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.

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

Clinical Protocols
- Localizers
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  - Pediatrics
  - Vessel Wall

Dark Blood Morphology
- DB TSE, DB STIR
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Bright Blood Morphology

FLASH: spoiled gradient echo

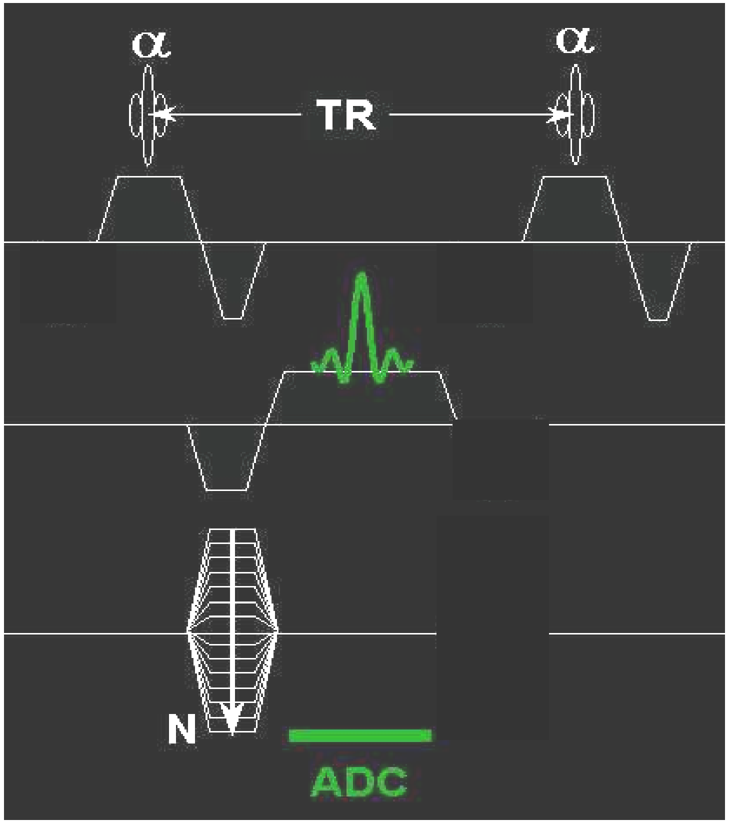


image contrast depends on inflow enhancement of blood

Bright Blood Morphology

TRUEFISP: steady state gradient echo

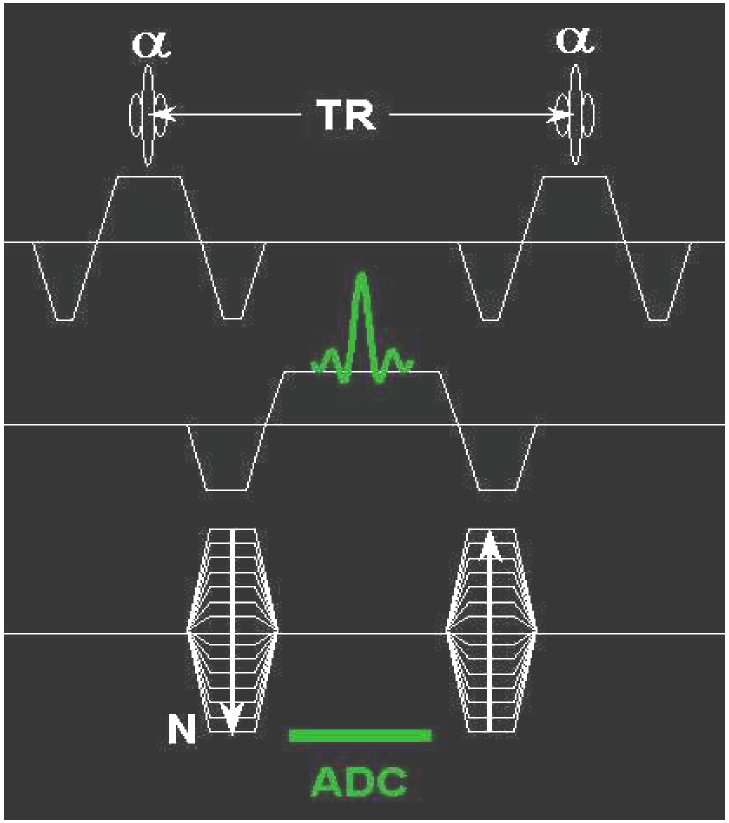
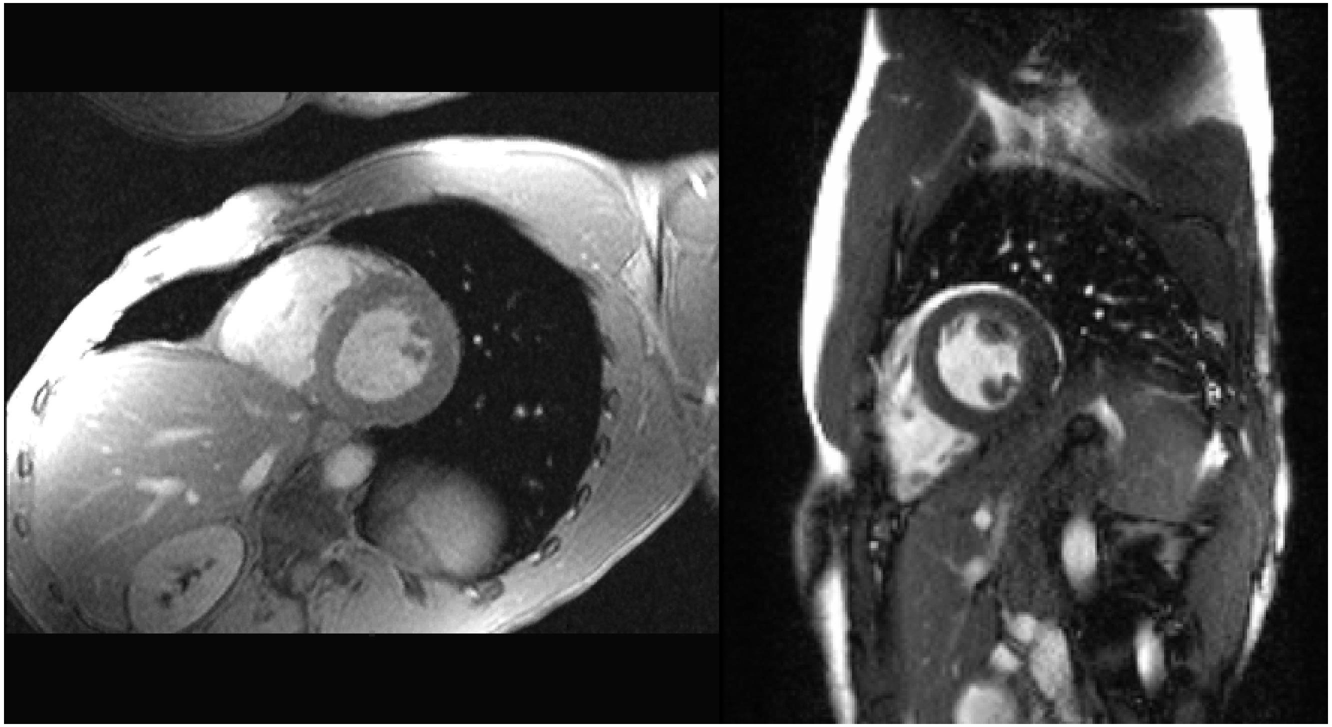


image contrast depends on steady state signal of blood

Bright Blood Morphology

sequences



FLASH

Inflow Enhancement

TRUEFISP

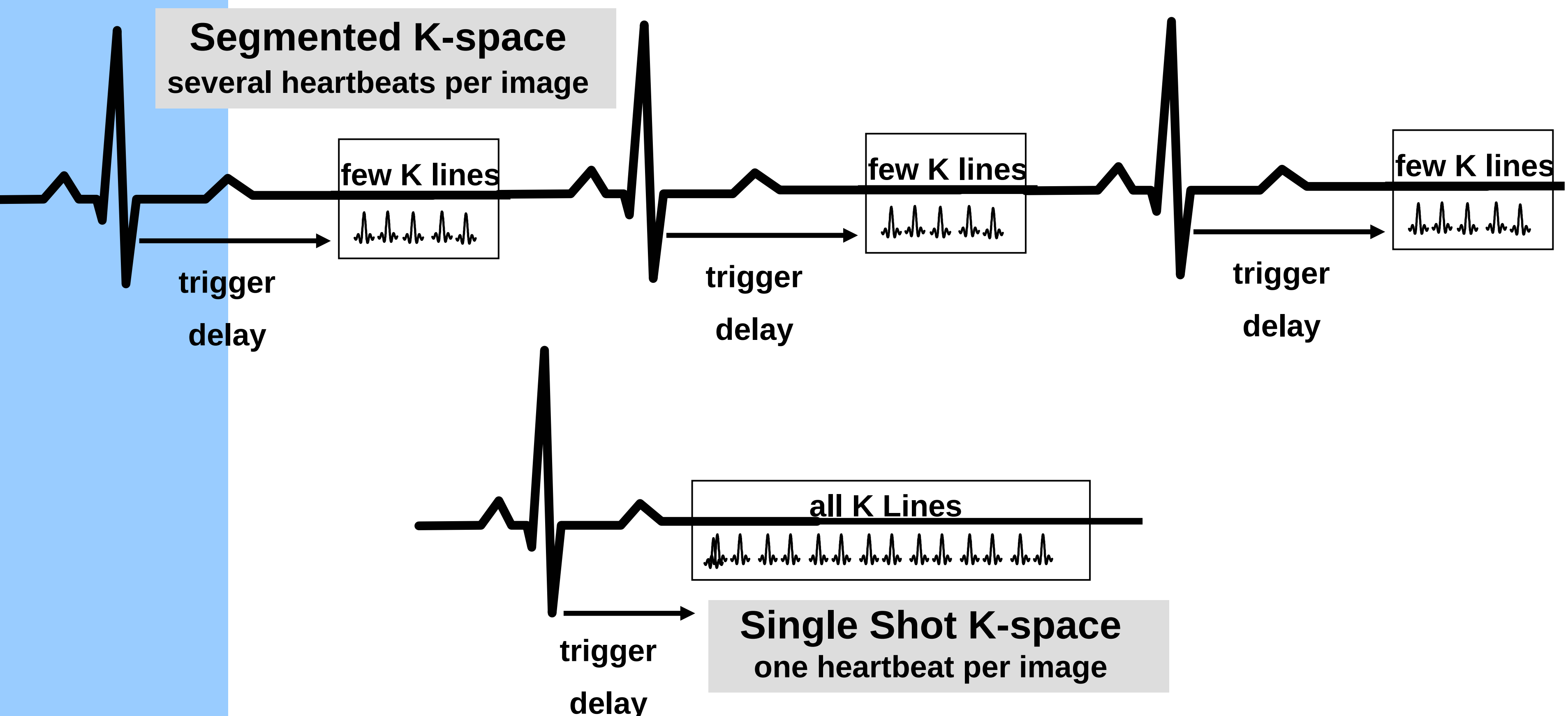
Steady State Signal

Bright Blood Morphology
sequences

FLASH	TRUEFISP
Inflow Enhancement	Steady State Signal

Bright Blood Morphology

K-space Filling



Bright Blood Morphology
K-space Filling

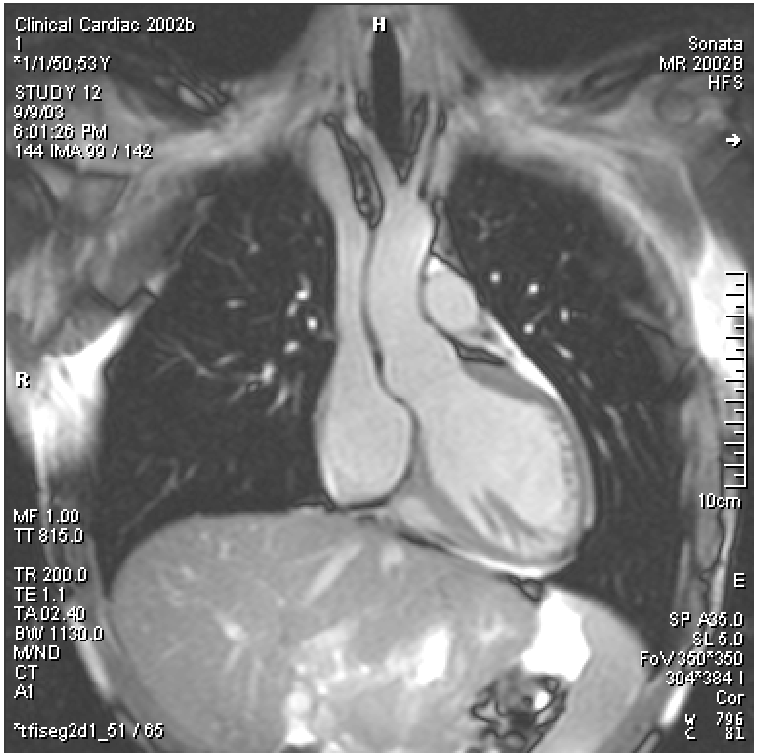
Segmented K-space

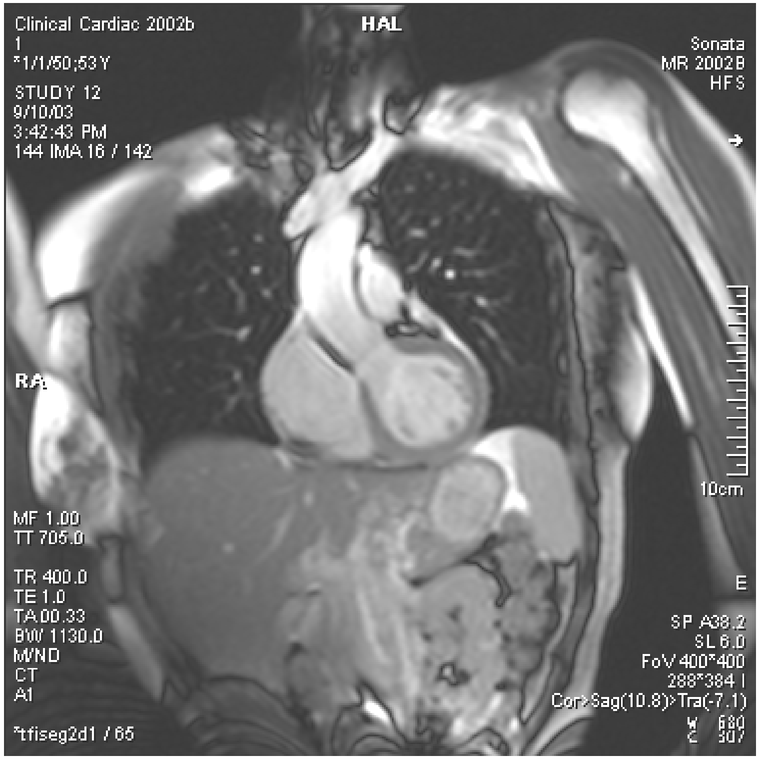
- Several heartbeats
- Higher spatial & temporal resolution
- Sensitive to arrhythmias
- Sensitive to breathing

Single Shot K-space

- One heartbeat
- Lower spatial & temporal resolution
- Not sensitive to arrhythmias
- Not sensitive to breathing

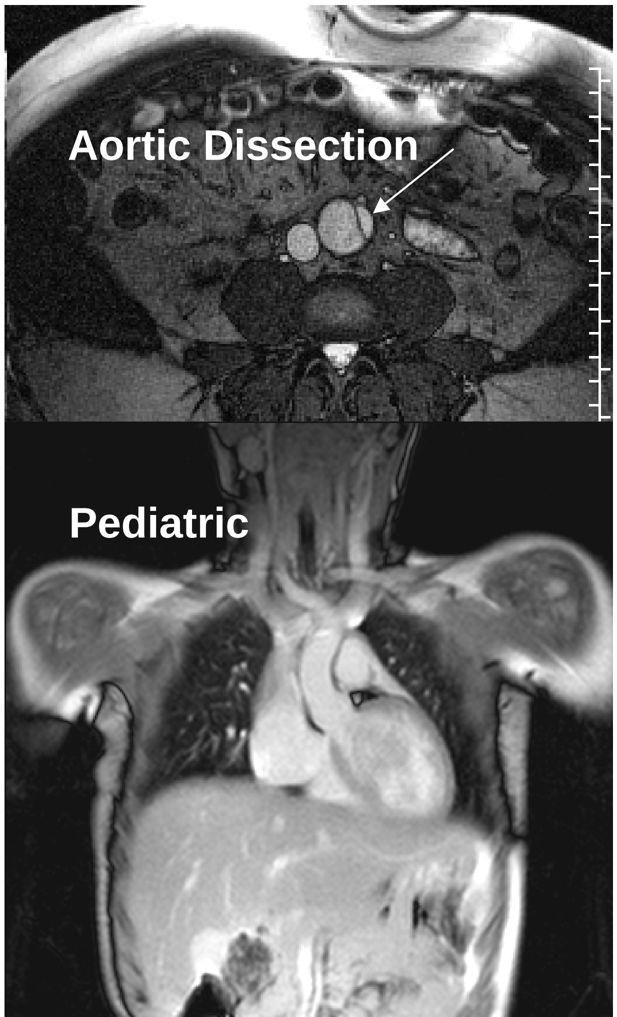
Bright Blood Morphology
K-space Filling

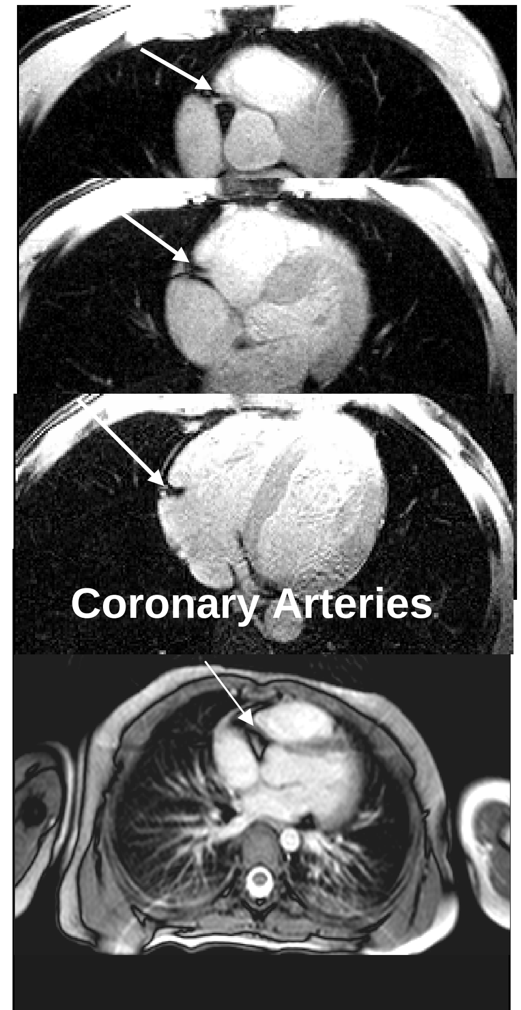




TRUEFISP Segmented	TRUEFISP Single Shot
6 heartbeats	1 heartbeat
Higher spatial & temporal resolution	Lower spatial & temporal resolution

Bright Blood Morphology
Segmented TrueFISP High Resolution





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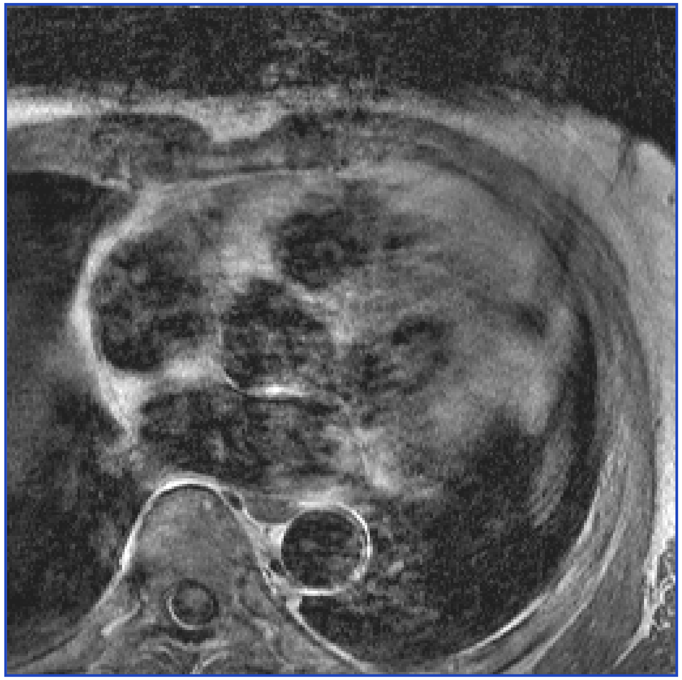
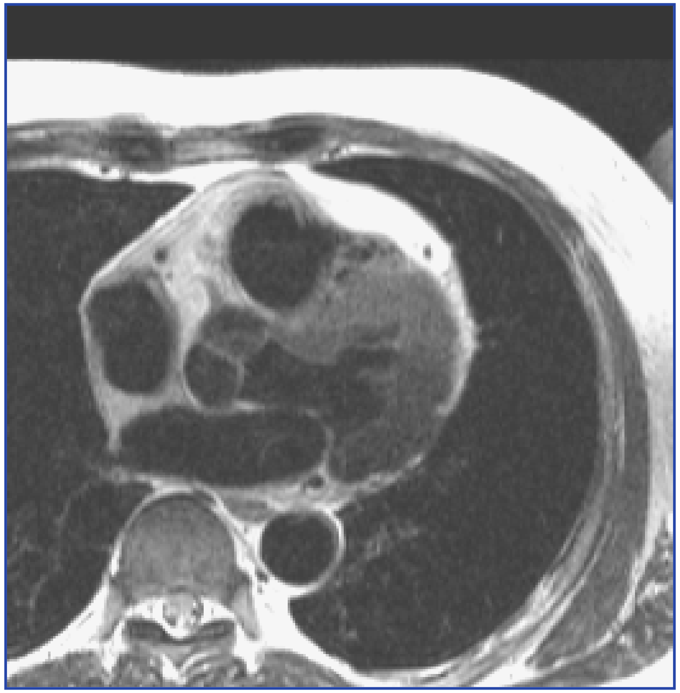
Dark Blood Pulse
Why do we need it ?

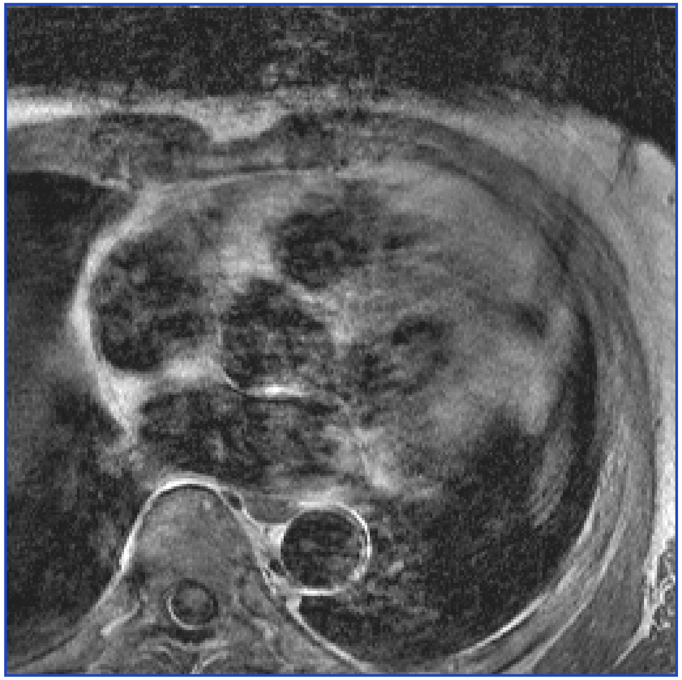


Standard Spin Echo
13 min scan
Motion artifacts



Dark Blood TSE
Breath hold scan
Artifact free

Without Dark Blood Pulse

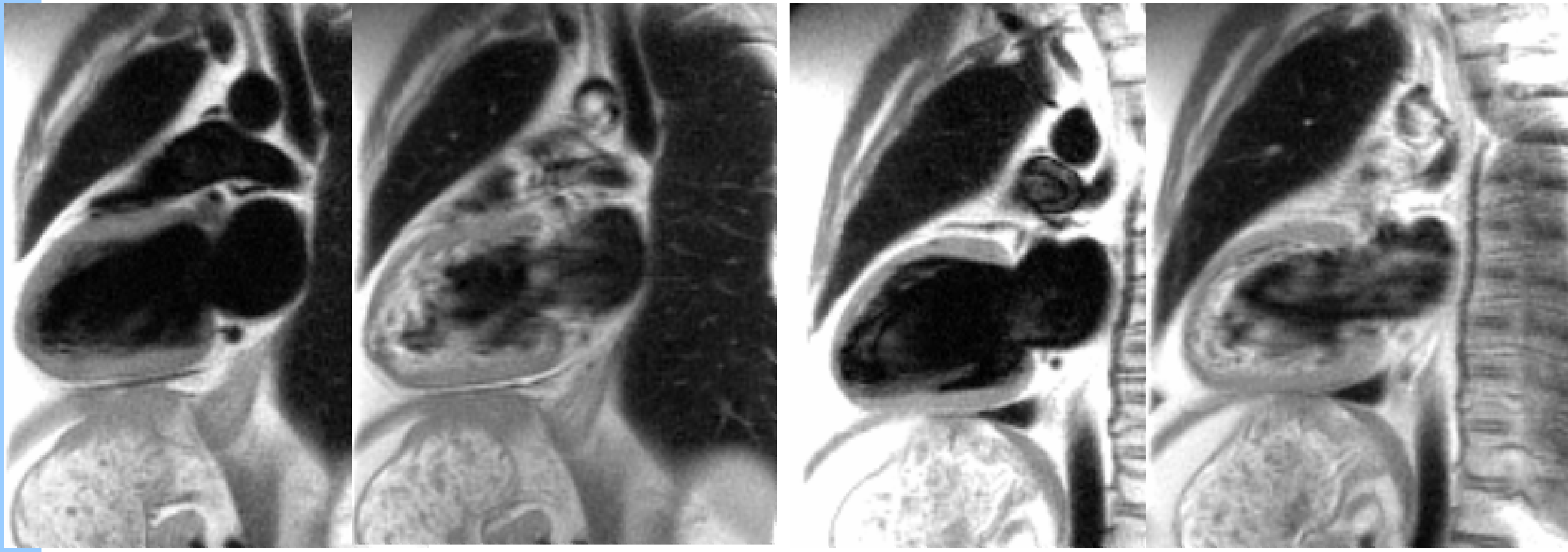


- Respiratory motion artifacts
- Cardiac motion artifacts
- Blood flow artifacts
- Long scan times

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

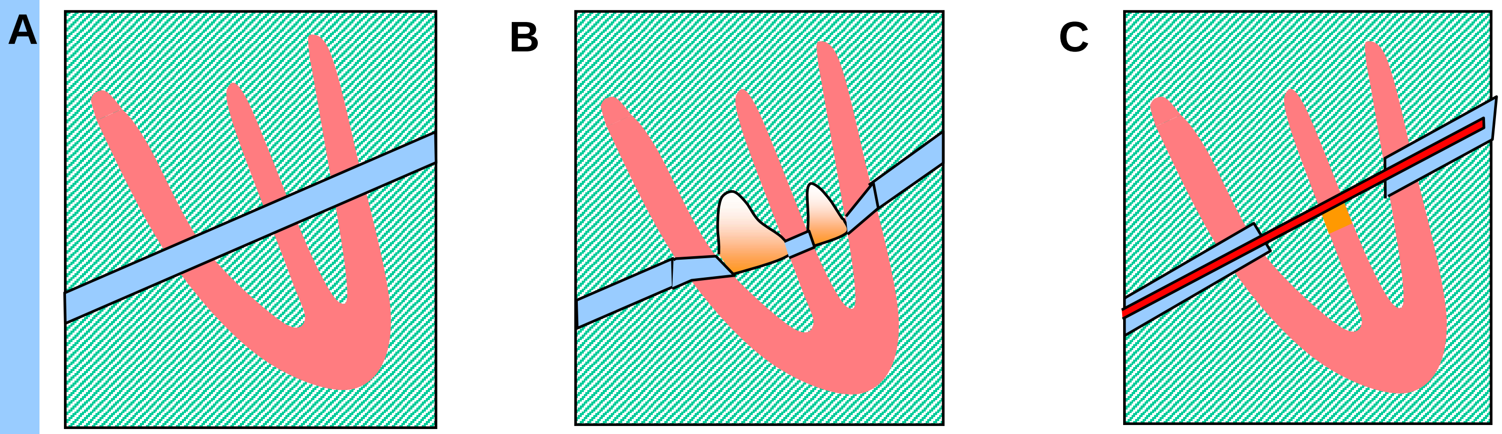
Dark Blood Pulse
Why do we need it ?



With db Without db With db Without db

Dark Blood Pulse

How does it work ?



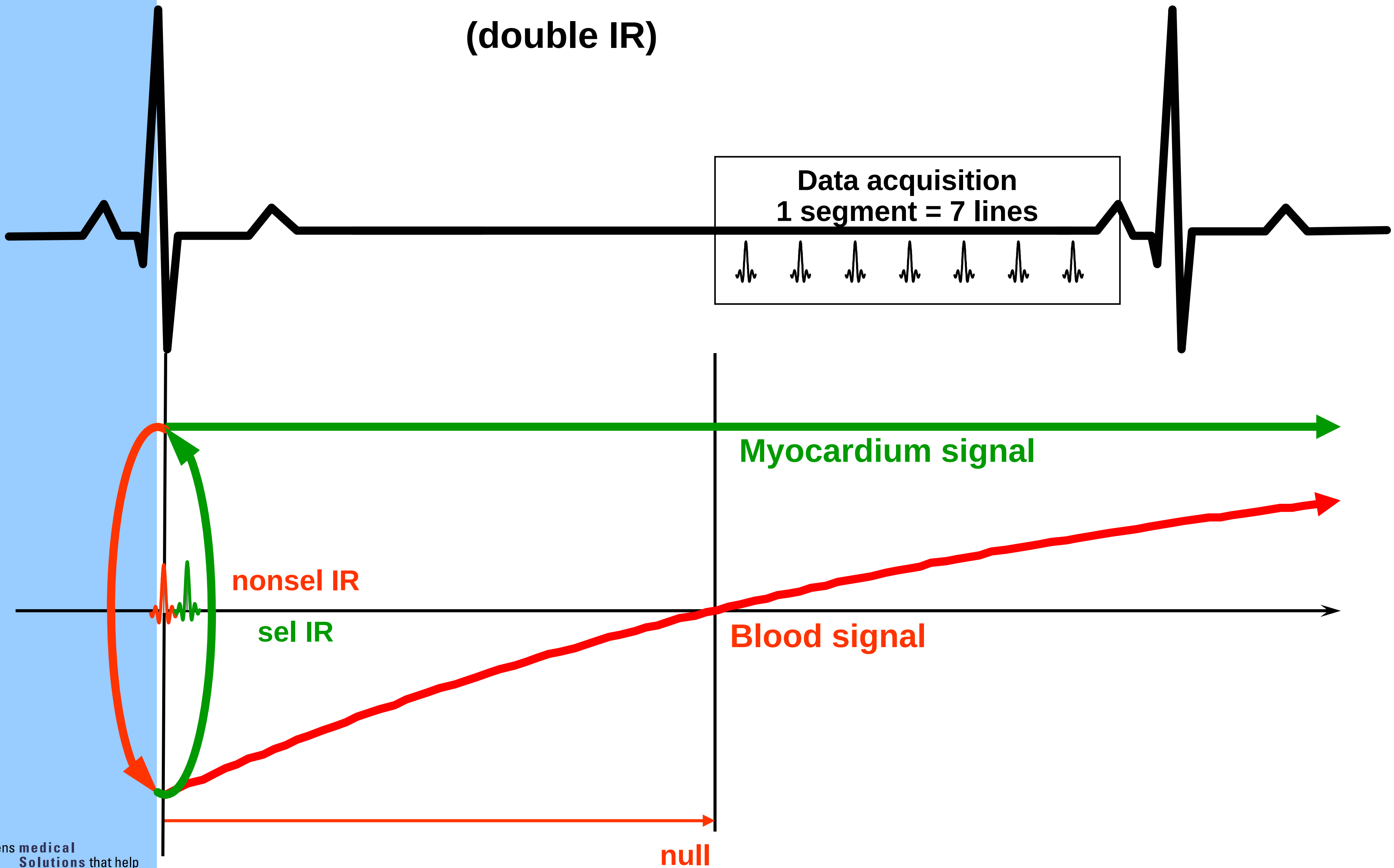
R-wave (end-diastole) | Systole | Late diastole

= non-selective inversion

= slice-selective “reversion”

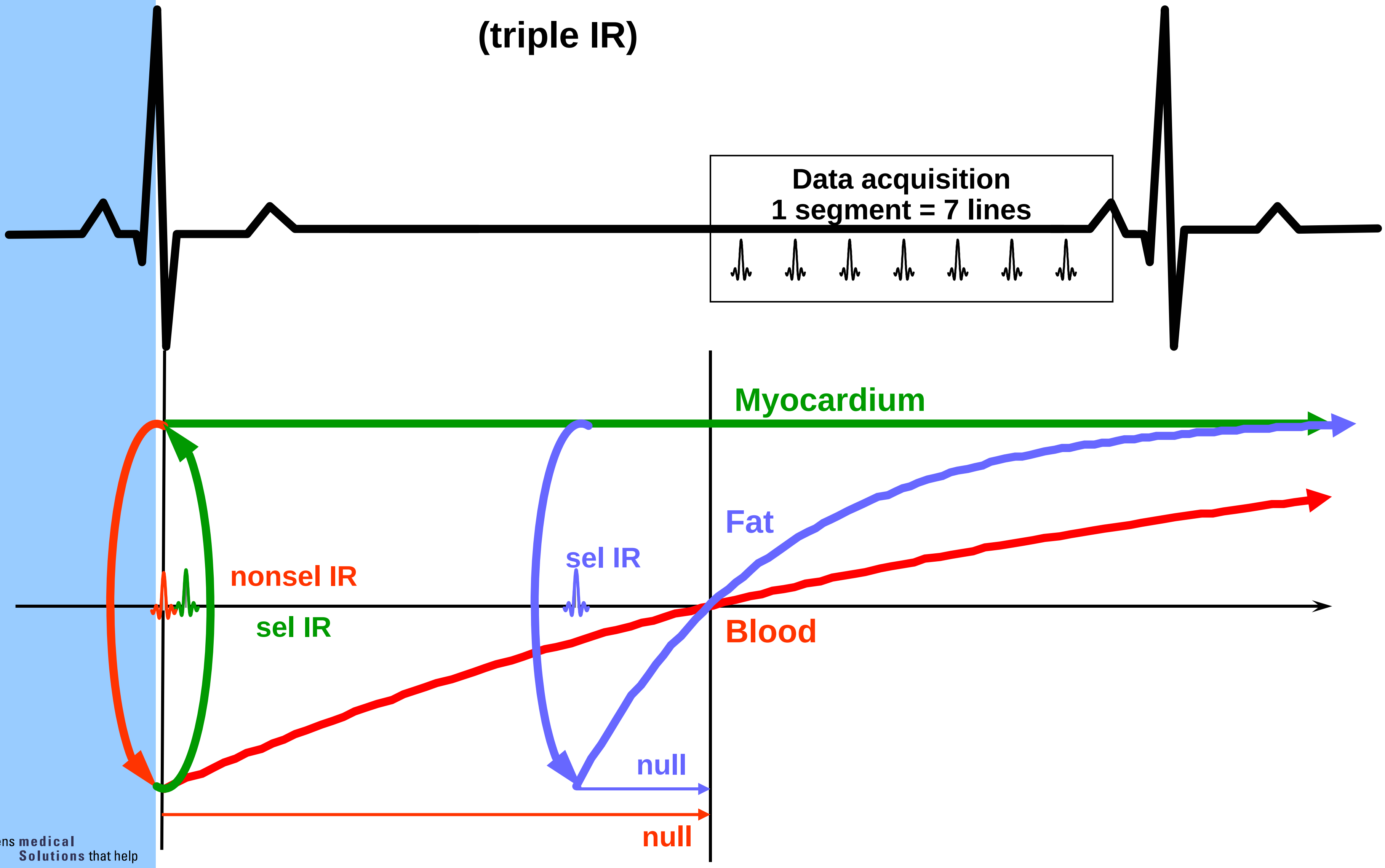
= imaged slice

Dark Blood TSE
(double IR)

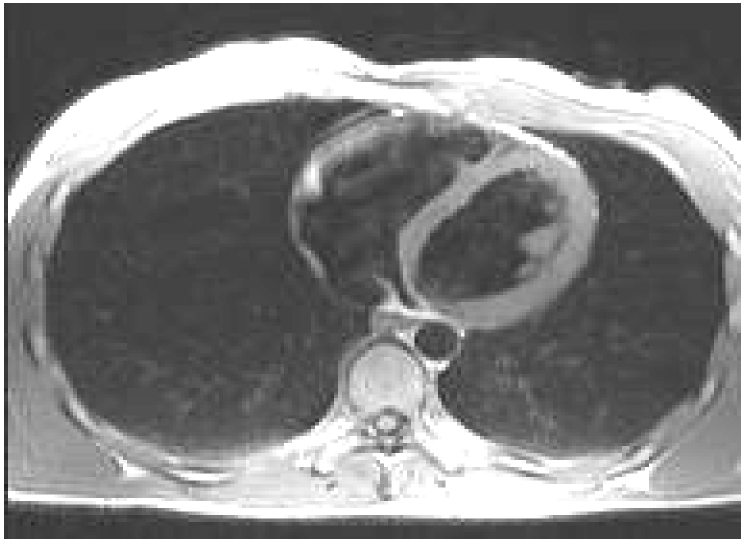


Dark Blood STIR

(triple IR)

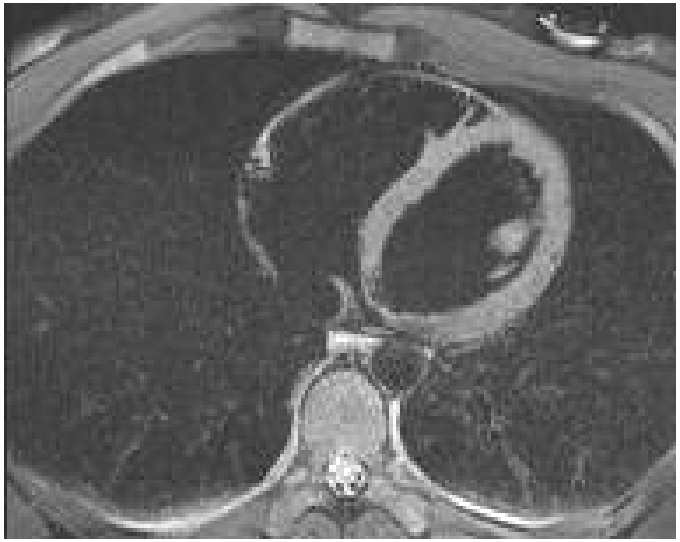


Dark Blood TSE

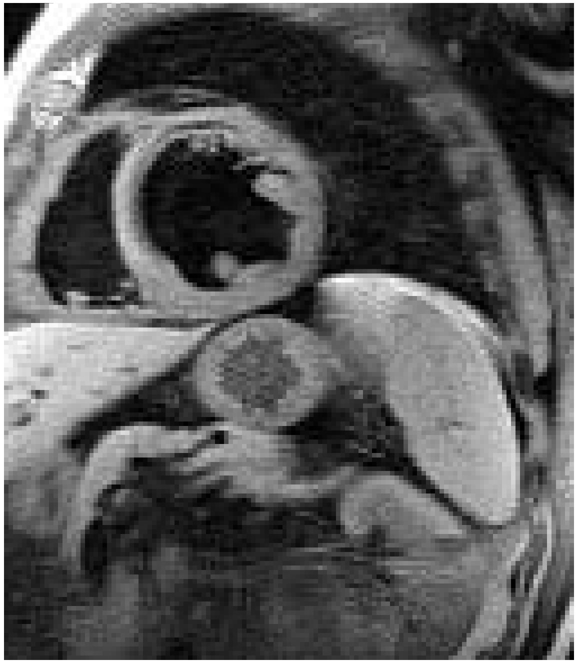


blood nulled

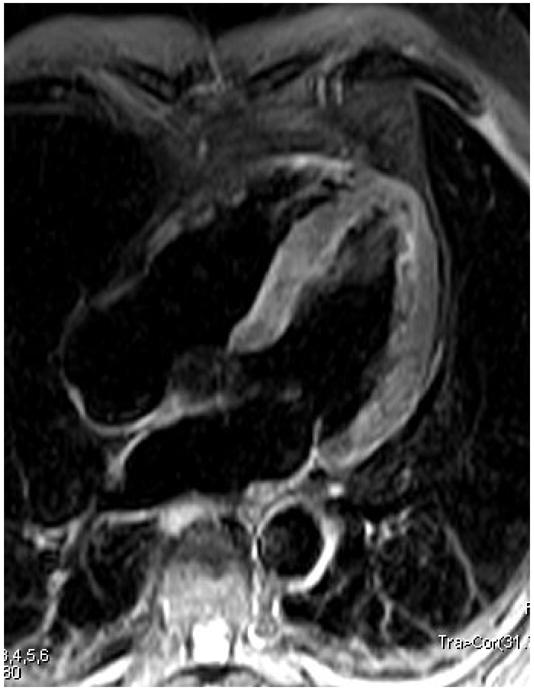
Dark Blood STIR



blood + fat nulled

Dark Blood TSE	Dark Blood STIR
	
blood nulled	blood + fat nulled

Dark Blood TSE T2 Fatsat



blood + fat nulled

Dark Blood STIR

blood + fat nulled

What if Segmented Breath Hold Fails ?

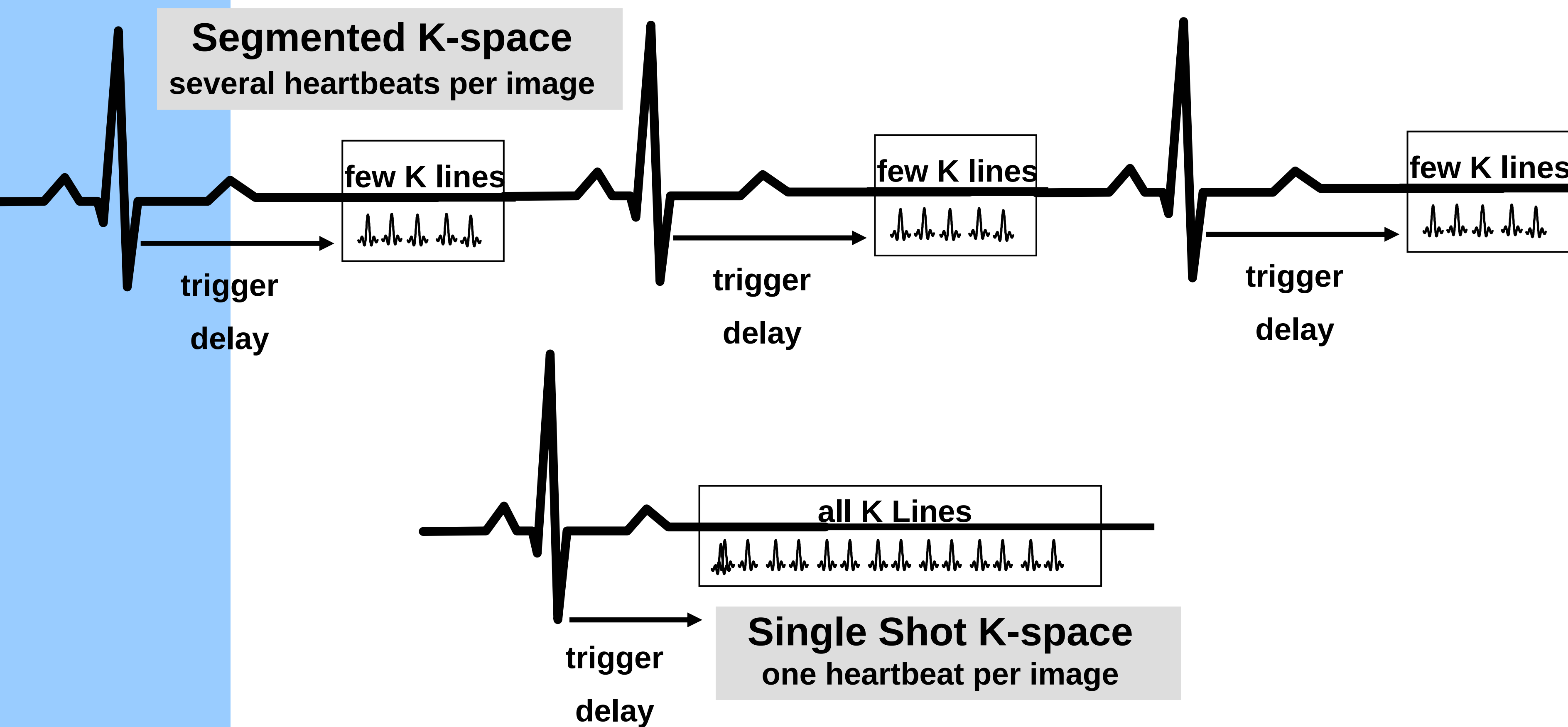
Use Single Shot Free Breathing !

Breath Hold TSE
Segmented K-space
FAILED

Free Breathing HASTE
Single Shot K-space
SUCCESSFUL

Dark Blood Sequences

K-space filling



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
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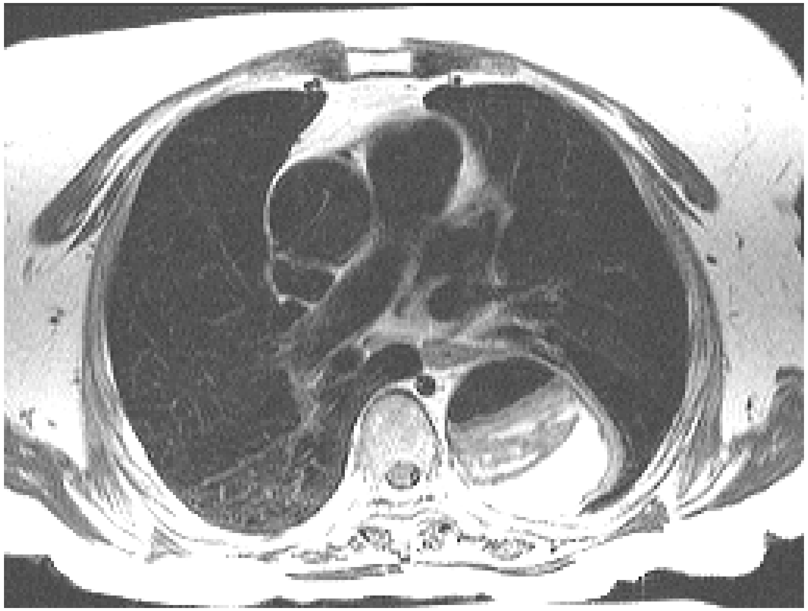
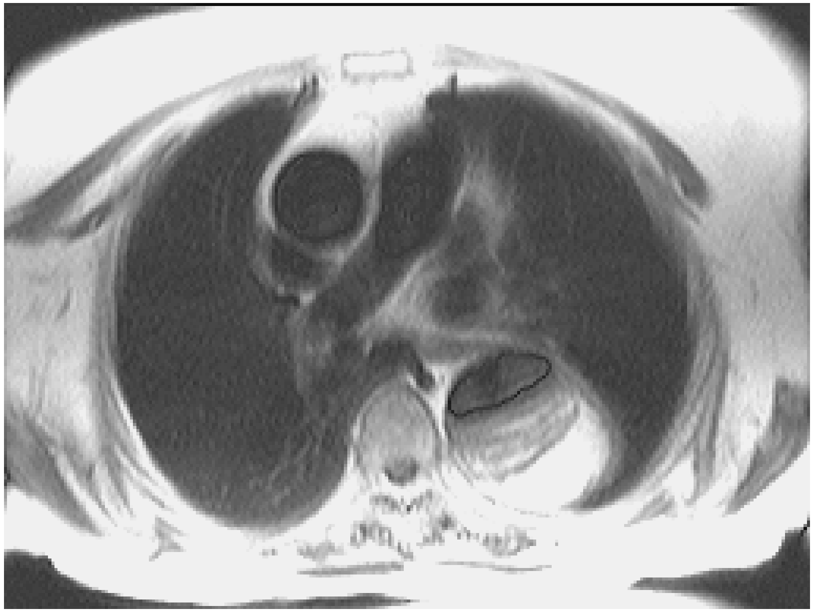
Dark Blood Morphology
K-space filling





Segmented DB TSE

8 heartbeats

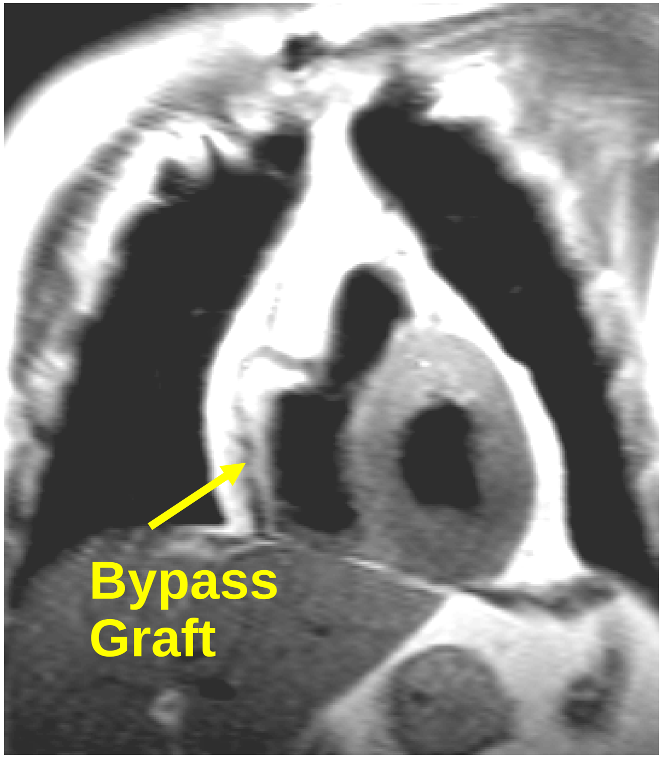
Higher spatial & temporal resolution

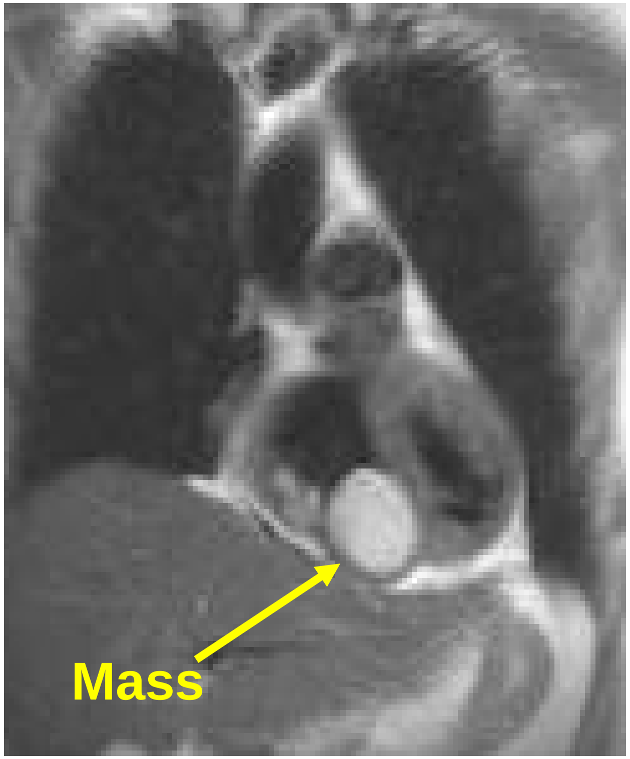
Single Shot DB HASTE

1 heartbeat

Lower spatial & temporal resolution

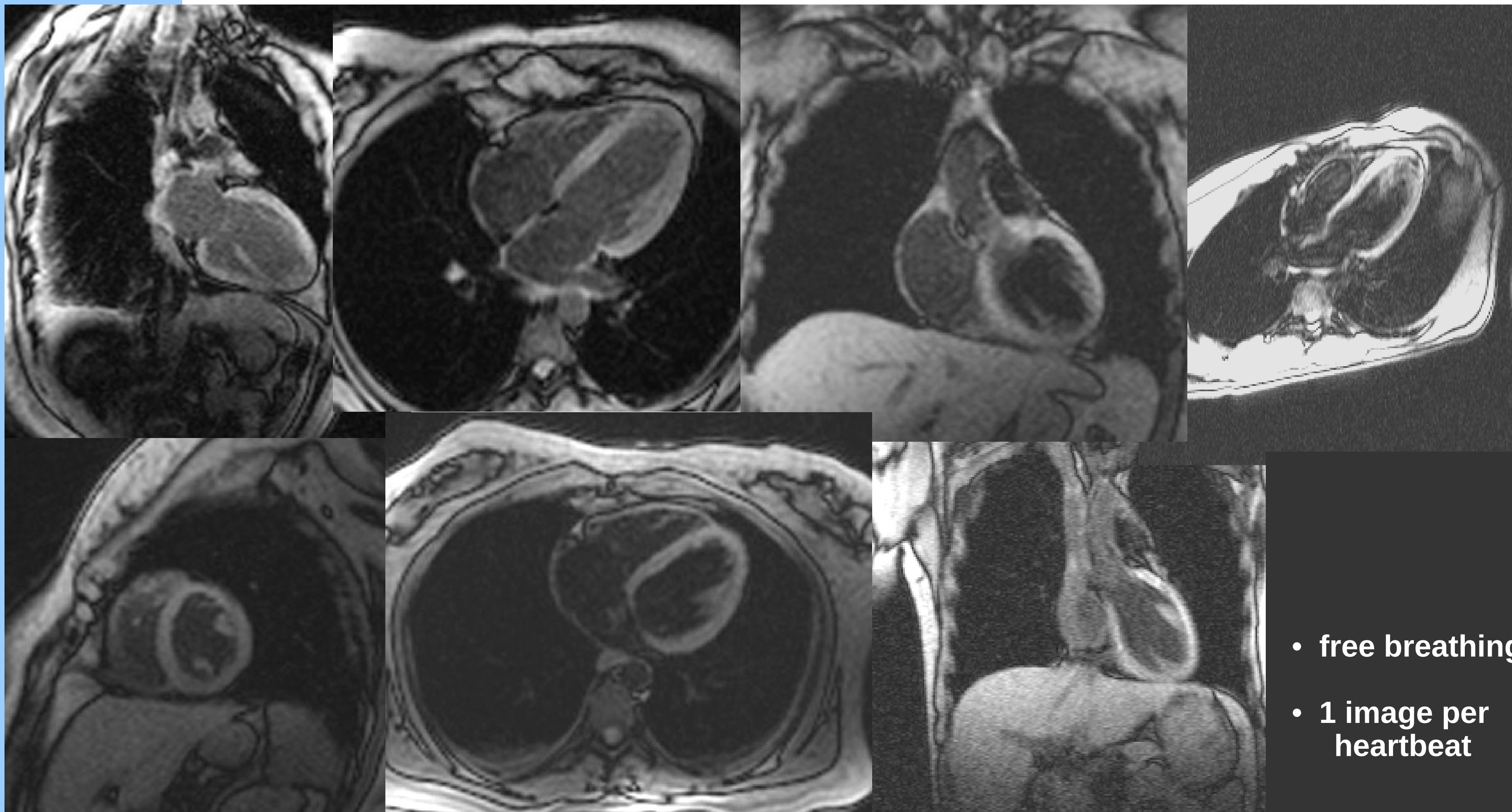
Dark Blood HASTE Single Shot





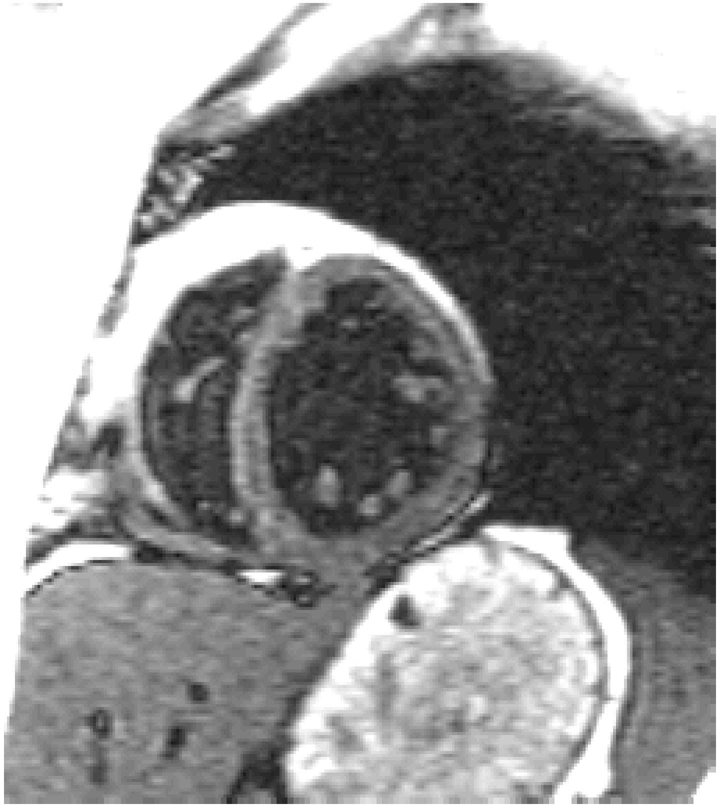
- free breathing
- 1 image per heartbeat

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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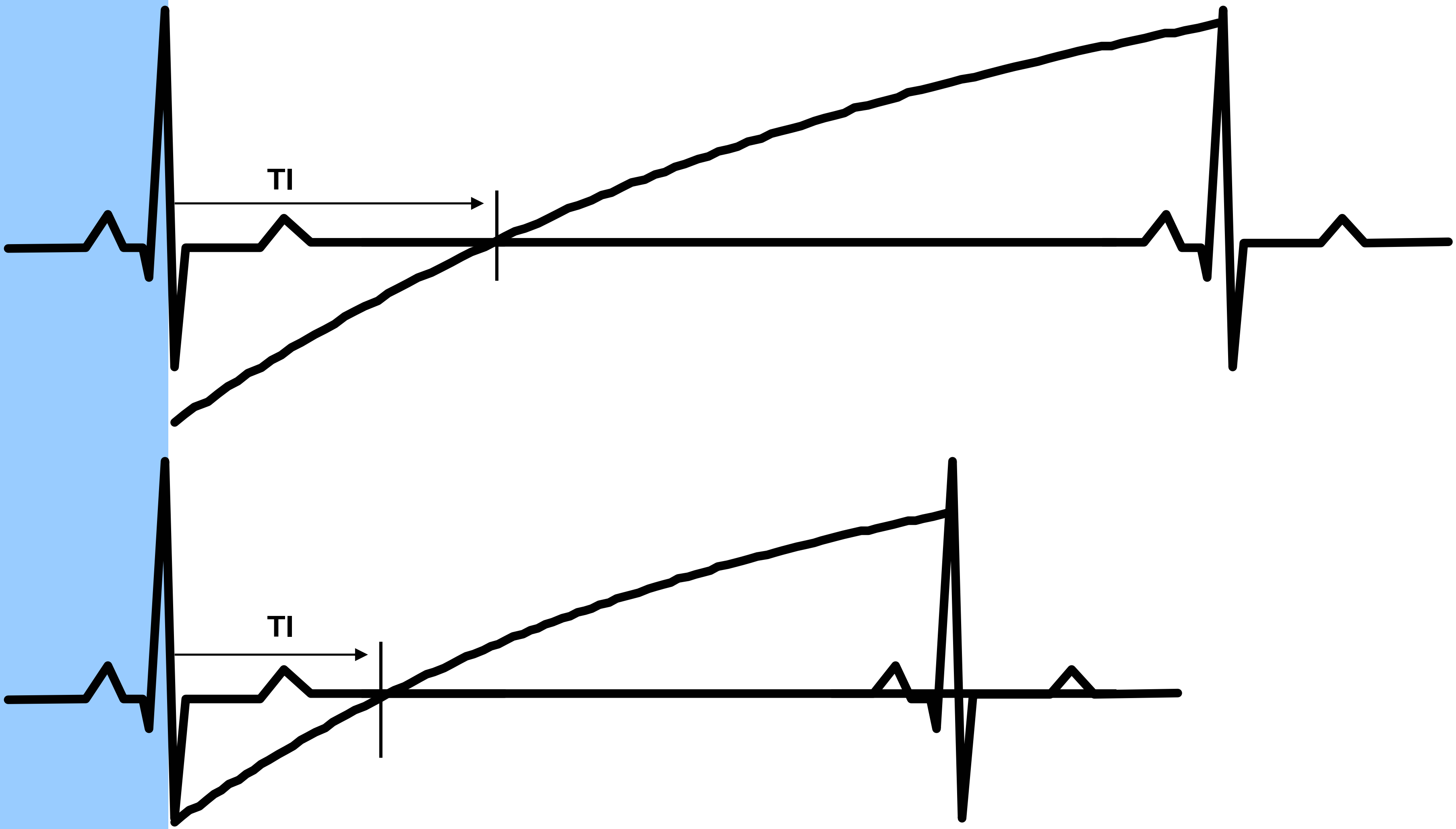
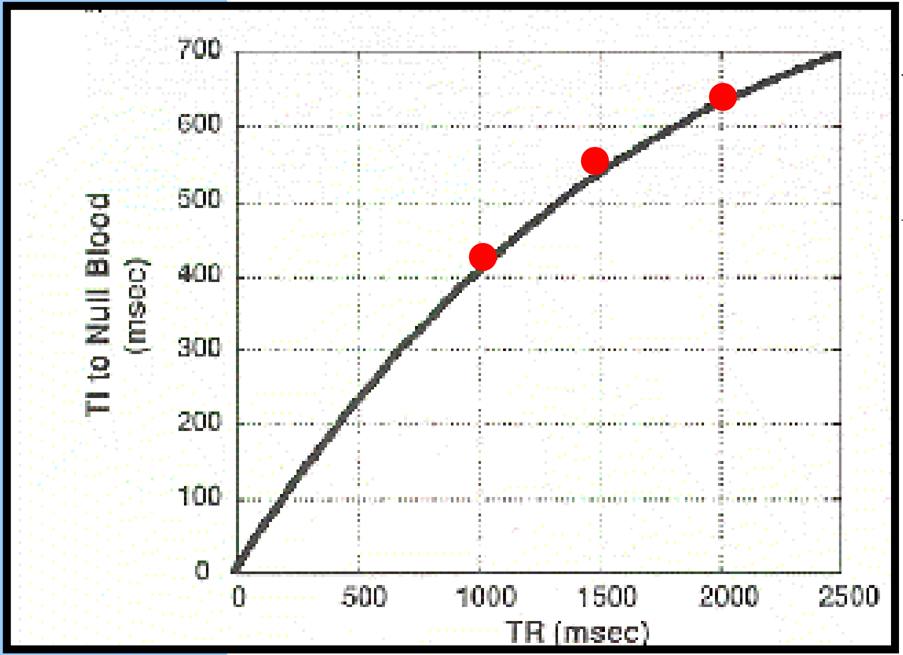
Dark Blood Optimization



Faster HR → Shorter RR → Less Recovery → Shorter TI

Dark Blood Optimization



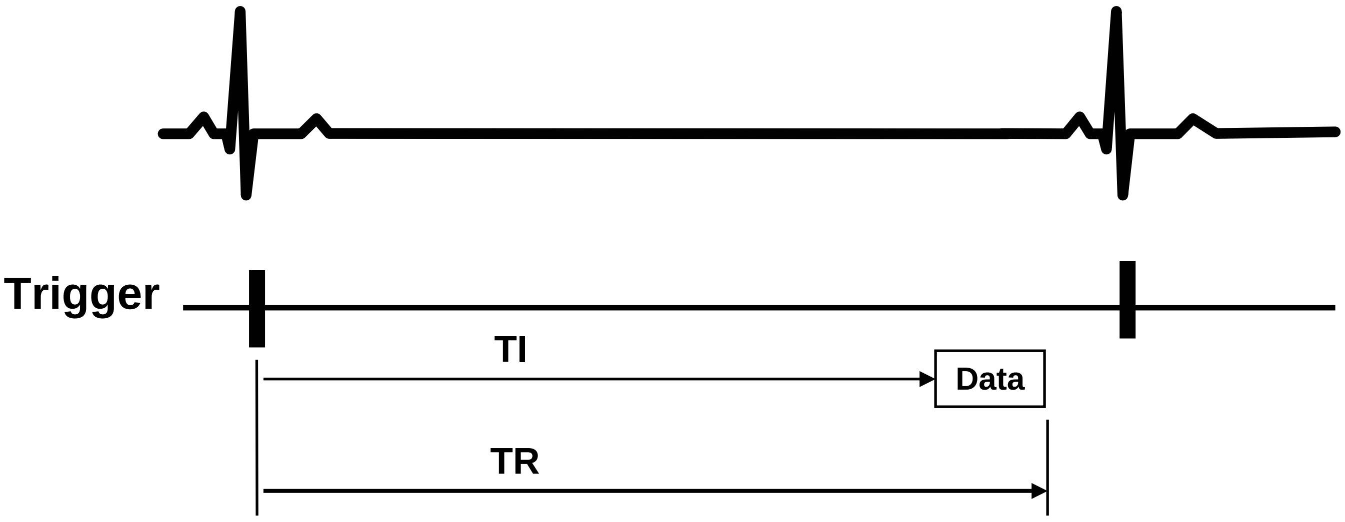
Heart Rate BPM	RR msec	TR msec	TI msec
100	600	1200	420
80	750	1500	550
60	1000	2000	630

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

Faster HR → Shorter TR → Shorter TI

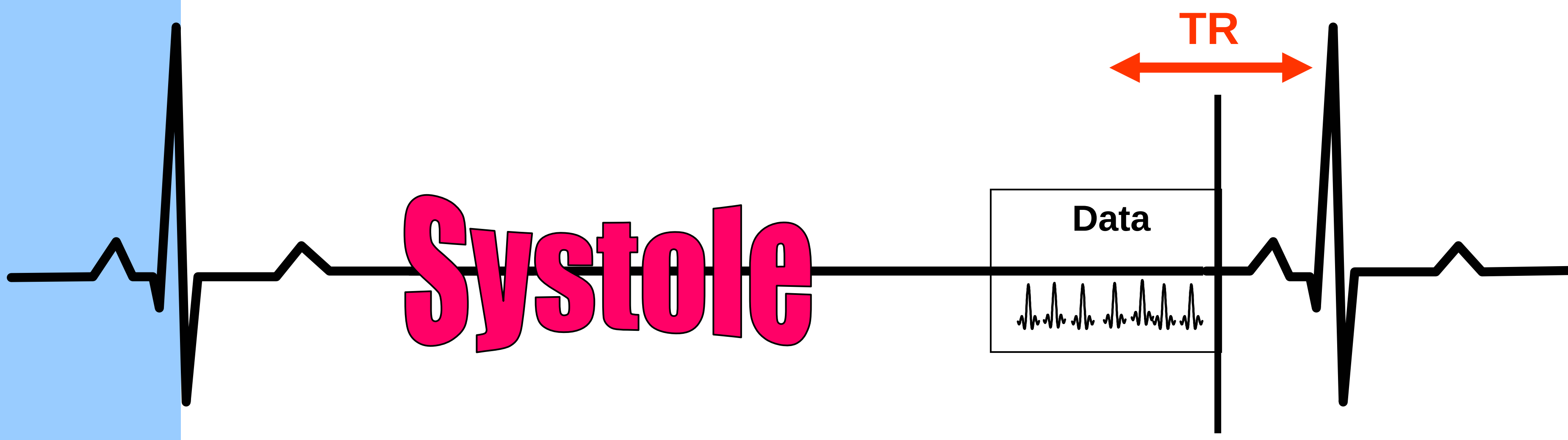
Dark Blood Optimization

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



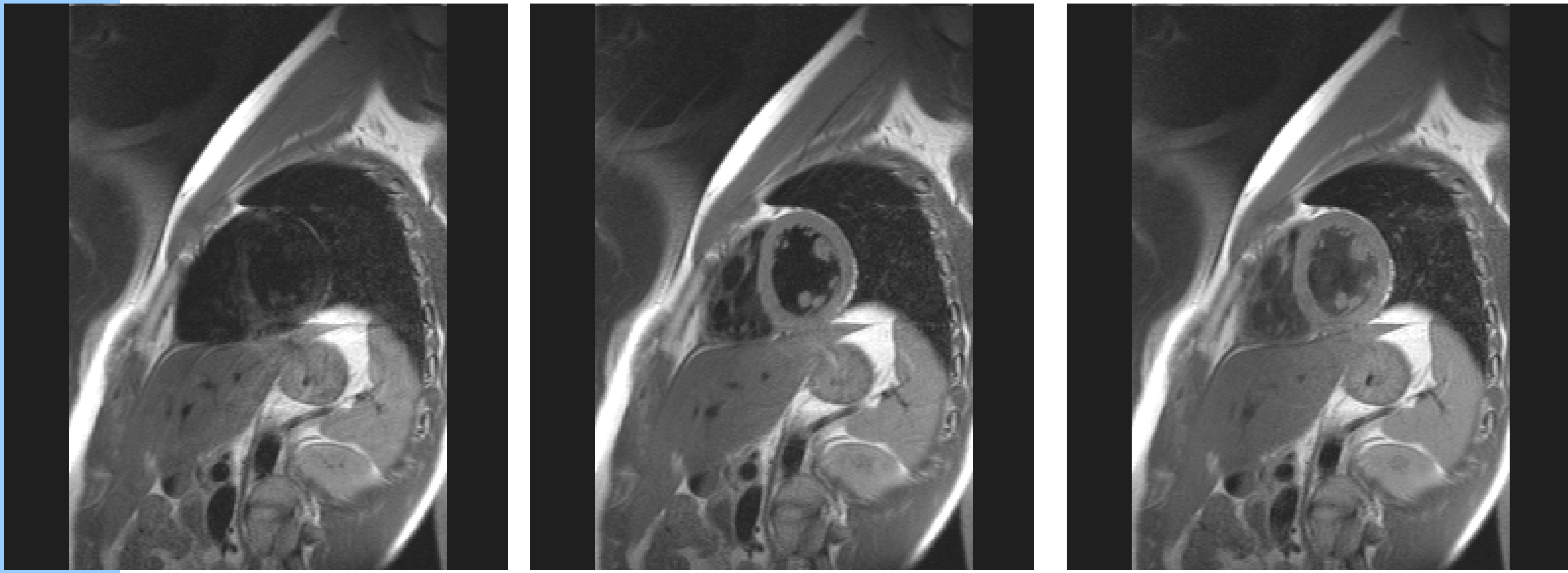
* non-conventional definition of TR

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

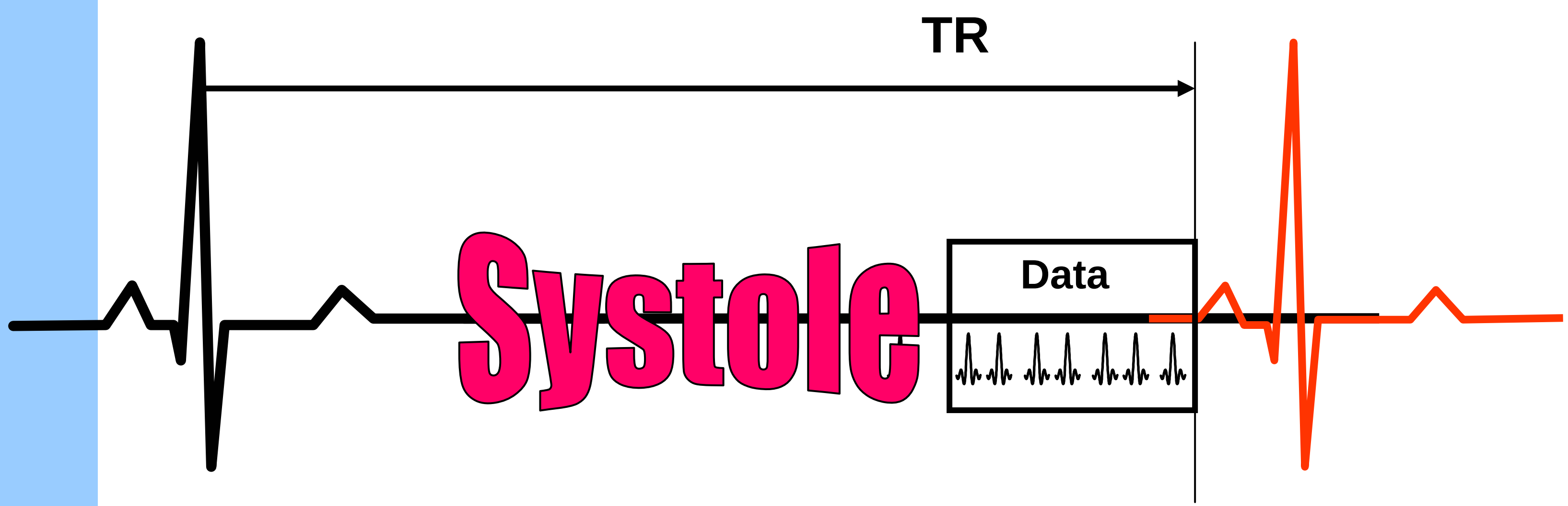
TR optimized

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



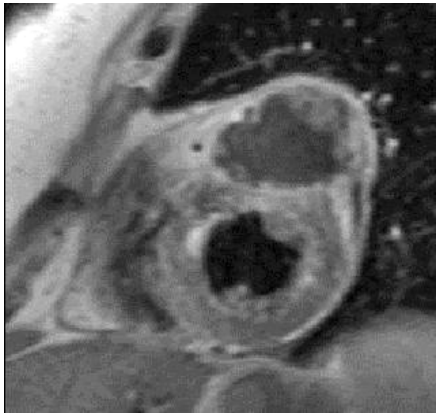
Segmented Sequence
(TSE T1, T2, STIR)

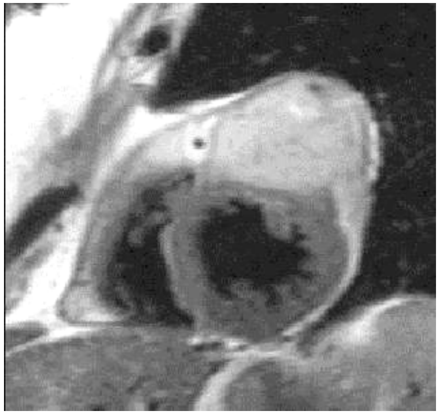
- **reduce lines/segment**
- **reduce echo spacing**
  - ➢ **increase bandwidth**
  - ➢ **fast RF & gradient pulses**

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

Siemens medical
Solutions that help