

Cardiac MR Functional Imaging



Purpose

This document provides information regarding cardiac MR functional imaging on a 1.5T Philips MRI system.

The planning images in this guide are shown as examples; the actual planning required should be discussed with the radiologist.

Safety

Refer to the general safety rules in the *Instructions for Use* and the *MR the Safe Way* eReading.

For scanning pay extra attention to:

- Patient positioning: refer to the *Instructions for Use* for information on how to prevent patients from touching the bore.



Setting up

Coils and accessories

This examination makes use of the following coils and accessories:

- Cardiac coil
- Nurse call
- Earplugs or headphone
- Extra padding for patient comfort
- VCG
- Respiratory sensor
- Strap to fixate the respiratory bellow

Prepare for scanning and patient positioning

Prepare for scanning

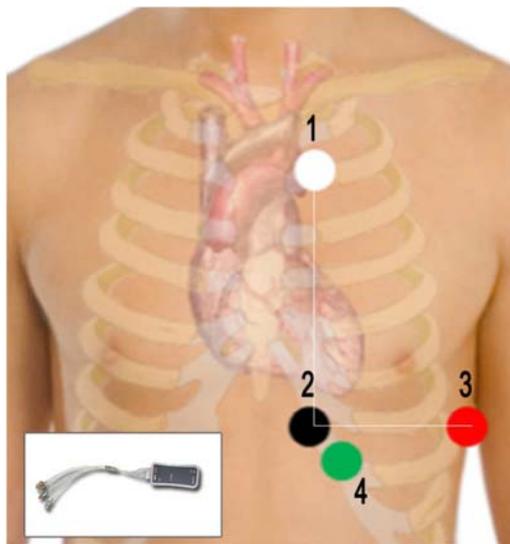
1. Enter a new patient.
 2. To prepare the Scan list do one of the following:
 - For InterActive planning:
 - From the **Philips > ExampleCards > Heart** folder add the **Cardiac InterActive** ExampleCard to the Scan list.
 - For regular planning:
 - From the **Philips > Heart > Function Cine > Cine** folder add multiple **sBTFE_BH** scans to the Scan list.
 3. Click **Show ExamCard properties** .
 4. In the **General** tab:
 - a. Identify the Patient Position and Patient Orientation.
 - b. Define the correct Anatomic Region.
 5. Confirm the Geonames are entered and if necessary enter Geonames:
 - For InterActive planning:
 - Enter all the Geonames for the **InterActive** scan.
 - For regular planning:
 - Enter the Geonames for the related **sBTFE_BH** scans.
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Patient positioning

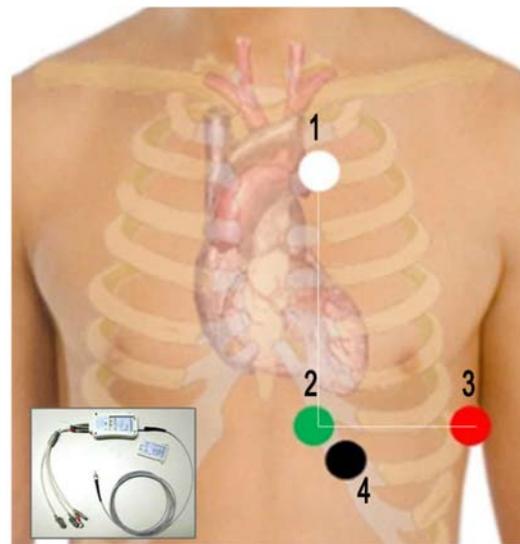
1. Instruct the patient to remove all metal.
2. Position the volunteer in head first, supine position.

As with all anatomies, patient comfort is important in reducing patient movement and thereby motion artifacts.

3. To position the VCG electrodes:
 - a. Position the VCG electrodes as recommended.



Wireless hardware



Wired hardware

- c. Connect the leads to the VCG electrodes
- d. Note the Network on the VCG device.



To view the help topic for positioning advice:

Tip

1. At the top of the window, click **Help** > **Help Topics** > **Search**.
2. In the **Search** field enter **VCG** and click **List Topics**.
3. Double-click **Positioning of the VCG electrodes**.

4. Observe the area on the patient's abdomen that moves the most while breathing and position the respiratory sensor on this spot.
5. Note the network on the respiratory device.



Note

For the VCG device and the respiratory device use the same Network.

6. To set the Network and Calibration method:

a. Right-click the **Physiology Display** to and do the following:

1. Click **VCG+Resp.** to specify the type of the physiology signal.
2. Set the physiology display window to **5** seconds.

For cardiac imaging 5 seconds is recommended to enable good visualization of the RR interval in combination with the respiratory cycle.

b. Click **Choose Physiology Properties...**

c. Click the **Network Selection** drop down arrow and select the Network as displayed on the VCG and respiratory device and click **Hide**.

d. Determine if you want to use **Manual Calibration** or **Continuous Calibration**.



The Calibration setting is persistent over exams and reboots.

7. Instruct the patient to follow breath hold direction.
8. Instruct the patient to use ear protection. Position the headset.
9. Check and position the nurse call.
10. Position the coil and place the patient inside the bore.



Planning



Note

Protocols are designated by physicians. Philips does not determine which sequences should be acquired for a particular anatomy or examination.

Commonly used sequences

For commonly used sequences to perform cardiac MR functional imaging refer to the following materials:

- *R5.3 IS Cardiac MR Functional Imaging.*
- *Relevant scan techniques* section of this workflow guide.

Relevant scan techniques and synchronization techniques

For relevant scan techniques to perform cardiac MR functional imaging refer to the following materials:

- *R5.3 IS Cardiac MR Functional Imaging.*

Supplementary scan techniques

You can use the following techniques as alternative techniques for arrhythmia patients:

- **B-FFE_BH_prospective:**

This is a retrospective technique with gating for operators who do not want to use a retrospective technique.

With this technique the steady state signal is maintained. The onset of the R wave triggers the image data acquisition. To compensate for physiologic variations in the heart rate, the acquisition window is usually 10-20% shorter than the average RR interval. Unfortunately, this means that the end of the cardiac cycle (late diastole, which often includes atrial contraction) is excluded from the image acquisition. Thus, this method is not the first choice for evaluating diastolic function (including valvular flow), although it is suitable to use when evaluating systolic function.

One potential advantage of prospective gating over retrospective gating is that it is less sensitive to variations in the duration of the diastole such as those seen in patients with common heart rate irregularities such as sinus arrhythmia or atrial fibrillation.

- **sBTfE_MS_SSh:**

This technique acquires all phases of one slice in one RR interval and acquires all slices in one breath hold. The number of phases acquired per cardiac cycle depends on the heart rate and the usual tradeoff between spatial and temporal resolution.

Relevant Cardiac MR Synchronization technique

There are two methods of cardiac synchronization used to time the pulse sequences with the patient's cardiac rhythm:

- Retrospective synchronization
- Prospective synchronization

For cardiac MR functional imaging retrospective synchronization is preferred. When using the retrospective synchronization technique there is a continuous collection of data and phases are reconstructed at the end of the sequence. This is different from triggered or gated techniques where everything is already set before the scan starts. An advantage of retrospective synchronization is that the atrial contraction, occurs just before detection of the R-peak, can be imaged as well. With triggered or gated techniques this is not possible, as the scan has to stop before the R-peak to allow detection of that peak.

Planning

For planning cardiac MR functional views refer to the following materials:

- *R5.3 IS Cardiac MR Functional Views.*



The planning images in this guide show example planning. The actual planning required should be discussed with the radiologist or cardiologist.

Important considerations

For cardiac MR planning the following guidelines are important:

- Take your time.
- Use PlanAlign to avoid in-plane rotation/fold-over in double-oblique scans.
- Change one orientation at the time for orthogonal planning.

Parameter considerations

For cardiac MR functional Imaging, it is important to anticipate to heart rate variations, and so:

- To make sure that the R-peaks are detected even if the RR interval varies.
- To reject data when an RR interval varies more than acceptable.

The RR interval (cardiac cycle) is defined by the heart rate entered:

- Increased heart rate results in → shorter RR interval
- Reduced heart rate results in → longer RR interval

The following parameters are the main parameters related to triggering:

■ R-R window (%)

Specifies the anticipated variation in duration of the RR interval

Summary	Physiology	Geometry	Contrast	Motion
Cardiac synchronization device		retrospective ECG		
Cardiac frequency		64		
▼	R-R window (%)			
1		20		
2		30		

- 1st % defines the upper limit of accepted heart rate (= shorter RR interval)
- 2nd % defines the lower limit of accepted heart rate (= longer RR interval)



Note

The RR-window determines the allowed heart rate variation:

- A high RR-window % means that a large variation is accepted at the cost of blurring.
- A low RR-window % means that cardiac blurring is minimized at the cost of scan time.

■ Arrhythmia rejection

When retrospective synchronization is used, the **arrhythmia rejection** parameter has to be set to **yes**. This method directs the system to reject data if the heart rate varies more than allowed by the specified RR-window.

If the next R-peak is not within the RR-window, the system will not use the data from the last RR interval. The R-peak that is not within the RR-window is used as a new starting point for the next RR interval and the TFE shots of all phases will be resampled in the next RR interval. This happens at the cost of scan time.

Example:

R-R window + arrhythmia rejection = **yes**

Entered heart rate 80 bpm:

➔ RR interval (60 sec / 80 bpm) = 750 ms

1st % = 10: 8 beats or 75 ms

2nd % = 20: 16 beats or 150 ms

If **arrhythmia rejection** = **yes**:

Data accepted if RR interval is between 675 and 900 ms

OR

Data accepted if heart rate is between 88 and 64 bpm

When performing cardiac MR functional imaging, the same image is acquired repeatedly over time during the cardiac cycle. This method gives an impression of the motion of the heart during the cardiac cycle, and is used to:

- Visualize the pump function of the heart.
- Get information about:
 - Wall motion
 - Wall thickness/thickening
 - Ventricular volumes, and all related statistics

To acquire information for accurate post-processing results, the following parameters are important:

- **Temporal resolution**
- **Heart phases**

In R5.3 there are two ways to determine the temporal resolution:

- *Indirectly* by defining the number of **heart phases** and **the phase percentage (%)**

Summary	Physiology	Geometry	Contrast	Motion
Cardiac synchronization device		retrospective ECG		
Cardiac frequency		70		
		R-R window (%)		
		Number of heart phases		user defined
		heart phases		30
		phase percentage (%)		67

The temporal resolution is expressed as TFE shot duration on the Info page

TFE shots	8
TFE dur. shot / acq (ms)	42.2 / 42.2
TFE shot interval (ms)	42.2

- *Directly* (new in R5.3) by defining the **phase interval (ms)** which determines the temporal resolution.

Summary	Physiology	Geometry	Contrast	Motion
Cardiac synchronization device		retrospective ECG		
Cardiac frequency		70		
		R-R window (%)		
		Number of heart phases		maximum
		phase interval (ms)		45
		phase percentage (%)		67

The actual number of heart phases is determined by the phase interval and the RR interval, and is expressed as **Max. heart phases** on the **Info** page.

TFE shot interval (ms)	42.2
Max. heart phases	28
Act. Phase acq (%)	72.5



The recommended temporal resolution is 40-45 ms.
The recommended value for the number of heart phases is 15-20 phases.

Image quality

Image quality degradation may be caused by the following artifacts:

- **Foldover in combination with SENSE:**
During planning pay attention to the foldover direction and the oversampling area when using SENSE. If there is anatomy outside the oversampling area this folds back into the image.
- **Motion:**
During patient positioning patient comfort is very important to reduce motion. You should give very explicit breath hold instructions to your patient.
- **Cardiac blurring:**
During scanning pay attention to the RR-window % and the temporal resolution. A high RR-window% and a high temporal resolution can cause cardiac blurring.

■ Zebra stripe artifacts:

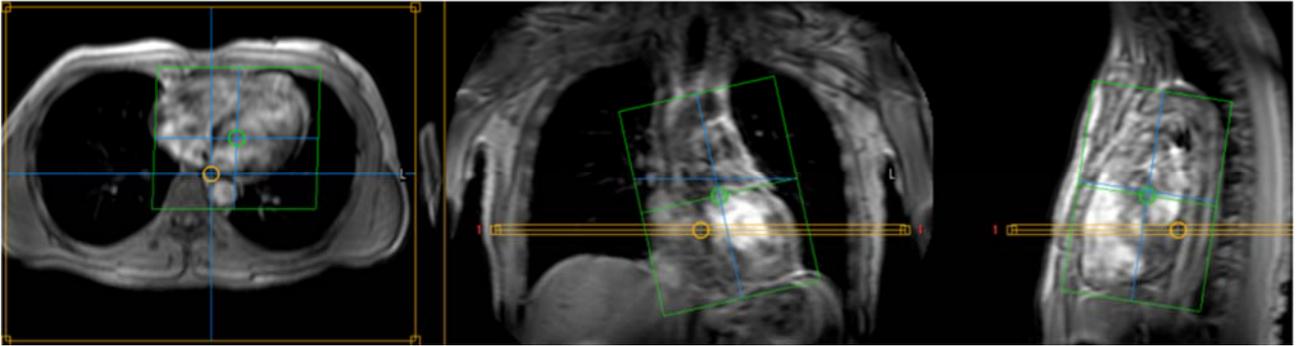
The Balanced FFE scan technique is sensitive to B0 inhomogeneities, which are seen as zebra stripe artifacts. With B0 and TR, the severity of the artifacts scales linearly.

To optimize the magnetic field homogeneity (B0) it is mandatory to use **shim = volume** (or **auto**).

3.0T requires **RF shim = volume** to optimize for B1 variations. **RF shim = volume** applies shimming to the heart specifically.

When planning the shim volume:

- The shim volume is best positioned over the area of the great vessels and the four chambers.
- Position the shim volume directly over the problematic areas to significantly reduce artifacts.
- The shim volumes for B1 and B0 shimming are equal and therefore no extra planning is required.



Scanning

SAR

Monitor the SED to maintain recommended levels refer to the *Instructions for Use* for more information.

Pop up messages

During the scan, pop-up messages may display on the console. You should refer to the IfU for a description of each message.

Maintain contact with the patient

Verbally communicate with the patient during the exam.

Visually monitor the patient during the exam; this is particularly important for anesthetized and compromised patients.

During scanning

When performing cardiac MR functional imaging the following is important:

- Visually monitor the VCG signal during the exam.
- For good image quality always check the actual heart rate of the patient before you start a scan, and update the entered heart rate if necessary.



Post processing

The Philips system provides many options to post process the examination.

Please refer to following materials for cardiac MR post-processing:

- Customer Application Training (CAT) Materials, IntelliSpace Portal CAT

Other relevant Info Sheets

Refer to the following materials for additional information:

- *Instructions for Use* for the additional information about coils
- *R5.3 IS Cardiac MR Functional Views*
- *R5.3 IS Cardiac Functional Imaging*
- *AW9901_VCG_PhysDispl_PhysProp*
- *IntelliSpace Portal CAT*

Cardiac MR Functional Imaging

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Images shown in this guide are examples; the planning required should be discussed with the radiologist.

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