THE MAGNIFICENT SEVEN in PARAUTERINE MASSES

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Learning objectives

To review the spectrum of parauterine masses by CT and MRI, emphasizing the features that allow their proper location and characterization.

In order to make a practical guide to differential diagnosis we considered 7 parameters: cystic lesions, presence of blood, fat, smooth muscle, fibrous tissue or calcium, and solid-cystic appearance (complex masses).

Background

INTRODUCTION

Ovarian cancer is the 6th cancer incidence in women and is the most lethal gynecologic malignancy, so it is vital to diagnose it early and accurately. In characterizing parauterine masses MRI is the technique that allows us to locate the lesion, determine the main component and additional findings. We focus on the characterization of seven common components ("The magnificent seven") in parauterine masses to guide us in the preparation of the differential diagnosis:

1. Cystic component
2. Blood products
3. Smooth muscle
4. Fat tissue
5. Fibrous tissue
6. Complex Tumors
7. Calcifications

Step 1) LOCATION

When a parauterine adnexal mass is visualized, verification of the origin of the mass is essential for appropriate patient management. (Fig 1-6).

If the gonadal vessels lead to the lesion and no ipsilateral ovary is visualized, an ovarian lesion is considered to be a possibility. On the other hand, visualization of both ovaries as separate and distinct from the lesion confirms that the lesion is extraovarian in origin. Visualization of hyperintense ovarian follicles or a functional cyst on T2WI helps identify the ovaries.
The presence of a pedicle between the uterus and the lesion indicates that the lesion arises from the uterus.

The bridging vessel sign represents tortuous vascular structures passing between the uterus and the lesion. However, this sign is most clearly visualized on T2WI or after contrast administration on T1WI, which demonstrate vascular flow voids. This sign confirms that the lesion originates from the uterus and excludes an ovarian origin.

**Step 2) COMPOSITION** (Fig. 7)

**1. CYSTIC LESIONS** (Fig. 8-12)

The majority of adnexal lesions contain cystic components, which demonstrate high signal intensity on T2WI and low signal on T1WI. Simple fluid does not enhance after contrast agent administration. Common cystic masses that can contain simple fluid include: functional ovarian cysts, serous cystadenomas, mucinous cystadenomas, hydrosalpinx and peritoneal inclusion cysts.

**2. BLOOD PRODUCTS** (Fig. 13-15)

The signal characteristics of a hemorrhagic lesion at MR imaging depend of the age of the hemorrhage and state of degradation of blood products. Typically methemoglobin appears relatively hyperintense on T1WI in endometriomas (93%), cystic adenomiosis and hematosalpinx. Instead 43% of functional hemorrhagic cysts are hypointense on T1WI (because of preexisting fluid and low concentration of methemoglobin).

- **Hemorrhagic Ovarian Cyst.**

Functional hemorrhagic ovarian cysts, including follicular cysts (usually <1 cm) and corpus luteal cysts (often > 1 cm), are related to ovulation and are typically not seen after menopause. Distinguishing between a hemorrhagic cyst and an endometrioma remains a diagnostic problem in some cases. Both entities appear hyperintense on fat-suppressed T1WI. Frequently endometriomas appears more hyperintense on T1WI than hemorrhagic cyst. Instead hemorrhagic cyst appears more hyperintense on T2WI than endometrioma.

- **Endometrioma**
Diagnostic MR imaging criteria with a high specificity for endometriosis include multiple hyperintense cysts on fat suppressed T1WI and, in the case of a solitary lesion, a T1-hyperintense and T2-hypointense cyst. Homogeneous T2 shading is a characteristic feature of endometrioma. The term shading refers to signal loss on T2WI in an ovarian cyst that appears hyperintense on T1WI. However, not all endometriomas show this degree of T2 shortening, depend of their age, the amount of hemosiderin, and the protein concentration. Malignant transformation is a rare complication of endometriosis and is estimated to occur in about 0.6-0.8% of patients. The most common histologic subtypes include endometrioid and clear cell carcinoma. Suspicious features include a large or growing endometrioma, presence of solid mural nodules and lack of the characteristic shading on T2WI.

- **Endometrioid tumor**

  Is the third most common malignant ovarian tumor. The finding most frequent is a solid-cystic mass. Endometrioid cyst with wall nodules that enhance after contrast administration is the most characteristic image finding.

- **Hematosalpinx**

  The most helpful and specific findings of a hematosalpinx are T2 hypointensity, a tubular shape with small round projections, and diametrically opposed indentations in the walls resulting in the "waist" sign, which reflects a tubular cystic structure with a folded configuration.

- **Cystic Adenomyosis**

  Subserosal cystic adenomyosis of the uterus may also mimic a T2-hypointense adnexal lesion. It is characterized by a cystic myometrial lesion with extensive glandular changes and hemorrhage. The hemorrhage can be seen at different stages of organization, from subacute blood to hemosiderin deposits in the wall of the adenomyotic cyst, and this can appear similar to an endometriotic cyst. The uterine origin of cystic adenomyosis can be confirmed on the basis of the presence of myometrial splaying around the lesion, visualization of the bridging vessel sign, and identification of the ovaries as separate and distinct entities.

3. **FAT TISSUE** (Fig. 16)

Is tipically hyperintense on non-fat supressed T1WI and T2WI. On fat supressed MR images, macroscopic lipid signal will be suppresed. After contrast agent administration,
lipid does not enhance. Pelvic tumors with fat component include mature teratomas, lipomas, liposarcomas, lipoleiomyomas and immature teratomas.

- **Teratoma**

Mature teratoma is the most common ovarian neoplasm, and most occur in fertile women. Develop from the three primitive germ cell layers and contain lipid, calcifications and hair.

Immature teratoma represents less than 1% of all teratomas and contains immature tissue from all three germ cell layers. Radiologic examination reveals a large, complex mass with cystic and solid components and calcifications. Small foci of fat are also seen in immature teratomas. These tumors grow rapidly and frequently demonstrate perforation of the capsule.

4. **CALCIUM** (Fig. 17)

Calcification has been reported in a wide range of parauterine masses: benign lesions, primary neoplasms and metastatic diseases.

Calcifications are not specific to a lesion, but sometimes the pattern of calcification can help to narrow the differential diagnosis.

Calcification in ovaries is well described and can be attributed to non neoplastic conditions such as infarction and mature teratoma; it can also be an incidental finding in an otherwise normal ovary and may be the only indication of neoplasia.

**Calcification patterns:**

- **Punctate**: well-circumscribed homogeneous nodules. Ex: peritoneal metastases.

- **Linear or curvilinear**: thin straight pattern (curved lines or sheets). Ex: Psammomatous calcifications

- **In the cyst wall**: Ex: mucinous cystic tumor.

- **Amorphous**: shapeless heterogeneous conglomerations. Ex: Brenner, fibrothecoma, uterine leiomyomas.

- **Coarse calcifications**: Ex: Disgerminoma, Yolk sac tumor.

- **Speckled calcifications**: Ex: Disgerminoma, Yolk sac tumor.
- **Scattered**: Ex: Inmature teratoma

- **Tooth**: Ex: Mature teratoma

5. SMOOTH MUSCLE (Fig. 18)

Uterine leiomyoma represents the classic example of a pelvic neoplasm that is composed predominantly of smooth muscle and therefore typically demonstrates low to intermediate signal intensity on T1WI and lower signal intensity on T2WI, which results from the T2 shortening effects of intramuscular actin, myosin and collagen, as well as decreased extracellular fluid relative to surrounding tissues.

The T2 signal of leiomyomas may vary due to the presence of specific components (edema, hemorrhage, fat, myxoid, necrosis, and calcification) in leiomyomas with degeneration.

Because leiomyomas are the most common gynecologic tumors and are usually benign, they should be included in the differential diagnosis given the characteristic T2 hypointensity of smooth muscle tumors.

6. FIBROUS TISSUE (Fig. 19)

Fibrous tissue represents low cellularity or acellular material in combination with spindle, oval, or round cells that result in collagen formation.

Fibrosis typically demonstrates intermediate signal intensity on T1WI and very low signal intensity on T2WI. The solid fibrous component of fibroma, fibrothecoma, and cystadenofibroma characteristically demonstrates very low T2 signal intensity, allowing the differentiation of these benign tumors from malignant solid ovarian lesions. Although MR imaging criteria for malignant ovarian tumors include visualization of a solid mass or a large solid component in association with a cystic mass, awareness of the typical MR imaging characteristics of fiber containing tumors allows the diagnosis of benign ovarian disease.

- **Fibroma and Fibrothecoma**.
Fibroma and fibrothecoma represent a spectrum of benign stromal ovarian tumors composed of fibrous tissue and theca cells. Fibromas can be associated with ascites and pleural effusions in classic Meigs syndrome, or with elevated carcinogenic antigen levels.

On T1WI fibrothecomas demonstrate nonspecific hypo to isointensity with mild enhancement following the intravenous administration of a gadolinium chelate. Therefore, identification of the characteristic predominantly low signal intensity of fibromas on T2WI allows their differentiation from other solid ovarian masses.

Fibrothecomas are responsible for the endocrine activity that results in endometrial hyperplasia and polyps in some cases.

- **Brenner Tumor.**

Brenner tumor is an uncommon epithelial-stromal tumor that represents about 2% of ovarian neoplasms and typically contains a fibrous stromal component in association with calcifications and transitional cells that are histologically similar to urothelial epithelium. The fibrous components, as well as calcifications (when present), are markedly hypointense on T2WI. Although the T2WI findings of Brenner tumors overlap with those of fibrothecomas, Brenner tumors typically demonstrate at least moderate enhancement after contrast material administration, whereas fibrothecomas are hypovascular.

The 20% of these tumors are associated with mucinous cystadenomas or other epithelial neoplasms. In these cases, the lesion has a complex cystic and solid appearance, with the Brenner tumor (representing the solid part) characteristically demonstrating very low signal intensity on T2WI.

7. COMPLEX LESIONS. (Fig 20-23)

We must be careful in the characterization of this type of lesions because most ovarian cancers are found in this category.

Solid component in complex masses is hypointense to isoentense on T1WI, hypointense to isointense on T2WI, and shows variable enhancement after contrast administration. The water content is hypointense on T1WI, and hyperintense on T2WI.

At MR imaging performed with conventional protocols, morphologic features that are indicative of a malignant adnexal mass include the presence of both solid and cystic areas within a lesion; necrosis within a solid lesion; papillary projections from the wall or septum.
of a cystic lesion; an irregular septum or wall; multiple thickened (>3 mm) septations; a large size (>6 cm); bilateral lesions; and ascites, peritoneal disease or lymphadenopathy.

The use of intravenous gadolinium-based contrast-enhanced MR imaging may be helpful. T1WI fat-suppressed obtained before and after contrast administration enable distinguishing enhancing solid components or papillae (features that are suspicious for malignancy), from debris and clots within a cystic lesion, which do not enhance.

It has been shown that, on multiphase dynamic contrast-enhanced MR images, malignant ovarian masses exhibit strong early enhancement (within 60 seconds of injection) more frequently than do benign lesions.

Step 3) CLINICAL CONTEXT (Fig. 24)

Laboratory values and clinical antecedentes often provides a helpful in the differential diagnosis.

The presentation of symptoms as well as medical and surgical history are very important for the differential diagnosis.

There are some serological markers that guide in the diagnosis.

Images for this section:
Fig. 1
Fig. 2: When a parauterine adnexal mass is visualized, verification of the origin of the mass is essential for appropriate patient management.
Fig. 3: Fig. 1. Axial T2WI, intraperitoneal mass. Histology confirmed a serous carcinoma. Fig. 2. Axial fat-suppressed T2WI, extraperitoneal mass. Histology confirmed a neurofibroma.
**Fig. 4:** Fig. 1. Sagital T2WI, ovarian (O) mass (M). Histology confirmed a carcinoma. Fig. 2. Sagital T2WI, ovarian (O) mass (M). Histology confirmed a cystic teratoma.
Fig. 5: Fig. 1. Axial T2WI, ovarian mass (M) and normal left ovarian (LO). Histology confirmed a serous cystadenoma. Fig. 2. CT coronal MIP reconstruction, bilateral enlargement of vessels. Histology confirmed bilateral metastases.
**Fig. 6:** Fig. 1. Sagittal T2WI, multiple vessels (arrow) between subserosal leiomyoma (L) and the uterus (U). Fig. 2. Sagittal T2WI, subserosal uterine leiomyoma (L). The myometrial is "grasping" around the mass.
**Fig. 7:** The seven common components ("The magnificent seven") in parauterine masses to guide us in the differential diagnosis.
Fig. 8: Imaging features of the cystic parauterine lesions.
Fig. 9: The most common ovarian cystic lesions. Imaging features.
**Fig. 10:** Fig. 1. Sagital T2WI and fat-suppressed T1WI after contrast administration, multiple follicular cysts. There isn't enhancement. Fig. 2. Sagital T2WI and fat-suppressed T1WI after contrast administration, corpus luteum cysts (arrows) with enhancement after contrast administration. Fig. 3. Axial T2WI, fat-suppressed T1WI and fat-suppressed T1WI after contrast administration, right cystic ovarian lesion, uniloculated, with septa and without enhancement after contrast administration. Histology confirmed a serous cystadenoma. Fig. 4. Axial T2WI, T1WI and fat-suppressed T1WI after contrast administration, multiloculated cystic ovarian lesion. The lesion is hyperintense on T2 and hypointense on T1, with a small papillary projections (arrow). Histology confirmed a mucinous cystadenoma.
Fig. 11: The most common no ovarian cystic lesions. Imaging features.
Fig. 12: Fig.1. Axial T2WI, coronal T2WI and CT after contrast administration, adnexal dilated tubular structures with fluid and incomplete septa in different patients. On MRI the signal may be varied depending on the content features (liquid, hemorrhagic, proteinaceous). Fig. 2. Coronal T2WI, T1WI and fat-suppressed T1WI after contrast administration, woman with a history of abdominal surgery presents multilocular cystic mass. Both ovaries (arrow) of normal appearance are displayed. Peritoneal inclusion cyst was confirmed. Fig. 3. Coronal fat-suppressed T2WI, T2WI and fat-suppressed T1WI after contrast administration, uniloculated cyst that is independent of to the ovary (Negative peak sign).
**IMAGING FINDINGS**

Usually the hemorrhagic masses are hyperintense on T1WI and hypointense on T2WI (shadowing effect, in relation to subacute hemorrhage).

Lesions with proteinaceous or mucinous content may have a similar findings.

In CT there are hyperdense lesions.

The signal intensity characteristics of hemorrhagic lesions is variable on MRI, depending on the age and state of degradation of blood products.

**HEMORRHAGIC LESIONS**

- Hemorrhagic cyst
- Endometrioma
- Endometrioid tumor
- Hematosalpinx
- Uterine leiomyoma with hemorrhagic degeneration
- Ectopic pregnancy
- Hematoma
- Cystic adenomyosis

**TIME EVOLUTION**

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**Fig. 13:** The most common hemorrhagic parauterine lesions. Imaging features.
Fig. 14: The most common hemorrhagic parauterine lesions. Imaging features.
Fig. 15: Fig. 1. Unilateral hemorrhagic cyst (star). Hyperintense on T1WI and hypointense on T2WI and fat-sat. Fig. 2. Axial T2WI, fat-suppressed T1WI and T1WI fat sat after contrast administration, left ovarian endometrioma (star). We can observe the shading sign on T2WI. Papillary projection (arrow) don't enhance after contrast administration. Fig. 3. Axial T2WI, fat-suppressed T1WI and T1WI fat sat after contrast administration, blood products with different states of degradation. Left endometrioma has an enhancing nodule after contrast administration. Histology confirmed a endometrioid carcinoma. Fig. 4. Tubular bilateral parauterine structure hyperintense on fat-suppressed T1WI. Right lesion is hyperintense on T2WI (late subacute hematosalpinx) and the left lesion is hypointense on T2WI (early subacute hematosalpinx).
**Fig. 16:** The most common fatty parauterine lesions. Imaging features. Fig. 1. CT with heterogeneous lesion with fat, solid component and mural calcification (histology confirmed a teratoma). Axial T1WI, T2WI and fat-suppressed T2WI with left parauterine teratoma. Imaging of PET- CT: Heterogeneous parauterine pelvic mass (*), with fat inclusions (arrow) and show mild FDG uptake (uterus: u). Diagnostic: leiomyoma with fatty degeneration.
Fig. 17: The most common calcificated parauterine lesions. Imaging features. Fig. 1. CT with heterogeneous lesion with fat, solid component and mural calcification (histology confirmed a teratoma). Fig. 2. CT with amorphous calcifications. Histology confirmed a Brenner’s tumor. Fig. 3. Yolk sac tumor in a 7 year-old woman with a palpable abdominal mass. (a) Axial CT without contrast image shows a large mass with speckled calcifications (arrows). (b) Contrast-enhanced CT image shows a multilobulated, heterogeneously enhancing mass.
**Fig. 18:** Parauterine lesions with smooth muscle. Imaging features. Fig. 1. Parauterine lesion hypointense on T2WI and T1WI, lesion compatible with leiomyoma (L). The most important thing is to demonstrate the uterine (U) origin. Fig. 2. Parauterine lesion hyperintense on T2WI and hypointense on T1WI, lesion compatible with leiomyoma (L) with cystic degeneration.
6. FIBROUS TISSUE

IMAGING FINDINGS
The fibrous component shows a very low signal intensity in T2 WI.
Some of them show mild enhancement after contrast administration.
In bigger lesions edema and cysts may be seen (hyperintense in T2).
Ascitis and pleural effusion (Meigs Syndrome) and a high level of carcinogenic can be present.
Endocrine activity may be present (hyperplasia and endometrial polyps).

LESIONS with FIBROUS TISSUE
Fibroma – fibrothecoma
Cystadenofibroma
Brenner tumor
Struma Ovari

Fig. 19: Para uterine lesions with fibrous tissou. Imaging features. Fig. 1. Left fibrous para uterine lesion (arrow) hypointense in all sequences and non-enhancing after contrast administration. Histology confirmed a ovarian fibroma. Fig. 2. Right fibrous para uterine lesion (arrow) hypointense on T1WI, very low signal intensity on T2WI and mild enhancement after contrast administration. Histology confirmed a Brenner tumor.
**IMAGING FINDINGS**

Solid and cystic components.
Central necrosis.
Papillary projections in the wall o in the septa.
Thick wall and septa (> 3 mm)
Large (> 6 cm) and frequently bilateral.

Enhance: peripheral enhancement in inflammatory disease and earlier enhancement in malignance disease.

Diffusion-weighted imaging with apparent diffusion coefficient maps has limited utility in characterizing pelvic masses, but it may be useful for tumor detection and for monitoring response to treatment.

In malignant tumors usually observed: ascites, peritoneal implants, lymphadenopathy and elevated tumor markers (CA-125 and HE4).

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**Fig. 20:** The most common complex parauterine lesions. Imaging features.
**Fig. 21:** Differential diagnosis between serous and mucinous cystadenocarcinoma.

Fig. 1. Right complex parauterine lesion (arrow) with enhancement after contrast administration. Histology confirmed a serous cystadenocarcinoma. Fig. 2. Multiloculated cystic mass with mural nodule (arrow). The mural nodule enhances after contrast administration. Histology confirmed a mucinous cystadenocarcinoma.
Fig. 22: Differential diagnosis between complex parauterine lesions. Fig. 1. Large complex mass with enhancement after contrast administration. Absence of normal ovaries. Histology confirmed a Müllerian sarcoma. Fig. 2. Yolk sac tumor in an 7 year old girl: (a) Axial Fat supressed T2WI shows a large, well-circumscribed, heterogeneous, complex mass, with hypointense areas corresponding to intratumoral hemorrhage (arrows). (b) Axial gadolinium-enhanced T1WI of the mass (arrows) shows striking enhancement of the solid components. Fig. 3. Five years old girl. Left adnexal solid mass. Isointense on T2WI. Enhacement after contrast administration.
Fig. 23: Differential diagnosis between complex parauterine lesions.
**Fig. 24:** Laboratory values and clinical history often are helpful in the differential diagnosis.
CONCLUSIONS

1. MR imaging plays a crucial role in characterizing adnexal masses that are indeterminate at US and determining the origins of pelvic masses.
2. In general, benign epithelial ovarian neoplasms are predominantly cystic, whereas malignant epithelial neoplasms contain both cystic and solid components (complex mass).
3. When an adnexal lesion is hypointense on T2-weighted images but has a signal intensity that is clearly higher than that of skeletal muscle, the specificity for benign disease decreases.
4. Most hypointense T2WI adnexal lesions that are at least as dark as skeletal muscle are benign nonaggressive entities.
5. Enhancing mural nodule within an endometriotic cyst on T1WI after contrast administration is the most valuable imaging finding in suggesting malignant transformation of an endometrioma.
6. Most masses with fatty component are mature teratomas, that is the most common benign ovarian tumor in young women.
7. Pattern calcification can help us to limit the differential diagnosis.
8. Primary ovarian tumors in children and adolescents are uncommon. Evaluation of imaging features at US, CT, and MR imaging, serum tumor markers and karyotyping can assist in differential diagnosis.
9. Laboratory values and clinical context often provides a short meaningful differential diagnosis.

Fig. 25: Conclusions
Findings and procedure details

We show the MRI and CT findings of 69 cases received at our institution during the last 5 years, as well as its correlation with the pathological report.

Definitive diagnosis included:

- **Ovary**: normal variants (follicular cyst), benign neoplasms (fibrothecoma, dermoid ...), malignant tumors (cystadenocarcinoma, clear cell carcinoma, mature teratoma...), endometriomas and hemorrhagic cysts.

- **Uterus**: Congenital malformations, benign neoplasms (leiomyomas), malignant neoplasms and adenomyomas.

- **Fallopian tubes**: hydrosalpinx, hematosalpinx, tubo-ovarian abscesses, salpingitis, leiomyomas and malignant neoplasms.

- **Peritoneum**: inclusion cysts and malignant neoplasms.

Conclusion

1. MR imaging plays a crucial role in characterizing adnexal masses that are indeterminate at US and determining the origins of pelvic masses.

2. In general, benign epithelial ovarian neoplasms are predominantly cystic, whereas malignant epithelial neoplasms contain both cystic and solid components (complex mass).

3. When an adnexal lesion is hypointense on T2-weighted images but has a signal intensity that is clearly higher than skeletal muscle, the specificity for benign disease decreases.

4. Most T2-hypointense adnexal lesions that are at least as dark as skeletal muscle are benign non-aggressive entities.
5. Enhancing mural nodule within an endometriotic cyst on postcontrast T1-weighted images, is the most valuable imaging finding in suggesting malignant transformation of an endometrioma.

6. Most masses with fatty component are mature teratomas, that is the most common benign ovarian tumor in young women.

7. Calcification pattern can help us to limit the differential diagnosis.

8. Primary ovarian tumors in children and adolescents are uncommon. Evaluation of imaging features at US, CT, and MR imaging, serum tumor markers and karyotyping can help in differential diagnosis.

9. Laboratory values and clinical context often provides a short meaningful differential diagnosis.

Personal information

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