MRI - Female Pelvis
Normal anatomy
Congenital uterine anomalies

- Sequelae of developmental abnormalities of the Müllerian duct system
- Wide variety of clinical presentations
  - Difficult to diagnosis clinically
- Actual incidence and prevalence not definitively known
  - Range 0.1-4% for general population
  - Up to 10% in patients with recurrent pregnancy loss
**Congenital uterine anomalies**

<table>
<thead>
<tr>
<th>I Hypoplasia/agenesis</th>
<th>II Unicornuate</th>
<th>III Didelphus</th>
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<tbody>
<tr>
<td>(a) Vaginal</td>
<td>(a) Communicating</td>
<td>(a) Complete</td>
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<tr>
<td>(b) Cervical</td>
<td>(b) Non Communicating</td>
<td>(b) Partial</td>
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<tr>
<td>(c) Fundal</td>
<td>(c) No cavity</td>
<td>(c) No cavity</td>
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<td>(d) Tubal</td>
<td>(d) No horn</td>
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<td>(e) Combined</td>
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<th>IV Bicornuate</th>
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Figure 2. Classification system of müllerian duct anomalies developed by the American Fertility Society (43).
13 yo F, primary amenorrhea
Cervical agenesis; uterus torsed

Ax precontrast T1

Sag precontrast T1

T2 hi-res

Sag T2
22 yo F, uterus and vaginal agenesis
25 yo F, uterine didelphyis
17 yo F, didelphyis- obstructed horn

http://www.atlasofpelvicsurgery.com/
Septate vs bicornuate

- Typically defined by depth of indentation of the fundal contour
  - Bicornuate: > 1.0 cm indentation
  - Septate: < 1.0 cm indentation

- Arbitrary designation based on subjective assessment by gynecologists at laparoscopy
Septate vs bicornuate

US literature: measurement of fundal indentation relative to straight line between tubal ostia

33 yo F, septate uterus
Septate uterus
23 yo F, bicornuate, bicollis configuration
52 yo F, bicornuate uterus
Surgical therapies

- Metroplasty
- Hysteroscopic resection of septum
Septoplasty
62 yo F, unicornuate uterus
41 yo F, arcuate uterus
Endometrium- normal
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

61 yo F, endometrial polyp
30 yo F, endometrial polyp

Sag T2

T2 hi-res

Postcontrast
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
Staging

- FIGO staging system revised in 2010
  - IA: Tumor confined to uterus, ≤ 50% myometrial invasion
  - IB: Tumor confined to uterus, ≥ 50% myometrial invasion
  - II: Cervical stromal invasion, not beyond uterus
  - IIIA: Tumor invades serosa or adnexa
  - IIIB: Vaginal/parametrial involvement
  - IIIC1: Pelvic nodal involvement
  - IIIC2: Para-aortic nodal involvement
  - IVA: Tumor invasion into bladder/bowel mucosa
  - IVB: Distant metastases (including abdominal/inguinal lymph nodes)

http://info.cancerresearchuk.org/cancerstats/types/uterus/symptomsandtreatment/
FIGO 2

Sag T2

Postcontrast

T2 hi-res

Sag T2

Postcontrast
Endometrial carcinoma (serous papillary)- metastatic
Endometrial Stromal Sarcoma

- 63 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).
Endometrial carcinoma
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)


Uterine leiomyoma

- Benign tumor of the uterus
  - Extremely common cause of pelvic symptoms
  - Pain, abnormal bleeding

- **Pathology:**
  - Smooth muscle tumors interlaced with connective tissue
**Uterine leiomyoma - 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
  - Variable vascularity
41 yo F, fibroids
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 outcomes
- Long term fibroid symptom relief with UAE
  - 13-15% ultimately go to hysterectomy
40 yo F, fibroids and adenomyosis
Adenomyosis- US and MRI
37 yo F, focal adenomyosis
72 yo F, degenerating fibroid
37 yo F, degenerating fibroid
Degenerated Leiomyoma

- Fig: 15 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

- Fig: 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 Leiomyomatosis**

- The mass was resected and pathology returned as intravascular leiomyomatosis.
44 yo F, leiomyosarcoma
44 yo F, recurrent leiomyosarcoma
**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 leiomyomomas (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).
Ovarian Neoplasms

- Main differential
  - Surgical vs. non-surgical

- Questions:
  - Neoplastic septations?
    - Cystic neoplasm versus functional cyst
  - Enhancing elements?
    - Surgical; carcinoma is primary consideration
Ovarian lesions - non-tumor

- Ovarian follicles/PCOD/corpus luteum
- Hemorrhagic cysts
- Endometriomas
- Pelvic inclusion cyst
22 yo F, functional cyst

3 months later
Polycystic ovarian syndrome
32 yo F, hemorrhagic ovarian cyst
43 yo F, hemorrhagic cyst

Initial

3 mo FU
54 yo F, ovarian lesion
Endometrioma
Endometriomas

Hemorrhagic cyst (ruptured)
37 yo F, abdominopelvic pain
Ruptured endometrioma
Clear cell CA in endometrioma
51 yo F, bleeding
51 yo F cervical cancer
51 yo F right adnexal met in endometrioma
44 yo F, pelvic inclusion cyst
Ovarian Masses - tumor

- **Epithelial (65%)**
  - Serous/Mucinous/Endometrioid/Clear Cell/Brenner

- **Germ Cell (25%)**
  - Dermoid (younger)/ Malignant transformation (older) / Dysgerminoma*/Embryonal*/Chorio*/Mixed*
    - *solid/young/~fat/~calcium/AFP/HCG

- **Stromal (5%)**
  - Thecoma (estrogen)/Fibroma (Meigs)/Granulosa Cell Tumor (estrogen +hemorrhage-complex)/Sertoli/Leydig Cell Tumors

- **Gonadoblastoma (5%)**
Surface epithelial tumors

- Typically cystic
  - Neoplastic septations
- Solid elements = Surgical
  - Borderline tumor versus carcinoma
73 yo F, ovarian cyst on US
Serous cystadenoma
Serous cystadenomas
58 yo F, serous papillary carcinoma
Serous cystadenoma (borderline)
33 yo F, mucinous cystadenoma
29 yo F, mucinous cystadenoma
33 yo F, mucinous cystadenoma-borderline
**Sex cord stromal tumors**

- Tumors in this category composed of cells that resemble:
  - Female/male endocrine apparatus
  - Granulosa cells, theca cells, sertoli/leydig
  - Other stromal elements (fibroblasts)

- Overlap!

- Hormonally active
40 yo F, ovarian fibroma
61 yo F, fibroma
27 yo F, granulosa cell tumor

Ax T2

Ax pre

Delayed

Sag T2
Germ cell tumors

- Except for dermoids, these are typically aggressive tumors
  - Frequently mixed type

- Tumor subtypes: Dysgerminoma, embryonal carcinoma, endodermal sinus tumor, choriocarcinoma
42 yo F, dermoid
Dermoid: In and Out-of-Phase
24 yo F, metastatic embryonal cell CA
4 yo F, dysgerminoma, torsed ovary
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
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, flip angles, ↓TR, ↓ RF pulse

4. ACR has no recommendation regarding magnet strength
   a. 3.0 T magnet has 4x SAR exposure for equivalent 1.5 T exam

Figure 6: Ruptured right ectopic pregnancy with pelvic hemoperitoneum
Fat suppressed 3D T1W (Dixon- Water only)
- Blood products
- Proteinaceous material

3D T1W Dual echo GRE (Dixon- In and opposed phase)
- Fat (loss of signal on opposed phase)
- Iron (loss of signal on in phase)

T2W (motion resistant)
- Assessment of fluid containing structures
- Organ morphology

T2W (motion resistant) with fat saturation
- Acute inflammation (-itis sequence)
- Fat (dermoid, lipoma)

True FISP (motion resistant)
- Vascular analysis (noncontrast)
- Back up- analysis of fluid containing structures

MRCP
- Bile ducts
- Fluid containing structures
Acute Pelvic Pain:
Case A

Coronal T2w

Coronal T2w

Coronal T1w

Coronal T1w
Ectopic Pregnancy

- 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
Ectopic Pregnancy (Companion Case B)
Ectopic Pregnancy (Companion Case C)
**Ectopic Pregnancy (Companion Case C)**

**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. A missed interstitial pregnancy can have associated high morbidity and mortality.

*Diagram of ectopic pregnancies*

Ectopic Pregnancy (Companion Case D)
Ectopic Pregnancy (Companion Case D)

Sagittal T2w

Coronal T2w
Ectopic Pregnancy (Companion Case E)
Ectopic Pregnancy (Companion Case F)

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

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 demonstrates 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).
Companion Case H: Acute Appendicitis in a Pregnant Patient
Companion Case I: Acute Appendicitis in a Pregnant Patient
Summary

- MRI provides most detailed analysis of congenital uterine anomalies, which may be mixed and complex.
- Distinction between endometrial CA and polyp is mostly straightforward, though there may be overlap of imaging features.
- Ovarian tumors are typically best assessed with MRI, especially regarding diagnostic specificity.
Thank you