Navigator-gated 3D MR Angiography of the Pulmonary Arteries using Steady-State Free Precession

B. Hui[1], M. Noga[2], A. Wilman[1]

[1]Biomedical Engineering, University of Alberta, Edmonton, Alberta, Canada, [2]Radiology and Diagnostic Imaging, University of Alberta, Edmonton, Alberta, Canada

Introduction

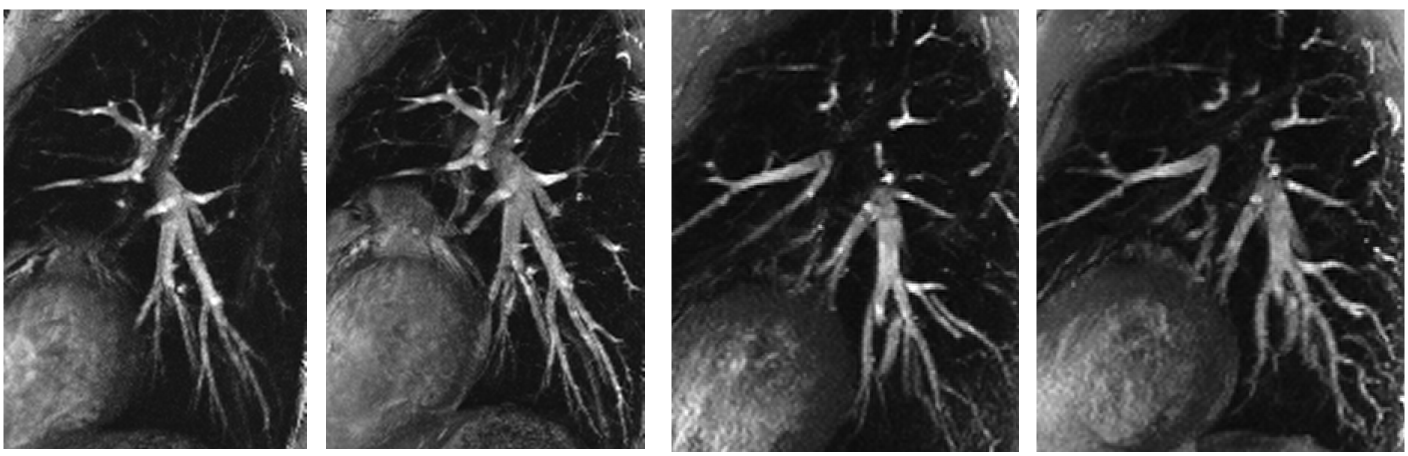
Navigator gated 3D MR Angiography (MRA) has been used previously for the pulmonary arteries (1). However, the navigator technique has typically been compared to a free breathing approach, with the navigator method found to be preferable. A breathhold 3D technique was rarely used as a comparison standard because of the extremely long time required. However, with the recent revival of the steady-state free precession technique (SSFP), and the availability of fast gradient systems, it is now realistic to consider a 3D breathhold scan (2) as a more rigorous comparison standard for the navigator technique. In this work, we consider a cardiac triggered, navigator-gated 3D MRA technique using SSFP for the pulmonary arteries and compare it to the same technique performed as a single breathhold. Our study group of 10 volunteers were healthy and capable of completing a 30 second breathhold.

Methods

A 1.5T MR imaging system (Siemens Sonata) with 40 mT/m maximum gradient strength and 200 mT/m/ms slew rate was used. Ten normal volunteers were studied (34 ± 17 years), using both a breathhold and a navigator gated version of a 3D SSFP sequence that was cardiac triggered and segmented. The 3D SSFP sequence was performed as a sagittal acquisition with: matrix 256 by 256 by 16 slices of 2mm thickness; FOV 240-180mm in frequency, 135-158 in phase; ¾ partial Fourier encoding in phase and slice directions; 570 Hz/pixel bandwidth; TE/TR of 2.0/5.4ms and a 60^o flip angle. A pulse oximeter was used with a 150 ms delay before each segment of 99 phase encoding views ordered centrically. The same 3D SSFP technique was used for the breathhold and navigator approaches. The navigator technique was performed immediately before and after each segment. A navigator acceptance window of $\pm$ 1.5 mm was used at end expiration. Because each segment acquired 99 imaging views, the navigator immediately after each segment was also important to rule out motion during each playout. A radiological evaluation was performed by a body radiologist evaluating vessel sharpness, overall image quality and degree of artifact. A five point scale was used from –2 to +2. Positive numbers indicated that the navigator technique was favorable. Specifically: 0 no difference, +1 navigator slightly better, +2 navigator significantly better, -1 breathhold slightly better, -2 breathhold significantly better.

Results

The ten navigator scans took on average 180 sec $\pm$ 79 sec with an average acceptance rate of 19% $\pm$ 7 %. The breathhhold scans took 29 ± 3 sec, with variations relating to heartrate differences. The average R-R interval was 1.0 sec $\pm$ 0.1 sec. Both methods had similar SNR ratios: 42 ± 13 for breathhold and 40 ± 14 for the navigator study. The Figure below shows two examples of the comparison, where the sagittal maximum intensity projections are shown.



Volunteer 1 Breathhold Volunteer 1 Navigator Volunteer 7 Breathhold Volunteer 7 Navigator

Results from the qualitative radiological comparison were as follows: Image Quality 0.7 ± 1.4, Sharpness 0.6 ± 1.5, Artifact 0.6 ± 1.5.
All of these results suggest the navigator technique is slightly preferred, but the results are not significant.

Discussion

The use of navigator gating both before and after each segmented playout led to images equal in quality to those produced by a single breathhold. This result is particularly promising because patients suffering from pulmonary vascular disease are unlikely to be able to tolerate a long breathhold, making the navigated technique essential. The promise of the navigator technique is further emphasized by the fact that the healthy volunteers used in this study were capable of completing the 30 sec breathhold. The lack of background signal in the lung makes the SSFP sequence an appropriate choice. SSFP is known for its high signal-to-noise and fast scanning ability. SSFP also allows a high number of RF excitations within a segment without concern over saturation of the blood signal. Although the capability of SSFP under complex flow is still unclear (3), it performed well in the normal pulmonary vasculature seen here.

Acknowledgements

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References

1. Y. Wang et al. Magn Reson Med ;**36**:579-87 (1996).
2. K. Scheffler et al. Magn Reson Med **45**:1075-80 (2001).
3. M. Markl et al, Magn Reson Med **50**:892-903 (2003).