The Role of MRI in Evaluating the Benign Uterus

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Objectives:

Review pelvic imaging techniques
Review of normal anatomy
Demonstrate cases where MR is utilized for assessment of:
- Mullerian anomalies
- Fibroids vs. adenomyosis
- Uterine artery embolization (pre- and post-procedure)

Background:

Ultrasound is the screening method of choice for evaluation of pelvic anatomy. However, there are times when the sonographic diagnosis is nonspecific, and MRI is helpful in clarifying abnormalities. Advantages of MR include a detailed view of anatomy in three dimensions, and the ability of MR to characterize tissues. Endometrial pathology such as polyps and hyperplasia are best assessed by ultrasound, and therefore will not be addressed in this lecture.
**Technique**

The basic sequences used for pelvic MR include a 3 plane localizer followed by T1 and T2 sequences. Use of fast spin echo techniques dramatically decreases exam time, and is generally utilized. A typical protocol includes axial T1 in and out of phase, a VIBE (3D fat suppressed T1), sagittal fast spin echo (FSE) T2, and coronal and axial high resolution FSE T2. If the uterus or endometrium is of concern, oblique coronal views angled to the uterus are used. When gadolinium is needed it is given in a dose of .1 mmol/kg. T1WI are obtained pre- and post-contrast in the same orientation to allow for subtraction images. Fat saturation is utilized such that any enhanced area will not blend into the surrounding fat. It is important to view the pre- and post-contrast images with the same window and width levels to assess for enhancement. In general we use dynamic imaging with spoiled gradient echo to allow for rapidly obtaining views in the capillary and interstitial phases to assess for tumor vascularity.

Other sequences that may be utilized include time of flight gradient echo MR gadolinium-enhanced MRA and in cases where vascular abnormalities are suspected.

Glucagon (1 mg IM) can be utilized prior to imaging, except in cases where it is contraindicated. Glucagon gives 2-30 minutes of decreased bowel peristalsis, and thus decreases motion artifact and image blur. With fast imaging sequences, not all centers currently use glucagons. Contraindications include diabetes, pheochromocytoma, insulinoma, and known sensitivity. It may cause nausea and vomiting up to 1 hour after administration.

Scanning is typically performed with a surface coil. Patients are instructed to void prior to the examination in order to minimize ghost artifacts from a distended bladder.
Normal appearance of the cervix and uterus

Normal anatomy of the uterus and cervix is best assessed on T2 weighted images. The cervix has a high signal intensity central lumen with corrugated inner margin from plica palmitae. This is surrounded by a low signal intensity fibrous ring, and an intermediate signal intensity outer layers. Nabothian cysts are typically of high signal intensity on T2 weighted images, but can contain proteinaceous material.

The uterine innermost layer is the endometrium with high signal intensity on T2 weighted images. The high signal intensity can be seen with blood products, fluid in the cavity, and glandular layer. Surrounding this is a low signal intensity junctional zone. The myometrium is of intermediate signal intensity. The thin serosa has a thin outer layer of low signal.

Mullerian anomalies

Congenital anomalies of the Mullerian system affect 0.5-2% of women. However, in the population of women with infertility or history of multiple miscarriages, up to 25% have these anomalies. These anomalies occur because of improper fusion or development of the paramesonephric ducts or incomplete canalization of the vaginal plate (imperforate hymen, hydrometrocolpos).

The American Fertility Society Classification[1] is as follows:

Class I Partial or complete Mullerian agenesis
Class II Unicornuate Uterus
Class III Uterus Didelphys
Class IV Bicornuate Uterus
Class V Septate Uterus
Class VI Anomalies associated with diethylstilbestrol (DES)

3D ultrasound has improved our ability to diagnose uterine anomalies, but may still be limited in patients where the uterine horns are incompletely visualized secondary to patient body habitus or bowel gas. The visualization of the external uterine contour is important in the distinction between bicornuate and septate uteri since a uterine septum can removed with hysteroscopic resection. In contrast to this, treatment of a bicornuate uterus requires open surgery for metroplasty and is not currently recommended. In addition, the prognosis for fertility is affected by the diagnosis. Septate uteri are associated with multiple miscarriages,[2] and this risk can be decreased if the septum is removed. Bicornuate uteri are associated with incompetent cervix and should be followed during pregnancy to assess the cervical length.

Mullerian anomalies are well assessed by MRI. Classic bicornuate uteri have a contour indentation of greater than 1 cm, have separation of horns greater than 105 degrees and have tissue of signal intensity of myometrium separating the horns. Classic septate uteri have a smooth external contour of the uterus, have separation of less than 90 degrees and have a septum of low signal intensity between the horns. However, one of the problems in the diagnosis of uterine anomalies is the wide range of descriptions for diagnosis (Table 1, 2).

| Table 1. Criteria for Fundal contour in the distinction between bicornuate and septate uteri |
|---------------------------------|-----------------|-----------------|
| Bicornuate Uterus               | Septate Uterus  | Reference       |
| > 10 mm indentation             | ≤ 10 mm         | Fedele, 1989[4] |
| Flat or concave                 | Convex          | Carrington, 1990[5] |
| ≥ 10 mm indentation             | Flat or convex  | Letterie, 1995[6] |
| Not specified                   | Flat or convex  | Fielding, 1996[7] |
| Fundal midpoint < 5 mm          | Over interostial line | Homer, 2000[8] |
Common errors in assessing uterine anomalies on either ultrasound or MRI are: 1) a small fundal indentation is not sufficient for the diagnosis of bicornuate uterus; 2) an atrophic horn is in the spectrum of unicornuate, not bicornuate uterus; and 3) a complete septum extending to the cervix does not indicate a uterus didelphys.[3] An issue specific to MR is that the uterine septum can be of intermediate signal intensity in a septate uterus.

Another problem with the appropriate classification of anomalies is that there is a gray zone where differentiation between septate and bicornuate can occur. For example, some patients with a deep external contour indentation also have a uterine septum. Since the experience with duplication anomalies varies, and since criteria for diagnosis vary, it is best to fully describe the number of cervices and uterine horns, communication of any atrophic horn, and presence and composition of any uterine septum. This description can then be used to guide any therapy or management.

**Evaluation of the enlarged uterus/abnormal bleeding**

The initial imaging examination for a patient with an enlarged uterus and/or abnormal bleeding is ultrasound. Patients with endometrial abnormalities typically then

<table>
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<tr>
<th>Bicornuate</th>
<th>Septate</th>
<th>Author</th>
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<tr>
<td>&gt; 105</td>
<td>&lt; 75</td>
<td>Reuter, 1989[9]</td>
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<td>&gt; 75</td>
<td>Not specified</td>
<td>Fielding, 1996[7]</td>
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<td>Not specified</td>
<td>&lt;90</td>
<td>Siegler, 1986[10]</td>
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<td>Not important</td>
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<td>Pellerito, 1992[11]</td>
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go on to biopsy. Patients with fibroids are followed with ultrasound. However, at times the uterus will be enlarged and focal fibroids will not be identifiable. The distinction between fibroids that cause abnormal bleeding and adenomyosis is important, since fibroids can be treated by medication, myomectomy, or embolization whereas adenomyosis is treated with hysterectomy.

Fibroids are the most common uterine mass, and are present in up to 25% of female population older than 35 years of age. Fibroids typically are round, well-defined, and are low signal intensity on T1 and T2WI. Areas of increased signal intensity in fibroids can be due to hyaline or hemorrhagic degeneration.

Adenomyosis occurs when endometrial glands and stroma are located within the myometrium. The condition affects perimenopausal patients. Symptoms of adenomyosis occur in about 50% of patients. These symptoms include pain, menorrhagia and dysmenorrhea. Adenomyosis is present in 80% of patients with menorrhagia in the absence of fibroids or endometrial hyperplasia. Adenomyosis is diagnosed by ultrasound when there is an asymmetric thick uterine wall with poorly defined myometrial masses, myometrial cysts, and heterogenous myometrial echotexture. However, there are many false negative ultrasound reports in which adenomyomas are misinterpreted as fibroids.[12] On MR, adenomyosis is diagnosed when a wide junctional zone is present (greater than 12 mm) and nests of endometrial tissue are seen in the myometrium as well-defined regions of bright signal on T2WI.

The distinction between adenomyomas and fibroids is also possible with MR. Adenomyomas are seen as myometrial masses with ill-defined margins that are low signal on T1 and T2WI. Adenomyomas are ovoid whereas fibroids tend to be round.
MR is also helpful in patients with symptomatic fibroids to triage for the appropriate modality of therapy. MR has been shown to be superior to ultrasound and hysterosalpingography for the localization of small fibroids[13]. MR allows for precise delineation of fibroids and their position with respect to the endometrial cavity, thus it is helpful in preoperative planning for myomectomy (as an open procedure or hysteroscopic removal).

**Uterine artery embolization (UAE)**

MR is also useful in the pre- and post-procedure evaluation of patients undergoing UAE. UAE is utilized as an alternative to surgery for patients with menorrhagia and bulk-related symptoms. Multiple large prospective and retrospective studies have demonstrated the efficacy and safety of this procedure in reducing or eliminating bleeding, bulk symptoms, or pain with minimal morbidity and mortality, with short term and midterm clinical success in approximately 85% of patients.[14, 15]

Relative contraindications to UAE include endometriosis, adenomyosis (although some advocate treatment if fibroids and adenomyosis occur concurrently), pelvic malignancy, desired future fertility (although successful pregnancies have occurred after UAE), and pedunculated fibroids. Fibroids with hemorrhagic degeneration, and thus loss of vascular supply have poor response to UAE. Pre-procedure MR is helpful since it accurately depicts the location of fibroids, distinguishes between fibroids and adenomyosis, and demonstrates fibroid vascularity. In a study by Omary et al., pre-procedure MR changed the clinical management of 11/57 patients (19%) from fibroid embolization to some other mode of therapy.[16]
MR has also been shown to be useful for predicting outcome after fibroid embolization procedures since persistent perfusion of fibroids is predictive of treatment failure.[17-19] It is the degree of devascularization, not the degree of shrinkage that correlates with outcome.

Complications include fibroid expulsion, sloughing of submucosal fibroids, endometritis, and uterine abscess. It should be noted that air in fibroids post-embolization may be due to degeneration, and only rarely due to infection. Uncommon complications include DVT, inadvertent embolization of a malignant leiomyosarcoma, ovarian dysfunction, and rarely death.

MR is helpful for examining patients with potential complications after uterine artery embolization. For example, in the case of symptomatic fibroid expulsion, MR can be utilized to demonstrate the migration of the fibroid and any viable attachment to the uterine wall, allowing for pre-operative planning.[20]

References: