Adnexal Masses: Five Imaging Pearls

Highlights:

- Adnexal masses are a major indication for gynecologic surgery.
- 20% of adnexal masses are indeterminate on transvaginal ultrasound.
- MRI is the most accurate imaging modality to characterize adnexal masses and is often able to make a specific diagnosis if the lesions contain: fat, blood, fibrous tissue, papillary projections or multi-locular variable T2-W signal intensity cysts.

One of the leading indications for gynecologic surgery in the US is the presence of an adnexal mass. In fact, it is estimated that up to 10% of women will undergo surgery for a suspected adnexal mass during their lifetime[1] . Imaging is performed to characterize adnexal lesions and triage patients to appropriate therapy. Specifically, if malignancy is suspected, the patient will be referred to a gynecologic oncologist for staging surgery; whereas if a benign entity is suspected, the patient can be managed more conservatively by a general gynecologist. While ultrasound remains the initial imaging modality for women with a known or suspected adnexal mass, up to 20% of premenopausal patients will have an indeterminate US interpretation and require further imaging[2]. MRI, and especially gadolinium-enhanced MRI is highly accurate in characterizing adnexal masses, so much so, that a recent ACR White Paper on managing incidental adnexal masses included a table of MRI features that allow specific diagnoses to be made[3].

Arriving at specific MR diagnosis relies on exploiting the tissue characterization abilities of MRI. In the ovary, or more broadly in the adnexa, this can often be accomplished by asking the following 5 questions:

1. Does the mass contain fat?
2. Does the mass contain blood?
3. Does the mass contain fibrous tissue?
4. Does the mass have papillary projections?
5. Does the mass have locules of varying signal intensity (SI) on T2-W images?

Armed with the above information, the following entities are often diagnosed with confidence: mature cystic teratoma, endometrioma/hemorrhagic cyst, fibroma, borderline malignancy and mucinous cystadenoma/cystadocarcinoma.

Does the mass contain fat?

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[1] Hricak H, Chen M, Coakley FV, et al. Complex adnexal masses: Detection and Characterization with MR Imaging—Multivariate Analysis. Radiology; 2000;214:39-46.

[2] Aultman CJ, Feller JF, Jain et al. MR imaging of sonographically indeterminate adnexal masses: cost-benefit study (abstr): Radiology 1995; 197(P):354.

[3] Patel MD, Ascher SM, Paspulati RJ, et al. Managing incidental Findings on Abdominal and Pelvic CT and MRI, Part 1: White paper of the ACR Incidental findings committee II on adenexal findings.

Macroscopic fat, or more accurately, fat cells, are readily diagnosed on MRI when a region has high SI on T1-W images and falls in SI on chemically selective fat saturated T1-W images (T1FS). In the ovary, these imaging features are diagnostic of a mature cystic teratoma (MCT)[4],[5]. These neoplasms are the most common benign tumor of reproductive age women. While the majority of MCTs are asymptomatic, complications include torsion (10%), rupture (1-4%), and malignant degeneration (1-2%)[6]. Therefore, MCTs greater than 6 cm are surgically removed. Occasionally, a MCT will be lipid-poor. In those instances, loss of SI on T1-W out-of-phase spoiled gradient echo (SGR) compared with T1-W in-phase SGE images detects microscopic intra-cytoplasmic lipid.

Does the mass contain blood?

MRI reliably diagnoses proteinaceous material. Blood products have high SI on T1FS images and depending on their protein concentration and viscosity, have variable signal intensity on T2-W images. The hallmark of endometriomas are high SI adnexal masses on T1FS images that demonstrates loss of SI, "shading", on T2-W images [7],[8],[910] . A low SI rim often circumscribes the mass, though this is less reliable imaging feature than SI[11]. Endometriomas can often be differentiated from hemorrhagic cysts as the latter are solitary finding and retain high SI on T2-W images, a reflection of their lower protein content and viscosity. MRI is poor at detecting superficial peritoneal endometriosis, but is able to identify deep pelvic disease (see next section).

Does the mass contain fibrous tissue?

Fibrous tissue typically images as low SI on both T1- and T2-W sequences. The differential diagnosis for this imaging feature includes ovarian fibromas, the most common solid adnexal mass, versus a pedunculated fibroid, the most common "apparent" solid adnexal mass [12]. Fibromas are part of spectrum of benign sex-cord stromal cell tumors that include pure fibroma, fibrothecoma and pure thecoma. Fibromas are characterized by bundles of spindle cells producing collagen that render them low SI on MRI; whereas thecomas have swollen lipid-laden stromal cells and may have heterogenous SI on MRI. A separate ipsilateral ovary and/or the "claw" or "bridging vessel" signs reliably differentiates a

[4] Imaoka I, Sugimura K, Okizuka H, Iwanari O, Kitao M, Ishida T. Ovarian cystic teratomas: value of chemical fat saturation magnetic resonance imaging. Br J Radiol 1993; 66:994-997.
[5] Outwater E, Siegelman ES, Hunt JL. Ovarian Teratomas: Tumor types and imaging characteristics. RadioGraphics 2001; 21:475-490.
[6] Park SB, Kim JK, Kim K-R, Cho k-S. Imaigng findings of complications and unusual manifestations of ovarian teratomas. RadioGraphics 2008; 28:969-983.
[7] Togashi K,Nishimura K, Kimura I et al. Endometrial cysts: diagnosis with MRI. Radiology 1991; 180:73-78.
[8] Takahashi K, Okada S, Ozaki T, et al. Diagnosis of pelvic endometriosis by magnetic resonance imaging using fat saturation technique. Fertil Steril 1994; 62:973-7.
[9] Ascher SM, Agrawal R, Bis KG et al. Endometriosis: appearance and detection with conventional and contrast-enhanced fat suppressed spin-echo techniques.
[10] Siegelman ES, Oliver ER. MR imaging of endometriosis: Ten imaging pearls. RadioGraphics 2012; 32:1675-1691.
[11] Outwater E, Schiebler ML, Owen RS, Schnall MD. Characterization of hemorrhagic adnexal lesions with MR imaging: blinded reader study. Radiology 199; 186:489-494.
[12] Weinreb JC, Barkoff ND, Megibow A, Demopoulos R. The value of MR imaging in distinguishing leiomyomas from other solid pelvic masses when ultrasonography is indeterminate. Am J of Roentgen 1990. 154:295-299

subserosal fibroid from a fibroma[13]. While this distinction may be insignificant if the mass is small and asymptomatic, it is important to diagnose deep (invasive) pelvic endometriosis from subserosal fibroids or ovarian fibromas as the treatment for deep pelvic endometriosis is very different from the other two entities. Deep pelvic endometriosis is primarily low SI on T2-W images and reflects the preponderance of fibrosis and smooth tissue that "strangle" the ectopic and hemorrhagic endometriotic glands.

Does the mass have papillary projections?

At pathology, papillary projections are diagnostic of ovarian epithelial neoplasms. Microscopically a papillary projection has a fibrovascular core surrounded by proliferating neo-epithelium[14]. The T2-W MRI correlate of a papillary projection reflects its size. When small, it images as non-specific 2-4 mm nodule in the cyst wall; whereas when large, it has a low SI fibrous core surrounded by very high SI edematous papillae[15]. At times, the high T2-W SI papillae may be difficult to distinguish from high T2-W SI fluid within a cystic neoplasm. Intravenous contrast aids the conspicuity of enhancing papillary projections. Papillary projections on MRI (and CT) are most commonly noted (67%) in borderline serous neoplasms, especially in absence of solid elements[16]. A peritoneal inclusion cyst can be reliably differentiated from a borderline or malignant serous epithelial neoplasm by noting an ovary entrapped within peritoneal-conforming pseudocyst.

Does the mass have locules of varying signal intensity on T2-W images?

The SI of mucin reflects its concentration and varies inversely between T1- and T2-W images. Loculi with a watery concentration of mucin have lower T1-W SI than loculi with more viscous mucin; this relationship is reversed on T2-W images[17]. These MR imaging features have been likened to "stained glass"[18]. Mucinous tumors are less common and often larger than their serous counterparts though size does not equate with malignancy. Rather, solid elements, ascites, peritoneal disease and lymphadenopathy favor mucinous cystadenocarcinoma.

Conclusion:

Advances in ovarian cancer surgery and chemotherapy require initial risk stratification. Where and how extensive a surgery is planned is often based on the imaging appearance of an adnexal mass in concert with physical exam and laboratory values. While no one imaging modality has perfect specificity, MRI

[13] Kim JC, Kim SS, Park JY. "Bridging vascular sign" in the MR diagnosis of exophytic uterine leiomyoma. J of Computer Assisted Tomography 2000; 24:57-60.
[14] Hassan K, Ghossain MA, Rousset P, et al. Characterization of papillary projections in benign versus borderline and malignant ovarian masses on conventional and color Doppler ultrasound. Am J of Roentgen 2011; 196:1444-1449.
[15] Outwater EK, Huang AB, Dunton CJ, et al. Papillary projections in ovarian neoplasms: Appearance on MRI. J Magn Reson Imaging 1997; 7:689-695.
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[17] Jeong Y-Y, Outwater EK, Heoun KK. Imaging evaluation of ovarian masses. Radiographics 2000; 20:1445-1470.
[18] Tanaka YO. Differential diagnosis of gynaecological "stained glass" tumours on MRI. Br J Radiol 1999; 72:414-420.

ably characterizes many adnexal masses and is especially helpful in cases where US is indeterminate. The MRI features of a mature cystic teratoma, endometrioma, fibroma, serous epithelial neoplasm (borderline or malignant) and mucinous cystadenoma/cystadenocarcinoma have been described and allow a specific diagnosis to be made in most cases.