Role of MRI in usual and unusual female pelvic pathologies with usual presentations and their histopathological correlation: case based review

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Learning objectives

Role of MRI

1-To diagnose, characterize and stage the usual and unusual female pelvic pathologies undiagnosed by other imaging modalities.

2-To evaluate the utility of various available protocols and techniques with their modifications in further diagnostic accuracy and decision making.

Background

MR imaging is a useful non invasive tool for demonstrating anatomy and pathology of female pelvis. The aim was to assess the applications of current state-of-art MR imaging in the diagnosis and management of female pelvic pathologies.

Scope of various modalities in pelvic imaging are:

• Hysterosalpingography - luminal evaluation and tubal patency only
• CT - Limited tissue characterization, excellent bony details, good for detection of the peritoneal deposits.
• USG - modality of choice for primary evaluation.

Ultrasound is the first imaging modality of choice for the female pelvis.

Advantages are:

1. It is widely available with broad acceptance by patients as a "familiar test," and is relatively inexpensive.
2. Real time assessment of pelvic structures.
3. Doppler ultrasound helps in assessing blood flow in pelvic vasculature & pelvic masses.
4. Good tool for guiding minimally invasive procedures such as aspirations and biopsies.

However, there are some shortcomings with this modality, such as:

1. Dependence on the skill and experience of the operator.
2. Limited field of view.
3. Inherent limitations dependent on patient size.
4. Ultrasound waves are disrupted by bowel gas.
5. Less accurate assessment of parametrial spread and hence staging.
The dilemma for referring physicians and general radiologists is to decide when it is justifiable to refer patients for MRI.\(^2\)

Ultrasound remains the initial modality of choice for patients with suspected leiomyomas. However it is neither as sensitive nor as specific as MRI especially in cases of large masses whose organ of origin cannot be reliably assessed by ultrasound due to limited field of view. In addition, ultrasound may not be able to differentiate leiomyomas from adnexal masses or adenomyosis. **MRI is the most accurate imaging modality for detection and localization of leiomyomas**\(^3\).

USG can be used as a screening modality for detection of pelvic malignancies; however it is inadequate in staging. **MRI is an important tool for accurate staging in cases of cervical, endometrial & ovarian malignancies and plan management accordingly.** It can also aid in **differentiating recurrence/residual from post-operative scarring**.\(^4\)

The major contribution of MRI in evaluating pelvic pathologies lies in its ability to **determine whether a mass is truly ovarian** in origin and to accurately identify certain benign entities e.g. dermoid cyst, endometriomas, hemorrhagic cysts and fibromas. It precisely defines the internal architecture of ovarian masses. Contrast enhancement, FAST imaging, fat suppression, diffusion weighted imaging, dynamic contrast study and angiography have all been reported to improve the sensitivity and accuracy of MR imaging.

Miscellaneous pelvic pathologies that create a diagnostic dilemma can be optimally diagnosed by MRI which include teratoma, broad ligament fibroid, adenomyosis and chocolate cyst.

Thus MRI has an established role in the pre and post-procedural assessment for uterine artery embolization, diagnosis of adenomyosis, staging of known endometrial and cervical carcinoma, evaluation of suspected müllerian ductal anomalies, and pre-surgical workup for uterine prolapse.

Hence, MRI is being increasingly used to evaluate various female pelvic pathologies due to:

1. Lack of ionizing radiation and iodinated contrast material.
2. High contrast resolution with complete view of entire pelvis.
3. Multiplanar imaging capabilities.
4. Good tissue characterization.
5. Ability to differentiate between recurrence/residual from post-operative scarring in pelvic malignancies.

**MRI is often used as a problem-solving tool in patients where ultrasound is inconclusive or sub-optimal.**\(^5\) Thorough knowledge of the spectrum of MR imaging features of various physiologic variations and pathologic conditions that affect the
female pelvis is essential for establishing an accurate diagnosis and guiding further management.

**Findings and procedure details**

75 patients were studied by using Philips Achieva 1.5 Tesla MRI machine for 1 year from oct 2012 to oct 2013. (MR imaging was performed by taking axial, sagittal and coronal T2-weighted, axial and sagittal T1-weighted and fat-suppressed T1 weighted images in axial plane. Post gadolinium (dose 0.1mmol/kg) enhanced MRI was performed in axial, coronal and sagittal planes in selected cases depending on clinical suspicion and patient’s affordability. Images are acquired with high spatial resolution and small field of view with slice thickness of 3-5 mm.)

**Distribution of pathologies in study (table 1)**

**TABLE 1 - DISTRIBUTION OF PATHOLOGIES**

<table>
<thead>
<tr>
<th>Pathology</th>
<th>Number of patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uterocervical pathology</td>
<td>45</td>
<td>60.0</td>
</tr>
<tr>
<td>Adnexal pathology</td>
<td>23</td>
<td>30.67</td>
</tr>
<tr>
<td>Vaginal pathology</td>
<td>5</td>
<td>6.67</td>
</tr>
<tr>
<td>Bladder pathology</td>
<td>2</td>
<td>2.67</td>
</tr>
<tr>
<td>Rectal pathology</td>
<td>1</td>
<td>1.33</td>
</tr>
<tr>
<td>Peritoneal and retroperitoneal pathology</td>
<td>7</td>
<td>9.33</td>
</tr>
</tbody>
</table>

Eight patients had multiple lesions affecting more than one sub site.

Most common site in the study was utero-cervical region followed by adnexa.

**CLASSIFICATION OF PELVIC PATHOLOGIES (Fig. 1)**

**MRI APPEARANCES OF PELVIC PATHOLOGIES**

Congenital anomalies (Fig. 7, Fig. 8)
Uterovaginal anomalies are caused by alterations in development or fusion of the müllerian ducts. In the general population, the prevalence of uterine anomalies is 0.5% and of vaginal anomalies is 0.025%. The following parameters are recorded in MR images: uterine size, external fundal contour, intercornual distance, zonal anatomy, and presence of uterine or vaginal septa.

Mullerian duct anomalies are classified according to the system established by the American Fertility Society.

Table: Mullerian duct anomalies and their MRI criteria:

<table>
<thead>
<tr>
<th>DIAGNOSIS</th>
<th>MRI CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORMAL UTERUS AND VAGINA</td>
<td></td>
</tr>
<tr>
<td>Fundus</td>
<td>Convex</td>
</tr>
<tr>
<td>Uterine body</td>
<td>Mean endometrial-myometrial width ratio=1:3.6, no septum</td>
</tr>
<tr>
<td>Cervix</td>
<td>Single cervix, body-cervix ratio=3:2-3:1, patent endocervical canal</td>
</tr>
<tr>
<td>Vagina</td>
<td>Single</td>
</tr>
<tr>
<td>CLASS I (AGENESIS)</td>
<td></td>
</tr>
<tr>
<td>Uterine body and fundus</td>
<td>No uterine tissue (agenesis) or uterine tissue but no complete uterus (remnant)</td>
</tr>
<tr>
<td>Endometrium</td>
<td>Endometrial tissue may be present</td>
</tr>
<tr>
<td>Cervix</td>
<td>Absent, distorted, or length &lt;1/3 of uterine body; absent or distorted endocervical canal</td>
</tr>
<tr>
<td>Vagina</td>
<td>Absent or replaced by a thin band of fibrous tissue</td>
</tr>
<tr>
<td>Other</td>
<td>Obstruction may be present</td>
</tr>
<tr>
<td>CLASS II (UNICORNUATE)</td>
<td></td>
</tr>
<tr>
<td>Uterine body and fundus</td>
<td>Elongated banana-shaped, eccentric uterus</td>
</tr>
<tr>
<td></td>
<td>One normal sized horn with normal endometrial-myometrial width ratio</td>
</tr>
</tbody>
</table>
A rudimentary horn may be present, may have endometrial tissue, and may communicate with main canal. Classified according to rudimentary horn as follows: absent rudimentary horn, rudimentary horn present with no endometrial tissue (nonfunctioning), rudimentary horn present with endometrial tissue that communicates with main cavity, and rudimentary horn present with endometrial tissue that does not communicate with main cavity and may obstruct.

Cervix

**CLASS III (DIDELPHYS)**

Uterine body and fundus

Two separate uteri, which can be joined at body; deep

Endometrium

No communication between the endometrial cavities, normal endometrial-myometrial width ratio in each uterus.

Cervix

Normal

Vagina

Longitudinal or oblique vaginal septum always present.

**CLASS IV (BICORNUATE)**

Fundus

Indented; cleft, 1 cm or more deep

Septum

Present, muscular or combined muscular and fibrous

Bicollis; septum to external os; unicollis; septum does not reach external os.

Cervix

Single or divided by a septum.

Vagina

Vaginal septum may be present in some cases.

**CLASS V (SEPTATE)**

Fundus

Convex, Flat, or minimally indented (cleft<1 cm deep)
Morphology of outer fundal contour is key to diagnosis.

**Septum**
- Muscular, fibrous or combined muscular and fibrous
- Complete: septum to external os; partial: incomplete septum that does not reach external os.
- A short septum can be difficult to differentiate from arcuate uterus on MRI. In fact, there may be continuum between these two entities.

**Cervix**
- Single, divided by septum, or double

**Vagina**
- Vaginal septum may be present in some cases.

**CLASS VI (ARCUATE)**
- Fundus: Convex
- Endometrial cavity: Short muscular saddle like thickening of fundal myometrium that indents endometrial cavity
- Cervix: Single

**CLASS VII (DES-RELATED DISORDER)**
- Fundus: Convex
- Endometrial cavity: Single
- Cervix: Single

Note - DES = Diethylstilbestrol.

**Leiomyomas (Fig. 9)**

Uterine leiomyomas, also known as fibroids or myomas, are the most common tumors of the female genital tract. They are found in 40% of women older than 35 years.

Degeneration-including hyaline or myxoid degeneration, calcification, and cystic and red degeneration—is related to a lack of blood supply and is more commonly found in postmenopausal women.
According to their location within the uterus:

1. **Submucosal**
2. **Intramural (interstitial)**
3. **Subserosal** - lateral growth of subserosal myomas may extend between the folds of broad ligament (intra-ligamentous leiomyomas). Parasitic leiomyoma is a pedunculated subserosal fibroid that develops a new blood supply from adjacent structures, usually the omentum, and becomes completely detached from the uterus.

**Variants of Leiomyomas:**

1. **Non-degenerated leiomyomas**- The typical MR appearance is solitary or, more commonly, multiple round, well-circumscribed lesions, often with homogeneously decreased signal intensity relative to myometrium on T2W images.
2. **Cellular leiomyomas**- are composed predominantly of smooth muscle cells. They tend to show homogeneously high signal intensity on T2W images and enhance strongly after intravenous contrast administration.
3. **Degenerated leiomyomas**- leiomyomas with hyaline or calcific degeneration have low signal intensity on T2W, an appearance similar to standard leiomyomas. Myomas with cystic degeneration have high signal intensity on T2W and cystic areas don't enhance. Myomas with myxoid degeneration show very high signal intensity on T2W and enhance minimally on post-contrast scan. Myomas with red degeneration show peripheral or diffuse high signal on T1W and variable signal intensity with or without a low signal intensity rim on T2W images.
4. **Lipoleiomyoma** is an otherwise normal leiomyoma that contains a striking amount of fat. They have high signal intensity on T1W images, with signal loss on fat-suppressed T1W images.

Leiomyomas are best diagnosed with T2W images, and lesions as small as 5 mm can be routinely depicted by MRI. In pedunculated fibroids, passing vessels may be identified within the stalk. Most myomas enhance similar to or less than the surrounding myometrium on contrast-enhanced MRI.

The differential diagnosis of leiomyomas can be adenomyosis, solid adenexal masses and leiomyosarcomas.

**Adenomyosis(Fig 2)**

Adenomyosis is characterized by the presence of ectopic endometrial tissue within the myometrium. It is typically found in multiparous pre- and perimenopausal women. Two types of adenomyosis - the more common diffuse type and the focal type or adenomyoma.
Adenomyosis may result in marked uterine enlargement with a globular contour, but usually only minimal mass effect on the uterine contour or the endometrial cavity is found. On T2W images, thickening of the hypointense junctional zone greater than 12 mm reliably diagnoses adenomyosis. Foci of high signal intensity measuring 2 to 6 mm within the low-signal-intensity areas are seen in 50% of cases on T2W images and represent endometrial cysts, glands, or hemorrhagic foci. Focal adenomyosis or adenomyoma is characterized by uterine enlargement with only mild deformity and ill-defined elliptical or ovoid lesions.

**Differentiating leiomyoma from adenomyosis is important because the therapeutic options differ.** Mass effect; round contour with sharp delineation, often with a pseudocapsule; and perilesional vessels are typical features of uterine fibroids. While adenomyosis have ill defined infiltrating margins, causes minimal mass effect and shows presence of cysts.

<table>
<thead>
<tr>
<th>MRI</th>
<th>Leiomyoma</th>
<th>Adenomyoma</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Most are well defined hypointense lesions, surrounding hyperintense zone</td>
<td>Lesions are poorly marginated hypointense lesions with hyperintense foci within</td>
</tr>
<tr>
<td></td>
<td>Not related to the junctional zone</td>
<td>Abutting the junctional zone with thickening of the junctional zone</td>
</tr>
</tbody>
</table>

**Endometrial Polyps**

Endometrial polyps are benign tumors of the endometrial cavity.

On MRI, polyps display intermediate signal intensity on T1W images and often heterogeneous signal intensity on T2W images. A central fibrous core with low signal intensity and small, well-delineated cysts with very high signal intensity on T2W images are features favoring the diagnosis of endometrial polyps. After intravenous contrast administration the central core exhibits intense enhancement and can be differentiated from intracavitary clots.

**Endometrial carcinoma**

Adenocarcinomas account for 90% of endometrial neoplasm, whereas uterine sarcomas are relatively rare and account for only 2%-6%; the remaining histologic types include adenocarcinoma with squamous cell differentiation and adenosquamous carcinoma.
Endometrial cancer is staged with the International Federation of Gynecology and Obstetrics (FIGO) system, which recently underwent a major revision.

Diffusion-weighted and dynamic multiphase contrast medium-enhanced MR imaging sequences have been shown to improve the accuracy of MR imaging in assessing the depth of myometrial invasion and can be used to assess tumor response to therapy and to differentiate tumor recurrence from post treatment changes.

### 2009 FIGO Staging System for Endometrial Cancer

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA</td>
<td>Tumor confined to uterus, &lt;50% myometrial invasion</td>
</tr>
<tr>
<td>IB</td>
<td>Tumor confined to uterus, #50% myometrial invasion</td>
</tr>
<tr>
<td>II</td>
<td>Cervical stromal invasion</td>
</tr>
<tr>
<td>IIIA</td>
<td>Tumor invasion into serosa or adnexa</td>
</tr>
<tr>
<td>IIIB</td>
<td>Vaginal or parametrial involvement</td>
</tr>
<tr>
<td>IIIC1</td>
<td>Pelvic node involvement</td>
</tr>
<tr>
<td>IIIC2</td>
<td>Paraaortic node involvement</td>
</tr>
<tr>
<td>IVA</td>
<td>Tumor invasion into bladder or bowel mucosa</td>
</tr>
<tr>
<td>IVB</td>
<td>Distant metastases (including abdominal metastases) or inguinal lymph node involvement</td>
</tr>
</tbody>
</table>

Imaging features - endometrial carcinoma is usually isointense relative to the normal endometrium on T1W images and hypointense relative to endometrium on T2W images. On dynamic multiphase contrast-enhanced T1W images, endometrial tumours demonstrate mild homogeneous enhancement that is slower and less avid than that in the adjacent myometrium. At 50-120 seconds after intravenous administration of gadolinium contrast material, the myometrium demonstrates maximal enhancement compared with the relatively low signal intensity of endometrial tumors.

At conventional MR imaging, the depth of myometrial invasion is optimally depicted with T2W sequences.

**Carcinoma Cervix**\(^{(13)}\) (Fig.10)
The International Federation of Gynecology and Obstetrics (FIGO) staging system is widely used for treatment planning but more often for standardization of epidemiologic and treatment results.

Imaging Findings- Cervical carcinoma has intermediate signal intensity at T2W imaging and is seen disrupting the low-signal-intensity fibrous stroma. The tumor can demonstrate a wide variety of morphologic features and may be exophytic, infiltrating, or endocervical with a barrel shape. The bulk of the lesion is centered at the level of the cervix, with either protrusion into the vagina or invasion of the lower myometrium. Small tumors may be more readily identified by their early enhancement after dynamic injection of gadopentetate dimeglumine.

Disruption of the hypointense vaginal wall with hyperintense thickening at T2W imaging and contrast material enhancement at T1W imaging are signs of vaginal invasion.

Preservation of a hypointense fibrous stromal ring at T2W MR imaging has a high negative predictive value for parametrial invasion. Complete disruptions of the ring with nodular or irregular tumor signal intensity extending into the parametrium are reliable signs of invasion.

Tumor extending to involve the internal obturator, piriform, or levator ani muscles, with or without a dilated ureter, indicates pelvic wall invasion. Ureteral obstruction at the level of the tumor is considered to be an indication of wall invasion.

Bladder or rectal invasion is present when disruption of their normal hypointense walls is seen at T2W imaging, with or without a mass protruding into the lumen. Dynamic gadolinium-enhanced T1W sequences are helpful for confirming invasion and identifying fistulous tracts.

Lymph Nodes:

Lymph node disease detection is based only on a size criterion, the most widely accepted being a transverse diameter exceeding 10 mm. Lymph nodes are best detected with T2W imaging, at which they demonstrate intermediate signal intensity and are well differentiated from the hypointense muscles and blood vessels.

### Correlation between FIGO Staging and MR Imaging Staging.(Fig 3)

<table>
<thead>
<tr>
<th>FIGO Staging</th>
<th>MR Imaging Staging</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Carcinoma in situ</td>
</tr>
<tr>
<td></td>
<td>Not visible</td>
</tr>
<tr>
<td>I</td>
<td>Confined to cervix</td>
</tr>
<tr>
<td></td>
<td>IA Microscopic</td>
</tr>
</tbody>
</table>
IA-1 Stromal invasion <3 mm  No tumor visible
IA-2 >3 mm, <5-mm invasion, <7-mm width  Small enhancing tumor may be seen
IB Clinically visible (>5 mm)  Tumor visible, intact stromal ring surrounding tumor

IB-1 <4 cm  …
IB-2 >4 cm  …

II  Extends beyond uterus but not to pelvic wall or lower one-third of vagina

IIA Vaginal extension, no parametrial invasion  Disruption of low-signal-intensity vaginal wall (upper two-thirds)

IIB Parametrial invasion  Complete disruption of stromal ring with tumor extending into the parametrium

III  Extension to lower one-third of vagina or pelvic wall invasion with hydronephrosis

IIIA Extension to lower one-third of vagina  Invasion of lower one-third of vagina

IIBB Pelvic wall invasion with hydronephrosis  Extension to pelvic muscles or dilated ureter

IV  Located outside true pelvis

IVA Bladder or rectal mucosa  Loss of low signal intensity in bladder or rectal wall

IVB Distant metastasis  …

GESTATIONAL TROPHOBLASTIC DISEASE

Characterized by abnormal proliferation of trophoblastic tissue. It encompasses a spectrum from hydatiform mole, invasive mole to choriocarcinoma. Presence and course of disease can be monitored with HCG levels.
1. Hydatiform mole appears as heterogenous mass of high signal intensity distending the endometrial cavity. Numerous cystic spaces may be seen.
2. Invasive mole is locally invasive and rarely metastasizes.
3. Choriocarcinoma- arises from hydatiform mole in approximately half of cases but may also develop after normal birth or abortion. There is diffuse enlargement of the uterus with presence of an ill-defined mass composed of necrosis and hemorrhage. On MRI it often displays very high signal intensity on T2W images owing to its cystic architecture.

**BENIGN ADNEXAL LESIONS (Fig. 4)**

**Physiological ovarian cysts**

Ovarian cysts under 3 cm are regarded as physiologic cysts. They include follicles of various stages of development, corpus luteum cysts, and surface inclusion cysts. Most cysts display intermediate to low signal intensity on T1W images, and very high signal intensity on T2W images with thin hypointense wall. Hemorrhagic ovarian cysts and corpus luteum cysts tend to display a high SI on T1 and intermediate to high SI on T2W images. Corpus luteum cysts tend to have thicker walls than follicle cysts, with distinct enhancement.

**Paraovarian Cysts**

Paraovarian cysts (paratubal) cysts arise from Wolffian duct remnants in the mesovarium. Paraovarian cysts tend to be large thin-walled unilocular cysts, located typically within the broad ligament. Rarely they may contain internal septations. On MRI, they display typical criteria of ovarian cysts, but are found separate from the ipsilateral ovary.

**Peritoneal Inclusion Cysts**

Peritoneal inclusion cysts (pseudocysts) are accumulations of uid produced by the ovaries that become entrapped by peritoneal adhesions. These lesions are typically encountered in patients with previous surgery.

On MRI, peritoneal inclusion cysts appear as unilocular or multilocular cystic lesions. They have irregular contours that are defined by surrounding structures. A finding highly suggestive of peritoneal inclusion cyst is a cystic adnexal mass that contains the ovary in the centre or the periphery of the lesion. In most cases they contain fluid with low signal intensity on T1W images and very high signal intensity on T2W images.

**Polycystic Ovary Syndrome**
Polycystic ovary syndrome (PCOS), also known as Stein-Leventhal syndrome, is a complex endocrinologic disorder characterized by hyperandrogenism and chronic anovulation. The classic triad of amenorrhea, hirsutism, and obesity is found in only half of patients. MRI is used as a complement to US to confirm the diagnosis of PCOS or to exclude a virilizing ovarian tumor.

The imaging findings in PCOS include bilateral moderately enlarged (up to 5 cm) spherical ovaries with an abnormally high number of peripherally distributed follicles. At least ten follicles ranging between 2 and 8 mm in size encircle the abnormally hypointense central stroma.

**FIGURE: MR IMAGING OF THE SONOGRAPHICALLY INDETERMINATE ADENEXAL MASS**

**MR criteria indicative of benignity:**
- Dimensions less than 4 cm
- Entirely cystic structure
- Thick walls (greater than 3 mm)
- Absence of internal septations or mural nodules
- Absence of ascites, lymphadenopathies and peritoneal carcinosis.

**MR signs suggestive of malignancy:**
- Dimensions greater than 4 cm
- Thick walls (greater than 3 mm)
- Septations
- Solid lobulated mass
- Mixed structure (cystic and solid)
- Intralusalional circles
- Psammomatous calcifications
- Mural nodules or solid components in cystic lesions
- Necrosis within solid components (most predictive element)
- Peritoneal carcinoma
- Lymphadenopathies
- Ascites (particularly if abundant and/or sparing of the recto uterine pouch)
**Endometriosis**

Endometriosis, which is defined as the presence of ectopic endometrial glands and stroma outside the uterus, is a common cause of pelvic pain and infertility, affecting as many as 10% of premenopausal women.

The three hallmarks of endometriosis are:

- peritoneal endometrial implants
- endometriomas (endometriotic cysts)
- Adhesions.

The most common peritoneal sites of involvement (in decreasing order of frequency) are the ovaries, uterine ligaments, cul-de-sac, and pelvic peritoneum reflected over the uterus, fallopian tubes, recto sigmoid, and bladder. Rare extra peritoneal sites include the lungs and the central nervous system.

**Imaging features:**

Endometriomas ("chocolate cysts") of the ovary contain dark gelatinous material surrounded by a fibrous wall of variable thickness. Endometriomas are usually multiple and bilateral.\(^{18}\)

They are characteristically homogeneous hyperintense on T1W sequences with relatively low signal intensity on T2W sequences (T2-shading effect). This loss of signal intensity on the T2W sequences is caused by high concentrations of intracystic methemoglobin and other protein or iron products. Some lesions are heterogeneous in signal intensity because the blood products are in various stages of degradation from multiple episodes of bleeding.

Deep endometriotic lesions are found at vesicouterine pouch, vesicovaginal septum, bladder, uterine ligaments, vaginal fornices, retrocervical area, pouch of Douglas, rectovaginal septum and recto sigmoid junction.

**Pelvic Inflammatory Disease**

Pelvic inflammatory disease (PID) represents a spectrum of acute to chronic inflammatory conditions of the upper genital tract, including the endometrium, ovaries, and fallopian tubes; it commonly involves the adjacent pelvic peritoneum as well.

MRI may show mildly enlarged and inhomogeneously enhancing ovaries. Haziness of the pelvic fat, periovarian stranding, and enhancement of the adjacent peritoneum are common associated findings.\(^{19}\) Inhomogeneous high signal intensity on T2W images and wall enhancement on MRI support the diagnosis of inflammatory changes.

**Tubo-ovarian Abscess**
The vast majority of tubo-ovarian abscesses (TOAs) result from complications of PID.

On imaging, a unilateral or bilateral, unilocular or, more frequently, multilocular thick-walled adnexal lesion accompanied by tubal dilation is the typical finding of TOA. The fluid within the abscess has variable signal intensity but usually exhibits low to intermediate signal intensity on T1W images and very high signal intensity on T2W images. On post contrast study there is enhancement of the fallopian tube due to pyosalpinx, of the abscess wall, and of adjacent tissues due to peritonitis.

**Ovarian tumors**

Ovarian tumors are classified as epithelial tumors, germ cell tumors, sex cord-stromal cell tumors, and metastatic tumors on the basis of tumor origin.

**Benign Ovarian Tumors**

**Mature Cystic Teratoma**

Dermoid cysts, also known as mature cystic teratomas or dermoids, are benign germ cell tumors that account for the most common ovarian neoplasm in women of reproductive age and may be bilateral in approximately 10% to 25% of cases.

The specific MRI feature of a dermoid is fat within a cystic, often unilocular, encapsulated ovarian lesion.\(^{20}\) Fat demonstrates high signal intensity on T1W images, Frequency-selective fat saturation must be used to differentiate fat from hemorrhagic contents. The use of short tau inversion recovery (STIR) imaging is not recommended because signal suppression may be observed in endometriomas as well.\(^{85}\) Chemical shift imaging may assist in the depiction of microscopic foci of fat in the cyst wall or dermoid plug.

**Cystadenoma (Fig.11)**

Cystadenomas account for the majority of epithelial ovarian tumors. Cystadenomas present as thin-walled, unilocular or multilocular cystic lesions filled with serous, mucinous, and sometimes hemorrhagic contents. Cystadenomas appear as cystic ovarian masses with thin, regular walls; thin, enhancing septations (<3mm) may be present.\(^ {21}\) Serous cystadenomas tend to present as unilocular or bilocular cystic tumors. Signal intensity on T1 are similar to that of water, with very high signal intensity on T2W images.\(^ {21}\) Mucinous cystadenomas are often large (>10cm) at diagnosis and may fill the pelvis and abdomen. In contrast to serous cystadenomas, mucinous cystadenomas often present as multilocular cystic lesions with varying contents on T1W and T2W images.\(^ {21}\)

**Fibroma and Fibrothecoma**

Fibromas, fibrothecomas, and thecomas are benign tumors of stromal origin and constitute 3% to 4% of all ovarian tumors.
On MRI, Fibromas and fibrothecomas are well-circumscribed solid ovarian tumors with low to intermediate signal intensity on T1W images and very low signal intensity on T2W images and show mild or delayed contrast enhancement on MRI.22

**MALIGNANT OVARIAN TUMOURS**

Ovarian cancer can be categorized as surface epithelial neoplasms (epithelial carcinomas), germ cell tumors, sex cord-stromal neoplasms, and lymphoma. The vast majority (86%) of these tumors arise from the surface epithelium.

**Epithelial Ovarian Cancer** 6

The incidence of ovarian cancer rises continuously between the ages 30 and 70 years and peaks at age 59 years. Histologically, ovarian cancer can be categorized as serous cystadenocarcinoma cancer (40% to 65%); mucinous cancer (10%), endometrioid cancer (10%), and clear cell cancer (5%); malignant Brenner tumor (2%); and undifferentiated cancers (5% to 10%).

**Imaging Findings:**

Findings that strongly support the diagnosis of ovarian cancer include a unilateral or bilateral solid and cystic ovarian mass. Other typical features of ovarian cancer are a multiloculated lesion with thick (>3 mm), sometimes irregular enhancing septations; enhancing solid, nonfibrous components; and papillary excrescences. Cystic components within the tumor may contain serous, hemorrhagic, or mucinous fluid, which is best characterized on T2W images. Secondary signs supporting the diagnosis of metastatic spread are ascites, peritoneal implants, or lymph node enlargement.23 It is impossible to differentiate the subtypes of ovarian cancer by imaging, but serous cancers are commonly bilateral and may contain calcifications.

**Modified International Federation of Gynecology and Obstetrics (FIGO) Staging of Ovarian Cancer by CT and MRI**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Imaging Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Tumor limited to the ovaries</td>
</tr>
<tr>
<td>IA</td>
<td>Limited to one ovary, no ascites</td>
</tr>
<tr>
<td>IB</td>
<td>Limited to both ovaries, no ascites</td>
</tr>
<tr>
<td>IC</td>
<td>Stage IA or IB with ascites</td>
</tr>
<tr>
<td>II</td>
<td>Tumor involving one or both ovaries, with pelvic extension</td>
</tr>
<tr>
<td>IIA</td>
<td>Extension or metastases to the uterus or fallopian tubes</td>
</tr>
<tr>
<td>Stage</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
<td>-------------</td>
</tr>
<tr>
<td>IIB</td>
<td>Extension to other pelvic tissues</td>
</tr>
<tr>
<td>IIC</td>
<td>Stage IIA or IIB with ascites</td>
</tr>
<tr>
<td>III</td>
<td>Tumor involving one or both ovaries, peritoneal implants outside the pelvis, or implants in retroperitoneal or inguinal lymph nodes</td>
</tr>
<tr>
<td>IIIA</td>
<td>Tumor grossly limited to the true pelvis, large volume of ascites</td>
</tr>
<tr>
<td>IIIB</td>
<td>#2 cm implants in abdominal peritoneal surfaces</td>
</tr>
<tr>
<td>IIIC</td>
<td>&gt;2 cm implants in abdominal peritoneal surface or retroperitoneal or inguinal lymph nodes</td>
</tr>
<tr>
<td>IV</td>
<td>Growth involving one or both ovaries, distant metastases, parenchymal liver metastases, pleural effusion with positive cytology</td>
</tr>
</tbody>
</table>

Uterine invasion is suggested by distortion or irregularity between the interface of the tumor and the myometrium. Invasion of bowel or bladder may be suggested by loss of the tissue plane between the solid components of the tumor, encasement, or localized wall thickening. A distance less than 3 mm between the ovarian mass and the muscular pelvic sidewall or displacement or encasement of the iliac vessels is highly suggestive of pelvic side wall invasion.

**Sex Cord-Stromal Tumors**

**Granulosa cell tumor**

Granulosa cell tumor of the ovary is the most common malignant sex cord-stromal tumor as well as the most common estrogen-producing ovarian tumor. Two types - Adult (most common) and juvenile.

Ovarian granulosa cell tumors vary widely and range from solid masses, to tumors with varying degrees of hemorrhagic or fibrotic changes, to multilocular cystic lesions, to completely cystic tumors. Estrogenic effects on the uterus may manifest as uterine enlargement or as endometrial thickening or hemorrhage.

**Sertoli - Leydig cell tumor**

Sertoli-Leydig cell tumors occur in young women (<30 years of age) and are considered to be a low-grade malignancy. These tumors constitute 0.5% of ovarian tumors and are
the most common virilizing tumor. Signal intensity at MR imaging reflects the extent of fibrous stroma.6

**Dysgerminoma**

Dysgerminomas are the most common malignant germ cell subtype. They typically occur in children and young women, with 80% of those affected being younger than 30 years.

On MRI, dysgerminomas typically present as unilateral, multilobulated, well-delineated solid masses. On MRI, they exhibit low signal intensity on T1-weighted images and intermediate signal on T2-weighted images. Strongly enhancing internal fibrovascular septations and central areas of necrosis or hemorrhage may be seen.24

**Ovarian Lymphoma**

Lymphoma affecting the ovary is most often a manifestation of generalized disease, particularly B-cell lymphomas. Primary lymphoma of the ovary is extremely rare, with Burkitt’s lymphoma being the most common type.

On imaging, ovarian lymphomas appear as unilateral or, more commonly, bilateral solid, mildly enhancing, homogeneous masses without ascites, necrosis, or calcifications. On MRI, ovarian lymphoma exhibits intermediate signal intensity on T1W images and low to intermediate signal intensity on T2W images.25

**Metastases to the Ovaries**23

Approximately 5% to 15% of malignant ovarian tumors are metastases. Stomach, colon, breast, and lung cancers are the most common neoplasms that metastasize to the ovaries. Bilateral involvement is a typical feature, occurring in up to 75% of cases of ovarian metastasis.

On imaging, two types of ovarian metastases can be differentiated. Krukenberg’s tumors display characteristic imaging features, including bilateral oval, often lobulated tumors that tend to preserve the contour of the ovary. They are solid or predominantly solid with central necrosis or cysts.

On MRI they display medium signal intensity on T1-weighted images and an inhomogeneous low to intermediate signal intensity on T2-weighted images.23 On CT and MRI they tend to show strong contrast enhancement of solid components or septations. Imaging findings in non-Krukenberg ovarian metastases may be similar to those in primary ovarian cancer, making definitive differentiation impossible.23

**Vaginal pathologies**
Vaginal septum:

It is a type of vertical fusional defect. It can occur at almost any level of the vagina commonly at the level of superior and mid vagina. Transverse vaginal septum be either perforate (incomplete) or imperforate (complete) and results from varying degrees of failure in reabsorption of the tissue between the vaginal plate and the caudal aspect of the fused mullerian ducts.

MRI is useful to depict pelvic anatomy and thickness of septum.

Vesicovaginal fistula (Fig. 12)

Abnormal fistulous connection between bladder and vagina. It can be due to obstructed/prolonged labor, surgery, radiotherapy, pelvic malignancy and uterine rupture.

Vaginal carcinoma:

It arises from the posterior wall of the upper third of the vagina most often as an ulcerating or fungating mass or an annular constricting lesion with squamous cell carcinoma of the vagina as the most common histological subtype. On MRI they are of low signal intensity on T1W and intermediate to high signal intensity on T2W images.

Staging of vaginal carcinoma.  

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Cancer is found in the vaginal wall only.</td>
</tr>
<tr>
<td>II</td>
<td>Cancer has spread through the wall of the vagina to the tissue around the vagina. Cancer has not spread to the wall of the pelvis.</td>
</tr>
<tr>
<td>III</td>
<td>Cancer has spread to the wall of the pelvis.</td>
</tr>
<tr>
<td>IV A</td>
<td>Cancer may have spread to one or more of the following areas:</td>
</tr>
<tr>
<td></td>
<td>- The lining of the bladder.</td>
</tr>
<tr>
<td></td>
<td>- The lining of the rectum.</td>
</tr>
<tr>
<td></td>
<td>- Beyond the area of the pelvis that has the bladder, uterus, ovaries, and cervix.</td>
</tr>
</tbody>
</table>
Stage IVB
Cancer has spread to parts of the body that are not near the vagina, such as the lung or bone.

**Botryro Rhabdomyosarcoma:**

Rhabdomyosarcoma is the most common tumor of the lower genitourinary tract in children in the first 2 decades of life. Most cases of genitourinary rhabdomyosarcoma are of the embryonal histologic subtype and include tumors of the bladder, prostate, testes and paratesticular sites, penis, perineum, vagina, and uterus. The botryoid variant of embryonal rhabdomyosarcoma results when submucosal tumor produces a polypoid mass resembling a cluster of grapes within a hollow structure. Invasion of adjacent structures by the primary tumor may make the precise anatomic origin of genitourinary rhabdomyosarcoma difficult to determine on cross-sectional images.¹²

**BLADDER AND RECTAL PATHOLOGY**

**Transitional cell carcinoma**

Transitional cell carcinoma is the most common primary bladder malignancy and accounts for 85% of all bladder malignancies. In women, it rarely invades the uterus or cervix. Invasion of the ureters or urethra is common when the tumor originates near one of these structures.

**Rectal carcinoma**

Rectal carcinoma occurs in persons older than 50 years. Majority are adenocarcinoma though squamous cell carcinoma can also occur.

**Imaging features**

On MRI, a colorectal cancer appears as a discrete mass or short-segmental wall thickening. Asymmetrical wall thickening of the colon with or without an irregular surface suggests a neoplastic process. The tumor appears of low signal intensity on T1W images and high signal intensity on T2W images. Histologic subtypes of colorectal cancer are generally indistinguishable on CT or MRI. Staging of rectal cancers by MRI is largely based on differences in T2 signal intensity between the tumor and the rectal wall and/or peri rectal fat. The tumor itself has an intermediate signal intensity between the high signal intensity of the submucosa or peri rectal fat tissue and the low signal intensity of the muscular layer.

**Other peritoneal and retroperitoneal pathologies:**
Germ Cell Tumours - A variety of germ cell tumors occur in the sacrococcygeal region in infants and children. The benign sacrococcygeal teratoma is the most common solid tumor in neonates.

Role of imaging is to help confirm the diagnosis, depict intrapelvic extension and relationship to other structures, revealing the tissue characteristics and to detect the metastatic disease.

Classification:

- seminoma
- non-seminomatous germ cell tumours (NSGCT)
  - embryonal cell carcinoma
  - choriocarcinoma
  - yolk sac tumour
  - teratoma
  - mixed germ cell tumour

Sacrococcygeal teratoma - The 4 morphological types are as follows:

- Type I: Developing only outside the pelvis (can have small pre-sacral component); accounts for the majority of cases: 47%.
- Type II: Extra-fetal with intra-pelvic pre-sacral extension
- Type III: Extra-fetal with abdomino-pelvic extension
- Type IV: Tumour developing completely in the pelvis

Table: Clinical and radiologic findings of benign and malignant sacrococcygeal germ cell tumors:

<table>
<thead>
<tr>
<th></th>
<th>Benign</th>
<th>Malignant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>Neonate</td>
<td>&gt;1y</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td><strong>Morphologic characteristic</strong></td>
<td>External (type I)</td>
<td>Large, internal component (types II-IV), invasion of adjacent structures</td>
</tr>
<tr>
<td><strong>Composition</strong></td>
<td>Cystic, fatty, calcified</td>
<td>Solid, necrotic</td>
</tr>
</tbody>
</table>

Mesenteric cyst (Fig. 6)

Mesenteric cyst are part of a spectrum that includes any mesenteric or omental cyst, which includes mesothelial cyst, lymphangioma, nonpancreatic pseudocyst, neuroteric cyst and mesothelial cyst.
Sacral masses - primary benign and malignant tumors of the scarum are rare lesions accounting for <7% of all the intra spinal tumors. Metastasis, myeloma and lymphoma are far more common then primary tumors. 29

Table - Dominating features of primary sacral tumors

<table>
<thead>
<tr>
<th>Tumors</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giant cell tumor</td>
<td>Frequently eccentric abutting or extending across the sacro iliac joint.</td>
</tr>
<tr>
<td></td>
<td>Purely lytic destructive lesion with absence of matrix calcifications and septations.</td>
</tr>
<tr>
<td></td>
<td>Frequently heterogeneous with because of necrosis, hemorrhage and cystic spaces.</td>
</tr>
<tr>
<td></td>
<td>Low signal intensity is frequently noted on T2W images due to high hemorrhagic and fibrotic content.</td>
</tr>
<tr>
<td>Aneurysmal bone Cyst</td>
<td>Osteolytic expansile lesion surrounded by thin shell of bone. There are multiple fluid-fluid levels noted reflecting hemorrhage with sedimentation.</td>
</tr>
<tr>
<td>Chordoma</td>
<td>Most common primary malignant sacral tumor.</td>
</tr>
<tr>
<td></td>
<td>Large lytic lesion centered in midline with associated soft tissue mass. Calcification seen In 30-70% pateints. They are iso to slightly hypointense on T1W and hyperintense on T2W due to intratumoral accumulation of mucin.</td>
</tr>
<tr>
<td>Chondrosarcoma</td>
<td>Large destructive lesion with chondroid type of matrix mineralization.</td>
</tr>
<tr>
<td>Hemangiomas</td>
<td>Most osseous hemangiomas have coarse vertical or radiating trabecular thickening.</td>
</tr>
</tbody>
</table>

In our study sensitivity and specificity of MRI for benign pathologies were 89.36 % and 96.42 % respectively.

For malignant pathologies sensitivity and specificity were 96% and 36% respectively.
### CLASSIFICATION OF GENITAL TRACT PATHOLOGIES

<table>
<thead>
<tr>
<th>VAGINAL PATHOLOGY</th>
<th>UTERINE PATHOLOGY</th>
<th>CERVICAL PATHOLOGY</th>
<th>ADNEKAL PATHOLOGY</th>
<th>RECTAL PATHOLOGY</th>
<th>PELVIC PERITONEAL AND RETROPERITONEAL PATHOLOGIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congenital malformations&lt;br&gt;Cysts - Bartholin’s gland cyst, Gardner’s duct cyst, Retention cysts, Epidermal inclusion cysts&lt;br&gt;Endometriosis&lt;br&gt;Benign tumours - fibroepithelial polyp, Leiomyoma, Lipoma, Malignant tumours - squamous cell carcinoma, adenocarcinoma&lt;br&gt;Metastasis, Vaginal carcinoma, Embryonal rhabdomyosarcoma.</td>
<td>Congenital malformations&lt;br&gt;Congenital abnormalities of uterus (Mullerian duct anomalies)&lt;br&gt;Benign lesions - Leiomysarcoma, Adenomyosis&lt;br&gt;Malignant lesions - Endometrial carcinoma, Sarcoma-leiomyosarcoma, endometrial stromal sarcoma, fibrosarcoma, liposarcoma, rhabdomyosarcoma, Choriocarcinoma.</td>
<td>Congenital malformations&lt;br&gt;Benign lesions - Nabothisian cyst, Polyp&lt;br&gt;Leiomyoma, Cervicitis&lt;br&gt;Endometriosis&lt;br&gt;Malignant tumour - Cervical carcinoma, Metastasis&lt;br&gt;Malignant melanoma, Lymphoma</td>
<td>Congenital abnormalities&lt;br&gt;Cystic follicular cyst, Luteal celladenoma cyst, Follicle cyst&lt;br&gt;Endometrioid carcinoma, Endometriosis&lt;br&gt;Ovarian teratoma&lt;br&gt;Pelvic inflammatory disease&lt;br&gt;Benign tumours - Serous cystadenoma, mucinous cystadenoma, Brenner tumour, Brenner tumour&lt;br&gt;Endometrial carcinoma, Ovarian carcinoma, Ovarian sarcoma, Ovarian lymphoma, Metastasis</td>
<td>Duplication cysts&lt;br&gt;Ancient rectal malformations&lt;br&gt;Baniglottal carcinomas&lt;br&gt;Polyp, Lipoma, Varices&lt;br&gt;Malignant Tumours - Adenocarcinoma, Squamous cell carcinoma, Gastrointestinal stromal tumours&lt;br&gt;Lymphoma, Metastasis&lt;br&gt;Inflammatory and infectious lesions&lt;br&gt;Crohn's disease, Ulcerative colitis</td>
<td>Abscess, Haematoma, Ectopic pregnancy, Pelvic inflammatory disease, Malignant tumours, Ovarian carcinomas, Metastasis, Surgical and inflammatory lesions, Rectal and sigmoid diverticulitis, Retropertoneal sarcomas, Leiomyosarcoma, Malignant fibrous histiocytoma, Metastasis, Sacral tumours - Chordoma, Giant cell tumour, Angiomyxoma, Bone cyst, Pseudotumours</td>
</tr>
</tbody>
</table>

---

**Fig. 1: CLASSIFICATION OF GENITAL TRACT PATHOLOGIES**
Fig. 2: Adenomyosis- T2W sagittal image reveals marked thickening of the junctional zone with ectopic foci of endometrial glands. Relative absence of mass effect on endometrium and ill defined margins suggest the diagnosis of adenomyosis
Fig. 3: Staging of cervical carcinoma (FIGO)
Fig. 4: MR IMAGING OF THE SONOGRAPHICALLY INDETERMINATE ADENEXAL MASS.
Fig. 5: Morphological types of sacrococcygeal teratoma
Fig. 6: Mesenteric Cystic lesions (types)
Fig. 7: MAYER ROKITANSKY KUSNER HAUSER SYNDROME-T2W sagittal image shows absence of uterus, cervix and upper part of vagina with pelvic kidney
Fig. 8: UTERINE DIDELPHYS
Fig. 9: BROAD LIGAMENT FIBROID-T2W, images reveal large heterogenous mass lesion in between uterus and right ovary abutting and displacing the uterus laterally.
**Fig. 10:** carcinoma cervix- T2W and Post Contrast T1FS shows an ill defined heterogeneously enhancing mass lesion involving the cervix and isthmus with parametrial invasion.
Fig. 11: MUCINOUS CYSTADENOMA- T2W images reveal multiloculated ovarian cystic lesion which appears hyperintense on both sequences.
Fig. 12: POST OPERATIVE VESICO-VAGINAL FISTULA-T2 SPAIR images reveal small defect in the posterior wall of bladder communicating with upper 1/3 rd of vagina.
Conclusion

1. The various sequences viz. T1W, T2W, FAT SAT etc. helped in characterizing the nature of the lesions with great accuracy.
2. MRI due to its excellent soft tissue contrast and multiplanar imaging capacity was extremely valuable in detecting soft tissue extension of pelvic malignancies and in staging.
3. MRI does not involve use of ionizing radiation which is a desirable advantage particularly while imaging females of reproductive age group.
4. MRI was justified if following questions are answered:
   - Whether MRI would help in finding out the origin of mass.
   - Whether the extent of pathology has been accurately assessed.
   - Whether the differentials have been narrowed down due to excellent tissue characterization.
   - Whether associated features have been shown to best possible extent.

   Thus, we can conclude that MRI due to its excellent soft tissue contrast is going to play an important role in diagnosing and characterizing female pelvic pathologies. MRI with its modifications proved to be excellent tool in evaluating female pelvic pathologies especially the lesions which were indeterminate lesion on ultrasound.

Personal information

References


