The efferent limb as well as the ureteric insertions can be appreciated depending on the technique used. In cases of ileocolic reservoirs, the left ureter crosses the midline to reach the pouch and needs to be carefully assessed for strictures. In pouches using an intussuscepted nipple valve in the afferent or efferent limb (e.g., Koch and Mainz I pouches), the valve is seen as a filling defect in the pouchogram images [16]. Small amount of reflux and mild hydronephrosis are often seen with fluoroscopic or CT pouchogram when contrast is injected with positive pressure. Aberrant 'waist'-like constriction of the pouch, calculi or enhancing masses, anastomotic site leakages, and moderate to marked hydronephrosis are always abnormal.

In the Mitrofanoff technique, the appendix is visualized as a tubular channel arising from the bladder apex and ending at the umbilical stoma. Air may be seen within the bladder from recurrent catheterization. Neobladders are seen as round structures similar to the urinary bladder; however, the former may show residual folds in the pouchogram images, and has afferent and efferent limbs connected to it. Both the ureteric and urethral anastomotic sites need to be carefully analyzed for leak and strictures.

Imaging of surgical complications following urinary diversion

Urinary diversions can be associated with several surgical complications of relevance to the radiologist. These complications can be early (occurring within 30 days) or delayed (occurring after 30 days) [17]. The early complications include anastomotic leaks, collections, and small bowel obstruction. The delayed complications include delayed-onset collections, anastomotic strictures, reservoir calculi, parastomal herniation, small bowel obstruction, and disease recurrence.

Leaks and collections

Leaks are relatively common complications, occurring in about 5% of the patients undergoing diversions. They result from dehiscence of a suture or staple line, usually at the ureterointestinal anastomosis, but can also occur at the rear end of the ileal conduit, wall of the reservoir and at urethroneovesical anastomosis [20]. The usual mechanism is suboptimal anastomosis or secondary dehiscence at the ureteric anastomosis from tension, ischemia, or post-radiotherapy tissue necrosis. Hence it is important to preserve the periureteric soft tissue cuff and vascularity at the time of tunneling. The left ureter is more predisposed since it has to cross over the midline and travel a greater distance prior to the anastomosis, with a greater likelihood of tension and vascular compromise. Leaks clinically manifest as increased output through the incision site or the drain. Neglected leaks may later lead to periureteric fibrosis and stricture formation. Persistent leaks may organize to form fistulas or urinomas.

On fluoroscopic and CT loopogram or pouchogram, leaks manifest as irregular, persistent extravasation of the contrast showing progressively increasing density with time, usually at the anastomotic sites (Fig. 6). Cautious interpretation is required as subtle leaks draining into large urinomas gets diluted, making them difficult to pick up. When the clinical suspicion is high despite a negative fluoroscopic study or sometimes as an upfront procedure, a CT cystogram is performed with injection of contrast into the lumen or pouch. CT has a higher sensitivity in picking up subtle leaks and helps assess the extent of any associated collection. Usually an unenhanced CT suffices, but sometimes intravenous contrast administration helps by demonstrating the defect within the ureteric or bowel wall. Oral contrast should not be administered since it may obscure the leak. Delayed (excretory) phase imaging should not be ideally used since this doesn't generate positive pressure within the loop unlike percutaneous contrast injections, and small leaks may be missed. Non-contrast MRI (heavily T2-weighted images) is also useful in demonstrating leaks without the use of contrast agents, but is less sensitive than CT pouchogram.

Urinomas are contained collections of leaked out urine occurring around the anastomotic sites. Uncomplicated urinomas are seen as fluid-attenuating collections on CT without perceptible wall and are highly bright on T2-weighted images. The causative leak may or may not be demonstrable on the contrast study and if present, helps to confirm the diagnosis. Even when a leak is not readily apparent, an increase in the density of the collection seen between two temporally-spaced scans during a CT pouchogram suggests the diagnosis. High creatinine level within the aspirated fluid also confirms the collection as an urinoma.

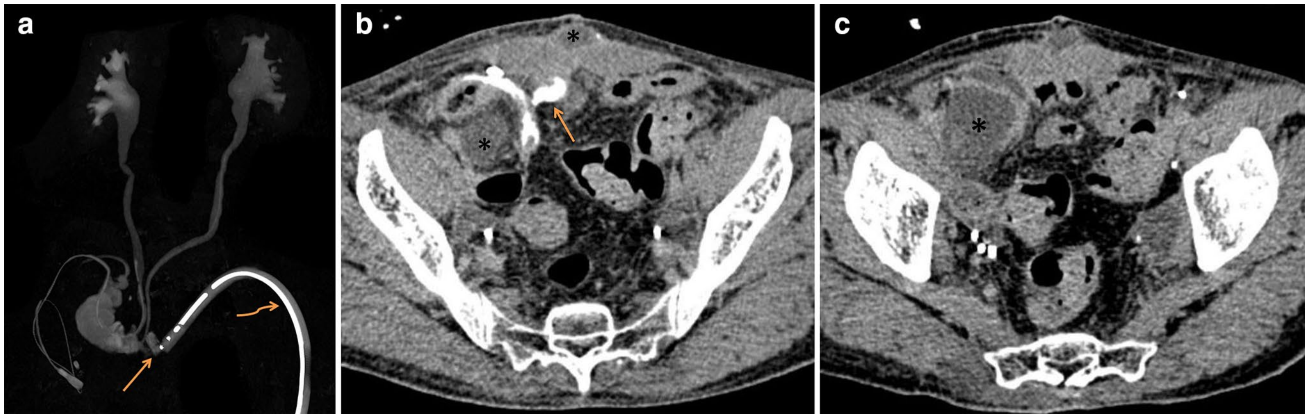

Fig. 6 Case of ileal conduit diversion complicated by ureteroileal anastomotic site leak in the immediate postoperative period. **a** Coronal maximum intensity projection images of CECT in the excretory phase, showing leakage of contrast (*arrow*) at the ureteroileal anastomosis. The contrast is also seen filling the drainage tube (*curved arrow*). **b** and **c** Axial images showing the site of contrast leakage (*arrow*) as well as the secondary collections (*asterisk*)

Lymphoceles are another group of collections which are seen adjacent to surgical clips, show fluid attenuation and have an imperceptible wall. They arise from contained leakage of lymphatic fluid in patients undergoing lymphadenectomy. Unlike urinomas, these do not show associated leakage of contrast. Hematomas may be seen in the immediate postoperative period and are difficult to miss since they are hyperdense on the unenhanced CT with a heterogeneous or laminated pattern due to layering of clots. Surrounding fat stranding is frequently seen. Multiphase CT may be required if underlying active bleed or pseudoaneurysm is suspected. On MRI, the signal intensities vary depending on the phase; however, presence of T1-hyperintensity (in subacute clots), susceptibility artifacts (on gradient-echo images), and fallacious diffusion restriction are valuable clues.

Abscesses can form in the early postoperative period from primary contamination or in the late phase from secondary infection of a urinoma or hematoma. They have a typical clinical presentation and on imaging show enhancing rim with surrounding fat streakiness and inflammatory changes. Strong diffusion restriction within the collection is also a useful adjunct feature. Pockets of air suggest infection with gas-forming bacteria (either gram-negative bacilli or anaerobes) as long as any percutaneous intervention or bowel communication is excluded as the cause.

Small bowel obstruction

Small bowel obstruction may be seen in the acute or late postoperative period, the most common cause being paralytic (adynamic) ileus secondary to the surgery itself or from the electrolyte abnormalities associated with chronic diversion. Here the radiographs show dilated small as well as large bowel, and there is hypoperistalsis on ultrasound and fluoroscopy [6]. The causes of mechanical small bowel obstruction include adhesions, strictures (usually at the site of enteroenteric anastomosis), hernias (parastomal or internal) and bowel ischemia. The diagnosis may be made clinically with or without the help of radiographs, however contrast-enhanced CT is usually required in identifying the transition point, cause and severity of obstruction as well as the presence of strangulation since these features guide management. Marked collapse (> 50% reduction in the luminal diameter) of the bowel at the transition point with severely impaired flow of contrast across even in the delayed scans (24 h) suggest high-grade mechanical obstruction and necessitates surgery [21]. The presence of strangulation (vascular compromise) as indicated by wall thickening and high attenuation (due to hemorrhage), absence of enhancement, pneumatosis of the bowel wall or portal vein also necessitate surgery to prevent fatal peritonitis. The cause also has to be looked for at the level of the transition point. Adhesive bands, the most common cause, are not visualized on CT and hence are diagnosis of exclusion when no definite pathology (herniation, wall thickening, or mass) is seen at the transition point. Sometimes acute angulation at the transition site may provide a valuable additional clue.

Strictures

Strictures are late complications which carry significant morbidity with the potential for permanent renal damage. Ureteric obstruction occurs in about 10% and may be benign or malignant, the former occurring most commonly at the ureterointestinal anastomotic site [20]. Majority of the benign strictures occur within 1 year of surgery and result from either ureteric ischemia or injury at the time of surgical mobilization or from healing and fibrosis of a leak. The left ureter is more predisposed since it has a longer course before anastomosis and is prone to tension and ischemia at the anastomotic site. Strictures are more common with antireflux anastomosis. Sometimes, stenosis of left mid-ureter is seen in patients with ileocolic pouch diversions when the left ureter is brought across the midline below the level of the origin of the inferior mesenteric artery (IMA). This phenomenon, called the "nutcracker ureter syndrome", results from compression of the ureter between the IMA and the aorta [7].

Strictures are usually unilateral, clinically occult and picked up on follow-up imaging. On CECT or MRI, they are seen as dilatation of the pelvicalyceal system and ureters till the anastomotic site (Fig. 7). It is important to perform a contrast-enhanced CT or MRI the first time a stricture is being evaluated. Benign strictures may show mild symmetric wall thickening at the anastomotic site. Malignant strictures manifest as nodular, asymmetric thickening or as polypoidal

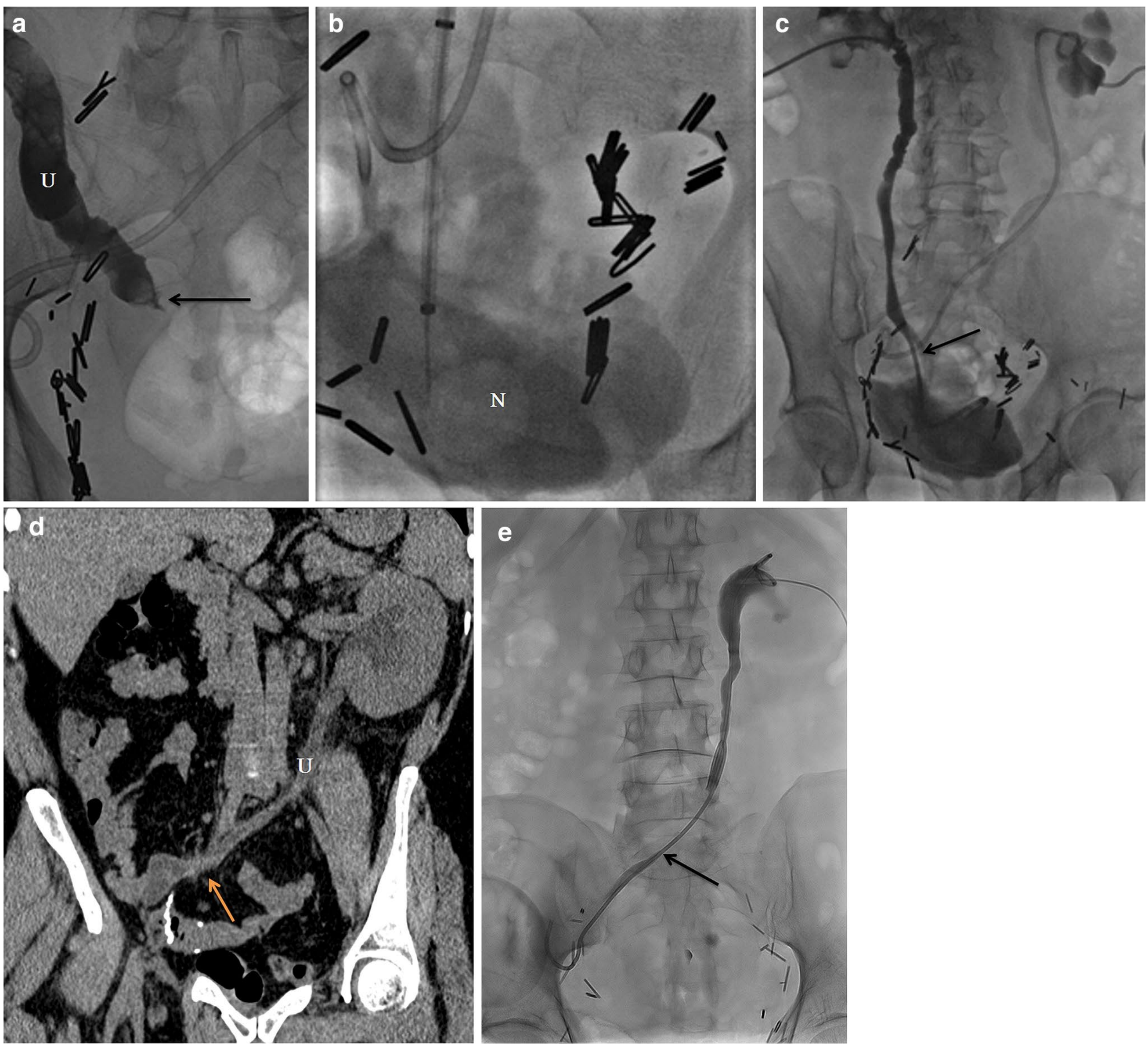

Fig. 7 **a–c** A case of ureteroneovesical anastomotic site stricture following neobladder diversion. **a** Nephrostogram showing a dilated right ureter (*U*) with abrupt tapering at the anastomotic site (*arrow*) and no distal passage of contrast, suggestive of a tight (complete) stricture. **b** A sharp needle is used to negotiate the stricture and the neobladder (*N*) could be delineated on subsequent contrast injection. **c** A nephroureteral stent (*arrow*) is placed across the stricture. **d** and **e** A case of ureteroileal anastomotic site stricture which occurred after ileal conduit diversion. **d** CECT, coronal curved reformat image, showing the left ureter (*U*) which is dilated till the anastomotic site (*arrow*). **e** A double-J stent (*arrow*) was placed after negotiating the stricture using a soft hydrophilic guidewire

lesions showing enhancement. Diffusion restriction on MRI is also a differentiating feature. Strictures may be complicated by secondary pyoureteronephrosis which is suspected in the appropriate clinical setting when USG shows dense echoes or debris and when urothelial enhancement is seen on CT. In patients with a reflux-permitting anastomosis, an important differential is hydronephrosis secondary to ureteric reflux. However, this can be confirmed on a loopogram or pouchogram. Strictures are often managed with stent placement; however, stent occlusion is a common complication. Balloon dilatation is another option but is associated with high risk of recurrence.

Strictures may also occur within the pouch or at the stoma site (stoma stenosis). Pouch strictures are seen as waist-like contractions, usually along the staple lines. In the sigma rectum pouch, any stricture should be evaluated further with endoscopy since these pouches are highly predisposed to adenocarcinoma. Although stoma stenosis is readily apparent clinically, a pouchogram or loopogram may help delineate the internal extent of the stricture. It is best assessed in the lateral decubitus position with the stoma and loop in profile, where any loop dilatation is easily picked up [19]. Post-evacuation images are also helpful in looking for residual contrast in the loop.

Urolithiasis

Both upper tract and reservoir calculi are common delayed-onset complications seen with all types of diversion, but much more commonly in stapled continent diversions than conduits [22]. These are multifactorial in origin and result from stasis, low-grade infection of the reservoir, exposed staple lines as well as the metabolic complications (hypercalciuria, oxaluria) secondary to diversion. Calculi are easily evaluated with unenhanced CT or CT urogram. The location, number, morphology as well Hounsfield attenuation of the calculi should be evaluated since these may influence the management (lithotripsy vs. nephrolithotomy).

Parastomal and incisional hernias

Parastomal hernias are common complications, seen in up to 50% of patients within 2 years of surgery [20]. They are particularly common in obese patients and ileal conduits, where small or large bowel loops along with mesentery herniate through the abdominal wall defect alongside the stoma (Fig. 8). These hernias are often painless and present as a bulge at the stoma site; however, sometimes acute intestinal obstruction may occur.

Management becomes necessary only in acute obstruction or if the patient complains of chronic pain affecting the quality of life. On imaging, the size of defect, contents of the hernia as well as presence of any complications should be assessed. Like in all other surgeries, ventral incisional hernias are also common after diversion and more common in neobladders where the patients are required to strain for micturition.

Oncologic recurrence

Patients with operated cancer of the urinary bladder are at risk of local recurrence (5–15%) or metachronous upper tract urothelial cancers (2–6%) [23]. Upper tract recurrence is

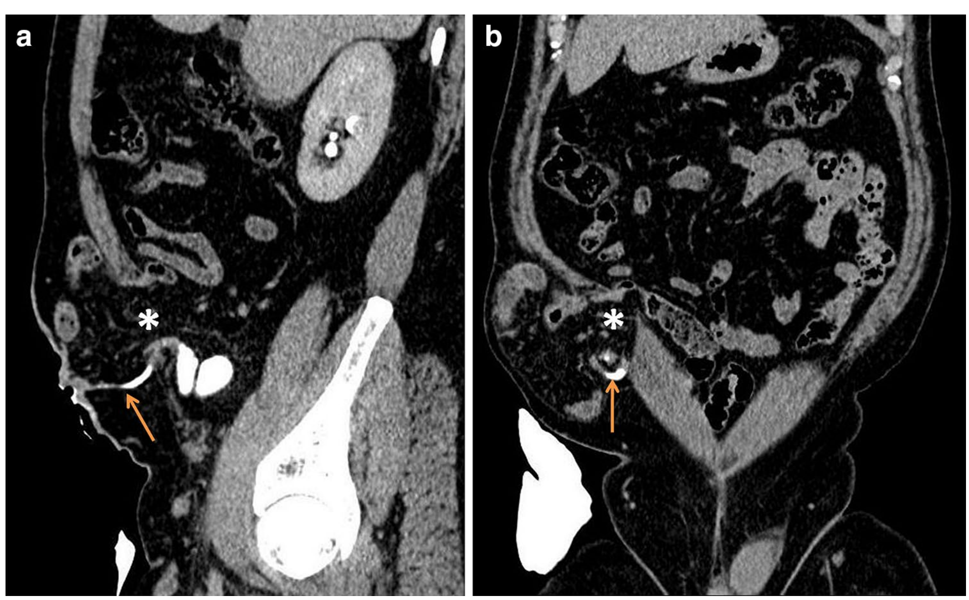

Fig. 8 Case of parastomal hernia after ileal conduit diversion. **a** Sagittal and **b** coronal excretory phase CECT images show a large abdominal wall defect (*asterisk*) at the stoma site with herniation of bowel loops and omentum through it. The ileal conduit can be appreciated as a contrast-filled tubular channel (*arrow*) within the hernia

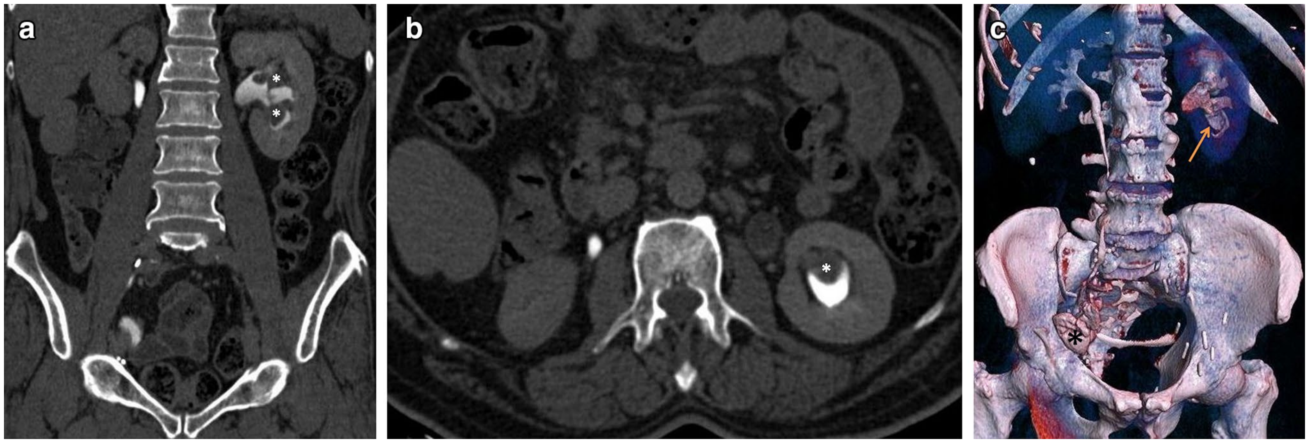

Fig. 9 Case of upper tract recurrence in a patient who underwent ileal conduit diversion following radical cystectomy for muscle-invasive urothelial carcinoma of urinary bladder. **a** Coronal and **b** axial CECT images in the excretory phase showing multiple non-dependant polypoidal filling defects (*asterisk*) within the left-sided interpolar and lower polar calyces. **c** Volume-rendered image showing the filling defects (*arrow*) in left side collecting system. The conduit (*asterisk*) is also appreciable

more common in patients with ureteral involvement at initial presentation and occurs from field cancerization which predisposes the entire urothelium to malignant transformation. Most recurrences occur within the first 2 years and it is important to perform regular follow-up imaging as well as urine cytology to pick up early recurrence. On imaging, local recurrence presents as a new enhancing pelvic nodule or mass. In case of neobladders, it usually occurs at the urethroneovesical anastomosis, where it presents as outlet obstruction. Upper tract metachronous tumors can be picked up on CT urogram as new strictures, wall thickening with enhancement or polypoidal lesions which are seen as filling defects in the excretory phase images (Fig. 9). MRI is more sensitive in assessing subtle lesions in view of the higher soft tissue-contrast and also adds the additional dimension of diffusion-weighted imaging. PET–CT is the most sensitive modality in picking up recurrence as well as nodal and distant metastasis.

Malignancy (adenocarcinoma) can also occur within the reservoir, with sigma rectum pouches (Mainz II) being the most susceptible [24]. Hence, these patients should undergo regular screening sigmoidoscopy [25]. On imaging, the pouch needs to be carefully assessed for the presence of any intraluminal growth. Pouch adenocarcinomas are seen as nodular asymmetric wall thickening, napkin-ring like constrictions (strictures), or irregular polypoidal lesions. Surface ulceration is frequent in all forms, and is best demonstrated on a pouchogram.

Conclusion

Urinary diversions are performed frequently in tertiary care set-ups, mainly after radical cystectomy for urinary bladder carcinoma. Many different types of surgeries have been devised, which can be broadly classified as continent and incontinent diversions. With increasing experience gained in managing patients post-diversions, a large number of complications have also been recognized. Many of these complications are clinically occult and may be picked up for the first time on imaging. Hence, it is important for the radiologists to be familiar with the surgical as well as the imaging anatomy of diversions and pick up abnormalities even when they are subtle. Each time, a high index of suspicion must be kept and the genitourinary as well as gastrointestinal tract needs to be thoroughly evaluated for any potential abnormalities.

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