Diagnosis of Adenexal Masses Using Gynecology Imaging Reporting and Data System (GI-RADS) and Risk of Malignancy Index

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Abstract: Ovarian cancer is the fourth cause of death from cancer in women worldwide. The differentiation of benign from malignant adnexal masses is of great therapeutic significance. Hence, the pre-operative detection of the nature of adnexal mass becomes extremely important for appropriate management.

Keywords: detection, adnexal, management, therapeutic, malignant

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Introduction

Uterine adnexal masses detected among premenopausal women include functional cysts, ectopic pregnancies, tubo-ovarian abscesses, endometriomas, benign tumors, and malignant tumors (1). By contrast, adnexal masses detected among postmenopausal women are likely to be caused by fibroids, fibromas, or cancer (2).

Ultrasonography offers a sensitive method for the routine detection and evaluation of adnexal masses (3,4).

Indeed, ultrasonographic appearance is a key point to consider when determining clinical suspicion of malignancy among these lesions (5,6). Nonetheless, accurate preoperative differentiation of benign and malignant adnexal masses with indeterminate ultrasonographic findings is required because the clinical management of these two conditions varies widely. A conservative or minimal procedure is sufficient to treat patients with benign masses; however, those with malignant masses require specialist referral and major surgery (6).

The ability of ultrasonography to establish whether an adnexal mass is malignant can vary (7), with an accurate diagnosis dependent on both technical skill and experience(2). The

International Ovarian Tumor Analysis consensus nomenclature and definitions for all tumor features evaluated by ultrasonography has improved discrimination of adnexal masses by including quantitative assessment of morphological features **(3, 8)**. However, the findings of the ultrasonographic report can be confusing (or even misleading) for clinicians, with potential adverse effects for patient-management decisions. Such miscommunication between the sonographer and the clinician often reflects differing expertise, which in turn might lead to unwarranted concern and unnecessary testing or interventions **(9)**. Consequently, a strategy that provides a unified and structured language for ultrasonographic reporting of adnexal masses is clearly required.

The Breast Imaging Reporting and Data System (BI-RADS) was developed by the American College of Radiology to address the issue of miscommunication during the diagnosis of breast cancer **(10)**. The use of BI-RADS has been widely adopted as it can help to predict the presence of malignancy, thereby improving treatment options **(11)**.

A similar approach has been taken to enable structured reporting of adnexal masses. In 2009, **Amor et al. (12)** developed the Gynecology Imaging Reporting and Data System (GI-RADS), which was based on the BI-RADS classification. A prospective multicenter study of GI-RADS was published in 2011**(13)**. That study found GI-RADS to be effective at identifying the malignant risk of adnexal masses among patients from Spain and Chile; however, these findings still required verification in other countries.

Clinical features helpful in evaluation of adnexal masses:

Adnexal masses may be identified in asymptomatic women during routine pelvic examination or may cause symptoms. Typical complaints include pain, pressure sensations, dysmenorrhea, or abnormal uterine bleeding **(14)**.

Women who report abdominal or pelvic pain, increased abdominal size or bloating, difficulty eating, or rapid satiety that occurs more than 12 times per month in less than a year should be evaluated for ovarian cancer **(2)**.

Clinical criteria stated for diagnosis of ovarian masses include*(15)*:

- Family history of breast or ovarian cancer (in a first-degree relative).
- Evidence of abdominal or distant metastases (by examination or imaging study).
- Ascites.
- Nodular or fixed pelvic mass in postmenopausal women (>50 years).

Investigations used in evaluation of adnexal masses include:

A. Laboratory Investigations:

Different laboratory investigations are important in evaluation of adnexal masses, the most important, is the "Tumor markers".

Tumor markers are produced by the tumor itself or by the body in response to the presence of cancer or certain benign conditions. Following the development of monoclonal antibodies, an array of new tumor markers has been discovered during the past 4 decades **(16)**.

Tumor markers can be used to:

(1) **Screen** a healthy or high-risk population for presence of cancer.
(2) Assist in confirming a **diagnosis** of cancer or of a specific type of cancer.
(3) Assist in determining a patient's **prognosis.**
(4) **Monitor** the disease course in a patient in remission or in a patient who is undergoing surgery, radiation, or chemotherapy. Currently, tumor markers are primarily used to help assess tumor response to treatment and to check for recurrence *(17).*

The following are important gynecologic tumor markers*(18)*:

- Cancer antigen 125 (CA125).
- Carbohydrate antigen 19-9.
- Urinary gonadotropin fragment.
- Carcinoembryonic antigen (CEA).
- Alpha-fetoprotein (AFP).
- Human epididymis protein- 4 (HE-4).
- Ovarian antigen1 (OVA-1)

CA 125:

Cancer Antigen 125 (CA 125) and Human Epididymis Protein 4 (HE4) are the most studied ovarian tumor markers. Their diagnostic performance for identification of ovarian cancer are superior to CA19-9, and carcinoembryonic antigen, which are not recommended for the diagnosis of presumed benign ovarian tumor **(19)**.

CA 125, the first and most widely used serum tumor marker test for epithelial cancer of the ovary, was introduced by Bast et al. in 1983 **(20, 21)**.

CA 125 is expressed by amniotic and coelomic epithelium during fetal development. In the adult, it is found in structures derived from coelomic epithelium (the mesothelial cells of the pleura, pericardium, and peritoneum) and in tubal, endometrial, and endocervical epithelium. The surface epithelium of normal fetal and adult ovaries does not express the determinant **(22)**.

A serum value of 35 U/ml is often accepted as the upper limit of normal in clinical practice. Overall approximately 85% of patients with epithelial ovarian cancer have CA125 levels >35 U/ml **(23, 24)**.

Elevated levels >35 U/ml are found in 50% of patients with stage I disease but raised levels are found in >90% of the women with more advanced stages **(21, 25, 26)**.

CA 125 is less often elevated in mucinous, clear cell and borderline tumors than in serous tumors. While CA125 is most commonly elevated in association with ovarian malignancy, it can also be raised in some physiological situations, benign and malignant conditions **(27).**

▪ **Table (1):** Medical conditions known to elevate CA125 levels *(28)***Physiological conditions:**
○ Ovulation
○ Pregnancy
○ Retrograde menstruation
▪ **Benign conditions:**
○ Endometriosis
○ Benign Ovarian Cysts
○ Uterine Leiomyomas (fibroids)
○ Adenomyosis
○ Pelvic inflammatory disease
○ Meig's syndrome
○ Peritonitis, Pleuritis
○ Peritoneal dialysis
○ Acute pancreatitis
○ Chronic alcoholic hepatitis
▪ **Non-ovarian malignant conditions:**
○ Carcinomas
- Endometrium
- Endocervix
- Fallopian tube
○ Malignant Ascites
○ Disseminated Malignancy (as Breast &Lung cancers)
○ Disseminated Malignancies to serous membranes

This tumor marker often provides confirmatory evidence of ovarian cancer in women with a pelvic mass and a suspicious finding on ultrasound evaluation **(29).**
Several studies suggested that pre-operative CA125 measurements may be of value in the differential diagnosis of benign and malignant pelvic mass **(30).**
Aside from ovarian cancer, CA125 is used most frequently as a marker for monitoring carcinomas of the endometrium, peritoneum and the Fallopian tube **(28, 95).**

Human Epididymis 4 protein:

Human Epididymis 4 protein (HE4) was first identified in males in the distal epithelium of the epididymis. It functions as a protease inhibitor essential for sperm maturation. It has since been found in other healthy epithelial tissues such as the respiratory tract and female reproductive organs, including the ovaries and uterus, where its function is not fully elucidated. It is normally secreted only in very low concentrations by healthy ovaries **(31)**.

HE4 is found in high levels in the serum of women with serous epithelial ovarian cancer. Serum levels are less affected by menstruation, ovulation and other benign ovarian conditions (e.g.endometriosis) compared with CA125 **(17)**.

In pre-menopausal women, HE4 is the more sensitive and specific marker of ovarian malignancy, including early stage ovarian cancer. In post-menopausal women, the very non-specificity of CA125 can be helpful in determining whether an ovarian mass is malignant or not, as the incidence of secondary malignancy to the ovary in this group of women is more common, and the occurrence of minor rise due to benign ovarian conditions is less likely **(17)**.

In a study evaluating multiple biomarkers for ovarian cancer, the combination of CA125 and HE4 was superior compared with any other marker alone or two markers in combination **(17)**.

OVA-1:

In September 2009, OVA1 was cleared by the Food and Drug Administration (FDA) for use in women scheduled for surgery for an ovarian mass to facilitate clinical decisions about referral to an ovarian cancer specialist. The FDA approved it as a new tumor marker for ovarian cancer **(32)**.

OVA1 measures a group of hormones (CA-125/pre-albumin/ apolipoprtein-A1/ Beta 2-microglobulin and serum transferrin). The validity of OVA-1 has been demonstrated by researchers from university of Kentucky United States who demonstrated that OVA-1 had a high sensitivity and specificity which were far more superior than CA-125 **(32)**.

Ostoepontin:

Osteopontin is a glycoprotein present in the extracellular matrix and is secreted by osteoblasts and endothelial cells. It is one of the early tumour biomarkers in the blood known to be elevated in EOCs. However, no significant difference in its expression is observed across various subtypes of EOCs, thereby limiting its utility as a subtype-specific biomarker. The sensitivity and specificity of osteopontin are approximately 90% in serum and 98% in ascites in HGSOC patients **(33)**.

In a study by Lan et al., osteopontin combined with CA-125 presented a higher AUC than osteopontin alone (0.93 vs. 0.91) **(34)**.

Furthermore, contrary to the findings for CA-125, the OPN levels were found significantly lower in the sera of patients with endometriotic cysts than in the sera of patients with other benign ovarian tumors **(35)**.

B- Imaging Modalities:

1- Ultrasonography and Doppler studies:

Ultrasonography is currently considered as the primary imaging modality for identifying and characterizing adnexal masses **(36)**. Several scoring systems and mathematical models using ultrasound variables have been developed for the preoperative prediction of probability of malignancy **(9)**.

Optimal ultrasound imaging of the female pelvic organs by transabdominal u/s is difficult to achieve. This is due to the pelvis being crowded with various structures of similar acoustic impedance making them poor reflectors. The distance from the abdominal probe to these organs is relatively large, precluding the use of frequencies higher than 5 MHz. This limits both axial and lateral resolution. The concept of the vaginal probe solved many of these problems and made it possible to obtain high quality images of the pelvic anatomy **(37)**.

The main improvement is achieved by placing the ultrasonic probe closer to the pelvic structures. Most of the relevant anatomy for transvaginal imaging is within 9 cm of the vaginal fornices. This makes it possible to increase the transducer frequency up to 7 MHz **(37)**.

Because of probe proximity to the organ of interest and higher frequency, resolution is dramatically improved. Problems previously encountered during transabdominal scanning such as obesity, bowel gas and retroverted uterus, no longer preclude accurate diagnosis **(38)**.

Furthermore, significant anterior abdominal wall scarring does not restrict evaluation of the pelvis, as the transvaginal probe may be used as an alternative approach **(39)**.

However, the limited field of view with transvaginal probes cannot accommodate longitudinal measurements of the uterus, provides incomplete viewing of large masses and does not permit assessment of associated pathology, for example, liver metastases, and hydronephrosis. Occasionally, ovaries are sited high in the pelvis and cannot be viewed transvaginally. Finally, the acceptability to patients must be considered **(40)**.

It Was Proposed That TVS Can Provide(41):

1. Confirmation of the presence or absence of a pelvic mass.
2. Delineation of the size, internal consistency and contour of the mass.
3. Establishment of the origin and the anatomic relationship of the mass to other pelvic structure.
4. A survey to establish the presence of abnormalities associated with malignant diseases, such as ascites or metastatic lesions.
5. Guidance for aspiration or biopsy of selected pelvic masses.

Pattern recognition

One of the best methods for discriminating between benign and malignant adnexal masses is subjective assessment; i.e. subjective evaluation of gray-scale and Doppler ultrasound findings by an experienced ultrasound examiner **(9)**.

The specific diagnosis most commonly suggested on the basis of pattern recognition of the gray-scale ultrasound image were endometriosis, dermoid cyst, tubal disease, myoma, paraovarian cyst, peritoneal cyst, ovarian fibroma/thecoma and pelvic abscess. All these entities may manifest characteristic features on gray-scale ultrasound examination **(42).**

Simple cysts are readily identified on gray scale ultrasound by their unilocular appearance and lack of cyst wall papillae. Small simple cysts, usually less than 2.5–3 cm, are of little clinical importance in reproductive age women. **(43).**

Simple cysts are very common and comprise a wide range of pathologies, from the self-limited follicular cysts which will resolve spontaneously upon follow-up of several months, to benign persistent cysts of epithelial origin (most commonly serous cystadenoma), to the very rare case of malignancy **(44).**

It was found possible to diagnose serous and mucinous cyst adenomas with gray-scale sonography. The characteristic features of a serous cystadenoma were: a unilocular or bilocular cystic mass of homogeneous echogenicity comparable to that of water, with a thin regular wall, thin regular septum (when present) and no vegetations.

Those of a mucinous cystadenoma were described as a multilocular cyst containing fluid of differing echogenicities, with a regular wall and septa and no vegetations. Using these criteria, serous cystadenomas were diagnosed with a sensitivity of 78% and a specificity of 96%, and mucinous cystadenomas with a sensitivity of 50% and a specificity of 96 %**, (42).**

Benign cystic teratoma, also called dermoid cysts, are the most common type of germ cell tumors, most often diagnosed in adolescents and reproductive-age women. Because these cysts contain sebaceous material and sometimes hair, their appearance on gray scale ultrasound is of a hyperechoic mass producing an acoustic shadow, i.e., gradual attenuation of the sound and obscuring of the structures beyond the cyst.

Occasionally, these cysts contain mostly sebaceous fluid, seen on ultrasound as a hypoechoic cyst with echogenic wall components which represent a mixture of hair and more solid sebaceous material. In addition, in those cases where the hair component of the cyst disperses into the cystic fluid, the ultrasound picture is of fine hyperechoic lines called “dermoid mesh”**, (45).**

Endometrioma occurs in the ovary where ectopic endometrial tissue is implanted. The characteristic US features of endometrioma are homogeneously diffuse low-level echoes in the cyst, compromising the so called ground-glass appearance, which is indicative of chronic repetitive hemorrhages within the cyst **(46).**

However, less than 15% of endometrioma have atypical findings, such as fluid-fluid level, hyperechoic mural irregularity, heterogencity, or calcification **(47).**

Ovarian fibroma is the most common sex-cord stromal neoplasm and is almost always benign. It typically occurs in middle-aged women and appears as heterogeneous or homogenous solid masses similar to pedunculated fibroid. Marked acoustic shadowing is a predictive feature that occurs in 18%-52% of fibromas **(48).**

Ultrasound criteria for differentiating of ovarian masses:

- ***Morphology***

1. Size: Larger masses more likely to be malignant.
2. Wall thickness:Thick-walled masses score higher for malignancy.
3. Composition: Complex masses score higher for malignancy.
4. Papillae: score higher for malignancy.
5. Thick septae: score higher for malignancy.

- ***Doppler***

1. Presence: Non-vascular masses more likely to be benign.
2. Distribution: Irregular vascular pattern score more for malignancy.
3. Resistance: Low- resistance and high end-diastolic flow velocity scores more highly for malignancy *(49)*.

Another suggested criteria for malignancy:

1. An irregular internal or external ovarian outline with solid structures.
2. Thick septa (>5 mm) or papillae.
3. Bilateralality.
4. Ascites.
5. Matted loops of bowel or other signs of metastases. *(50)*

The older the patient is, the higher the predictive value of these signs of carcinoma. Even in postmenopausal patient, a small (<5 cm) purely cystic tumor is rarely malignant **(51)**.

As proportion of solid components of the lesion increases, so does the likelihood of it being malignant. Solid portions of the lesion consist of irregular septations, 2 mm thick or greater, and papillary growths **(52)**.

Color Doppler:

The use of color Doppler increases the diagnostic accuracy of B-mode ultrasonography in the diagnosis of adnexal malignancies and therefore the evaluation of vessel distribution by color Doppler seems a safe diagnostic procedure permitting to treat by laparoscopy 91% of benign masses **(53)**.

The utilization of color Doppler has evolved from the quantitative to the qualitative. Hence, rather than utilizing a specific RI or PI cut-off for benign and malignant, the presence or absence of vascular flow into specific regions of a mass are evaluated **(54)**.

In the latter instance, central vascular flow within the mass, flow within a papillary excrescence or flow along septations would be considered indicators of malignancy, while peripheral flow is more indicative of a benign process **(55)**.

Hence, with a unilocular cyst, Doppler flow would not improve the diagnostic accuracy of morphology **(56)**.

Color Doppler detects blood flow in small low-resistance vessels, which is formed in neoplastic tissue. Pulsed Doppler is then used to quantify such color-coded flow. In this way ovarian

malignancy is differentiated from other lesions that produce similar but not identical flow patterns **(57)**.

Of all the vessels identified, central vessels within malignant masses tend to have lower velocities and lower vascular impedance than benign lesions **(58)**.

Cystic benign masses such as hemorrhagic cysts, serous cystadenomas, mucinous cystadenomas and others show typical pericystic vascular supply at the level of the ovarian hilus **(58)**. This can be explained by the fact that in these cystic lesions, no angiogenesis occurs, and the main vascular supply is derived from ovarian hilum **(59)**.

Analysis for the presence or absence of color flow in the different portions of the mass: wall, septa, and large echogenic portion or small echogenic, nodular portion against the wall of the cyst is performed. The presence of color flow in the portion characterized as malignant at convectional sonography indicated the solid hypervacularized nature of this portion, and the mass was confirmed as malignant **(19)**.

The absence of color flow in the echogenic portion of the mass characterized as malignant on sonography indicated the cystic or hypovascularized nature of this portion, and the mass was benign **(60)**.

However, internal color flow was not always useful as a predictor of malignancy (Stein et al., 1995), and the absence of color flow in the malignant papillary projections has already been reported **(61)**.

Also, increased vascularity has been demonstrated in some benign entities as well as tubo-ovarian abcesses, endometriomas, active hemorrhagic luteal cysts and some cystic teratomas **(62)**, and false positive results were found in inflamed endometriomas in which the vascularization in central and septal parts showed lower impedance to flow **(58)**.

The blood flow of endometriomas was described as ‘scattered’, i.e. only two or three discrete spots of color were detected in the wall of endometriotic cysts. This was in contrast to corpora lutea, which were all richly vascularized. It was found that the pulsatility index (PI) and RI values did not discriminate between endometriomas and other benign cysts **(63)**.

Dermoid cysts are devoid of blood flow, the flow detection rate being 24% from the cyst capsule, and found the blood flow pattern to be different in struma ovarii, which yielded abundant color Doppler signals in solid areas as well as in the cyst capsule.Tubo-ovarian abscesses have been reported to be characterized by low PI and RI values, especially in the acute phase **(64)**.

An ultrasonographic feature of vascular morphology described in solid ovarian metastases: a major vessel penetrating from the periphery of the lesion into the inner part of the mass, which was defined as the ‘lead vessel’. This ultrasonographic parameter was present in approximately one third of metastatic tumors, while it was identified in only 0.01% of primary ovarian tumors **(65)**.

Risk of malignancy Index (RMI)

Using subjective assessment, a small proportion of masses cannot be confidently classified as benign or malignant ('unclassifiable masses'). For such masses, methods other than subjective assessment are needed **(66).**

Optimization of the diagnostic performance of transvaginal ultrasonography by creating predictive models with the use of scoring systems, logistic regression analysis, neural networks, and support vector machines has been attempted **(67).**

The "Risk of Malignancy Index" was the first prediction model to combine clinical, ultrasound and tumor marker information.

It was first described by Jacobs in 1990 and has since evolved into RMI II, RMI III and RMI IV **(68,94).**

Asystematic review of diagnostic studies concluded that the RMI I was the most effective to use for women with suspected ovarian malignancy. RMI I combines three presurgical features: serumCA-125; menopausal status (M); and ultrasound score (U).

The RMI is a product of the ultrasound scan score, the menopausal status and the serumCA-125 level (IU/ml) as follows: RMI=UxM x CA-125.

Table (2): Showing how to calculate the risk of malignancy index (RMI I) ***(69).***

Parameter	Score	
Ultrasound (U)	*U* = 0 for ultrasound score of 0; *U* = 1 for ultrasound score of 1; *U* = 3 for ultrasound score of 2–5	**Ultrasound scans are scored one point for each of the following characteristics:** • multilocular cyst • evidence of solid areas • evidence of metastasis • presence of ascites • bilateral lesions
Menopausal status (M)	M=1 for premenopausal M=3 for postmenopausal	
CA125	serum CA125 measurement in u/ml	
RMI	*U* X *M* X *CA125*	

Previous studies have shown that an RMI with a cut-off of 200 gives the most optimal result **(70).**

An systematic review showed the pooled sensitivities and specificities of an RMI score of 200 in the detection of ovarian malignancies to be: RMI sensitivity 78%, specificity 87% **(47).**

Performances of RMI, CA-125 were poor in Borderline and in early stage ovarian cancers as they had poor scores both on ultrasound and CA- 125 levels **(70, 71)**.
When evaluated independently, an ultrasound score of 3, menopause and a CA125 level of 35U/ml or higher were considered predictive of malignancy. A RMI ≥ 200 was considered predictive of malignancy as shown in **Table (3)**.

Table (3): The interpretation of the results of RMI *(72)*

Parameter	**Predictor of malignancy**
Ultrasound (U)	*3*
CA125	≥35
Menopausal status	*3*
RMI	≥200

RMI II **(72)** = U × M × CA-125, where a total ultrasound score of 0 or 1 made U=1, and a score of ≥2 made U=4; premenopausal status made M=1 and postmenopausal M=4. The serum level of CA-125 was applied directly to the calculation
RMI III **(73)** = U × M × CA-125, where a total ultrasound score of 0 or 1 made U=1, and a score of ≥2 made U=3; premenopausal status made M=1 and postmenopausal M=3. The serum level of CA-125 was applied directly to the calculation.
RMI IV **(74)** = U × M × S (size in centimeters) × CA-125, where a total ultrasound score of 0 or 1 made U=1, and a score of ≥2 made U=4. Premenopausal status made M=1 and postmenopausal status made M=4. A tumor size (single greatest diameter) of <7 cm made S=1, and ≥7 cm made S=2. The serum level of CA-125 was applied directly to the calculation (cutoff 450).

International Ovarian Tumor Analysis:
The multicenter "International Ovarian Tumor Analysis" (IOTA) study was designed to create improved risk prediction models to discriminate between benign and malignant adnexal tumors **(75)**.
The International Ovarian Tumor Analysis (IOTA) consensus has allowed a better, homogeneous description of adnexal masses. However, there is still significant variation in the reporting of ultrasound examination results for adnexal masses *(7)*.

2- Computed Tomography (CT) of abdomen and pelvis:
CT is one of the most important tools used in evaluation of the pathology of the lower abdomen and the pelvis. Optimal bowel opacification is essential for the detection and staging of

gynecologic diseases on CT. Also optimal vascular enhancement can be achieved by administering iodinated contrast material via the peripheral vein **(76)**.
CT is the preferred technique in the pretreatment evaluation of ovarian cancer to define the extent of disease and assess the likelihood of optimal surgical cytoreduction **(77)**.
Ovarian cancer is usually in an advanced stage at diagnosis due to the presence of peritoneal carcinomatosis, which develops as a result of peritoneal fluid circulation. Tumor implants of varying size can occur anywhere from the diaphragm to the pelvis.
Computed tomography (CT) can be used to detect these metastatic lesions, which can be miliary or large and appear as soft-tissue or low-attenuation masses. Recent advances in CT technology have increased the flexibility of image acquisition, thereby allowing the use of thin sections and multiplanar reformatting **(78)**.

3- Positron Emission Tomography (PET):
It is an imaging modality, helpful in the diagnosis of recurrent ovarian cancer which can be difficult on cross-sectional imaging; variable sensitivities and specificities have been reported for positron emission tomography **(79)**.
Although not a preferred technique for cancer detection, PET/CT is playing an expanding role in treatment planning and follow-up. For predicting the correct stage, the addition of PET to contrast-enhanced CT has been shown to improve accuracy **(80).**

4- Magnetic resonance imaging (MRI) of abdomen and pelvis:
MRI is an adjunctive imaging modality useful for characterizing indeterminate or complex ovarian masses after ultrasonographic assessment. MRI can also help determine additional diagnostic information, such as the presence of fat, blood products, fibrosis and enhancement pattern or diffusion restriction **(81)**.
Ovarian neoplasms range from benign to malignant and may be primary or secondary. Usually, they are classified by tissue of origin (surface epithelial, germ cell and sex-cord stromal) and metastatic (one secondary). However, ovarian masses are often classified into three main MRI categories: Cystic neoplasms (with septations), Complex neoplasms (solid-cystic) and Solid neoplasms (predominantly solid) **(81)**.
These three categories are further subdivided according to specific MR imaging features, such as the presence of calcifications, fat, blood, proteinaceous content and signal intensities. This MRI classification can help to narrow the differential diagnosis and, in some cases, reach a specific diagnosis. It may also add to the diagnostic confidence needed to guide the type and extent of definitive surgical management prior to a pathological tissue diagnosis **(81)**.
Owing to its multiplanar capability and excellent tissue contrast, MRI imaging is one of the preferred imaging modalities of the female pelvis in many instances, particularly for the staging of malignant gynecologic diseases **(82)**.

MRI is non-invasive, and imaging of pelvis is practically advantageous due to the natural contrast of the pelvic fat, bowel gas, and urine in urinary bladder. Its multiplanner capability is especially useful in evaluation of the base and dome of bladder, uterus, and rectum despite their close proximity. MRI causes no known harmful effects on the fetus, embryo, or reproductive organs, and is apparently safe in pregnancy**(83)**.
However, MRI is expensive and has limited availability compared to ultrasonography. Also it does not visualize adhesions, and cannot always distinguish between malignant and inflammatory changes, which decrease specificity. In addition, a long scanning time is usually required **(84)**.

C. Cytological and Pathological Investigations:

1- U/S guided aspiration:

Fluid collections in the pelvic cavity can be aspirated using a fine needle, if the collected fluid is uncomplicated and small in amount. The problems of US-guided aspiration of ovarian cysts are high recurrence rate, potential risk for seeding malignant cells along the needle track and the risk of sampling error that could delay diagnosis of an occult malignancy. Therefore, only ovarian cysts with clearly benign US appearance should be managed with this technique **(85)**.

2- Percutaneous Catheter Drainage:

Percutaneous Catheter Drainage is a well-accepted technique for draining abdominal and pelvic fluid collections such as abscesses, hematomas, lymphoceles, and peritoneal pseudocysts. Infected tumors also can be drained percutaneously to relieve debilitating symptoms **(86)**.

3- U/S guided biopsy:

Biopsy of the masses in the female pelvis can be performed by using various types of the needles and biopsy guns. Biopsy guns are preferred for solid pelvic masses, whereas fine needle aspiration biopsy is commonly used for cystic masses. Injury to the bladder, intestine, or vessels can be avoided by US monitoring during the biopsy **(87)**.

GIRADS

Imaging is a cornerstone in the diagnosis of AMs, from the early detection to categorization **(88)**. Pelvic ultrasound (US) is still the most frequently used imaging method for detecting and characterizing AMs **(89)**.
The rationale of the Gynecology Imaging Reporting and Data System (GI-RADS) classification is to be illustrated to the gynecological clinicians.
In previous studies, other scoring systems or combination diagnostic system had been established for the diagnosis of malignant adnexal masses. However, most of these methods had complex scoring system for ultrasonographic findings, or even required for additional clinical and laboratory indexes combining with the ultrasonographic findings **(90)**. As a result, the clinicians cannot easily assess the malignancy risk immediately only by ultrasonography examination.

The International Ovarian Tumor Analysis consensus nomenclature and definitions for all tumor features evaluated by ultrasonography have improved the discrimination of adnexal masses by including quantitative assessment of morphological features **(8)**. However, the findings of the ultrasonographic report can also be confusing or even misleading for clinicians who are not majoring in Ultrasonics. Such miscommunication between the sonographer and the clinician often lead to unwarranted concern or interventions **(9)**. An approach has been taken to enable structured reporting of adnexal masses.

In 2009, **Amor et al (12)** developed the Gynecology Imaging Reporting and Data System (GI-RADS), which was based on the Breast Imaging Reporting and Data System (BI-RADS) classification. Prospective multicenter studies of GI-RADS were published in 2011 and 2017, respectively **(91)**. These studies found GI-RADS to be effective at identifying the malignant risk of adnexal masses.

The GI-RADS is based on subjective characterization of the adnexal images, by a trained operator, In contrast to the IOTA models, GI-RADS does not involve objective criteria for AM evaluation and depends on the subjective assessment of the sonographer **(92)**.

Table (4): The Gynecology Imaging Reporting and Data System (GI-RADS) classification system for adnexal masses *(93)*.

GI-RADS Grade	Diagnosis	Est. prob. malignancy	Detail
1	Definitive benign	0%	Normal ovaries identified and no adnexal mass seen
2	Very probably benign	<1%	Adnexal lesions thought to be of functional origin, e.g. follicles, corpora lutea, hemorrhagic cysts
3	Probably benign	1–4%	Neoplastic adnexal lesions thought to be benign, such as endometrioma, teratoma, simple cyst, hydrosalpinx, paraovarian cyst, peritoneal pseudocyst, pedunculated myoma, or findings suggestive of pelvic inflammatory disease
4	Probably malignant	5–20%	Any adnexal lesion not included in GI-RADS 1–3 and with one or two findings suggestive of malignancy
5	Very probably malignant	>20%	Adnexal masses with three or more findings suggestive of malignancy

The morphological features suspicious of malignancy include:

a- Thick wall and septae.
b- Solid papillary projection.
c- Solid areas.
d- The presence of ascites.
e- Central blood flow. **(75).**

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