Retrospective Self-Navigated Cine Imaging Using the Unused Echo in Alternating TR SSFP

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Introduction

Respiratory motion is a major issue in cardiac imaging. Short breath-holds and respiratory navigators [1-3] are often used to eliminate the problem. However, the breath-holding relies on the subjects' ability to hold their breath; and navigators (usually placed at the right diaphragm) only provide an indirect assessment of the heart's position and require the use of a separate navigator sequence. Thus a self-navigation method would be beneficial to continuous cardiac images.

We developed a retrospective self-navigated cine sequence using wideband SSFP. In alternating SSFP sequences [4,5], a short TR (TR_s) is typically added in order to establish a favorable spectral response (e.g. avoid banding, or suppress fat). No data is acquired during that period. In the case of wideband SSFP [4], the echo in short TR has extremely high SNR and can provide direct information about the imaging plane. In this work we acquired signals during TR_s, and used them as indications of current heart position for self-navigation.

Methods

In-vivo wideband SSFP scans were performed on a GE Signa Excite 3T scanner with an 8-channel phased-array receiving coil. 2DFT readout and k-space segmentation were used for ECG gated wideband SSFP imaging with parameters: FOV = 32 cm, slice thickness = 8 mm, 256 × 128 acquisition matrix, flip angle = 35°, and TR/TR_s = 3.8/2.4 ms. Free-breathing scans were 32 RR intervals in length, with sequential phase-encode ordering and a k-space segment of 16 lines. A 32-point readout of the k-space center line was performed in TR_s and the signal intensity at the k-space origin was used as the navigating index. The acceptance window was chosen manually, and k-space lines that fell into the acceptance window were used for reconstruction.

Results

The navigator signal curve during one 32-RR interval free-breathing cine scan is shown in Figure 1. Periodic variation indicates the respiratory motion. Shaded area is the chosen acceptance window. Full k-space for each cardiac phase was then assembled using accepted k-space lines. Figure 2 shows sample cardiac phases from images before and after the self-navigated reconstruction. The images without navigation (bottom row) exhibit blurring from respiratory motion, which was successfully suppressed with retrospective self-navigation (top row).

Discussion and Conclusion

We demonstrated free-breathing wideband SSFP cine imaging. Using an echo in TR_s as navigator eliminates the need for breath-holds during cardiac scans, which reduces the dependence on patient cooperation and allows for longer scan time so higher spatial or temporal resolution can be achieved. With this technique we can perform continuous imaging, since it doesn't use a separate navigator sequence that would require the steady-state to be interrupted and re-established in between heartbeats. Prospective navigation is also possible, if a short pre-scan is added to determine the acceptance window.

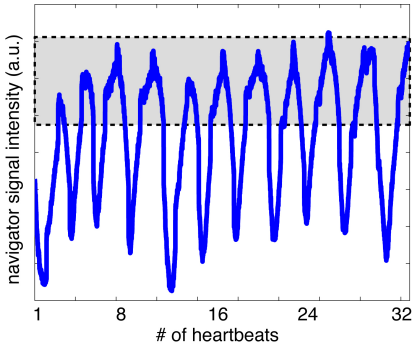

Figure 1 Navigator signal during one free-breathing cine scan, which shows periodic variation that matches respiratory motion. The shaded area represents the acceptance window. The total number of acquisition was 4608.

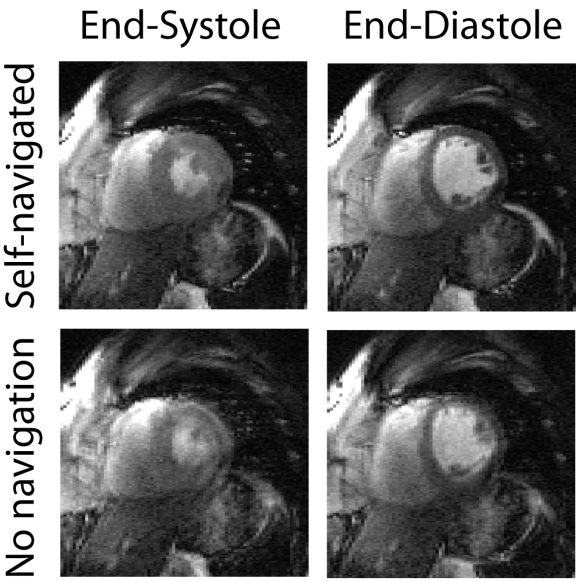

Figure 2 Sample frames from a free-breathing cine acquisition. Top row: with retrospective self-navigated reconstruction. Bottom row: no navigation. The use of self-navigation eliminates the motion blur that affects non-navigated images.

References

[1] Ehman *et al*., Radiology 173:255 (1989); [2] Wang *et al*., MRM 36:117 (1996); [3] McConnel *et al*., MRM 37:148 (1997); [4] Leupold *et al*., MRM 55:557 (2006); [5] Nayak *et al*., MRM 58:931(2007)