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# Cardiac MR Viability Imaging Parameters that Lead to Common Associated Image Artifacts and How to Troubleshoot Them

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# Disclosures

None

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# Introduction

- Viability magnetic resonance imaging is the standard technique for identifying myocardial infarction or scar.
- Numerous imaging parameters must be properly utilized to result in a clinically relevant exam.
- Inappropriate settings of the imaging parameters result in deteriorated image quality which can lead to incorrect or inaccurate scar assessment.
- Optimal settings of various parameters are discussed here along with the associated artifacts generated from inappropriate settings.

# Important Imaging Parameters

- Spatial resolution
- Slice thickness
- Contrast washout
- Myocardial nulling/T1 scouting
- Phase-encoding direction/data acquisition
- Orthogonal verification
- Flip angle
- Shot duration
- Breathing & High SENSE artifacts
- Fat suppression
- Acceleration factor

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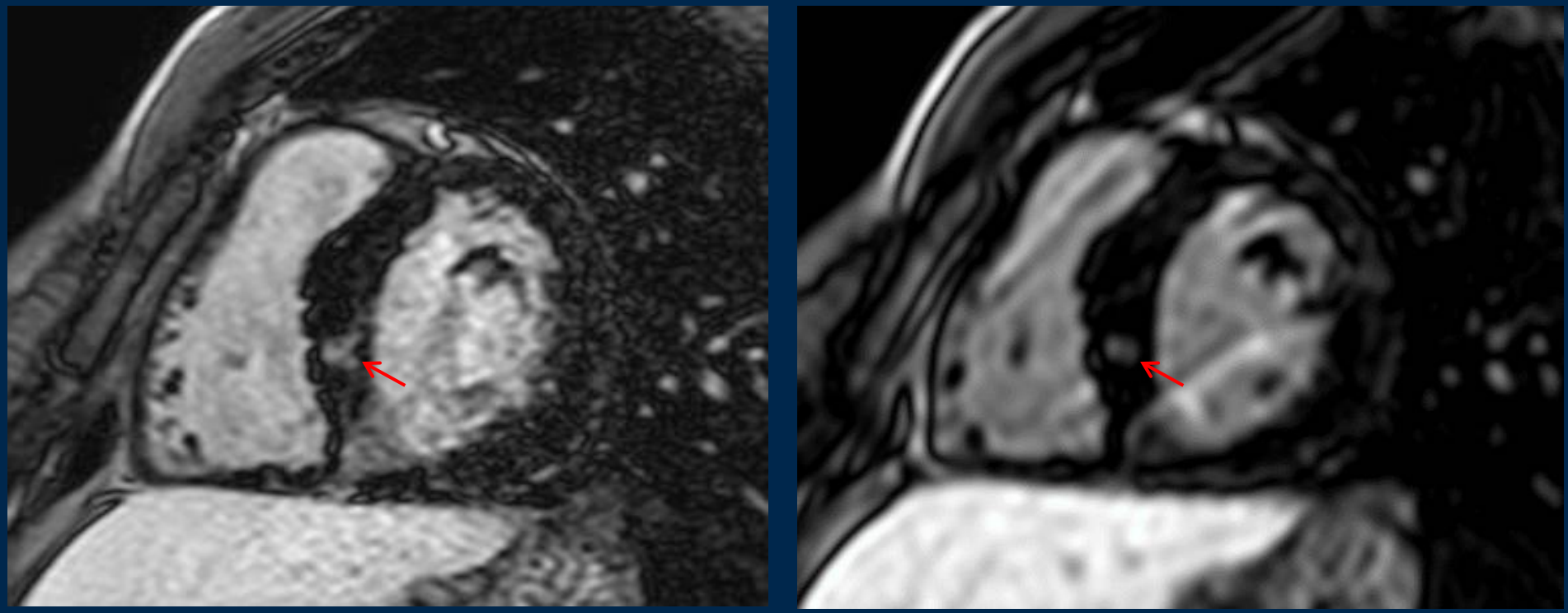
# Spatial Resolution

The spatial resolution should be sufficiently high to visualize small scars and allow for accurate measurement of their size.



Late gadolinium enhancement (LGE) images showing a small scar (arrow). The high-resolution image on the left shows exact shape and size of the scar. The image on the right has low spatial resolution, which results in inaccurate determination of the scar's shape and size.

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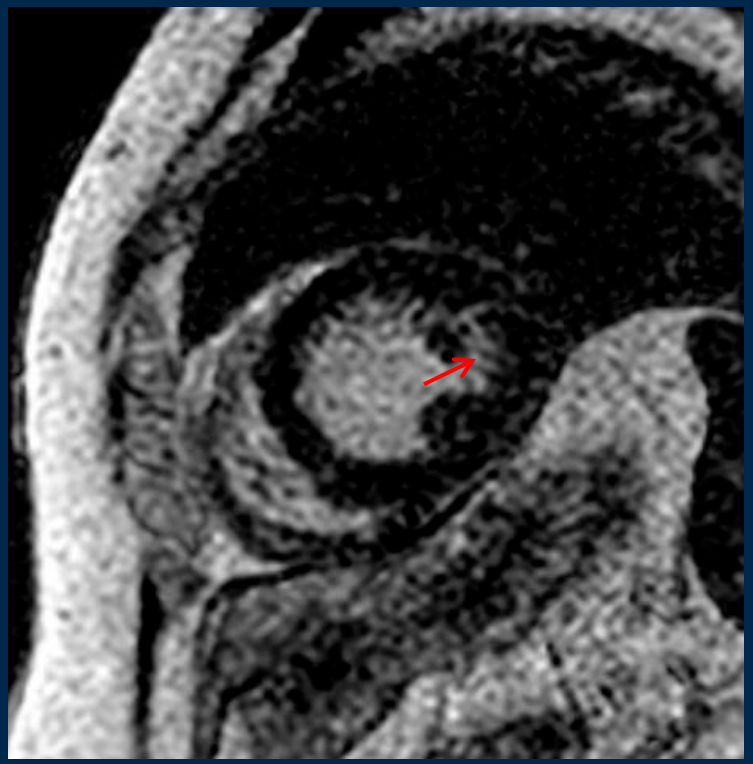
# Slice Thickness

Setting slice thickness too high results in partial volume artifacts that smoothes out fine details in the image, including small scars.



Slice thickness is set to 16 mm (left) and 8 mm (right). Although the image on the left has higher signal-to-noise ratio (i.e. better image quality), fine details are smoothed out due to partial volume averaging (e.g. see the difference near the endocardial septal wall in both images; arrows).

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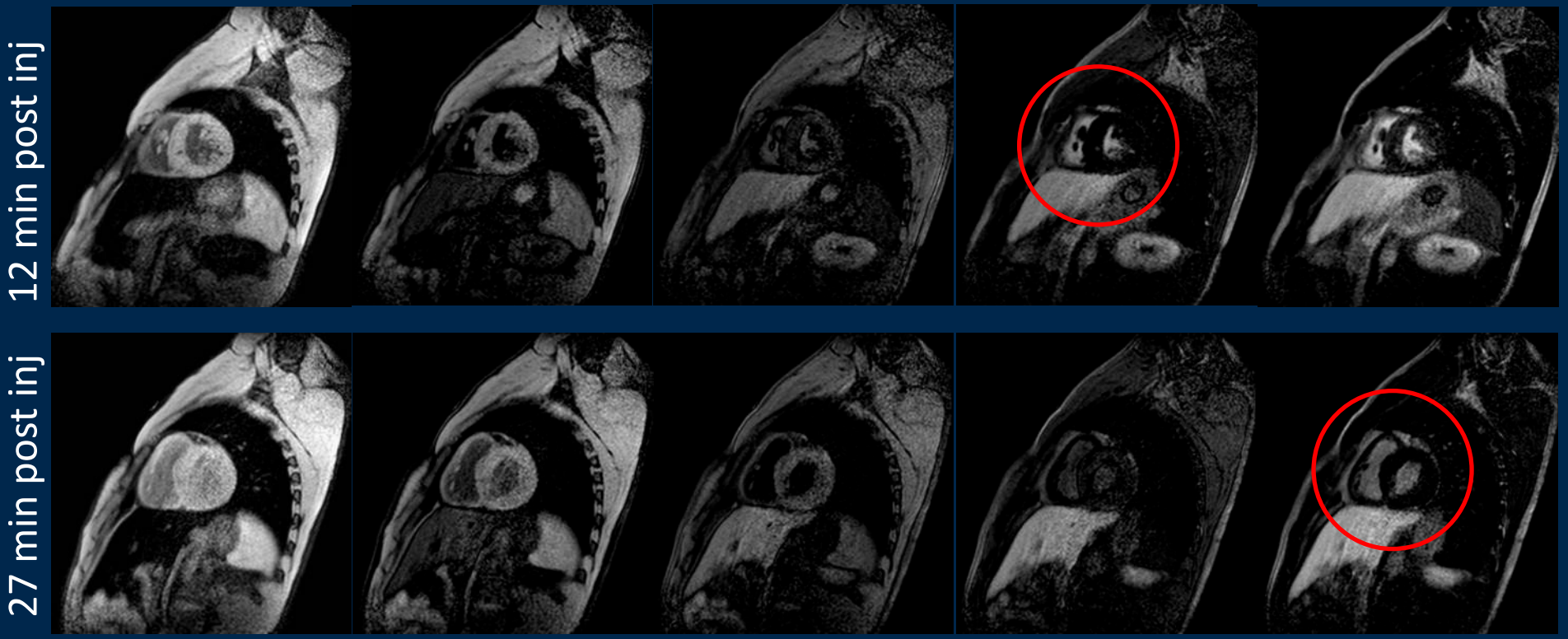
# Contrast Washout after Injection

Optimal TI changes with time after injection due to washout of the contrast material. Therefore, TI scouting is needed every few minutes to assure optimal scar-myocardium contrast.




A series of images with different TI acquired 12 min (top) and 27 min (bottom) after contrast injection. Optimal TI is different based on time after injection (red circles) at ~ 270 ms (top) and 360 ms (bottom).

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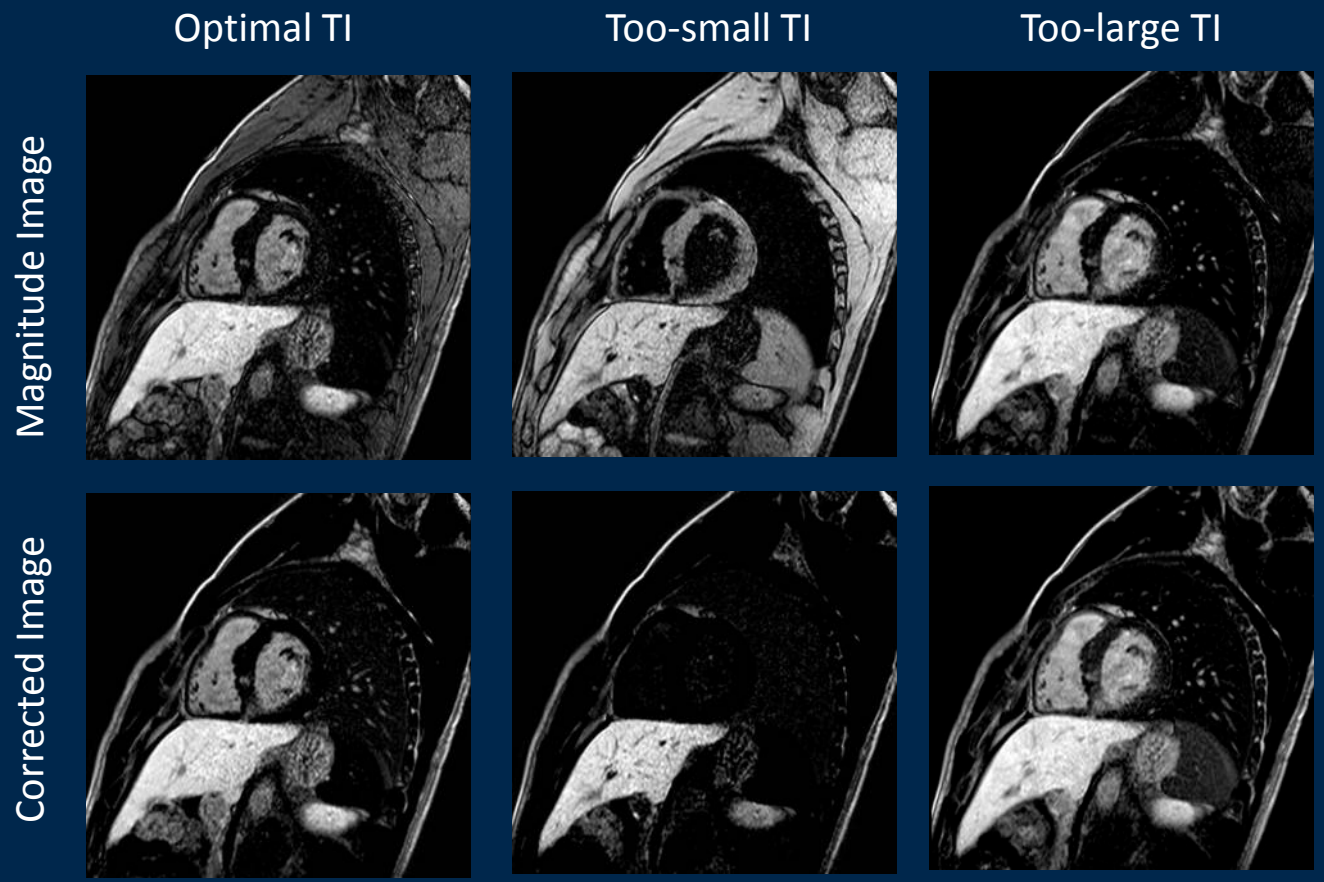
# Nulling the Myocardial Signal

For accurate identification of the scar tissue, the scar-myocardium contrast has to be optimized by nulling the myocardial signal. This is achieved through appropriate selection of the inversion time, TI.




Correct TI results in optimal scar-myocardium contrast. Too-small TI results in incorrect contrast. Too-large TI results in reduced contrast. The corrected images (2nd row) cannot correct for large TI deviation.

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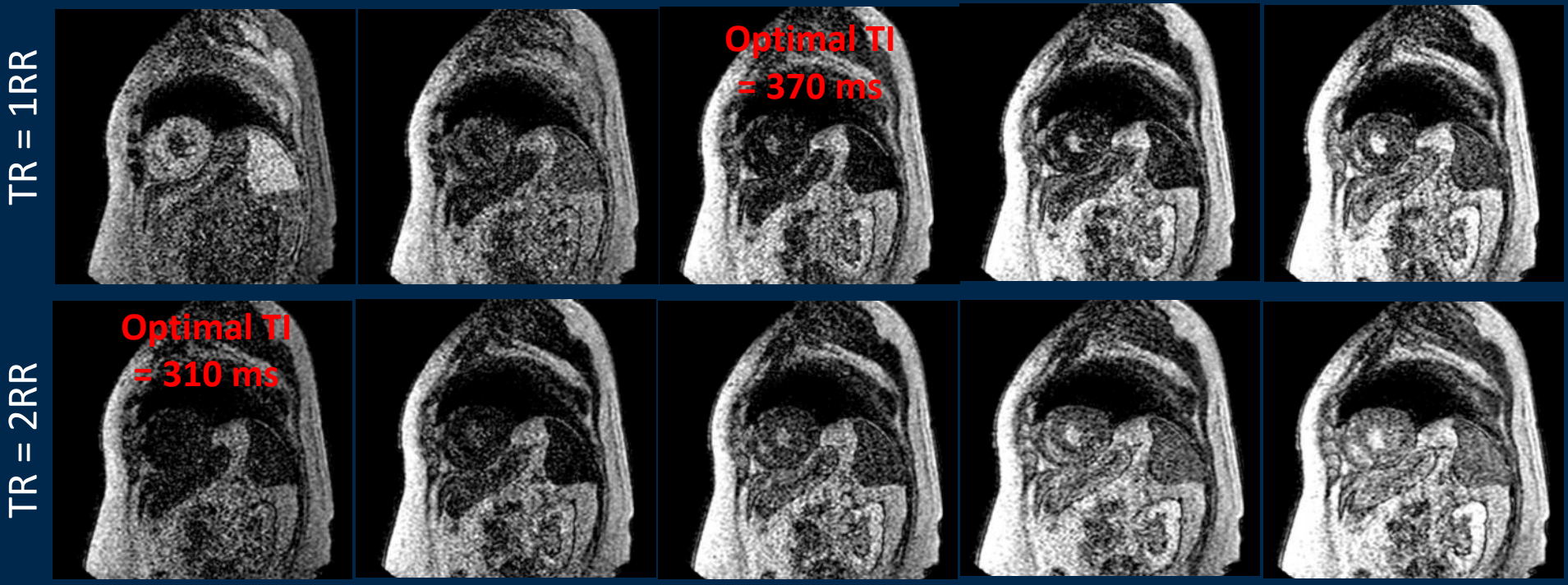
# TI Scouting:

## every / every-other breath-hold

In TI scouting, TR should be set the same as it will be used in the delayed enhancement scan; otherwise, incorrect TI will be used.




Two Look-Locker sequences acquired with TR = 1RR on top; TR=2RR on bottom. Note change in optimal TI based on TR setting. Therefore, the same TR should be used in TI scouting (Look-Locker) and LGE imaging (*Please note that the low SNR in the images is typical of the fast-acquisition TI scouting, as the images are not used for diagnosis*).

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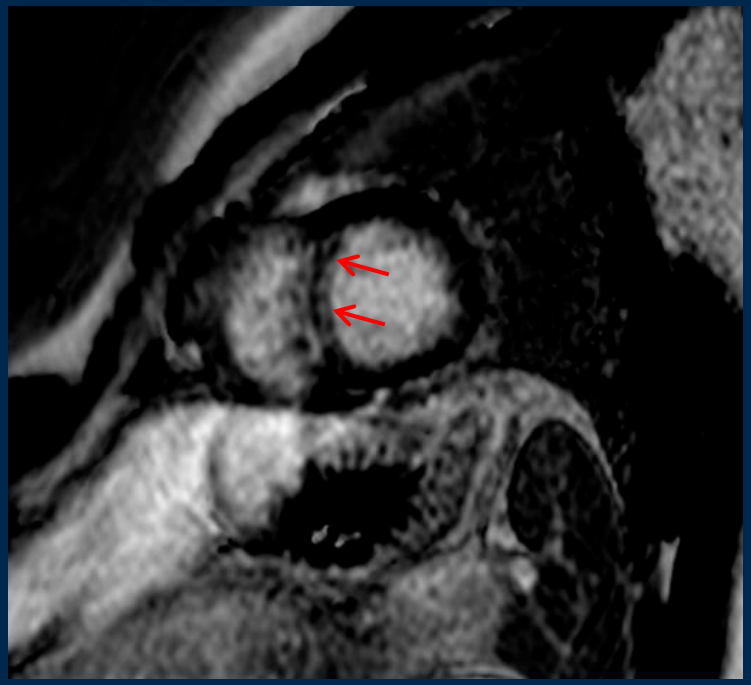
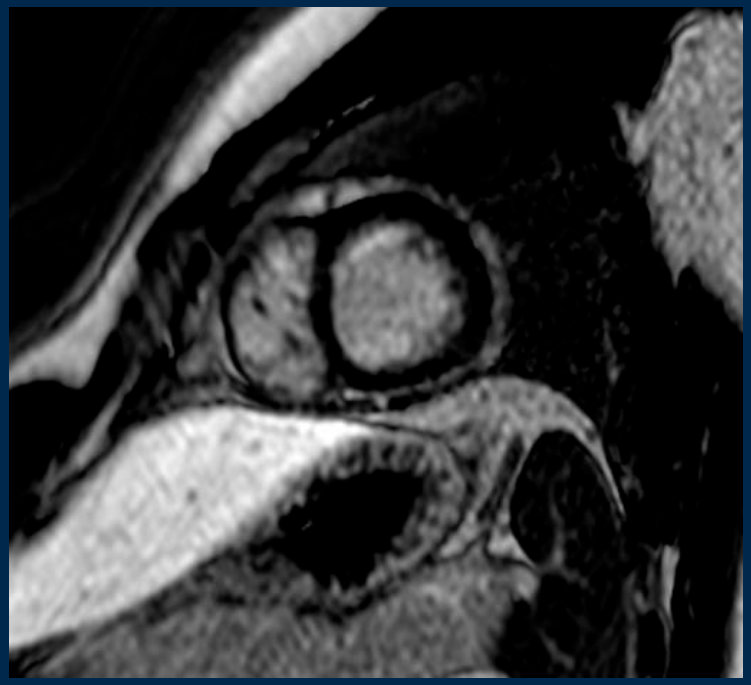
# Phase-Encoding Direction

In the case of small regions of apparent increased signal, these could be due image artifacts.

Re-acquire with swapped phase-encoding direction





Late gadolinium enhancement (LGE) images on the left shows a small region of increased signal (arrows).

For confirmation, the image is re-acquired with the phase-encoding direction swapped. Increased signal was in fact **NOT** a scar.

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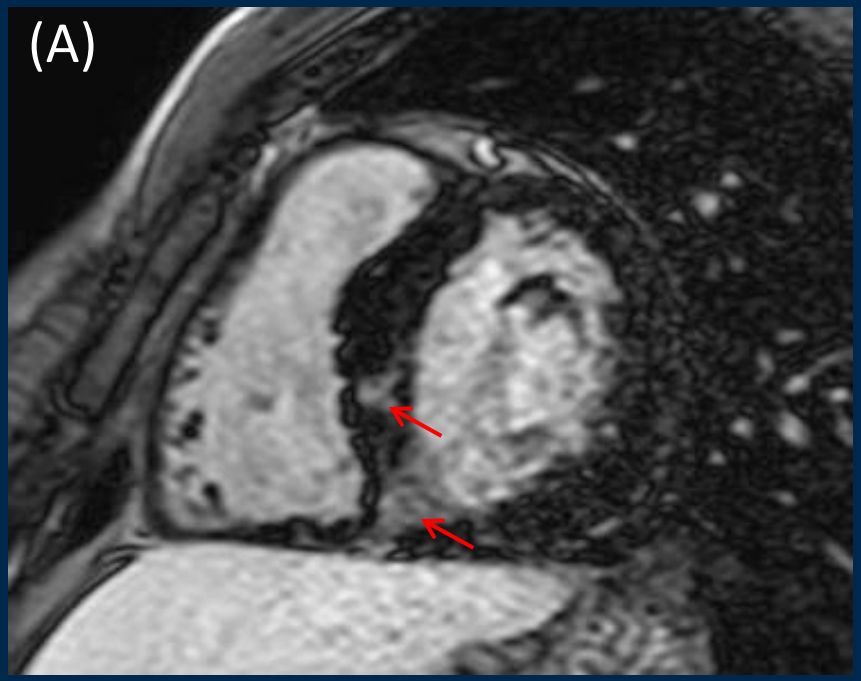
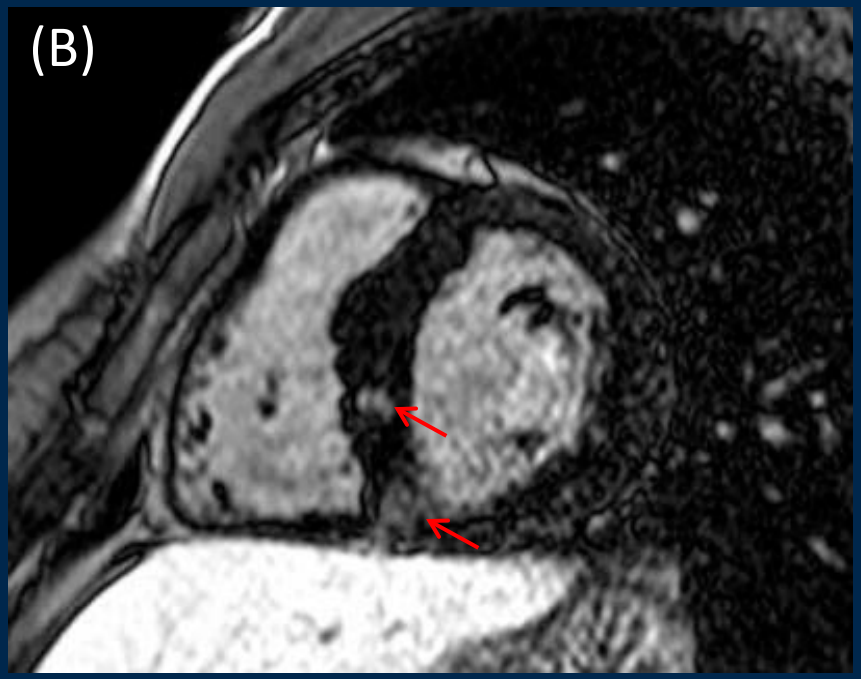
# Data Acquisition Strategy

Changing the phase-encoding direction moves the acquisition artifacts to the opposite direction in the image. For small scars, it is important to acquire the image with a swapped phase-encoding direction to confirm that the observed bright signal represents a scar; not an image artifact.




When the phase-encoding direction is changed from left-right (A) to superior-inferior (B), this results in slight change in shape of the enhanced areas (arrows). This helps differentiate real scar from acquisition artifacts.

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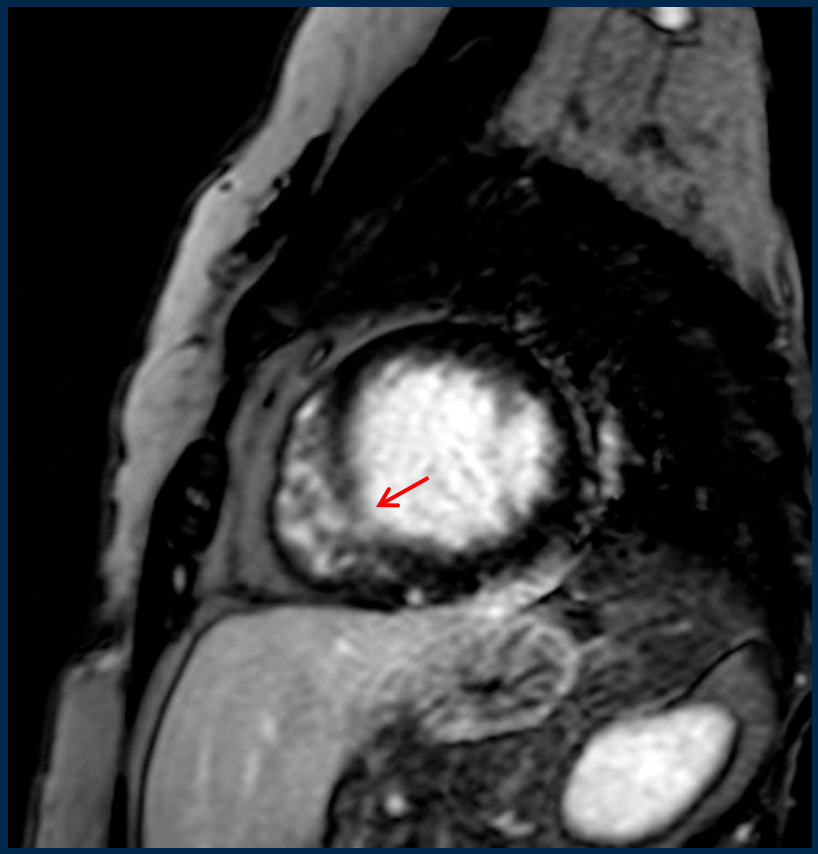
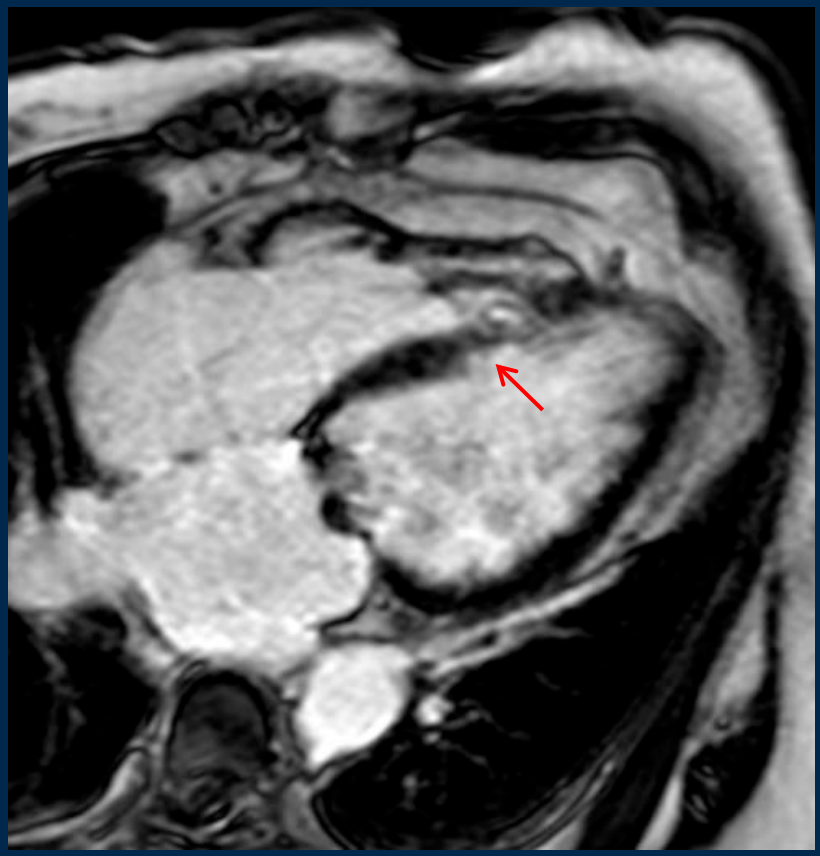
# Verification from Orthogonal Views

Small scars should be confirmed by acquiring orthogonal images through the suspected scar to confirm it is not an artifact.





The small region of signal hyperenhancement on the short-axis image on the left (arrow) is confirmed by acquiring a four-chamber image at the same level on the right (arrow).

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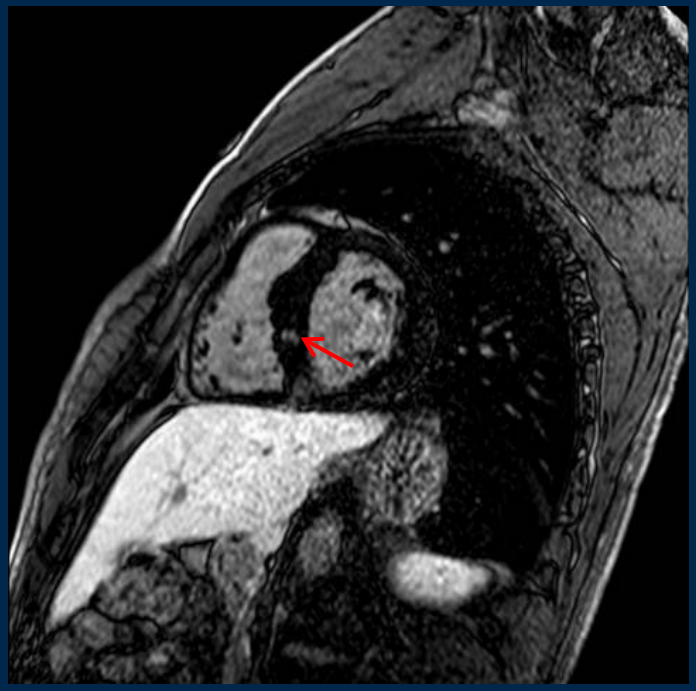
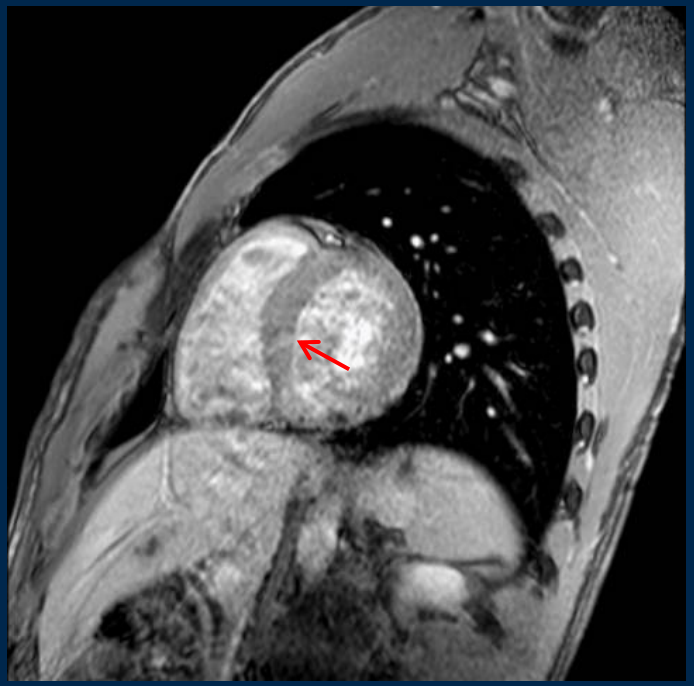
# Preparation Flip Angle

Optimal scar-myocardium contrast depends on the inversion flip angle. Angles < 180° result in reduced contrast; but may be useful in the case of severe arrhythmia.





Late gadolinium enhancement (LGE) images acquired with the same inversion time (TI); but with different preparation flip angle (180° inversion recovery pulse on the left, and 90° saturation recovery pulse on the right). Note the diminished scar-myocardium contrast on the right (arrow).

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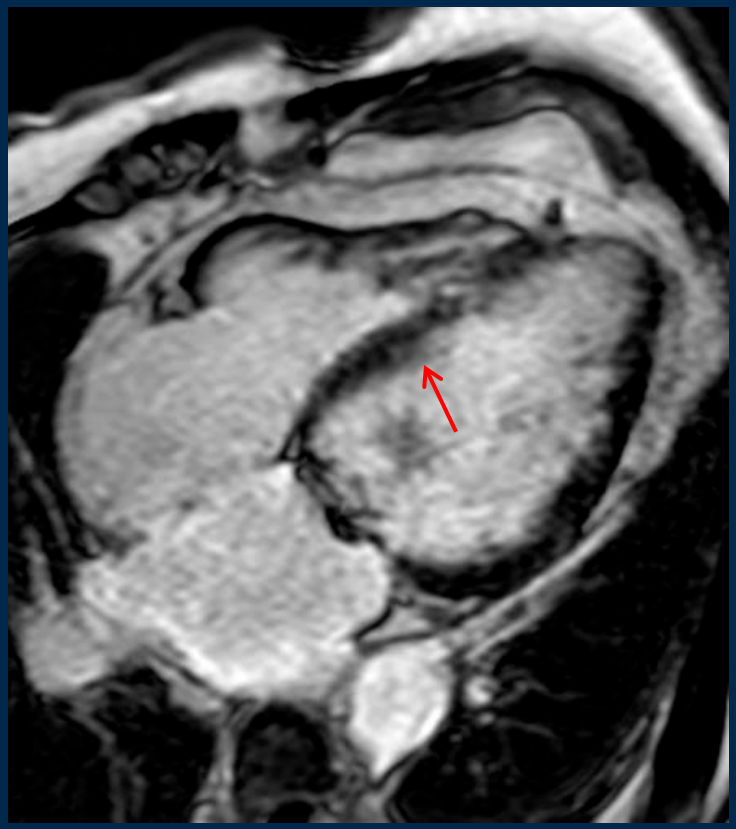
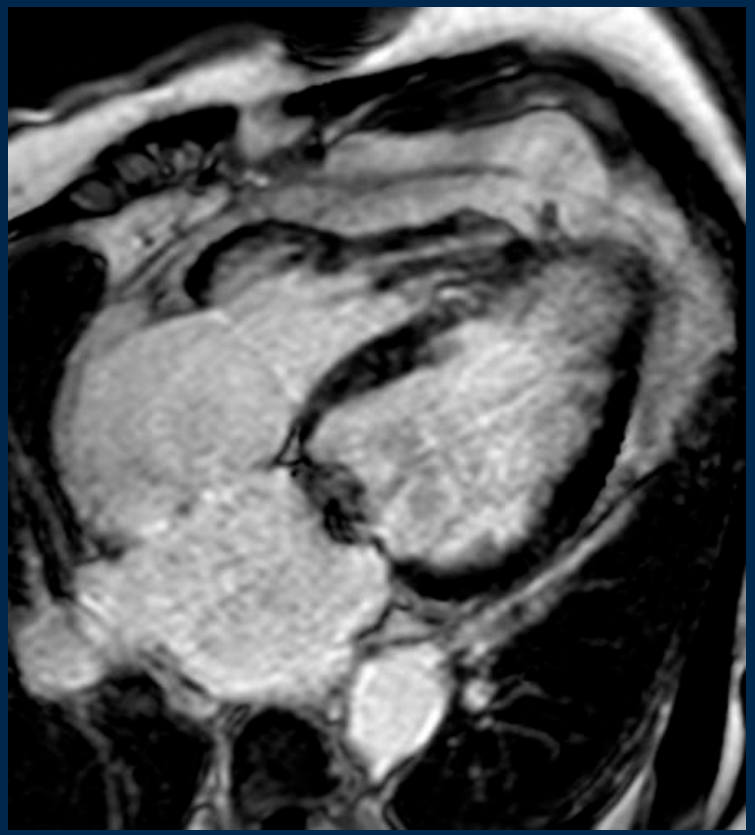
# Shot Duration

Shot duration should not be too large to avoid image blurring and motion artifacts.





The left image has shot duration = 200 ms, which results in blurred myocardial boundaries (arrow) compared to the image on the right acquired with shot duration = 120 ms during minimal heart motion.

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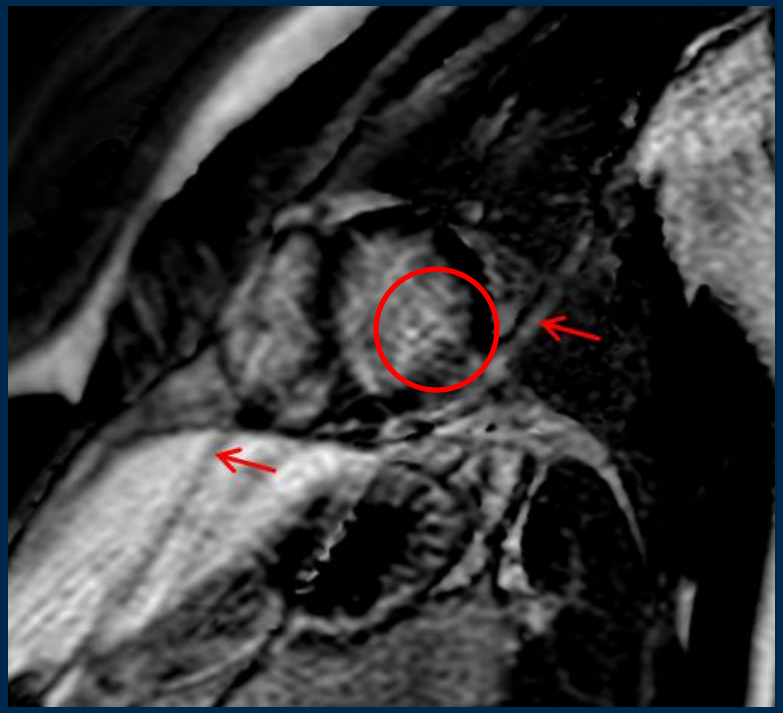
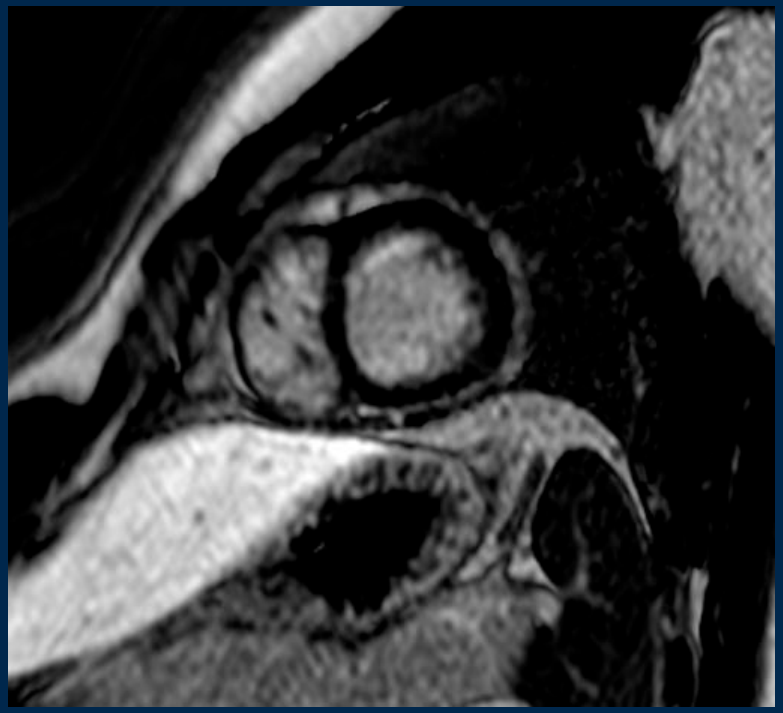
# Breathing / High SENSE Artifacts

Breathing results in motion artifacts, while high acceleration rate (SENSE) results in fold-over artifacts; both deteriorate the image quality and could introduce scar mimics.





Late gadolinium enhancement (LGE) image on the left shows breathing (left arrow) and high acceleration rate (right arrow) artifacts, which obscure the anatomy and produce scar mimics (circle).

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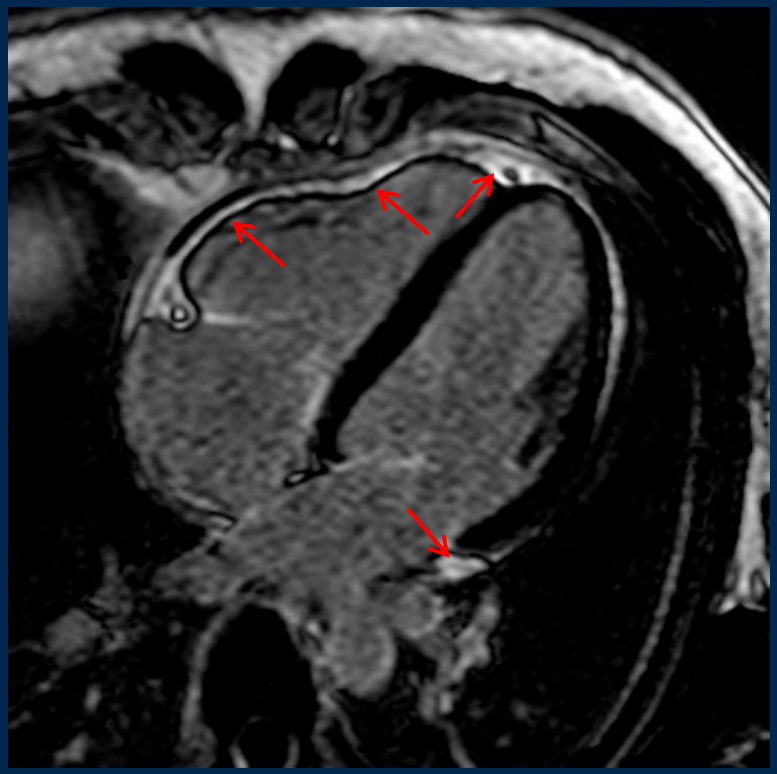
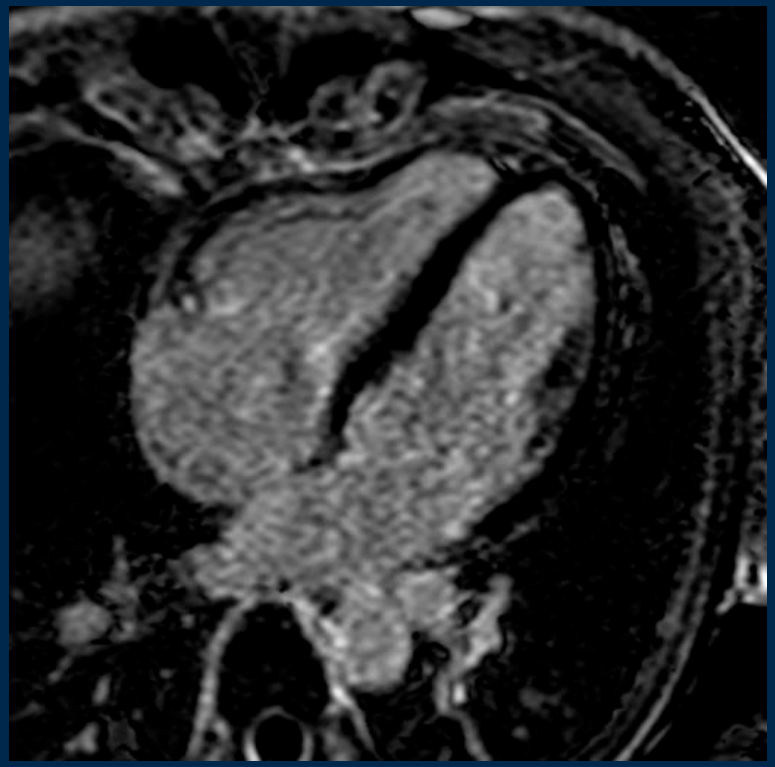
# Fat Suppression

Fat saturation results in better myocardial visualization and scar evaluation.





Late gadolinium enhancement (LGE) image on the left is acquired without fat suppression, which results in increased signal from fat tissues (arrows). The image on the right is acquired with fat suppression for better myocardial visualization and scar evaluation.

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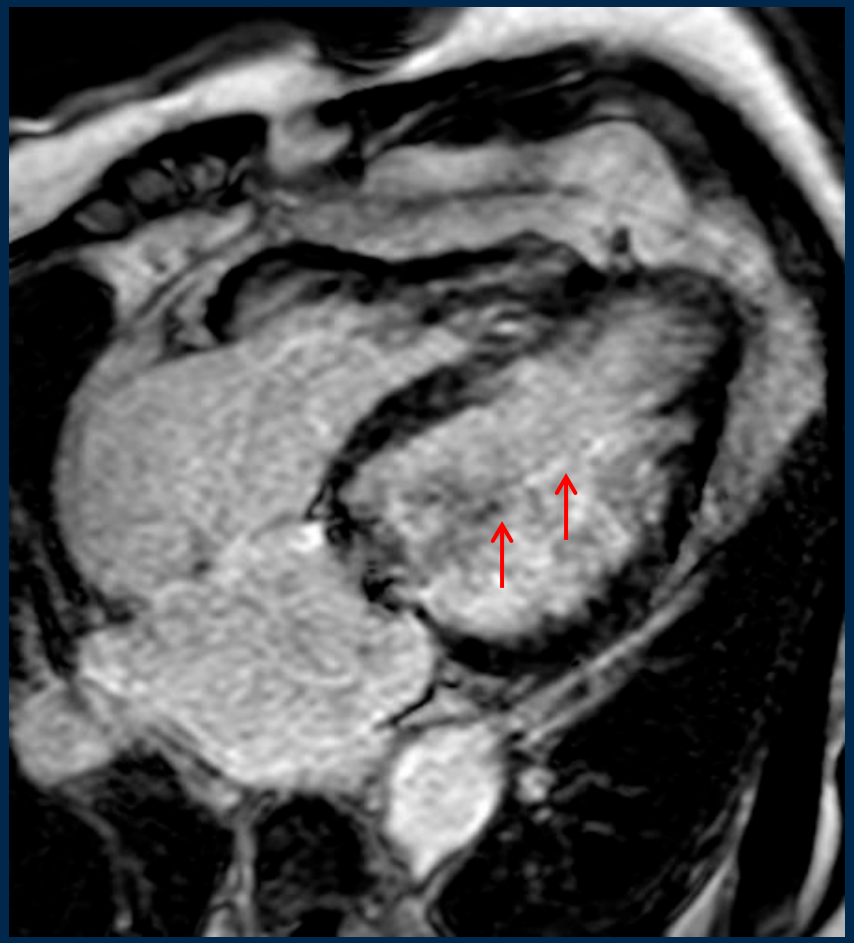
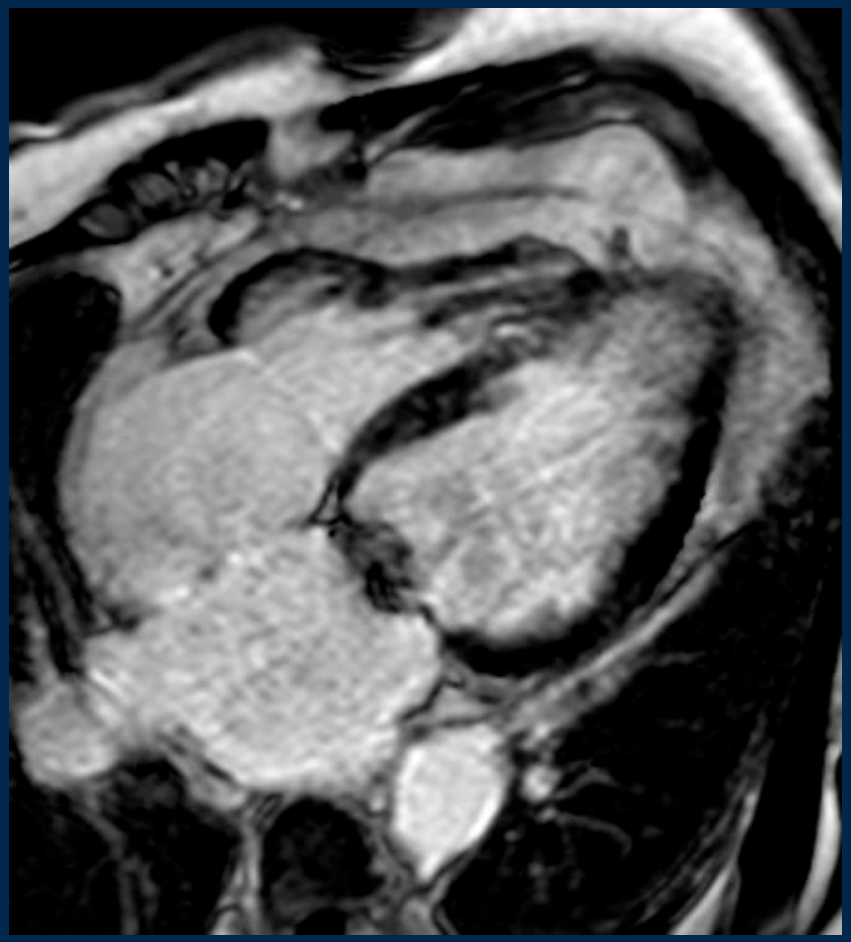
# Acceleration Factor

Acceleration factor should not be too high to avoid fold-over artifacts.





The left image has SENSE factor = 3 which introduces some image artifacts (arrows) compared to SENSE = 1.6 on the right.

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# Conclusions

- Optimal settings of the imaging parameters are necessary for successful viability MR imaging.
- Low spatial resolution or large slice thickness results in partial volume effect with inaccurate measurements.
- Proper TI should be selected for optimal myocardial signal nulling.
- TI scouting should be repeated every few minutes to update TI based on contrast washout.
- The same TR should be used for TI scouting and delayed-enhancement imaging.

# Conclusions (*continued*)

- Inversion recovery ($180^{o}$ flip angle) results in optimal myocardium-scar contrast.
- Recommendation for *small scars*:
  - Image should be re-acquired with swapped phase-encoding direction to confirm scar existence and exclude artifacts.
  - An orthogonal image should also be acquired to confirm scar existence.
- Shot duration should not be long to avoid image blurring.
- Acceleration factor in parallel imaging should not be set too high to avoid fold-over artifacts.

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# Thank You

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