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Review Article / Artigo Revisão

MRI Characterisation of T2 Hypointense Ovarian Lesions

Caracterização por RM das Lesões do Ovário Hipointensas em T2

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Abstract

The evaluation of sonographically indeterminate adnexal lesions should be performed with MRI (Magnetic Resonance Imaging). It is fundamental to determine the exact location of the lesion, since the differential diagnosis and therapeutic approach are distinct according to the organ of origin. Some signs that may indicate an ovarian origin are: the presence of ovarian follicles and normal ovarian parenchyma surrounding the lesion, without a cleavage plane ("embedded organ sign"); a change in the ovarian contour by the mass ("beak sign"); visualisation of a vascular pedicle or the gonadic veins leading to the lesion ("suspensory ligament sign"); deviation of the iliac vessels laterally and of the pelvic ureters posteriorly or postero-laterally.
The majority of ovarian lesions show cystic components with high signal-intensity on T2 weighted-imaging. Hypointense lesions on T2 are less frequent. The differential diagnosis for T2 hypointense ovarian lesions can be vast: haemorrhagic lesions (namely endometrioma); presence of smooth muscle (leiomyoma); presence of fibrous tissue (fibroma, thecoma and cystadenofibroma) and tumours with mixed cellularity (Brenner tumour, "struma ovarii" and Krukenberg tumour).
According to the ESUR recommendations published in 2017, diffusion-weighted imaging (DWI) should be applied for those lesions, using high *b*-values. The lesions that show low-signal intensity on DWI are classified as benign and do not require further investigation. On the other hand, for lesions that demonstrate intermediate or high signal on DWI, it is essential to administrate intravascular contrast, ideally with dynamic-contrast enhanced imaging (DCE).

Keywords

T2-hypointense lesions; Ovarian lesions; MR; Haemorrhagic lesions; Fibrous tissue; Mixed-cellularity tumours.

Resumo

A avaliação de lesões anexiais indeterminadas em ecografia deve ser efectuada por Ressonância Magnética (RM). Em primeiro lugar, é fundamental a determinação da sua localização exacta, dado que os diagnósticos diferenciais e abordagem terapêutica são completamente distintos consoante o órgão de origem. Alguns sinais que podem auxiliar na determinação de origem ovárica são: presença de folículos e de parênquima ovárico normal em redor da lesão sem plano de clivagem ("embedded organ sign"); deformação do contorno do ovário pela lesão ("beak sign"); visualização de um pedículo vascular ou das veias gonádicas em continuidade com a lesão ("sinal do ligamento suspensor do ovário"); desvio dos vasos ilíacos lateralmente e dos ureteres pélvicos posterior ou póstero-lateralmente.
A maioria das lesões do ovário têm componente quístico com elevado sinal em T2, sendo menos frequente a identificação de lesões hipointensas em T2. Existe uma ampla lista de diagnósticos diferenciais para lesões com hipossinal em T2, que inclui: lesões hemorrágicas (nomeadamente endometrioma), com componente de músculo liso (leiomioma), com tecido fibroso (fibroma, tecoma e cistadenofibroma) e tumores com celularidade mista (tumor de Brenner, "struma ovarii" e tumor de Krukenberg). De acordo com as recomendações da ESUR publicadas em 2017, é fundamental a sua avaliação em sequência de difusão com valor de *b* elevado. Quando nas sequências de *b* elevado estas lesões apresentam sinal baixo, tratam-se de lesões benignas, não sendo necessária investigação adicional. Por outro lado, quando demonstram sinal elevado ou intermédio é essencial a administração de contraste endovenoso, idealmente com estudo dinâmico.

Palavras-chave

Lesões hipointensas em T2; Lesões ováricas; RM; Lesões hemorrágicas; Tecido fibroso; Tumores com celularidade mista.

Introduction

The identification of ovarian tumours is frequent in clinical practice, either incidentally or in symptomatic patients,[1] and these constitute the main indication for gynaecological surgery.[2] There is a wide spectrum of differential diagnoses for adnexial pelvic tumours, including benign and malignant tumours and non tumoral pathology.[3] Thus, a preoperative radiological characterisation is essential for therapeutic decision purposes and the definition of a surgical protocol as, for example, in the case of benign ovary tumours, laparoscopy has been replacing open surgery.[4]
Ultrasound is the first line technique in the study of adnexal tumours.[2] However, this technique may be limited in particular by poor acoustic window and depth of penetration.[3] When an adnexal lesion is sonographically

indeterminate, magnetic resonance imaging (MRI) should be performed.[5,6] MRI multiplanar characteristics and high tissue contrast allow more detailed morphological information to be obtained, namely the location, dimensions and cystic/solid composition of the lesion.[7] In fact, MRI has high specificity, namely in the diagnosis of benign pathology.[8]

In the characterisation of adnexal lesions, some questions must be answered by the radiologist: definition of the exact origin of the lesion (ovarian/extra-ovarian); for ovarian lesions, determination of its physiological or pathological nature (namely neoplastic); if it is a neoplastic lesion with surgical indication, definition of the risk of malignancy and potential differential diagnoses.[4,9]

The T2-weighted sequences are included in the usual MRI protocol for the characterisation of adnexal lesions. Most of the identified ovarian lesions have a cystic component with a high T2 signal, and the identification of T2[7] hypointense lesions is less frequent.

The present article is intended to indicate the differential diagnoses of the T2 hypointense lesions of the ovary and their characteristics in MRI. In addition, the diagnostic algorithm established by the most recent ESUR recommendations (2017) is presented.[10]

1. Determination of lesion location (ovarian vs. uterine origin)

When a pelvic tumour is identified, the first step is to determine its compartment or organ of origin, since the differential diagnoses and therapeutic approach are completely different depending on the location.[3,4,7] Some aspects that may help in this evaluation include: visualisation of ovarian structures, type of contour deformity at the interface between ovary and pelvic tumour, deviation of vessels, ureters and other pelvic organs.[4]

When both ovaries are visualised separately from the lesion, it will necessarily have an extra-ovarian origin.[7] However, when it is a large tumour, it may not be possible to visualise the ovary.[4] The observation of follicles can help to identify the ovaries, especially when dealing with small lesions.[4,7] Thus, the presence of follicles and normal ovarian parenchyma adjacent to the lesion, without a cleavage plane (embedded organ sign), and the non-identification of the homolateral ovary, point to ovarian origin (Fig. 1).[3,4] Similarly, when the mass deforms the edge of the ovary into a beak shape (beak sign), it points to ovarian origin.[4] Another sign that may indicate ovarian origin is the visualisation of a vascular pedicle or gonadal veins in continuity with the lesion.[3,7,11] This sign is termed

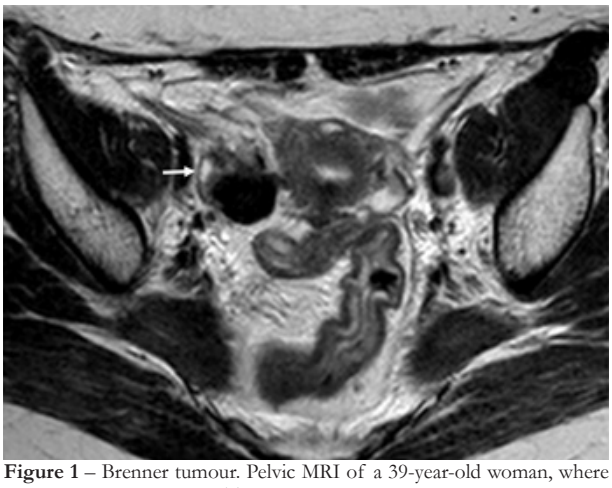

Figure 1 – Brenner tumour. Pelvic MRI of a 39-year-old woman, where it is possible to observe a T2 hypointense lesion, surrounded by normal ovarian parenchyma. The tumour deforms the edge of the ovary into a beak shape (beak sign) A small ovarian follicle can be identified at the periphery (arrow). These findings favour its origin in the right ovary.

"ovary suspensory ligament sign".[11] Typically, an adnexal lesion laterally displaces the iliac vessels, while extra-ovarian tumours originating from the pelvic wall/adenomegalies tend to medially dislocate the iliac vessels.[4] Since the ovaries are located anterior or anteromedial to the ureters, an ovarian mass may displace the ureters posteriorly or posterolaterally, whereas a tumour in the extraperitoneal space usually displaces the ureter anteriorly and medially.[3,11]

The identification of a pedicle between the uterus and the lesion indicates its uterine origin.[7] The most frequent T2 hypointense uterine lesions are leiomyomas. In the majority of leiomyomas, the claw sign can also be observed, which consists of the presence of a myometrial band around the lesion.[4] The bridging vessel sign is characterised by the presence of tortuous vascular structures between the tumour and the uterus, also indicating uterine origin[11] (Fig 2). This aspect can be visualised by ultrasound, in which it is also possible to identify movement of the tumour with the mobilisation of the uterus. On MRI, the bridging vessel sign is better identified on T1-weighted sequences after gadolinium and also on T2-weighted imaging, where the vascular "signal voids"[7] can be seen.

When a para-uterine lesion with no uterine or ovarian origin is identified, the hypothesis of fallopian tube pathology should be considered. Tubal tumours can usually be individualised from the uterus and ovary, although they may be attached to the ovary by adhesions.[7] The presence of incomplete septa in the wall of a cystic adnexal tumour points to its tubal origin[4,9] (Fig. 3). The most frequent

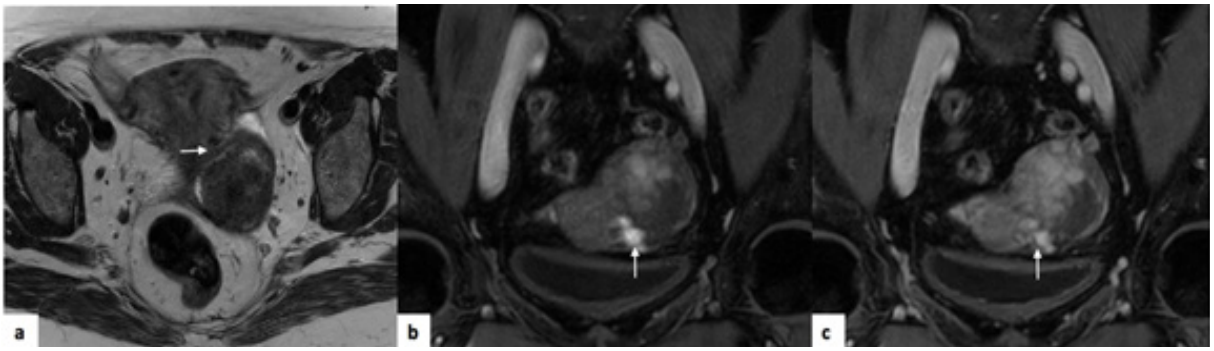

Figure 2 – Subserosal uterine leiomyoma. Pelvic MRI of a 64-year-old woman. (a) Axial T2-weighted image, where it is possible to detect a signal void corresponding to of vascular structures between the lesion and the uterus (bridging vessel sign) - arrow. These vascular structures are best visualised on coronal T1-weighted images with fat saturation after intravenous contrast (b) and (c) - arrows.

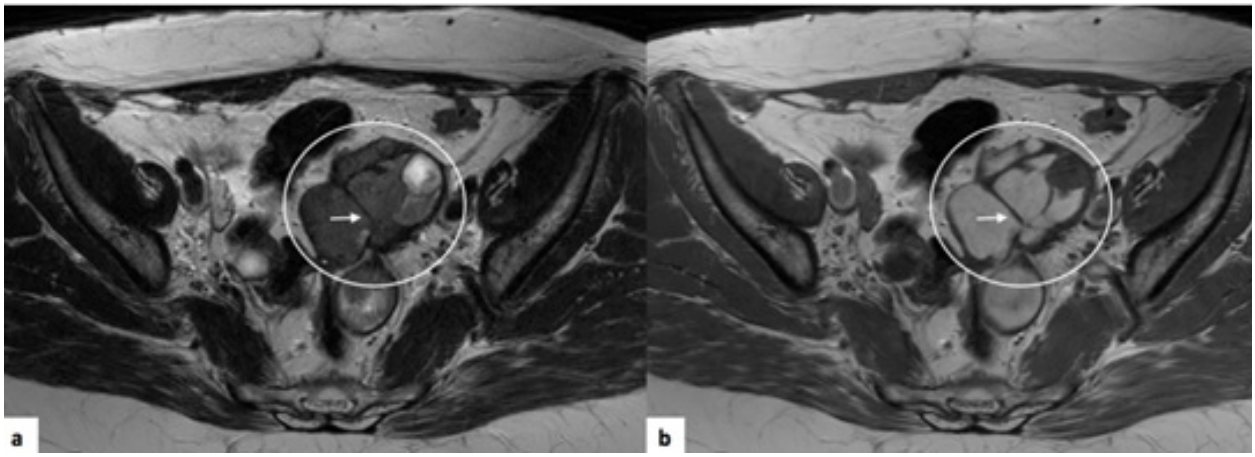

Figure 3 – Haematosalpinx. Pelvic MRI of 49-year-old woman. (a) Axial T2-weighted image; (b) Axial T1-weighted image. It is possible to visualise a complex tumour in the left adnexal region (circle) with incomplete septa in its wall (arrows), which point to its tubal origin. On the T1-weighted image, it shows spontaneous high signal intensity, which corresponds to blood content (haematosalpinx).

T2 hypointense lesions of the fallopian tube include haematosalpinx, tubal leiomyoma, fibroma, and abscess.[7]

2. T2 Hypointense ovarian lesions

There are different morphological and histological entities that can result in T2 shortening and, therefore, present with low signal in this sequence. These include haemorrhagic lesions, smooth muscle, fibrous tissue, calcifications, air, "signal void" artifact and paramagnetic substances such as melanin.[7]

A. Haemorrhagic lesions

Signal characteristics of a haemorrhagic lesion on MRI depend on the age of the hemorrhage and whether the blood components are intra- or extracellular.[7] Acute haemorrhage behaves according to intracellular deoxyhemoglobin: low signal intensity on T1-weighted images and it shows markedly low signal intensity on T2-weighted images (WI). In subacute haemorrhage (3-5 days), there is intracellular methemoglobin and therefore high signal intensity on T1WI, which results from its paramagnetic effects. T2 signal is variable and depends on methemoglobin location. When intracellular, there is T2 shortening and so low signal intensity on T2WI.[14] By contrast, extracellular methaemoglobin (late subacute haemorrhage) shows high signal intensity on T2WI.[7] In the chronic phase, haemorrhage can show low signal on T1WI and T2WI, given the presence of intracellular forms of ferritin and hemosiderin, which produce a magnetic susceptibility effect.[14,15] The deposition of hemosiderin on the wall of a mature hematoma may also present low signal on T2WI as a result of magnetic susceptibility effects.[7,15] These effects also result in significant signal intensity loss on T2*.[15]

• *A.1 Endometrioma*

Endometriosis is defined as the presence of stroma and endometrial glands outside the uterine cavity[8,12-14] and usually occurs in women of childbearing age.[14] Its prevalence is around 15%.[9] The most common locations include the ovaries, uterine ligaments, fallopian tubes, recto-vaginal septum, Douglas pouch, and bladder wall.[13] About 80% of endometriosis cases present ovary involvement.[14] Endometrioma occurs when implants of ectopic endometrial tissue increase in volume and undergo repeated haemorrhage, forming cystic lesions, which are more common in the ovary.[12]

On MRI, endometriomas are usually multiple and show high signal intensity on T1WI (given the presence of methemoglobin).[7,9,12-14,16] This high signal is frequently easier to detect on T1WI with fat saturation, especially when of reduced dimensions.[7,13] On T2WI, they usually exhibit homogeneous shading, which is characterised by the loss of signal on T2 from a ovarian cyst with high signal intensity on T1WI[4,7,12,16] (Fig. 4). This low signal on T2WI images results from the presence of iron, high protein concentration and increased viscosity over time, which is caused by repeated haemorrhage and degradation of non-recent blood components.[7,12,13]

However, not all endometriomas present this degree of T2 shortening, depending on their age, hemosiderin concentration and proteins. Dependent layering and a hypointense fluid level that represents the presence of blood components with different ages can be seen.[7] A T2 hypointense peripheral ring (by deposition of hemosiderin on the wall of chronic lesions)[7,13] may also be seen. Another sign that can be visualised in endometriomas is the T2 dark spot sign, which is characterised by the presence of small spots markedly hypointense on T2 inside the lesion, which constitutes a very specific sign of endometriomas(Fig 5).[12] The shading on T2WI is not exclusive of endometriomas,[4] and may occur in other haemorrhagic lesions such as haemorrhagic cysts, although they are usually hyperintense on T2WI[7,12] (Fig. 6). Recent studies indicate that diffusion weighted-imaging (DWI) may play a role in distinguishing between endometriomas and haemorrhagic cysts with this behaviour, particularly through ADC values (lower in haemorrhagic cysts).[16]

Malignant transformation of endometriomas is rare and is estimated to occur in about 1% of patients. The most common histological subtypes are endometrioid carcinoma and clear cell carcinoma. The radiological aspects that should raise suspicion of malignant transformation are the increase in size and loss of T2 shading. The presence of contrast-enhancing mural nodules is the most important signal.[7]

• *A.2 Ovarian torsion with haemorrhagic infarction*

Torsion of the ovary is a common gynaecological emergency.[11] The radiological aspect of ovarian torsion depends on the severity and chronicity of the vascular compromise. When the torsion of the ovary remains untreated, it may progress to haemorrhagic infarction.[15]

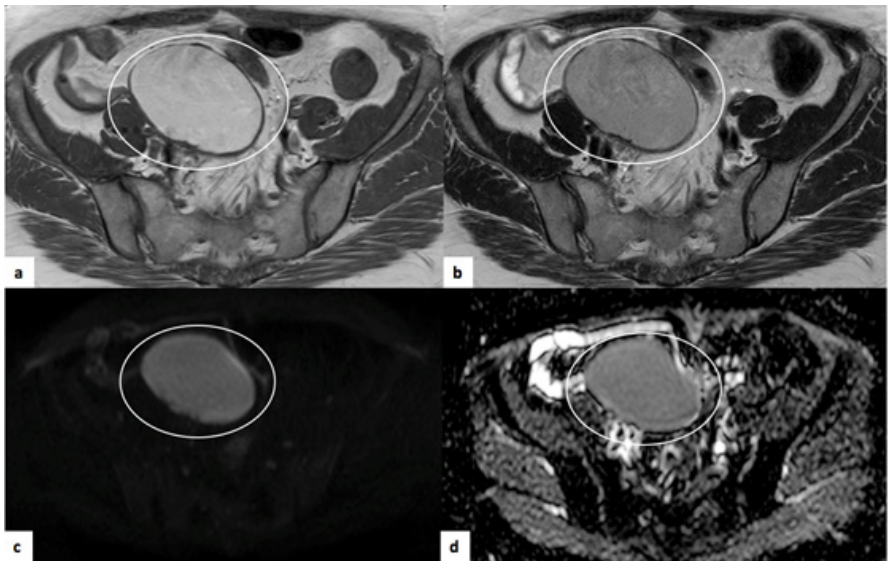

Figure 4 – Endometrioma. Pelvic MRI of 42-year-old woman. (a) Axial T1-weighted image where it is possible to see an adnexal tumour with spontaneous high signal intensity (circle), which loses signal in a relatively homogeneous way on the T2-weighted image (b) - shading; (c) and (d) represent DWI (*b*-1000) and ADC map, respectively, where it is possible to appreciate that this lesion presents restricted diffusion.

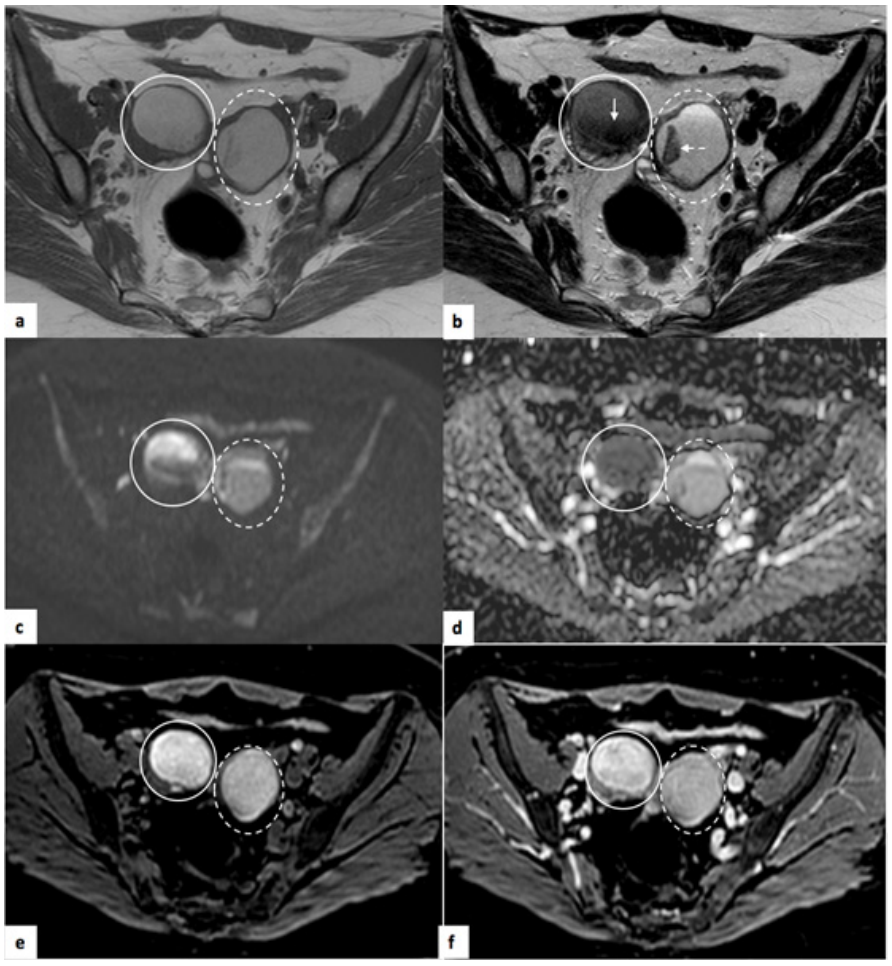

Figure 5 – Bilateral endometriomas. Pelvic MRI of a 45-year-old woman. (a) Axial T1WI, where bilateral adnexal lesions with spontaneous high T1 signal are shown. On T2WI (b), the right adnexial lesion (circle) shows heterogeneous loss of signal, with fluid-fluid level (arrow). Left adnexal lesion (dashed circle) presents T2 hypersignal, with focus of T2 hypointensity (T2 dark spot sign) – dashed-line arrow. (c) and (d) correspond to DWI (*b*-1000) and ADC map, respectively, where there is a restricted diffusion, more evident in the right ovarian endometrioma. (e) and (f) T1-weighted images with fat saturation before and after intravenous contrast, respectively, in which the endometriomas maintain an identical appearance, since they present spontaneous T1 high signal, without enhancement after intravenous contrast.

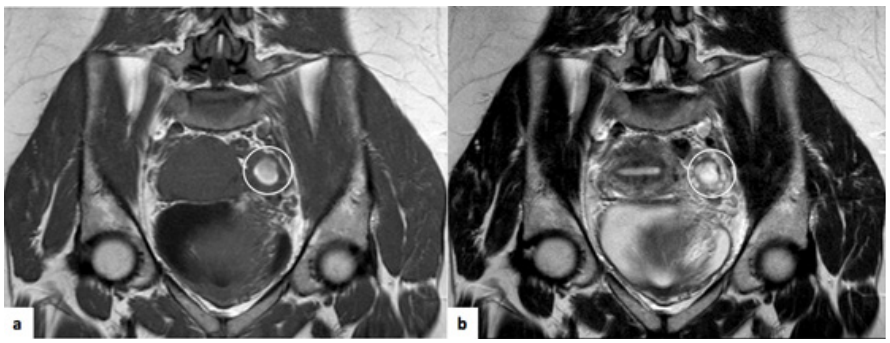

Figure 6 – Haemorrhagic cyst. Pelvic MRI of a 33-year-old woman. (a) Coronal T1-weighted image, where it is shown a left adnexal lesion with spontaneous hypersignal (circle). (b) Coronal T2-weighted image where this lesion also shows hypersignal. This is the most typical behaviour of haemorrhagic cysts on MRI.

On MRI, findings of ovarian torsion are nonspecific and are characterised by increased ovarian volume, peripheral distribution of the follicles, deviation of the uterus to the affected ovary, engorgement of the homolateral vessels, thickening of the fallopian tube and ascites.[11,15] When the torsion progresses to haemorrhagic infarction, in addition to these signs, low T2 signal intensity is observed due to the presence of interstitial haemorrhage. A thin T1 hyperintense halo may also be visualised, which does not enhance after intravenous contrast. It is easily distinguished from endometriomas, namely since they do not usually involve the entire ovary.[15]

B. Smooth muscle

The smooth muscle shows low signal on T2WI, due to the T2-shortening effect caused by actin, myosin and collagen, as well as by the lower extracellular fluid component in relation to the adjacent tissues.[7]

Leiomyomas are benign tumours that originate in any structure or organ containing smooth muscle.[14] Uterine leiomyomas constitute the most frequent gynaecological tumour, occurring in about 20-30% of women of childbearing age.[17] In the absence of degeneration, they present low to intermediate signal on T1WI and low signal on T2WI[9] and are usually well circumscribed.[14] Exophytic uterine leiomyomas may mimic T2 hypointense adnexal tumours, thus constituting an important differential diagnosis.[7] To distinguish them, it is important to note the characteristics described above in section 1. Determination of lesion location (ovarian vs. uterine origin).

Primary leiomyoma of the ovary is a very rare entity, with fewer than 80 cases reported in the medical literature. It presents radiological characteristics identical to the smooth muscle in other locations (Fig. 7). Other extrauterine leiomyomas may originate in the fallopian tubes and round ligament.[7]

C. Fibrous tissue

Fibrous tissue is characterised by low cellular or acellular material with a high proportion of collagen and few cells and vessels. Like compact smooth muscle, this type of tissue demonstrates intermediate signal on T1WI and very low signal on T2WI.[7,15] Different amounts of fibrous tissue can be found within the tumours, but in the ovarian tumours described below fibrosis is a dominant component (fibroma, thecoma and cystadenofibroma).[15]

• *C.1 Fibroma and Thecoma*

These are the most common benign solid tumours of the ovary[6] and correspond to most ovarian sex cord-stromal tumours[4]. They occur in both pre-menopausal and postmenopausal women[18] and are typically asymptomatic and incidentally detected.[13] Most of them are unilateral (90%).[4]

Fibromas are composed mostly of fibroblasts and spindle cells and abundant collagen[4,19] and they are not hormone producers.[4] They may be associated with ascites and pleural

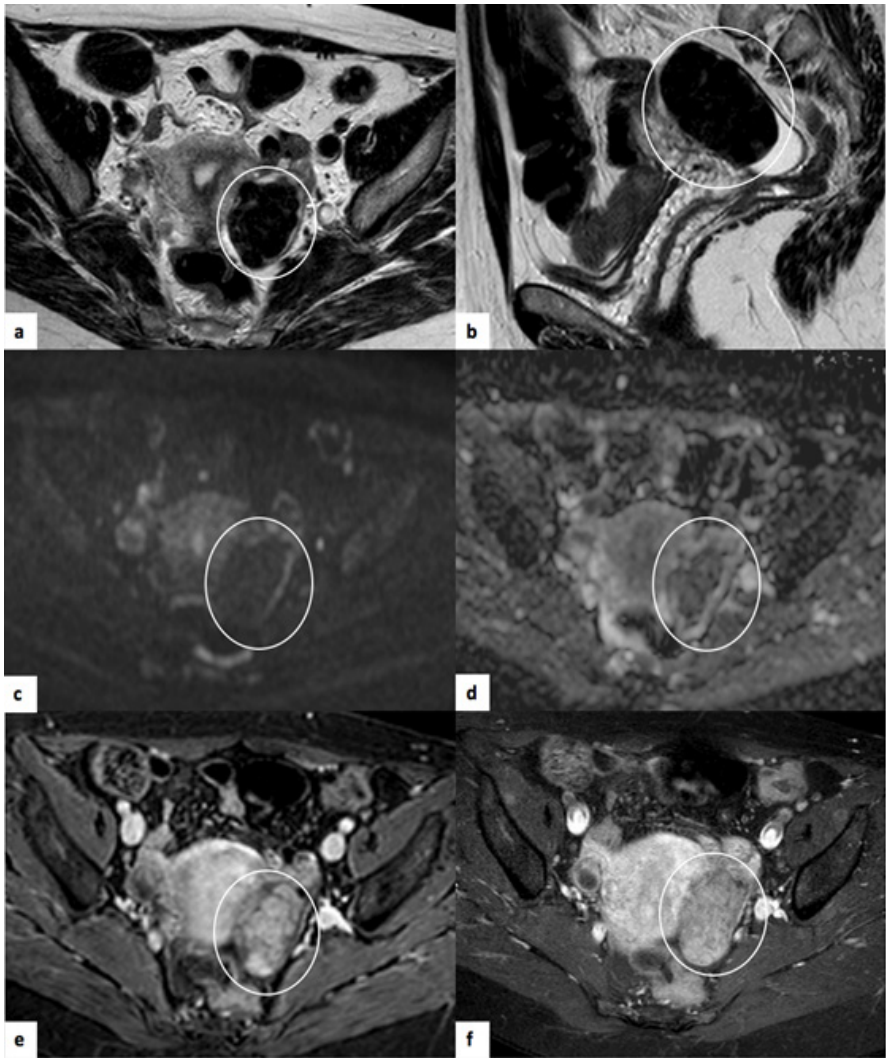

Figure 7 – Primary leiomyoma of the left ovary. Pelvic MRI of 52-year-old woman. (a) Axial T2-weighted image: the left ovarian lesion (circle) is markedly hypointense on T2WI (signal similar to muscle tissue). (b) Sagittal T2-weighted image where it is possible to appreciate the same characteristics. (c) and (d) correspond to DWI (*b*-1000) and ADC map, respectively, where it is shown that this lesion does not present restricted diffusion. (e) T1WI with fat saturation after intravenous contrast-enhancement - T1 SPAIR (dynamic study) and (f) delayed phase after intravenous contrast - T1 SPIR, where it is possible to appreciate the enhancement of the lesion, which is not superior to that of the myometrium.

effusion, constituting the Meigs Syndrome.[7] This triad may also be associated with elevation of CA-125 values[4]

Thecomas are composed of thecal cells with abundant and variable amounts of fibrosis, and may contain amorphous calcifications.[4] As opposed to fibromas, they present estrogenic endocrine activity that can result in endometrial hyperplasia and formation of polyps,[7] which can cause uterine haemorrhage. In addition, in more than 20% of the cases, endometrial carcinoma occurs, concomitantly.[4] Thus, an endometrial thickening associated with an ovary tumour with low T2WI signal should raise the suspicion of a functioning thecoma.[15]

Its main MRI characteristics are: non-specific hypo or isointensity on T1WI and low signal on T2WI, which is characteristic of these tumours.[7] They thus present features similar to uterine leiomyomas without degeneration,[4] which constitute its main differential diagnosis[6]. Areas of high T2 signal within the solid low signal intensity lesion, attributable to oedema or cystic degeneration, are frequent in larger tumours(Fig. 8).[4,7,13,15]

A small amount of ascites is also common, which is not a sign of malignancy.[4] Both the fibromas and the thecomas usually present mild and delayed enhancement after intravenous contrast (type 1 curve),[4,7,10] lower than that of myometrium and leiomyomas(Fig. 9 and 10).[19]

Rarely, cellular fibromas may be found, corresponding to about 10% of fibrous tumours of the ovary (Fig. 11).[20] These are well vascularised and have a low potential for malignancy.[21]

• *C.2 Cystadenofibroma*

Cystadenofibroma corresponds to an unusual benign ovary tumour consisting of fibrous stroma and an epithelial cystic component.[7,22] The presence of rims, septa or nodules with low signal intensity on T2WI within a multiloculated cystic ovarian tumour suggests the diagnosis.[15] The radiological aspect of cystadenofibromas depends on the predominant component (cystic or fibrous).[7] The T2 hypointense portions may range from 2 mm to 4 cm and correspond to the regions of fibrous intra-tumoral tissue.[15] These regions usually present mild enhancement on the post-contrast study(Fig. 12).[7] Cystadenofibromas may also behave on MRI as purely cystic lesions, practically indistinguishable from cystadenomas, although this appearance is less frequent.[1]

Although most cystadenofibromas are benign, they have malignant potential and therefore surgical indication. Despite this, it is of the utmost importance to establish a pre-surgical MRI diagnosis, since it can avoid performing more extensive surgeries, which are only necessary in the approach of malignant tumours.[7]

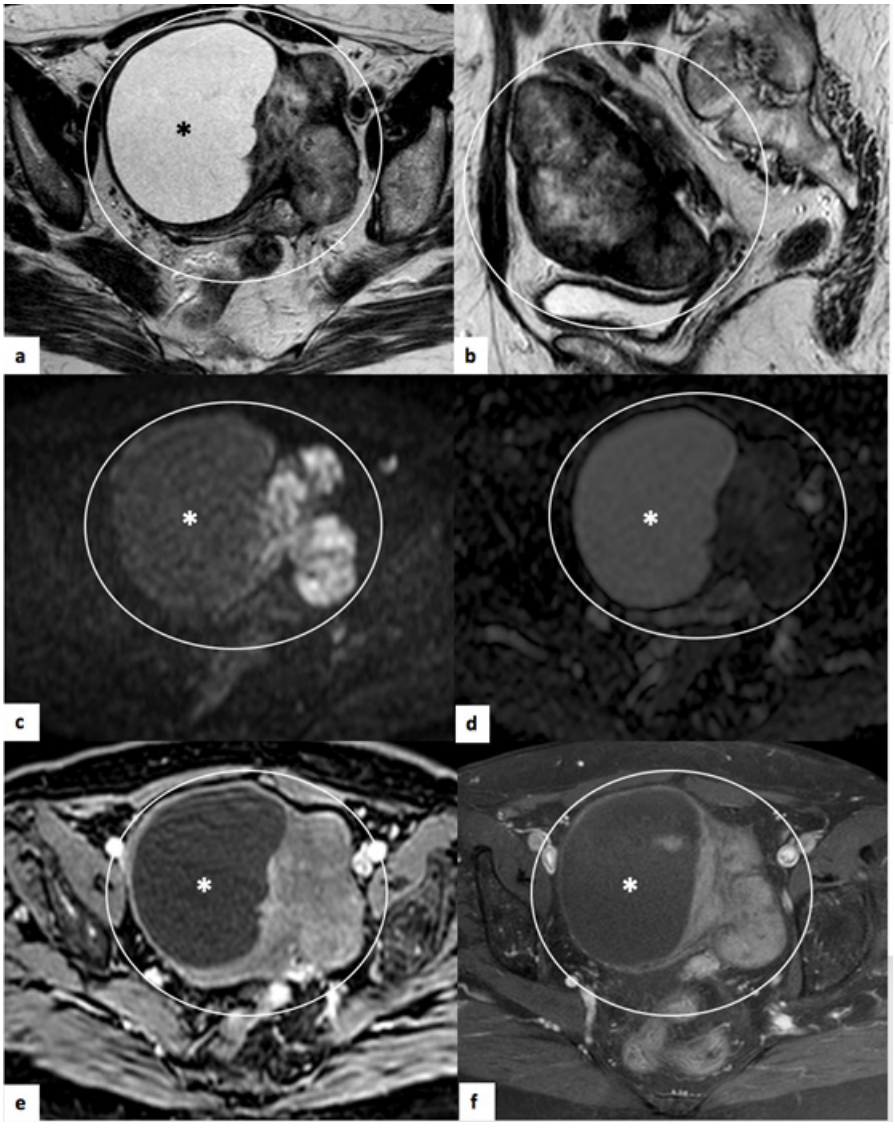

Figure 8 – Right ovarian fibroma. Pelvic MRI of a 77-year-old woman. (a) Axial T2-weighted image, which shows a large lesion (circle) with a hypointense solid component and also with a high T2 signal component (*), corresponding to cystic degeneration, common in lesions with a large dimension. (b) Sagittal T2WI. (c) and (d) DWI (*b*-1000) and ADC map, respectively. There is restricted diffusion of the solid component. (e) Axial T1-weighted image with fat saturation after intravenous contrast- T1 SPAIR (dynamic study) and (f) delayed acquisition (T1 SPIR), where it is possible to detect mild enhancement of the solid component.

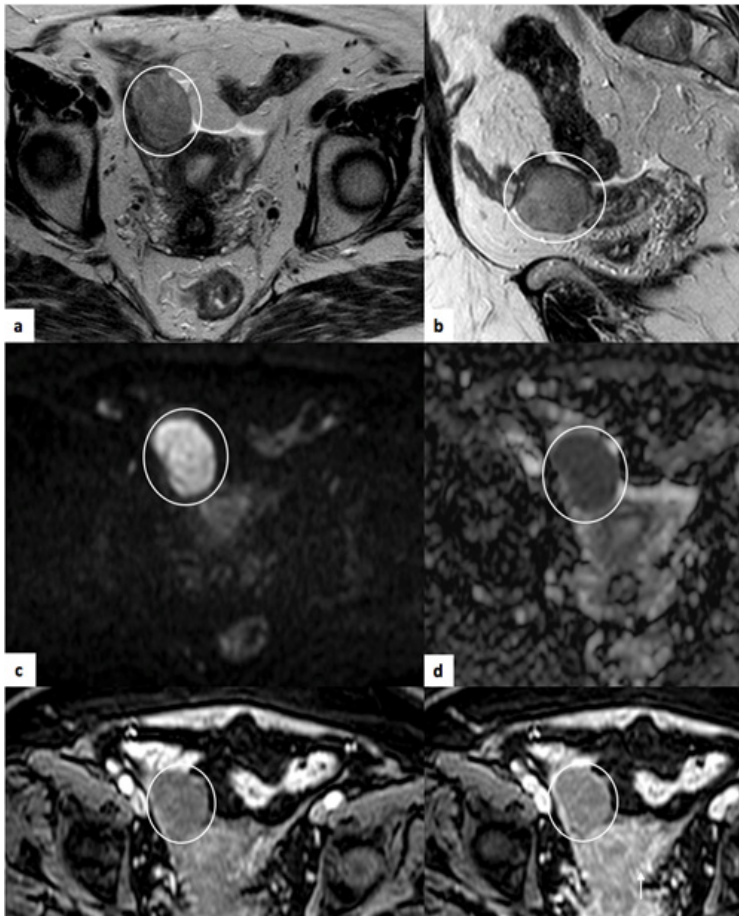

Figure 9 – Thecoma of the right ovary. Pelvic MRI of a 69-year-old woman. (a) and (b) correspond to axial and sagittal T2-weighted images, respectively, where a right ovarian lesion is shown, with an intermediate T2 signal (circle). (c) and (d) DWI (*b*-1000) and ADC map, respectively, showing restricted diffusion. On the post-contrast images-axial T1 SPAIR (e) and (f) there is a mild and delayed enhancement of this lesion, inferior to that of the myometrium (arrow). Although the T2 signal is intermediate, which does not correspond to the more typical aspect, the behaviour of the lesion in the dynamic study favours its fibrous nature. The anatomopathological study revealed a thecoma.

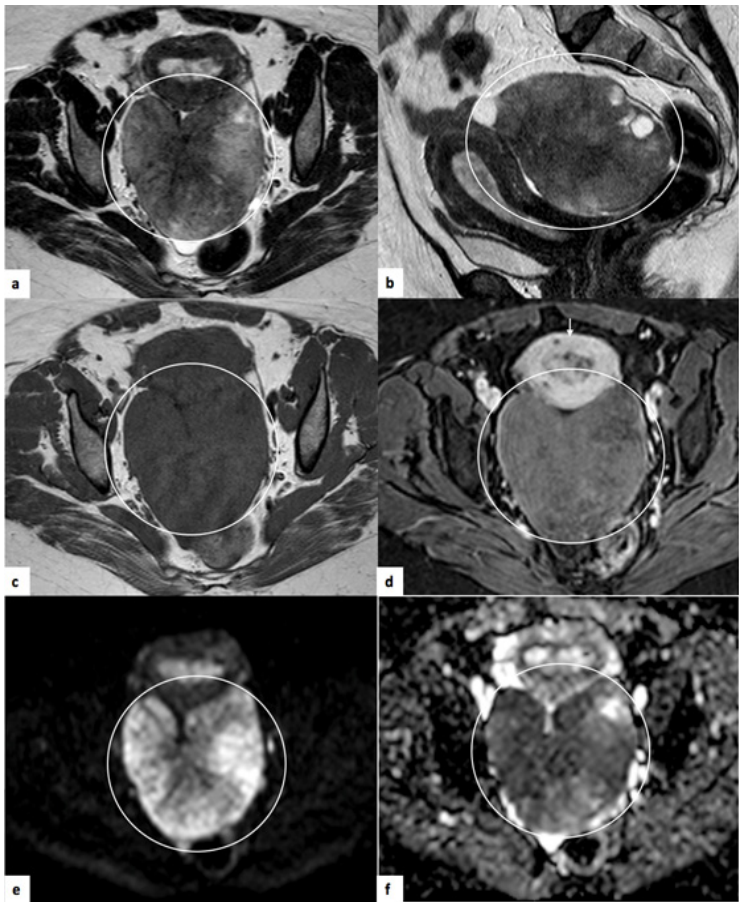

Figure 10 – Right ovarian thecoma. Pelvic MRI of a 60-year-old woman. (a) and (b) Axial and sagittal T2-weighted images, respectively, where a large heterogeneous right ovarian tumor (circle) is shown, with an intermediate T2 signal and central areas of marked low T2 signal. (c) axial T1 and (d) axial T1 with fat saturation after intravenous contrast -axial T1 SPAIR, where a mild enhancement is observed, inferior to that of the myometrium (arrow). (e) and (f) DWI (*b*-1000) and ADC map, respectively, showing restricted diffusion,, especially of the more peripheral region. The anatomopathological study revealed a thecoma.

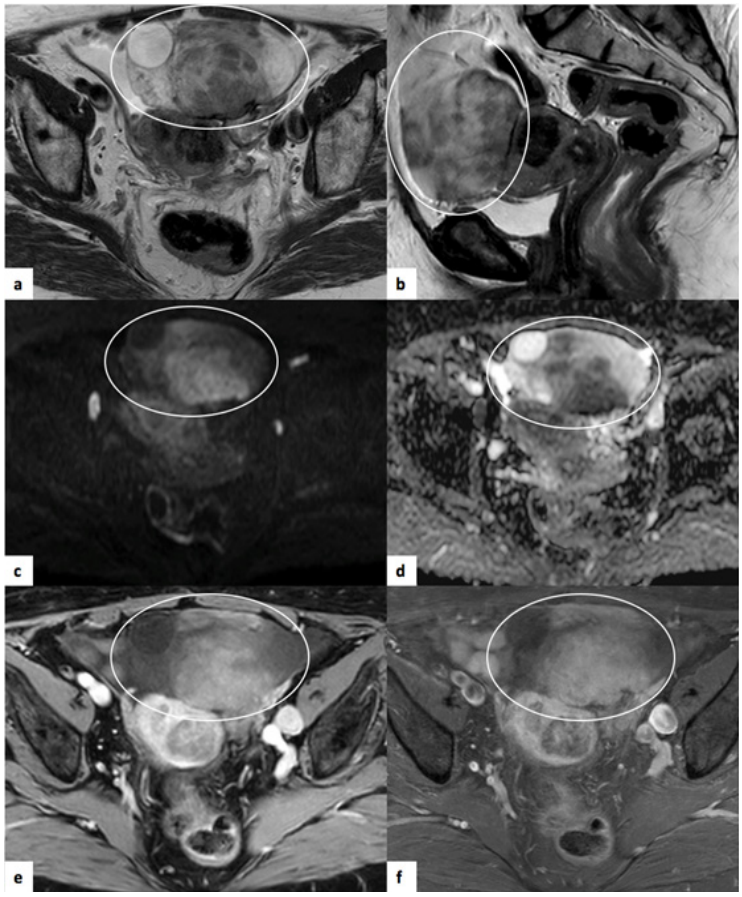

Figure 11 – Cellular fibroma of the left ovary. Pelvic MRI of a 60-year-old woman. (a) and (b) Axial and sagittal T2-weighted images, respectively, where it is possible to observe a heterogeneous tumour (circle), of mixed nature, with multicystic component and solid regions of intermediate T2 signal. (c) and (d) DWI (*b*-1000) and ADC map, respectively, showing restricted diffusion of the solid component. In the study after intravenous contrast - axial T1 SPAIR (e) and in the delayed axial acquisition SPIR (f) there is heterogeneous enhancement of the solid component. The anatomopathological study revealed a cellular fibroma.

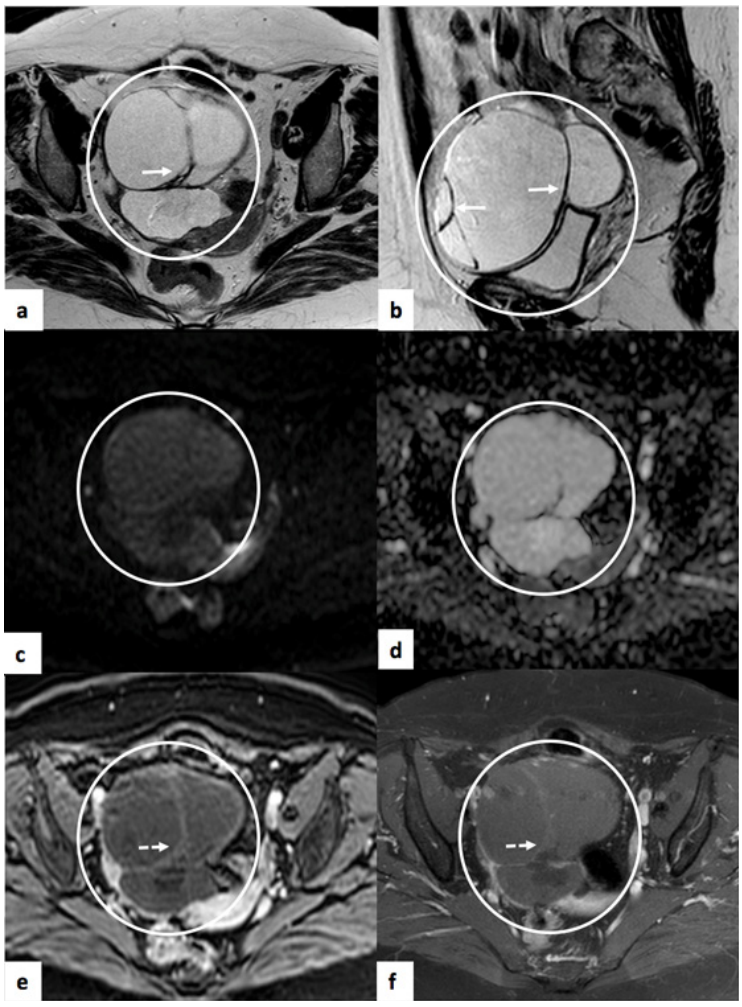

Figure 12 – Cystadenofibroma of the right ovary. Pelvic MRI of a 75-year-old woman. (a) and (b) Axial and sagittal T2-weighted images, respectively, showing a large cystic tumour (circle), which shows T2 hypointense septae (arrows). (c) and (d) DWI (*b*-1000) and ADC map, respectively, showing no restricted diffusion.
In the study after intravenous contrast - axial T1 SPAIR (e) and in the delayed axial acquisition SPIR (f), there is mild enchancement of the septae (dashed arrows).

D. Mixed Cellularity

• *D.1 Brenner Tumour*

Brenner tumour is a rare ovarian epithelial-stromal tumour,[7] usually benign,[1] corresponding to about 2% of ovarian tumours. Typically it consists of a fibrous stromal component associated with calcifications and transitional cells, which are histologically similar to the urothelial epithelium.[7,14] Most of them occur between 30 and 59 years of age.[23] They may be associated with other ovarian tumours, in particular cystadenomas, in about 30% of cases.[6,14,18] Although rare, there are borderline and malignant forms (transitional cell carcinoma),[1] corresponding to less than 2% of the cases. They are rarely oestrogen producers.[4]

The most common radiological features of Brenner tumours are: solid and small lesions (about 60% below 2 cm), most commonly unilateral.[4] They usually present low signal intensity on T2WI, due to its solid components (fibrous stroma).[6,14] The presence of amorphous calcifications in small tumours is typical of this entity, but sometimes difficult to detect by MRI.[4,6,18] Although the radiological features of the Brenner tumour overlap those of fibromas and thecomas, they typically exhibit at least moderate enhancement after intravenous contrast, whereas fibromas and thecomas are usually hypovascular(Fig. 13).[7,14]

The borderline Brenner tumour is characteristically manifested as a cystic tumour with solid elements and papillary projections. On the other hand, malignant Brenner tumour is typically a multilocular cystic tumour with large solid components.[7]

• *D.2 Struma ovarii*

The designation struma ovarii refers to mature cystic teratomas consisting entirely or predominantly of thyroid tissue and containing follicles of varying dimensions with colloid material,[14] which is associated with haemorrhage, fibrosis and necrosis.[4] Rarely they can manifest with thyrotoxicosis.[1,4] They constitute a rare type of ovarian tumour (0.30-0.65% of ovarian tumours and 2% of ovarian teratomas). They are benign in about 95% of cases and occur mainly in premenopausal women.[7]

Some cystic spaces usually show low signal on both T1 and T2WI, due to its thick and gelatinous colloid component.[1,6,7,14] Other cystic spaces show high T1 signal due to hemorrhage.[7] Fat components are not present in this type of tumour.[1,4] They usually demonstrate strong enhancement of the solid components on T1WI after intravenous contrast(Fig. 14).[7]

• *D.3 Krukenberg Tumour*

Krukenberg tumours are matastatic ovarian tumours that contain mucin-secreting signet-ring cells.[1,18] They thus correspond to adenocarcinomas, which originate most frequently from the stomach (70%), breast, colon and appendix. They constitute about 1-2% of all ovarian tumours and are bilateral in 60-80% of patients.[7]

Ovarian metastases may have cystic and solid or predominantly solid characteristics[1] and may mimic primary tumours.[18] Krukenberg tumours in particular usually present as solid tumours with poorly defined intra-tumoural cysts (haemorrhage or cystic necrosis). They show variable hypointensity on T2WI due to the presence of cells filled with mucin, ovarian stroma and abundant

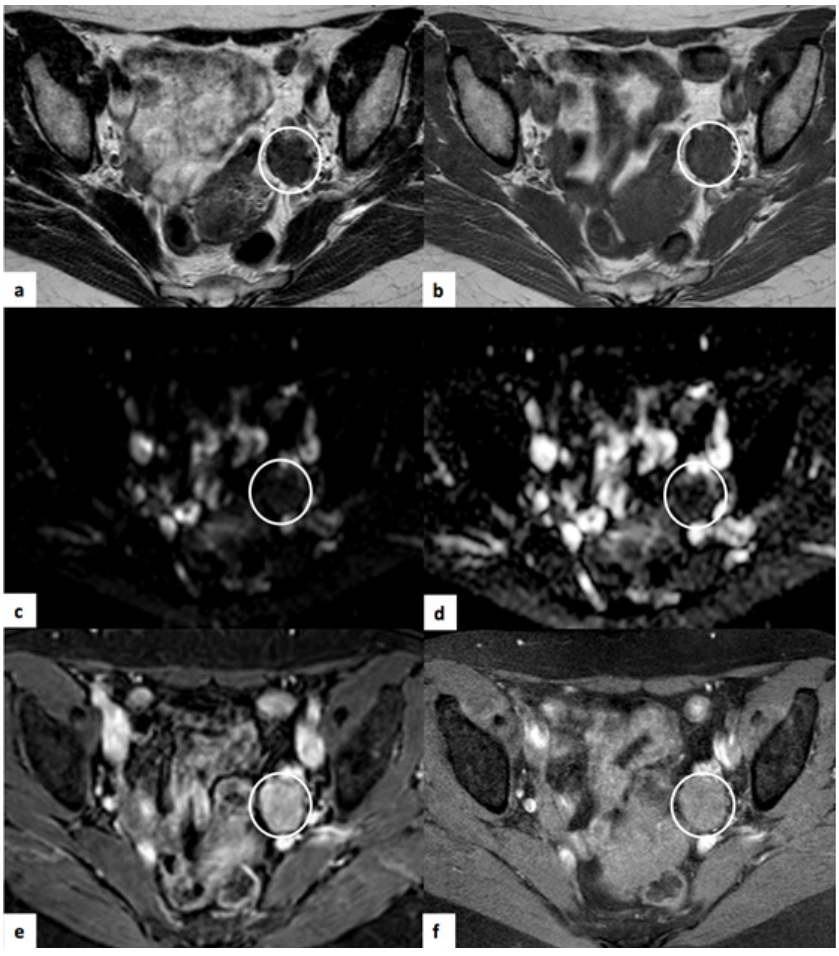

Figure 13 – Brenner tumour of the left ovary. Pelvic MRI of 58-year-old woman. (a) Axial T2-weighted image, where a a small solid tumour of the left ovary is shown, with marked T2 low signal. (b) T1-weighted image, where the tumour is isointense with the muscle. (c) and (d) DWI (*b*-1000) and ADC map, respectively, where it can be seen that there is no restricted diffusion. On the axial T1-weighted image after intravenous contrast T1 SPAIR (e) and on the delayed axial acquisition SPIR (f) there is moderate enhancement, which is more expressive than the usual for fibromas and thecomas (suggestion: comparison with Fig. 9e) .

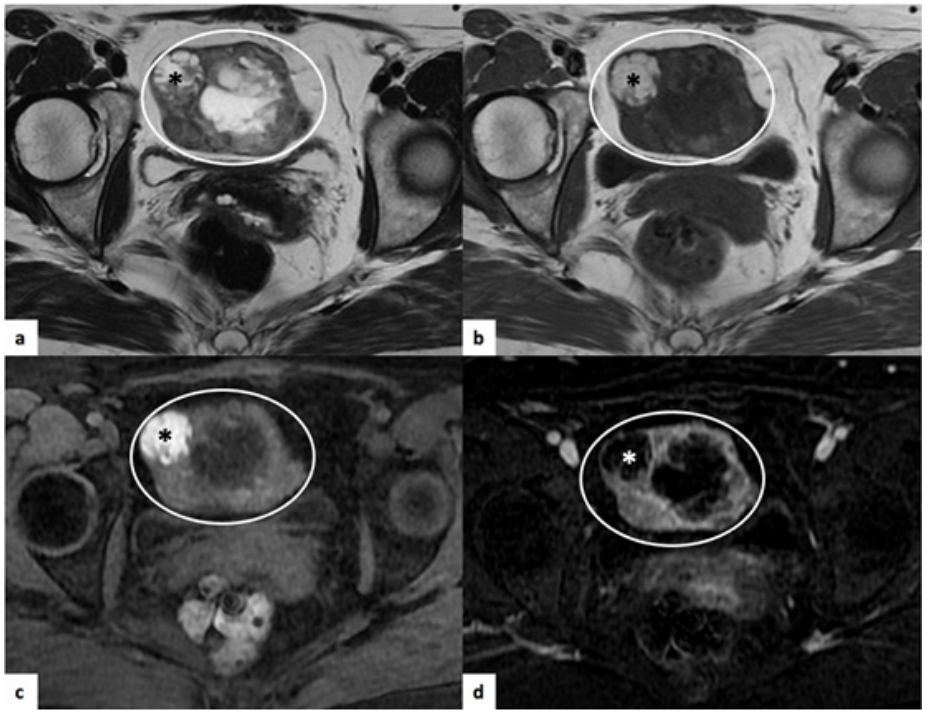

Figure 14 – Struma ovarii of the right ovary. Pelvic MRI of a 46-year-old woman. (a) Axial T2-weighted image where there is a large lesion with mixed characteristics (circle), with heterogeneous solid and cystic components. (b) Axial T1-weighted image, where a spontaneously hyperintense area(*) is identified, which shows no loss of signal on the T1-weighted image with fat saturation (c), thus corresponding to haemorrhage. On the T1-weighted image after intravenous contrast T1 SPAIR (d) the solid component shows enhancement.

collagen formation.[7] In fact, the presence of hypointense solid components on T2WI, peripheral or with random distribution (corresponding to the stromal collagen), although not specific, should suggest the diagnosis, especially when bilateral[14,18,25] (Fig. 15). After intravenous contrast, they show moderate to strong enhancement of the solid component and pericystic rim, which is uncommon for other solid ovarian lesions.[7]

MRI evaluation protocol (ESUR recommendations 2017)

In 2017, an update of the recommendations of ESUR[10] was published for evaluation of indeterminate adnexal tumours by ultrasound. According to these guidelines the baseline protocol for evaluation of T2 hypointense lesions of the ovary should include: a sagittal T2WI of the pelvis,

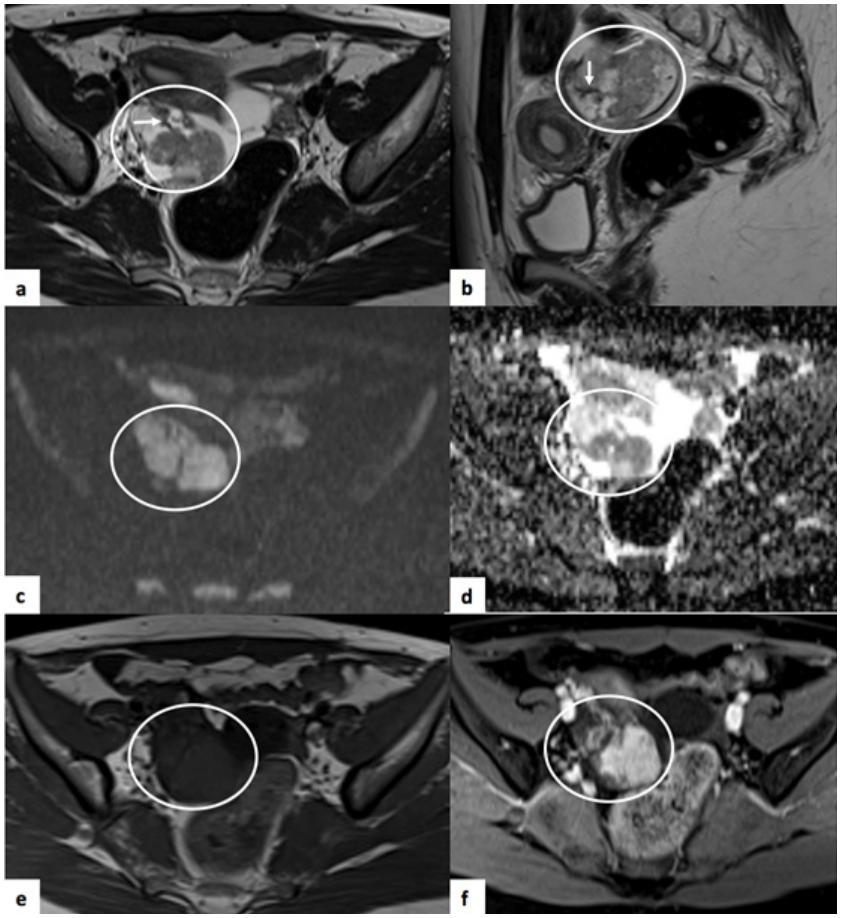

Figure 15 – Krukenberg tumour of the right ovary. Pelvic MRI of a 30-year-old woman with a history of mucinous adenocarcinoma of the colon. (a) and (b) correspond to axial and sagittal T2 sequences, respectively, where it is possible to observe a large heterogeneous tumour (circle), of mixed nature, with multicystic component and solid regions of predominantly T2 intermediate signal. The presence of peripheral solid components with significant low signal on T2WI(arrows) is highlighted. (c) and (d) DWI (*b*-1000) and ADC map, respectively, showing restricted diffusion of the solid component. (e) T1 weighted-image; (f) T1 weighted-image with fat saturation after intravenous contrast (T1 SPAIR), where there is moderate to strong enhancement of the solid component.

a pair of axial T1WI and T2WI through the indeterminate mass and eventually a T2WI in the long axis of the uterus. To determine the origin of the tumour (ovarian or uterine) in doubtful cases, an oblique sequence through the point of maximum contact between the tumour and the uterus can be useful, namely to identify bridging vessels and confirm the origin of the lesion.

Solid tumours of the ovary with a low T2 signal should also always be evaluated by DWI. When these demonstrate low signal on DWI with high *b* values (greater than 800 s/mm^2), they can be considered benign and intravenous contrast administration is not necessary. On the other hand, when this is not its behaviour on DWI, intravenous contrast should be administered, ideally conducting a dynamic study. These recommendations are summarised in Fig.16.

In the evaluation of DWI, it is important to ensure that the used *b*-value is adequate. According to the rules of ESUR 2017[10], the urine signal inside the bladder must be observed. When urine still shows a high signal, the *b*-value should be increased. The *b*-value from which urine has very low signal intensity is adequate and then evaluation of the ovarian tumour can be performed.

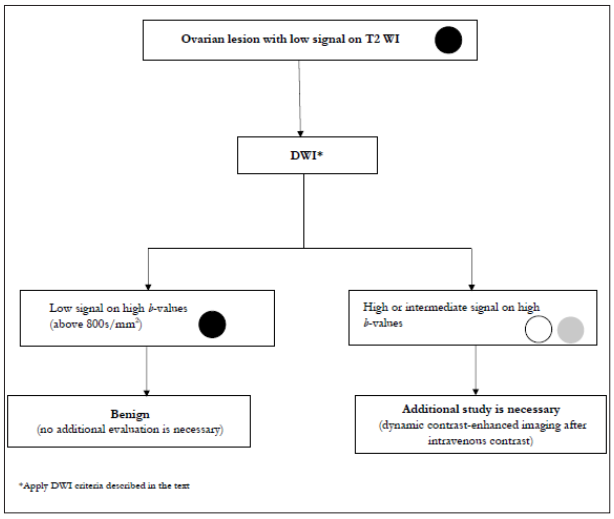

Figure 16 – Flowchart. Summary of ESUR recommendations (2017) for evaluation of T2 hypointense adnexal lesions

Conclusion

The first step in evaluating a tumour with possible adnexal origin is to determine its exact location. There is a broad spectrum of T2 hypointense lesions of the ovary, including haemorrhagic lesions (namely endometrioma), with smooth muscle component (leiomyoma), fibrous tissue (fibroma, thecoma and cystadenofibroma) and tumours with mixed cellularity (Brenner tumour, Struma ovarii and Krukenberg's tumour).

For the diagnosis of these lesions, the approach recommended by ESUR (2017) consists of its evaluation on DWI with high *b*-values. When they show low signal on this sequence, these are benign lesions and no further investigation is necessary. However, if they exhibit high or intermediate signal on DWI, it is mandatory to carry out post- intravenous contrast evaluation, ideally with dynamic study. Fibrous tumours, such as fibroma and thecoma, usually show a mild and delayed enhancement after intravenous contrast, inferior to that of the myometrium and leiomyomas.

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