Patient Specific Adoptions of Imaging Techniques: MRI

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MRI Acquisition in a Nutshell

T/R Switch
Array
coil
POLARIZE
EXCITE
ENCODE
DETECT

\[(B_0)\]
\[(G)\]
\[(B_1 +)\]
\[(B_1 -)\]
rf
coils

\[(k_x, k_y)\]
\[(t_t, t_x, t_y)\]
\[\text{(Pulse sequence timing)}\]
\[\text{(image space)}\]


tt
xx
yy

\[\text{and }\]
\[\text{and }\]

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Patient Specific Adaptations of Imaging Techniques: MRI

• MR Scan Prescription
• RF Coils
• Image reconstruction
• MR Scanner Tuning
• Patient Motion Management
• MR Safety

Patient adaptable coils

• Goal is to improve image quality
• Trade in for higher scan speed or reduced hardware needs
• High reliability? - A likely benefit will simply be more consistent image quality over a variety of patient setups and body habitus conditions

Artificial intelligence assisted reconstruction using deep learning

Cardiac

48-channel
73 x 54 cm² active area
2.2 kg patient felt weight

Peripheral signal artifact control

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Peripheral signal artifact control
Patient specific system tuning: B₀ shimming

Slice-by-slice B₀ adjustment
‘Broken spine artifact’
B₀ shim built into H&N coil

Adapting to patients with implants: metal artifact reduction

MAVRIC – Composite image created from spectral offset images
Spectral calibration adapts to the type of implant by adding spectral offsets

Adapting to patient motion: ‘Navigators’

• Advances in adaptive navigators include automated navigator placement and moving navigator acceptance to adapt to slight shifts in location

Adapting to patient motion

• To achieve desired contrast and coverage, MR acquisitions can be long compared to physiological motion (respiratory, cardiac, involuntary, etc) making susceptible to motion

• Navigators technology has been applied to brain as well in addition to non-Cartesian acquisitions like PROPELLER/BLADE

Adapting to patient motion: Hardware improvements

• VitalEye (Philips)
• KinetiCore (Siemens)

Respiratory sensors built into table
Cardiac triggering built into coil
MR Safety Considerations

- MR systems have traditionally used body weight and sometimes height, sex, age or orientation in magnet to estimate whole body and local SAR
- More recently systems utilized real-time feedback to update SAR in real-time
- Now, to accommodate more restrictive heating conditions associated with implants vendors are moving toward models that predict, estimate and/or help control either SAR (conservative) or B1+rms
- Vendors are now starting to use localizer scans to help estimate the amount of tissue exposed for even more refined calculations

Adapting to patient: SAR model

- AI algorithm for identification of anatomy
- Protocol optimized to take advantage of usable RF power

Managing SAR in the patient via the pulse sequence

- Concerns: Fast spin echo and fast imaging sequences (high density of refocusing pulses) and fast sequences utilizing large flip angle pulses (balanced steady state free precession, magnetization transfer angiography, etc)
- Use of emerging B1+rms limits instead of SAR more accommodating

Examples of Modifications

<table>
<thead>
<tr>
<th>Potential Tradeoff</th>
<th>Modifications</th>
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<tbody>
<tr>
<td>Reduce number of k-space views</td>
<td>reduced phase encodes, rectangular field of view, parallel imaging acquisition</td>
</tr>
<tr>
<td>Modify RF pulse shape or flip angle</td>
<td>reduced flip excitation pulses, reduced flip 180° refocusing pulses</td>
</tr>
<tr>
<td>Scan less efficiently</td>
<td>reduced flip excitation pulses, reduced flip 180° refocusing pulses</td>
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<tr>
<td>Gradient-echo instead of SE, FSE or bSSFP</td>
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Adapting to patient: Implants

- Low SAR mode on GE 1.5T

Summary

- MR has a long history of needing to adapt to a specific patient or anatomical region via tuning of the pulse sequence.
- Artificial intelligence in combination with fast calibration sequences or new hardware are facilitating a more patient adaptive MR environment
  - Patient scan prescription
  - Patient specific acquisition tuning
  - Patient specific safety management
- Potential for increased workflow, increased patient safety management potentially with more robust and consistent image quality
Thank you for your time!

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