Functional MR imaging of the uterus

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Topics

• Cine MR in reproductive medicine
• Diffusion Weighted Imaging (DWI) and Apparent Diffusion coefficient (ADC) in oncology
• Perfusion in oncology
MR imaging in Gynecology

• Excellent modality to evaluate female pelvis because of its noninvasive nature.
• A variety of uterine diseases are easily diagnosed on MR.
• MR has had a great impact on patient management.
Typical uterine leiomyomas

Sharply marginated mass of distinct low SI
**Pseudolesions**

- An area of Low SI that bulges into the cavity
- Normally considered to represent leiomyoma or adenomyosis
- Actually represent **Uterine contractions**
  - *Contraction squeezes out blood from the contracted area*

*Togashi K, Radiology 1993, JMRI 1993*

Midsagittal images sequentially obtained with static FSE
Cine MR

Sequentially obtained HASTE images/2-3s under breathing

These 60-300 images (1slice/0.4-1sec) into cine mode (12x real speed)

Corresponding T2WI

Nakai A, JMRI 2003, 2004
Dysmenorrhea evaluated on cine MR

CD1 with severe pain
Wide area of Low SI, E Distortion

CD3 without pain
Narrow low SI, No E Distortion

Kataoka M, Togashi K et al  Radiology 2005
Uterine Peristalsis on cine MR

Subtle & Rythmic contractions
Surging Waves at EM Junction

31y.o. periovulatory phase, Cervicofundal waves
Differences are observed among cycles

Periovulatory phase

Menstrual period
Direction, Frequency, and Strength of Uterine Peristalsis varies throughout menstrual cycle

- Periovulatory phase
- Luteal phase
- Menstrual phase
Contractility and peristalsis seem to be closely related with important uterine functions:

**Fertility problems and Effects of drugs**

- **Submucosal Leiomyomas**
- **Effect of drugs, anticholinergic etc.**
- **Recurrent IVF failure**
Uterine contractility is markedly reduced in OC users.

Menstrual phase, pre OC use

Withdrawal bleeding, 3Month after OC usage

IUD-bearing uterus shows reversed waves and increased contractility

41y.o. IUD 6years

30y.o. IUD 3years, OC 1 year

Leiomyoma

Subserosal M: no wave

Submucosal M: uncoordinated contractions

Nishino M, Togashi K, et al. EJR 2005
## Endometriosis & Peristalsis

### Presence of Peristalsis

<table>
<thead>
<tr>
<th>Phase</th>
<th>Endometriosis</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Periovulatory phase</td>
<td>6/13</td>
<td>87/96</td>
</tr>
<tr>
<td>Luteal phase</td>
<td>4/15</td>
<td>29/96</td>
</tr>
<tr>
<td>Menstrual phase</td>
<td>3/3</td>
<td>50/96</td>
</tr>
</tbody>
</table>

### Incidence of Peristalsis

![Frequency vs. Menstrual Cycle Graph](image)

Infertility: Evaluation from a different point of view

34 y.o. Primary infertility
5 times failure of IVF
Abnormal waves

With wave suppression,
Successful IVF

Kido A, Togashi K, et al.
Mysterious Myometrium

27y.o. pre Menstrual phase

Rich vasculature
extracellular component such as collagen or elastin increases from the cervix to the fundus
Estrogen ?? Contractile elements
Diffusion Weighted Imaging

Originally used to identify acute Cerebral infarction
Now attracting attention in Oncology

- Represents Brownian motion of molecules
- Provides different tissue contrast
  - Viscosity of fluid
  - Cellularity
- Enables quantitative measurement of ADC
  - Decreased ADC values in malignant tumor

Cervical Cancer diffusely invading into posterior myometrium

T2WI    DWI (b = 1000)    ADC map
Malignant uterine tumors on DWI

- Malignant uterine lesions show high SI on DWI
- Fusion image enables to evaluate both anatomic and additional information obtained from DWI.
Implants shown on DWI

S/O rec. Ovarian CA with ascites and elevated serum marker.

MRT2WI

DWI onto T2
ADC and Tumor Grading

DWI allows quantitative measurement of the ADC. Decreased ADC in malignant tumor have been reported.

- Endometrium & cancer show high SI on DWI. However, Cancer has low ADC values (mm²/s)
  - Ca. (0.88 ± 0.16) < normal (1.53 ± 0.10)
- High grade cancer (G3) tends to show low ADC


The ADC value provides a new tool for evaluating the pathologic grading of cervical cancer

Well-differentiated endometrial cancer (G1, pT1b) 35 y.o.

Low grade tumor shows relatively low SI on ADC map. The ADC value was $1.13 \times 10^{-3}$ mm$^2$/s.

T2WI  fusion image  ADC map

Poorly-differentiated endometrial cancer (G3, pT3a) 69 y.o.

High grade tumor shows prominent low SI on ADC map. The ADC value was $0.62 \times 10^{-3}$ mm$^2$/s, extremely low.

ADC is a potential cancer biomarker. However, there are several problems:

- ADC may be dependent on the scanners as well as parameters:
  - due to different $b$ values used
  - Cutoff values proposed in papers are not directly applicable to other sites
- Comparison of ADC and cutoff values in different institutions are difficult.
- Protocol standardization is mandatory.
Dynamic contrast-enhanced MRI

- Technique that can reflect tumor vascularity
  - The contrast between the lesion and myometrium is greater on DCFMR imaging
Perfusion MRI using DCE-MR

- Focuses on hemodynamics of cancer rather than morphology
  - Increasing temporal resolution allows to analyze detailed time-course of SI of cancer
  - DCE offers many analytic values: Ktrans, Kep and Ve represent characteristics of vascular permeability, its reverse speed constant and extracellular space volume, respectively
Take home messages

- Recent MR techniques have enabled us to evaluate the functional assessment of the uterus.
- Cine MR offers direct visualization of uterine contractility, which closely related with uterine functions, fertility problems and menstrual symptoms.
- DWI and ADC provide tissue contrast based on molecular diffusion phenomenon, and might be a promising tool in oncology as a possible cancer biomarker.
- DCE and perfusion analysis help evaluate hemodynamics of lesions.
Thank you for your attention