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Imaging Features of Uncommon Gynecologic Cancers

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Abstract

OBJECTIVE—The role of imaging in patients with suspected gynecologic malignancies is to provide an accurate diagnosis to achieve the best and most tailored treatment plan. Uncommon cancers pose a distinct challenge, because current knowledge of these diseases is still limited. Our purpose is to highlight the role of cross-sectional imaging techniques, including ultrasound, CT, MRI, and PET/CT, in the diagnosis and pretreatment stratification of patients with rare gynecologic cancers.

CONCLUSION—This review shows the relevance of imaging findings for diagnosis, staging, and treatment planning in patients with uncommon uterine, cervical, vaginal, vulvar, and ovarian cancers.

Keywords

CT; MRI; oncologic imaging; PET/CT; rare gynecologic cancers; ultrasound

Uncommon cancers pose a distinct challenge from both the diagnostic and therapeutic perspectives. Their management is hampered by difficulties in conducting research that is sufficiently powered to reach robust conclusions that can be integrated into clinical guidelines and recommendations and by limited incentives to develop profitable drugs to treat them. These issues highlight the need for increased collaborative efforts to develop diagnostic and therapeutic models for rare diseases. The gynecologic tract is the fourth most common site of cancer in American women after breast, lung, and gastrointestinal primary cancers [1]. Most gynecologic cancers present as one of a few typical histologic subtypes involving the endometrium, cervix, and ovaries, and the contribution of imaging to the clinical pathway in this context has been extensively described. Much less has been published about the value of imaging in uncommon gynecologic cancers, which include uterine sarcomas, gestational trophoblastic neoplasia (GTN), vaginal or vulvar cancers, and atypical uterine and ovarian cancer histologic subtypes.

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Although some of these rare gynecologic cancers do not have a pathognomonic appearance on imaging and a precise diagnosis is not always straightforward, certain imaging findings may be helpful in achieving an accurate diagnosis. In the era of multidisciplinary patient care, the role of radiologists has become crucial for the accurate evaluation of the extent of disease to achieve better treatment selection and planning (e.g., primary surgery vs neoadjuvant chemotherapy or primary chemoradiotherapy). In this review, we will discuss imaging appearances of rare gynecologic tumors using ultrasound, CT, MRI, and ^{18}F -FDG PET/CT. Imaging findings corresponding to International Federation of Gynecology and Obstetrics (FIGO) staging of these gynecologic malignancies are also described. We will illustrate the relevance of imaging findings for diagnosis, staging, and treatment planning in patients with uncommon gynecologic cancers.

Imaging Techniques: Technical Requirements

The techniques used for imaging rare gynecologic cancers are identical to those used to image the more common gynecologic malignancies. A brief overview of the different modalities used is provided below.

Ultrasound

Ultrasound is the primary imaging modality used in the initial evaluation of the female pelvis. Ultrasound is performed with a trans-abdominal approach, using a 3.5–5-MHz curvilinear probe. A full bladder is necessary to provide a sonic window for ultrasound transmission from the body surface to internal organs. Transvaginal ultrasound is used for a more accurate evaluation of the endometrial cavity and ovaries. Transvaginal ultrasound is performed using a 5–8-MHz transducer. Color power and spectral Doppler techniques are used to evaluate vascularity.

CT

In the evaluation of suspected gynecologic cancers, contrast-enhanced CT of the abdomen and pelvis is performed in the portal venous phase (60–90 seconds after IV contrast medium administration at an injection rate of 2.5–3 mL/s in 70-kg patients). The use of water-density oral contrast agent is required to allow detection of small peritoneal deposits. The use of positive oral contrast agents may be useful for the recognition of small-bowel cystic peritoneal deposits, thanks to increasing contrast resolution. However, this may limit the identification of calcified peritoneal deposits. The use of ionizing radiation represents a disadvantage in young patients. Other limitations include artifacts with metallic implants and the morbidity associated with allergic reactions to iodinated contrast agents.

MRI

Fasting is typically required for 4–6 hours before MRI examination to limit artifacts from bowel peristalsis. Before MRI examination, antiperistaltic agents may also be administered. Patients are asked to void before the examination, because a full bladder may cause motion artifacts. Images are acquired in the supine position using a pelvic surface-array multichannel coil. Vaginal gel opacification may be used in cases of suspected vaginal invasion. The basic imaging protocol MRI for suspected gynecologic malignancies is

presented in Table 1. Advantages of MRI include superior soft-tissue contrast, multiplanarity, and the absence of ionizing radiation.

PET/CT

PET/CT is a functional imaging modality using a short-lived radionuclide, FDG. FDG is a glucose analog that is taken up by metabolically active cells, such as tumor cells, and subsequently is detected by PET. To provide anatomic localization of the tracer uptake, PET is combined with CT. Patients are asked to fast at least 6 hours before undergoing PET/CT. FDG is excreted by the kidneys and, therefore, the patient should empty the bladder before imaging to reduce urinary FDG obscuring tracer uptake in the rest of the pelvis. In the evaluation of suspected gynecologic cancers, false-positive findings related to physiologic radiotracer uptake may be seen in the endometrium, ovarian follicles, and corpus luteum cysts in premenopausal patients with hypercellular uterine leiomyoma and inflammatory processes within the pelvis.

Rare Malignant Neoplasms of Uterine Corpus and Cervix

Uterine Sarcoma

Epidemiology, risk factors, and diagnosis—Uterine sarcomas are rare and aggressive mesenchymal tumors, representing 2–3% of all uterine malignancies. Uterine sarcomas are divided into two main groups: mesenchymal tumors and mixed epithelial and mesenchymal tumors. Mesenchymal tumors include endometrial stromal sarcoma, leiomyosarcoma, and undifferentiated endometrial or uterine sarcoma.

Mixed epithelial and mesenchymal tumors include adenosarcoma and carcinosarcoma. Carcinosarcoma, previously known as uterine malignant mixed müllerian tumor, is regarded as a subset of endometrial carcinoma. Perivascular epithelioid cell tumors (i.e., “PEComas”) are recently described new entities, including some forms of angiomyolipoma and lymphangiomyomatosis, are composed predominantly or exclusively of epithelioid cells, and are defined as mesenchymal tumor composed of histologically and immunohistochemically distinctive perivascular epithelioid cells. Risk factors include a history of radiotherapy for an unrelated pelvic malignancy and long-term tamoxifen use [2, 3]. Abnormal uterine bleeding or pelvic pain are the primary symptoms. Definitive diagnosis requires biopsy or histopathologic analysis.

Staging and the role of imaging—Recently, carcinosarcoma has been reclassified as a dedifferentiated or metaplastic form of endometrial carcinoma. This change is reflected in the most recent revision of the FIGO staging system [4] (Table 2). Key imaging features for uterine sarcomas are summarized in Table 2. Imaging (MRI and CT) is useful to make a correct preoperative diagnosis and to evaluate the extent of disease. The role of ultrasound is limited.

Ultrasound—Uterine sarcoma may present with different patterns on ultrasound: a polypoid mass protruding into the endometrial cavity with nodular myometrial extension, an ill-defined endometrial mass, an intramyometrial mass with ill-defined margins and

heterogeneous echogenicity, or diffuse myometrial thickening [5]. On color Doppler imaging, irregular vessel distribution, low impedance flow, and high peak systolic velocity are suspicious for malignancy but are not specific for mesenchymal sarcomas [5].

MRI—Carcinosarcoma accounts for approximately 50% of all uterine tumors with mesenchymal components [6] and can arise anywhere along the müllerian axis. On MRI, carcinosarcomas are heterogeneous progressively enhancing central uterine masses with internal areas of hemorrhage and necrosis. These tumors have variable signal intensity on T2-weighted MR images [7]. On contrast-enhanced images, carcinosarcoma typically shows heterogeneous enhancement, with the polypoid portion of the tumor showing intense enhancement compared with the adjacent normal myometrium, with cervical stromal invasion and metastatic nodal disease [8–10] (Fig. 1). The differential diagnosis includes other sarcomas of the uterus and endometrioid cancer.

Endometrial stromal sarcoma (ESS) accounts for 10% of primary uterine sarcomas [6] and is subdivided into low- and high-grade categories. Low-grade ESS usually occurs in young premenopausal women. In this setting, the role of MRI is important in providing a preoperative diagnosis. On MRI, ESS commonly appears as an endometrial-based mass with predominantly myometrial components and homogeneous high signal intensity on T2-weighted images, although areas of necrosis or hemorrhage may also be seen [11, 12]. Low-grade ESS may mimic the appearance of adenomyosis; however, multiple marginal intramyometrial tumor nodules with T2-hypointense bands are suggestive of low-grade ESS. Multiple intratumoral flow voids due to neovascularity and infiltrative tumor nodules with extension along vessels, ligaments, and fallopian tubes due to marked vascular and lymphatic invasion are highly suggestive of high-grade ESS [11–13]. The differential diagnosis includes endometrial carcinoma of the uterus.

Adenosarcoma is a rare mixed epithelial-mesenchymal tumor that contains both benign glandular epithelial elements and malignant mesenchymal components. On MRI, the endometrial cavity may be distended by a heterogeneous mass characterized by high-signal cystic areas on T2-weighted images with numerous thin septa, yielding a lattice-like appearance [14], and hypointense solid components with intense enhancement compared with the adjacent myometrium.

Leiomyosarcomas account for approximately 35% of primary uterine sarcomas [7]. On MRI, benign leiomyomas have a well-defined margin. Leiomyosarcomas are usually irregular and ill-defined heterogeneously enhancing masses, with extensive internal areas of necrosis (> 50%) (Fig. 2A) and hemorrhage and extrauterine tumor nodules [11]. They can also appear as a diffuse uterine enlargement. DWI cannot reliably differentiate leiomyosarcomas from a benign degenerating or hyper-cellular leiomyoma [15]. The most suggestive features of leiomyosarcomas remain irregular margins, the presence of internal necrosis, and rapid growth [16]. The differential diagnosis for leiomyosarcomas includes adenomyoma, leiomyoma, and lipoleiomyoma.

Uterine perivascular epithelioid cell tumors should be considered a tumor of uncertain malignant potential [17]. Their imaging appearance on MRI may vary. Malignant subtypes may show irregular margins and internal heterogeneity.

CT—CT has limited ability in primary diagnosis because of its poor soft-tissue contrast. On contrast-enhanced CT, uterine sarcoma may appear as a large lobulated hypervascular solid mass that is inseparable from the uterus (Fig. 2B). CT is able to identify extrauterine spread of disease, including enlarged pelvic or retroperitoneal lymph nodes, extension to the pelvic sidewall, and the presence of distant parenchymal metastases. Lymph node involvement is more frequent in carcinosarcomas, whereas parenchymal metastases from leiomyosarcomas are usually hypervascular [18].

PET/CT—PET/CT is now mostly used for the evaluation of suspected disease recurrence, because uterine sarcomas express high levels of glucose transporter receptors and show high FDG uptake [19]. PET/CT is a highly sensitive and specific modality in detecting recurrence in patients with uterine sarcoma after therapy, with reported sensitivity, specificity, and accuracy of 85.7%, 100%, and 93.3%, respectively. However, no significant advantage over MRI or CT has been reported [19].

Gestational Trophoblastic Neoplasia

Epidemiology, risk factors, and diagnosis—GTN encompasses a spectrum of lesions derived from components of the normal human placenta, including hydatidiform mole (HM), and malignant lesions, such as invasive HM, choriocarcinoma, placental site trophoblastic tumor, and epithelioid trophoblastic tumor. The incidence is estimated at 1–3/1000 pregnancies for HM. The incidence rate of choriocarcinoma is about 0.18/100,000 women 15–49 years old [20]. Risk factors include prior spontaneous abortions and prior molar pregnancy. GTNs most commonly present with vaginal bleeding in the first trimester of pregnancy. Histologic examination is essential to achieve a correct diagnosis. Measurement of the urine or serum β -HCG level is indicated. The quantitative serum β -HCG level is higher than normal, often exceeding 100,000 IU/L. The standard treatment of women who wish to preserve fertility is dilation and curettage. For women who no longer wish to preserve fertility, hysterectomy may be indicated. In locally advanced or metastatic disease, chemotherapy is required.

Staging and the role of imaging—The role of imaging in gestational trophoblastic disease is to evaluate the extent of uterine or pelvic involvement (by ultrasound and MRI), to identify patients who are at risk for uterine perforation who would benefit from hysterectomy or chemotherapy, and to document the presence of metastatic disease (by CT). Key imaging features for gestational trophoblastic disease are summarized in Table 3.

Ultrasound—Transvaginal ultrasound is the primary choice in the evaluation of suspected GTN, and it typically reveals an echogenic and heterogeneous soft-tissue mass containing numerous cystic spaces and distending the endometrial cavity [21–23]. In the case of HM, small cystic spaces corresponding to the hydropic villi may be seen (i.e., the villous pattern). Irregularity of the mass border or asymmetric extension into the myometrium suggests

myometrial invasion in locally invasive HM and choriocarcinoma. GTNs are extremely vascular, showing increased vessel density and an abnormal uterine arterial waveform characterized by high peak systolic velocity and high diastolic blood flow (low resistance index) compared with the normal uterine arterial waveform on color Doppler ultrasound [24]. The ovaries may become enlarged with numerous cysts (i.e., theca lutein cysts).

MRI—MRI is the most accurate technique for local staging (Fig. 3). On T2-weighted images, GTN is seen as a heterogeneous high-signal-intensity mass [25]. On T1-weighted images, the mass may be hyperintense compared with the adjacent normal myometrium. Tumors are hypervascular with enlarged vessels depicted as signal voids in the uterus or in the broad ligament on both T1- and T2-weighted images. Tumors avidly enhance, and multiple internal enlarged vessels may be seen. MRI is able to define myometrium tumor invasion and extension to the parametria, adnexa, and vagina, which is suggestive of malignant aggressive disease and is characteristic of choriocarcinoma. On MRI, parametrial and vaginal involvement is seen as high-T2-signal masses within the parametria or vagina that avidly enhance after administration of gadolinium-based contrast agent. Metastatic disease is usually hypervascular.

CT—The role of CT in the evaluation of GTN is related to the detection of metastatic disease. Uterine enlargement is the most common CT feature of choriocarcinoma. After IV contrast media administration, uterine enhancement is heterogeneous with irregular hypodense regions within the myometrium, corresponding to hemorrhage or necrosis and dilated uterine and broad ligaments vessels [26]. Locoregional spread is characterized by avidly enhancing soft-tissue nodules in the parametria or pelvic organs. Choriocarcinoma spreads hematogenously. Metastases to the lung, liver, and brain are hypervascular and prone to hemorrhage.

PET/CT—Limited data are available on the use of PET/CT for patients with GTN. PET/CT may be useful to accurately determine sites of metabolically active or viable disease. One study showed PET/CT to be useful in the detection of metastatic disease [27].

Rare Histologic Subtypes of Uterine Cancer

Lymphoma

Primary uterine lymphoma is rare, occurring in only 1% of patients with lymphoma. However, secondary uterine involvement is more common (40–50% of patients at autopsy) [18]. On imaging, uterine lymphoma may appear as myometrial masses with a diffuse uterine enlargement. On MRI, uterine lymphoma characteristically appears as a homogeneous T1-hypointense and relatively T2-hyperintense mass, with homogeneous contrast enhancement causing diffuse uterine enlargement in the presence of preserved endometrium line [28].

Metastasis

Uterine metastases of extrapelvic malignant tumors are rare. The breast is the most frequent primary site [29]. The primary tumor is usually known, and patients may present with

abnormal vaginal bleeding. On imaging, the metastatic uterus appears enlarged, but with a preserved shape. On MRI, intramyometrial infiltrative nodules are suggestive of diffuse metastatic vascular and lymphatic uterine invasion [16].

Rare Histologic Subtypes of Cervical Cancer

Epidemiology, Risk Factors, and Diagnosis

Cancer of the uterine cervix is the third most common gynecologic malignancy and the third leading cause of death among gynecologic cancers in the United States [1]. The most common histologic type of cervical carcinoma is squamous cell carcinoma (90%) followed by adenocarcinoma (5–10%). Adenoma malignum (also known as minimal deviation adenocarcinoma) is a subtype of mucinous adenocarcinoma of the cervix. Its prevalence is about 3% of all cervical adenocarcinomas. Neuroendocrine cancers are rare and highly aggressive cervical malignancies. They are classified as typical carcinoid, atypical carcinoid, small cell carcinoma, and large cell neuroendocrine carcinoma. Other rare histologic types include melanoma and, among nonepithelial types, lymphoma and sarcoma. Patients may present with abnormal vaginal discharge and bleeding. Definitive diagnosis requires biopsy during physical examination or histopathologic analysis.

Role of Imaging

Imaging plays a fundamental role in the evaluation of extent of disease. MRI is the modality of choice for evaluating the extent of disease; CT and PET/CT are viable for the evaluation of nodal and distant metastasis. FIGO staging is the most widely used staging system for cervical carcinoma, regardless of histologic subtype [30] (Table 4). The MRI findings for rare cervical cancers are summarized in Table 5.

Adenoma Malignum

Adenoma malignum is often associated with Peutz-Jeghers syndrome, which is characterized by mucocutaneous pigmentation, multiple hamartomatous polyps of the intestinal tract, and ovarian mucinous tumors. The most common initial symptom is a watery vaginal discharge. The tumor is composed of well-differentiated endocervical glands filled with mucin, which invade the deeper portion of the cervical stroma. The role of the radiologist is differentiating adenoma malignum from a broad spectrum of multicystic benign lesions in the uterine cervix, including deep nabothian cysts and florid endocervical hyperplasia. On ultrasound, adenoma malignum may appear as a hyperechoic multilocular endocervical mass with cystic components. On MRI, adenoma malignum is seen as a multicystic mass showing slightly high signal intensity on T1-weighted images and markedly high signal intensity on T2-weighted images, with some internal enhancing solid components that extend into the cervical stroma. The locules of the multicystic lesions have smooth margins and diameters of less than 1 cm [31]. The presence of internal enhancing solid nodules is more likely to be associated with local invasion (i.e., endometrial cavity, parametria, and vagina) and nodal metastases (Fig. 4). Adenoma malignum may disseminate into the peritoneal cavity even in the early stage of the disease [32]. The differential diagnosis includes deep nabothian cysts, tunnel cluster, and endocervical glandular hyperplasia. The role of CT for local staging is limited. It is used in the assessment of distant

disease. PET/CT may be useful in identifying the primary site of disease in patients with adenoma malignum; however, its utility in detecting metastatic disease remains undetermined.

Neuroendocrine Cancers

Neuroendocrine tumors of the uterine cervix tend to show aggressive growth [33]. Although imaging cannot reliably differentiate neuroendocrine carcinoma from other types of epithelial cervical carcinomas, on MRI, neuroendocrine tumors tend to be large lobulated masses and tend to show slightly homogeneous high signal intensity on T2-weighted images and intense enhancement on dynamic multiphase T1-weighted images [34]. Small cell carcinoma is frequently accompanied by lymphadenopathy and bilateral parametrial invasion [34] (Fig. 5).

Melanoma

Melanoma rarely involves the uterine cervix. It usually occurs in the vaginal mucosa. Because of the presence of melanocytes, melanoma is typically hyperintense on T1-weighted MR images. However, melanoma may have different signal intensity characteristics according to the melanin concentration and the presence of hemorrhage [32].

Sarcoma

Patients with cervical sarcomas tend to be younger and to have more-advanced disease at diagnosis than do patients with squamous cell carcinoma. Carcinosarcomas are the most common histologic subtype followed by leiomyosarcomas and adenosarcomas [35]. The prognosis is poor. No specific imaging diagnostic features have been described for cervical sarcoma. However, a lesion with diffusely infiltrating growth through the cervical stroma could be suggestive of the diagnosis.

Lymphoma

Malignant lymphoma frequently infiltrates the uterus in advanced disease. However, it rarely involves the uterine cervix. On MRI, the tumor tends to be hypointense on T1-weighted images and relatively hyperintense on T2-weighted images and to extensively infiltrate the cervical stroma [28]. The presence of preserved cervical epithelium may suggest the diagnosis of malignant lymphoma [28].

Vaginal Cancer

Epidemiology, Risk Factors, and Diagnosis

Primary vaginal carcinoma is rare, accounting for only 2–3% of gynecologic malignancies; squamous cell carcinomas account for approximately 90% of vaginal malignancies. Squamous cell carcinoma is more commonly seen in postmenopausal women and tends to occur in the proximal third of the vagina, in the posterior wall. Risk factors include older age and human papillomavirus infection. Adenocarcinoma may also arise in the vagina. Vaginal cancer is most often diagnosed clinically. Imaging has no role in the diagnosis of vaginal cancer.

Staging and the Role of Imaging

MRI has a role in local staging and preoperative assessment of vaginal cancer. CT is often performed for the detection of pelvic lymphadenopathy or metastatic disease. Limited data are available on the utility of PET in vaginal cancer. Lamoreaux et al. [36] found that PET was superior to CT in the detection of the primary tumor and pelvic adenopathy in these patients. Clinical management depends on the size, location, and stage of tumor.

MRI

On MRI, vaginal mucosa shows high signal intensity on T2-weighted images. The submucosal and muscularis layers are low signal intensity on both T1- and T2-weighted images. The surrounding external layer contains fat and a venous plexus that has slow flow, showing high signal intensity on T2-weighted images. Vaginal tumors appear isointense on T1-weighted images and as a soft-tissue mass with intermediate-to-high signal intensity on T2-weighted images [37–39]. Thin-section T2-weighted images in sagittal and axial planes with a small FOV are useful for detection. Tumors may also show restricted diffusion on DWI. Fat-saturated T2-weighted images and contrast-enhanced sequences are used for assessment of local invasion.

Prognosis and treatment of vaginal cancer depend on the stage of the disease, as outlined by FIGO. MRI criteria that correlate to the FIGO staging system have been evaluated. In stage I disease, the tumor has invaded the epithelium but is confined to the vaginal mucosa. These lesions may be occult on MRI. The surrounding perivaginal fat is preserved. Stage II disease is defined as vaginal tumor invading the paravaginal tissues but not involving the pelvic sidewall. When tumor extends into paravaginal tissues, the high-T2-signal perivaginal fat is invaded by intermediate-T2-signal tumor (Fig. 6). Stage III disease is considered when tumor extends to involve the pelvic sidewall or pelvic adenopathy. Stage IV disease is defined as tumor invading the bladder or rectum or as extrapelvic spread of disease. A mucin-producing adenocarcinoma may show higher signal components on T2-weighted images than squamous cell carcinoma, although a confident prediction of histologic subtype cannot be made on MRI alone. In advanced disease, tumor may involve pelvic floor muscles (tumor tissue visualized within 3 mm of the levator ani, obturator internus, or the piriformis muscle) and invades the bladder or rectum or both with extrapelvic spread of disease. Invasion of the bladder or rectal or both is diagnosed by identifying disruption of the normal high T2 signal of the bladder or rectal mucosa or both. Lymph node involvement is an important prognostic factor and is related to the size of the primary tumor and the depth of vaginal stromal invasion. The most commonly used MRI criteria for lymph node metastases (i.e., femoral, inguinal, and pelvic nodes) are the short-axis diameter greater than 1 cm, round shape, irregular margins, and enhancement.

Rare Histologic Subtypes

Melanoma—Vaginal melanoma can appear on T1-weighted images as a mass with higher signal intensity than the pelvic muscles, due to the paramagnetism of melanin.

Sarcoma—Vaginal sarcomas account for 2% of vaginal cancers, with rhabdomyosarcoma being the most common soft-tissue sarcoma in children and adolescents, and

leiomyosarcoma the most common sarcoma in adult women. Nonspecific characteristics on imaging are seen for rhabdomyosarcoma, characterized by heterogeneous low signal intensity on T1-weighted images and high signal intensity on T2-weighted images. Heterogeneity is due to hemorrhage and necrosis within the tumor. Leiomyosarcoma on MRI appears as a bulky mixed cystic solid mass of intermediate-to-high signal intensity on T2-weighted images that shows avid contrast enhancement. Extension to the cervix, parametria, and lymph nodes can be present [39].

Lymphoma—Primary lymphoma of the vagina is rare, accounting for 1% of primary extranodal lymphoma. Secondary lymphoma is more common. The mass is infiltrative and is of homogeneously intermediate signal intensity on T2-weighted images with homogeneous contrast enhancement. An intact mucosa is a characteristic feature of lymphoma.

Vulvar Cancer

Epidemiology, Risk Factors, and Diagnosis

Vulvar carcinoma is rare, accounting for 5% of female genital tract cancers, with peak incidence occurring in the 65- to 75-year age group. Squamous cell carcinoma accounts for more than 85% of cases. Other histologic types include melanoma, mesenchymal tumors, adenocarcinoma, extramammary Paget disease, basal cell carcinoma, and Bartholin gland cancer. Risk factors for squamous cell carcinoma include older age, lichen sclerosus, human papillomavirus infection, and vulvar intraepithelial neoplasia, especially in young women. Vulvar cancer is diagnosed clinically [4].

Staging and the Role of Imaging

Imaging plays a role in assessing locally advanced disease (Table 6). Imaging techniques include MRI for local and pelvic nodal staging, CT or PET/CT for the assessment of distal disease, and ultrasound, which is often used for image-guided biopsy procedures.

Ultrasound

Ultrasound is useful to evaluate nodal involvement. Lymphatic supply to the vulva is rich; thus, nodal metastases occur at an early stage. Primary lymph drainage is to the femoral and inguinal nodes and then to the pelvic nodes. All vulvar cancers located within 1 cm of midline structures (i.e., clitoris, vagina, or anus) have the potential to spread bilaterally. Typical ultrasound features are increase in size (e.g., > 5 mm in short-axis diameter), rounded shape, irregular contour, and loss of the fatty hilum. Ultrasound-guided fine-needle aspiration can help with proving nodal metastatic disease [40–42].

MRI

On MRI, vulvar cancer appears as a solid mass with nonspecific low signal intensity on T1-weighted images and moderate-to-high signal intensity on T2-weighted images. Occasionally, it may also be difficult to discriminate whether tumors originate from the right or left labia. MRI is fundamental in determining the involvement of adjacent structures (e.g., the anal sphincter, urethra, or vaginal wall) to assist in surgical planning (Table 6). Disruption of the target appearance of the urethra on T2-weighted images and interruption of

the low-T2-signal vaginal wall and anal sphincter by an intermediate-T2-signal tumor are suggestive of invasion. Fat-saturated T2-weighted images, DWI, and contrast-enhanced sequences are useful for assessment of local invasion. Contrast-enhanced MRI sequences can increase staging accuracy from 75% to 85% [43]. High-resolution MRI sequences have been to achieve an accuracy of 87% in the detection and characterization of inguinal and pelvic lymph nodes [43], indicating that MRI may be useful to evaluate patients for ultrasound-guided biopsy versus sentinel lymph node detection.

CT

The primary tumor may be visualized on CT as an area of soft-tissue density in the vulva. CT provides information on the presence of pelvic lymphadenopathy and distant metastases with a sensitivity and specificity of 58% and 75%, respectively [40].

PET/CT

PET/CT is performed for detection of lymphadenopathy or metastatic disease. Cohn et al. [44] evaluated the role of PET/CT in detecting groin lymphadenopathy in locally advanced vulvar cancer, before nodal dissection. A 67% sensitivity, 95% specificity, 86% positive predictive value, and 86% negative predictive value were reported.

Rare Histologic Subtypes

Melanoma—Melanoma is the second most common vulvar malignancy. It shows intermediate-to-high signal intensity on T1-weighted imaging due to the paramagnetic effect of melanin, with corresponding low-to-intermediate signal intensity on T2-weighted imaging.

Angiomyxoma—Angiomyxoma of the vulva is a slow-growing mesenchymal tumor arising usually in premenopausal women. High signal intensity is seen on T2-weighted imaging, possibly reflecting the myxomatous stroma, and high water content may also be seen. The mass straddles the urogenital diaphragm and displaces, rather than invades, the adjacent tissues or organs [39].

Nonepithelial Ovarian Cancer

Epidemiology

Nonepithelial ovarian cancers (accounting for 7% of primary ovarian cancers) include malignant germ cell tumors, malignant sex-cord stromal tumors, and metastases.

Role of Imaging

Transvaginal ultrasound represents the primary imaging modality for assessing the presence of ovarian lesions. Sonographic indicators suggestive of malignancy include solid or cystic lesions with a maximum diameter greater than 4 cm; papillary projection (vegetation), thick wall, and thick internal septa (> 3 mm) in a cystic lesion; and irregular non-fat solid vascularized components. The presence of ascites, peritoneal implants, or hydronephrosis is also suggestive of malignancy. MRI represents a problem-solving technique and is the modality of choice for characterization of adnexal lesions (Table 7). CT is the modality of

choice for staging. PET/CT may play a role in preoperative staging of patients with advanced ovarian cancer and in case of suspected recurrences.

Malignant Germ Cell Tumors

Germ cell tumors are more frequent among women younger than 20 years. The most common subtypes are dysgerminoma, immature teratoma, and endodermal sinus tumor. Dysgerminoma is unilateral and predominantly solid but may contain areas of hemorrhage and necrosis. The finding of a homogeneously enhancing multilobulated mass, with prominent enhancing fibrovascular septa, has been described as a characteristic feature on MRI or CT for dysgerminoma [45]. The disease is often limited to the pelvis at presentation. If metastatic disease is present, it tends to involve lymph nodes. Immature (malignant) teratoma is usually unilateral and solid, although internal cystic areas are common. Calcification and small amounts of fat in a predominantly solid mass in a young female patient are diagnostic. The tumor capsule is not well defined, and ascites with peritoneal implants may be present. In addition, a coexistent mature teratoma may be present in the ipsilateral and in the contralateral ovary [45]. Endodermal sinus tumor or yolk sac tumor of the ovary is a malignant germ cell tumor that usually presents as a rapidly growing unilateral adnexal mass. The imaging features may range from predominantly solid to predominantly cystic; hemorrhage and hypervascular enhancement may be seen (Fig. 7).

Sex-Cord Stromal Tumors

The most common subtype of sex-cord stromal tumors is granulosa cell tumors. Granulosa cell tumors are characterized histologically by granulosa cells, which secrete estrogens and progesterone. Thus, granulosa cell tumors can be functional (i.e., hormonally active). They are divided into adult and juvenile types. Adult granulosa cell tumors present with menstrual disturbance or uterine bleeding in pre- or postmenopausal patients, due to estrogenic secretion and induced endometrial hyperplasia. At imaging, granulosa cell tumors are unilateral, large, encapsulated, and predominantly solid masses with cystic components [45]. The tumors may have a characteristic spongelike appearance on T2-weighted MRI [45]. Granulosa cell tumors have a particular predisposition to hemorrhage [45]. Associated endometrial thickening or mass may be seen [45].

Carcinosarcoma

Carcinosarcomas, also referred to as mixed müllerian tumor of the ovary, are aggressive rare tumors composed of both malignant epithelial and mesenchymal elements [46]. On conventional imaging, tumors generally are heterogeneous, large, mixed solid, and cystic adnexal masses characterized by enhancing internal septa and solid components [47]. Peritoneal implants and large amounts of ascites are usually present at diagnosis (Fig. 8).

Lymphoma

Primary ovarian lymphoma is a rare manifestation of non-Hodgkin lymphoma, with diffuse large B cell lymphoma being a dominant histologic type. On MRI, ovarian lymphoma may show lower T2 signal intensity compared with most ovarian carcinomas [48]. On CT, it appears as a solid homogeneously enhancing mass, without ascites.

Metastasis

Metastases to the ovary usually arise from primary malignancy in the stomach or colon and less frequently from the breast, lung, and pancreas. Krukenberg tumor refers to metastasis consisting of mucin signet-ring cells in a cellular stroma, arising from a carcinoma of the gastric antrum. The age at diagnosis is typically younger than that for ovarian cancer. There are no specific imaging findings. However, metastases to the ovary are typically bilateral, solid, and strongly enhancing [45]. Diffuse ovarian edema may also be present, related to the stromal infiltration by the signet-ring cells (Fig. 9). Cystic and necrotic areas may be seen.

CT

CT is the primary cross-sectional imaging modality used to stage ovarian cancer. Cytoreductive surgery is the treatment of choice for patients with ovarian cancer. Optimal cytoreductive surgery (i.e., residual disease < 1 cm) is a strong predictor of survival. Accurate imaging will help to guide the surgeon to areas of disease that may be difficult to identify surgically and to describe the volume and extent of disease likely to be optimal resectable disease. Criteria for nonoptimal resectable disease have been developed. They include lymph node enlargement above the renal hilum, the presence of abdominal wall invasion, parenchymal liver metastases, and peritoneal implants of larger than 2 cm along the diaphragm, lesser sac, porta hepatis, intersegmental fissure, gallbladder fossa, gastrosplenic, gastrohepatic ligament, and root small-bowel mesentery [49]. Ascites on CT is easily identified; the presence of ascites on CT had a high positive predictive value as a sign of peritoneal metastasis.

Conclusion

In uncommon gynecologic cancers, an accurate pretreatment diagnosis based on imaging features alone may be difficult to achieve; however, imaging input in the multidisciplinary setting is crucial for optimal treatment selection. MRI may be useful to suggest the diagnosis and to evaluate the extent of disease in rare malignant neoplasms of the uterine corpus and is the most accurate technique for local staging. MRI plays a fundamental role in the evaluation of the extent of disease in cervical, vaginal, and vulvar cancer. Ultrasound represents the primary imaging modality for assessing the presence of ovarian lesions. MRI is used as a problem-solving technique and represents the modality of choice for the characterization of adnexal lesions. CT and FDG PET/CT are helpful in detection of lymphadenopathy and distant metastatic disease.

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Fig. 1.

54-year-old woman with stage IA polypoid endometrial carcinosarcoma.

A and B, Sagittal (**A**) and axial (**B**) oblique fast spin-echo T2-weighted images show heterogeneously hyperintense polypoid endometrial mass (T) without myometrial invasion. Hypointense junctional zone is preserved (*arrow*), excluding myometrial invasion.

C, Sagittal fat-saturated contrast-enhanced T1-weighted image shows intense enhancement (*thick arrow*) on posterior part of tumor (T), representing stalk of polyp, and intact enhancement of junctional zone (*thin arrow*).

Fig. 2.

Two patients with uterine leiomyosarcoma.

A, 45-year-old woman with uterine leiomyosarcoma. Sagittal fast spin-echo T2-weighted image shows enlarged uterus (U) with heterogeneous T2-hyperintense mass (T) suspicious for partially necrotic sarcoma.

B, 65-year-old woman with uterine leiomyosarcoma. Axial contrast-enhanced CT image shows enlarged uterus (U) with areas of necrosis (n) and heterogeneously enhancing internal nodules. No pelvic lymphadenopathy is seen.

Fig. 3.

32-year-old woman with choriocarcinoma.

A and B, Sagittal (**A**) and axial (**B**) fast spin-echo T2-weighted images show retroverted uterus containing fundal mass (T) that is predominantly hyperintense with internal low-T2-signal flow voids. Mass shows loss of myometrium-tumor interface in posterior margin (*arrow*), which is associated with myometrial thinning and is suspicious for myometrial invasion. Note left ovarian serous cystadenoma (*asterisk*).

C, Axial fat-saturated contrast-enhanced T1-weighted image shows enhancement of mass (T) extending into myometrium (*arrow*).

Fig. 4.

30-year-old woman with adenoma malignum with metastatic pelvic lymph node. Reprinted from Akin O, ed. *Atlas of oncology imaging*. New York, NY: Springer Science+Business Media, 2014 with permission of Springer Science+Business Media.

A and B, Axial fast spin-echo T2-weighted (**A**) and axial fat-saturated contrast-enhanced T1-weighted (**B**) images show multicystic endocervical mass (T) with enhancing internal solid components. On T2-weighted image (**A**), locules of multicystic lesion are characterized by heterogeneous hyperintensity due to different proteinaceous content.

C, Axial fat-saturated contrast-enhanced T1-weighted image shows enlarged right external iliac node (*arrow*) suspicious for metastasis.

Fig. 5. 40-year-old woman with International Federation of Gynecology and Obstetrics stage IIB small cell carcinoma of cervix.

A and B, Axial fast spin-echo (FSE) T2-weighted image (**A**) and axial oblique FSE T2-weighted image (**B**) obtained perpendicular to cervical canal show large mushroom-shaped cervical mass (T) with parametrial invasion (*arrows*, **B**).

Fig. 6.
45-year-old woman with vaginal tumor.
A–C, Sagittal (**A**) and coronal (**B**) fast spin-echo T2-weighted and axial fat-saturated T2-weighted (**C**) images show large vaginal mass (**T**). Disruption of hypointense right posterior vaginal wall (*arrow*, **B** and **C**) is seen, indicating early perivaginal fat tissue extension.

Fig. 7.

29-year-old woman with yolk sac tumor.

A–C, Axial contrast-enhanced CT images show large multiseptate cystic pelvic mass with strongly enhancing irregular thick septa and nodular soft-tissue components (*arrow*, **B** and **C**).

Fig. 8.

60-year-old woman with bilateral ovarian carcinosarcoma, ascites, and peritoneal implants.

A and B, Axial contrast-enhanced CT images show large mixed cystic and solid left ovarian mass (LT, **A** and **B**), with enhancing internal septa and solid mural components, and solid right ovarian lesion (RT, **B**). U = uterus.

C, Peritoneal implants (*arrows*) and large amount of ascites are present.

Fig. 9.

40-year-old woman with bilateral ovarian metastasis from gastric carcinoma.

A and B, Axial fast spin-echo T2-weighted (**A**) and axial fat-saturated contrast-enhanced T1-weighted (**B**) images show bilateral ovarian masses (T), characterized by hyperintensity on T2-weighted images due to diffuse stromal edema, and intense diffuse enhancement.

TABLE 1**Contrast-Enhanced DWI Protocols for Gynecologic Cancers**

MRI Protocol	Relevance
Axial T1-weighted imaging of the pelvis	FS T1-weighted images are useful to differentiate fat from hemorrhage.
Axial FS T1-weighted imaging of the pelvis	
Axial and sagittal T2-weighted imaging	
Axial FS T2-weighted imaging of the pelvis	In cervical cancers, high-resolution small-FOV axial oblique FSE T2-weighted images taken perpendicular to the long axis of the cervix are essential to accurately evaluate the depth of cervical stroma and parametria invasion [50].
DWI performed at two or more b values: low (0–100 s/mm ²) and high (750–1000 s/mm ²)	In uterine corpus cancers, high-resolution small-FOV axial oblique FSE T2-weighted images taken perpendicular to the long axis of the endometrial cavity are essential to accurately evaluate endometrial cavity and depth of myometrial invasion [51]. In vaginal and vulvar cancer, axial FS T2-weighted images are used for assessment of local invasion.
Dynamic multiphase contrast-enhanced 3D gradient-echo T1-weighted imaging after IV gadolinium administration before and at 2–3 time points after gadolinium injection (e.g., 1, 2, and 3–5 minutes)	Cancers are characterized as a bright area of restricted diffusion; ADC is lower in neoplastic tissue and may also provide additional prognostic factors.
	Used in staging patients with uterine, vaginal, and vulvar cancer; in characterization of complex adnexal mass; and in the detection of peritoneal implants. Use of dynamic multiphase contrast-enhanced 3D T1-weighted image is not necessary in staging cervical carcinoma.

Notes—FS = fat saturated, FSE = fast spin-echo, ADC = apparent diffusion coefficient.

TABLE 2

Revised International Federation of Gynecology and Obstetrics (FIGO) Staging (2009) for Uterine Sarcoma

Pathologic Entity, FIGO Stage	Definition	Key Imaging Features
Endometrial stromal sarcoma and adenosarcoma		
Stage I	Tumor limited to the uterus.	MRI: Endometrial polypoid mass containing high T2 signal–intensity cystic areas with thin septa (lattice-like appearance) and hypointense hypervascular solid components is characteristic of adenosarcoma.
IA	Tumor limited to the endometrium or endocervix with no myometrial invasion.	Ultrasound: Endometrial mass with heterogeneous echogenicity and ill-defined intramyometrial margins, or diffuse myometrial thickening.
IB	Less than or equal to half myometrial invasion.	MRI: Heterogeneous endometrial mass with T2-hypointense bands and intratumoral flow voids, showing intense enhancement compared with the adjacent normal myometrium.
IC	More than half myometrial invasion.	MRI is able to accurately determine the depth of tumor invasion into the myometrium. On T2-weighted images, presence of multiple marginal high-signal-intensity intramyometrial tumor nodules. If the junctional zone is intact on dynamic contrast-enhanced T1-weighted imaging and DWI, deep myometrial invasion is excluded.
Stage II	Tumor extends to the pelvis.	MRI: On T2-weighted images, high-signal-intensity tumor nodules along vessels, ligaments, and fallopian tubes due to marked vascular and lymphatic invasion, showing enhancement after administration of contrast material.
IIA	Adnexal involvement.	
IIB	Tumor extends to the extrauterine pelvic tissue.	
Stage III	Tumor invades abdominal tissues (not just protruding into the abdomen).	
IIIA	One site.	
IIIB	More than one site.	
IIIC	Metastases to pelvic or paraaortic lymph nodes.	Short axis > 10 mm, round shape with short axis > 8 mm.
Stage IV		MRI: Disruption of normal high T2-weighted signal in bladder and rectal mucosa.
IVA	Tumor invades bladder or rectum.	
IVB	Distant metastases.	
Leiomyosarcoma		
Stage I	Tumor limited to the uterus.	Ultrasound and MRI: Heterogeneous hypervascular central uterine mass with irregular margins.
IA	< 5 cm.	MRI: Presence of internal necrosis and areas of hemorrhage.
IB	> 5 cm.	
Stage II	Tumor extends to the pelvis.	
IIA	Adnexal involvement.	
IIB	Tumor extends to the extrauterine pelvic tissue.	
Stage III	Tumor invades abdominal tissues (not just protruding into the abdomen).	
IIIA	One site.	

Pathologic Entity, FIGO Stage	Definition	Key Imaging Features
IIIB	More than one site.	Short axis > 10 mm, round shape with short axis > 8 mm.
IIIC	Metastases to pelvic or paraaortic lymph nodes.	
Stage IV		
IVA	Tumor invades bladder or rectum.	MRI: Disruption of normal high T2-weighted signal in bladder or rectal mucosa.
IVB	Distant metastases.	CT: Parenchymal metastases are usually hypervascular.

Note—Malignant mixed müllerian tumor should be staged as endometrial carcinoma.

TABLE 3

Key Imaging Features for Gestational Trophoblastic Neoplasia (GTN)

Pathologic Entity, FIGO Staging	Definition	Ultrasound Key Imaging Features	MRI Key Imaging Features
Invasive hydatidiform mole, stage I	The tumor is confined to the uterus.	Echogenic and heterogeneous soft-tissue mass containing numerous cystic spaces, distending the endometrial cavity. Irregularity of mass border or asymmetric extension into the myometrium suggests myometrial invasion. Blood flow signal within the myometrial portion of the uterus on color Doppler ultrasound (snowstorm appearance).	Heterogeneous mass distending the endometrial cavity and containing numerous T2-hyperintense cystic spaces corresponding to the hydropic villi (villous pattern). MRI is able to evaluate the depth of tumor invasion into the myometrium using either dynamic contrast-enhanced T1-weighted imaging or DWI. Ovaries may become enlarged with numerous cysts (theca lutein cysts).
Choriocarcinoma			
Stage I		Vascular heterogeneous uterine mass. Signs of neovascularization on color Doppler ultrasound.	Hypervascular uterine mass with enlarged vessels depicted as signal voids on both T1- and T2-weighted imaging in the uterus or in the broad ligament.
Stage II	GTN extends outside the uterus but is limited to the genital structures (adnexa, vagina, broad ligament).		High-T2-signal masses avidly enhancing after gadolinium within parametria, ovaries, and vagina.
Stage III	GTN extends to the lungs with or without known genital tract involvement.		Metastases to the lung, liver, and brain are hypervascular and prone to hemorrhage.
Stage IV	All other metastatic sites.		

Note—FIGO = International Federation of Gynecology and Obstetrics.

TABLE 4

Revised International Federation of Gynecology and Obstetrics (FIGO) Staging of Cervical Carcinoma

FIGO Stage	Definition
Stage 0	The carcinoma is confined to the surface layer (cell lining) of the cervix. Also called carcinoma in situ.
Stage I	The carcinoma has grown deeper into the cervix but has not spread beyond it (extension to the corpus would be disregarded).
Stage IA	Invasive carcinoma that can be diagnosed only by microscopy, with deepest invasion < 5 mm and the largest extension > 7 mm
IA1	Measured stromal invasion of < 3.0 mm in depth and extension of < 7.0 mm.
IA2	Measured stromal invasion of > 3.0 mm and not > 5.0 mm with an extension of not > 7.0 mm.
Stage IB	Clinically visible lesions limited to the cervix uteri or preclinical cancers greater than stage IA
IB1	Clinically visible lesion < 4.0 cm in greatest dimension.
IB2	Clinically visible lesion > 4.0 cm in greatest dimension.
Stage II	Cervical carcinoma invades beyond the uterus but not to the pelvic wall or to the lower third of the vagina.
Stage IIA	Without parametrial invasion.
IIA1	Clinically visible lesion < 4.0 cm in greatest dimension.
IIA2	Clinically visible lesion > 4.0 cm in greatest dimension.
Stage IIB	With obvious parametrial invasion.
Stage III	Tumor extends to the pelvic wall or involves lower third of the vagina or causes hydronephrosis or nonfunctioning kidney.
Stage IIIA	Tumor involves lower third of the vagina, with no extension to the pelvic wall.
Stage IIIB	Extension to the pelvic wall or hydronephrosis or nonfunctioning kidney.
Stage IV	The carcinoma has extended beyond the true pelvis or has involved (biopsy-proven the mucosa of the bladder or rectum. Bullous edema does not convey stage IV disease.
Stage IVA	Spread of the growth to adjacent organs.
Stage IVB	Spread to distant organs.

TABLE 5**MRI Key Imaging Features for Rare Histologic Subtypes of Cervical Cancer**

Pathologic Entity	MRI Key Imaging Features
Adenoma malignum	Multicystic mass showing slightly high signal intensity on T1-weighted images and markedly high signal intensity on T2-weighted images, with internal enhancing solid components extending into the cervical stroma. The presence of internal enhancing solid nodules is more likely to be associated with local invasion and nodal metastases.
Neuroendocrine	Large lobulated mass showing slightly homogeneous high signal intensity on T2-weighted images and intense enhancement on dynamic multiphase T1-weighted images, frequently accompanied by lymphadenopathy and bilateral parametrial invasion.
Melanoma	Solid mass hyperintense on T1-weighted images.
Lymphoma	Solid mass hypointense on T1-weighted images and relatively hyperintense on T2-weighted images, infiltrating the cervical stroma with preserved cervical epithelium.

TABLE 6

International Federation of Gynecology and Obstetrics (FIGO) Staging of Vulvar Carcinoma

FIGO Staging	Definition	MRI Key Imaging Features
Stage I	Tumor confined to the vulva.	Solid enhancing mass with low signal intensity on T1-weighted images and moderate-to-high signal intensity on T2-weighted images.
Stage IA	Lesions $\leq$ 2 cm, confined to the vulva or perineum and with stromal invasion $\leq$ 1.0 mm, no nodal metastasis	
Stage IB	Lesions $>$ 2 cm or with stromal invasion $>$ 1.0 mm, confined to the vulva or perineum, with negative nodes.	
Stage II	Tumor of any size with extension to adjacent perineal structures (1/3 lower urethra, 1/3 lower vagina, anus) with negative nodes.	Disruption of the normal T2-weighted image target appearance of lower 1/3 of urethra by intermediate-T2-signal tumor. Disruption of the low T2 signal intensity of the lower 1/3 of vaginal wall and anal sphincter by intermediate-T2-signal tumor.
Stage III	Tumor of any size with or without extension to adjacent perineal structures (1/3 lower urethra, 1/3 lower vagina, anus) with positive inguinofemoral lymph nodes.	Disruption of the normal T2-weighted image target appearance of lower 1/3 of urethra by intermediate-T2-signal tumor. Disruption of the low T2 signal intensity of the lower 1/3 of vaginal wall and anal sphincter by intermediate-T2-signal tumor. Inguinofemoral lymphadenopathy ($\geq$ 5 mm in short-axis diameter).
Stage IIIA	With 1 lymph node metastasis ($\geq$ 5 mm), or 1–2 lymph node metastasis ($\geq$ 5 mm).	
Stage IIIB	With 2 or more lymph node metastases ($\geq$ 5 mm), or 3 or more lymph node metastases ($\geq$ 5 mm)	
Stage IIIC	With positive nodes with extracapsular spread.	
Stage IV	Tumor invades other regional (2/3 upper urethra, 2/3 upper vagina) or distant structures.	Disruption of the normal T2-weighted image target appearance of upper 2/3 of the urethra by intermediate-T2-signal tumor. Disruption of the low T2 signal intensity of the upper 2/3 of vaginal wall. Disruption of the normal high T2 signal of the bladder or rectal mucosa by intermediate-T2-signal tumor. Bone invasion. Distant metastasis.
Stage IVA	Tumor invades any of the following: upper urethral or vaginal mucosa, bladder mucosa, rectal mucosa, or fixed to pelvic bone, or fixed or ulcerated inguinofemoral lymph nodes.	
Stage IVB	Any distant metastasis including pelvic lymph node invasion.	

TABLE 7**MRI Key Imaging Features for Nonepithelial Ovarian Cancers**

Pathologic Entity	MRI Key Imaging Features
Germ cell tumors	
Dysgerminoma	Unilateral multilobulated homogeneously enhancing solid mass with prominent fibrovascular septa.
Immature teratoma	Unilateral solid mass with calcification and small amounts of fat. Tumor capsule is not well defined, and ascites with peritoneal implants may be present.
Endodermal sinus tumor	Unilateral solid or cystic mass with heterogeneous and avid enhancement.
Sex-cord stromal tumors, granulosa cell tumor	Unilateral, large, encapsulated, and predominantly solid mass with cystic components, with a characteristic spongelike appearance on MRI. Predisposition to hemorrhage. Associated endometrial thickening or mass may be seen.
Carcinosarcoma	Bilateral large mixed solid and cystic adnexal masses, with enhancing internal septa and solid components. Peritoneal implants and large amount of ascites are usually present.
Lymphoma	Solid homogeneously enhancing mass, without ascites.
Metastasis	Bilateral, solid, and strongly enhancing. Diffuse ovarian edema may be present, related to the stromal infiltration.