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PICTORIAL ESSAY

Multidetector CT of expected findings and complications after contemporary inguinal hernia repair surgery

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ABSTRACT

Inguinal hernia repair (IHR) with prosthetic mesh implantation is the most common procedure in general surgery, and may be performed using either an open or laparoscopic approach. This paper provides an overview of contemporary tension-free IHR techniques and materials, and illustrates the expected postoperative imaging findings and iatrogenic injuries. Emphasis is placed on multidetector CT, which represents the ideal modality to comprehensively visualize the operated groin region and deeper intra-abdominal structures. CT consistently depicts seroma, mesh infections, hemorrhages, bowel complications and urinary bladder injuries, and thus generally provides a consistent basis for therapeutic choice. Since radiologists are increasingly requested to investigate suspected iatrogenic complications, this paper aims to provide an increased familiarity with early CT studies after IHR, including complications and normal postoperative appearances such as focal pseudolesions, in order to avoid misinterpretation and inappropriate management.

Arguably the most frequent general surgery procedure, inguinal hernia repair (IHR) reaches an annual rate of approximately 200 operations per 100.000 people/years. Since the introduction of the open-mesh IHR by Lichtenstein in 1989, tension-free hernioplasty with prosthetic mesh (PM) implantation became the standard of care and decreased the likelihood of recurrence by approximately 50%. Furthermore, the increasing use of laparoscopy in IHR allows faster recovery, decreased postoperative pain, lower risk of postoperative seroma, wound infection and hemorrhage, lower incidence of chronic pain and long-term hernia recurrence—at the price of longer operative time and higher risk of rare yet serious visceral injuries (1–5).

Since most general hospitals perform hundreds of IHR procedures each year, radiologists are increasingly requested to investigate suspected iatrogenic complications (6, 7).

Some authors recommend ultrasonography (US) as a helpful first-line modality to assess the operated groin, which allows rapid and confident detection of anechoic fluid seromas abutting the PM. However, US is often hampered by obesity, thickened subcutaneous fat, medications, and local tenderness at the surgical wound. Furthermore, hypo-anechoic or septated collections corresponding to hematomas or abscesses are sonographically challenging to interpret (7, 8).

During the last decade, some focused radiologic reports described the expected postsurgical computed tomography (CT) appearances after PM-IHR, particularly the characteristic pseudolesions which are discussed in-depth in a dedicated section of this paper (6, 9). Conversely, very limited literature exists on cross-sectional imaging of iatrogenic complications, mostly including a 2004 review based on axial CT (10) and a recent paper generally devoted to imaging complications related to laparoscopic access (11).

This paper provides an overview of contemporary IHR, reviews and illustrates the expected postoperative imaging appearances and iatrogenic injuries with emphasis on multidetector CT findings.

Overview of surgical techniques

As recent studies estimated a very low (<1%) risk of incarceration, a reducible inguinal hernia is not an indication for surgery unless the patient complains of pain or discomfort.

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Still popular particularly for large or recurrent hernias, the classical open Lichtenstein IHR involves multiple steps: surgical incision to access the external inguinal ring, mobilization of the spermatic cord and opening of its coverings, hernia sac exposure and isolation from nerves, sac opening and repositioning of its contents in the abdominal cavity, sac resection, peritoneal suture, placement of the PM to cover the defect at the posterior aspect of the inguinal canal, and finally PM anchoring to the inguinal ligament and oblique abdominal muscle (1–5, 12).

Opposed to a single cut, laparoscopic IHR involves creation of three or four small incisions and is preferred over open IHR in bilateral inguinal hernias and recurrences after open surgery. For primary unilateral inguinal hernias, the choice between open and laparoscopic IHR relies on surgeon's expertise and patient preference. The two standardized techniques, namely the trans-abdominal preperitoneal (TAPP) and totally extraperitoneal (TEP), are both considered safe surgeries with similar reliable long-term results, and limited contraindications such as anesthesiologic risk, obesity, large hernias, pregnancy, history of pelvic operations, previous failed laparoscopy (1–5). Specifically, TAPP involves laparoscopic access to the peritoneal cavity, incision of the peritoneum under direct vision to create a peritoneal flap, hernia sac removal, PM positioning behind the serosa, and suture of the peritoneum to limit the risk of adhesion formation. Conversely, TEP surgery is extraperitoneal and therefore the risk of visceral injury is practically absent: after direct entry and insufflation of the preperitoneal space, the surgeon exposes the hernia sac, reposi-

Main points

- Inguinal hernia repair currently represents the most common procedure in general surgery and relies on prosthetic mesh implantation.
- Multidetector CT provides a comprehensive assessment of the operated groin and postoperative complications after mesh inguinal hernioplasty such as infection, hemorrhage, bowel obstruction, intestinal and bladder injury.
- Familiarity with expected CT appearances including focal pseudolesions and seroma is warranted during interpretation of early postoperative studies.

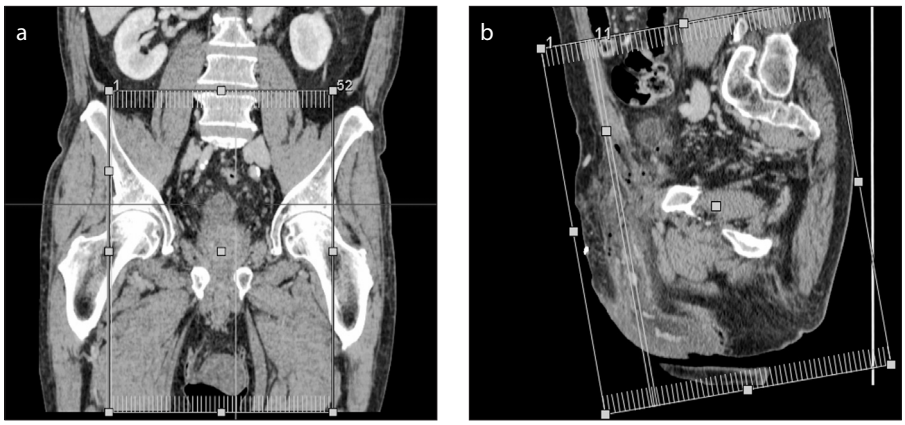

Figure 1. a, b. Example of dedicated multiplanar CT reconstruction technique at the workstation. Following initial study review on native thin-section axial images, contrast-enhanced multidetector CT acquisition (same patient as in Fig. 5) is completed by reconstruction of contiguous 4 mm thick average-intensity sagittal images between the lateral acetabular margins **(a)** and of oblique images of similar thickness, tilted approximately 10°–15° from the coronal plane along the longitudinal axis of the extra-inguinal spermatic cord **(b)**.

Table. Differential diagnosis of focal pseudolesions after inguinal hernioplasty

Entity	Features
Focal postsurgical pseudolesion (FPL)	Well-demarcated contour. Round, ring, or ovoid shaped Mean size 2.5–3 cm Usual appearance: moderately thick peripheral solid ring, partly adipose center Typical site: abutting the internal inguinal ring Fat plane interposed between FPL and colon or external iliac vessels
Postoperative seroma	Usually demarcated. Thin or absent wall Homogeneous fluid attenuation Possible thin peripheral enhancement in early phases
Postoperative hematoma	Clinically: tender ecchymosis, blood loss Localized (sometimes mass-forming) or elongated collection Characteristic hyperattenuation (30–80 Hounsfield Units) of fresh blood, depending on age of bleeding; possible fluid-blood level Occasional: contrast extravasation indicating active bleeding
Abscess	Clinically: tenderness, cutaneous inflammation, fever, leukocytosis, elevated acute phase reactants More or less homogeneous hypoattenuating collection Peripheral more or less thick enhancing ring Inflammatory changes of the surrounding fat planes
Lymphadenopathy	Clinically: neoplastic history Demarcated ovoid or roundish masses Homogeneous solid attenuation (except for necrotic forms) Closely adjacent to iliac vessels
Epiploic appendagitis	Clinically: acute lower abdominal pain Most commonly left-sided, abutting the sigmoid colon wall Ovoid lesion measuring 1.5–3.5 cm Internal fat attenuation, thin peripheral ring Surrounding inflammatory changes, thickened adjacent parietal peritoneum
Acute omental infarction	Clinically: acute lower abdominal pain Typical location: right lower quadrant, nearby transverse or right colon Well-demarcated, solitary, often fairly large lesion Fatty attenuation, absent contrast enhancement Heterogeneity with "whorled" pattern of concentric linear fat stranding Absent peripheral hyperattenuating ring

Table was adapted from reference 15.

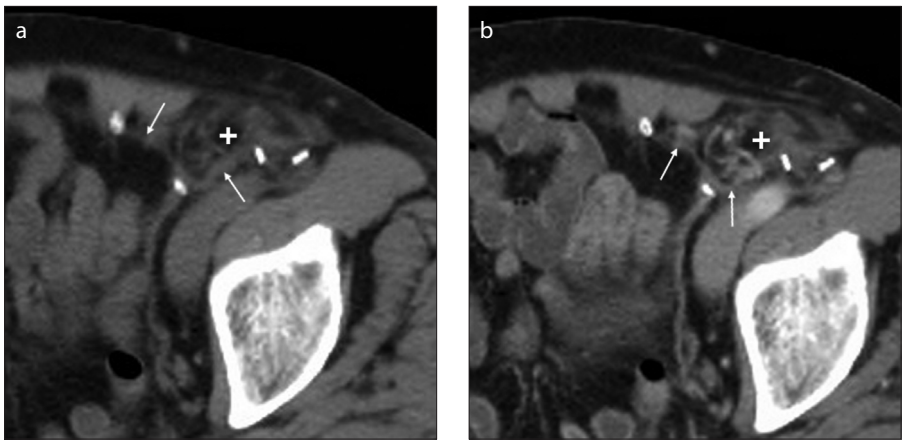

Figure 2. a, b. Expected CT findings after inguinal hernia repair (IHR). Axial unenhanced **(a)** and contrast-enhanced **(b)** multidetector CT images a few days after open left IHR in a 77-year-old male show the isoattenuating-to-muscle prosthetic mesh (PM, *thin arrows*) at the internal inguinal ring, with metallic clips at its fixation sites. Note postsurgical edematous stranding of the fat *(plus sign)* at the site of operation.

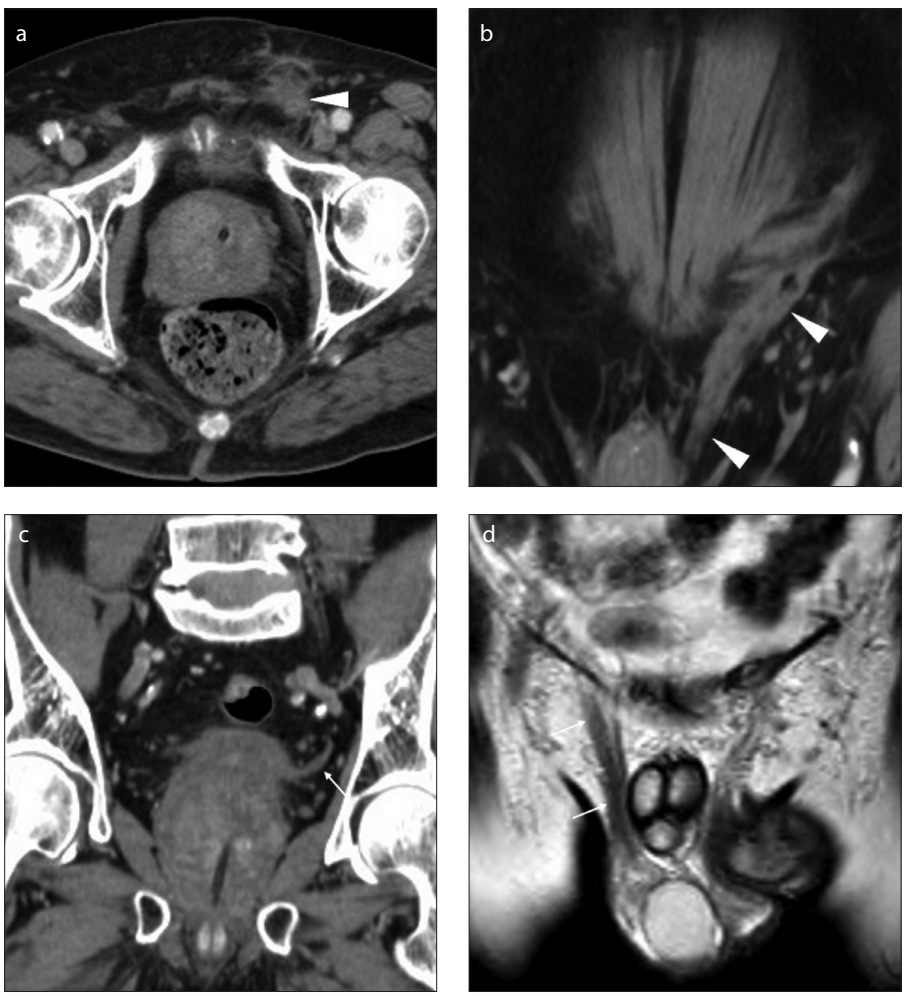

Figure 3. a–d. Expected postoperative appearance of the spermatic cord in a 90-year-old male nine days after open left IHR. Axial **(a)** and oblique-coronal **(b)** contrast-enhanced CT images show uniform, moderate (1 cm) thickening along the extra-inguinal spermatic cord *(arrowheads)* consistent with uncomplicated postoperative appearance, which resolved at follow-up CT **(c)**. Compared with the contralateral side the ipsilateral pelvic vas deferens (*thin arrow* in **c**) remained minimally thickened (5 mm). In a 62-year-old male, coronal T2-weighted MRI image **(d)** show low-signal intensity thickening of the right extrainguinal spermatic cord *(thin arrows)* ipsilateral to previous uncomplicated IHR performed sixteen months earlier. This stabilized finding remained appreciable in subsequent CT follow-up studies (not shown).

tions the hernia contents in the abdominal cavity, and introduces the PM through the hernia opening (13, 14).

Postoperative imaging after inguinal hernioplasty

Role of imaging techniques

Following open and laparoscopic IHR, the vast majority of patients experience an uneventful postoperative course. However, iatrogenic injuries occasionally occur, particularly in patients over 65 years of age, with diabetes, obesity, cigarette smoking, elevated anesthesiologic risk scores (1–5). Patients commonly complain of pain, sensory disturbances after open and, less frequently, laparoscopic IHR. Furthermore, a more or less tender groin swelling develops in up to 40% of cases, most usually because of impaired venous flow and tissue edema, but generally resolves over time. Since nonspecific local symptoms and physical findings may sometimes herald postoperative complications, imaging may provide useful additional information.

Multidetector CT outperforms US in PM visualization, provides a comprehensive visualization of normal structures and postoperative abnormalities involving the inguinal canal and spermatic cord. Generally limited from the umbilicus to the scrotum, the region to be scanned should be extended to encompass the entire abdomen when concern for peritonitis or bowel obstruction exists. A preliminary unenhanced acquisition is usually beneficial to identify fluid, purulent, or bloody collections, but could be omitted to reduce the exposed radiation dose in young patients. The acquisition parameters on our 64-slice CT scanner include 120 KV, 300 mAs, 0.891 pitch, 0.75 s rotation time, and 64×0.625 mm collimation. In most patients we recommend a portal-venous phase acquisition with a 70 s scan delay after intravenous injection of 110–130 mL of nonionic iodinated contrast medium (such as 350 mgI/mL iomeprol or 370 mgI/mL iopromide) using automated power injection at a 2.5–3 mL/s flow rate. When bleeding is suspected, an additional arterial-dominant acquisition (using a bolus-tracking technique with the region of interest placed in the abdominal aorta) is warranted to identify active hemorrhage. In addition to reviewing native axial images, we recommend routine reconstruction of

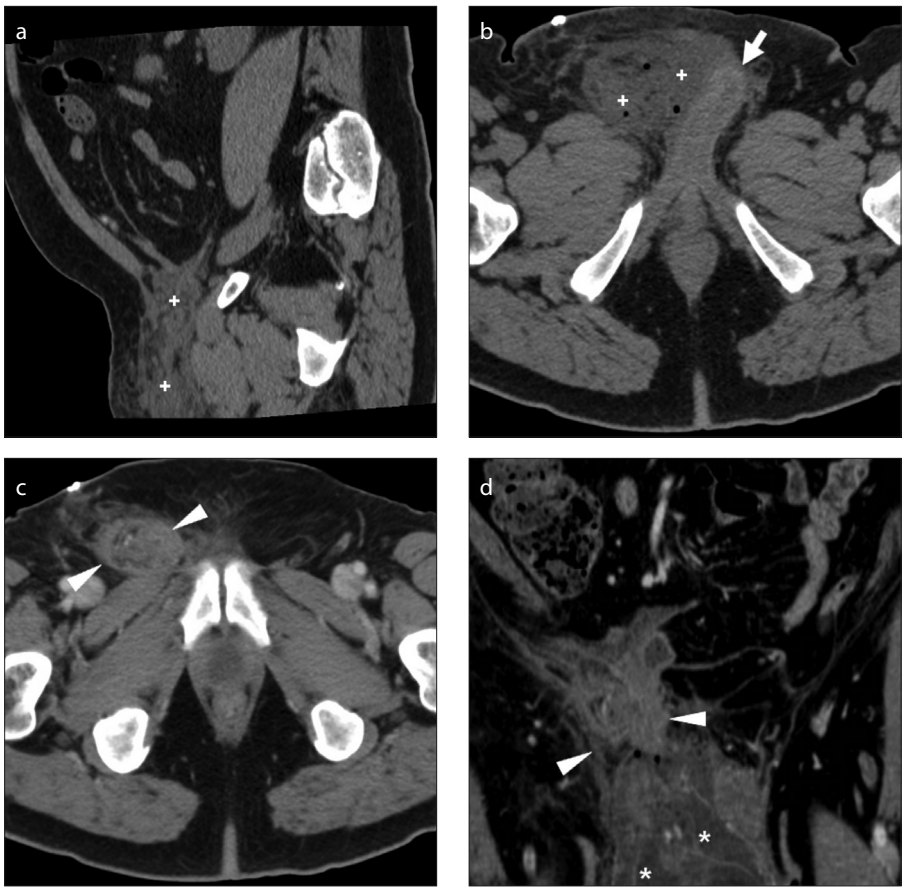

Figure 4. a–d. Multidetector CT was performed to investigate persistent groin and scrotal swelling three days after open right IHR in a 68-year-old obese male. Unenhanced images **(a, b)** confirmed prominent edematous fat stranding *(plus sign)* and gas bubbles along the extrainguinal spermatic cord. Note contralateral dislocation of the corpora cavernosa (*short arrow* in **b**). Abnormal contrast enhancement and active bleeding along the thickened spermatic cord (*arrowheads* in **c, d**) were excluded. Without clinical and laboratory signs of infection, this appearance was attributed to surgical manipulation. Ipsilateral reactive hydrocele *(asterisks)* was confirmed sonographically, without signs of orchitis or testicular ischemia. The patient had an uneventful course with conservative treatment.

contiguous 3–5 mm thick sagittal (between the lateral acetabular margins) CT images plus focused oblique-coronal images tilted parallel to the extrainguinal spermatic cord (Fig. 1) (9–11).

Expected postoperative imaging findings

Alloplastic materials used in IHR include mesh patches (most usually measuring 15×10 cm in size), cup-like mesh plugs deployed into the inguinal canal, or a combination of both such as in the Prolene hernia system (Ethicon, Inc.). At CT, the thin polypropylene PMs correspond to soft-tissue linear structures (Fig. 1) positioned just behind the peritoneum, which are often difficult to identify from the serosa, the adjacent isoattenuating muscles, and fascia. Conversely, expanded polytetrafluoroethylene PMs such as those made of Gore-Tex (W. L. Gore & Associates, Inc.) are hyperdense to muscle and therefore easily visible. Surgical staples for fascial fixation (Fig. 2) are increasingly uncommon (7, 10, 11).

Shortly after IHR, expected findings include inhomogeneity of the anterior pelvic wall and subcutaneous tissues at the operated inguinal region (Fig. 2), and spermatic cord thickening (Figs. 3, 4): the latter results from surgical manipulation, is typically tubular in shape, generally does not exceed 1 cm in diameter, and generally regresses at follow-up. However, mild or moderate asymmetry of the pelvic (Fig. 3c) or extrainguinal spermatic cord (Fig. 3d) between the operated side and the contralateral one may be sometimes encountered months to years after uncomplicated IHR: this imaging appearance causes diagnostic uncertainty when the radiologist is unaware of the previous ipsilateral surgery. Furthermore, after laparoscopy subcutaneous and preperitoneal air is commonly observed, and should not be reported as abnormal (6, 9, 10).

Characteristic well-demarcated round-, ring-, or ovoid-shaped focal pseudolesions (FPLs) (Fig. 5) are observed after IHR in 40%–80% of patients treated with mesh plugs (6). Typically located at the internal inguinal ring, these findings generally measure 2.5 cm (range, 1.3–3.9 cm) in size, display variable attenuation (partly adipose in two-thirds of cases), and correspond to the plug plus trapped fluid, blood, or fibrous tissue. Similar, smaller appearances are encountered in up to 24% of patients after flat-mesh IHR (6, 9, 10). FPLs do not represent complications, and should not be misinterpreted as hematomas, abscesses, pelvic lymphadenopathy, or epiploic appendagitis, to obviate unnecessary treatment. Useful findings for differential diagnosis are listed in Table 1 (9, 15).

Postoperative seroma

After IHR, serous fluid commonly collects at the inguinal canal or nearby the PM and generally resolves within 4–6 weeks. Seromas characteristically appear sonographically anechoic and show fluid-like CT attenuation values. Confident diagnosis of seroma allows obviating inappropriate management. However, differentiation from abscess may be challenging when thin peripheral enhancement (Fig. 6) is observed shortly after surgery (2, 11).

Multidetector CT appearances of complications

The most common post-IHR complications include urinary retention and infection, epididymo-orchitis, hydrocele, seroma, hemorrhage, and infection in descending order of frequency. With current mesh-based techniques early recurrences are exceptional (below 0.5% of cases). Particularly with the laparoscopic approach, occasional serious injuries may involve the bowel, iliac vessels, or urinary bladder (1–5, 11).

Mesh-related infections

Compared with wound infection, deep abscesses are highly uncommon and mostly associated with obesity, diabetes, prolonged duration of surgery, treatment of bowel strangulation. Suppuration manifests with

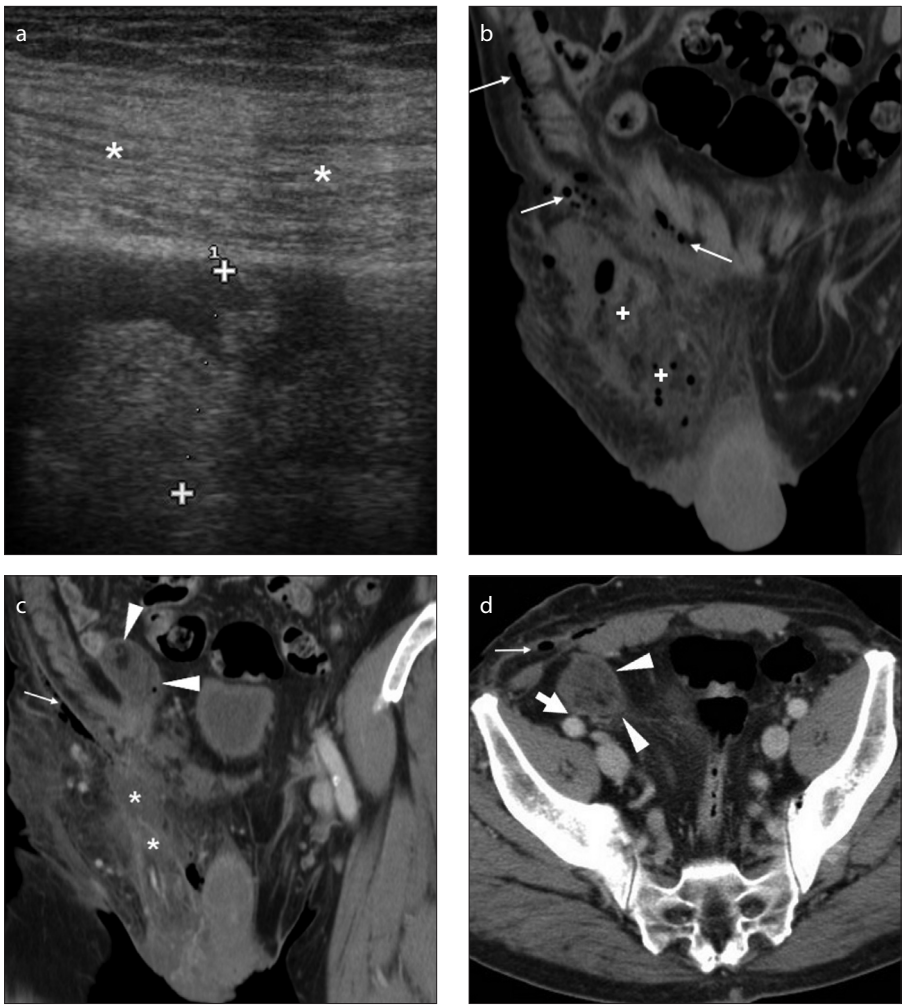

Figure 5. a–d. A 62-year-old male presented 48 hours after right open-mesh IHR with swollen, tender ecchymosis along the ipsilateral spermatic cord. Sonography showed normal testis, thickened extrainguinal spermatic cord, and a mixed anechoic collection (*calipers,* **a**) behind the rectus abdominis muscle *(asterisk)*. Urgent CT **(b–d)** showed moderate postsurgical abdominal wall air *(thin arrows)*, edematous fat stranding (*plus sign*, **b**) and sparse gas bubbles at the swollen groin, nonhemorrhagic fluid (18 Hounsfield Units - HU attenuation) along the extra-inguinal spermatic cord *(asterisk)*. Corresponding to sonographic finding **(a)** a 3.5 cm well-demarcated nonenhancing structure with internal fatty attenuation *(arrowheads)* was noted in the iliac fossa, abutting the internal inguinal ring. Expected postoperative appearance from mesh plug was diagnosed considering the consistent surgical details and the fat plane (*short arrow,* **d**) interposed between lesion and external iliac vessels. The clinical course evolved favorably. Partially reproduced from reference 15.

irreducible tender groin mass, fever, and leukocytosis, and usually requires surgical toilette and PM removal. CT depicts the characteristic abscess appearance including nonenhancing purulent content and thick hyperenhancing peripheral ring (Fig. 7) (2, 16).

Hemorrhage

Relatively common, spermatic cord hematoma may occur with all repair techniques, secondary to injury to the pubic branch of the obturator artery, the deep inferior epigastric vessels, or the external iliac artery and vein. Bleeding is more frequent and severe in anticoagulated patients, it may be limited by careful hemostasis and postoperative compression, and is generally treated conservatively. Surgical management to prevent superinfection is required in large or actively bleeding hematomas (3–5). Hematomas display a variable, generally hypoechoic or complex sonographic appearance. The CT hallmark is represented by a localized mass-like or thick elongated collection with the characteristic hyperattenuation (over 30 HU) of fresh blood (Fig. 8). Additionally, contrast medium extravasation indicating ongoing hemorrhage may be occasionally identified (7, 11, 17).

Bowel complications

Postoperative intestinal obstruction frequently requires surgical revision, and is due to either entrapment of bowel loops in Trocar access ports, or formation of adhesions at the PM site (Fig. 9) (5, 10, 11).

Bowel perforation represents an exceptional, severe complication of laparoscopic IHR, which may lead to fecal peritonitis, enterocutaneous fistula formation, sepsis, and death if unrecognized (5, 11).

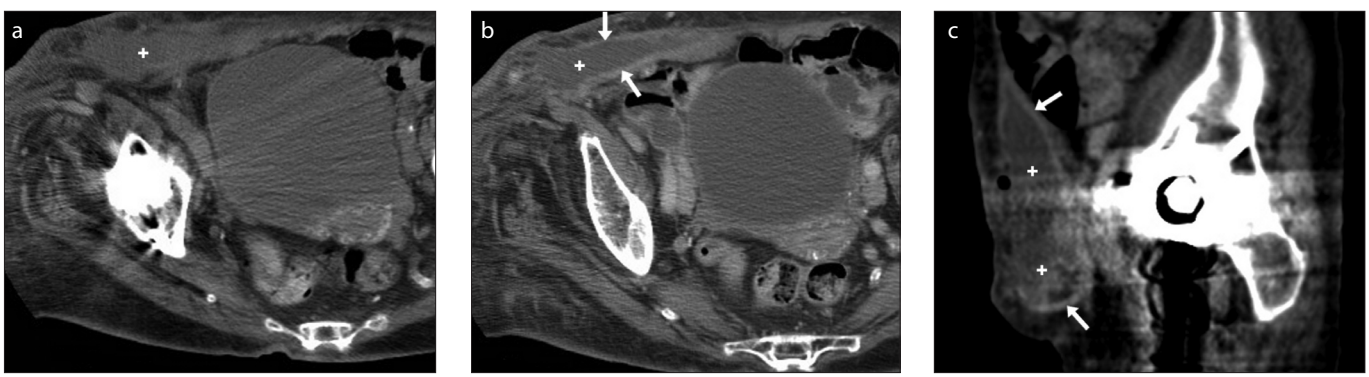

Figure 6. a–c. Postoperative seroma in an 85-year-old female patient with persistent groin swelling after open right IHR. Unenhanced **(a)**, axial **(b)** and sagittal **(c)** contrast-enhanced CT images shows a sizeable pear-shaped fluid-attenuating collection *(plus sign)* abutting the external inguinal ring, with peripheral enhancing rim *(arrows)*. Note artifacts from ipsilateral metal hip prosthesis. Sterile serous fluid was aspirated.

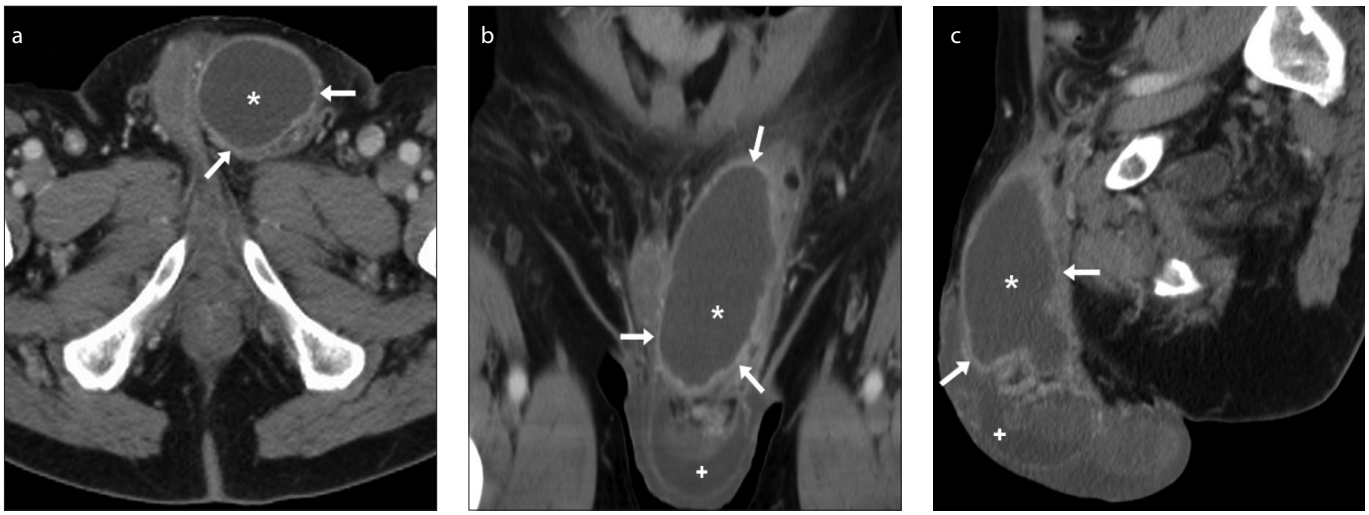

Figure 7. a–c. A 77-year-old male presented to emergency department complaining of painful, tender left groin swelling ten days after PM-IHR performed at another hospital. Laboratory tests disclosed moderate leukocytosis and increased C-reactive protein (98 mg/L) levels. Axial **(a)**, oblique-coronal **(b)** and sagittal **(c)** contrast-enhanced CT images show a large fluid-attenuation abscess *(asterisk)* with strongly enhancing thickened walls *(arrows)* along the entire spermatic cord, causing mass effect on penile structures. Ipsilateral hydrocele *(plus sign)* and vascular engorgement at the epididymal head were associated. Color Doppler ultrasonography *(not shown)* excluded testicular ischemia and acute orchitis. Surgical drainage was required to prevent sepsis. Partially reproduced with permission from reference 16.

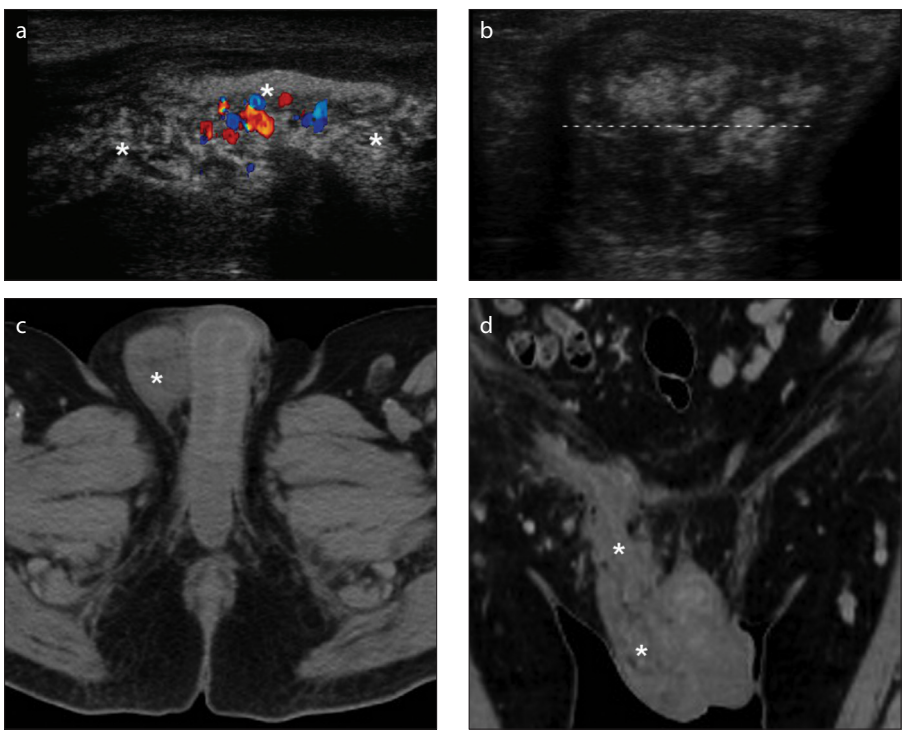

Figure 8. a–d. A 68-year-old male presented with fever, pulsatile groin mass and painful, tender scrotal swelling nine days after right-sided IHR. His medical history included aortocoronary bypass surgery and aortic valve replacement one year earlier. Color Doppler scrotal ultrasonography **(a, b)** showed extensive echogenic spermatic cord thickening, without hydrocele, orchitis and testicular ischemia. Multidetector CT **(c, d)** depicted hyperattenuating (35–40 HU) spermatic cord thickening from the outer inguinal ring to the upper scrotum, consistent with postoperative hematoma without contrast extravasation indicating active bleeding. The hematoma regressed over two months with conservative treatment. Partially reproduced with permission from reference 17.

Urogenital injuries

Bladder injury may occasionally (0.2% of cases) result from use of laparoscopic Veress needle or Trocar. Risk factors include inadequate preoperative bladder decompression, congenital abnormalities, previous preperitoneal space dissection, and surgical scars. Delayed injuries present with unexplained or persistent hematuria, pelvic discomfort, low-grade fever and oliguria. Radiographic or better CT-cystography allows confident identification or exclusion (Fig. 10) of extraluminal contrast leakage indicating perforation (18). While large bladder defects need repair, small mural defects can be managed conservatively with catheter bladder decompression (4, 5, 11).

Albeit rare (0.03%–0.5%), male genital tract injuries occur after both open and endoscopic IHR. Spermatic cord transection or compression injury represents the most rare yet feared occurrence since it may result in testicular ischemia, long-term testicular atrophy, and impaired fertility. Postoperative hydrocele (Figs. 4, 7) is commonly encountered following IHR. Color Doppler scrotal US represents a useful complementary modality, particularly to confirm presence of hydrocele, and to identify signs of testicular ischemia or hypervascularization indicating epididymo-orchitis (4, 7).

Conclusion

Multidetector CT allows a comprehensive assessment of the operated groin, and is therefore recommended to elucidate suspected postoperative complications after PM-IHR, in order to provide a consistent basis for choice between conservative treatment, percutaneous or open surgical drainage. Familiarity with expected CT ap-

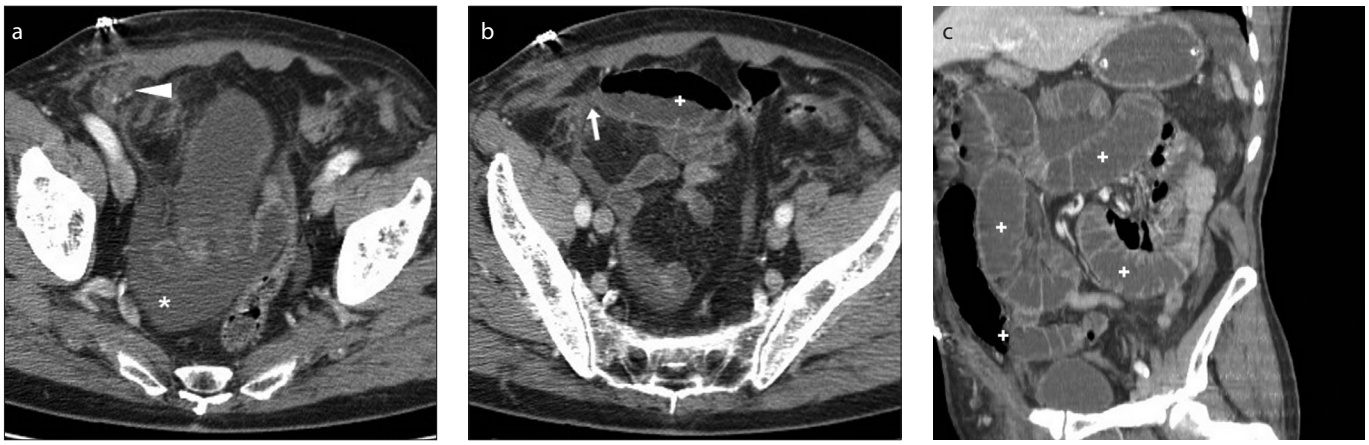

Figure 9. a–c. A 70-year-old male experienced early postoperative bowel obstruction after laparoscopic right IHR. Multiplanar contrast-enhanced CT images showed usual postsurgical appearance at the site of intervention (*arrowhead*, **a**; note similarity with Fig. 1), plus tapering (*arrow,* **b**) of a distended ileal loop with diffuse dilatation of the upstream small bowel *(plus sign)* with air-fluid levels. Note moderate ascites (*asterisk,* **a**) in the pelvic cul-de-sac. Surgical reintervention was required to relieve obstruction.

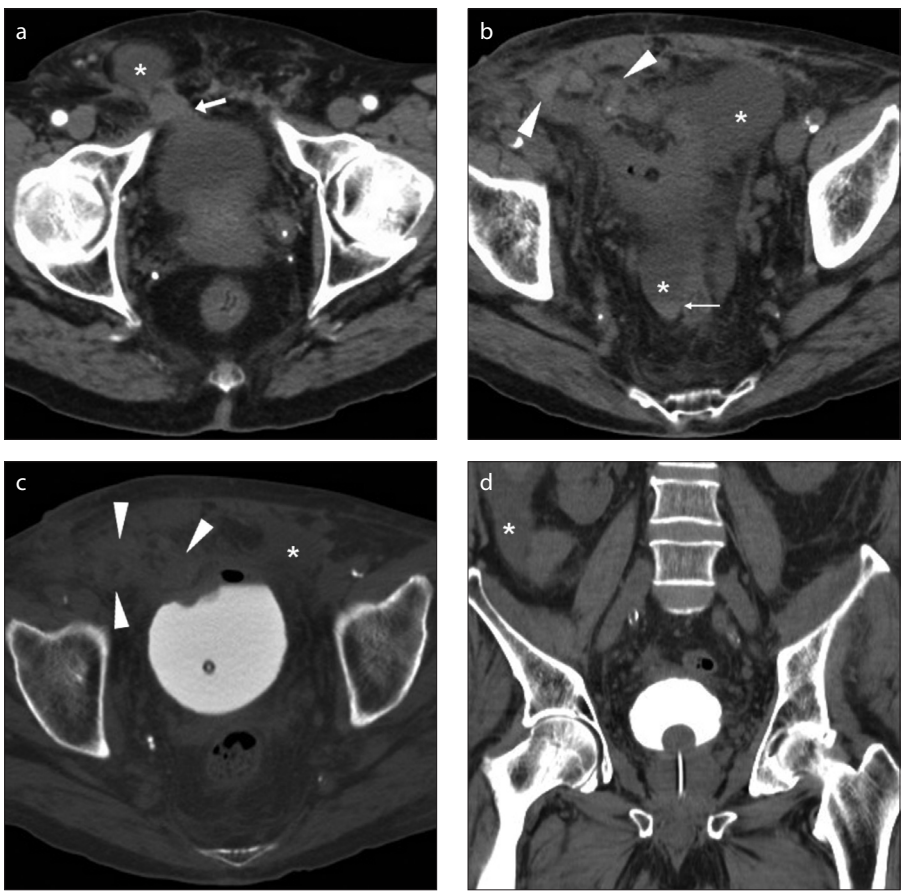

Figure 10. a–d. An 81-year-old male with several comorbidities underwent emergency open right IHR. Preoperative CT **(a)** shows peritoneal fluid *(asterisk)* in the hernia sac, herniation of the ipsilateral aspect of the urinary bladder *(arrow)* in the inguinal canal. Postoperative CT **(b)** without intravenous contrast medium because of acute kidney injury reveals appearance consistent with surgical plug and blood *(arrowheads)* at the internal inguinal ring, peritoneal effusion *(asterisk)* with minimal blood *(thin arrow)* in the peritoneal cul-de-sac. Additional CT-cystography **(c, d)** excludes residual bladder herniation and extraluminal contrast leakage indicating iatrogenic injury. The patient experienced a prolonged postoperative course complicated by Fournier's gangrene.

pearances is required to avoid misinterpretation of early postoperative studies.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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