C. Cardiac MRI: possible problems and how to avoid them

Poster No.: A-515  
Congress: ECR 2013  
Type: Invited Speaker  
Authors: E. A. Mershina; Moscow/RU  
Keywords: Cardiac, MR, Diagnostic procedure, Artifacts  
DOI: 10.1594/ecr2013/A-515

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR’s endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method ist strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Learning objectives

1. To learn the importance of patient selection and preparation in achieving high quality scans
2. To understand the practical techniques available for performing a successful scan in difficult patients such as those with arrhythmia or poor breath-holding ability
3. To learn how imaging parameters can be changed for optimal results

Main

Lack of movement artifacts is one of major prerequisites for getting good image quality in cardiac MR. Data acquisition should be synchronized with patient's ECG or pulse. Prospective gating allocates the MR signal data to points in the cardiac cycle as it is acquired (Fig. 1 on page 4a). This will always lead to the last few time points in most heart beats being excluded, resulting in a "blind spot" at the end of the cardiac cycle. Retrospective gating allocates the MR signal data at the entire k-space acquisition (Fig. 1 on page 4b). This approach provides more flexibility when imaging patients with beat-to-beat variations in heart rates (most patients). This method acquires data from the whole of each heart beat.

Special attention should be paid to good quality of ECG recordings and recognition of artifacts related to influence of permanent and alternating magnetic fields during examination. It is more difficult to perform cardiac MRI in patients with atrial fibrillation or frequent extrasystoli then in ones with sinus rhythm. In patients with arrhythmia prospective ECG synchronization should be used instead of retrospective one or special antiarrhythmic protocols may be designed.

Breathing artifacts usually are not a problem for cardiac MRI because most sequences are acquired during a single breath-hold. Using SSFP and parallel imaging allows to obtain a complete set of cine MR images through the whole heart in 1-8 short breath-hold periods. Possible way to perform successful examinations in difficult patients, especially the ones with heart failure, is a technique of ultra-fast (real-time) image acquisition (Fig. 2 on page 4, Fig. 3 on page 5). A more accurate method is to monitor diaphragm position by the use of navigator echoes for high resolution applications such as coronary artery imaging.
To meet the challenges and the benefits of cardiac MRI one must balance the constraints of signal-to-noise ratio, contrast-to-noise ratio, spatial and temporal resolution, scan time and image quality.

Image aliasing (wrap-around or fold-over artifacts) occurs when the imaged subject is larger than the field-of-view (FOV) in the phase encoding gradient (Fig. 4 on page 6a, Fig. 5 on page 7a). While the number of the phase encoding steps used to complete the image acquisition is sufficient to uniquely encode all the locations within the FOV, locations outside the FOV are not uniquely encoded. Common solutions to remove or reduce image aliasing are increasing FOV, using phase-oversampling (Fig. 4 on page 6b, Fig. 5 on page 7), swapping phase and frequency direction, using selective tissue saturation or switching off unwanted elements of array coil.

Radiologist performing cardiac MRI should be aware of specific flow artifacts which are more prominent in case of 3T systems. They should not be misinterpreted with intracardiac masses or abnormal flow jets. In the presence of flow jets a signal void is often seen at the location of the jet (Fig. 6 on page 8). This effect is commonly observed while imaging regurgitant valves, stenotic vessels, or the flow through septal defects. The signal void is caused by a de-phasing of the magnetization in the presence of the jet. It is due to velocity-related phase shift caused by motion along the magnetic field gradients. The flow jet contains a large range of velocities (velocity gradient). The flow-related signal void is often qualitatively related to the size and severity of the flow jet and is sometimes used to grade regurgitation. Qualitative assessment must be done with caution, as the size of the signal void also depends on the pulse sequence type, the echo time, and a number of other parameters that affect the imaging gradients strength and duration. For example, increasing the echo time increases the apparent size of the flow jet.

At phase-contrast studies it is very important to remember about flow velocity. Due to a wrong VENC (the maximum measurable velocity range) aliasing of the velocity value (when positive velocities are displayed as negative ones and vice versa) appears (Fig. 7 on page 9) and leads to incorrect calculations. Selecting a VENC that is too low is a common pitfall of velocity-encoded cine MR imaging that leads to unreliable calculations as well.

Late-enhancement imaging is performed using an inversion-recovery fast (or turbo) gradient echo pulse sequence. This fast sequence allows the image acquisition to be completed within a few heart beats. The higher concentration of contrast agent within scar tissue results in a faster T1 relaxation rate and therefore an increased signal compared to the blood pool and normal myocardium. Nulling the signal from normal myocardium maximizes the scar tissue contrast. The quality of late enhancement imaging depends on the effective suppression of the signal from normal myocardium. This requires very
precise selection of the appropriate inversion time (TI), which may be selected with use of TI-scout (Fig. 8 on page 10). TI for "nulling" of normal myocardium slowly changes over time. Therefore every couple of minutes the TI needs to be increased by 10-15 ms.

Modern MR scanners allow getting good cardiac images even in very difficult cases.

Images for this section:

![ECG-gating](image)

**Fig. 1:** Prospective (a) versus retrospective (b) ECG-gating
Fig. 2: Four-chamber view acquired with breath-hold (a) or without - real-time image(b)
**Fig. 3:** Short-axis view acquired with breath-hold (a) or without - real-time image(b)
Fig. 4: Wrap-around artifact. Delayed enhancement of the apex is not seen at Fig 4a due to small FOV.
**Fig. 5:** Wrap-around artifact. LV myocardium and thrombus in the apex are not seen correctly at the Fig 5a due to wrong encoding frequency direction.
Fig. 6: a) LV inflow/outflow view through the aortic valve and LVOT in systole shows a high-velocity jet in ascending aorta (arrows) in patient with severe aortic valve stenosis. b) Through-out plane image in the aortic root above the aortic valve in systole.
Fig. 7: Phase-contrast images. Aliasing artifact in ascending aorta with VENC=120sm/s (Fig 7a) and absense of aliasing with VENC=150cm/s (Fig 7b)
Fig. 8: Selection of TI (TI scout): A) "nulling" of blood B)-C) - transitional stages D) "nulling" of normal myocardium
References


Personal Information