MRI Female Pelvis: Cervix, Uterus, and Endometrium

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Outline

- Endometrium
- Cervix
- Uterus
- MRI of Pregnant Patients
Endometrium - normal

Normal T2 signal on MR irrespective of age, sagittal T2 sequence a must
Endometrium - menstrual changes
Endometrial polyps

- Focal protrusion of the endometrium
  - Composed of benign endometrial glands and stroma
  - Unresponsive to progesterone stimulation
  - Frequent cystic change of endometrial glands in polyp

- MRI
  - Cystic change within the polyp
  - Central fibrous core (low signal T2W images)
  - +/- stalk of connection with endometrium

Endometrial cancer

- Most common malignancy of the female genital system
  - Risk factors: estrogen stimulation
- Pathology: tumor composed of malignant glandular cells
  - Multiple subtypes: endometroid (most common), clear cell, adenosquamous, papillary serous
Endometrial carcinoma- staging

- FIGO staging
  - **Stage I:** Limited to uterus
    - IA: ≤ 50% myometrial invasion
    - IB: ≥ 50% myometrial invasion
  - **Stage II:** cervical stromal involvement
  - **Stage III:** local/regional spread of disease
    - IIIa (invades through uterine serosa), IIIb (vaginal/parametrial invasion), IIIc (pelvic/para-aortic lymph nodes)
  - **Stage IV:** invasion into adjacent organs (bladder/rectum) and/or distant metastases

Risk of deep pelvic nodes
FIGO 1A: Integrity of sub-endometrial enhancement
FIGO 2: Cervical stromal invasion
FIGO 3A: serosal extension
Endometrial carcinoma: (serous papillary)- metastatic
Endometrial polyps versus cancer

Endometrial carcinoma

Endometrial polyp
Endometrial polyps versus cancer

- Controversies in potential for malignant change
  - 8.5% polyps associated with endometrial carcinoma
- Factors associated with coexistent carcinoma:
  - Symptomology (uterine bleeding)
  - Age (postmenopausal)


Cervix

- Normal Anatomy and signal of cervix
- Parametrium is like interstitium rich in lymphatics
- 3 D T2 volumetric imaging
- Lymph nodes important
Cervix - normal, T2 dark signal
Cervical carcinoma

- FIGO staging (revised 2018)
  - **Stage I**: Confined to cervix
    - IA: invasive carcinoma by microscopy only
    - IB: invasive carcinoma, deepest invasion ≥ 5 mm
  - **Stage II**: beyond the uterus, NOT into the lower 1/3 of vagina or pelvic sidewall
    - IIB: with para metrial involvement
  - **Stage III**: involves the lower 1/3 of the vagina and/or pelvic sidewall and/or hydronephrosis and/or pelvic/para-aortic lymph nodes
  - **Stage IV**: extends beyond true pelvis and/or invasion into adjacent organs (bladder/rectum)

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Non surgical
51 yr F, bleeding: Parametrium
Cervical carcinoma

White: Large, infiltrative tumor replacing the cervix.
Red: Soft tissue extending into the parametrial soft tissues.
Blue: Distended endometrial cavity with blood products and no internal enhancement.
Cervical carcinoma: Necrosis and nodes on contrast images

White: Large, infiltrative enhancing tumor replacing the cervix.
Parametrial extension: Nodal disease evaluation

Axial T2 hi-res
**Benign Uterus:**

- Sagittal T2 weighted sequence is a must.
- Appreciate junctional, myometrium and serosal layers. Layers less distinct in older age group.
- DWI use is limited
Uterine leiomyoma

- Benign tumor of the uterus
  - Extremely common cause of pelvic symptoms
    - Pain, abnormal bleeding.
    - Location of Fibroid
    - Growth (Leiomyomatosi, Leiomyosarcoma)
  - Degeneration on MRI
Uterine leiomyoma - MR Imaging

- Ultrasound frequently used
  - Poorly defined
  - Difficulty in distinguishing fibroids from adenomyosis
- MRI provides optimal evaluation, especially for pre-procedure planning
  - Well-circumscribed uterine lesions
  - T2 hypointense
    - Reflective of muscular component
    - Degeneration evaluation
  - Variable vascularity
Fibroids: T2 imaging is essential, low T2
Fibroids: FIGO classification for sub mucosal

Reporting: Intramural, sub-serosal and intra cavitory fibroid (3 lesions)
IUP, large fibroid: Red degeneration in pregnancy, notice T1 bright signal.
Fibroid embolization

- Effective method of controlling symptoms of uterine fibroids

- **UAE vs myomectomy**
  - Razavi et al (*AJR 2003*) found UAE better at pain and bleeding control, while myomectomy perhaps better at relieving symptoms of mass effect
  - Mara et al (*Cardiovasc Interven Radiol 2008*) - randomized trial, found UAE to have shorter hospital stay and recovery, similar outcome

- **Long term fibroid symptom relief with UAE**
  - 13-15% ultimately go to hysterectomy
Fibroid embolization - Imaging

- Ultrasound versus MRI
  - MRI provides considerably more information than ultrasound regarding fibroid volume, location and characterization
  - Spielmann et al (AJR 2006):
    - MRI changed management decisions in 11/49 (22%) of patients from pre-procedure ultrasound
  - Difficulties in distinguishing between fibroids and adenomyosis
    - ~40% patients with adenomyosis will not have long term symptom relief (treatment failure and/or recurrent symptoms)


Fibroids and adenomyosis: co exist
Adenomyosis - US and MRI
Adenomyosis - focal adenomyoma, notice the tiny T2 signal
Fibroids - post embolization

Pre-embolization

Post-embolization
Fibroid- Hyaline degenerating
Fibroid- degenerating
Degenerating Leiomyoma

- 25 y/o old female presented to ED complaining of urinary retention for one day.
- A,B: Centrally necrotic mass with well defined contour (bold arrow) and peripheral dark T2 signal (short arrow). Note the uterine body displaced posteriorly (long arrow).
- C: Hemorrhage/proteinaceous material (long arrow) within the central necrotic part of the mass.
- D: Enhancement of non-necrotic parts of leiomyoma (long arrow).
Intravascular Leiomyomatosis

- 33 y/o female with history of uterine leiomyoma.
- A,B: A well defined mass with smooth contours (long arrows) and loculated T2 signal representing central foci of necrosis (small arrows).
- C,D: Avid enhancement of the lesion after injection of contrast (long arrow) (D).
Intravascular Leiomyomatosis

Fig: E,F: Extension of tumor into the IVC and ascending up to the level of the right atrium (arrows). Given the extensive and invasive findings of this uterine mass, presumed imaging diagnosis was leiomyosarcoma.
Intravascular Leiomyomatosi

The mass was resected and pathology returned as intravascular leiomyomatosi.
Leiomyosarcoma

- 63 y/o female with initial presentation of pelvic pain.
- A,B: Large invasive mass with heterogeneous and hyperintense T2 signal (long arrows) and extensive areas of necrosis (short arrows). Areas of darker signal show pre-existing uterine leiomyomatas (bold arrow).
- C: Complex peritoneal fluid with proteinaceous content (short arrow).
- D: The tumor shows enhancement (chevron) except for the necrotic portions (short arrow). Note peritoneal (long arrows) and anterior abdominal wall invasion (bold arrow).
Leiomyosarcoma
Leiomyosarcoma, recurrent
Endometrial Stromal Sarcoma

- 66 y/o female with postmenopausal bleeding.
- A,B: Locally aggressive and infiltrative uterine mass. The tumor fills the endometrial cavity and invades the myometrium, demonstrating heterogeneous but predominantly hyperintense T2 signal (long arrows).
- C: High resolution 3D T2 weighted images provide excellent delineation of the local extent of the tumor. The tumor is locally infiltrative through the serosa at the lower uterine segment (bold arrows).
- D: The tumor shows heterogeneous enhancement (short arrows).
MRI of Pregnant Patient

- Include MRI Abdomen and Pelvis
- Non contrast MRI, no need for contrast
- 4 mm cuts are very helpful
- Coronal, Sagittal Single shot T2 and T1 (in and out), T2 FS
MRI abdomen/pelvis safety considerations in pregnant patients

1. Concern with Energy Deposition into the body
   a. static magnetic field
   b. time varying magnetic fields
   c. RF pulses

2. Literature has detailed no causal relationship between fetal development and exposure to non-contrast MRI
MRI abdomen/pelvis safety considerations in pregnant patients

(Tissue Heating)

1. With MRI there is a theoretical concern for heating of the fetus.

2. Energy deposited by RF pulses
   a. SAR units (Watts/kg)
   b. increase in maternal temperature by 2-2.5°C can increase fetal abnormalities
   c. FDA permits 4W/kg » 0.6°C for 30 min MRI

3. SAR increases with magnet strength, high flip angles, ↓TR, ↓RF pulse spacing

4. ACR has no recommendation regarding magnet strength
   a. 3.0 T magnet has 4x SAR exposure for equivalent 1.5 T exam
1. Gadolinium crosses the placenta and is excreted into the amniotic fluid. It is categorized as a class C drug (animal studies show adverse effect).
   a. Increased risk of disassociation
   b. Extended exposure if fetus swallows amniotic fluid

2. Retrospective studies:
   a. 1st trimester
      i. No risk of congenital anomalies
      ii. No risk of NSF
      iii. Increased risk of rheumatoid, inflammatory, and infiltrative skin conditions
   b. 2nd and 3rd trimester
      i. Slightly increased risk of still birth
MRI abdomen/pelvis safety considerations in pregnant patients (Sensorineural Hearing Damage)

1. Fast switching gradients can result in 80 – 120 dB
2. > 90 dB can result in damage to fetal hearing
3. Maternal tissue attenuates by 30 dB
   a. recent retrospective study documented no association with in utero MRI and sensorineural hearing loss
30-year-old pregnant female with acute abdominal pain. Ultrasound showed a viable intrauterine pregnancy with normal Doppler flow to both ovaries.

Figures A - C demonstrates a thickened appendix arising from the cecum. Increased T2 signal/edema is noted within the appendiceal wall. There is also surrounding periappendiceal fluid. Findings are in keeping with appendicitis. A gravid uterus is present.
Companion Case A: 18 yr F, RLQ pain
Companion Case B: Acute Appendicitis in a Pregnant Patient
Acute Right Sided Abdominal Pain
Acute Right Sided Abdominal Pain
Ectopic Pregnancy

- A fertilized ovum implanted outside of the uterus
  - Fallopian tube
  - Interstitial ectopic
  - Ovarian
  - Cervical
  - Cesarean Scar
  - Abdominal

- Differential diagnosis:
  - Ruptured Corpus Luteal Cyst
  - Appendicitis
1. 1.4% of all pregnancies present as an ectopic pregnancy.

2. Classic clinical triad of pelvic pain, vaginal bleeding, and an adnexal mass. Hypovolemic shock may occur if ruptured.

3. 95% of ectopic pregnancies occur in the fallopian tubes. They may also occur in the cervix, myometrium, ovary, or peritoneal cavity (3).
Clinical background of ectopic pregnancies, cont’d.

4. Risk factors for an ectopic pregnancy include: pelvic inflammatory disease, fallopian tube scarring, prior ectopic pregnancy, pelvic surgery, advanced maternal age, endometriosis, salpingitis isthmica nodosa, and IUDs.

5. Differential Diagnosis includes: Incidentally noted adnexal mass, exophytic corpus lutein cyst, and bowel (3).
Ectopic Pregnancy

Imaging features of ectopic pregnancies

1. Positive Beta-hCG (>3000 mIU/mL) without sonographic findings of an intrauterine gestation sac.
2. Heterogeneous adnexal mass with peripheral Doppler flow (“ring of fire”) which is separate and distinct from the ovary.
3. When free fluid is present, a detailed examination should be performed to exclude the presence of hemoperitoneum (3).

Figure A: Ultrasound Images of an ectopic pregnancy

Figure B: Ultrasound images of an ectopic pregnancy
Ectopic Pregnancy (Companion Case A)
Ectopic Pregnancy (Companion Case A)

Sagittal T2w

Coronal T2w

Axial T2w

Axial T2w
Ectopic Pregnancy (Companion Case A)

Interstitial Ectopic Pregnancies

1. Interstitial pregnancies make up approximately 2-4% of ectopic pregnancies.

2. The interstitial portion of the fallopian tube connects the uterine cavity to the isthmus. An interstitial pregnancy occurs when the blastocyst implants into the interstitial portion of the fallopian tube.

3. The gestational sac is usually high in the fundus and eccentrically located relative to the endometrium.

4. Less than 5 mm of surrounding myometrium is highly suggestive of an interstitial pregnancy.

5. The “interstitial line sign” refers to an echogenic line connecting an empty endometrium to the interstitial gestational sac. The “interstitial line sign” has an 80% sensitivity and a 98% specificity.

6. Early interstitial pregnancies are missed in up to 42% of cases and can become very large (4). A missed interstitial pregnancy can have associated high morbidity and mortality.

Diagram of ectopic pregnancies

Ectopic Pregnancy (Companion Case B)
Ectopic Pregnancy (Companion Case B)

Sagittal T2w

Coronal T2w
Ectopic Pregnancy (Companion Case C)
Ectopic Pregnancy (Companion Case C)
Ectopic Pregnancy (Companion Case D)

MRI of an indeterminate pelvic mass in a patient with a history of a recent miscarriage.

Figure B shows ultrasound images of a heterogeneous mass along the fundus of the uterus. MRI images A, C and D demonstrate a large ruptured ectopic in the right fallopian distinct and separate from the ovaries with associated hemoperitoneum.

Figure A: Axial 3D axial TSE Image with variable flip angle
Figure B: Grayscale ultrasound image
Figure C: Axial T1
Figure D: Sagittal T2

Young female with a history of a recent miscarriage presented to the E.R. with acute abdominal pain. Figure B shows ultrasound images of a heterogeneous mass along the fundus of the uterus. MRI images A, C and D demonstrate a large ruptured ectopic in the right fallopian distinct and separate from the ovaries with associated hemoperitoneum.
MRI images A-C demonstrate a ruptured **ectopic pregnancy** with a large amount of surrounding **hemoperitoneum**. Note the marked **irregularity** of the fallopian tube with an indistinct anterior wall. Hemoperitoneum is hypointense on T2w imaging (Figures A and B) and demonstrates intrinsic T1 signal (Figure C) which becomes even brighter in the **dependent portion of the cul de sac** (more inferior arrow).
New Case
GTD:
Acute Pelvic Pain

Transabdominal gray-scale transverse and sagittal images of the uterus
Acute Pelvic Pain

Transvaginal color Doppler images of the transverse uterus

Power Spectral Doppler images of the transverse uterus
Acute Pelvic Pain

Coronal 5 minute postcontrast fat-saturated T1-weighted image of the pelvis

Axial 3 minute postcontrast image of the pelvis
Acute Pelvic Pain

• MRI of the pelvis were acquired preoperatively to delineate potential myometrial invasion.
Gestational Trophoblastic Disease

- Spectrum of trophoblastic tissue proliferative disorders, including both benign and malignant etiologies:
  
  **Benign:**
  - Complete Hydatidiform Mole (diploid, e.g. 46 XX)
  - Partial Hydatidiform Mole (triploid, e.g. 69 XXY)

  **Malignant:**
  - Invasive Mole
  - Choriocarcinoma
  - Placental site trophoblastic tumor
    - Epithelioid trophoblastic tumor
MRI

- Superior sensitivity and characterization of metastatic disease.

- Distortion of the uterine zones and uterine enlargement.

- Highly vascular.

- T2w sequence: heterogenous with cystic areas of T2 prolongation.

- T1w signal similar to myometrium with focal bright regions representing hemorrhage.
Summary

- Staging of cervical carcinoma is key for therapeutic decision making
- Distinction between endometrial CA and polyp is mostly straightforward, though there may be overlap of imaging features
- Fibroids
  - Pre and post embolization imaging with MRI
  - Distinction from sarcoma
- MRI Safe for the Pregnant Patient
  - Important Tool for Acute Pelvic Pain