Slice refocusing signal for retrospective reconstruction of CINE cardiac MR images

A. Nauerth[1], E. Heijman[2], C. Diekmann[1]

[1]Bruker BioSpin MRI GmbH, Ettlingen, Germany, [2]Department of Biomedical Engineering, Eindhoven University of Technology, Eindhoven, Netherlands

Introduction

Retrospective reconstruction of a non-triggered and non-gated MRI sequence opens up a wide variety of new applications especially in the field of animal cardiac MRI. Contrarily to conventional ECG triggering and respiratory gating, self-gating sequences keep the spin system in a steady-state condition by a constant repetition of the MRI experiment and provide an MR signal which is used to derive the cardiac- and respiration cycles retrospectively. Another characteristic is a short repetition time (TR) in order to provide a high temporal resolution for the determination of the cardiac cycles. A very short TR can be achieved with the implementation proposed by [2]. However, this implementation is restricted to a radial type of K-space encoding. Another implementation proposed by [1] generates an additional gradient echo allowing also rectilinear K-space encoding techniques which significantly increases TR.

In this work we propose to record the slice refocusing signal for the retrospective determination of the respiration and cardiac cycles. The recording of the refocusing slice signal usually requires only one additional gradient switching point allowing a high temporal resolution of cardiac cycles. In case of an inflow saturation sequence no additional time is required. Another advantage in recording the slice refocusing signal is that there are no restrictions to the type of K-space encoding. Furthermore, taking the whole slice refocusing signal into account facilitates the evaluation of its magnetization, its phase and its trend.

Methods and materials

Several mice, rats and rabbits were examined on various Bruker spectrometers (Bruker BioSpin MRI GmbH, Ettlingen, Germany) such as 4.7 T 40 cm, 7.0 T 30 cm 9.4 T 20 cm. Two basic sequence implementations providing a slice refocusing signal were used. One implementation recorded the slice refocusing signal from the slice of interest while the second implementation recorded the slice refocusing signal out of a saturation slice.
Four signals were derived from the refocused slice signal by taking the magnetization, the phase and the trend thereof into account. The most promising signal was selected for the determination of the cardiac and respiration cycles respectively.

Results

- The content of the four calculated signals varied from animal to animal. A dependency of the slice position and slice orientation was also observed. A valuable signal could be selected for the determination of the cardiac and respiration cycles in all cases.
- Some sources modulating the slice refocusing signal could be located within the calculated cardiac signal as shown in Figure 1 where signal from the pulsary artery is represented by the small hump at the end of the cycle.
- The cardiac- and respiration cycles were recorded with a temporal resolution of 6.5 ms for rabbits down to 3.5 ms for mice
- Both sequence implementations gave excellent results in various orientations through the cardiac views

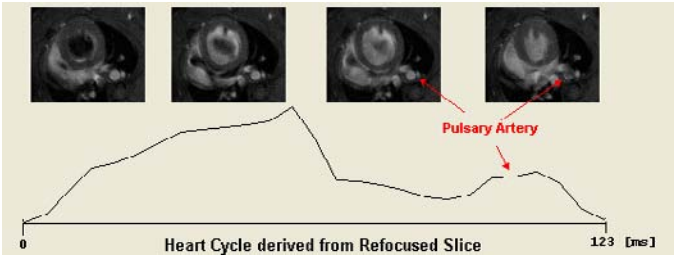

Figure 1: Comparison between the different cardiac phases and the recorded phase of the slice refocusing signal. An artery within the images has a large contribution to the recorded signal (red arrows).

- Full cardiac- and respiration cycles were reconstructed with an arbitrary number of movie frames per cycle
- Interleaved multi-slice scans were performed from which synchronized movies were reconstructed
- Cardiac movies were successfully reconstructed from a mouse with an heavily diseased heart whereas conventional triggering failed

Conclusion

- The refocused slice signal provides sufficient information for the retrospective reconstruction of cardiac and respiration movies
- The evaluation of the magnetization, the phase and the trend of the refocusing slice signal is mandatory for a successful retrospective reconstruction
- The recording of the refocused slice signal can basically be implemented in all types of sequences providing a reasonably short TR
- Synchronized movies of multi-slice acquisitions can be achieved by interleaved slice excitation within a reasonable time
- Retrospective reconstruction provides a better image quality
- Retrospective reconstruction permits examinations of diseased cardiac models

Reference List

[1] Spraggings, MRM 8, 675-681 (1990)
[2] Larson, MRM 51, 93-102 (2004)