Cardiac MR Functional Imaging

This document provides information for Cardiac MR Functional Imaging.

Functional Imaging

Cine scans are typically used to study wall motion and ventricular function. A variety of scan methods are available for cine imaging. However, balanced FFE is the preferred method for breath-hold cine scans. This retrospective triggered method has a number of advantages over other techniques:

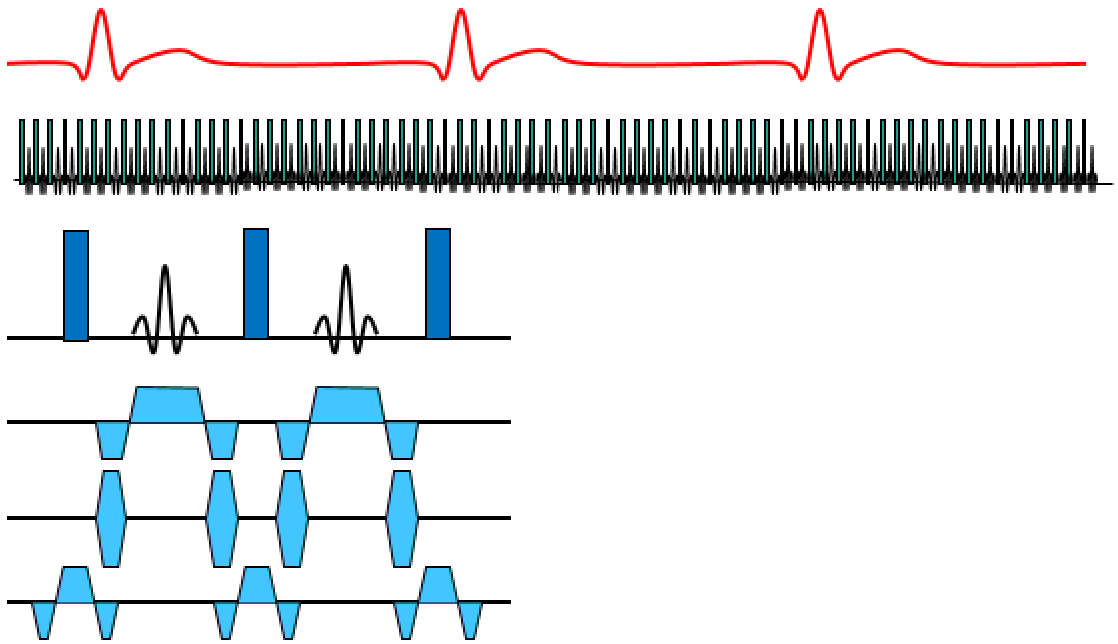
- Full coverage of the cardiac cycle, including late diastole and early systole
- Intrinsic high signal-to-noise
- High signal of blood, dark myocardium
- Short TR and thus a short scan time
- Balanced FFE is rather flow-insensitive
  - The maximum intrinsic flow compensation is achieved when the TE is half the TR

Balanced FFE is available for the scan modes 2D, M2D, and 3D. Interleaving (multislice) is not allowed because the TR must be as short as possible.

Balanced FFE

Scan technique

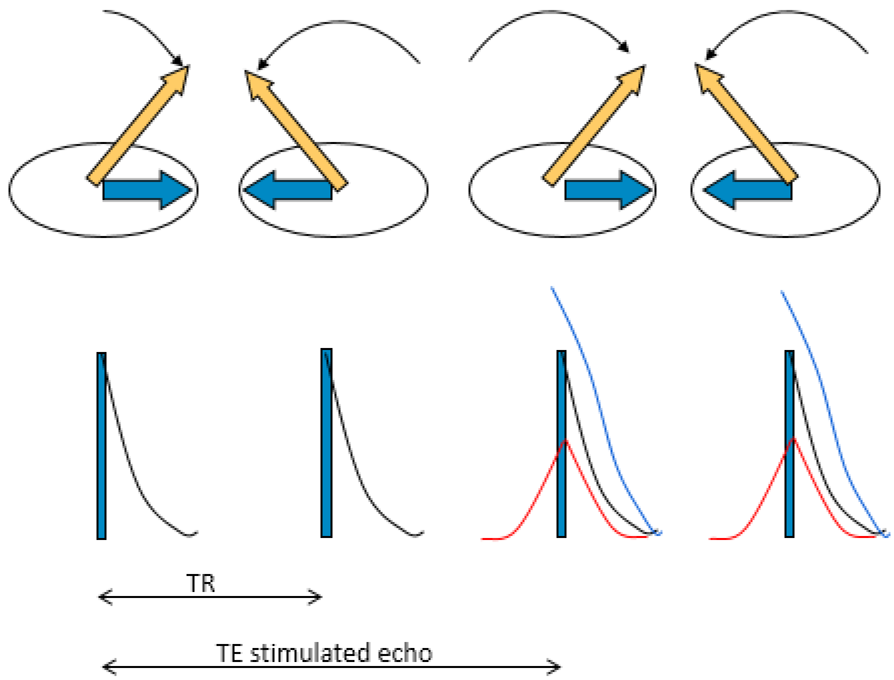
Balanced FFE is a real steady state technique. The image contrast strongly depends on stimulated echoes.



In balanced FFE all gradient lobes are equal in size, which results in completely de-encoded signal before the next excitation takes place. A stimulated echo that now occurs in a second TR will contain the same phase information (as in the first TR) and can be used for image generation without causing artifacts.

In normal FFE and TFE the second gradient area is large. This results in an incorrectly (phase) encoded signal. As a result the stimulated echo signal generates artifacts. In normal FFE sequences the stimulated echo signal is usually destroyed to create ''real'' T1 or T2-weighting based on the TR/TE used.

Signal generation



In balanced FFE the first (half) excitation generates a FID-signal (shown as the black curve in the figure above).

The second full excitation flips the magnetization to the other side, and the resulting transverse magnetization generates a FID-signal (shown as the black curve in the figure above). This excitation also acts as a refocusing pulse on the FID-signal of the first (half) excitation.

The third full excitation flips the magnetization again to the other side resulting in another FID-signal (black curve). The FID-signal of the first excitation is however completely re-phased by the second excitation and generates a stimulated echo signal at the exact same time (shown as the red curve in the figure above).

The total measured signal available for the image is shown as the light blue curve in the figure above.

The fourth excitation generates another FID-signal and creates a stimulated echo from the FID-signal of the second excitation and so on.

To improve the stimulated echoes:

- Use a very short TR, < 4ms
  - Maximum gradient mode
  - Minimum water-fat shift
- Use a high flip angle (1.5T: 60^o, 3.0T: 45^o)
  - A higher flip angle increases TR/TE again

Contrast

In balanced FFE:

- The stimulated echo signal is larger for tissues that have a long T2-relaxation. The FID-signal is larger for tissues that have a short T1-relaxation. This results in very high signal for tissues with a high T2/T1 ratio independent of the absolute value of T1 and T2 itself and independent of the TR.
- Excellent fluid-tissue contrast can be achieved with the use of very short TR's and large flip angles.

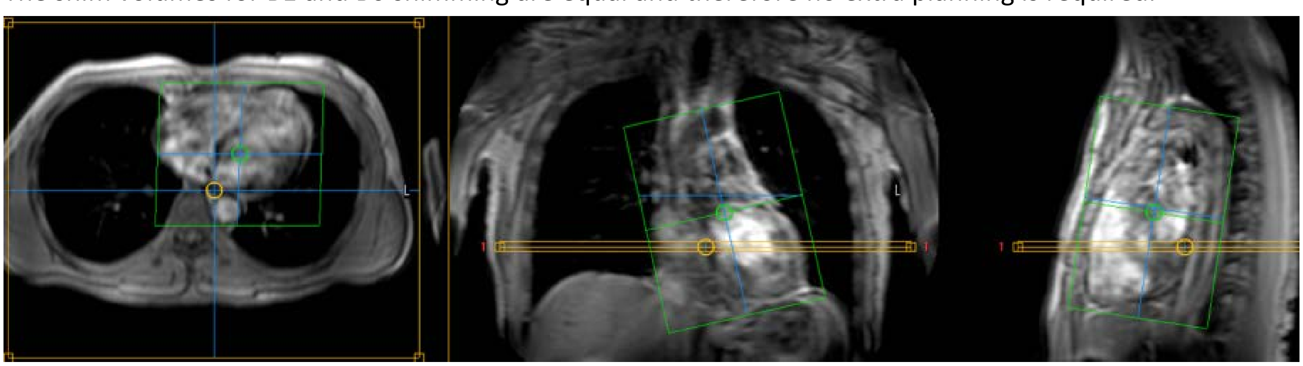
Artifact level

Balanced FFE:

- Is flow-insensitive
  - The large steady state signal of fluids with T2/T1 ratio is hardly deteriorated by flow.
  - Maximum intrinsic flow compensation is achieved when the TE is half of the TR.
- Is sensitive to B0 inhomogeneities represented by zebra stripe artifacts in the images
  - The severity of the artifacts scale linearly with B0 and TR.
  - To optimize the magnetic field homogeneity (B0) it is mandatory to use **shim = volume** (or **auto**).
- At 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.

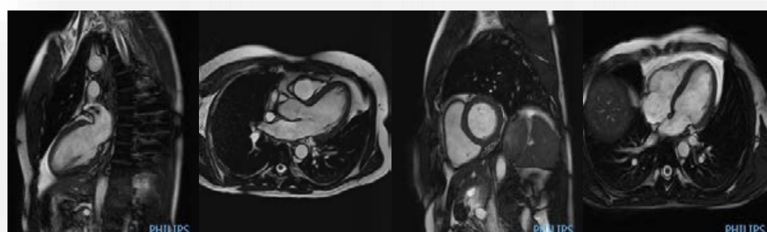


Functional imaging

For Cardiac MR Functional imaging the following is important:

- Cardiac MR planning guidelines:
  - Take your time
  - Plan in expiration only
  - Knowledge about useful tools to facilitate planning:
    - Interactive Scanning Tool
    - 3 Points Planscan
    - PlanAlign
  - Always plan orthogonal
    - Change one orientation at the time
  - Avoid in-plane rotation or fold-over in double-oblique planes.

- Knowledge of the basic cardiac views:
  - Transverse
  - Long axis
    - Vertical
    - Horizontal
  - Short axis
  - Four chamber



- Knowledge of the cardiac inflow and outflow tracts:
  - Left two chamber
  - Right two chamber
  - Left ventricle (inflow/) outflow tract
  - Right ventricle (inflow/) outflow tract

Interactive Scanning Tool

Interactive scanning is especially useful for cardiac imaging, because the required geometry angulations can be determined in real time for the different cardiac views.

An interactive scan has to fulfil the following prerequisites:

- One slice only
- Scan mode 2D, M2D or MS
- One heart phase only
- No dynamic scan
- Any scan technique as SE, FFE, balanced (FFE, TFE), TSE, GRASE or EPI (TSE is not used due to saturation effects using continuous mode)
- Cardiac triggering possible
- 3 Points Plan scan possible
- Can be combined with SENSE
- Should be performed in continuous mode, which is also referred to as real-time mode.

3 Points Planscan (3 PPS)

3 PPS is a tool which helps to define an irregular plane which is determined by the placement of three points on one or more images of different orientations.

This tool can be used in any application; however it is especially useful in cardiac MR planning.

PlanAlign

PlanAlign is developed for applications where double oblique scans are made with large angulations. It is a parameter to avoid in-plane rotation and to avoid SENSE artifacts. When switched to yes, any modification of the angulations will result in a recalculation of the angulations such that the resulting images show no in-plane angulation.

When **PlanAlign = yes**:

- Transverse scans will align such that the horizontal image direction (RL) is in a non-angulated coronal plane
- Sagittal scans will align such that the vertical image direction (FH) is in a non-angulated coronal plane
- Coronal scans will align such that the vertical image direction (FH) is in a non-angulated sagittal plane.
- Double angulated coronal scans tending to the sagittal plane will align like sagittal scans, such that the vertical image direction (FH) is in a non-angulated coronal plane.

Note When the geometry has been planned using InterActive scanning, **PlanAlign** is automatically set to **no**.

Relevant materials

Refer to the following materials for additional information:

- *R5.3 IS Cardiac MR Functional Views*
- *R5.3 WFG Cardiac Functional Imaging*
- *VCG: Physiology Display and Physiology Properties* module in the *What's New in Release 5.3?* course. You can find this course on the Philips Online Learning Center.