Cardiac MRI
Morphology
2004
Disclaimers

- The information in this presentation is strictly educational and is not intended to be used for instruction as to the practice of medicine.

- Healthcare practitioners reading this presentation must use their own learning, training, and expertise in dealing with their individual patients.
CONTENTS

Bright Blood Morphology
- Flash, TrueFisp
- Inflow, Steady State
- Segmented, Single Shot
- Examples

Dark Blood Morphology
- DB TSE, DB STIR
- Segmented, Single Shot
- Tse, Haste, Tfl, TrueFisp
- Examples

Clinical Protocols
- Localizers
- Morphology
  - General
  - Pediatrics
  - Vessel Wall

Optimization
- Dark Blood
Bright Blood Morphology

FLASH: spoiled gradient echo

image contrast depends on inflow enhancement of blood
Bright Blood Morphology
TRUEFISP: steady state gradient echo

image contrast depends on steady state signal of blood
Bright Blood Morphology
sequences

FLASH
Inflow Enhancement  
TRUEFISP
Steady State Signal
Bright Blood Morphology sequences

FLASH
Inflow Enhancement

TRUEFISP
Steady State Signal
Bright Blood Morphology
K-space Filling

Segmented K-space
several heartbeats per image

Few K lines
trigger
delay

Single Shot K-space
one heartbeat per image

All K lines
trigger
delay
Bright Blood Morphology
K-space Filling

Segmented K-space
• Several heartbeats
• Higher spatial & temporal resolution
• Sensitive to arrhythmias
• Sensitive to breathing

Single Shot K-space
• One heartbeat
• Lower spatial & temporal resolution
• Not sensitive to arrhythmias
• Not sensitive to breathing
Bright Blood Morphology
K-space Filling

TRUEFISP Segmented
6 heartbeats
Higher spatial & temporal resolution

TRUEFISP Single Shot
1 heartbeat
Lower spatial & temporal resolution
Bright Blood Morphology
Segmented TrueFISP High Resolution

- Aortic Dissection
- Pediatric
- Coronary Arteries
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Optimization
- Dark Blood
Dark Blood Pulse
Why do we need it?

Standard Spin Echo
13 min scan
Motion artifacts

Dark Blood TSE
Breath hold scan
Artifact free
Without Dark Blood Pulse

- Respiratory motion artifacts
- Cardiac motion artifacts
- Blood flow artifacts
- Long scan times
With Dark Blood Pulse

- Breath hold eliminates respiratory motion artifacts
- Diastolic gating eliminates cardiac motion artifacts
- Dark blood pulse eliminates blood flow artifacts
- Short scan times
Dark Blood Pulse
Why do we need it?
Dark Blood Pulse
How does it work?

A = R-wave (end-diastole)
B = Systole
C = Late diastole

= non-selective inversion
= slice-selective “reversion”
= imaged slice
Dark Blood TSE
(double IR)

Data acquisition
1 segment = 7 lines

Blood signal
Myocardium signal
null
nonsel IR
sel IR
Dark Blood STIR
(triple IR)

Data acquisition
1 segment = 7 lines

nonsel IR

sel IR

null

null

Blood

Myocardium

Fat
Dark Blood TSE  blood nulled

Dark Blood STIR  blood + fat nulled
Dark Blood
TSE

blood nulled

Dark Blood
STIR

blood + fat nulled
Dark Blood
TSE T2 Fatsat

blood + fat nulled

Dark Blood
STIR

blood + fat nulled
What if Segmented Breath Hold Fails?
Use Single Shot Free Breathing!

Breath Hold TSE
Segmented K-space
FAILED

Free Breathing HASTE
Single Shot K-space
SUCCESSFUL
Dark Blood Sequences

K-space filling

Segmented K-space
several heartbeats per image

Single Shot K-space
one heartbeat per image
Dark Blood Morphology

K-space filling

**Segmented K-space**
- Several heartbeats
- Higher spatial & temporal resolution
- Sensitive to arrhythmias
- Sensitive to breathing

**Single Shot K-space**
- One heartbeat
- Lower spatial & temporal resolution
- Not sensitive to arrhythmias
- Not sensitive to breathing
Dark Blood Morphology
K-space filling

Segmented DB TSE
8 heartbeats
Higher spatial & temporal resolution

Single Shot DB HASTE
1 heartbeat
Lower spatial & temporal resolution
Dark Blood HASTE Single Shot

- free breathing
- 1 image per heartbeat
Dark Blood TurboFlash Single Shot

- free breathing
- 1 image per heartbeat
Dark Blood TrueFisp Single Shot

- free breathing
- 1 image per heartbeat
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- Segmented, Single Shot
- Tse, Haste, Tfl, TrueFisp
- Examples

Clinical Protocols
- Localizers
- Morphology
  - General
  - Pediatrics
  - Vessel Wall

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CONTENTS

Bright Blood Morphology
- Flash, TrueFisp
- Inflow, Steady State
- Segmented, Single Shot
- Examples

Dark Blood Morphology
- DB TSE, DB STIR
- Segmented, Single Shot
- Tse, Haste, Tfl, Truefisp
- Examples

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  - Pediatrics
  - Vessel Wall

Optimization
- Dark Blood
Dark Blood Optimization

Faster HR → Shorter RR → Less Recovery → Shorter TI
Dark Blood Optimization

Blood Null Point (TI) varies with RR interval (TR)

Faster HR $\rightarrow$ Shorter TR $\rightarrow$ Shorter TI

<table>
<thead>
<tr>
<th>Heart Rate BPM</th>
<th>RR msec</th>
<th>TR msec</th>
<th>TI msec</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>600</td>
<td>1200</td>
<td>420</td>
</tr>
<tr>
<td>80</td>
<td>750</td>
<td>1500</td>
<td>550</td>
</tr>
<tr>
<td>60</td>
<td>1000</td>
<td>2000</td>
<td>630</td>
</tr>
</tbody>
</table>
Dark Blood Optimization

- TR is used to place Data into late Diastole *
- No additional Trigger Delay is needed
- TI effectively equals TR minus Data acquisition

* non-conventional definition of TR
Dark Blood Optimization

Adjust TR so that Data acquisition avoids Systole and is acquired in late Diastole
Dark Blood Optimization

TR too short: systolic motion reduces myocardial signal

TR optimized

TR too long: blood signal begins to recover
Dark Blood Optimization

With short RR intervals Data Acquisition is too long and spans through either late Systole or next R wave, thereby causing blurring.
Dark Blood Optimization

Segmented Sequence
(TSE T1, T2, STIR)

- reduce lines/segment
- reduce echo spacing
  - increase bandwidth
  - fast RF & gradient pulses

Single Shot Sequence
(HASTE, TrueFISP)

- reduce Phase FOV
- reduce Phase lines
- use minimum TE
- use iPAT
Dark Blood Optimization

For T1 Weighting
- use 1 trigger pulse
- use short ETL
- use moderate TE (centered)

For T2 Weighting
- use 2-3 trigger pulses
- use long ETL
- use long TE (centered)
- use fatsat
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