T1-hyperintense adnexal lesions : how to narrow the accurate diagnosis?

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Learning objectives

Our purpose is:

• To list the potential causes of T1-hyperintense adnexal lesions,
• To discuss the differential diagnosis and MR imaging key features of these lesions,
• To describe an imaging algorithm, based on a multisequential MRI.

Background

Pelvic MRI has proved its usefulness for diagnosis of adnexal masses incompletely evaluated by pelvic ultrasound. MRI provides excellent tissue characterization and high contrast resolution. T1-weighted sequences are an integral part of MRI protocol in the pelvic imaging. The finding of a T1-hyperintense adnexal lesion is not uncommon and represents an important diagnostic criterion. Various physical entities can cause T1 shortening, and T1 hyperintensity of different degrees may be observed in the tube, in the ovary or close to the adnexa. Haemorrhage, fat and high concentration of protein are the three main causes of high T1 signal intensity in different pathologic conditions. However, additional entities may be responsible for abnormal T1-hyperintensity. These include paramagnetic substances as melanin, calcifications, flow artifact, and magnetic susceptibility effects due to metallic devices.

We propose a diagnostic algorithm, which takes the morphologic findings into account as well as the additional sequences imaging features and enhancement characteristics, to assist in the correct interpretation of T1-hyperintense adnexal lesions.

Imaging findings OR Procedure details

1. MR imaging technique

We performed MR imaging on a 1.5T unit. MR imaging protocol should at least include:

• T2-weighted sagittal and axial sequences of the pelvic +/- coronal sequence,
• T1-weighted axial sequence of the pelvis with similar slice thickness,
• Fat-suppressed T1-weighted (FST1-W) axial sequence using chemical lpresaturation, in case of T1-hyperintense lesion or to improve detection of small T1 hyperintense foci,
• Diffusion weighted imaging (DWI) in neoplastic context,
Dynamic gadolinium-enhanced fat-suppressed T1-W should be added when the wall of the lesion, septa or solid portions need to be studied or depicted. Moreover, subtraction postprocessing may be useful to depict enhancement because of the spontaneous T1 hyperintensity of the lesion.

2. Define the site of origin:

- The first step is to define the origin of the adnexal T1-hyperintense lesion: ovarian or extra-ovarian. We do not describe extra-adnexal masses in our work.

- To make the difference, it is important to know the normal anatomy and to analyse T2-weighted images. The adnexa include the fallopian tubes, the ovary and the supporting ligaments (fig. 1).

References: - LYON/FR

-Ovaries are located at the postero-lateral pelvic sidewall. Tracking the ovarian vein along the anterior surface of the psoas major muscle to the immediate vicinity of the ovary can help to identify the ovary (fig. 2). The left ovarian vein reaches the left renal vein whereas the right one reaches the inferior cava vena.

Fig. 2: Consecutive axial T2W images. Red arrow: right ovarian vein. Green arrow: right psoas muscle. Blue arrow: right ovary.

References: - LYON/FR

The appearance of the ovaries depends on the patient’s hormonal status or previous treatment. Ovaries in women of childbearing age range in size from 2 to 4 cm and contain T2-hyperintense follicles. Post-menopausal ovaries are smaller and have no follicles.
- The fallopian tube is a tubal structure extended laterally between the uterus to the ipsilateral ovary. Normally, the fallopian tubes range in length from 9 to 11 cm and in luminal diameter from 1 to 4 mm. Normal fallopian tubes are not usually seen on MRI unless there is pelvic fluid outlining them (fig. 1).

- Imaging features to assess ovarian origin of an adnexal mass are (fig. 3):
  - No ipsilateral ovary seen (3a),
  - Latero-uterine mass with acute connecting angles (3b),

Ovarian crescent sign or beak sign: the mass is partially or totally outlined by the ovarian parenchyma (3c).

![Fig. 3: Axial MR images. Imaging features in favour of ovarian origin of an adnexal mass.](image)

**References:** - LYON/FR

- Identification of both normal ovaries distinct from the mass indicates the extra ovarian origin. If a pedicule is seen between the uterus and the lesion, the uterine origin is confirmed.

- Key MRI features of tubal disease are dilated, tubular, tortuous, fluid-filled structures arising from the upper lateral margin of the uterus and closed to the ovaries region. If the hydrosalpinx is huge (diameter greater than to 10 cm), it can mimic an ovarian complex mass. Visualization of the normal ovarian parenchyma either separate from the tubal mass or stretched around is a helpful element to narrow the diagnosis. In such cases, a coronal T2-weighted sequence may be particularly helpful. Furthermore, presence of partially effaced mucosal or submucosal plicae within the tubular cystic structure is specific to fallopian disease (fig. 4).
3. T1-hyperintense adnexal masses:

3.1. Lipid-containing lesions: ovarian mature and immature teratomas

*T1-hyperintensity of lipid-containing lesions is related to the short T1 relaxation time of hydrogen nuclein in lipid molecules. A selective chemical fat-suppression sequence allows detection of lipid-containing lesions with a loss of signal intensity of the fatty component.*

A fatty component in an ovarian mass is pathognomonic of teratomas.

Teratomas are composed of tissues of germ cell origin. Mature teratoma (dermoid cyst) is the most common benign ovarian tumor under the age of 45 years. In 88% of cases, they are unilocular and typically show a small protuberance projecting into the cavity known as Rokitansky nodule (can be enhanced after Gadolinium) in which teeth, hair or bone may be found (fig. 5).
**Fig. 5:** Axial MR images. Ovarian mature teratoma with loss of signal of the fatty component on T1FS (red arrow). Note the chemical artifact (green arrows) at the site of the fat-fluid level.

**References:** - LYON/FR

Even if immature teratoma is rare (less than 1% of ovarian teratomas), diagnosis should be suspected when the lesion presents a predominant solid portion showing strong enhancement, small foci of fat and coarse calcifications (fig. 6).
Fig. 6: Axial MR images. Ovarian immature teratoma in a pregnant woman (14 weeks of amenorrhea). Small foci of fat (red arrow) and large tissular component (green arrow).

References: - LYON/FR

Nonetheless, there are some pitfalls in mature cystic teratomas MR features:

- Teratoma with small foci of fat: to reach the diagnosis, careful attention should be paid to find a small area of a loss of T1 signal intensity after fat-suppression (fig. 7).

Fig. 7: Axial MR images. Ovarian mature teratoma with small focus of fat (red arrow).

References: - LYON/FR

- Teratoma with intermediate T1-hyperintensity which increases on T1 fat-suppression. We assume that this fact is related to appendages (fig. 8).
Fig. 8: Axial MR images. Ovarian mature terotoma. Red arrow : fatty component. Yellow arrow : Appendages in intermediate T1 signal intensity.

References: - LYON/FR

3.2. Methemoglobin-containing lesions:

Blood metabolites appear in high T1 signal intensity as they shorten the T1 relaxation time because of their paramagnetic effects.

3.2.1. Ovarian origin :

3.2.1.1. Endometrioma :
Endometriomas are thick-walled cysts. They can be solitary or multiple and they are bilateral in 50% of cases. They typically show a high signal intensity on T1-weighted images and a «shading» on T2-weighted images. The shading sign (in favor of endometrioma) corresponds to a T2 shortening in an ovarian cyst that appears with high signal intensity on T1-weighted images. High viscosity, concentration of protein and iron from recurrent haemorrhage contribute to T2 shortening. However, endometriomas can appear in high signal intensity on T2-weighted images, depending on the protein and hemosiderin concentration and on their age. There is no enhancement of the wall (fig. 9).

Fig. 9: Axial MR images. Bilateral endometriomas: shading in the right endometrioma (red arrow) and fluid-fluid level in the left one (green arrow). T1-hyperintensity persistent after fat-saturation (blue arrow) and no cyst wall enhancement after Gadolinium administration.

References: - LYON/FR
Blood clots may be observed with a low signal on all sequences and without any enhancement. They are of different size and form (curvilinear ones are very suggestive of endometrioma), dependent or attached to the cyst wall (fig. 10). They should not be mistaken with papillary projection or tumour.

Besides, other endometriosis locations have to be searched carefully.

Fig. 10: Axial MR images. Bilateral endometriomas with T2 shading (red arrow) and clots in the left one (blue arrow).

References: - LYON/FR

3.2.1.2. Functional hemorrhagic ovarian cyst:

Functional hemorrhagic cysts (FHC) are usually unilocular with smooth linings and solitary contrary to endometriomas, which are more frequently bilateral. They range from 3 to 8 centimeters. They occur in women of reproductive age. Their content
is frequently heterogeneous related to clot formation. They have relatively high signal intensity on T1-weighted images and intermediate to high signal intensity on T2-weighted images. Sometimes, FHC can display a T1-hyperintense rim which is very suggestive of the diagnosis. This aspect is due to the same phenomenon as in acute haematoma where deoxyhemoglobin is oxidized peripherally in methemoglobin during the next subacute stage. FHC do not normally exhibit shading on T2-weighted images as they contain less concentrated hemoglobin (no repeated bleeding) and a lower viscosity than endometriomas. However, in a few cases the morphologic MR imaging appearance of functional hemorrhagic cysts can be similar to that of endometriomas. Administration of gadolinium-enhanced contrast agent may be helpful as the cysts wall of FHC is typically enhanced (fig. 11). A follow-up examination (which can be done with US) can definitely confirm the diagnosis as they usually regress within two months, contrary to endometriomas.
Fig. 11: Axial MR images. Left functional hemorrhagic cyst with T1-hypersignal persistent after fat-saturation (red arrow), T2-hypersignal (blue arrow) and wall enhancement (green arrow).

References: - LYON/FR

3.2.1.3. Ovarian tumors with hemorrhagic component:
Ovarian tumors can demonstrate a high signal intensity on T1-weighted images due to hemorrhagic areas. Haemorrhage may occur in malignant tumors and in granulosa cell tumors (sex cord ovarian tumors).

Granulosa cell tumors have allowed malignant potential and appear in middle to older-aged women. Characteristic MR features are a multilocular cystic mass (sponge-like) with fluid/blood levels and solid areas. Some loculi appear bright on T1W and low on T2W with regard to haemorrhage. Solid component shows marked enhancement after gadolinium injection (fig. 12).

Another key finding of granulosa cell tumors is endometrial hyperplasia as they produce estrogen.

Haemorrhage can also be seen in epithelial ovarian tumors (serous or mucinous cystadenocarcinoma, endometrioid carcinoma), germ cell tumors (yolk sac tumor and choriocarcinomas) and metastasis.
**Fig. 12:** Axial MR images. Granulosa cell tumour with small foci in T1-hypersignal persistent after fat-saturation (red arrow). Note the presence of diffuse fluid/fluid levels on T2 weighted image.

**References:** - LYON/FR

### 3.2.2. Tubal lesions

Hematosalpinx can occur in endometriosis, ectopic pregnancy and adnexal torsion. It appears with high signal on T1W and FST1W.

#### 3.2.2.1. Endometriosis:

Endometriosis is a frequent cause of dilatation of fallopian tube. Dilatation of fallopian tube in women with endometriosis has T1-hyperintense contents in 40% of cases, whereas 60% have MR features suggestive of a simple hydrosalpinx. T2 shading may not be present within endometriotic hematosalpinx, because endometrial implants can develop either on the serosal surface of the tubes, or in the tubes (fig.13).

**Fig. 13:** Axial MR images. Right hematosalpinx with T2 shading (red arrow).

**References:** - LYON/FR

#### 3.2.2.1. Ectopic pregnancy:
Ectopic pregnancies occur in almost 80% of cases in the fallopian tube. Diagnosis of tubal pregnancy is not usually done in MRI but it must be recognized because of the life threatening context. MR features include hematosalpinx with a marked tube wall enhancement and sometimes a gestational sac. Tube wall enhancement is related to an increased vascularisation after following implantation (fig.14). The gestational sac appears as a cystic mass with a thick wall enhanced after injection. Presence of a haemoperitoneum may help with the diagnosis.

Fig. 14: Axial MR images. Right tubal ectopic pregnancy (red arrow). Peritoneal fluid consistent with a haemoperitoneum (green arrow). Medial tubal rupture: no enhancement at the medial part of the wall (blue arrow).

References: - LYON/FR

3.2.2.1. Adnexal torsion:

Isolated fallopian tube torsion is exceptional with an estimated incidence of 1 per 1.5 million women. Acute pelvic pain is the main symptom. MRI typically shows (fig. 15):
- a dilated fallopian tube with a whirl sign and a bloody content (a fluid-fluid level can be observed),

- an abnormal ipsilateral ovary,

- fallopian tube wall can enhance before necrosis,

- a hemoperitoneum.
Fig. 15: MR images. Left isolated fallopian tube torsion. Left hydrosalpinx with a whirl sign (red arrow), a fluid-fluid level (blue arrow) and a normal ipsilateral ovary (green arrow). T1-hypersignal of the tubal wall persistent after fat-saturation (yellow arrow). Tubal wall enhancement (pink arrow).

References: - LYON/FR

3.2. Protein-containing lesions:

T1-hyperintensity of protein-containing lesions is related to a shortening of the T1 relaxation time, dependent on the protein content. T1 signal intensity increases until a percentage of 25% of protein in a liquid and beyond decreases. Up to a concentration of 25% protein in the liquid, T1 signal intensity increases. Over and above 25%, T1 signal intensity decreases.

3.3.1. Mucinous ovarian lesion :

Mucinous tumors generally occur during the third to fifth decades. They are usually unilateral and can reach a very large size. Typical MR appearance of mucinous tumors is a multilocular cyst with loculi of various signal intensity on T1- and T2-weighted images (fig. 16).
Fig. 16: Axial MR images. Mucinous cystadenoma of the right ovary: multilocular cyst with loculi of various signal intensity. No loss of signal in T1-FS (red arrow).

References: - LYON/FR

3.3.2. Struma ovarii

Struma ovarii is a rare monodermal teratoma (approximately 3% of all mature teratomas) mostly composed of mature thyroid tissue. Most of the cases are benign (95-99.9%) and 85% of the cases occur in premenopausal women (median age of 42 years old). Struma ovarii typically appears as a complex multilocular mass with thickened septa and a variable content of solid tissue. Loculations have various signal intensities on T1- and T2-weighted images: depending on the amount of proteinaceous component (colloid) or on the presence of haemorrhage (fig. 17).
After contrast injection, solid tissue shows moderate to intense enhancement, which can be related to the thyroid tissue and abundant vascularisation in struma. Most of the cases of struma ovarii are clinically silent, although there are rare cases of hyperthyroidism and pseudo-Meigg's syndrome (ascites, pleural effusion).

Fig. 17: Axial MR images. Left struma ovarii with loculi in T1-hyperintensity persistent after fat-saturation (red arrow) and enhancement after Gadolinium administration (purple arrow). Ascites (green arrow).

References: - LYON/FR
3.4. Melanin-containing lesions: ovarian metastatic melanoma

*T1-hyperintensity is caused by paramagnetic effects of the stable free radicals contained in melanin.*

Melanoma rarely metastasizes to the ovary. Typical MR features of ovarian melanoma metastasis are a hyperintense tissular mass on T1-weighted images (less than fat signal intensity) with hypointensity on T2 and no loss of signal after fat suppression. T1-hyperintensity in melanoma metastasis is generally less than T1 signal intensity of endometrioma (fig. 18). Moreover, after contrast injection, melanoma metastasis show enhancement, which is better seen after subtraction. It is the only ovarian lesion to be enhanced by the hypersignal T1 area because the hypersignal T1 is related to a tissue. After all, the clinical context with a past history of cutaneous melanoma helps find a correct diagnosis.
Fig. 18: Axial MR images. Left ovarian melanoma metastasis (red arrow).

References: LYON/FR

3.5. Calcium-containing lesions:

Even if calcium is a diamagnetic substance, it may appear in T1-hypersignal under specific conditions. Thus, large calcium crystals have numerous free electrons on
their surface that lead to a relaxation effect similar to that observed in paramagnetic substances.

Calcium-containing lesions are rare in adnexa. Calcifications are proved by computed tomography (CT).

3.5.1. Unilateral tuboovarian autoamputation

Unilateral tuboovarian autoamputation is an exceptional cause of pelvic calcification. MR findings are a T2-hypointense ovarian mass without normal ovarian parenchyma. On T1W, a hyperintense rim is seen persistent after fat saturation (fig.19). Computed tomography helps to narrow the diagnosis with the identification of a calcified mass. The most likely explanation for this phenomenon is subclinical adnexal torsion with separation from its blood supply leading to necrosis and secondary calcification.
Fig. 19: Axial MR images. Right unilateral tuboovarian autoamputation.

References: - LYON/FR

The residual adnexa corresponds to a calcified mass (red arrow) in the pouch of Douglas, completely detached from the tube at the level of its isthmic segment.

3.5.2. Calcified ovarian fibroma
Ovarian fibromas are benign tumors, which have typically low-signal intensity on T1W and very low-signal intensity on T2W. They can have areas of oedema or cystic degeneration in high T2 signal intensity. Calcifications can be seen and can appear bright on T1 imaging (fig. 20).

**Fig. 20**: Axial MR images. Left ovarian fibroma with calcifications in T1-hyperintensity (red arrow).

**References**: - LYON/FR

### 3.6. Artifacts

#### 3.6.1. Metallic artifacts:

Metallic particles (Essure® inserts in the tube or clip sterilization) create heterogeneity in the magnetic field. They appear on T1-weighted images as areas with no signal, but with peripheral hyperintense dots or rim. (fig. 21).
Fig. 21: Axial MR images. Bilateral metallic artifacts (red arrowheads) close to the uterus horn due to a clip sterilization at the proximal isthmics segment of the tubes. Green arrow : uterus, blue arrow : left ovary.

References: - LYON/FR

3.6.2. Flow artifacts:

Motion artifacts related to entry section phenomena (in iliac vessels) along the phase-encoding direction may produce T1 signal hyperintensity(fig. 22).
Fig. 22: MR images. Flow artifacts in the left ovarian vein with T1-hyperintensity (red arrow) and central low T2-intensity (blue arrow).

References: - LYON/FR

4. Diagnosis workup of T1-hyperintense adnexal masses:
We sum up our MR approach for T1-hyperintense adnexal lesions in a decision tree (fig. 23).

**Fig. 23**: MR algorithm for T1-hyperintense adnexal images

**References**: - LYON/FR

**Conclusion**

When a T1-hyperintense adnexal lesion is visualized, an MR algorithmic approach, based on knowledge of common and uncommon causes and coupled with the research of other key findings on additional sequences, can significantly help to achieve a more accurate diagnosis, resulting in an appropriate patient management.
References

- Bonneville F and al. T1 signal hyperintensity in the sellar region: spectrum of findings. Radiographics 2006;26:93-113
- De Kerviler E and al. Qu’est ce qui est blanc en T1? Journal de radiologie 1998;79:117-26
- Kopec M and al. MRI appearance of isolated fallopian tube torsion in an adolescent with a congenital müllerian duct anomaly and ipsilateral renal agenesis. Clinical radiology 2010;65:89-93
- Saksouk FA. Recognition of the ovaries and ovarian origin of pelvic masses with CT. Radiographics 2004;24:S133-S14
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