Emerging MRI Techniques for Abdominal and Pelvic Imaging

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Background

PhD in Biomedical Engineering – 2004
- Case Western Reserve University
- Cleveland, OH
- Sequence programming
- Optimal design

Collaboration Manager
- Siemens Healthcare
- Cary, NC
- IDEA and Physics Team
- Abdominal MRI at 3 T

Outline

- Hepatic fat quantification
- Abdominal workflow
- MRI of the female pelvis
- Cancer characterization with 4D imaging
  - Will not cover in depth
  - FDA constraints
  - Overlap with Dr. Lin
-References

Fatty Liver Disease Progression

Incidence
- 10% - 24% overall
- Up to 75% of obese

Primary FLD
- NAFLD
- NASH

Secondary FLD
- Alcoholic
- Hepatitis
- Drug-induced
- Surgically-induced

Cirrhosis

Symptoms
- Fatigue
- Bleeding/bruising
- Nausea
- Weight loss
- Ascites

Diagnosis
- Liver biopsy
- FibroTest

Irreversible
- Prevent further damage
- Liver transplant

How Can We Detect FLD Early?

Early Stage FLD
- Treatable
- Asymptomatic
- Fat is present

MR Signal Characteristics
- Short T1
- Chemical shift 3.5 ppm
Sequence Overview

3D spoiled steady state
- T1 weighted
- Dual-echo
- In-phase
- Opposed-phase
- Single breath-hold
- Routine liver exam
- Dixon reconstruction

Terminology
- Siemens: VIBE Dixon
- GE: Lava IDEAL
- Philips: mDixon

Physics – Microenvironment Magnetic Shielding

Opposed Phase – Destructive Interference

TR = 2.2 ms

Standard IP/OP Approach

In- and Opposed-Phase Images
- Magnitude reconstruction
- Signal drop due to fat/water cancellation
- Pure voxels un-cancelled
- Ambiguous

VIBE Dixon Approach

In- and Opposed-Phase Images
- Magnitude and phase reconstruction
- Unambiguous fat/water separation
- Phase unwrapping required

Quantitative Measure of Fat

Fat Only

Fat Percentage Map

Water
Remaining Limitations

- Unproven for early stage FLD
- No good gold standard
- Liver biopsy
- Focal disease
- Phase unwrapping errors
- Mathematically ill-posed

Abdominal MR Exam Workflow

- Long duration compared to CT
  - Expensive
  - Error prone
- Value added time
  - Image acquisition
- Non-value added time
  - Coil set-up
  - Localizers
  - Adjustments
  - Breathing commands
  - Contrast delay
  - Parameter changes
- Hardware solutions
  - Dockable table
  - Array coils
- Software solutions
  - Parallel imaging
  - Automatic localization
  - Parameter optimization
  - Protocol strategies
  - Automatic voice commands

Terminology
- Siemens: DOT
- Philips: Smart Exam
- GE: ?

Dot*

Day optimizing throughput Engine

- Personalized
  - Best possible results for virtually any type of patient
- Guided
  - Guides the novice user helping them to scan more expertly
- Automated
  - With intelligent, automated workflows a new level of efficiency can be reached

Personalized

- Every patient is different – different breathhold
  - Abdomen and cardiac: just state patients breathhold capability – Dot* adapts to each patient’s breathhold capacity and links to your best scanning protocol to match
  - Breathhold settings can be changed at any time during the exam
  - Easy set-up of the best scan for each patient – higher resolution and reduction of errors

Excellent results – guided intuitively

- Dot* guides the novice user helping them to scan more expertly
- This enables results with greater efficiency at all levels and improved image consistency
Guided

The right choice when needed

- Your decisions are seamlessly integrated into the scanning process
- After a decision is taken, Dot automatically links to your protocol and updates the queue
- E.g. for Abdomen – MRCP or Diffusion
- One click, less mistakes, faster

Automated

- With intelligent, automated workflows – customizable to your standards – a new level of efficiency can be reached
- Scans are completed faster and more easily with less chance of errors or repeats

Automated Dynamic VIBE Timing

- Timing is never off – synchronized contrast timing and breathing
- AutoBolusDetection – more accurate contrast timing
- Voice commands integrated into the scanning workflow
- Automatically played at the right point in time - synchronized timing of scanning and breathing
- Personalized voice commands – easy language selection

Automated abdominal exam

- Timing is never off – even inserting sequences between venous and delayed
- Intelligent automation – no navigator positioning, no FoV adaptations necessary anymore
- Reduced user interaction – be fast, with excellent image quality
- Comprehensive liver exam in only 15 min*

Remaining Limitations

Unproven time savings
Community acceptance
Customization
Best practices strategies

Standard Female Pelvis Protocol

3-plane localizer
- Sagittal, axial, & coronal 2D TSE T2w
- Congenital anomalies
- Cancer staging
- Fibroid treatment planning

Axial 2D TSE T1w
- Congenital
- Cancer

Prep, off
- Pre- and post-contrast
- Consent planning

9 pulse sequences
In-room time > 30 min
### 3D T2w TSE
- Acquire 3D isotropic
- Reformat any plane
- Long echo train
  - T2 decay causes blurring
  - Variable flip angle refocusing

### Terminology
- Siemens: SPACE
- GE: CUBE
- Philips: Vista

### Offline Multiplanar Reformat

#### Coronal oblique TSE T2w
- Congenital anomalies

#### Axial oblique TSE T2w
- Endometrial cancer

### 3D TSE T2w MRI w SPACE
- Acquired
- Offline reconstructed

### 2D TSE T2w vs SPACE
- 50 patients (49.4 ± 14.5 yrs)
- Ax, cor & sag 2D TSE T2w
- Sag SPACE
- 4 readers
### Time Savings

<table>
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<th>Acquisition Time</th>
<th>Sagittal 3D (+ Recons)</th>
<th>Ax, cor &amp; sag 2D</th>
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<tr>
<td>Mean ± StDev</td>
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<td>12:11 ± 2:08</td>
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<tr>
<td>Median</td>
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<tr>
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<td>9:31</td>
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<tr>
<td>Maximum</td>
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</table>

N = 50, unpublished data

### Results

- **Image quality**
  - Overall, uterus, cervix, ovaries
  - Endometrium/junctional zone/myometrium
  - Cervical epithelium/stroma/parametrium
  - Vagina/surrounding tissue

- **Contrast**
  - Width/thickness

- **Lesion detection**

- **Artifacts**
  - Respiratory motion
  - Bowel motion

**P > 0.05**

**P < 0.001**
“Fast Female Pelvis”

3-plane localizer
Single plane 3D FSE T2w
Ax 3D dual echo GRE w/wo Gad

4 pulse sequences
In-room time < 15 min

Remaining Limitations
- Manual reformat on scanner
- Manual reformat on PACS
- Automatic inline reformat
- Reformat image quality
- Optimal thickness
- Oblique slices
- Small study
- More patients
- More pathologies

Thank You

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