6
Obstetrics and Gynecology

Standard Imaging Methods for Obstetrics and Gynecology

Overview

MRI has been established as a modality of choice for staging uterine cervical and endometrial cancer and for the differential diagnosis of pelvic masses. MRI should not be used for differential diagnosis of atypical genital bleeding, since cytological or histopathological diagnosis of the uterine cervix and endometrium can be easily performed with a Pap smear or biopsy. In Japan, concomitant contrast-enhanced CT is also commonly used for staging diagnosis, including intraperitoneal dissemination and distant metastases. Therefore, the role of MRI in staging gynecological cancer has been limited to local extension On the other hand, adnexal masses are often detected by chance by ultrasound or CT performed in a checkup or to diagnose other diseases. However, when they meet certain conditions (see FQ10), MRI, which is noninvasive and provides excellent diagnostic performance, is recommended for their differential diagnosis. Just before obtaining pelvic MRI, administration of a parasympatholytic agent (scopolamine butylbromide, Buscopan®) is recommended to inhibit intestinal peristalsis.[1)]

The basic procedure for diagnosing gynecological disease is the use of FSE T2-weighted images**.** High-speed imaging sequences such as SSFSE, HASTE, and SSFP should not be substituted because they result in contrast changes. However, these sequences play an important role in fetoplacental imaging, in which inhibiting motion artifacts is the top priority.[2)]

Because it permits post hoc reconstruction in any arbitrary plane, the use of 3D T2-weighted-images enables acquisition of images in planes perpendicular to the uterine body and cervix.[3)] However, tissue contrast is slightly inferior compared with 2D FSE T2-weighted images. It is therefore suitable for use in preoperative examinations in benign conditions such as uterine fibroids. However, it currently should not be used when determining treatment options, such as parametrial invasion of cervical cancer or myometrial invasion of endometrial cancer.

As discussed on page 366, the usefulness of diffusion-weighted images in diagnosing the local extension of endometrial cancer[4)] and cervical cancer[5)] has been established. This is also a useful method for distinguishing between benign and malignant ovarian tumors[6)] and between uterine fibroids and uterine sarcomas.[7)] Consequently, additional diffusion-weighted images from at least 1 plane are essential.

In recent years, 3T systems have also been extensively used for abdominal and pelvic imaging. With regard to performance, the signal-to-noise ratio (SNR) of these systems is better than that of 1.5T systems, which enables thinner slice thicknesses and more detailed images to be obtained. However, tissue contrast in T2-weighted images is better with 1.5T systems. Consequently, in the area of gynecology, clearly depicting the zonal anatomy of the uterus was initially difficult with 3T systems. Recently, however, it has become possible to obtain contrast that compares favorably with that of 1.5T systems, even in the uterus.[8)] There have been reports of the non-inferiority, and superiority in some diseases when using 3T systems compared with 1.5T systems. However, because the wide field of view makes it difficult to maintain the

uniformity of the magnetic field with 3T systems, their use is not recommended for giant uterine and ovarian tumors.

Detailed discussion

1. Endometrial cancer

MRI is used to stage the local extension of endometrial cancer. Myometrial invasion is the most important prognostic factor in endometrial cancer. The types of images used in its diagnosis are T2-weighted images, diffusion-weighted images, T2-weighted and diffusion-weighted fusion images, and contrast-enhanced T1-weighted images, including those obtained by dynamic contrast enhancement. Investigations in recent years have emphasized the usefulness of diffusion-weighted images.[4] To accurately evaluate the depth of myometrial invasion, scanning in planes perpendicular to the long and short axes of the uterus is important.[9] If cervical stromal invasion is seen, it is stage II disease, and extended surgery such as modified radical hysterectomy is recommended, which makes preoperative diagnosis important. Diffusion-weighted images have also been reported to be useful in this setting.[10]

As previously mentioned, concomitant contrast-enhanced CT is also used to diagnose dissemination and distant metastasis. However, fat-suppressed contrast-enhanced T1-weighted images are useful for diagnosing uterine serosal invasion or adnexal extension (stage IIIA), direct invasion to the vesical or rectal mucosa (stage IVA), and intraperitoneal dissemination (stage IVB). If a contrast medium is administered, dynamic contrast enhancement, which provides excellent diagnostic performance with respect to myometrial invasion,[4] should be performed.

○ Standard imaging methods for endometrial cancer (Table 1, Fig. 1)

As mentioned previously, the main role of MRI in Japan as a pretreatment examination for endometrial cancer is to evaluate local extension. MR examination including the following sequences may be sufficient: T2-weighted images parallel to the long and short axes of the uterus, T1-weighted images, diffusion-weighted images, and fat-suppressed contrast-enhanced T1-weighted images that includes dynamic contrast imaging. However, endometrial cancer is often low-risk pathology, i.e. well-differentiated endometrioid carcinoma, and stage IA disease. Therefore, omitting CT can be considered, particularly in young patients. When CT is omitted, a possible option is the addition of transverse imaging perpendicular to the body axis to facilitate the evaluation of lymph node metastases. Selecting sagittal and transverse planes parallel to the long and short axes of the uterus is often difficult for radiation technologists who are not familiar with gynecological examinations. Additional T2-like contrast-enhanced fast sequences, such as HASTE, may be considered to determine the uterine axis. The preferred settings to examine endometrial cancer are an FOV of 25 to 30 cm, slice thickness of 4 to 5 mm for a 1.5T system and 3 to 4 mm for a 3T system, and an interslice gap of approximately 10% to 20%.

Table 1. Examples of sequences for staging endometrial cancer (1.5/3T systems, phased-array coil)

	Imaging Method/Plane	Sequence	Imaging Range	Slice Thickness (mm)		Remarks
				1.5T	3T	
Required	T2-weighted/sagittal	FSE	Uterus/vagina	4 to 5	3 to 4	Parallel to long axis of uterine body
	T1-weighted/sagittal	SE				
	T2-weighted/transverse	FSE	Uterus/adnexa			Perpendicular to long axis of uterine body (short axis of uterine body)
	Diffusion-weighted/transverse or sagittal	EPI or FSE	Same range as T1- and T2-weighted images			Sagittal recommended if cervical stromal invasion suspected ADC map generation with b-value = 800 to 1,500 s/mm^2 required
	Dynamic contrast/transverse or sagittal	2D or 3D GRE		2 to 5	1.5 to 4	Sagittal recommended if cervical stromal invasion suspected Temporal resolution, ≤ 30 seconds, through minimum of 2 minutes
	Fat-suppressed contrast-enhanced T1-weighted images/sagittal					Parallel to long axis of uterine body
	Fat-suppressed contrast-enhanced T1-weighted images/transverse					Perpendicular to long axis of uterine body (short axis of uterine body)
Options for detailed evaluation	Additional survey imaging	SSFSE, HASTE, SSFP, etc.	Whole pelvis	Up to 10		Additional T2 contrast survey imaging to accurately determine the long and short axes of uterus
	T1-weighted/transverse	SE	Uterus/adnexa	4 to 5	3 to 4	Perpendicular to uterine body long axis (uterine body short axis)
	Diffusion-weighted /transverse, sagittal, or coronal	EPI or FSE	Uterus/vagina or uterus/adnexa	4 to 5	3 to 4	Addition of required angles that were not acquired
	Fat-suppressed contrast-enhanced T1-weighted images/coronal	2D or 3D GRE	Uterus/vagina/adnexa	2 to 5	1.5 to 4	Entire pelvic cavity
Options when CT omitted	T2-weighted/transverse or coronal	FSE	Whole pelvis or renal hilus and below	5 to 6		Perpendicular to body axis (normal transverse or coronal plane)
	T1-weighted/transverse or coronal	SE				
	Diffusion-weighted/transverse or coronal	EPI or FSE	Whole pelvis or whole abdomen			

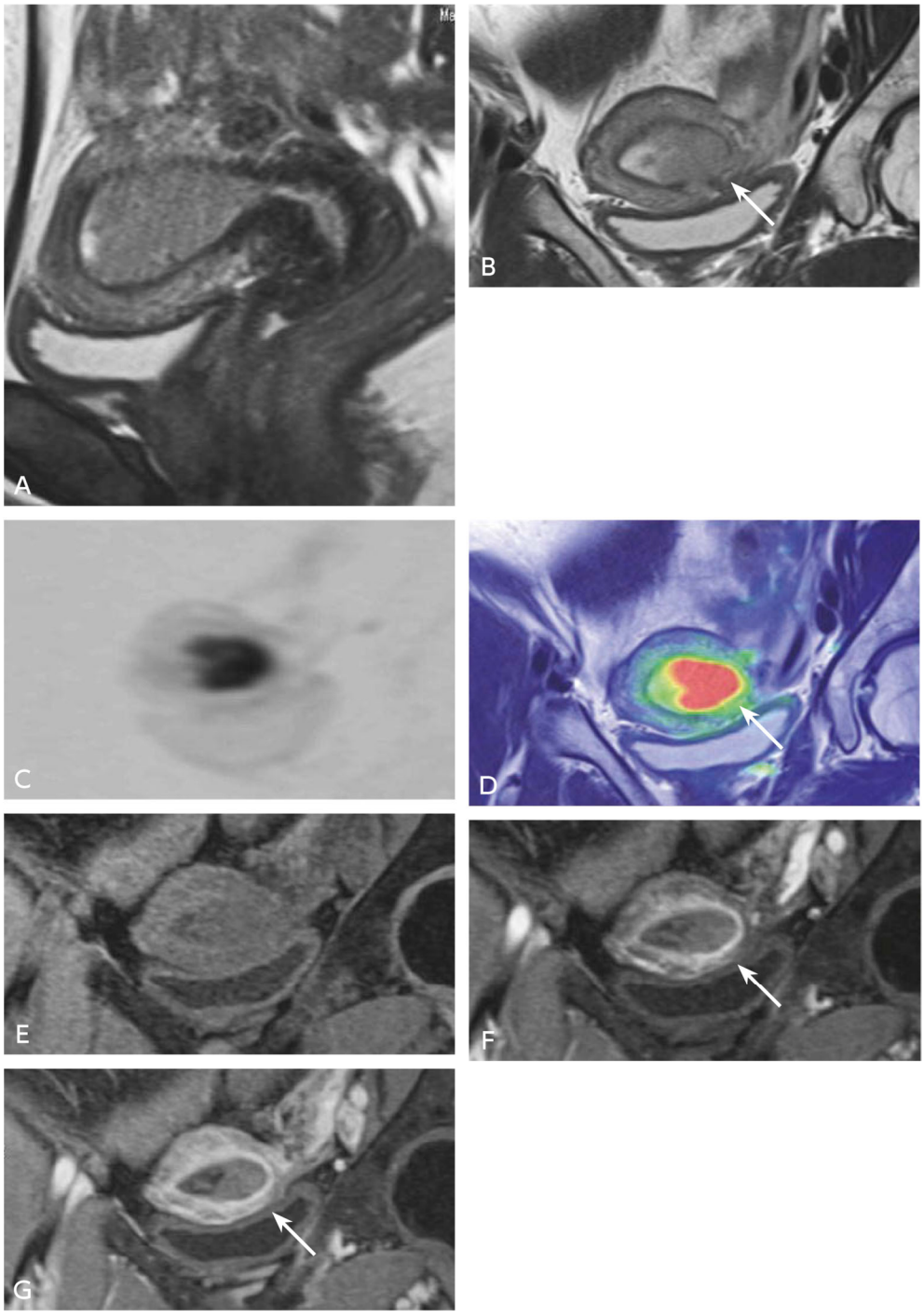

Figure 1. Endometrial cancer (stage IA)

A: sagittal T2-weighted image; B: coronal T2-weighted image; C: coronal diffusion-weighted image; D: coronal T2-/diffusion-weighted fusion image; E: Dynamic contrast-enhanced coronal image, pre-contrast; F: Coronal dynamic contrast-enhanced image, 60 seconds post-contrast; G: coronal fat-suppressed contrast-enhanced T1-weighted image

An exophytic mass that fills the endometrial cavity causes thinning of the junctional zone in the T2-weighted images (→) and is associated with superficial myometrial infiltration. This condition can also be clearly demonstrated on T2-/diffusion-weighted fusion imaging and early-phase dynamic contrast-enhanced imaging.

2. Cervical cancer

As in endometrial cancer, the role of MRI in cervical cancer is to assess local extension and measure tumor diameter. However, invasive cancer, which is an indication for radical hysterectomy, and microinvasive/noninvasive cancer are differentiated histopathologically, and microinvasive (stage IA) and noninvasive cancer are generally not indications for MRI.[11] However, MRI should be aggressively used in the following situations: the results of cytology and histology are inconsistent; an endophytic tumor is suspected on palpation and transvaginal ultrasound without any evidence of macroscopic masses on visual inspection or colposcopy; or histological type indicative of a poor prognosis. MRI can also provide some useful information in differentiating from hyperplastic lesions of the cervix, such as lobular endocervical glandular hyperplasia (LEGH), which is considered a precursor lesion of gastric-type endocervical adenocarcinoma, and Nabothian cysts and tunnel clusters. Gastric-type endocervical adenocarcinoma has a poor prognosis and is common in Japan.

○ Standard imaging methods for cervical cancer (Table 2, Fig. 2)

The basic approach is similar to that for endometrial cancer. Although tumor diameter is an important prognostic factor in cervical cancer, the General Rules for Clinical and Pathological Management of Uterine Cervical Cancer (4th edition) include size in staging the progression for stages IB and IIA exclusively. It therefore requires exact measurement. In particular, subdividing stage IB in the staging of cervical cancer is closely related to determining whether fertility preservation is indicated. T2-weighted images alone or with the addition of diffusion-weighted images are considered sufficient for staging the local extension of cervical cancer.[12] The usefulness of contrast-enhanced examinations has not been established, but there are several reports indicating that dynamic contrast enhancement is useful for visualizing non-invasive cancer and diagnosing parametrial invasion.

3. Myometrial lesions

The established roles played by MRI include qualitative diagnosis (mainly differentiating between fibroids and adenomyosis,[13] and distinguishing benign from malignant lesions) when myometrial lesions are suspected. In the case of fibroids, the roles include determining the number, size, and location of the lesions and predicting and assessing the effectiveness of uterine artery embolization (UAE) treatment.[14] Although MRI is expected to differentiate between fibroids and sarcomas in the clinical setting, a literature search did not provide strong evidence for such use, as discussed in FQ9.

○ Standard imaging methods for suspected myometrial lesions (Table 3)

As previously mentioned, differentiating between fibroids and adenomyosis and determining the size, location, and number of lesions are important for selecting treatment, and T2-weighted images are the basic sequence for this purpose. As in the examination of cervical and endometrial cancer, 3D T2-weighted images are useful despite limited contrast resolution. The multiplanar capability of 3D images clarifies the

relationship of the lesions to the endometrium and peripheral organs after reconstruction.[3] Although relevant evidence is lacking, MR is also useful in differentiating fibroids from sarcomas. In this setting, high signal intensity on T2-weighted images, restricted diffusion, and the presence of transient early enhancement and hemorrhagic necrosis are reported to be signs of malignancy. Therefore, we recommend contrast-enhanced examinations including dynamic contrast enhancement to exclude sarcomas.[7, 15]

4. Recommended MR sequences for diagnosing patients with suspected uterine malformations or with primary amenorrhea

Müllerian duct anomalies (MDAs) such as bicornuate uterus are mainly diagnosed in the reproductive period. To evaluate uterine morphology, T2-weighted images (sagittal and transverse or 3D imaging) with a slice thickness of ≤ 4 mm are required. Since MDAs may appear in combination with unilateral vaginal atresia, the vulva should be included in transverse T2-weighted images. Because an obstructed hemivagina may cause endometriosis, T1-weighted images (with and without fat suppression) are occasionally necessary. Coronal T2-weighted images including the upper abdomen should be added to screening for co-existing urinary tract malformations (unilateral renal agenesis is common). During childhood and adolescence, diagnosing disorders of sexual development is important. MR can provide morphological information about the uterus, vagina, and clitoris. In addition, we should diagnose the morphological characteristics and the location of the gonads. When cryptorchidism is highly suspected, the addition of diffusion-weighted images to fat-suppressed T2-weighted images or STIR covering the inguinal region is helpful, where cryptorchids are highly likely to be located. If there are no uterine or ovarian abnormalities, MRI of the sella turcica is recommended to explore the hypothalamic or pituitary abnormalities in addition to endocrine testing. If congenital adrenal hyperplasia is suspected, it is important investigating the morphology of the adrenals in the coronal plane.

5. Adnexal lesions

The aims of obtaining MRI in evaluating adnexal masses are determining the organ of origin, qualitative diagnosis, and staging (Fig. 3). The standard sequences required for these aims are shown in Table 4. Because ovarian tumors often become very large, the FOV and slice thickness/slice interval need to be flexibly adjusted to include the entire mass. With high-grade serous carcinoma, the most common adnexal malignancies, extensive intraperitoneal dissemination is often already present at onset. As discussed later, distant metastasis, including dissemination, is often diagnosed by contrast-enhanced CT in Japan. However, in patients such as those for whom the use of a contrast medium is contraindicated, diffusion-weighted images can be used to evaluate the abdominal cavity as a whole.

Table 2. Examples of sequences in staging cervical cancer (1.5/3T systems, phased-array coil)

	Imaging Method/Plane	Sequence	Imaging Range	Slice Thickness (mm)		Remarks
				1.5T	3T	
Required	T2-weighted/sagittal	FSE	Uterus/vagina	4 to 5	3 to 4	Parallel to long axis of uterine cervix
	T1-weighted/sagittal	SE				
	T2-weighted/transverse	FSE	Uterus/adnexa			Perpendicular to long axis of uterine cervix
	Diffusion-weighted/transverse or sagittal	EPI or FSE	Same range as T1- and T2-weighted images			Sagittal plane recommended if vaginal invasion is suspected ADC map generation with b-value = 800 to 1,500 s/mm^2 required
Option for detailed evaluation	Additional survey imaging	SSFSE, HASTE, SSFP, etc.	Whole pelvis	Up to 10		Additional T2 contrast survey imaging to accurately determine the long and short axes of uterus
	T1-weighted/transverse	SE	Uterus/adnexa	4 to 5	3 to 4	Perpendicular to long axis of uterine cervix
	Diffusion-weighted/transverse, sagittal, or coronal	EPI or FSE	Uterus/vagina or uterus/adnexa	4 to 5	3 to 4	Any projections are acceptable
	MR urography	2D	Kidney to urinary bladder	30 to 40		
	Dynamic imaging /transverse	2D or 3D GRE	Uterus/vagina	2 to 5	1.5 to 4	Transverse plane recommended for parametrial invasion, sagittal for invasion to the urinary bladder/rectum Temporal resolution ≤ 30 seconds, through minimum of 2 minutes
	Fat-suppressed contrast-enhanced T1-weighted/sagittal		Uterus/vagina			Parallel to long axis of uterine cervix
	Fat-suppressed contrast-enhanced T1-weighted/transverse		Uterus/adnexa			Perpendicular to long axis of uterine cervix
	Fat-suppressed contrast-enhanced T1-weighted/coronal		Uterus/vagina/adnexa	2 to 5	1.5 to 4	Entire pelvic cavity
Options when CT omitted	T2-weighted/transverse or coronal	FSE	Whole pelvis or renal hilus and below	5 to 6		Perpendicular to body axis (normal transverse or coronal plane)
	T1-weighted/transverse or coronal	SE				
	Diffusion-weighted/transverse or coronal	EPI or FSE				

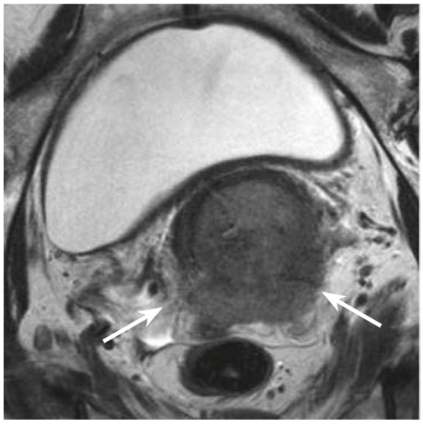

Figure 2. Cervical cancer (stage IIB)

T2-weighted transverse image of the short axis of the cervix: A mass occupying an extensive area of the cervix is penetrating the cervical stroma postero-laterally and protruding into parametrium (→).

Table 3. Examples of sequences for diagnosing myometrial lesions (1.5/3T systems, phased-array coil)

<table>
<tr><th rowspan="2"></th><th rowspan="2">Imaging Method/Plane</th><th rowspan="2">Sequence</th><th rowspan="2">Imaging Range</th><th colspan="2">Slice Thickness (mm)</th><th rowspan="2">Remarks</th></tr>
<tr><th>1.5T</th><th>3T</th></tr>
<tr><td rowspan="4">Required</td><td>T2-weighted/sagittal</td><td>FSE</td><td rowspan="3">Uterus/vagina</td><td rowspan="4">4 to 5</td><td rowspan="4">3 to 4</td><td rowspan="3">Parallel to long axis of uterine body</td></tr>
<tr><td>T1-weighted/sagittal</td><td>SE</td></tr>
<tr><td>Fat-suppressed T1-weighted/sagittal</td><td>SPIR, SPAIR, Dixon, CHESS</td></tr>
<tr><td>T2-weighted/transverse</td><td>FSE</td><td>Uterus/adnexa</td><td>Perpendicular to long axis of uterine body (short axis of uterine body)</td></tr>
<tr><td>Diffusion-weighted/transverse or sagittal</td><td>EPI or FSE</td><td>Same range as T1- and T2-weighted images</td><td>ADC map generation with b-value = 800 to 1,500 s/mm^2 required</td></tr>
<tr><td>Option for detailed evaluation</td><td>Additional survey imaging</td><td>SSFSE, HASTE, SSFP, etc.</td><td>Whole pelvis</td><td colspan="2">Up to 10</td><td>Additional T2 contrast-enhanced survey imaging to accurately determine the long and short axes of uterus</td></tr>
<tr><td rowspan="4">Option to exclude sarcoma/assess whether uterine artery embolization (UAE) indicated</td><td>T1-weighted/transverse</td><td>SE</td><td>Uterus/adnexa</td><td>4 to 5</td><td>3 to 4</td><td>Perpendicular to long axis of uterine body (short axis of uterine body)</td></tr>
<tr><td>Dynamic imaging/ transverse or sagittal</td><td rowspan="3">2D or 3D GRE</td><td>Uterus/vagina/adnexa</td><td rowspan="3">2 to 5</td><td rowspan="3">1.5 to 4</td><td>Temporal resolution 15 to 20 seconds, through minimum of 2 minutes</td></tr>
<tr><td>Fat-suppressed contrast-enhanced T1-weighted /sagittal</td><td>Uterus/vagina</td><td>Parallel to long axis of uterine body</td></tr>
<tr><td>Fat-suppressed contrast T1-weighted/transverse</td><td>Uterus/adnexa</td><td>Perpendicular to long axis of uterine body (short axis of uterine body)</td></tr>
<tr><td>Option to shorten test duration</td><td>3D T2-weighted/sagittal</td><td>Cube, VISTA, SPACE, etc.</td><td>Uterus/vagina</td><td colspan="2">0.6 to 1.2</td><td>Isotropic imaging of whole uterus is required in any direction</td></tr>
</table>

○ Standard imaging methods when an adnexal lesion is suspected (Table 4)

The differential diagnosis of an adnexal mass is performed with the combination of lesion morphology, signal intensity, degree of restricted diffusion, and contrast enhancement. T2-weighted images are important for evaluating the morphological characteristics of masses[16] and elucidating their relationships to other pelvic organs. They should be obtained with FSE sequences to maintain tissue contrast. T1-weighted images and fat-suppressed T1-weighted images are useful for detecting hemorrhage and fat and are

necessary for the differential diagnosis of masses.[6, 16 17] In addition, in-phase GRE imaging and opposed-phase GRE imaging are effective in depicting small amounts of fat and should be added for this purpose. The enhancement pattern in dynamic contrast enhancement and the ADC values in diffusion-weighted images are important for distinguishing between benign and malignant ovarian tumors.[6, 16] With some exceptions (e.g., endometriotic cysts of the ovary without complicating malignancy, simple cysts without mural nodules), these methods are virtually essential. In these instances, the dynamic curve should be visually assessed and an ADC map generated whenever possible.

6. CT imaging to determine the clinical stage of gynecological malignancies

CT is useful for diagnosing lymph node and distant metastases, as well as intraperitoneal dissemination, in gynecological malignancies.

The patients should be scanned from the diaphragm to the inferior border of the pubis. However, the chest is included in the case of an advanced tumor or highly malignant histological subtype that may have metastasized to the chest. Use of an oral contrast medium facilitates the differentiation of gastrointestinal tract and peritoneal lesions. The imaging generally involves pre-contrast and post-contrast single-phase imaging performed 60 to 100 seconds after contrast medium injection. Particularly in ovarian, fallopian tube, and peritoneal cancers (high-grade serous carcinomas), accurately determining the location of disseminated lesions is extremely important. Because coronal and sagittal images generated by MPR are considered superior to standard transverse images for detecting dissemination,[18] it is important to use a thin slice thickness that can generate MPR images, in addition to acquiring images with a standard 5-mm slice thickness.

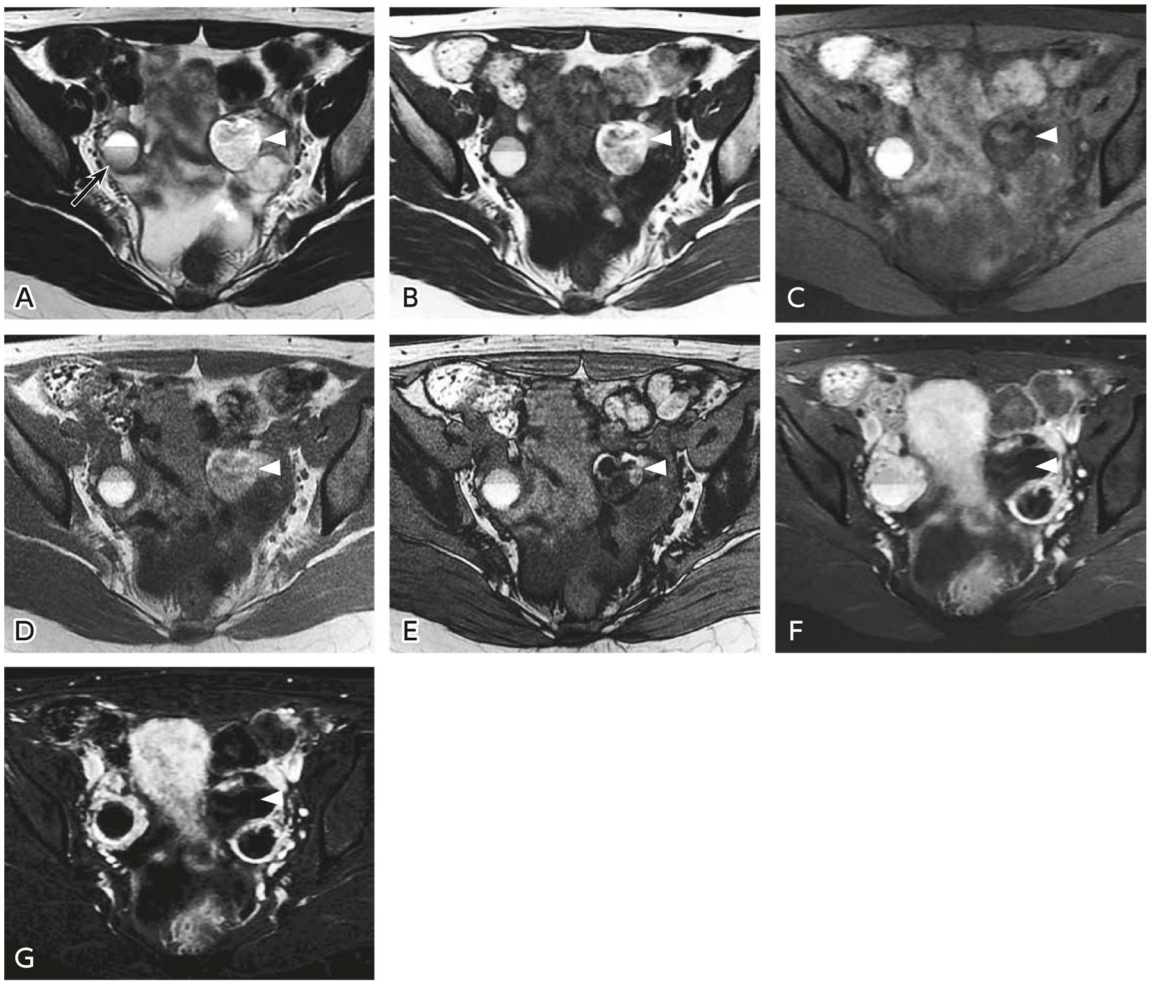

Figure 3. Endometriotic cyst of the right ovary and mature teratoma of the left ovary

A: T2-weighted image; B: T1-weighted image; C: Fat-suppressed T1-weighted image; D: GRE T1-weighted image, in phase; E: GRE T1-weighted image, opposed phase; F: Fat-suppressed T1-weighted image; G: Contrast subtraction image

Formation of a fluid level is seen in a cystic mass in the right ovary (→). A hyperintense region in the dorsal part is not suppressed on the fat-suppressed T1-weighted image, indicating hemorrhagic contents. This region shows slight hypointensity (shading) on the T2-weighted image, suggesting an endometriotic cyst. The existence of the enhanced region is hard to detect on contrast-enhanced T1-weighted images because the contents show hyperintensity before contrast administration. However, no enhanced solid portion is seen on the subtraction image. A cystic mass in the left ovary (▷) that appears as a region of hyperintensity in the T1-weighted images shows a reduced signal on the fat-suppressed T1-weighted image, and a mature teratoma characterized by fat contents is diagnosed. Compared with the in-phase image, the signal reduction in the region interspersed with a fat component is more distinct in the opposed-phase image. However, the region that contains only fat remains hyperintense.

^{18}F-FDG-PET has been found to provide high diagnostic performance in detecting lymph node and distant metastases.[19] In Japan, ^{18}F-FDG-PET in staging and diagnosing recurrence of gynecological malignancies is covered by national health insurance only when they cannot be definitively diagnosed by other imaging modalities. However, as mentioned in CQ16, many guidelines from Europe and the United States indicate that ^{18}F-FDG-PET/CT should be selected from the outset for high-risk patients.[9, 20] On the

other hand, there are regional differences in accessibility of not only PET/MRI, but also PET/CT. Given these circumstances, it is currently not recommended as a routinely performed modality.

Table 4. Examples of sequences in diagnosing adnexal mass (1.5/3T systems, phased-array coil)

	Imaging Method/Plane	Sequence	Imaging Range	Slice Thickness (mm)		Remarks
				1.5T	3T	
Required	T2-weighted/sagittal	FSE	Pelvic cavity, including the whole tumor	4 to 8	3 to 6	Slice thickness/interval and FOV depend on tumor diameters
	T1-weighted/transverse	GRE				Both in-phase and opposed-phase imaging
	Fat-suppressed T1-weighted/transverse	SPIR, SPAIR, etc.				
	T2-weighted/transverse	FSE				
	Diffusion weighted/transverse or sagittal	EPI or FSE				ADC map generation with b-value = 800 to 1,500 s/mm^2 required
	Dynamic contrast imaging/ transverse or sagittal	2D or 3D GRE		2 to 8	1.5 to 6	Temporal resolution ≤ 30 seconds, through minimum of 2 minutes
	Fat-suppressed contrast-enhanced T1-weighted/sagittal					
	Fat-suppressed contrast-enhanced T2-weighted/transverse					
Options to shorten test duration	T1-weighted/transverse and fat-suppressed T1-weighted/transverse	3-point DIXON (e.g., LAVA-FLEX, mDIXON)		4 to 8	3 to 6	Imaging with and without fat suppression and in-phase and opposed-phase T1-weighted images can be obtained once using the 3-point Dixon method.
Options for simultaneous evaluation of intraperitoneal dissemination	Fat-suppressed T2-weighted or STIR/coronal	FSE/STIR	From diaphragm to pelvic floor	4 to 8	3 to 6	Can be divided into 2 stacks for upper and lower abdomen
	Diffusion-weighted/coronal	EPI or FSE				
	Fat-suppressed contrast-enhanced T1-weighted/coronal	2D or 3D GRE				

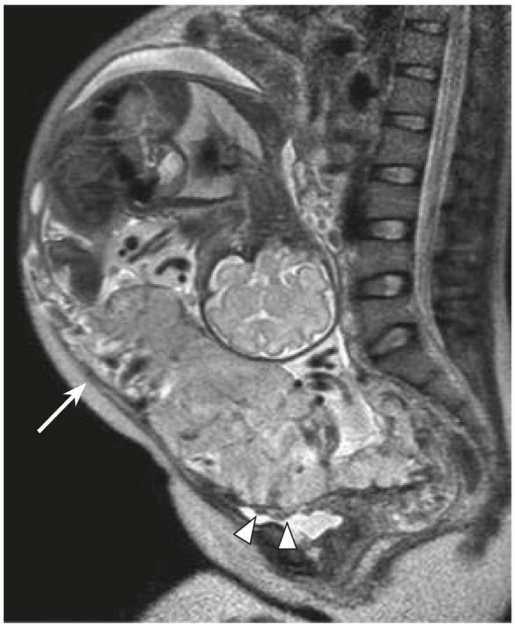

Figure 4. Placenta percreta, 32 weeks of gestation

SSFSE, T2-weighted sagittal image: The inferior part of the anterior uterine wall at the placental attachment site is protruding, and the myometrium in this area is indistinct (▷). Arrow indicates normal myometrium below the placenta.

Table 5. Examples of sequences in placental imaging (1.5T systems, phased-array coil)

	Imaging Method/Plane	Sequence	Imaging Range	Slice Thickness (mm)	Remarks
				1.5T	
Required	T2-weighted/sagittal	SSFSE	Uterus	5 to 10	Parallel to long axis of uterine body
		SSFP			
	T1-weighted/sagittal	SE or GRE			
	T2-weighted/transverse	SSFSE or SSFP			Perpendicular to long axis of uterine body (short axis of uterine body)
Options for detailed evaluation	T2-weighted/coronal	SSFSE, HASTE, SSFP, etc.			In placenta accreta spectrum, the plane perpendicular to the placenta–myometrium interface at the site of suspected adhesion should be added.
	Diffusion-weighted/transverse or sagittal	EPI or FSE			ADC map generation with b-value = 800 to 1,500 s/mm^2 required
	Fat-suppressed T1-weighted/sagittal	SPIR, SPAIR, etc.			Added when diagnosing hemorrhagic lesions such as subchorionic hematomas

7. Placental lesions

Because most placental lesions (e.g., placenta accreta spectrum, uteroplacental circulatory disturbance, placental tumor) are detected by ultrasonography, MRI is often performed when sufficient information is not obtained by ultrasound, or a more precise evaluation is required.[21] Although the use of 1.5T systems is recommended, taking into account factors such as the specific absorption ratio (SAR) and magnetic field, the use of 3T systems is also permitted.[21] Although imaging is performed in the supine position when possible, examinees in late pregnancy may have difficulty maintaining this position due to pressure on the inferior vena cava by the uterus. Consequently, the imaging obtained in the left lateral decubitus position is acceptable.[22] Moreover, the longer the imaging duration, the greater the artifacts caused by fetal movement. The total examination time should therefore be shortened with fast sequences.[21] As sequences with breath-holding such as SSFSE can reduce artifacts, it is worth trying if the patient can hold her breath.

○ Standard methods for antepartum imaging of the placenta (Table 5)

Although recommended sequences are different by suspected condition, placenta accreta spectrum may be the condition that most frequently requires MR. The sequences indicated below are an example for diagnosing placenta accreta spectrum. Specifically, they are SSFSE T2-weighted images and SSFP, which are used to evaluate placental morphology and detect lesions, and T1-weighted images, which are useful for detecting hemorrhage and hematomas near the placenta or in the cervical canal. T1-weighted images are also useful for evaluating the relationship to the surrounding organs based on the presence or absence of interposed fatty tissue.[21] The sagittal plane is the basic plane to diagnose placenta accreta spectrum, because it often occurs in an area of Caesarean section scarring. However, the angle should be changed as needed depending on the site of placental adhesion and the purpose of the imaging.

Secondary source materials used as references

1) Johnson W et al: The value of hyoscine butylbromide in pelvic MRI. Clin Radiol 62: 1087-1093, 2007
2) Kim JA, Narra VR: Magnetic resonance imaging with true fast imaging with steady-state precession and half-Fourier acquisition single-shot turbo spin-echo sequences in cases of suspected placenta accreta. Acta Radiol 45: 692-698, 2004
3) Proscia N et al: MRI of the pelvis in women: 3D versus 2D T2-weighted technique. AJR Am J Roentgenol 195: 254-259, 2010
4) Andreano A et al: MR diffusion imaging for preoperative staging of myometrial invasion in patients with endometrial cancer: a systematic review and meta-analysis. Eur Radiol 24: 1327-1338, 2014
5) Park JJ et al: Parametrial invasion in cervical cancer: fused T2-weighted imaging and high-b-value diffusion-weighted imaging with background body signal suppression at 3 T. Radiology 274: 734-741, 2015
6) Sala E et al: The role of dynamic contrast-enhanced and diffusion weighted magnetic resonance imaging in the female pelvis. Eur J Radiol 76: 367-385, 2010
7) Lakhman Y et al: Differentiation of uterine leiomyosarcoma from atypical leiomyoma: diagnostic accuracy of qualitative MR Imaging features and feasibility of texture analysis. Eur Radiol 27: 2903-2915, 2017
8) Kataoka M et al: MRI of the female pelvis at 3T compared to 1.5T: evaluation on high-resolution T2-weighted and HASTE images. J Magn Reson Imaging 25: 527-534, 2007
9) Nougaret S et al: Endometrial cancer MRI staging: updated guidelines of the European Society of Urogenital Radiology. Eur Radiol, 2018
10) Lin G et al: Endometrial cancer with cervical stromal invasion: diagnostic accuracy of diffusion-weighted and dynamic contrast enhanced MR imaging at 3T. Eur Radiol 27: 1867-1876, 2017
11) Lee SI, Atri M: 2018 FIGO Staging system for uterine cervical cancer: enter cross-sectional imaging. Radiology 292: 15-24, 2019

12) Woo S: Magnetic resonance imaging for detection of parametrial invasion in cervical cancer: an updated systematic review and meta-analysis of the literature between 2012 and 2016. Eur Radiol 28: 530-541, 2018
13) Togashi K et al: Enlarged uterus: differentiation between adenomyosis and leiomyoma with MR imaging. Radiology 171: 531-534, 1989
14) Siddiqui N et al: Uterine artery embolization: pre- and post-procedural evaluation using magnetic resonance imaging. Abdom Imaging 38: 1161-1177, 2013
15) Bi Q et al: Utility of clinical parameters and multiparametric MRI as predictive factors for differentiating uterine sarcoma from atypical leiomyoma. Acad Radiol 25: 993-1002, 2018
16) Thomassin-Naggara I et al: Adnexal masses: development and preliminary validation of an MR imaging scoring system. Radiology 267: 432-443, 2013
17) Sugimura K et al: Pelvic endometriosis: detection and diagnosis with chemical shift MR imaging. Radiology 188: 435-438, 1993
18) Pannu HK et al: Multidetector CT of peritoneal carcinomatosis from ovarian cancer. Radiographics 23: 687-701, 2003
19) Gee MS et al: Identification of distant metastatic disease in uterine cervical and endometrial cancers with FDG PET/CT: analysis from the ACRIN 6671/GOG 0233 multicenter trial. Radiology 287: 176-184, 2018
20) Expert Panel on Women's Imaging and Radiation Oncology-Gynecology: Siegel CL, et al. Pretreatment planning of invasive cancer of the cervix, 2020
21) Jha P C et al: Society of Abdominal Radiology (SAR) and European Society of Urogenital Radiology (ESUR) joint consensus statement for MR imaging of placenta accreta spectrum disorders. Eur Radiol 30: 2604-2615, 2020
22) Leyendecker JR et al: Maternal MRI during and after pregnancy: Leyendecker JR et al (eds): Practical guide to abdominal and pelvic MRI 2nd ed. Lippincott Williams & Wilkins, p171-172, 2010

BQ 61 Does MRI contribute to diagnosing uterine fibroids?

Statement

In patients who cannot be diagnosed by bimanual examination or ultrasound, MRI contributes to qualitative diagnosis and is therefore recommended.

In patients scheduled to undergo invasive uterus-preserving treatment [e.g., myomectomy, UAE, and focused ultrasound surgery (FUS)] MRI is useful for accurately determining the locations, sites, and number of fibroids and is therefore recommended.

Background

Bimanual examination and ultrasonography are the first choices for diagnosing uterine fibroids. However, for patients for whom these methods do not result in a diagnosis, an MRI examination may be ordered. In patients scheduled to undergo invasive uterus-preserving treatment (e.g., myomectomy, UAE, and FUS), MRI is performed to accurately determine the locations, sites, and number of fibroids. This discussion outlines the usefulness of MRI for diagnosing uterine fibroids.

Explanation

The diagnosis of uterine fibroids is made primarily through bimanual examination and the use of transvaginal ultrasonography (TVUS). MRI is not generally performed as a screening examination.[1)] The main circumstances in which MRI is ordered are: ① for detailed examination in patients for whom ultrasound does not provide a diagnosis (particularly when malignancies such as sarcoma cannot be ruled out clinically because a tendency for rapid enlargement is seen or based on pelvic examination findings, for example); and ② for preoperative evaluation of patients scheduled to undergo invasive uterus-preserving treatment (e.g., myomectomy, UAE, and FUS). In a comparison with surgical specimens of submucosal leiomyoma, MRI (sensitivity, 100%; specificity, 91%) provided better results than TVUS (sensitivity, 83%; specificity, 90%) and hysteroscopy (sensitivity, 82%; specificity, 87%).[2)] Multiple investigations of symptomatic fibroids showed that MRI results changed the diagnosis or treatment plan for approximately 20% of patients. Based on these investigations, MRI is recommended to accurately determine the locations, sites, and number of fibroids in patients scheduled to undergo invasive treatment (Fig. 1). In addition, MRI that includes diffusion-weighted imaging is considered useful for predicting and assessing the efficacy of UAE, and MRI-guided FUS (MRgFUS) contributes to intraoperative monitoring and the selection of indicated patients. A 2019 meta-analysis that examined the correlation between ADC values before UAE and the reduction in fibroid size reported that the ADC values were not clearly useful in predicting treatment efficacy.[3)] On the other hand, hormone therapy with gonadotropin-releasing hormone (GnRH) agonists or antagonists is a widely used drug therapy, and it has been reported that good tumor shrinkage is likely with such therapy in fibroids that show hyperintensity on T2-weighted images.[4)]

MRI of typical fibroids shows that they are hypointense masses with distinct borders in T2-weighted images. However, they may be visualized as areas of hyperintensity on T2-weighted images as the result of various types of degeneration or variants, complicating their differentiation from malignancies such as sarcomas.[5, 6] Some fibroids can be diagnosed based on characteristic imaging findings, as in the case of red degeneration and lipoleiomyomas. Referencing diffusion-weighted images and ADC maps is useful for diagnosing leiomyomas that show hyperintensity on T2-weighted images due to severe edema or hydropic degeneration. However, benign cellular leiomyomas have a high cell density that restricts water diffusion, which occasionally makes it difficult to distinguish them from sarcomas (Fig. 2). There have been a number of investigations in recent years regarding the differentiation of fibroids and sarcomas using MRI. The main points regarding differentiation are summarized in the guidelines of the European Society of Urogenital Radiology, and details are provided in FQ9. Both subserosal leiomyomas and benign fibromatous tumors of the ovaries (e.g., fibromas and Brenner tumors) often show hypointensity on T2-weighted images, which occasionally complicates differentiation. MRI visualization of flow voids that continue from the uterine body has been found to be useful for diagnosing subserosal leiomyomas, and analyzing the contrast pattern of dynamic MRI has been reported to be useful for differentiating fibroids and fibromas.[7]

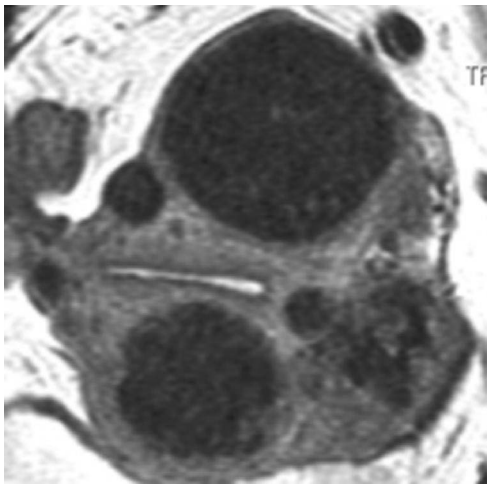

Figure 1. Multiple uterine fibroids

MRI, T2-weighted image: Imaging performed in the uterine body short-axis plane for pre-myomectomy evaluation. Aspects such as the sites and number of fibroids and the distances between the endometrium and fibroids are clearly visualized.

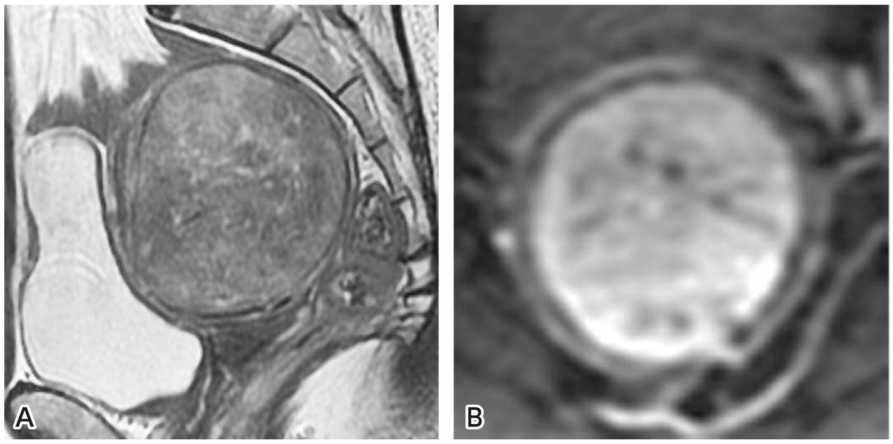

Figure 2. Cellular leiomyoma

A: MRI, T2-weighted sagittal image: An intramyometrial mass showing slight non-homogeneous hyperintensity is seen.
B: MRI, diffusion-weighted image, b-value = 800 s/mm^2: The mass shows hyperintensity and a relatively low ADC (1.08 × 10^{-3} mm^2/s).

Search keywords and secondary sources used as references

PubMed was searched using the following keywords: leiomyoma, myoma, fibroid, uterus, uterine, MRI, and magnetic resonance.

In addition, the following was referenced as a secondary source.

1) Kubik-Huch RA et al: European Society of Urogenital Radiology (ESUR) guidelines: MR imaging of leiomyomas. Eur Radiol 28: 3125-3137, 2018

References

1) Parker WH: The utility of MRI for the surgical treatment of women with uterine fibroid tumors. Am J Obstet Gynecol 206: 31-36, 2012
2) Dueholm M et al: Evaluation of the uterine cavity with magnetic resonance imaging, transvaginal sonography, hysterosonographic examination, and diagnostic hysteroscopy. Fertil Steril 76: 350-357, 2001
3) Dao D et al: The utility of apparent diffusion coefficients for predicting treatment response to uterine arterial embolization for uterine leiomyomas: a systematic review and meta-analysis. Diagn Interv Radiol 25: 157-165, 2019
4) Oguchi O et al: Prediction of histopathologic features and proliferative activity of uterine leiomyoma by magnetic resonance imaging prior to GnRH analogue therapy: correlation between T2-weighted images and effect of GnRH analogue. J Obstet Gynaecol 21: 107-117, 1995
5) Hricak H et al: Uterine leiomyomas: correlation of MR, histopathologic findings, and symptoms. Radiology 158: 385-391, 1986
6) Yamashita Y et al: Hyperintense uterine leiomyoma at T2-weighted MR imaging: differentiation with dynamic enhanced MR imaging and clinical implications. Radiology 189: 721-725, 1993
7) Thomassin-Naggara I et al: Value of dynamic enhanced magnetic resonance imaging for distinguishing between ovarian fibroma and subserous uterine leiomyoma. J Comput Assist Tomogr 31: 236-242, 2007

BQ 62 Is MRI recommended to diagnose adenomyosis?

Statement

MRI is recommended to confirm the diagnosis and clarify complications when transvaginal ultrasound shows abnormal findings in the myometrium that suggest adenomyosis.

Background

Because the symptoms of adenomyosis, such as dysmenorrhea and hypermenorrhea, are nonspecific, it is difficult to confirm the diagnosis based on clinical criteria alone. In routine practice, transvaginal ultrasonography is usually performed first, and MRI is often performed for patients for whom the diagnosis cannot be confirmed by ultrasonography. This discussion summarizes the evidence regarding the usefulness of MRI for diagnosing adenomyosis.

Explanation

The reported sensitivity and specificity for the diagnosis of adenomyosis range from 70% to 86% and 86% to 93%, respectively, for conventional MRI, compared with 65% to 89% and 65% to 98% for transvaginal ultrasonography; thus, no significant difference in diagnostic performance was seen between these modalities.[1-3] However, a 2010 meta-analysis found that sensitivity and specificity were 77% and 89%, respectively, for MRI and 72% and 81%, respectively, for transvaginal ultrasonography, indicating higher diagnostic performance with MRI.[4]

In patients with complicating uterine fibroids, who account for approximately 50% of patients with adenomyosis, sensitivity and specificity were 33% and 78%, respectively, for transvaginal ultrasonography and 67% and 82%, respectively, for MRI.[1] Thus, the diagnostic accuracy of MRI was superior to that of transvaginal ultrasonography. Moreover, in patients with uterine enlargement, MRI was found to provide high diagnostic accuracy in determining whether the cause was fibroids or adenomyosis.[5]

A frequently reported MRI finding in adenomyosis is diffuse or local thickening of the junctional zone (JZ) in T2-weighted images. This finding reflects smooth muscle hyperplasia associated with ectopic endometrium.[6] The normal JZ is ≤ 8-mm thick,[7] and the JZ thickness generally considered the criterion for adenomyosis is ≥ 12 mm. The reported rates of sensitivity and specificity with this criterion range from 63% to 93% and 91% to 96%, respectively.[1, 3] Also examined as a criterion for evaluating JZ thickening was the ratio of the thickness of the JZ at its thickest site to the thickness of the myometrium as a whole (JZmax/entire myometrium). Using a criterion of ≥ 40%, sensitivity and specificity of 65% and 92.5%, respectively, for adenomyosis were reported.[1] In addition, there have been numerous reports that the presence of punctiform areas of hyperintensity in the myometrium in T2-weighted images is also a useful finding for diagnosis. This finding reflects cystic ductal dilatation of ectopic endometrium within the lesion[6] and is highly specific (99%), although it is present in only half of cases (Figs. 1 and 2).[1]

In recent years, the classification of adenomyosis according to the findings of MRI into 3 subtypes (internal adenomyosis, external adenomyosis, and adenomyoma) has been described.[8] Internal adenomyosis is visualized as JZ thickening, as discussed above. External adenomyosis is visualized in T2-weighted images as hypointense masses with indistinct borders that include microcyst structures that are separate from the JZ and continuous with the uterine serosa. Adenomyoma is a subtype in which masses that are not continuous with either the JZ or the serosal surface form in the myometrium. External adenomyosis is often seen in the posterior wall, and evidence suggests that it is related to deep endometriosis (Fig. 3).[9]

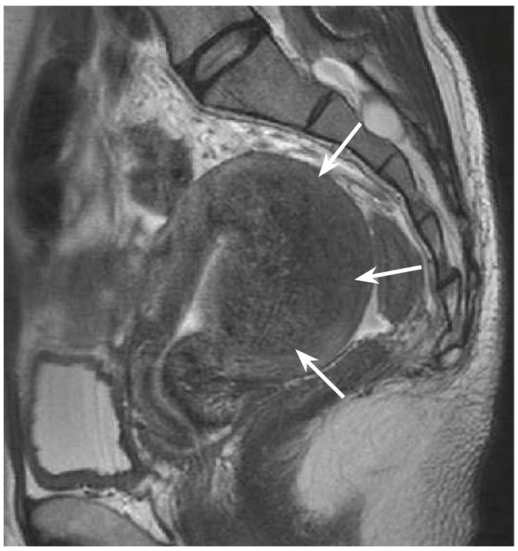

Figure 1. Adenomyosis

MRI, T2-weighted sagittal image: The thickened JZ (→) shows hypointensity on the posterior wall of the uterine body, and the interior includes numerous punctiform areas of hyperintensity. This is a typical image for adenomyosis.

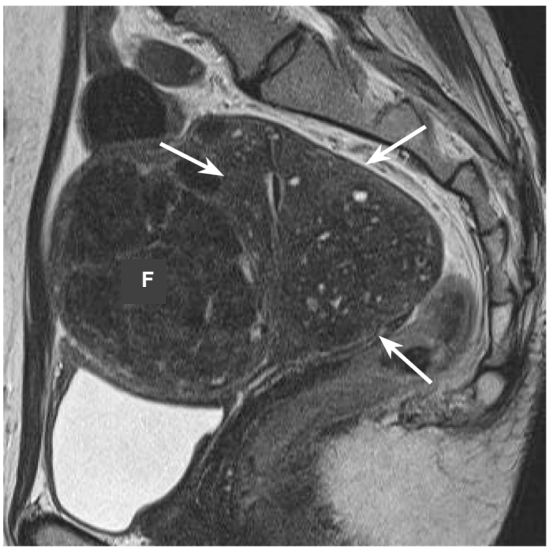

Figure 2. Adenomyosis with complicating fibroids

MRI, T2-weighted sagittal image: Example of concomitant uterine fibroids and adenomyosis. Adenomyosis lesions located predominantly in the posterior wall of the uterine body are visualized as areas of hypointensity with indistinct borders that include punctiform areas of hyperintensity (→). Fibroids are visualized as hypointense masses with distinct borders in the anterior wall (F).

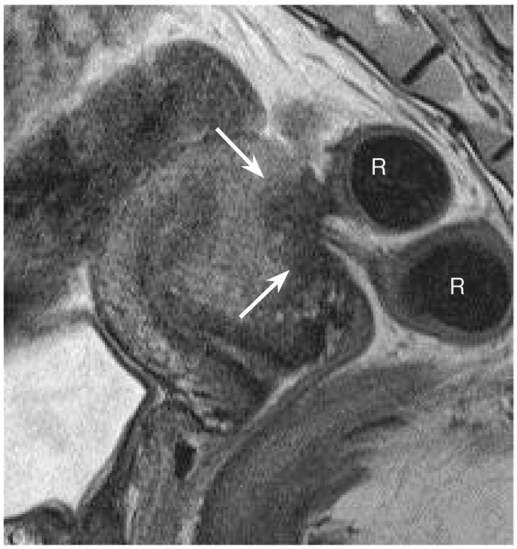

Figure 3. Adenomyosis that is continuous with the uterine serosa (external adenomyosis)

MRI, T2-weighted sagittal image: The lesion is visualized as an area of hypointensity continuous with the serosa on the posterior wall of uterine body (→); it is not continuous with the JZ. The rectum (R) is adherent to the lesion site.

Search keywords and secondary sources used as references

PubMed was searched using the following keywords: MRI, magnetic resonance imaging, and adenomyosis.

References

1) Bazot M et al: Ultrasonography compared with magnetic resonance imaging for the diagnosis of adenomyosis: correlation with histopathology. Hum Reprod 16: 2427-2433, 2001
2) Dueholm M et al: Magnetic resonance imaging and transvaginal ultrasonography for the diagnosis of adenomyosis. Fertil Steril 76: 588-594, 2001
3) Reinhold C et al: Diffuse adenomyosis: comparison of endovaginal US and MR imaging with histopathologic correlation. Radiology 199: 151-158, 1996
4) Champaneria R et al: Ultrasound scan and magnetic resonance imaging for the diagnosis of adenomyosis: systematic review comparing test accuracy. Acta Obstetricia et Gynecologica 89: 1374-1384, 2010
5) Stamatopoulos CP et al: Value of magnetic resonance imaging in diagnosis of adenomyosis and myoma of the uterus. J Minim Invasive Gynecol 19: 620-626, 2012
6) Togashi K et al: Adenomyosis: diagnosis with MR imaging. Radiology 166: 111-114, 1988
7) Kang S et al: Adenomyosis: specificity of 5 mm as the maximum normal uterine junctional zone thickness in MR images. AJR Am J Roentgenol 166: 1145-1150, 1996
8) Bazot M, Darai E: Role of transvaginal sonography and magnetic resonance imaging in the diagnosis of uterine adenomyosis. Fertil Steril 109: 389-397, 2018
9) Kishi Y et al: Four subtypes of adenomyosis assessed by magnetic resonance imaging and their specification. Am J Obstet Gynecol 207: 114.e1-e7, 2012

BQ 63 Is MRI recommended to diagnose and manage ovarian endometriotic cysts?

Statement

MRI is recommended when transvaginal ultrasonography: cannot differentiate ovarian endometriotic cysts from other ovarian tumors; cannot visualize entire lesions; or detects findings suggestive of developing ovarian cancer, such as mural nodules.

FQ 8 Is MRI recommended to diagnose deep infiltrative endometriosis?

Statement

In the diagnosis of deep infiltrative endometriosis by MRI, there are no differences between operators, and MRI provides greater objectivity and better ability to evaluate the spread of lesions than transvaginal ultrasonography.

Background

Endometriosis is a common condition that affects approximately 6% to 10% of women of reproductive age. Its clinical symptoms are variable, including dysmenorrhea, chronic lower abdominal pain, coital pain, dyschezia, and infertility. There are three distinct forms of pelvic endometriosis: ovarian endometriosis, peritoneal endometriosis, and deep infiltrative endometriosis. Deep infiltrative endometriosis is defined as endometriosis infiltrating the peritoneum by more than 5 mm from the surface, whereas peritoneal endometriosis involves the peritoneum superficially. Deep endometriosis is often associated with severe pain.[1)] Deep infiltrative endometriosis is generally found in the uterosacral ligament, posterior vaginal fornix, bowel, and bladder, and pain symptoms relate to the anatomic location of deep infiltrative endometriosis.[2)] Further, endometriosis is associated with ovarian cancer, such as endometrioid carcinoma and clear cell carcinoma.[3-5)]

The primary roles of imaging examinations in diagnosing and managing endometriosis are to characterize ovarian masses, evaluate the extent and localization of endometriosis, and detect cancer arising in ovarian endometriosis. Transvaginal ultrasonography is the first-choice imaging modality in clinical settings, and MRI may be performed as the next step. In this section, we discuss the usefulness of MRI in evaluating and managing ovarian endometriotic cysts and deep infiltrative endometriosis.

Explanation

Transvaginal ultrasonography is the first-line imaging modality to differentiate ovarian endometriotic cysts from other ovarian tumors, with sensitivity and specificity of 83% and 89%, respectively.[6] MRI may be performed as the next step when transvaginal ultrasonography is inconclusive. MRI has a higher sensitivity and specificity for diagnosing ovarian endometriotic cysts (90% and 98%, respectively) than transvaginal ultrasonography.[7] Typical MRI findings include a cystic lesion with hyperintensity on T1-weighted images and hypointensity on T2-weighted images (shading), and multiple hyperintense cysts on T1-weighted images (multiplicity, Fig. 1), which may reflect recurrent hemorrhage. Irregular or angular-shaped cysts, which may reflect adhesion to the surrounding structures, are other characteristic findings of ovarian endometriotic cysts. In addition, discrete, markedly hypointense foci in the cyst on T2-weighted images (T2 dark spot sign) are considered highly specific for endometriotic cysts.[8]

The risk factors for developing ovarian cancer in patients with endometriotic cysts are postmenopausal status and ovarian cyst diameter ≥ 9 cm.[9] If transvaginal ultrasonography detects mural nodules suspicious of ovarian cancer,[4, 5] contrast-enhanced MRI may be useful to distinguish ovarian cancer from pseudo-lesions.[10] Subtraction contrast-enhanced images may be valuable to evaluate the enhancement of mural nodules within hyperintense cysts on T1-weighted images.[6] Other ultrasonographic findings suggesting malignant transformation in endometriotic cysts include increased mass diameter[4] and decreased echogenicity of the cyst content, which may reflect the dilution of hemorrhagic fluid by tumor secretions.[5] If ultrasonography shows these findings, detailed MRI examinations may be performed (see BQ66 regarding differentiation between benign and malignant ovarian tumors).

In investigations of the diagnosis of deep infiltrative endometriosis in the rectum and sigmoid colon, where it occurs preferentially, sensitivity and specificity ranged from 75% to 88% and 98% to 100%, respectively, for MRI and from 33% to 70% and 96% to 100%, respectively, for transvaginal ultrasonography.[11, 12] Thus, MRI showed slightly superior sensitivity. In a recent meta-analysis of involvement of the rectum and sigmoid colon, sensitivity and specificity ranged from 73% to 100% and 50% to 100%, respectively, for MRI and from 73% to 98% and 67% to 100%, respectively, for transvaginal ultrasonography.[13] Thus, MRI and transvaginal ultrasonography were found to have comparable sensitivity and specificity. However, lesions are often missed with transvaginal ultrasonography because the range of observation is limited, and performance is largely dependent on the skill and circumstances of the operator. Japan's Clinical Practice Guidelines for Less Common Site and Rare Site Endometriosis demonstrate the usefulness of surgical treatment, and MRI plays an important role and allows for objective evaluation of lesion extent and depth for diagnosis of deep infiltrative endometriosis.

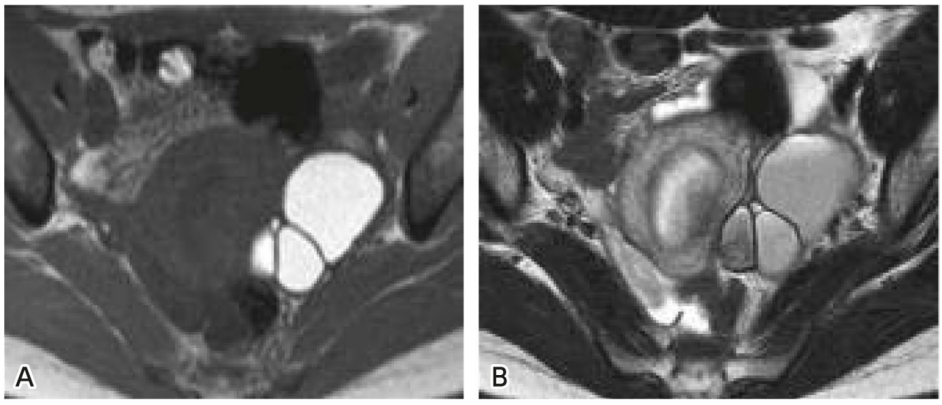

Figure 1. Ovarian endometriotic cysts

A: MRI, T1-weighted image; B: MRI, T2-weighted image: Multilocular cystic masses are seen in the left ovary, showing homogeneous hyperintensity on T1-weighted image (A) and inhomogeneous hypointensity (shading) on T2-weighted image (B).

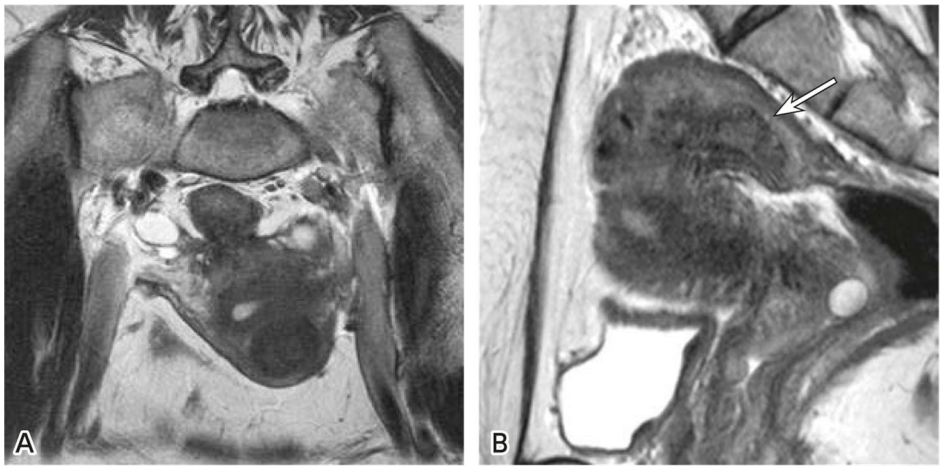

Figure 2. Deep infiltrative endometriosis (patient in her 40s)

A: MRI, T2-weighted oblique coronal image: A lesion with irregular margins that is nearly isointense with the iliacus muscle is present between the rectum and uterus and ovaries and interspersed with small hyperintensity foci. Bilateral ovaries and the rectum are concentrated at the point of the posterior wall of the uterine body.

B: MRI, T2-weighted sagittal image: A mass is present in the border region of the sigmoid colon and rectum (→). A lesion associated with a site of near isointensity with the iliacus muscle is present inferiorly.

Various MRI findings are obtained in deep infiltrative endometriosis. However, in the uterosacral ligament, rectum, and sigmoid colon, sites where deep infiltrative endometriosis occurs preferentially, elevation of the posterior vaginal fornix and contracture of the anterior surfaces of the rectum and sigmoid colon are seen. Moreover, it may result in mass formation, in addition to ovarian adhesion and high signal intensity of the endometrial glands (Fig. 2).[14] Although malignant transformation is known to occur, there have been no definitive reports in this regard, and diagnosis is often challenging.

Search keywords and secondary sources used as references

PubMed was searched for ovarian endometriotic cysts using the following keywords: sensitivity, specificity, endometriosis, diagnosis, and magnetic resonance imaging, and for deep infiltrative endometriosis using the following keywords: MRI and deep infiltrative endometriosis.

In addition, the following were referenced as secondary sources.

1) Japan Society of Obstetrics and Gynecology, Ed.: General Rules for Clinical Management of Endometriosis, Part 2: Diagnosis and Treatment (2nd Edition). KANEHARA & Co., 2010.
2) Panel for the Preparation of Guidelines on Classification, Diagnosis, and Treatment for Multimodal Therapy of Intractable Rare Site Endometriosis, Ed.: Clinical Practice Guidelines for Rare Site Endometriosis. SHINDAN TO CHIRYO SHA, 2018.
3) Bazot M et al: European Society of Urogenital Radiology guidelines: MR imaging of pelvic endometriosis. Eur Radiol 27: 2765-2775, 2017

References

1) Koninckx PR et al: Deep endometriosis: definition, diagnosis, and treatment. Fertil Steril 98 (3): 564-571, 2012
2) Fauconnier A et al: Relation between pain symptoms and the anatomic location of deep infiltrating endometriosis. Fertil Steril 78: 719-726, 2002
3) Pearce CL et al: Association between endometriosis and risk of histological subtypes of ovarian cancer: a pooled analysis of case-control studies. Lancet Oncol 13 (4): 385-394, 2012
4) Taniguchi F et al: Clinical characteristics of patients in Japan with ovarian cancer presumably arising from ovarian endometrioma. Gynecol Obstet Invest 77 (2): 104-110, 2014
5) Testa AC et al: Ovarian cancer arising in endometrioid cysts: ultrasound findings. Ultrasound Obstet Gynecol 38 (1): 99-106, 2011
6) Guerriero S et al: The role of endovaginal ultrasound in differentiating endometriomas from other ovarian cysts. Clin Exp Obstet Gynecol 22: 20-22, 1995
7) Togashi K et al: Endometrial cysts: diagnosis with MR imaging. Radiology 180 (1): 73-78, 1991
8) Corwin MT et al: Differentiation of ovarian endometriomas from hemorrhagic cysts at MR imaging: utility of the T2 dark spot sign. Radiology 271 (1): 126, 2014
9) Kobayashi H et al: Ovarian endometrioma: risks factors of ovarian cancer development. Eur J Obstet Gynecol Reprod Biol 138 (2): 187-193, 2008
10) Tanaka YO et al: Ovarian carcinoma in patients with endometriosis: MR imaging findings. AJR Am J Roentgenol 175 (5): 1423-1430, 2000
11) Bazot M et al: Deep pelvic endometriosis: MR imaging for diagnosis and prediction of extension of disease. Radiology 232: 379-389, 2004
12) Grasso RF et al: Diagnosis of deep infiltrating endometriosis: accuracy of magnetic resonance imaging and transvaginal 3D ultrasonography. Abdom Imaging 35: 716-725, 2010
13) Moura APC et al: Accuracy of transvaginal sonography versus magnetic resonance imaging in the diagnosis of rectosigmoid endometriosis: systematic review and meta-analysis. PLoS One 9 (14): e0214842, 2019
14) Marcal L et al: Deep pelvic endometriosis: MR imaging. Abdom Imaging 35: 708-715, 2010

BQ 64 Is MRI recommended to evaluate the local progression of cervical cancer?

Statement

MRI is strongly recommended to evaluate the local invasion of cervical cancer. Concomitant diffusion-weighted imaging is desirable.

Background

Surgery and chemoradiation therapy are the two pillars of treatment for cervical cancer. The treatment planning is based on the General Rules for Clinical and Pathological Management of Uterine Cervical Cancer (4th Edition) and Guidelines for Treatment of Uterine Cervical Cancer (2017 Edition) in Japan. In The General Rules for Clinical and Pathological Management of Uterine Cervical Cancer, the usefulness of pretreatment diagnostic imaging for staging is noted and recommended. This discussion summarizes the evidence regarding the usefulness of MRI for evaluation of the local invasion of cervical cancer.

Explanation

MRI is widely used in Japan to evaluate invasive cervical cancer (stage IB or higher) before treatment. Moreover, because subclassification based on tumor size was added to the 2018 revised FIGO classification, the role of diagnostic imaging that permits tumor diameter to be objectively measured has become increasingly important.

The usefulness of CT and MRI in staging has been noted since the 1990s. A multicenter meta-analysis found the sensitivity of MRI for parametrial invasion to be higher than that of CT (CT, 55%; MRI, 74%) and their diagnostic performance to detect lymph node metastasis to be comparable.[1)] A recent meta-analysis of the diagnostic performance of MRI with parametrial invasion reported excellent diagnostic performance, with sensitivity and specificity of 76% and 94%, respectively.[2)] A multicenter study of advanced cancer of stage IIb or higher (old classification) conducted from 2000 to 2002 by the American College of Radiology Imaging Network (ACRIN) and Gynecologic Oncology Group (GOG) found that, although the sensitivity of MRI and CT tended to be low (CT, 42%; MRI, 53%), their specificity was high (CT, 82%; MRI, 85%).[3)] Moreover, MRI has shown higher sensitivity than CT for evaluation of invasion to other organs, such as the urinary bladder and rectum,[4)] and is substitutable for cystoscopy, proctoscopy, and excretory urography.[5)] The 2018 revised WHO classification subdivided stage IB into 3 subclassifications (IB1-3) for the purpose of assessing the outcome of radical trachelectomy, a fertility-preserving procedure. Cutoff values of 2 cm and 4 cm are used in determining the subclassification, increasing the importance of tumor diameter measurement.[6)] MRI, which provides excellent tumor tissue contrast, is useful for measuring tumor diameter preoperatively. It is considered even more useful than ultrasonography for this purpose.[7)]

With diffusion-weighted imaging, cervical cancer shows high intensity and a low apparent diffusion coefficient (ADC).[8, 9] Diagnosis using both T2-weighted imaging and diffusion-weighted imaging has been reported to provide higher diagnostic performance than T2-weighted imaging alone for evaluating parametrial invasion.[2, 10]

An adequate consensus has not yet been reached regarding gadolinium contrast-enhanced imaging. For staging, T2-weighted imaging is the basic imaging method, and although improved tumor contrast and diagnostic performance have been reported with contrast-enhanced MRI,[11] its indications are limited. Consequently, its use does not necessarily contribute to improving diagnostic performance.[2]

Search keywords and secondary sources used as references

PubMed was searched using the following keywords: uterine cervical cancer, uterine cervical adenocarcinoma, uterine cervical carcinoma, CT, and MRI.

In addition, the following were referenced as secondary sources.

1) Japan Society of Obstetrics and Gynecology, et al., Ed.: The General Rules for Clinical and Pathological Management of Uterine Cervical cancer: Clinical Edition (4th Edition). KANEHARA & Co., 2020.
2) Japan Society of Gynecologic Oncology, Ed.: 2017 Guidelines for Treatment of Uterine Cervical cancer. KANEHARA & Co., 2017.
3) Balleyguier C et al: Staging of Uterine Cervical cancer With MRI: Guidelines of the European Society of Urogenital Radiology. Eur Radiol 21 (5): 1102-1110, 2011

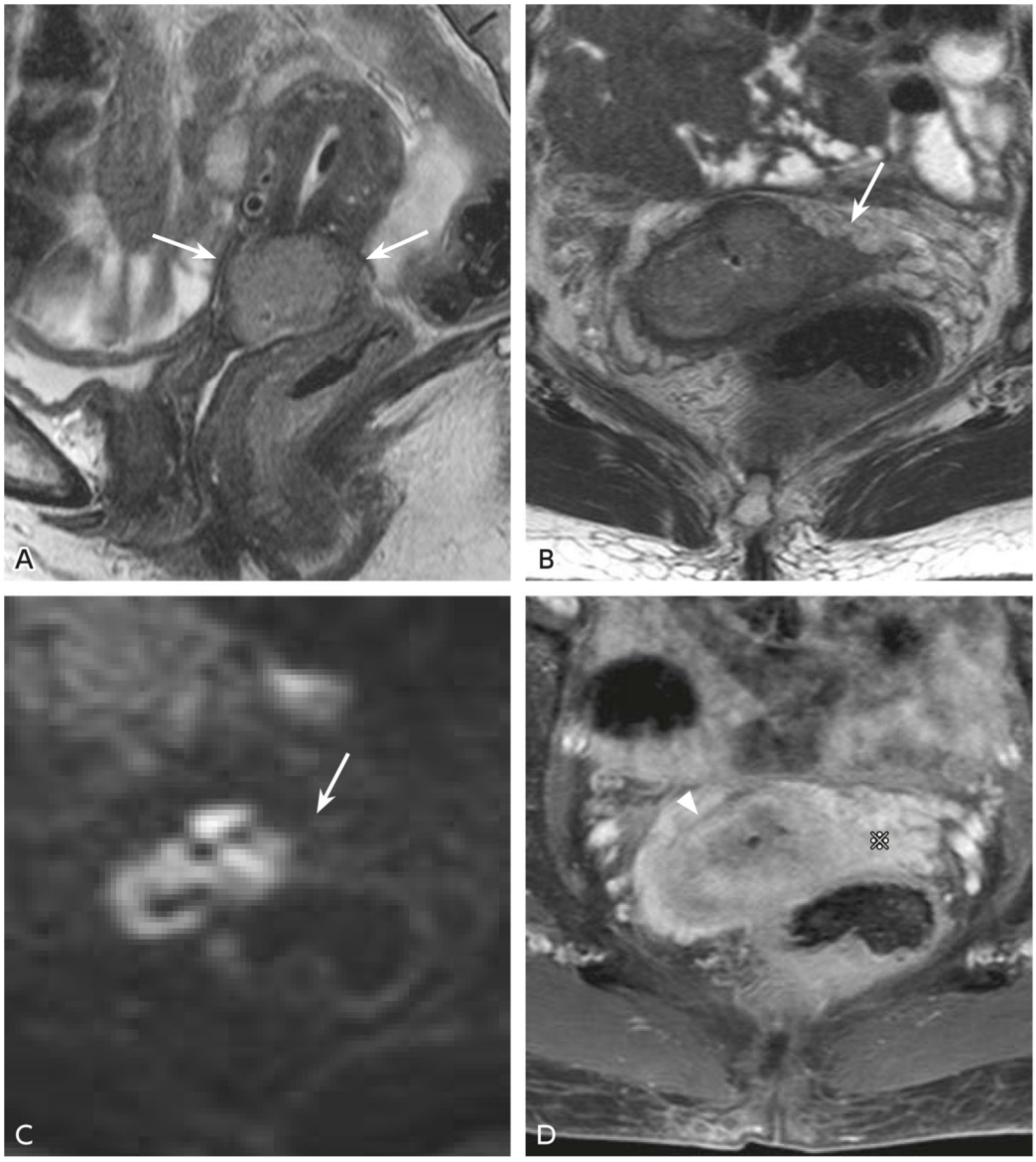

Figure　Cervical cancer, IB1 (pT2a), patient in her 60s

A: MRI, T2-weighted sagittal image: A mass that shows slight high intensity compared with the uterine body myometrium is seen in the cervical area (→).

B: MRI, T2-weighted transverse image: An almost fully circumferential stromal ring is observed. However, the left side is partially indistinct, so that parametrial invasion cannot be excluded (→).

C: MRI, diffusion-weighted imaging, b-value = 800 s/mm^2: The tumor is visualized as high intensity, and no areas of abnormal signal are observed in the left parametrium. (→).

D: MRI, fat-suppressed contrast-enhanced T1-weighted image: The tumor is visualized as a hypointensity lesion (▷). However, venous enhancement in the parametrial tissue is striking (*), making diagnosis of parauterine tissue infiltration difficult.

References

1) Bipat S et al: Computed tomography and magnetic resonance imaging in staging of uterine cervical carcinoma: a systematic review. Gynecol Oncol 91 (1): 59-66, 2003

2) Woo S et al: Magnetic resonance imaging for detection of parametrial invasion in cervical cancer: an updated systematic review and meta-analysis of the literature between 2012 and 2016. Eur Radiol 28 (2): 530-541, 2018

3) Hricak H et al: Role of imaging in pretreatment evaluation of early invasive cervical cancer: results of the intergroup study American College of Radiology Imaging Network 6651-Gynecologic Oncology Group 183. J Clin Oncol 23 (36): 9329-9337, 2005
4) Kim WY et al: Reliability of magnetic resonance imaging for bladder or rectum invasion in cervical cancer. J Reprod Med 56 (11-12): 485-490, 2011
5) Amendola MA et al: Utilization of diagnostic studies in the pretreatment evaluation of invasive cervical cancer in the United States: results of intergroup protocol ACRIN 6651/GOG 183. J Clin Oncol 23 (30): 7454-7459, 2005
6) Lee SI, Atri M: 2018 FIGO staging system for uterine cervical cancer: enter cross-sectional imaging. Radiology 292 (1): 15-24, 2019
7) Epstein E et al: Early-stage cervical cancer: tumor delineation by magnetic resonance imaging and ultrasound: a European multicenter trial. Gynecol Oncol 128 (3): 449-453, 2013
8) Hou B et al: Diagnostic significance of diffusion-weighted MRI in patients with cervical cancer: a meta-analysis. Tumour Biol 35 (12): 11761-11769, 2014
9) Naganawa S et al: Apparent diffusion coefficient in cervical cancer of the uterus: comparison with the normal uterine cervix. Eur Radiol 15 (1): 71-78, 2005
10) Park JJ et al: Parametrial invasion in cervical cancer: fused T2-weighted imaging and high-b-value diffusion-weighted imaging with background body signal suppression at 3 T. Radiology 274 (3): 734-741, 2015
11) Akita A et al: Comparison of T2-weighted and contrast-enhanced T1-weighted MR imaging at 1.5 T for assessing the local extent of cervical carcinoma. Eur Radiol 21 (9): 1850-1857, 2011

BQ 65 Is MRI recommended to evaluate the local progression of endometrial cancer?

Statement

MRI is strongly recommended to preoperatively evaluate the local progression of endometrial cancer. The use of contrast-enhanced MRI is favored. However, if contrast-enhanced examination is difficult, the evaluation can be performed by combined T2-weighted imaging and diffusion-weighted imaging.

Background

The prognosis of endometrial cancer depends on the tissue-type, grade, and stage of the tumor. The treatment plan, including the surgical procedure, varies according to these factors. Diagnostic imaging contributes greatly to preoperative staging. MRI is excellent for evaluating the local progression of tumors. Since deep myometrial invasion (≥ 1/2) is strongly correlated with lymph node metastasis and prognosis, accurate preoperative diagnosis is very important.

Explanation

Japanese guidelines for treatment of uterine body neoplasms recommend that myometrial and cervical stromal invasion should be evaluated by MRI preoperatively (grade A).

MRI is excellent for evaluating the local progression of endometrial cancer, and the guidelines of other countries also recommend MRI for evaluating local tumor extent.

In a 1999 meta-analysis of the preoperative staging of endometrial cancer, Kinkel et al. reported no significant difference among transvaginal ultrasonography (TVUS), CT, and MRI.[1)] The same report showed that contrast-enhanced MRI was useful and significantly better than non-contrast MRI, TVUS, and CT with respect to myometrial invasion.

Many reports have concluded that contrast-enhanced MRI is useful,[2, 3)] and various guidelines recommend it.

Dynamic contrast-enhanced (DCE)-MRI is the basic method. However, the equilibrium phase, during which the contrast between endometrial lesions and the myometrium is high, has been found to be the most suitable for evaluating myometrial invasion.[3, 4)]

Single-phase contrast-enhanced images in the equilibrium phase should be obtained if DCE-MRI is difficult to perform.

The usefulness of diffusion-weighted imaging (DWI) in evaluating deep myometrial invasion has been established.[5)]

A meta-analysis published by Andreano et al. in 2014 reported that there were no significant differences in sensitivity and specificity for evaluating deep myometrial invasion between DWI and DCE-MRI, and the diagnostic accuracy of DWI was at least the same as that of DCE-MRI.

Numerous subsequent meta-analyses also showed DWI to be useful for evaluating deep myometrial invasion.[8, 9)] Because the signal intensity (SI) on DWI is affected by the SI on T2WI, it is recommended that evaluations should be performed by combined DWI and T2WI.

Deng et al. reported that there was no significant difference in sensitivity for evaluating deep myometrial invasion between combined T2WI + DWI and DWI or DCE-MRI.

However, the specificity was significantly higher with combined T2WI and DWI compared with DWI or DCE-MRI, resulting in better diagnostic performance.[8)]

Other studies also reported that combined T2WI and DWI was superior to DCE-MRI alone or combined T2WI and DCE-MRI in evaluating myometrial invasion.[10, 11)]

When a gadolinium contrast medium cannot be used for a reason such as contrast allergy or nephropathy, myometrial invasion can be evaluated by combined T2WI and DWI.[11)]

As for the assessment of cervical stromal invasion (CSI), MRI shows high specificity, but the sensitivity is reportedly low.[12)] A similar result (sensitivity, 50%; specificity, 95%) was shown in a meta-analysis by Bi et al. in 2019.[9).] Because microscopic invasion is difficult to identify on MRI, sensitivity is therefore thought to be low.

There have been few reports showing the usefulness of DWI for evaluating CSI. However, a study that compared combined T2WI + DWI with combined T2WI + DCE-MRI found no significant differences in sensitivity, specificity, or accuracy for evaluating CSI.[11)] Another study reported that the specificity of DWI was higher than that of DCE-MRI, and its accuracy was superior.[13)] These findings suggest that it may also be possible to omit contrast-enhanced MRI for assessing cervical stromal invasion.

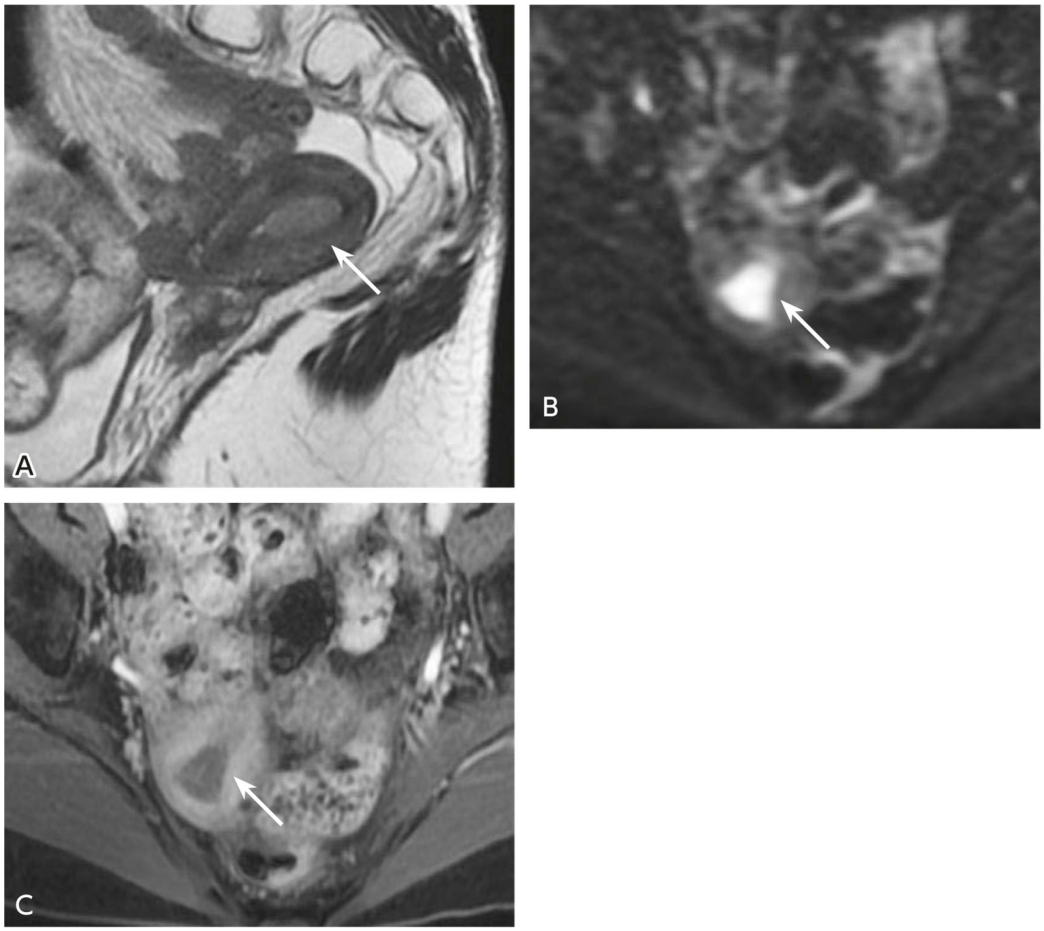

Figure 1. Endometrial cancer/endometrioid carcinoma IA (50s, F)

A: MRI, Sagittal T2WI (T2-weighted sagittal image)

B: MRI, Axial DWI (diffusion-weighted transverse image), b-value = 1,000 s/mm^2

C: DCE-MRI (Dynamic contrast-enhanced MRI) 90s (90 seconds post-contrast)

Compared with the myometrium, endometrial cancer shows hypointensity on T2WI (A) and hyperintensity on DWI (B). The tumor is less enhanced compared with the myometrium (C).

The border between the endometrial cancer and myometrium is clear and smooth on all images, indicating no myometrial invasion

With high-magnetic field MRI (3T), the SNR is high, and it has been reported to be superior to conventional 1.5T MRI for evaluating deep myometrial invasion. However, no significant difference has been found.[6, 8)]

PET/MRI has been reported to be superior to PET/CT for evaluating myometrial and cervical stromal invasion. However, there have been few reports on this topic, and a limited number of facilities can perform these examinations.[14)]

CT has low contrast resolution, and its ability to evaluate local progression is weaker than that of MRI. However, evaluating local progression by CT is considered if there is difficulty performing MRI. Dual-energy CT has been reported to increase the ability to evaluate local progression.[15)]

Its development is expected for use as a substitute for MRI when MRI cannot be performed.

Search keywords and secondary sources used as references

PubMed was searched using the following keywords: computed tomography, CT, magnetic resonance imaging, MRI, positron emission tomography, PET, PET/CT, FDG-PET, ultrasound, ultrasonography, US, uterine body cancer, uterine endometrial cancer, uterine endometrial carcinoma, and staging.

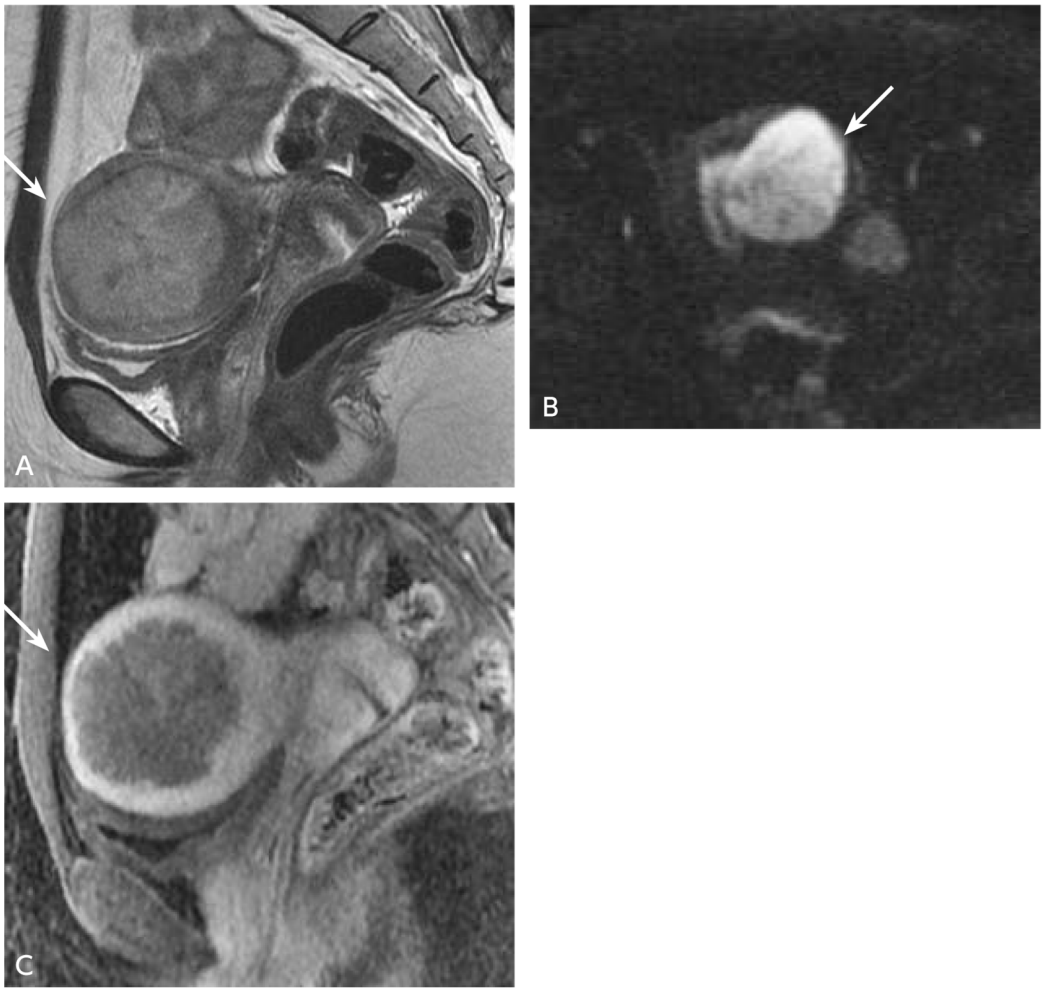

Figure 2. Endometrial cancer/endometrioid carcinoma IB (40s, F)

A: MRI, Sagittal T2WI (T2-weighted sagittal image)

B: MRI, Axial DWI (diffusion-weighted transverse image), b-value = 1,000 s/mm^2

C: DCE-MRI (Dynamic contrast-enhanced MRI) 90s (90 seconds post-contrast)

The border between the endometrial cancer and myometrium is indistinct. Abnormal signal intensity indicating endometrial cancer extends deeply into the myometrium, suggesting deep myometrial invasion. The findings are the same on T2-weighted imaging (A), diffusion-weighted imaging (B), and contrast-enhanced MRI (C).

The following were referenced as secondary sources.

1) Japan Society of Gynecologic Oncology, Ed.: 2017 Guidelines for the treatment of uterine body neoplasm. KANEHARA & Co., 2017.
2) Japan Society of Obstetrics and Gynecology, Japanese Society of Pathology, Ed.: The General Rules for Clinical and Pathological Management of Uterine Corpus Cancer: Pathological Edition (4th Edition). KANEHARA & Co., 2017.
3) Reinhold C et al: ACR Appropriateness Critera®: pretreatment evaluation and follow-up of endometrial cancer. J Am Coll Radiol 17: S472-S486, 2020
4) Nougaret S et al: Endometrial cancer MRI staging: updated guidelines of the European Society of Urogenital Radiology. Eur Radiol 29（2）：792-805, 2019

References

1) Kinkel K et al: Radiologic staging in patients with endometrial cancer: a meta-analysis. Radiology 212: 711-718, 1999
2) Sala E et al: Added value of dynamic contrast-enhanced magnetic resonance imaging in predicting advanced stage disease in patients with endometrial carcinoma. Int J Gynecol Cancer 19: 141-146, 2009
3) Manfredi R et al: Local-regional staging of endometrial carcinoma: role of MR imaging in surgical planning. Radiology 231: 372-378, 2004
4) Park SB et al: Dynamic contrast-enhanced MR imaging of endometrial cancer. optimizing the imaging delay for tumour-myometrium contrast. Eur Radiol 24 (11): 2795-2799, 2014
5) Das SK et al: Usefulness of DWI in preoperative assessment of deep myometrial invasion in patients with endometrial carcinoma: a systematic review and meta-analysis. Cancer Imaging 14: 32, 2014
6) Andreano A et al: MR diffusion imaging for preoperative staging of myometrial invasion in patients with endometrial cancer: a systematic review and meta-analysis. Eur Radiol 24: 1327-1338, 2014
7) Beddy P et al: Evaluation of depth of myometrial invasion and overall staging in endometrial cancer: comparison of diffusion-weighted and dynamic contrast-enhanced MR imaging. Radiology 262 (2): 530-537, 2012
8) Deng L et al: The combination of diffusion- and T2-weighted imaging predicting deep myometrial invasion of endometrial cancer: a systematic review and meta-analysis. J Comput Assist Tomogr 39: 661-673, 2015
9) Bi Q et al: The diagnostic value of MRI for preoperative staging in patients with endometrial cancer: a meta-analysis. Acad Radiol 27: 960-968, 2020
10) Kececi IS et al: Efficacy of diffusion-weighted magnetic resonance imaging in the diagnosis and staging of endometrial tumors. Diagn Interv Imaging 97 (2): 177-186, 2016
11) Bonatti M et al: MRI for local staging of endometrial carcinoma: is endovenous contrast medium administration still needed? Eur J Radiol 84 (2): 208-214, 2015
12) Antonsen SL et al: MRI, PET/CT and ultrasound in the preoperative staging of endometrial cancer: a multicenter prospective comparative study. Gynecol Oncol 128 (2): 300-308, 2013
13) Lin G et al: Endometrial cancer with cervical stromal invasion: diagnostic accuracy of diffusion-weighted and dynamic contrast enhanced MR imaging at 3T. Eur Radiol 27: 1867-1876, 2017
14) Kitajima K et al: Value of fusion of PET and MRI for staging of endometrial cancer: comparison with 18F-FDG contrast-enhanced PET/CT and dynamic contrast-enhanced pelvic MRI. Eur J Radiol 82 (10): 1672-1676, 2013
15) Rizzo S et al: Evaluation of deep myometrial invasion in endometrial cancer patients: is dual-energy CT an option? Radiol Med 123: 13-19, 2018

FQ 9 Which imaging examinations are recommended to diagnose uterine sarcoma?

Statement

MRI is recommended for qualitative diagnosis of uterine sarcoma. However, the level of evidence is not high due to the difficulty of conducting large studies of uterine sarcoma, which is a rare disease. In particular, diagnostic performance is improved by performing diffusion-weighted imaging and generating an ADC map. In addition, contrast-enhanced MRI may contribute to diagnosis.

^{18}F-FDG-PET/CT provides a good diagnostic accuracy rate in the qualitative diagnosis and staging of uterine sarcoma and can potentially assist in its preoperative diagnosis and treatment plan determination.

Background

Although most uterine myometrial masses are uterine fibroids, differentiation from uterine sarcomas is problematic. Although uterine sarcomas are diagnosed histologically following surgery, preoperative diagnostic imaging is required to determine a treatment strategy. This discussion provides an overview concerning MRI, which is usually used for differential diagnosis, and PET/CT, which is currently not covered by national health insurance, but its usefulness is promising. Uterine carcinosarcoma is considered to be metaplasia of endometrial cancer; therefore, uterine carcinosarcoma was excluded from this examination as much as possible.

Explanation

MRI provides good soft tissue contrast and is used to differentiate uterine myometrial masses. Uterine sarcomas are often large, irregularly shaped masses associated with hemorrhage and necrosis, and the diagnostic performance of T1- and T2-weighted imaging, diffusion-weighted imaging, ADC mapping, and contrast-enhanced MRI has been examined.

A uterine myometrial mass with irregular margins and an indistinct border is a finding suggestive of a uterine sarcoma. However, some uterine sarcomas have a distinct border and regular margins on imaging or macroscopically. Consequently, uterine sarcoma cannot be diagnosed based on an assessment of the margins alone.[1, 2)] Hyperintensity on T1-weighted imaging suggests hemorrhage. Although this assists in diagnosis, particularly in the case of leiomyosarcoma, there is no significant difference compared with uterine fibroids.[1-3)] Even when there is no area of hyperintensity on T1-weighted imaging, uterine sarcoma cannot be ruled out. Such areas are also seen on T1-weighted imaging even for uterine fibroids associated with red degeneration or uterine adenomyomas. Although hyperintensity in T2-weighted images is also seen for degenerative leiomyomas and cellular leiomyomas, hyperintensity in T2-weighted images is a finding suggestive of uterine sarcoma, which may not show hypointensity in T2-weighted images mainly.[2, 3)] Diffusion-weighted imaging and ADC mapping can identify areas of high cellularity. In recent years,

ADC measurement has resulted in improved diagnostic performance for uterine sarcoma,[4-6] although the sample sizes used in the investigations were small, and the ADC cutoff values of studies conducted at other facilities cannot be used. Evaluations may be performed visually combining diffusion-weighted images and ADC maps. In contrast-enhanced examinations, uterine sarcoma necrosis and degeneration are visualized as areas of poor contrast enhancement, which is useful for diagnosis.[7] In addition, early contrast enhancement in dynamic studies has been found to contribute to uterine sarcoma diagnosis.[8] Evaluation by multiparametric MRI, which combines several of T2-weighted imaging, diffusion-weighted imaging and ADC values, and dynamic contrast-enhanced MRI, was found to be useful for diagnosing uterine sarcomas, and the use of these methods for comprehensive evaluation is recommended.[9, 10] Although the diagnostic performance of MRI is relatively high for uterine sarcoma, differentiating from uterine fibroid variants such as cellular leiomyomas is difficult with MRI.[4, 5] It should be kept in mind that diagnosis by imaging is difficult in some patients, particularly for patients who wish to preserve fertility.

The main histological subtypes of uterine sarcomas are uterine leiomyosarcomas and endometrial stromal sarcomas, and reports that focus on MRI findings regarding each histological subtype provide useful information for diagnosis. The presence of hemorrhage or necrosis and hypervascularity are clues for the diagnosis of uterine leiomyosarcoma.[2, 8] With endometrial stromal sarcomas, characteristic MRI findings have been described, such as bands of low signal intensity in T2-weighted images of myometrial lesions, infiltration along vessels and ligaments, and cyst formation.[11]

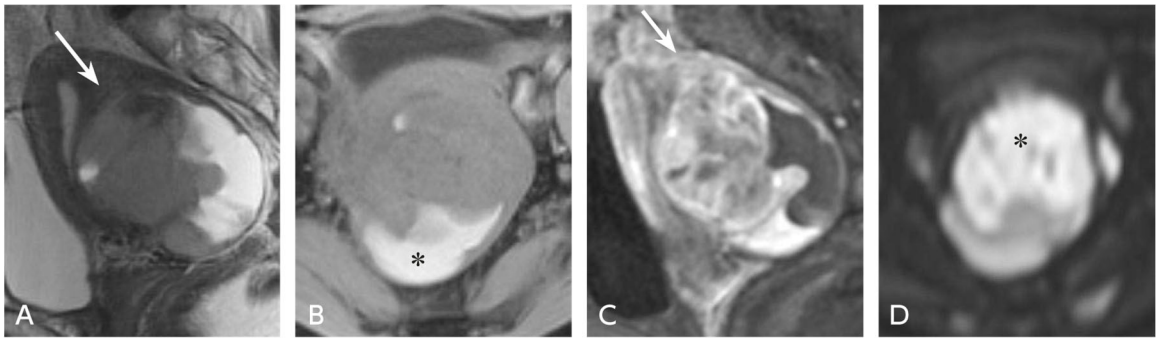

Figure. Woman in her 50s, uterine leiomyosarcoma

A: MRI, T2-weighted sagittal image: An irregularly shaped mass showing non-homogeneous hyperintensity is seen in the myometrium (→).

B: MRI, T1-weighted transverse image: An area of hyperintensity suggestive of hemorrhage is seen (*).

C: Contrast-enhanced MRI, sagittal early-phase image: Early enhancement is seen in the solid portion (→).

D: MRI, diffusion-weighted transverse image, b-value = 800 s/mm^2: The solid portion shows hyperintensity (*) and was hypointense in the ADC map (not shown).

There have been few studies of the diagnostic performance of ^{18}F-FDG-PET/CT with respect to uterine sarcoma, and the studies have had limited sample sizes. However, its usefulness in patients suspected of having uterine sarcomas based on MRI or ultrasonography has been examined. Although FDG shows strong accumulation in uterine sarcomas, it also accumulates in uterine fibroids, and accumulation decreases with age.[12, 13] When ^{18}F-FDG-PET/CT was performed for masses suspected of being uterine

sarcomas based on MRI (masses showing hyperintensity in both T2- and T1-weighted images or in either), the mean maximum standardized uptake value (SUVmax) was higher for uterine sarcomas than for uterine fibroids. Using a cutoff of SUVmax > 7.5, sensitivity and specificity were 80% and 100%, respectively. Moreover, when ^{18}F-FDG-PET/CT was combined with elevated serum lactate dehydrogenase (LDH), sensitivity and sensitivity were 86.6% and 100%, respectively, and false positives could be decreased.[14] For uterine myometrial masses for which rapid enlargement was seen on ultrasonography or MRI, a characteristic pattern of internal accumulation was found to be the hollow ball sign, which indicates a region of decreased accumulation in a uterine sarcoma corresponding to coagulation necrosis in the center of the mass.[15] In a study of uterine sarcoma staging with ^{18}F-FDG-PET/CT, sensitivity, specificity, and the diagnostic accuracy rate were 80%, 100%, and 91%, respectively. However, pulmonary metastases and peritoneal dissemination less than 1 cm in size were FDG-negative, which could result in false-negatives. In that case, however, combining the PET findings with CT findings was found to increase sensitivity.[16] The use of ^{18}F-FDG-PET/CT for the qualitative diagnosis or staging of uterine sarcomas can improve their management, and it has been surmised that ^{18}F-FDG-PET/MRI may serve as a one-stop-shopping type of diagnostic tool in the future.[6]

Search keywords and secondary sources used as references

PubMed was searched using the following keywords: uterine sarcomas, endometrial stromal sarcomas, uterine leiomyosarcomas, diagnostic imaging, MRI, diffusion weighted image, PET, and positron emission tomography.

In addition, the following was referenced as a secondary source.

1) Japan Society of Obstetrics and Gynecology, et al., Ed.: The General Rules for Clinical and Pathological Management of Uterine Corpus Cancer: Pathological Edition (4th Edition). KANEHARA & Co., 2017.

References

1) Cornfeld D et al: MRI appearance of mesenchymal tumors of the uterus. Eur J Radiology 74: 241-249, 2010
2) Li HM et al: Diffusion-weighted imaging or differentiating uterine leiomyosarcoma from degenerated leiomyoma. J Comput Assist Tomogr 41: 599-606, 2017
3) Malek M et al: Investigating the diagnostic value of quantitative parameters based on T2-weighted and contrast-enhanced MRI with psoas muscle and outer myometrium as internal references for differentiating uterine sarcomas from leiomyomas at 3T MRI. Cancer Imaging 19 (1): 20, 2019
4) Tamai K et al: The utility of diffusion-weighted MR imaging for differentiating uterine sarcomas from benign leiomyomas. Eur Radiol 18: 723-730, 2008
5) Sato K et al: Clinical application of diffusion-weighted imaging for preoperative differentiation between uterine leiomyoma and leiomyosarcoma. Am J Obstet Gynecol 368: e1-8, 2014
6) Dubreuil J et al: Diffusion-weighted MRI and 18F-FDG-PET/CT imaging: competition or synergy as diagnostic methods to manage sarcoma of the uterus ?: a systematic review of the literature. Nucl Med Commun 38: 84-90, 2017
7) Lin G et al: Comparison of the diagnostic accuracy of contrast-enhanced MRI and diffusion- weighted MRI in the differentiation between uterine leiomyosarcoma / smooth muscle tumor with uncertain malignant potential and benign leiomyoma. J Magn Reson Imaging 43: 333-342, 2016
8) Goto A et al: Usefulness of Gd-DTPA contrast-enhanced dynamic MRI and serum determination of LDH and its isozymes in the differential diagnosis of leiomyosarcoma from degenerated leiomyoma of the uterus. Int J Gynecol Cancer 12: 354-356, 2002

9) Namimoto T: Combined use of T2-weighted and diffusion-weighted 3-T MR imaging for differentiating uterine sarcomas from benign leiomyomas. Eur Radiol 19: 2756-2764, 2009
10) Bi Q et al: Utility of clinical parameters and multiparametric MRI as predictive factors for differentiating uterine sarcoma from atypical leiomyoma. Acad Radiol 25: 993-1002, 2018
11) Koyama T et al: MR imaging of endometrial stromal sarcoma: correlation with pathologic findings. AJR Am J Roentgenol 173: 767-772, 1999
12) Kitajima K et al: Standardized uptake value of uterine leiomyoma with ^{18}F-FDG PET/CT: variation with age, size, degeneration, and contrast enhancement on MRI. Ann Nucl Med 22: 505-512, 2008
13) Nagamatsu A et al: Use of 18F-fluorodeoxyglucose positron emission tomography for diagnosis of uterine sarcomas. Oncol Rep 23: 1069-1076, 2010
14) Kusunoki S et al: Efficacy of PET/CT to exclude leiomyoma in patients with lesions suspicious for uterine sarcoma on MRI. Taiwanese J Obstet Gynecol 56: 508-513, 2017
15) Ho KC et al: Presurgical identification of uterine smooth muscle malignancies through the characteristic FDG uptake pattern on PET scans. Contrast Media Molecul Imaging 2018: 7890241, 2018
16) Bélissant O et al: Value of ^{18}F-FDG PET/CT imaging in the staging, restaging, monitoring of response to therapy and surveillance of uterine leiomyosarcoma. Nucl Med Commun 39: 652-658, 2018

BQ 66 Is MRI recommended for the qualitative diagnosis of adnexal masses?

Statement

In patients who cannot be diagnosed by ultrasonography, which is the first choice of modalities, MRI contributes to the qualitative diagnosis of adnexal masses and is therefore recommended.

Contrast-enhanced MRI is recommended because it improves diagnostic accuracy for distinguishing between benign and malignant adnexal masses.

Background

An ultrasound examination is the first choice for diagnosing adnexal masses. However, in patients who cannot be diagnosed by ultrasonography, MRI is recommended. This discussion provides an overview regarding the usefulness of MRI for differentiating between benign and malignant adnexal masses.

Explanation

Although the sensitivity, specificity, and AUC of TVUS in distinguishing between benign and malignant adnexal masses are 92%, 89%, and 0.96, respectively,[1)] diagnosing lesions that consist of a mixture of solid and cystic portions is often difficult. MRI is useful for diagnosing patients undiagnosable by ultrasound.[2-5)] A meta-analysis of benign-malignant differentiation using 1.5T MRI published in 2011 showed relatively good diagnostic performance, with values for sensitivity, specificity, and AUC of 92%, 85%, and 0.95, respectively.[6)] The morphological criteria suggestive of malignancy are a large mass diameter (≥ 4 cm), bilaterality, the mass consists mainly of a solid portion, necrosis in the solid portion, the mass is cystic with a wall or septum ≥ 3 mm, and papillary mural nodules. Possible secondary findings include ascites, intraperitoneal dissemination, and lymph node swelling. The morphological findings that are thought to contribute the most to a diagnosis of malignancy are necrosis in the solid portion and mural nodules in a cystic mass.[3, 7)] An examination of signal patterns indicated that a finding of hypointensity in the solid portion of a mass at a level comparable to that of skeletal muscle on T2-weighted imaging suggested a benign fibrotic tumor. Moreover, a finding of hypointensity in the solid portion of a mass on diffusion-weighted imaging, which subsequently became widely available, was found to suggest a benign mass.[8)] On the other hand, hyperintensity of the solid portion on diffusion-weighted imaging suggests a malignant lesion. It should be noted, however, that even for benign lesions, the signal can increase for a lesion with a prolonged T2 value resulting from a change such as edema (T2 shine-through effect). In addition, hyperintensity may be seen in lesions such as thecomas, which have a relatively high cell density, potentially restricting diffusion. Although ADC values tend to be low, in adnexal masses that are malignant tumors, they may also be decreased in benign fibrotic tumors. On the other hand, ADC values tend to be increased in malignant tumors with necrosis or microcysts. Consequently, there is overlap in ADC values

between benign and malignant masses. In meta-analyses of the use of ADC values to differentiate between benign and malignant adnexal masses, a 2016 examination that included both the cystic and solid portions of masses found no significant differences.[9] However, a 2018 investigation that limited its scope to the solid portion of masses suggested that ADC values were useful, with sensitivity, specificity, and AUC values of 91%, 91%, and 0.96, respectively.[10]

In patients for whom benign-malignant differentiation is difficult with non-contrast MRI, including diffusion-weighted imaging, diagnostic accuracy is improved by the use of contrast-enhanced imaging.[3, 11] Consequently, contrast-enhanced MRI is recommended for patients without contraindications. Analysis of the time-intensity curve (TIC) in dynamic MRI has also been used for benign-malignant differentiation. The addition of diffusion-weighted imaging or dynamic MRI to conventional MRI has been found to improve the diagnostic accuracy rate to 95%.[11] Moreover, an effort to standardize diagnostic imaging (ultrasound and MRI) for the differentiation of benign and malignant adnexal masses called the Ovarian-Adnexal Reporting and Data Systems (O-RADS) has been underway since 2015, implemented mainly by the American College of Radiology (ACR). The results of a multicenter study of the MRI version (prospective cohort study), which is based on the scoring system using the characteristics of masses and TIC patterns and the signals of T2-weighted images and diffusion-weighted images of the solid portion of masses, were reported in 2020. When interpreted by skilled radiologists, they showed good diagnostic performance, with sensitivity, specificity, and AUC values of 93%, 91%, and 0.961, respectively.[12]

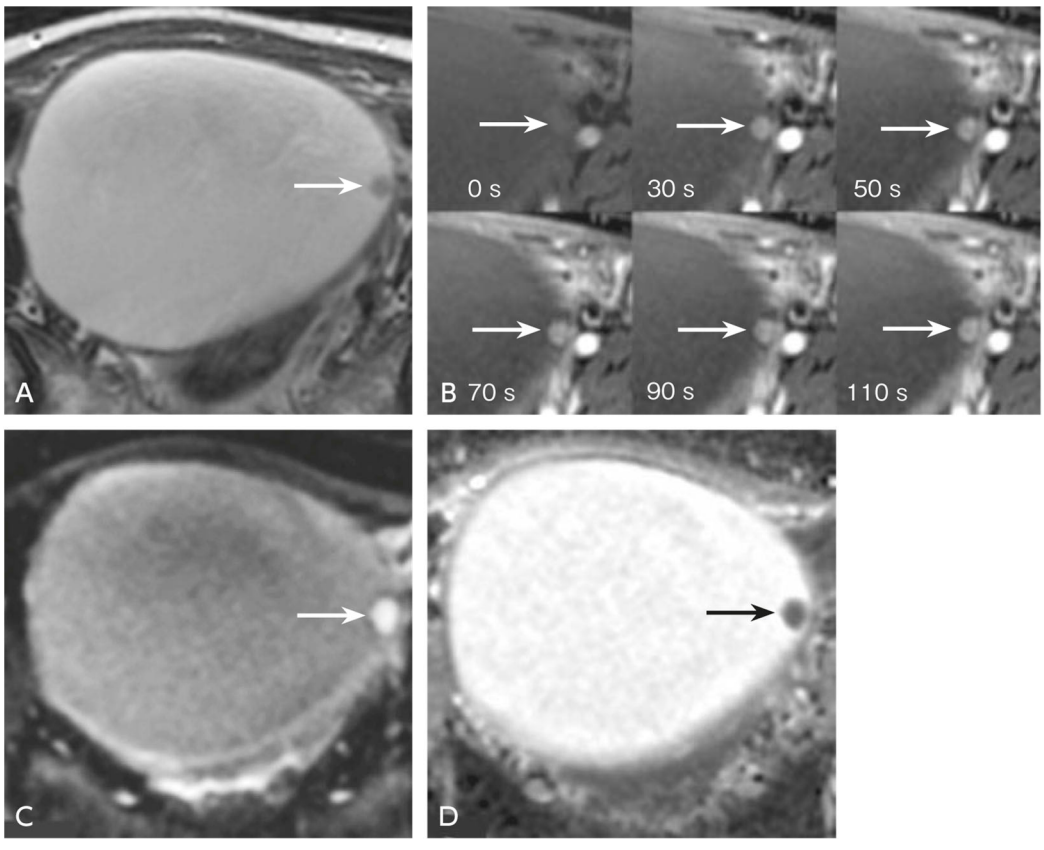

Figure　Ovarian clear cell carcinoma (woman in her 30s)

A: MRI, T2-weighted image: A unicameral cystic mass is seen in the ovary. A mural nodule that shows slight hyperintensity (→) is seen.

B: Dynamic MRI: The nodule shows enhancement that begins in the early phase and continues to the late phase.

C: MRI, diffusion-weighted image, b-value = 800 s/mm^2: The mural nodule shows strong hyperintensity.

D: MRI, ADC map: The mural nodule shows hypointensity.

Search keywords and secondary sources used as references

PubMed was searched using the following keywords, and further selections were made from the results: ovary, ovarian, adnexa, adnexal, and MRI.

In addition, the following was referenced as a secondary source.

1) Forstner R et al: ESUR recommendations for MR imaging of the sonographically indeterminate adnexal mass: an update. Eur Radiol 27: 2248-2257, 2017

References

1) Zhang X et al: Diagnostic accuracy of transvaginal ultrasound examination for assigning a specific diagnosis to adnexal masses: a meta-analysis. Exp Ther Med 20: 265, 2020
2) Yamashita Y et al: Adnexal masses: accuracy of characterization with transvaginal US and precontrast and postcontrast MR imaging. Radiology 194: 557-565, 1995
3) Hricak H et al: Complex adnexal masses: detection and characterization with MR imaging: multivariate analysis. Radiology 214: 39-46, 2000
4) Sohaib SA et al: Characterization of adnexal mass lesions on MR imaging. AJR Am J Roentgenol 180: 1297-1304, 2003
5) Bazot M et al: MR imaging compared with intraoperative frozen-section examination for the diagnosis of adnexal tumors; correlation with final histology. Eur Radiol 16: 2687-2699, 2006
6) Medeiros LR et al: Accuracy of magnetic resonance imaging in ovarian tumor: a systematic quantitative review. Am J Obstet Gynecol 204 (67): e1-10, 2011
7) Stevens SK et al: Ovarian lesions: detection and characterization with gadolinium-enhanced MR imaging at 1.5 T. Radiology 181: 481-488, 1991
8) Thomassin-Naggara I et al: Contribution of diffusion-weighted MR imaging for predicting benignity of complex adnexal masses. Eur Radiol 19: 1544-1552, 2009
9) Kim HJ et al: The value of diffusion-weighted imaging in the differential diagnosis of ovarian lesions: a meta-analysis. PLoS One 11: e0149465, 2016
10) Pi S et al: Utility of DWI with quantitative ADC values in ovarian tumors: a meta-analysis of diagnostic test performance. Acta Radiol 59: 1386-1394, 2018
11) Thomassin-Naggara I et al: Characterization of complex adnexal masses: value of adding perfusion- and diffusion-weighted MR imaging to conventional MR imaging. Radiology 258: 793-803, 2011
12) Thomassin-Naggara I et al: Ovarian-Adnexal Reporting Data System Magnetic Resonance Imaging (O-RADS MRI) score for risk stratification of sonographically indeterminate adnexal masses. JAMA Netw Open 3: e1919896, 2020

FQ 10 Is MRI recommended to diagnose incidental adnexal masses?

Statement

MRI is recommended for simple-appearing cysts larger than 10 cm, masses suspected of being malignant, hemorrhagic cysts in postmenopausal women, and masses with an uncertain diagnosis.

Background

Adnexal masses are frequently detected incidentally on CT or MRI. Although most are benign, they must be managed appropriately because of the high mortality rate of ovarian cancer. This discussion reviews the evidence concerning the types of incidental adnexal masses for which MRI is recommended.

Explanation

The guidelines of the Society of Radiologists in Ultrasound (SRU) advocate managing simple adnexal cysts based on ultrasound, whereas the white paper of the American College of Radiology (ACR) recommends the management of adnexal masses incidentally detected on CT and MRI. The flowchart based on these recommendations is shown in the figure.

The flowchart is based on the morphology and size of adnexal masses and menopausal status.

Morphology of adnexal masses is divided into 3 categories, “simple-appearing cyst”, “mass with characteristic features allowing presumptive diagnosis” and “mass with uncertain diagnosis”.

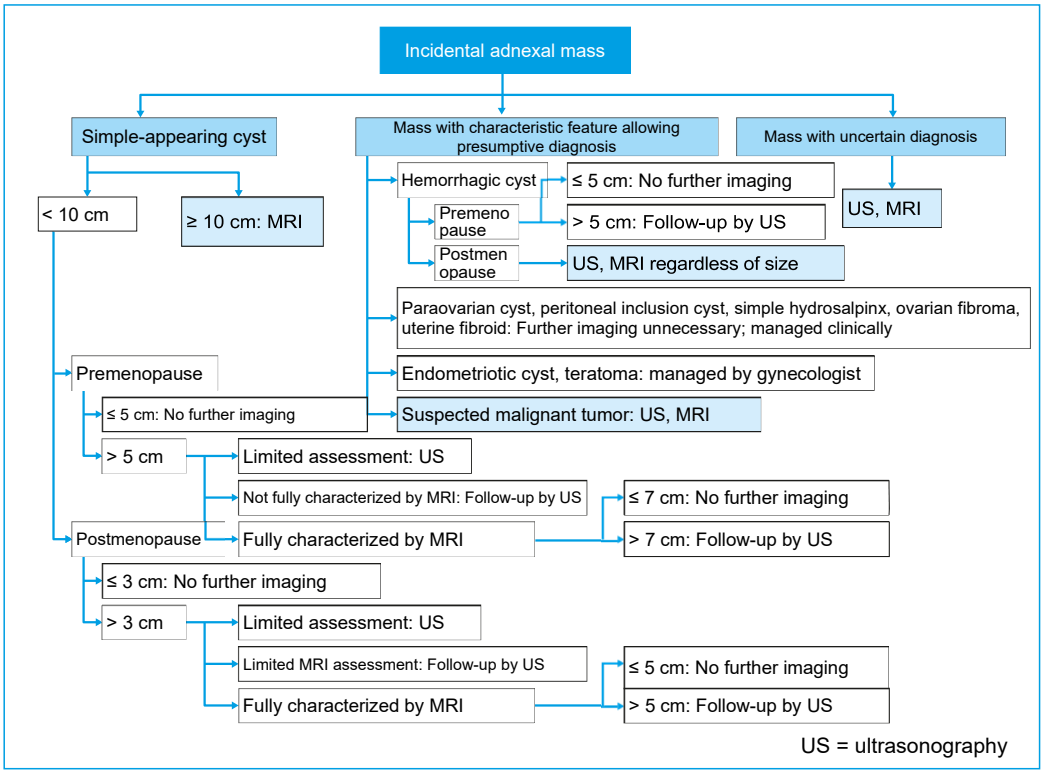

Figure Flow chart for managing incidental adnexal masses (prepared based on secondary source 1, 2)

A simple-appearing cyst is a round or oval anechoic fluid collection with a smooth thin wall and no solid component or septation. Most simple-appearing cysts are functional or non-neoplastic cysts; 14% to 20% of postmenopausal women have simple-appearing cysts, so they are not rare even in the postmenopausal period.[1, 2)] Spontaneous cyst resolution was seen in 82% of premenopausal cases and 44% to 69.4% of postmenopausal cases.[3-5)] Premenopausal cysts ≤ 3 cm in size are considered normal ovarian follicles, and postmenopausal cysts ≤ 1 cm in size are considered normal. Premenopausal cysts ≤ 5 cm in size and postmenopausal cysts ≤ 3 cm in size are mere existence and do not require follow-up. The management of premenopausal cysts > 5 cm and ≤ 7 cm in size and postmenopausal cysts > 3 cm and ≤ 5 cm in size differs according to the degree of certainty in characterizing them as simple-appearing cysts. “Evaluation inadequate” refers to poor image quality or non-contrast-enhanced imaging. “Fully characterized by MRI” refers to an incidental adnexal mass characterized by the following three elements: T2-weighted images; pre- and postcontrast T1-weighted images; and complete anatomic coverage of the mass in at least two image planes. For simple-appearing cysts > 7 cm (premenopausal) and > 5 cm (postmenopausal) sonographic follow-up is recommended. The ACR recommends a follow-up interval of 6 to 12 months. During this period, if the mass is shrinking, no follow-up is required, but if the mass grows, favoring neoplasm, but there is no evidence. For adnexal masses with diameters of 10 cm or larger, characterization by MRI is recommended because ultrasound may have limitations because of the size of the mass.

“Masses with characteristic features allowing presumptive diagnosis” are a group that are characteristic or highly suggestive of particular diagnostic entities by CT and MRI.[5] Most hemorrhagic cysts smaller than 5 cm in premenopausal women are corpus luteum cysts or functional cysts with hemorrhage, so imaging follow-up is not recommended, but for those larger than 5 cm in premenopausal women, sonographic follow-up is recommended. In postmenopausal women, sonographic or MRI follow-up is recommended, regardless of size.

Because endometriotic cysts and teratomas carry a risk of malignant transformation, they should be managed by a gynecologist. Masses suspected of being malignant require further examination by sonography or MRI (see BQ66).

A “mass with uncertain diagnosis” is a mass other than those described above. Ultrasound is required for further characterization, but there may be instances in which MRI is preferred. (see BQ66).

The management of simple-appearing cysts was revised in 2019. A recent study showed no increased risk of malignancy in women with simple-appearing cysts irrespective of cyst size. Unnecessary follow-up is not only a waste of time and money, but it also increases surgical intervention and, thereby, unintended harm.[6-8] Moreover, invasive ovarian serous adenocarcinoma is now known to primarily arise from solid precursors in the fallopian tubes, and simple-appearing cysts are not precursors to ovarian carcinoma.[9] Consequently, the revised recommendations have an increased size threshold for surveillance. It should be noted that this approach is limited to confidently characterized, simple-appearing cysts. If the mass has not been fully characterized, it should be evaluated by ultrasound and MRI. Contrast-enhanced MRI provides high specificity in determining that a mass is benign and should therefore be performed unless contraindicated.[10] Moreover, though the risk of malignancy is considered very low for simple-appearing cysts regardless of their size, their management varies depending on their size. SRU indicates that larger cyst size likely increases the possibility of mischaracterization, but there is no evidence regarding size. The Guideline for Gynecological Practice in Japan (2017 edition) states that, because of the increased risk of torsion with masses > 6 cm in size, regardless of whether the patient is pre- or postmenopausal, they should be managed by a gynecologist. That recommendation is on the basis of limited scientific evidence and depends on the expert’s opinion, so individual management is required to take into account the patient’s circumstances and background.

Search keywords and secondary sources used as references

PubMed was searched using the following keywords, and further selections were made from the results: ovary, ovarian, adnexa, adnexal, incidental, incidentaloma, asymptomatic, US, ultrasound, ultrasonography, CT, computed tomography, MRI, and magnetic resonance imaging.

In addition, the following were referenced as secondary sources.

1) Levine D et al: Simple adnexal cysts: SRU consensus conference update on follow-up and reporting. Radiology 293: 359-371, 2019
2) Patel MD: Management of incidental adnexal findings on CT and MRI: a white paper of the ACR incidental findings committee. J Am Coll Radiol 17: 248-254, 2020
3) Japan Society of Obstetrics and Gynecology and Japan Association of Obstetricians and Gynecologists, Ed.: 2017 Guideline for Gynecological Practice. Japan Society of Obstetrics and Gynecology, 2017.

References

1) Healy DL et al: Ovarian status in healthy postmenopausal women. Menopause 15: 1109-1114, 2008
2) Patel MD et al: Managing incidental findings on abdominal and pelvic CT and MRI, part 1: white paper of the ACR incidental findings committee II on adnexal findings. J Am Coll Raiol 10: 675-681, 2013
3) Borgfeldt. C et al: Transvaginal sonographic ovarian findings in a random sample of women 25-40 years old. Ultrasound Obstet Gynecol 13: 345-350, 1999
4) Modesitt SC et al: Risk of malignancy in unilocular ovarian cystic tumor less than 10 centimeters in diameter. Obstet Gynecol 102: 594-599, 2003
5) Castillo G et al: Natural history of sonographically detected simple unilocular adnexal cysts in asymptomatic postmenopausal women. Gynecol Oncol 92: 965-969, 2004
6) Greenlee RT et al: Prevalence, incidence and natural history of simple ovarian cysts among women over age 55 in a large cancer screening trial. Am J Obstet Gynecol 202: 373 e1-9, 2010
7) Smith-Bindman R et al: Risk of malignant ovarian cancer based on ultrasonography findings in a large unselected population. JAMA Intern Med 179: 71-78, 2019
8) Sharma A et al: Assessing the malignant potential of ovarian inclusion cysts in postmenopausal women within the UK Collaborative Trial of Ovarian cancer Screening (UKCTOCS): a prospective cohort study. BJOG 119: 207-219, 2012
9) Erickson BK et al: The role of the fallopian tube in the origin of ovarian cancer. Am J Obstet Gynecol. 209: 409-414, 2013
10) Anthoulakis C et al: Pelvic MRI as the “golden standard” in the subsequent evaluation of ultrasound-indeterminate adnexal lesions: a systematic review. Gynecol Oncol 132: 661-668, 2014

BQ 67 Is contrast-enhanced CT recommended for evaluating metastases when staging gynecological malignancies?

Statement

Contrast-enhanced CT is recommended because of the wide scanning range, high accessibility, and relatively high diagnostic performance for the staging of gynecological malignancies.

Background

The diagnosis of lymph node metastases and peritoneal dissemination is important in the evaluation of metastases from gynecological malignancies. Accurate diagnosis of these changes provides significant information not only for staging, but also for planning appropriate therapeutic treatment. Contrast-enhanced CT provides a wide scanning range and is particularly readily accessible in Japan. It is widely used to evaluate metastases from gynecological malignancies, and its usefulness for this purpose has been established in routine clinical practice. This discussion provides an overview of the usefulness of contrast-enhanced CT in evaluating metastases of cervical cancer, endometrial cancer, and ovarian cancer, which are common gynecological malignancies.

Explanation

The evaluation of lymph node metastasis is important for the staging of cervical, endometrial, and ovarian cancer. In particular, lymph node metastasis can be diagnosed by imaging according to the revised classification of the International Federation of Gynecological and Obstetrics (FIGO, secondary source 1) and the Japanese General Rules for Clinical Management (secondary source 2) of Cervical Cancer (stage IIIC).

Contrast-enhanced CT plays a certain role in the diagnosis of lymph node metastases of cervical cancer. A meta-analysis demonstrated that CT yielded a sensitivity and specificity of 50% and 92%, respectively, in evaluating lymph node metastases of cervical cancer, but its diagnostic performance was significantly lower than that of FDG-PET ("PET" below) and PET/CT.[1)] On the other hand, a more recent meta-analysis showed a sensitivity and specificity of 59% and 91%, respectively, with no significant differences compared with PET and PET/CT.[2)] A recent large, multicenter, controlled study found that the sensitivity and specificity of contrast-enhanced CT for lymph node metastases were 77% and 63%, respectively, which did not differ significantly from the results for PET/CT (sensitivity, 81%; specificity, 69%).[3)] The positivity criteria for lymph nodes in that study were as follows: A lymph node was considered positive on CT if the short axis was > 8 mm for a node with a short axis more than half the length of the long axis, and > 10 mm for a node with a short axis less than half the length of the long axis.

Regarding endometrial cancer, a meta-analysis revealed that the sensitivity and specificity of CT for lymph node metastases were 45% and 88%, respectively (no analysis for PET/CT).[4)] A recent meta-analysis

found that the sensitivity and specificity of CT were 44% and 93%, respectively.[5] The sensitivity and specificity of PET/CT were 67% and 91%, respectively, but no information about significant differences was provided. A large, multicenter, comparative study showed that the sensitivity and specificity of contrast-enhanced CT were 54% and 85%, respectively (same diagnostic criteria as used in reference 3), with no significant differences compared with the results for PET/CT (sensitivity, 63%; specificity, 83%).[6]

With regard to the lymph node metastases of ovarian cancer, a meta-analysis reported diagnosis with a sensitivity and specificity of 42.6% and 95%, respectively; the sensitivity and specificity of PET and PET/CT were 73.2% and 96.7%, respectively, with the sensitivity being significantly higher than that of CT.[7]

In view of these results, as well as the fact that CT is a readily accessible modality, contrast-enhanced CT is recommended particularly to evaluate lymph node metastases of cervical and endometrial cancer.

Peritoneal dissemination is observed mainly in ovarian cancer, and many of the articles about peritoneal dissemination involved investigations of ovarian cancer. Consequently, the following discussion concerns ovarian cancer. In a multicenter study of ovarian cancer staging, the sensitivity and specificity of CT for detecting peritoneal dissemination were 92% and 82%, respectively, on a per-patient basis. However, the detection performance of CT was poor for small lesions ≤ 2 cm in size.[8] The sensitivity and specificity on a per-site basis were 65% and 82%, respectively. Meanwhile, the sensitivity for dissemination to the serosa of the small intestine and colon was poor, at 17% and 45%, respectively.[9] Although peritoneal dissemination in several sites is not easily detected on contrast-enhanced CT, the use of contrast-enhanced CT is recommended to evaluate peritoneal dissemination because current CT examinations are usually performed using MDCT, which provides a wide scanning range and facilitates the generation of reconstructed sagittal and coronal images. In Europe and the United States, contrast-enhanced CT for the evaluation of peritoneal dissemination is often performed using an oral contrast medium. Because oral contrast media are not widely used in Japan, it should be noted that the diagnostic performance may actually be even lower in Japan than the reported diagnostic performance.

Diffusion-weighted MR imaging has been found to be useful and even superior to contrast-enhanced CT and PET/CT for detecting peritoneal dissemination and distant metastases.[9] It therefore needs to be discussed as an imaging method to consider when evaluating peritoneal dissemination and distant metastases.

Because remote metastasis such as pulmonary metastasis occurs with these gynecological cancers, CT scan from the chest to the pelvic region is increasingly being performed in routine clinical practice. Although it is difficult to stipulate scan ranges for contrast-enhanced CT, the ACR Appropriateness Criteria® indicate that chest CT may be appropriate for cervical cancer beyond stage IB (secondary source 3) and is also usually appropriate for endometrial cancer in high-risk groups (secondary source 4). For staging ovarian cancer, the guidelines indicate that imaging of both the abdominopelvic region and the area from the chest to the pelvic region is usually appropriate (secondary source 5). For endometrial cancer, the recommendation grades of the ACR Appropriateness Criteria® differ depending on the preoperative risk of

metastasis. Perhaps in Japan as well, rather than uniformly performing preoperative examinations, stratification according to risk level should be considered.

Search keywords and secondary sources used as references

PubMed was searched using the following keywords: gynecology, cervical cancer, endometrial cancer, ovarian cancer, metastasis, lymph nodes, peritoneal dissemination, staging, and CT.

In addition, the following were referenced as secondary sources.

1) Bhatla N et al: Cancer of the cervix uteri. Int J Gynecol Obstet 143 S2: 22-36, 2018
2) Japan Society of Obstetrics and Gynecology, et al., Ed.: The General Rules for Clinical and Pathological Management of Uterine Cervical Cancer: Clinical Edition (4th Edition). KANEHARA & Co., 2020.
3) Siegel CL et al: ACR Appropriateness Criteria®: pretreatment planning of invasive cancer of the cervix. J Am Coll Radiol 9: 395-402, 2012
4) Reinhold C et al: ACR Appropriateness Criteria®: pretreatment evaluation and follow up of endometrial cancer. J Am Coll Radiol 17: S472-S486, 2020
5) Kang SK et al: ACR Appropriateness Criteria®: staging and follow-up of ovarian cancer. J Am Coll Radiol 15: S198-S207, 2020

References

1) Choi HJ et al: Diagnostic performance of computer tomography, magnetic resonance imaging, and positron emission tomography or positron emission tomography/computer tomography for detection of metastatic lymph nodes in patients with cervical cancer: meta-analysis. Cancer Sci 101: 1471-1479, 2010
2) Liu B et al: A comprehensive comparison of CT, MRI, positron emission tomography or positron emission tomography/CT, and diffusion weighted imaging-MRI for detecting the lymph nodes metastases in patients with cervical cancer: a meta-analysis based on 67 studies. Gynecol Obstet Invest 82: 209-222, 2017
3) Atri M et al: Utility of PET-CT to evaluate retroperitoneal lymph node metastasis in advanced cervical cancer: Results of ACRIN6671/GOG0233 trial. Gynecol Oncol 142: 413-419, 2016
4) Selman TJ et al: A systematic review of tests for lymph node status in primary endometrial cancer. BMC Women's Health 8: 8, 2008
5) Reijnen C et al: Diagnostic accuracy of clinical biomarkers for preoperative prediction of lymph node metastasis in endometrial carcinoma: a systematic review and meta-analysis. Oncologist 9: e880-e890, 2019
6) Atri M et al: Utility of PET/CT to evaluate retroperitoneal lymph node metastasis in high-risk endometrial cancer: results of ACRIN 6671/GOG 0233 trial. Radiology 283: 450-459, 2017
7) Yuan Y et al: Computer tomography, magnetic resonance imaging, and positron emission tomography or positron emission tomography/computer tomography for detection of metastatic lymph nodes in patients with ovarian cancer: a meta-analysis. Eur J Radiol 81: 1002-1006, 2012
8) Tempany CM et al: Staging of advanced ovarian cancer: comparison of imaging modalities: report from the radio logical diagnostic oncology group. Radiology 215: 761-767, 2000
9) Michielsen K et al: Whole-body MRI with diffusion-weighted sequence for staging of patients with suspected ovarian cancer: a clinical feasibility study in comparison to CT and FDG-PET/CT. Eur Radiol 24: 889-901, 2014

CQ 16 Is the addition of FDG-PET/CT to diagnostic CT with IV contrast recommended for staging or re-staging in gynecological malignancies?

Recommendation

The addition of FDG-PET/CT to contrast-enhanced CT has the advantage of improving diagnostic accuracy, but radiation exposure needs to be considered. It is known that FDG-PET/CT is a minimally invasive procedure without marked adverse events, sometimes providing clinically relevant additional information for therapeutic strategies. Therefore, the addition of FDG-PET/CT to diagnostic CT with IV contrast is weakly recommended for detecting metastatic or recurrent lesions.

Recommendation strength: 2, strength of evidence: weak (C), agreement rate: 94% (17/18)

Background

In Japan, CT with IV contrast is routinely performed to detect lymph node metastases, intraperitoneal dissemination, and distant metastases for initial staging or re-staging after treatment for gynecological malignancies. The efficacy of contrast-enhanced CT has already been established in routine clinical practice, and the clinical usefulness of FDG-PET/CT has also been reported (Figure). To examine whether the addition of FDG-PET/CT has an add-on effect compared with contrast-enhanced CT alone and to determine a recommendation grade, this topic was specified as a CQ, and a systematic review was conducted. The subject of the review was diagnostic accuracy in screening for lymph node metastases, intraperitoneal dissemination, and distant metastases in the initial staging and re-staging after treatment of typical gynecological malignancies, such as ovarian cancer, cervical cancer, and endometrial cancer.

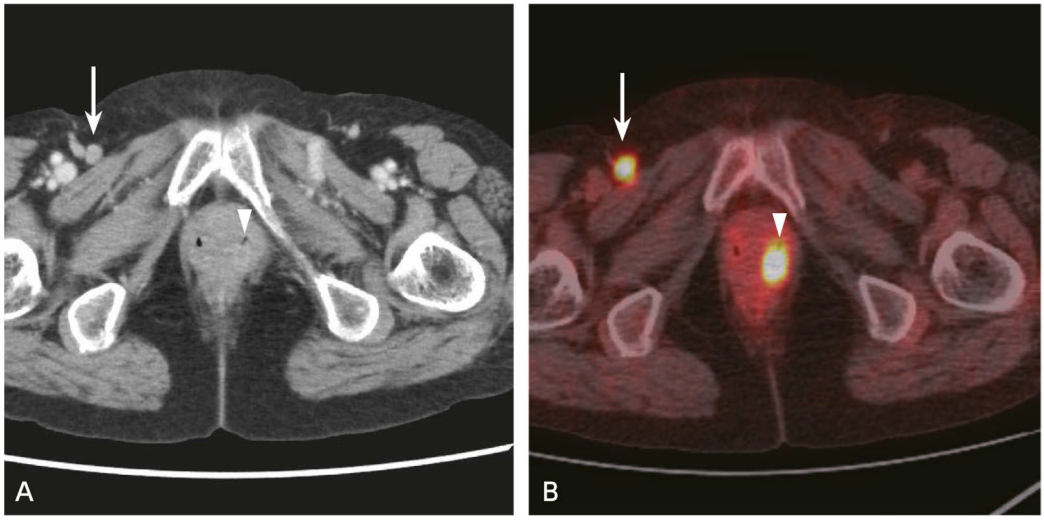

Figure　A postoperative case of endometrial cancer where FDG-PET/CT shows a nodal metastasis and local recurrence, for which contrast-enhanced CT provided inconclusive findings.

A: Contrast-enhanced CT; B: FDG-PET/CT

The patient was a woman in her 70s. Focal intense uptake is seen in a right inguinal lymph node (B →) and to the left side of the vaginal stump (B ▷), suggesting nodal metastasis and local recurrence, respectively. Neither had been identified on prior contrast-enhanced CT because the right inguinal node was < 1 cm in diameter (A →), and contrast of the recurrent tumor was weak (A ▷). The former lesion later enlarged, indicating a nodal metastasis, and the latter was histologically confirmed to be a recurrence.

Explanation

A literature search was conducted using the keywords indicated below, and articles were extracted in primary and secondary screenings. For ovarian cancer, one report of a nonrandomized, controlled study[1)] and 18 reports of observational studies (all cross-sectional studies)[2-19)] were extracted. Concerning cervical and endometrial cancers, two reports of nonrandomized, controlled studies[20, 21)] and three reports of observational studies (all cross-sectional studies)[22-24)] were extracted. These reports were then used in a qualitative systematic review. The plan was to compare two groups of studies, Group (A), in which assessments were performed with contrast-enhanced CT alone, and Group (B), in which assessments were performed with contrast-enhanced CT plus FDG-PET/CT. Studies of assessments by PET/CT alone (contrast-enhanced CT not included) were also included in Group (B). In addition, in evaluating the combination of contrast-enhanced CT and FDG-PET/CT in Group (B), whether fused images between contrast-enhanced CT and FDG-PET were available was not considered important. In the systematic review, the following aspects were considered first as outcomes: initial diagnostic performance (sensitivity, specificity, and accuracy), the contribution to the treatment plan, and the reduction in unnecessary tests (healthcare economics and patient burden). However, since there was a limited amount of articles demonstrating the contribution of treatment plans and the avoidance of unnecessary tests, only diagnostic performance was evaluated as an outcome.

The extracted studies on ovarian cancer were inconsistent in terms of population and methods because some focused on detecting only peritoneal metastasis, nodal metastasis, and recurrence. Overall, the diagnostic accuracy rate ranged from 56.9% to 96.7% for contrast-enhanced CT alone [pooled accuracy, 82.4% (95% CI, 80.3% to 84.2%)] and from 63.8% to 97.1% for contrast-enhanced CT plus FDG-PET/CT [pooled accuracy, 92.2% (95% CI, 90.7% to 93.5%)]. The diagnostic accuracy of contrast-enhanced CT plus FDG-PET/CT tended to be higher than that of contrast-enhanced CT alone. In most studies that performed statistical analyses (5/6), the diagnostic accuracy of contrast-enhanced CT plus FDG-PET/CT was statistically significantly superior.

The extracted studies of cervical and endometrial cancers, like those of ovarian cancer, were also inconsistent in populations and methods. Two studies were for cervical cancer plus endometrial cancer, two examined cervical cancer alone, and one examined endometrial cancer alone. The overall sample size for each type of cancer was small. In addition, the articles that examined both cervical and endometrial cancers were from the same hospital in Japan, suggesting possible bias. The diagnostic accuracy ranged from 77.8% to 87.0% [pooled accuracy, 81.3% (95% CI, 77.0% to 86.8%)] for CT alone and from 82.9% to 95.0% [pooled accuracy, 87.8% (95% CI, 89.3% to 96.3%)] for contrast-enhanced CT plus FDG-PET/CT. In studies with statistical analysis (3/5), the diagnostic accuracy or AUC of contrast-enhanced CT plus FDG-PET/CT was found to be statistically significantly superior. Thus, the studies showed that, as a method of improving accuracy in diagnosing metastases and recurrence of ovarian, cervical, and endometrial cancers, adding FDG-PET/CT to contrast-enhanced CT is clinically significant.

On the other hand, both contrast-enhanced CT and FDG-PET/CT are examinations associated with radiation exposure and relatively higher medical cost. Moreover, the availability of FDG-PET/CT examinations differs among regions. Therefore, performing PET/CT examinations for all cases everywhere is challenging. Nevertheless, the 2018 edition of the FIGO classification (secondary source 5) and Japan's General Rules for Clinical and Pathological Management of Uterine Cervical Cancer (4th edition, secondary source 6) indicate that cervical cancer metastases can be assessed by diagnostic imaging (stage IIICr). Consequently, the number of opportunities for detailed examination that includes FDG-PET/CT to improve diagnostic accuracy may increase.

The above considerations indicate that adding FDG-PET/CT to contrast-enhanced CT is helpful to a certain extent for increasing diagnostic accuracy in staging and re-staging for ovarian, cervical, and endometrial cancers, based on some investigations, although their evidence level was not very high. It is, therefore, weakly recommended in response to this CQ.

Search keywords and secondary sources used as references

PubMed was searched using the following keywords: FDG, CT, enhanced CT, cervical cancer, endometrial cancer, ovarian cancer, gynecological malignancies, sensitivity specificity, and uterine cancer.

In addition, the following were referenced as secondary sources.

1) Siegel CL et al: ACR Appropriateness Criteria®: pretreatment planning of invasive cancer of the cervix. J Am Coll Radiol 9: 395-402, 2012
2) Kang SK et al: ACR Appropriateness Criteria®: staging and follow-up of ovarian cancer. J Am Coll Radiol 15: S198-S207, 2018
3) Reinhold C et al: ACR Appropriateness Criteria®: pretreatment evaluation and follow-Up of endometrial cancer. J Am Coll Radiol 17: S472-S486, 2020
4) Survey of Medical Institutions [2017 Survey of Medical Institutions (static and dynamic surveys), Ministry of Health, Labour and Welfare]
5) Bhatla N et al: FIGO cancer report 2018: cancer of the cervix uteri. Int J Gynaecol Obstet 143 (S2): 22-36, 2018
6) Japan Society of Obstetrics and Gynecology, et al., Ed.: The General Rules for Clinical and Pathological Management of Uterine Cervical Cancer: Clinical Edition (4th Edition). KANEHARA & Co., 2020.

References

1) Hynninen J et al: A prospective comparison of integrated FDG-PET/contrast-enhanced CT and contrast-enhanced CT for pretreatment imaging of advanced epithelial ovarian cancer. Gynecol Oncol 131 (2): 389-394, 2013
2) Rubini G et al: Role of 18F-FDG PET/CT in diagnosing peritoneal carcinomatosis in the re-staging of patient with ovarian cancer as compared to contrast enhanced CT and tumor marker Ca-125. Rev Esp Med Nucl Imagen Mol 33 (1): 22-27, 2014
3) Kim HW et al: Peritoneal carcinomatosis in patients with ovarian cancer: enhanced CT versus 18F-FDG PET/CT. Clin Nucl Med 38 (2): 93-97, 2013
4) Kitajima K et al: Performance of integrated FDG-PET/contrast-enhanced CT in the diagnosis of recurrent ovarian cancer: comparison with integrated FDG-PET/non-contrast-enhanced CT and enhanced CT. Eur J Nucl Med Mol Imaging 35 (8): 1439-1448, 2008
5) Tawakol A et al: Diagnostic performance of 18F-FDG PET/contrast-enhanced CT versus contrast-enhanced CT alone for post-treatment detection of ovarian malignancy. Nucl Med Commun 37 (5): 453-460, 2016
6) Kitajima K et al: Diagnostic accuracy of integrated FDG-PET/contrast-enhanced CT in staging ovarian cancer: comparison with enhanced CT. Eur J Nucl Med Mol Imaging 35 (10): 1912-1920, 2008
7) Sari O et al: The role of FDG-PET/CT in ovarian cancer patients with high tumor markers or suspicious lesion on contrast-enhanced CT in evaluation of recurrence and/or in determination of intraabdominal metastases. Rev Esp Med Nucl Imagen Mol 31 (1): 3-8, 2012
8) Lee YJ et al: Diagnostic value of integrated ^{18}F-fluoro-2-deoxyglucose positron emission tomography/computed tomography in recurrent epithelial ovarian cancer: accuracy of patient selection for secondary cytoreduction in 134 patients. J Gynecol Oncol 29 (3): e36, 2018
9) Nasu K et al: Impact of positron emission tomography/computed tomography in the management of patients with epithelial ovarian carcinoma after treatment. Arch Gynecol Obstet 283 (5): 1121-1126, 2011
10) Mangili G et al: Integrated PET/CT as a first-line re-staging modality in patients with suspected recurrence of ovarian cancer. Eur J Nucl Med Mol Imaging 34 (5): 658-666, 2007
11) Gadducci A et al: Positron emission tomography/computed tomography in platinum-sensitive recurrent ovarian cancer: a single-center Italian study. Anticancer Res 40 (4): 2191-2197, 2020
12) Bhosale P et al: Clinical utility of positron emission tomography/computed tomography in the evaluation of suspected recurrent ovarian cancer in the setting of normal CA-125 levels. Int J Gynecol Cancer 20 (6): 936-944, 2010
13) Schmidt S et al: Peritoneal carcinomatosis in primary ovarian cancer staging: comparison between MDCT, MRI, and 18F-FDG PET/CT. Clin Nucl Med 40 (5): 371-327, 2015
14) Bilici A et al: Clinical value of FDG PET/CT in the diagnosis of suspected recurrent ovarian cancer: is there an impact of FDG PET/CT on patient management? Eur J Nucl Med Mol Imaging 37 (7): 1259-1269, 2010
15) Cho SM et al: Usefulness of FDG PET for assessment of early recurrent epithelial ovarian cancer. AJR Am J Roentgenol 179 (2): 391-395, 2002
16) Sala E et al: Recurrent ovarian cancer: use of contrast-enhanced CT and PET/CT to accurately localize tumor recurrence and to predict patients' survival. Radiology 257 (1): 125-134, 2010
17) Lopez-Lopez V et al: Use of (18) F-FDG PET/CT in the preoperative evaluation of patients diagnosed with peritoneal carcinomatosis of ovarian origin, candidates to cytoreduction and hipec: a pending issue. Eur J Radiol 85 (10): 1824-1828, 2016

18) Abdelhafez Y et al: Role of 18F-FDG PET/CT in the detection of ovarian cancer recurrence in the setting of normal tumor markers. Egypt J Radiol Nucl Med 47: 1787-1794, 2016
19) Michielsen K et al: Whole-body MRI with diffusion-weighted sequence for staging of patients with suspected ovarian cancer: a clinical feasibility study in comparison to CT and FDG-PET/CT. Eur Radiol 24 (4): 889-901, 2014
20) Atri M et al: Utility of PET-CT to evaluate retroperitoneal lymph node metastasis in advanced cervical cancer: results of ACRIN6671/GOG0233 trial. Gynecol Oncol 142 (3): 413-419, 2016
21) Atri M et al: Utility of PET/CT to evaluate retroperitoneal lymph node metastasis in high-risk endometrial cancer: results of ACRIN 6671/GOG 0233 trial. Radiology 283 (2): 450-459, 2017
22) Kitajima K et al: Performance of integrated FDG-PET/contrast-enhanced CT in the diagnosis of recurrent uterine cancer: comparison with PET and enhanced CT. Eur J Nucl Med Mol Imaging 36 (3): 362-372, 2009
23) Kitajima K et al: Low-dose non-enhanced CT versus full-dose contrast-enhanced CT in integrated PET/CT studies for the diagnosis of uterine cancer recurrence. Eur J Nucl Med Mol Imaging 37 (8): 1490-1498, 2010
24) Jung W et al: Value of imaging study in predicting pelvic lymph node metastases of uterine cervical cancer. Radiat Oncol J 35 (4): 340-348, 2017
25) Meads C et al: Positron emission tomography/computerised tomography imaging in detecting and managing recurrent cervical cancer: systematic review of evidence, elicitation of subjective probabilities and economic modelling. Health Technol Assess 17 (12): 1-323, 2013

FQ 11 Does CT or MRI during pregnancy affect the fetus?

Statement

With appropriate control of the imaging range, frequency, and parameters, radiation exposure with CT does not increase the incidence of fetal malformations. Although it slightly increases the frequency of pediatric cancer, the carcinogenic risk is low at the individual level. There have been no reports indicating that non-contrast MRI is harmful for fetuses.

FQ 12 Does contrast medium administration affect the fetus?

Statement

There have been no reports indicating that iodine contrast media for CT are harmful for fetuses. Gadolinium contrast media for MRI may increase the incidence of stillbirth, neonatal mortality, and postnatal inflammatory skin symptoms. CT or MRI, including contrast-enhanced imaging, can be performed if required to determine a treatment plan, there is no safer alternative, and it cannot be deferred until after the end of pregnancy. Contrast-enhanced MRI requires greater caution in determining whether it is indicated.

FQ 13 Is it possible to breast-feed after contrast medium administration?

Statement

There have been no reports of harm to infants resulting from breast-feeding after contrast medium administration. Consequently, unless there is a special reason, there is no need to restrict breast-feeding.

Background

The need may arise to perform CT or MRI during pregnancy, and CT or MRI may be performed without knowledge of a pregnancy. In addition, there may be situations that require that a decision be made during pregnancy or breast-feeding regarding an indication for contrast medium use. This discussion provides an overview regarding the safety of CT, MRI, and contrast medium use during pregnancy and breast-feeding.

Explanation

The effects of radiation on a fetus during pregnancy depend on the timing and dose of exposure. They are divided into deterministic effects with a threshold for impairment (e.g., malformation, mental retardation) and stochastic effects without a threshold (e.g., carcinogenic risk, genetic disorders). If the embryo is exposed to radiation 1 to 2 weeks after fertilization, it will either miscarry or be completely restored, and there is no risk of malformation. If exposure occurs during the organogenesis period between 4 and 10 weeks of pregnancy, the likelihood of teratogenicity increases. If it occurs during the period of brain formation between 10 and 27 weeks (particularly through 17 weeks), the likelihood of a central nervous system disorder increases. However, the threshold is considered to be 100 mGy, and the International Commission on Radiological Protection (ICRP) says that exposure of < 100 mGy should not be considered a reason for pregnancy termination. To ensure safety, the Guideline for Obstetrical Practice in Japan and the guidelines of the American College of Obstetricians and Gynecologists (ACOG) indicate that the permissible dose is 50 mGy. The level of fetal radiation exposure with CT is determined by the imaging range, frequency, and parameters. Under normal conditions, the exposure dose of a single CT imaging procedure does not reach 50 mGy and, therefore, does not result in deterministic effects. However, with multiple abdominopelvic CT imaging procedures (plain and contrast-enhanced CT or multiphase CT), the dose may exceed 50 mGy. Consequently, unless steps are taken to sufficiently reduce exposure, multiple procedures should be avoided. With regard to carcinogenic risk, the incidence of pediatric cancer may increase up to 2-fold even with low-dose exposure.[1-3] Because spontaneous cancer incidence is inherently very low, carcinogenic risk at the level of the individual has always been low. However, because stochastic effects are proportional to the exposure dose, effort should be made to reduce exposure as much as possible.

There have been no reports indicating that MRI performed using systems of ≤ 3T is harmful to a fetus at any stage of pregnancy,[4, 5] and the position of the ACR is that MRI can be performed at any stage. However, the Guideline for Obstetrical Practice in Japan indicates that MRI should be performed during or after the 14th week of pregnancy, and safety concerns have been expressed regarding the use of 3T systems.[4] Thus, adequate consensus has not been reached regarding the safety of testing during the 1st trimester and the use of 3T systems. Consequently, consideration should be given to avoiding such testing when possible.

An adverse event resulting from administration of iodinated contrast agents during pregnancy is neonatal hypothyroidism in neonates following amniotic fluid imaging performed using oil-soluble iodinated contrast agents, which was reported in the 1970s. However, there have been no reports of adverse events with transvenous administration of nonionized iodinated contrast agents.[6, 7] The European Society of Urogenital Radiology (ESUR) recommends that a thyroid function test be performed in neonates within 1 week after birth if an iodinated contrast agent is used during pregnancy. In Japan, however, this is an item included in the mass screening of neonates and therefore requires no special care.

Adverse events of gadolinium contrast media administration reported in 2016 with contrast-enhanced MRI performed at any stage of pregnancy were increases in the incidence of stillbirth, neonatal mortality, and postnatal rheumatoid skin rash and inflammatory skin symptoms.[4] However, objections have been raised about this study. For example, it has been noted that the relationship to skin disease was significant only in the 1st trimester, that the number of stillbirths and neonatal deaths was small (7 of 397 patients), that the control group consisted of patients who did not undergo MRI rather than patients who underwent non-contrast MRI, and that a linear chelating agent that was distributed during the first half of the study period may have caused the adverse events. Whether macrocyclic chelating agents carry a similar risk is not known. The ACR and ESUR have not designated their use as contraindicated.

As indicated above, effects sufficiently harmful to designate CT and MRI (including the use of contrast media) contraindicated during pregnancy have not been demonstrated. However, the long-term safety of such testing has not been established, and whether it is indicated depends on the degree to which it is needed. That is, after the procedure is explained to the patient, it can be performed if it is necessary to determine a treatment plan, there is no safer alternative, and it cannot be deferred until after the end of pregnancy. It should be explained that miscarriage or preterm labor (15%), malformation (3%), developmental disability (4%), and mental retardation (1%) can occur with no relationship to the test. Examples of indications for (contrast-enhanced) CT are pulmonary thromboembolism and trauma. Although MRI is recommended for acute abdomen, CT is permitted for institutions or time periods in which MRI scanning and interpretation are not available. A common indication for contrast-enhanced MRI is to evaluate malignancies detected during pregnancy. However, a more cautious approach to determining whether it is indicated is required, one that takes the estimated risk into account.

When a contrast agent is administered during breast-feeding, it is absorbed from the intestine of the neonate via the mother's milk at a level of < 0.01% in the case of an iodinated contrast agent and < 0.0004% in the case of a gadolinium contrast agent. There have been no reports of adverse effects on neonates, and the ACR, ESUR, and Japan Radiological Society have expressed the view that breast-feeding after contrast imaging is likely safe. On the other hand, the package inserts for iodinated and gadolinium contrast agents indicate that breast-feeding should be avoided for a certain period after an agent is administered, which contradicts the position of the academic societies. Theoretically, the possibility of an event such as an allergic reaction cannot be excluded, even with a trace amount of contrast agent. If the patient wishes to restrict breast-feeding after the situation is explained, she is instructed to express and discard breast milk for 24 hours.

Search keywords and secondary sources used as references

PubMed was searched using the following keywords: pregnancy, lactation, CT, MRI, contrast medium, gadolinium, and iodine. Animal studies and observational studies without a control group were excluded.

In addition, the following were referenced as secondary sources.

1) Japan Society of Obstetrics and Gynecology, Japan Association of Obstetricians and Gynecologists, Ed.: Guideline for Obstetrical Practice in Japan 2017. Japan Society of Obstetrics and Gynecology, 2017.
2) ACR committee on drugs and contrast media: ACR manual on contrast media 2020. American College of Radiology, 2020
3) ESUR contrast media safety committee: ESUR guidelines on contrast agents version10.0. European Society of Urogenital Radiology, 2018
4) ACOG committee on obstetric practice: ACOG committee opinion No.723: guidelines for diagnostic imaging during pregnancy and lactation. Obstet Gynecol 130 (4): e210-e216, 2017
5) Wang PI et al: Imaging of pregnant and lactating patients: part 1, evidence-based review and recommendations. AJR Am J Roentgenol 198: 778-784, 2012
6) Wang PI et al: Imaging of pregnant and lactating patients: part 2, evidence-based review and recommendations. AJR Am J Roentgenol 198: 785-792, 2012
7) Masselli G et al: Acute abdominal and pelvic pain in pregnancy: ESUR recommendations. Eur Radiol 23: 3485-3500, 2013
8) Expert panel on MR safety: ACR guidance document on MR safe practices: 2013. J Magn Reson Imaging 37: 531-543, 2013

References

1) Schulze-Rath R et al: Are pre- or postnatal diagnostic X-rays a risk factor for childhood cancer?: a systematic review. Radiat Environ Biophys 47: 301-312, 2008
2) Rajaraman P et al: Early life exposure to diagnostic radiation and ultrasound scans and risk of childhood cancer: case-control study. BMJ 342: d472, 2011
3) Ray JG et al: Major radiodiagnostic imaging in pregnancy and the risk of childhood malignancy: a population-based cohort study in Ontario. PLoS Med 7: e1000337, 2010
4) Ray JG et al: Association between MRI exposure during pregnancy and fetal and childhood outcomes. JAMA 316: 952-961, 2016
5) Chartier AL et al: The safety of maternal and fetal MRI at 3T. AJR Am J Roentgenol 213: 1170-1173, 2019
6) Rajaram S et al: Effect of antenatal iodinated contrast agent on neonatal thyroid function. Br J Radiol 85: e238-242, 2012
7) Kochi MH et al: Effect in utero exposure of iodinated intravenous contrast on neonatal thyroid function. J Comput Assist Tomogr 36: 165-169, 2012

FQ 14 Which imaging examinations are recommended to diagnose acute abdomen in pregnant women?

Statement

Ultrasonography should be performed first to diagnose acute abdomen in pregnant women.

If diagnosis by ultrasonography is difficult, non-contrast MRI is recommended.

CT is considered if diagnosis by ultrasonography and non-contrast MRI proves difficult, MRI cannot be performed, or the advantages of CT outweigh those of MRI. Contrast-enhanced imaging can be performed as needed (see FQ12)

Background

Appendicitis is the most frequent cause of acute abdomen during pregnancy, and diagnostic imaging is often relied upon for its diagnosis. If appendix perforation and panperitonitis occur concomitantly in a pregnant woman, problems such as miscarriage or preterm labor and maternal septicemia increase. Consequently, early diagnosis and treatment are required.

There is no debate regarding the fact that ultrasonography (US) is the first choice for diagnostic imaging of acute abdomen in pregnant women. This discussion provides an overview regarding the safety of CT and MRI as imaging examinations to be performed after US if definitive diagnosis by US proves difficult.

Explanation

The main guidelines are in agreement regarding the order of priority for diagnostic imaging examinations of acute abdomen in pregnant women. US is the first choice, and non-contrast MRI is the second choice if diagnosis by US proves difficult. In addition to this general rule, CT that takes radiation exposure into account can be performed if diagnosis by MRI proves difficult or MRI is difficult to perform due to problems related to factors such as time or the MRI emergency system.

Unlike non-pregnant women, white blood cell count elevation, and nausea and vomiting are frequently seen in pregnant women under normal circumstances, making it difficult to judge whether these findings are abnormal. Moreover, assessing abdominal findings becomes difficult as pregnancy progresses. Organ displacement resulting from exclusion by the enlarging uterus also complicates the diagnosis of acute abdomen in pregnant women. That is why diagnostic imaging plays an important role in acute abdomen during pregnancy.

Although the types of acute abdomen in pregnant women vary, they are broadly divided into 2 categories: gynecological and non-gynecological acute abdomen. Gynecological disease is often diagnosed at the US stage when the gynecologist strongly suspects acute abdomen based on the clinical and US findings. If further testing is needed in addition to US, selecting MRI is appropriate in view of its diagnostic performance. Non-gynecological disease can also often be diagnosed by US alone when a lesion

is easily identified by US despite anatomical displacement, or characteristic findings are seen on blood collection or urinalysis. In that case, no additional imaging examinations are needed. Appendicitis, which is frequently present in acute abdomen in pregnant women and for which the diagnostic performance of US decreases as pregnancy progresses, tends to require additional imaging examinations due to the possibility that it will require rapid treatment intervention.

Accurate diagnosis of appendicitis in pregnant women is important because of the complications that result from false-negatives and false-positives. Fetal mortality rates in pregnant women with appendicitis were found to increase to 5%, 20%, and 35.7% in patients without perforation, patients with perforation, and patients with complicating peritonitis, respectively.[1)] Delays in diagnosis resulting from false-negatives can have serious consequences. On the other hand, the frequency of negative appendectomy resulting from false-positives is higher in pregnant women (23% to 37%) than in non-pregnant women (14% to 18%), and negative appendectomy is considered a risk factor for preterm delivery (10% to 26%) and fetal death (3% to 7.3%).[2)] These findings show that false-negatives and false-positives should be avoided in diagnosing appendicitis in pregnant women. Moreover, they demonstrate the importance of imaging examinations that permit accurate and rapid diagnosis.

In prospective studies of the performance of US in diagnosing appendicitis in pregnant women, sensitivity and specificity in the 1st, 2nd, and 3rd trimesters of 92% and 66.7%, 63.7% and 75%, and 50% and 100%, respectively, were reported by Kazemini et al.,[3)] whereas sensitivity and specificity of 40% and 100%, 33% and 100%, and 0% and 100%, respectively, were reported by Butala et al.[4)] Thus, the reports show that diagnosing appendicitis by US is often difficult in acute abdomen in pregnant women, and that this tendency is particularly strong in late pregnancy, when the size of the uterus increases.

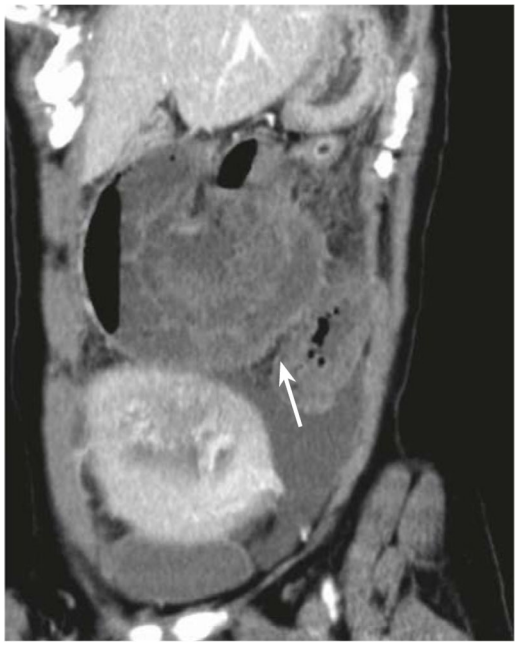

Figure　Strangulated intestinal obstruction in a pregnant woman (at 17 weeks of pregnancy)

Contrast-enhanced CT, MPR, oblique coronal image: The small intestine forms a closed loop, the wall in that area is thickened, and contrast enhancement is weak (→). Strangulated intestinal obstruction was diagnosed, surgery was planned, and the small intestine was partially resected.

In screening for the causes of acute abdomen in pregnant women, MRI has been found to be useful for many conditions. In addition to acute appendicitis, diagnosis of the following conditions is considered feasible with MRI: gastrointestinal disease (inflammatory bowel disease, diverticulitis, ileus), hepatobiliary disease (gallstones, choledocholithiasis, acute cholecystitis, pancreatitis, HELLP syndrome, acute fatty liver), urological disease (physiological hydronephrosis, ureteral calculus), vascular disease (venous thrombosis), and gynecological disease (uterine fibroids, ovarian masses and torsion).[5] Baron et al. reported sensitivity and specificity of 91% and 88%, respectively, for MRI and 85% and 90% for CT in acute abdomen in pregnant women, excluding that resulting from trauma; thus, the diagnostic performance of the 2 modalities was comparable.[6] Reports of the diagnosis of appendicitis by MRI that show high diagnostic performance have increased. A meta-analysis by Blumenfeld et al. reported sensitivity and specificity of 90.5% and 98.6%, respectively.[7] Non-contrast MRI is therefore recommended for acute abdomen in pregnant women when diagnosis by US is difficult.

However, the use of CT is permitted under certain circumstances due to the limited availability of emergency MRI in Japan. A questionnaire survey of radiology departments at general hospitals in the United States (85 institutions responded) found that 63 institutions (74%) had a written policy of using diagnostic imaging in pregnant women. Moreover, the proportion that prioritized the use of MRI and CT to diagnose appendicitis in the 1st, 2nd, and 3rd trimesters was 39% and 32%, 38% and 48%, and 29% and 58%, respectively.[8] Thus, MRI tended to be selected in early pregnancy and CT in late pregnancy. Moreover, CT can be considered if the patient has sustained serious trauma; if gastrointestinal perforation,

intestinal disease associated with strangulation, or thrombosis with a complicating pulmonary embolism is suspected; or if differential diagnosis is inconclusive and extensive imaging is required. To summarize, CT is considered if diagnosis by US and non-contrast MRI proves difficult, MRI cannot be performed, or CT is more advantageous than MRI. In such cases, contrast-enhanced imaging can be performed if necessary. If it is clear that contrast-enhanced CT would provide high diagnostic performance, it is recommended that non-contrast CT be omitted to reduce radiation exposure and that contrast-enhanced CT alone be performed. Reduction of radiation exposure by CT techniques such as low-dose CT should be aggressively applied clinically.

Search keywords and secondary sources used as references

PubMed was searched using the following keywords: acute abdominal pain, US, MR, CT, pregnancy, and appendicitis.

In addition, the following were referenced as secondary sources.

1) Bhosale PR et al: ACR Appropriateness Criteria®: acute pelvic pain in the reproductive age group. Ultrasound Q 32 (2): 108-115, 2016
2) Garcia EM et al: ACR Appropriateness Criteria®: right lower quadrant pain-suspected appendicitis. J Am Coll Radiol 15: S373-S387, 2018
3) Masselli G et al: Acute abdominal and pelvic pain in pregnancy: ESUR recommendations. Eur Radiol 23 (12): 3485-3500, 2013

References

1) Walker HG et al: Laparoscopic appendicectomy in pregnancy: a systematic review of the published evidence. Int J Surg 12 (11): 1235-1241, 2014
2) Aggenbach L et al: Impact of appendicitis during pregnancy: no delay in accurate diagnosis and treatment. Int J Surg 15: 84-89, 2015
3) Kazemini A et al: Accuracy of ultrasonography in diagnosing acute appendicitis during pregnancy based on surgical findings. Med J Islam Repub Iran. 31: 48-52, 2017
4) Butala P et al: Surgical management of acute right lower-quadrant pain in pregnancy: a prospective cohort study. J Am Coll Surg 211: 490-494, 2010
5) Spalluto LB et al: MR imaging evaluation of abdominal pain during pregnancy: appendicitis and other nonobstetric causes. Radiographics 32: 317-334, 2012
6) Baron KT et al: Comparing the diagnostic performance of MRI versus CT in the evaluation of acute nontraumatic abdominal pain during pregnancy. Emerg Radiol 19 (6): 519-525, 2012
7) Blumenfeld YJ et al: MR imaging in cases of antenatal suspected appendicitis: a meta-analysis. J Matern Fetal Neonatal Med 24 (3): 485-488, 2011
8) Jaffe TA et al: Practice patterns in imaging of the pregnant patient with abdominal pain: a survey of academic centers. AJR Am J Roentgenol 189: 1128-1134, 2007

FQ 15 Is MRI recommended to diagnose abnormalities of the placenta and umbilical cord?

Statement

MRI is recommended to diagnose abnormalities of the placenta and umbilical cord if sufficient information cannot be obtained by US or a more detailed evaluation is needed.

Background

US is usually performed periodically in the medical examinations of pregnant women. Consequently, most placental lesions and umbilical cord abnormalities are detected by US. Disorders of the placenta and umbilical cord were broadly divided into the following types, and the indication and the usefulness of MRI for each type were examined and are explained below: ① placenta accreta spectrum, ② placental abruption, ③ placental tumor, and ④ vasa previa.

Explanation

1. Placenta accreta spectrum

A 2013 meta-analysis regarding the diagnostic performance of US and MRI for placenta accreta spectrum reported sensitivity and specificity of 83% and 95%, respectively, for US and 82% and 88%, respectively, for MRI, with no significant differences between the two modalities.[1)] A 2018 meta-analysis also showed high diagnostic performance for MRI, with sensitivity ranging from 86.5% to 100% and specificity from 96.8% to 98.8%.[2)] Although MRI is inferior to US with respect to simplicity and spatial resolution, it is highly objective, and it is useful in patients with posterior placental wall adhesion, which is difficult to reach with US. It has been found to contribute to improved diagnostic performance when diagnosis is difficult with US.[3, 4)] However, the diagnostic performance of MRI can depend on the experience of the interpreting radiologist.[5)] MRI findings suggestive of placenta accreta spectrum are myometrial thinning of the uteroplacental interface, intraplacental dark bands in T2-weighted images, an intraplacental expanded flow void, protrusion of the placenta toward the urinary bladder, and interruption of the urinary bladder wall adjoining the placenta.[6-9)]

2. Placental abruption

Treatment must often be started quickly, and diagnosis is largely based on clinical findings. Although US is convenient, its sensitivity has been reported to be low, ranging from 24% to 53%.[10, 11)] MRI has been found to provide higher detection performance than US (sensitivity, 100%) and excellent visualization of the location and size of the retroplacental hematomas that occur with placental abruption.[11-13)] Moreover, because hematomas often appear as hyperintensities in T1-weighted images, they can be diagnosed

relatively easily regardless of the experience of the interpreting radiologist.[12] MRI is selected when US is negative, but excluding placental abruption is clinically important.

3. Placental tumor

With the exception of trophoblastic disease, hemangiomas are the most common placental tumors. Although tumors such as teratomas have also been reported, they are exceedingly rare. Case reports regarding the usefulness of MRI for these placental tumors are seen only sporadically. Review articles have shown that MRI is indicated when diagnosis by US is difficult.[14, 15]

4. Vasa previa

High diagnostic performance has been reported for color Doppler imaging, with sensitivity of 100% and specificity ranging from 99.0% to 99.8%.[16, 17] In patients with a succenturiate lobed placenta, which is a risk factor for vasa previa, MRI has been reported to be useful for the isolation and evaluation of succenturiate (accessory) placental lobes, the internal os, and blood vessels.[18, 19] Consequently, the ACR Appropriateness Criteria® state that, although US alone is usually adequate for diagnosing vasa previa, MRI may be indicated in some cases.

Search keywords and secondary sources used as references

PubMed was searched using the keywords indicated below for each type of disorder. Placenta accreta spectrum: MRI, ultrasound, invasive placenta, and placenta accreta; placental abruption: MRI, ultrasound, placenta, placental abruption, bleeding, and hemorrhage; placental tumor: MRI, ultrasound, placenta, placental, neoplasm, tumor, chorioangioma, and hemangioma; vasa previa: MRI, ultrasound, placenta, placental, and vasa previa.

In addition, the following were referenced as secondary sources.

1) Podrasky AE et al: ACR Appropriateness Criteria®: second and third trimester bleeding. Ultrasound Q 29: 293-301, 2013
2) Jauniaux E et al: Vasa praevia: diagnosis and management: green-top guideline No.27b. BJOG. 126 (1): e49-e61, 2019
3) Jha P et al: Society of Abdominal Radiology (SAR) and European Society of Urogenital Radiology (ESUR) joint consensus statement for MR imaging of placenta accreta spectrum disorders. Eur Radiol 30 (5): 2604-2615, 2020
4) Masselli G et al: Acute abdominal and pelvic pain in pregnancy: ESUR recommendations. Eur Radiol 23: 3485-3500, 2013
5) Jauniaux E et al: FIGO consensus guidelines on placenta accreta spectrum disorders: prenatal diagnosis and screening. Int J Gynaecol Obstet 140: 274-280, 2018

References

1) Meng X et al: Comparing the diagnostic value of ultrasound and magnetic resonance imaging for placenta accreta: a systematic review and meta-analysis. Ultrasound Med Biol 39: 1958-1965, 2013
2) Familiari A et al: Diagnostic accuracy of magnetic resonance imaging in detecting the severity of abnormal invasive placenta: a systematic review and meta-analysis. Acta Obstet Gynecol Scand 97: 507-520, 2018
3) Budorick NE et al: Another look at ultrasound and magnetic resonance imaging for diagnosis of placenta accreta. J Matern Fetal Neonatal Med 24: 1-6, 2016
4) Warshak CR et al: Accuracy of ultrasonography and magnetic resonance imaging in the diagnosis of placenta accreta. Obstet Gynecol 108: 573-581, 2006

5) Millischer AE et al: Magnetic resonance imaging for abnormally invasive placenta: the added value of intravenous gadolinium injection. BJOG 124: 88-95, 2017
6) Lax A et al: The value of specific MRI features in the evaluation of suspected placental invasion. Magn Reson Imaging 25: 87-93, 2007
7) Derman AY et al: MRI of placenta accreta: a new imaging perspective. AJR Am J Roentgenol 197: 1514-1521, 2011
8) Ueno Y et al: Novel MRI finding for diagnosis of invasive placenta praevia: evaluation of findings for 65 patients using clinical and histopathological correlations. Eur Radiol 24: 881-888, 2014
9) Bour L et al: Suspected invasive placenta: evaluation with magnetic resonance imaging. Eur Radiol 24: 3150-3160, 2014
10) Glantz C et al: Clinical utility of sonography in the diagnosis and treatment of placental abruption. J Ultrasound Med 21: 837-840, 2002
11) Masselli G et al: MR imaging in the evaluation of placental abruption: correlation with sonographic findings. Radiology 259: 222-230, 2011
12) Nguyen D et al: Imaging of the placenta with pathologic correlation. Semin Ultrasound CT MR 33: 65-77, 2012
13) Masselli G et al: Magnetic resonance imaging of clinically stable late pregnancy bleeding: beyond ultrasound. Eur Radiol 21: 1841-1849, 2011
14) Masselli G et al: MR imaging of the placenta: what a radiologist should know. Abdom Imaging 38: 573-587, 2013
15) Elsayes KM et al: Imaging of the placenta: a multimodality pictorial review. Radiographics 29: 1371-1391, 2009
16) Ruiter L et al: Systematic review of accuracy of ultrasound in the diagnosis of vasa previa. Ultrasound Obstet Gynecol 45: 516-522, 2015
17) Rebarber A et al: Natural history of vasa previa across gestation using a screening protocol. J Ultrasound Med 33: 141-147, 2014
18) Kikuchi A et al: Clinical significances of magnetic resonance imaging in prenatal diagnosis of vasa previa in a woman with bilobed placentas. J Obstet Gynaecol Res 37: 75-78, 2011
19) Oyelese Y et al: Magnetic resonance imaging of vasa praevia. BJOG 110: 1127-1128, 2003