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REVIEW /*Genitourinary imaging*

Imaging of postoperative endometriosis

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KEYWORDS
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Postoperative findings;
Disease recurrence

Abstract Endometriosis is a chronic gynecological condition that affects primarily young women. Imaging plays a pivotal role for the diagnosis and pre-surgical mapping of the disease. By comparison, the role of imaging in the identification of disease recurrence and postoperative complications are not well established. The goal of this review is to report the postoperative findings, including normal postoperative findings, initial disease recurrence and complications, with a special emphasis on magnetic resonance imaging (MRI), in women who have undergone surgery for pelvic endometriosis. This review is based on a literature search of manuscripts published between 2000 and 2018. Meta-analyses, systematic reviews and original scientific articles published in English language were included.

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The diagnosis of endometriosis is suggested on the combination of symptoms, clinical examination findings and imaging methods including transvaginal sonography (TVS), magnetic resonance imaging (MRI) and rectal echo-endoscopy (REE). But the definitive diagnosis is based on histology showing both endometrial gland and stroma outside the uterus [1]. Three main entities of pelvis endometriosis have been identified: peritoneal, ovarian and deep endometriosis (DE) [2].

The European Society of Human Reproduction and Embryology (ESHRE) Special Interest Group for Endometriosis and Endometrium has stated that laparoscopy is the standard of reference for diagnosing most forms of endometriosis in women with suggestive symptoms [3,4]. This statement is supported by the low accuracy of imaging techniques to detect peritoneal endometriosis. However, the high accuracy of TVS and MRI in the diagnosis of endometriomas and deep endometriosis (DE) allows to conclude that for endometrioma TVS can be qualified as a triage test and MRI displayed sufficient accuracy to suggest its utility as a replacement test for DE diagnosis, rending diagnostic laparoscopy obsolete [2,5]. Moreover, laparoscopy may fail to reveal nodules covered by adhesions and/or sub peritoneal disease [6]. Laparoscopy is the most conservative and less invasive surgical approach to

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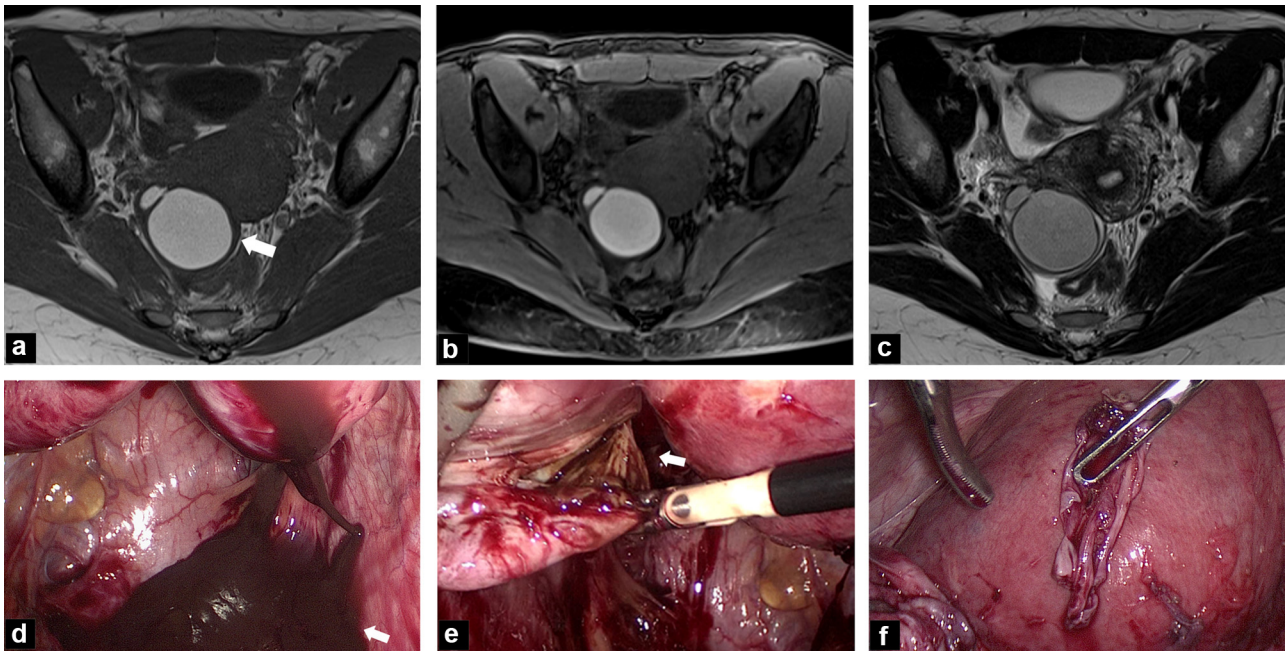

Figure 1. 35-year-old with deep pelvic endometriosis and right endometrioma. This figure illustrates MRI and surgical management of ovarian endometrioma: a: T1-weighted MR image in the axial plane; b: fat-suppressed T1-weighted MR image in the axial plane; c: T2-weighted MR image in axial plane. These pictures show typical right ovarian endometriosis cyst with high signal on T1-weighted image, arrow (a) and fat suppressed T1 weighted image (b) and with drop of signal on T2-weighted image (T2 shading); d, e and f show right ovarian cystectomy via stripping technique on laparoscopic view images. First the endometrioma is drained (d), this picture also shows endometrioma chocolate content, arrow; e: the cyst is removed from the ovarian tissue, and finally picture shows the endometrioma's wall removed above uterine fundus (f).

remove endometriosis-related lesions and to relieve pain [7].

MRI can provide a road map allowing adequate pre-surgical counseling and give valuable information to the surgeon for complete removal of all possible endometriotic implants [6,8,9]. After surgery, complications and recurrence rate of DE and endometrioma greatly vary among studies depending on the patient, study's sample size, type of surgery, extent of the disease and total follow-up [7]. Among these parameters, the variation in the length of follow-up appears crucial explaining the differences in recurrence rate according to series. The literature is scarce regarding the characterization of the surgical imaging aspects of endometriosis that can range from normal to sequalae fibrosis. Similarly, imaging criteria for the diagnosis of endometrioma or DE recurrence after surgery are not well established [9].

The aims of this review were to analyze the postoperative imaging findings of complications after surgery for endometriomas and DE, depending on the surgical approach and to define criteria for the diagnosis of recurrence based on the analysis of data from expert centers.

Surgical approach and postoperative complications

General considerations

Treatment options for endometriosis include expectant management, hormonal therapy and surgery [10]. Surgery should be considered depending on symptoms, failure of prior medical treatment, the extent of the disease and the expected benefit regarding pain relief and infertility. However, despite a large literature on fertility outcomes after surgery [11—16], a debate exists on the true indications for surgery in this specific setting. Another surgical issue is to determine which conservative procedures to perform [17]. Finally, the other objective of surgery is to avoid or to delay recurrence [18].

Surgery of endometrioma

Several surgical approaches can be performed for endometriomas. Ovarian cystectomy is the most commonly used surgical method for the management of endometrioma (Fig. 1) [19]. This technique is restricted to symptomatic endometrioma larger than 3 cm [19]. However, recent French guidelines recommend a less aggressive approach for endometrioma less than 5 cm in diameter [20]. In the context of infertility, especially for patients requiring assisted reproductive technology with in vitro fertilization-intracytoplasmic sperm injection (IVF-ICSI) cystectomy has no advantage either in terms of number of oocytes retrieved and pregnancy rate. Surgical treatment before IVF-ICSI is an option for endometrioma over 6 cm, which often convey potential difficulties for oocyte retrieval [20].

The evaluation of ovarian reserve should be performed preoperatively because cystectomy has an impact on ovarian reserve. A meta-analysis has demonstrated that removal of unilateral and single endometrioma is associated with a drop

of 1.1 ng/mL of anti-mullerian hormone serum level and that bilateral cystectomy is associated with a drop of at least 2 ng/mL, without improvement in the postoperative period [21].

Besides the alteration of ovarian reserve, ovarian surgery carries some specific complications, including hemorrhage, abscess and thrombosis. Tuboovarian abscess should be considered in the postsurgical context of fever with pelvic pain.

Surgery of deep endometriosis

Laparoscopic conservative surgical approach (LCSA) is the most conservative and less invasive surgical approach to remove deep endometriosis-related lesions and to relieve pain [7,10]. Resected lesions are usually located in the posterior compartment, involving the *torus uterinus*, uterosacral ligaments (USL), vagina, rectovaginal septum (RVS), pouch of Douglas, rectum and sigmoid. Diffuse deep endometriosis may need hysterectomy in combination with ipsilateral or bilateral oophorectomy and salpingectomy [10].

Postsurgical complications depend on the type of surgery and the extent of the disease [22]. Infection is the most common complication after hysterectomy, affecting 9—13% of patients [23]. The others post hysterectomy complications include vaginal vault hematoma and pelvic hemorrhage. Radical surgery for DE of the rectovaginal septum, parametrium as well as the visceral fascia can also result in autonomic nerve injury, resulting in voiding dysfunction [24].

Surgery of bowel endometriosis

Various surgical options are available for the treatment of bowel endometriosis, depending on lesion size, location, number and depth of infiltration [25,26]. Rectal shaving is mainly recommended for serosal endometriosis although some authors recommend its use for more invasive lesion; discoid resection is mainly recommended for nodules with < 3 cm in diameter, but even some larger nodules can be excised by double discoid resection. Segmental resection is restricted to large nodule, multifocal lesions or bowel lumen restriction > 50% [8]. The main complications of bowel surgery are anastomotic leakage, pelvic abscess, and rectovaginal fistula [10].

The major complication of colorectal resection is recto-vaginal fistulae with an incidence of 2.7% [27]. Bendifallah et al. demonstrated that the incidence of these complications was related on volume of cases per center and year [27]. The ENDORE trial did not reveal differences between radical surgery (segmental resection) and conservative surgery (rectal shaving and discoid resection) in terms of complication rates or quality of life [28]. This lack of difference may be probably due to the small sample size and the inclusion of a conservative surgery arm of multiple techniques. Jayot et al. have demonstrated similar surgical complications of the both surgical approaches but advantages of discoid resection over segmental resection especially concerning the rate of voiding dysfunction, operating time and hospital stay [16].

Bladder and urinary endometriosis

Deep endometriosis surgery carries a risk of ureteral dissection, with an estimated incidence of 80% [29]. The risk is major in cases of involvement of the lateral pelvic compartment by endometriosis especially the parametrium and visceral fascia. The surgical approach of ureteral endometriosis is to spare the ureter using ureterolysis as the involvement is mainly extrinsic [29].

Bladder shaving is used to remove superficial and serosal vesical endometriosis and, in other way partial bladder resection is used when the full thickness bladder wall is involved [29]. Cystotomy, ureteral injury (transection), vesicovaginal fistula, ureterovaginal fistula, urinary retention and bladder atony are the main postsurgical urinary complications after DE surgery [23]. Voiding dysfunction, as previous referred, is caused by damage the autonomic nerves in some more radical surgery techniques. Iatrogenic injury to the ureters includes inadvertent ligation or kinking with a suture, leading to ureteral stenosis and hydronephrosis.

Normal postoperative findings

Postoperative features after the endometrioma cystectomy depend on the size of endometrioma and surgical technique. Usually the ovary is smaller than normal [19] and can be surrounded by postoperative adhesions (Fig. 2).

To our knowledge, there is no published data regarding endometriosis postsurgical imaging findings. Postsurgical aspects range from almost normal to fibrotic sequela that manifest as adhesions, bands or linear tracks located in the pelvis in dissection planes of surgery. On MRI, these sequelae can be seen at these anatomical places as hypointense linear bands on T2-weighted images. Their signal is darker than that of fibrosis caused by endometriosis on T2-weighted images (Fig. 3). The adhesions can indirectly appear on MRI as distortion of normal pelvic anatomy.

Normal post hysterectomy findings include regular hypointense band of vaginal vault on T2-weighted images (Fig. 4) and H-shaped axial configuration, uniform walls and enhancing mucosa of vaginal walls. The vaginal vault is slightly retracted cranially compared to preoperative studies immediately after vaginal hysterectomy imaging appearance reflects vaginal edema with circumferential edematous mural thickening and mucosa enhancement [23]. After recent laparoscopic hysterectomy, minimal pelvic effusion and gas are common postoperative findings. These aspects typically resolve in a few days, up to a week (carbon dioxide is rapidly reabsorbed) and should decrease on serial imaging [23]. Conversely, gas that persists or increases should suggest visceral perforation.

Postsurgical findings after resection of bowel endometriosis depend on surgical approach and the depth of bowel wall infiltration. Although guidelines suggest removing all endometriotic lesions to relieve symptoms and to enhance fertility, incomplete surgery to treat endometriosis can also be an option due to the risk of severe complications [2,19]. Surgery is particularly

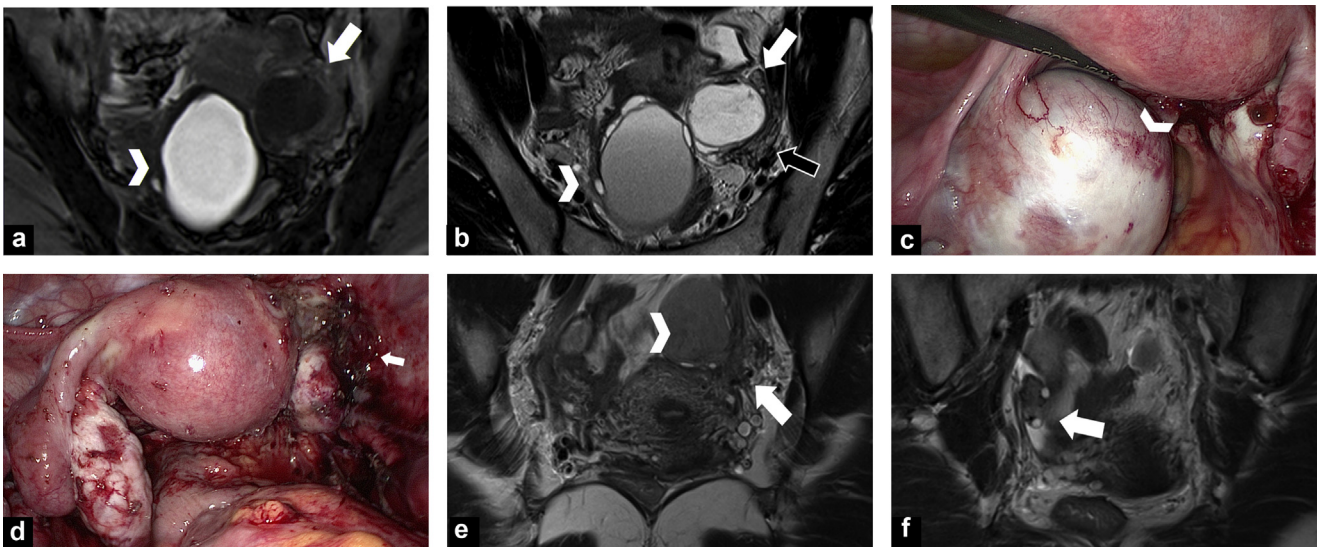

Figure 2. 30-year-old woman with infertility and pelvic pain due to deep pelvic endometriosis and right endometrioma and further postoperative endometriosis: a: fat-suppressed T1-weighted MR image in the axial plane shows right ovarian endometriosis cyst (arrowhead) that displays high signal and left functional ovarian cyst (arrow) that displays low signal on fat-suppressed T1-weighted image; b: on T2-weighted MR image in the axial plane the right endometrioma shows signal drop (shading effect) which is typical of endometrioma (arrowhead) whereas the functional cyst is hyperintense. Presence of deep pelvic endometriosis with kissing ovaries in the midline of pelvis and low signal nodule on left pelvic side wall, arrow (b); c: photograph shows laparoscopic view of enlarged right ovary caused by endometrioma (arrowhead); d: photograph shows laparoscopic view after right ovarian cystectomy and left pelvic side wall endometriotic nodule resection and left salpingectomy (arrow); e: T2-weighted MR image in the coronal plane, two years after the initial operation reveals endometriosis recurrence confirmed with left endometrioma ''de novo'' (arrowhead) and left pelvic sub-peritoneal deep endometriosis nodule (arrow) recurrence; f: T2-weighted MR image in the coronal plane, two years after the initial operation reveals postsurgical small right ovary (arrow) after cystectomy.

considered in DE with bowel involvement, having the option of leaving in situ the partial component of the disease inside bowel wall and removing vaginal and rectovaginal septum disease, allowing symptoms improvement and decreasing bowel risks complications. In case of rectal shaving, the lesion can be seen on the bowel wall on follow-up imaging examinations. Small bowel lesions are all removed when treated by discoid resection and no bowel wall infiltration is seen on postoperative imaging, unless initial disease relapses. Normal postoperative MRI findings of discoid resection include hemi-circular suture in anterior bowel wall. In case of segmental resection, the normal colo-rectal anastomosis demonstrates a circular hypointense band on T2-weighted images associated with postsurgical material that can be seen as a metallic artefact on images depending on surgical technique and material used (Fig. 5).

Normal postoperative findings after vesical and vesicouterine pouch resection include obliteration of vesicouterine pouch without fat tissue interface between uterus and bladder and, in the other hand, the bladder wall appears as asymmetric, dark, thickened fibrotic band on T2-weighted images (Fig. 6). After partial cystectomy, the bladder volume is reduced and vesical wall can appear irregular related with surgical anastomosis (Fig. 7).

The postsurgical imaging cues of the ureters are not quite different from the normal ureter. In some instances, low signal linear strands and fibrotic ureteral wall thickening can be seen on T2-weighted MR images (Fig. 7).

Imaging of postoperative complications

The clinical indications for endometriosis postoperative imaging examinations include suspected infection/sepsis, urological injuries or pelvic hemorrhage; abnormal vaginal discharge, persistent abdominal distension, pelvic and perineal pain [23]. Computed tomography (CT) and TVS are the main usual imaging methods to determine the extent and location of postoperative complications. We generally recommend a multiphase CT protocol including an unenhanced acquisition to identify fresh blood in the pelvis and a venous phase acquisition. An arterial phase for CT angiography can also be done to detected active hemorrhage in selected situations.

The main post hysterectomy complications are infections and hemorrhages. The hematoma manifests as hyperattenuating collection above vaginal vault. Infection can result from ascending polymicrobiana from vagina or from intraoperative bowel injury and manifest as heterogenous fluid collection with enhancing wall and internal gas mainly above the vaginal vault. Iatrogenic pelvic hemorrhage manifest as spontaneously hyperattenuating peritoneal fluid and CT during the arterial phase may reveal contrast material extravasation corresponding to active bleeding [23].

Imaging findings suggesting bowel injuries include the development of free intraperitoneal fluid or gas out of proportion for the expected postoperative period, direct visualization of discontinuity of bowel tract or enteric contrast leak, fluid collection/abscess, focal bowel wall thickening, or development of fistulous tracts between

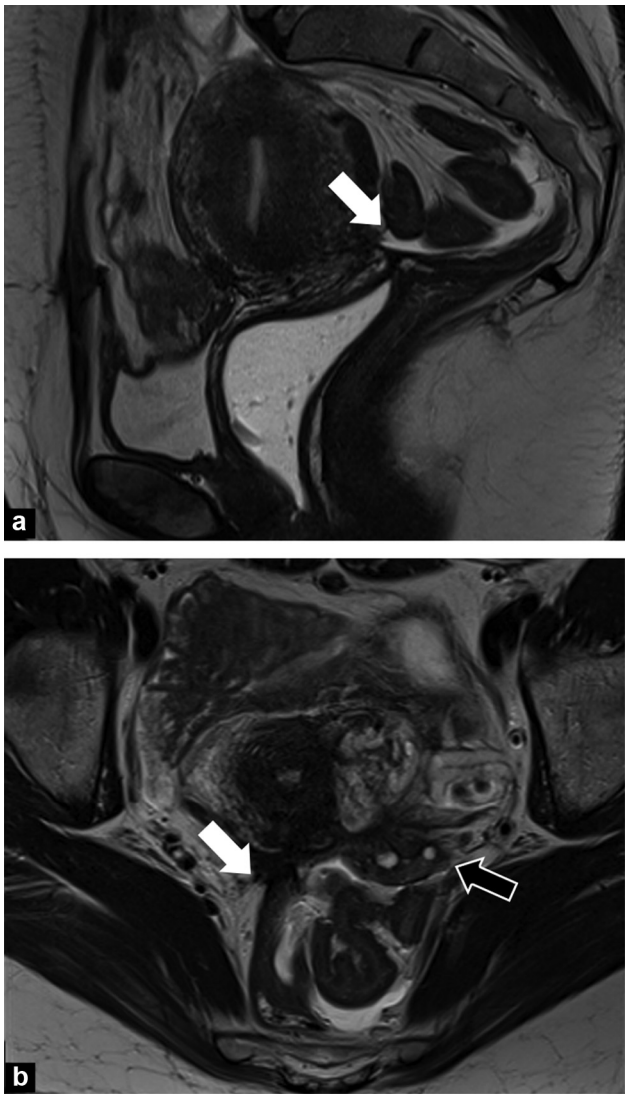

Figure 3. Postoperative findings after laparoscopic conservative surgical approach (LCSA), rectovaginal septum and right uterosacral ligament deep endometriosis lesions resections, in a 30-year-old woman with infertility and pelvic pain: a: T2-weighted MR image in sagittal plane with vaginal gel shows postsurgical fibrotic band and adhesions that manifests as distortion of normal anatomy including elevation of the posterior wall of vaginal fornix (arrow); b: T2-weighted MR image in the axial plane shows very low signal intensity band of variable thickness, extending from uterus to right uterosacral ligament track and right para-rectal space corresponding to the anatomical dissection planes (white arrow). This picture also shows postsurgical adhesions that manifest as posterior and median position of left ovary (black arrow).

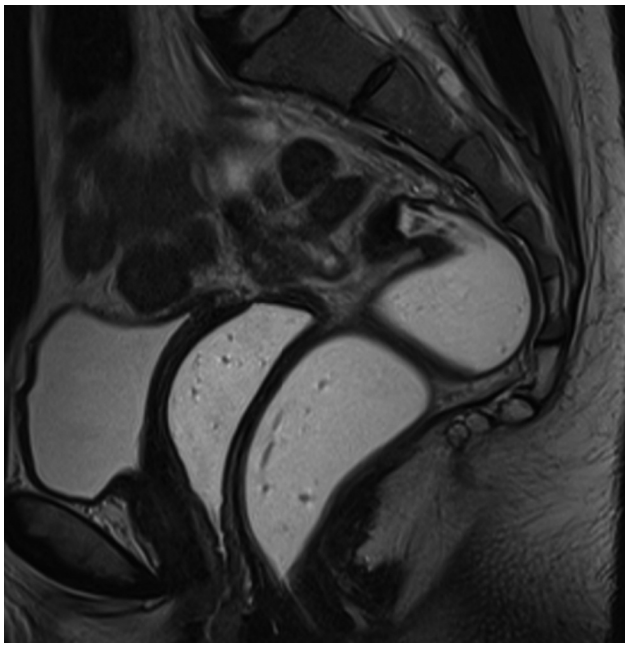

Figure 4. Normal postsurgical findings after hysterectomy on T2-weighted MR image in sagittal plane with vaginal gel. It demonstrates normal regular vaginal vault after hysterectomy in 45-year-old woman with adenomyosis and deep pelvic endometriosis who underwent hysterectomy.

the vagina or uterus and bowel, rectum or anal canal (Figs. 8 and 9) [23]. In woman with suspected pelvic fistulous tract, the use of rectal filling with contrast material is required to opacify and localize the fistulous tract on CT scan. In this specific setting, MRI has an excellent soft-tissue contrast resolution and the advantage of no radiation exposure [30].

Bladder voiding dysfunction after endometriosis surgery is mainly due to full resection of endometriosis nodule in RVS and parametrium that leads to distal transection of pelvic hypogastric plexus [24]. Bladder dysfunction can manifest as acute neurogenic bladder atony (sympathetic denervation), chronic neurogenic bladder atony (overdistention of the bladder over the time) or acute motor paralytic bladder (parasympathetic denervation) [24]. The diagnostic of acute bladder complications is clinical. In the case of chronic neurogenic bladder atony, the vesical ultrasound with post void residual volume measure is important to detect, indirectly, the detrusor disfunction over time. The post void residual volume measure by ultrasound is an imaging method to detect bladder retention. The post void residual volume should be < 100 mL [24]. No functional postoperative urinary complications include cystotomy, ureteral injury (transection), vesicovaginal fistula and ureterovaginal fistula. CT findings of fistulae between the bladder and vagina may include obliteration of fat planes between the urinary bladder and vagina with soft tissue stranding, presence of air in the bladder and/or fluid in the vaginal lumen and opacified abnormal track on the excretory-phase or cystography CT [23]. Iatrogenic stenotic injury to the ureters leads hydronephrosis define as pieloureteral dilation on imaging.

Imaging of recurrent endometriosis

Imaging techniques

Transvaginal ultrasonography (TVS) is the first-line imaging modality for the assessment of pelvic endometriosis but has limitations related to field-of-view and operator dependence [31]. MRI is usually performed as an additional examination in complex cases, in patients not eligible for TVS and for a comprehensive evaluation of the lesions

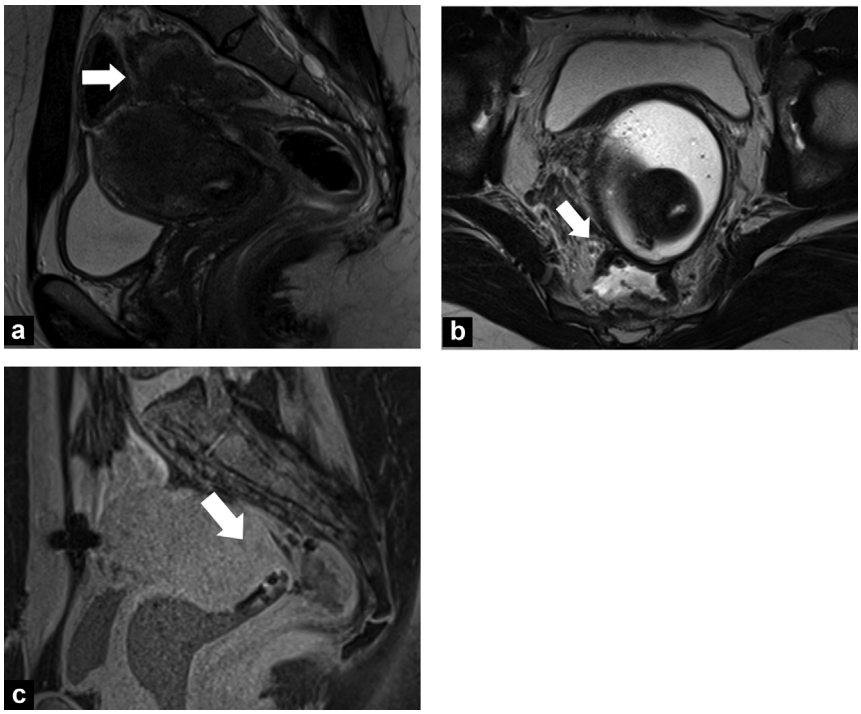

Figure 5. Pre-surgical and postsurgical findings after rectal anterior segmental resection of rectal endometriosis: a: T2-weighted MR image in sagittal plane; b: T2-weighted MR image in axial plane with vaginal gel; c: fat-suppressed T1-weighted MR image in sagittal plane with vaginal gel. The figure (a) demonstrates an infiltrating endometriotic lesion (arrow) located in posterior compartment with infiltration of the rectum/sigma wall and uterus, in a 36-year-old woman with rectovaginal septum, rectum and bowel endometriosis. This nodule manifests as low signal intensity mass that protrudes in to rectal lumen with hyperintense submucosal layer that cover the mass like a ''mushroom cap'', arrow (a). The patient underwent an anterior segmental rectosigmoid transition resection; b and c demonstrate the normal colo-rectal anastomosis after segmental rectosigmoid transition resection with homogeneous low signal intensity circular colo-rectal anastomosis, on axial T2-weighted image, arrow (b) and metallic postsurgical material artefact in colo-rectal anastomosis on fat-suppressed T1-weighted MR image, arrow (c).

prior to surgery [9,32—35]. In a recent systematic review including only studies in which patients underwent both techniques, Guerriero et al., concluded that TVS and MRI have similar accuracies for detecting DE involving rectosigmoid, uterosacral ligaments and rectovaginal septum [36].

According to the ESUR guidelines, the MRI protocol to diagnose endometriosis consists of three different anatomical sequences with and bowel preparation and administration of antispasmodic agent before the examination [9]. Vaginal and rectal opacification with sonographic gel is considered an option for the evaluation of DE [6,9]. According to our experience, in some cases where there is some uncertainty, the vaginal gel opacification can improve the vaginal and RVS endometriosis nodule and fibrosis detection. Use of rectal gel is debated in several studies as it can increase bowel peristalsis and distort rectal retraction caused by the endometriosis implants [37,38]. The use of contrast enhancement for detecting endometriosis is also controversial. Bazot et al. proved that postcontrast MRI images did not increase accuracy for the diagnosis of rectosigmoid, vaginal and bladder endometriosis [32]. However, it remains mandatory when malignant transformation of endometrioma is suspected and recommended in case of indeterminate adnexal endometriosis [9,33].

Diffusion-weighted (DW) MRI has no proven added value to the other morphologic sequences for the evaluation of endometriosis including DE [9,39,40]. New MRI sequences have been suggested but they are still limited to clinical trials such as the diffusion tensor imaging (DTI) to assess integrity of fiber tracts in pelvic endometriosis or susceptibility-weighted imaging to improve detection of blood products [41,42].

So far, there is no data in the literature regarding the best imaging method to detect endometriosis recurrence after surgery. No clear recommendation on TVS protocol exists regarding the diagnosis of recurrent endometriosis [2,9]. In our point of view the problem of posterior shadowing, representing a true limitation of TVS in the postoperative period to assess recurrence, does not exist with MRI that helps to correctly analyze anterior, lateral and posterior pelvic compartments [2]. However, further studies are required to evaluate whether MRI should be the first imaging technique to assess recurrent endometriosis. Furthermore, medico-economic evaluations are needed to assess its cost-effectiveness ratio.

We recommend TVS and MRI as imaging methods to document clinical endometriosis recurrence. The MRI ESUR guidelines protocol show great promising in detecting endometriosis recurrence, with optional vaginal gel in doubt cases of clinical suspicion of endometriosis recurrence involving vagina, rectovaginal septum or bowel and after hysterectomy.

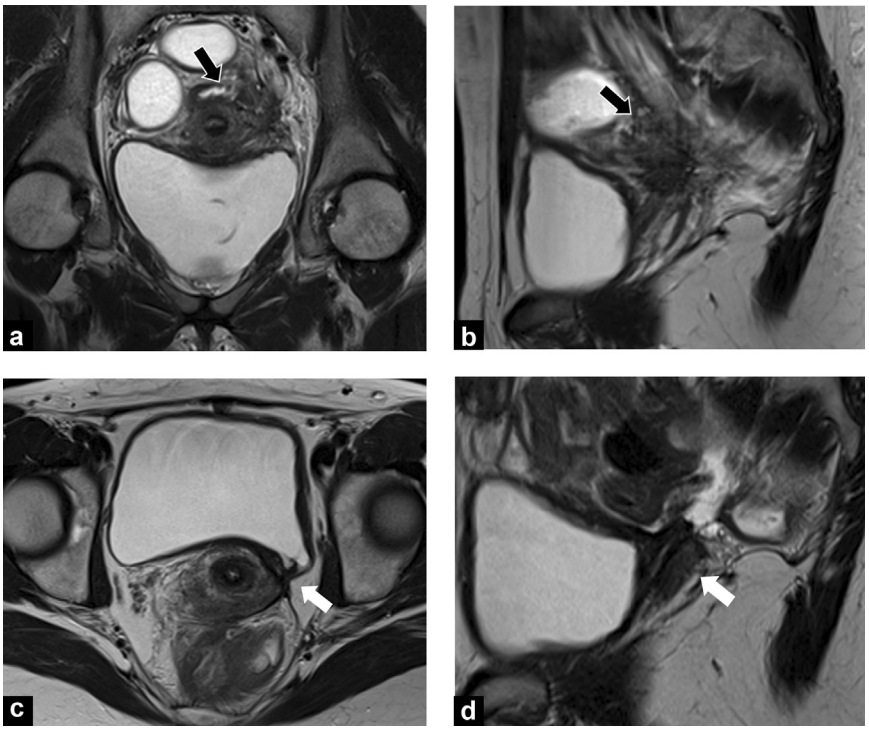

Figure 6. 34-year-old woman with pelvic pain and left hydronephrosis due to deep pelvic endometriosis and further postoperative findings: a: T2-weighted MR image in coronal plane; b: T2-weighted MR image in sagittal plane; c: T2-weighted MR image in axial plane; d: T2-weighted MR image in sagittal plane; a and b demonstrate left endometriotic spiculated nodule on left parametrium, arrow, with left ureter and vesical wall involvement before surgery; c and d demonstrate hyposignal intensity fibrotic band related to postsurgical sequelae fibrosis, in bladder wall, arrow (c) and surrounding the left ureter, arrow (d) after vesical shaving, parametrium left nodule resection and left ureterolysis.

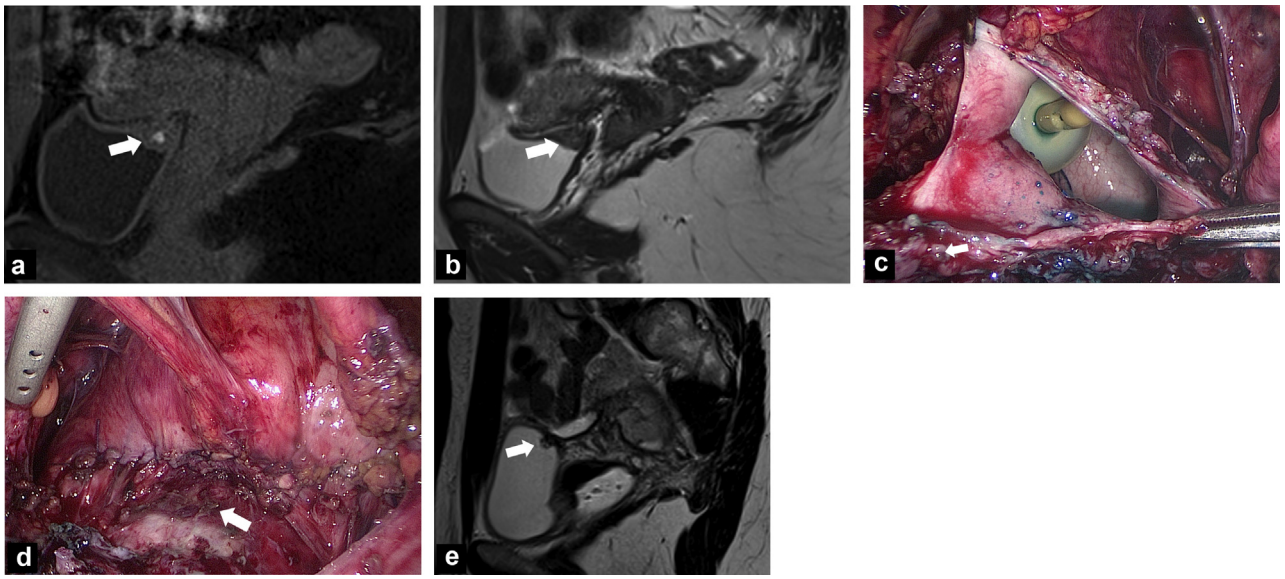

Figure 7. 31-year-old woman with right endometrioma, vesical, cecum and rectovaginal septum endometriosis treated with laparoscopic conservative surgical approach (LCSA): partial cystectomy, ileocecal and rectovaginal septum nodule resection. Four years after surgery, it was diagnosed postsurgical dysuria recurrence: a: fat-suppressed T1-weighted MR image in the sagittal plane; b: T2-weighted MR image in the sagittal plane; a and b show naïve endometriosis nodule in vesicouterine fold and vesical wall (arrow) with central high signal spot on fat-suppressed T1-weighted image (a) and low signal intensity on T2-weighted image (b); c: photograph shows laparosocpic view of opened bladder view with endometriosis vesical nodule being removed at laparoscopic, arrow; d: photograph shows laparoscopic view of cleaned vesicouterine fold after partial cystectomy and vesical anastomosis (arrow); e: T2-weighted MR image in the sagittal plane reveals postsurgical papillary lesion on postsurgical bladder scar with low signal intensity on T2-weighted image, arrow.

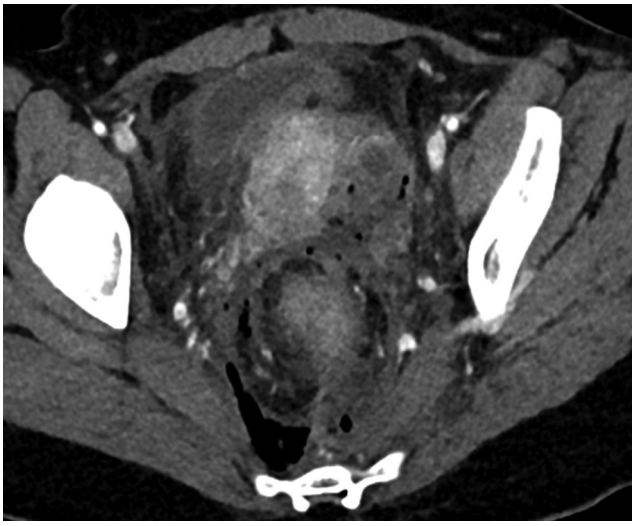

Figure 8. Contrast-enhanced pelvic computed tomography image in 38-year-old woman with postsurgical fever and leucocytosis caused by endometriosis rectum perforation complication after rectal and rectovaginal septum endometriosis nodule resection. The axial image shows pelvic abscess and peritonitis with air and fluid collection in the pelvis (arrow).

Figure 9. Rectovaginal fistula on pelvic computed tomography image with rectal contrast in 34-year-old woman with fecal vaginal discharge and fever two weeks after hysterectomy and rectal shaving treatment for deep pelvic endometriosis. It was diagnosed endometriosis rectovaginal fistula complication confirmed by fistulous tract between rectum and vagina (arrow).

Imaging findings

The 5-year disease recurrence rate of endometriosis after surgery ranges between 30—50% [43] and repeat surgery rate reaches 51% at 10 years [44]. Disease recurrence is suspected when:

- patient experiences recurrent symptoms;
- asymptomatic patient exhibits new lesions on systematic imaging or;
- patient has both recurrent symptoms and consistent imaging findings [45,46].

Recurrence may correspond to the growth of microscopic endometriosis undetected at surgery, the development of ''de novo'' lesions or the combination of both pathways [45,47].

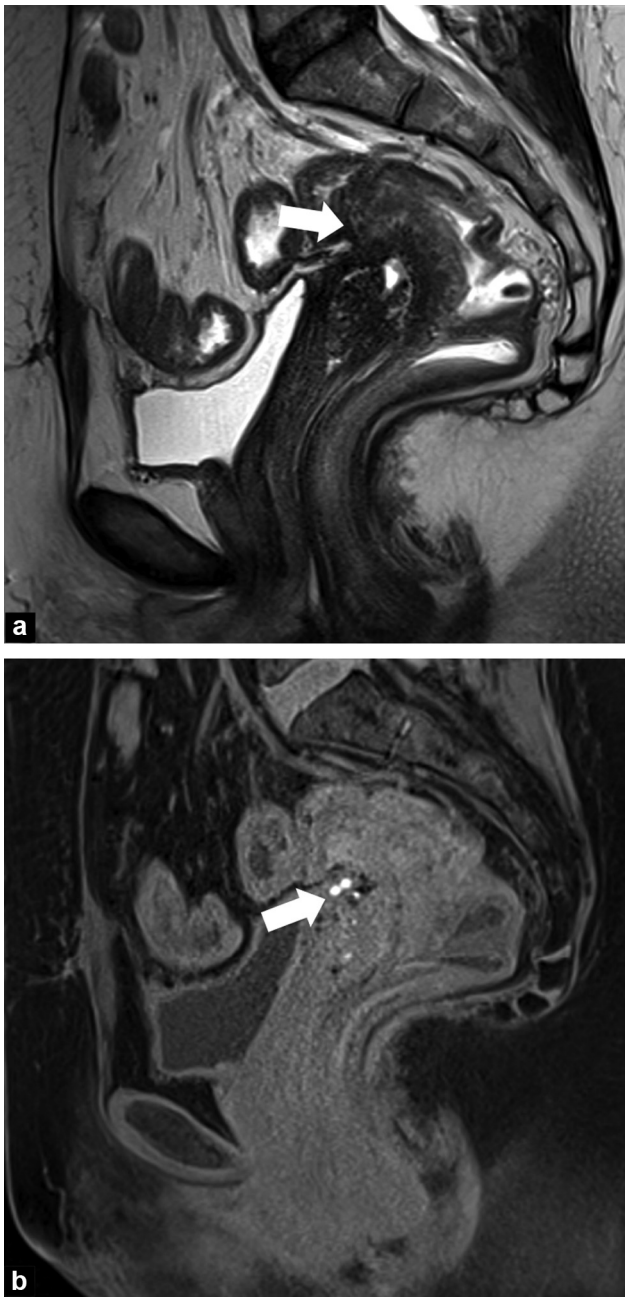

Figure 10. Illustrates endometriosis recurrence after hysterectomy in 47-year-old woman with pelvic pain (clinical recurrence) after hysterectomy and laparoscopic deep endometriosis lesions resection in rectovaginal septum and rectum shaving: a: T2-weighted MR image in sagittal plane; b: fat-suppressed T1-weighted MR image in sagittal plane. These pictures demonstrate infiltrating active disease on vaginal vault that manifests as low signal intensity spiculated nodule on T2-weighted image with the characteristic ''mushroom cap'' lesion (arrow) and this nodule has typical high glandular focus on fat-suppressed T1-weighted image (arrow), corresponding to active disease, and this sign is very important to confirmed recurrence of the disease.

Endometrioma recurrence

After resection, the endometrioma recurrence rate ranges between 6% and 30% corresponding to a newly developed

endometrioma or a recurrence of a previously removed one [19,46,47].

Typically, ultrasound reveals unilocular or multilocular cyst with diffuse low-level internal echoes with parietal hyperechoic foci [48,49]. On TVS recurrence of endometrioma is defined by the presence of ovarian cysts with the typical sonographic criteria of endometriomas and a diameter > 10 mm [46].

On MRI, recurrent endometrioma typically displays hyperintensity on T1-weighted images, that persists on fat-suppressed T1-weighted images, thus excluding fat content. The decrease in signal intensity from T1- to T2-weighted images has been described as the ''shading effect'' and is due to chronic bleeding with accumulation of high concentrations of iron and protein in endometriomas (Figs. 1 and 2) [48,50]. This specific feature helps differentiate endometrioma from functional hemorrhagic cyst that does not demonstrate shading effect [48,50]. After prior resection, the recurrence can develop in the removed ovary or in the naïve, contralateral ovary (Fig. 2).

Peritoneal and DE recurrence

Peritoneal endometriosis or superficial endometriosis lesions are defined by the presence of endometrial deposits detected on peritoneal surface of pelvic organs, pelvic side walls or pouch of Douglas. The diagnosis of native peritoneal endometriosis is suggested by indirect signs such as the presence of adhesions. On MRI, superficial endometriotic lesions appear hyperintense on T1-weighted images when recent, or hypointense on T1-weighted images and heterogeneously on T2-weighted images reflecting the fibrotic component [51]. The application of chemical frequency-selective fat saturation suppresses the high signal intensity of fat tissues, thus enhancing visibility of small hemorrhagic lesions of endometriosis [51]. These small hemorrhagic hyperintense lesions on fat-suppressed T1-weighted images indicate active disease in case of peritoneal endometriosis recurrence.

Native deep pelvic endometriosis appears as infiltrative lesion usually surrounded by fibrous tissue and smooth muscle, both showing low signal intensity or isointensity to muscle on T1- and T2-weighted images [6,52]. Fat-saturated T1-weighted images show a mass or thickening, isointense to muscle, possibly with interspersed hyperintense foci that reflect hemorrhagic blood products [37]. DE lesions are most frequently located in the posterior compartment, involving the *torus uterinus*, uterosacral ligaments (USL), vagina, rectovaginal septum, pouch of Douglas, and rectosigmoid [53]. Deep endometriosis recurrence has MRI features similar to those of native DE, or manifests as solid infiltrative nodule located on post-hysterectomy vaginal vault (Fig. 10). MRI may help discriminate between recurrence and postoperative fibrotic tissue. Fibrotic tissue typically displays a very low signal on T2-weighted MR images (Fig. 3) [51]. The endometriotic recurrence tissue is hypointense with some high signal glandular focus on T2-weighted images (Fig. 11) and also with bright ''spots'' on fat-suppressed T1-weighted images. These bright spots are due to foci of hemorrhage surrounded by fibrotic inflammatory reaction (Fig. 10).

In addition, endometriosis is frequently complicated by adhesions, which are usually seen as spiculated, low-to-intermediate signal intensity bands on T1- and T2-weighted images [51]. They can indirectly present as distortion of normal anatomy, including elevation of the posterior vaginal fornix, posterior and lateral displacement of the uterus, ovaries, or both, loss of fat planes between the structures without a clear interface, hydrosalpinx, angulation of bowel loops, transition points in bowel diameter, and loculated fluid collections [49]. These findings can also be seen in postsurgical fibrosis (Fig. 3) and it may mimic native peritoneal endometriosis [54]. The radiologist should be very cautious before claiming the recurrence as it is a very difficult situation to manage by the surgeon.

Recurrence in the USL is suggested when there is irregular or nodular thickening of the USL. However, in a postoperative context, these criteria are not specific enough to affirm recurrent disease, thus generating false positive findings. In sum, irregular or nodular thickening must be associated with consistent clinical symptoms to declare recurrence.

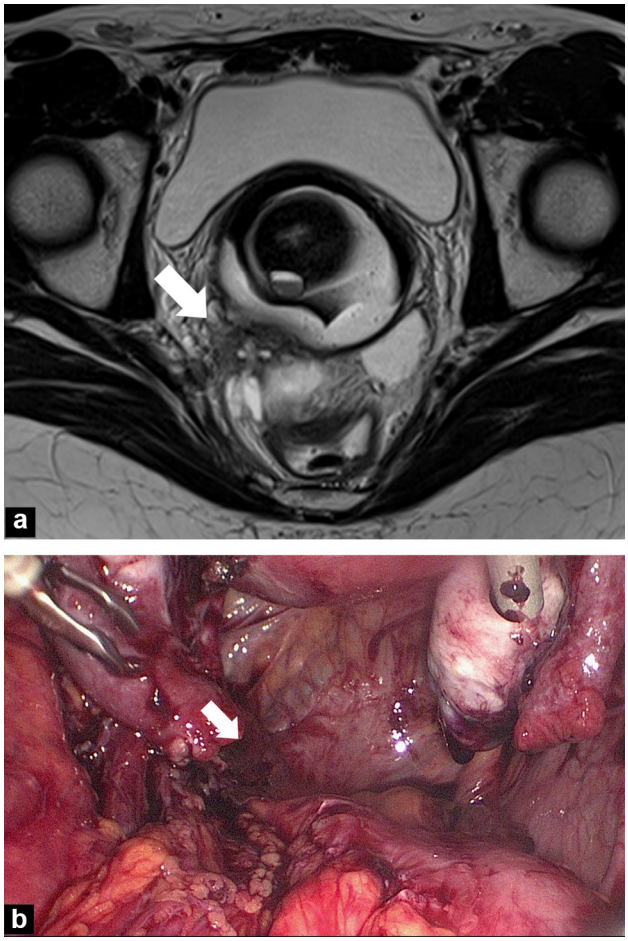

Figure 11. 32-year-old woman with endometriosis recurrence, 4 years after laparoscopic conservative surgical approach (LCSA) to remove right uterosacral ligament and vesical endometriosis: a: T2-weighted MR image in the axial plane, 4 years after the initial operation reveals a new recurrent spiculated low signal nodule in rectovaginal septum and on the local of right uterosacral ligament with some high signal glandular focus (arrow); b: photograph shows laparoscopic view of recurrence disease nodule on torus uterinus and a right uterosacral ligament thickening (arrow).

Adhesions and fibrotic nodule can cause extrinsic ureteral involvement and ureteral hydronephrosis without true endometrial tissue in ureteral wall. Intrinsic ureteral involvement occurs when ectopic endometriosis tissue is present in the mucosal or muscular layer of ureters, from deep infiltrating periureteral lesions [55]. The normal unopacified ureter can be difficult to analyze on MRI because it is only 4—5 mm in diameter, representing the limit of MRI spatial resolution [6]. On MRI the indirect signs of ureteral involvement are retractile periureteral adhesions associated or not with ureteral dilatation cranial to the obstruction site (Fig. 6) [56]. An indirect sign of ureteral endometriosis recurrence is ureterohydronephrosis. However, this sign can also be associated to postsurgical ureteral iatrogenic injury. The comparative studies and the appearance of an endometriotic ''de novo'' nodule surrounding the ureteral track can help differentiate between these two entities.

The postsurgical endometriosis bladder involvement can be related to iatrogenic endometrial implants by previous pelvic surgery or recurrence of previous bladder endometriotic lesions. The classical presentation of bladder endometriosis is a nodule infiltrating primarily the vesicouterine fold then extending to the round ligament and finally infiltrating the bladder wall, from the serosa to the mucosa, exhibiting typical hyperintense glandular elements on T1-weighted images that become hypointense on T2-weighted images (Fig. 7) [52,56]. In woman with postsurgical endometriosis recurrence, it is very important to find ''de novo'' lesion in vesical wall with typical high signal T1-weighted images glandular elements (Fig. 7). The bladder lesions can also be detected on TVU as hypoechogenic nodules in the vesicouterine pouch or bladder wall [2,6,57].

For some organs, endometriosis can exhibit some specific signs: the ''mushroom cap'' sign refers to the appearance of rectosigmoid lesions on T2-weighted images as a hypointense low fibrotic signal mass in the muscularis layer that protrudes into the intestinal lumen with hyperintense submucosal and mucosal layers that cover the mass and create an outline similar to that of a ''mushroom cap'' (Fig. 5) [52]. In the specific context of bowel endometriosis, the incidence of recurrence seems relatively low after segmental resection [58]. However, so far, little data is available with a sufficient follow-up. Afors et al. have evaluated the risk of recurrence according to surgical technique, and showed that the risk was significantly increased after rectal shaving while discoid and segmental resection had similar relatively low risk of recurrence (6.3%) [59].

To diagnose postoperative bowel endometriosis recurrence, it is very important to take in account the surgical approach, as in some cases, the surgeon can choose leaving in situ partial component of the disease, as mentioned before on postoperative findings of shaving bowel receptions. The radiologist must compare the postsurgical findings with presurgical examinations in order to find nodule ''de novo'' in rectum or bowel wall to differentiate recurrent from persistent disease.

It is also important to remember that DE recurrence could be extra-pelvic. The most common location of extra-pelvic endometriosis is the abdominal wall [60]. It is often associated with prior laparoscopic or surgical intervention and manifest as low signal nodule with some bright signal dilated gland in abdominal wall [60]. The diaphragm is an important site of endometriotic implants and manifests as atypical recurrence right-sided chest pain. MRI allows the diagnosis of diaphragmatic endometriosis with sensitivity between 78% and 83% [61]. In woman with suspected diaphragmatic or thoracic endometriosis, a diaphragmatic MRI examination should be added to pelvic MRI to detect recurrent disease.

Hence the true incidence of recurrence cannot be evaluated without knowledge of preoperative imaging findings as well as analysis of data from surgical report particularly to differentiate recurrence from residual lesions. These criteria agree the CORDES statement suggesting considering DE surgical sheet using the anatomical and surgical terminology [62].

Conclusion

The imaging features of patients with clinical endometriosis recurrence can be normal with postsurgical sequelae fibrosis or with active endometriosis disease TVS and MRI are good imaging methods to confirm clinical suspicion and to do a preoperative mapping of the native and recurrent endometriosis. Ultrasound is the first imaging method used to diagnose endometrioma recurrence; MRI could be superior to diagnose DE recurrence thanks to the capacity to detect small hemorrhagic peritoneal implants and pelvic fibrosis in order to differentiate active endometriotic tissue from sequelae fibrosis. Further large studies are needed to improve performance of imaging techniques to diagnose recurrence. CT scan and TVU are the most common imaging methods used to detect postsurgical complications.

Disclosure of interest

The authors declare that they have no competing interest.

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