Cardiac Steady-State Free Precession Cine MR: Influence of different reconstruction algorithms on image quality

K-U. Waltering[1], P. Hunold[1], O. Bruder[2], T. Schlosser[1], M. Jochims[2], J. Barkhausen[1]

[1]Department of Diagnostic and Interventional Radiology, University Hospital, Essen, NRW, Germany, [2]Department of Cardiology, Elisabeth Hospital, Essen, NRW, Germany

Introduction:

Steady state free precession (SSFP) Cine MRI provides images with high spatial and temporal resolution and must be considered as the standard of reference for the assessment of ventricular volumes and ejection fraction. To compensate for cardiac motion two different techniques are currently available: prospective ECG-triggering and retrospective ECG-gating. The aim of this study was to assess the image quality of a recently developed triggered-retrogated (Tretro) data acquisition scheme combining the advantages of both modalities in comparison to the standard prospectively triggered technique.

Materials and Methods:

81 patients (60 male, 21 female, mean age 61,9±36,1 years) referred to cardiac MRI were included into this study. 62 patients had sinus rhythm, whereas 10 patients suffered from atrial fibrillation and 9 patients had frequent extrasystoles. All examinations were performed on a 1.5 T scanner (Magnetom Sonata, Siemens). Long axis Cine-loops were performed three times with a SSFP sequence (TR 2.8 ms, TE 1.4 ms, FA=60°, pixel size 1.9mm x 1.7mm, temporal resolution 43ms) using different reconstruction algorithms in random order: (a) prospective triggering, (b) triggered-retrogated (Tretro) and (c) a modified triggered-retrogated sequence which allows for arrhythmia rejection (Tretro-mod). Using prospective triggering segments will be measured for a fixed length of time after each R-wave trigger independent of the length of the RR-interval (Fig 1a). The triggered-retrogated technique (Fig 1b and 1c) repeats each phase encoding step until the next trigger occurs and the phase encoding is incremented to the next segment. Using a wide acceptance window between 600 and 1200 ms (Tretro, Fig. 1b) data from all heart beats are used for image reconstruction. For arrhythmia rejection (Tretro-mod, Fig 1c) a narrow acceptance window (800 -1000 ms) is used. If the RR interval is too long or to short, data are rejected and the phase encoding steps are repeated after the next trigger is detected. Image quality of all SSFP Cine sequneces was assessed based on a 5-point Likert scale ranging from 1=excellent, 2=good, 3=equivocal, 4=poor to 5=non-diagnostic. Additionally signal to noise (SNR) and contrast to noise (CNR) measurements were performed.

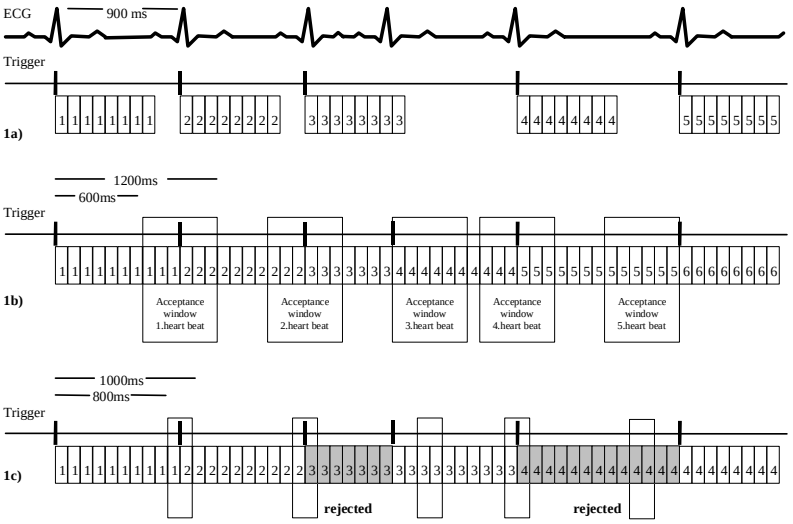

Figure 1a-c) Different reconstruction algorithms for SSFP Cine Images, prospectively triggered data acquisition mode (a), Tretro (b) and Tertro-mod (c). Numbers in rectangles indicate different phase-encoding steps.

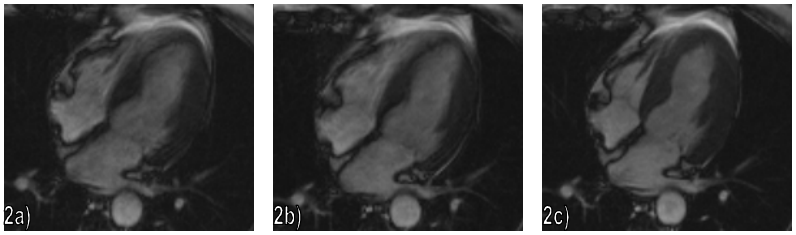

Figure 2a-c) 4-chamber view in a patient with arrhythmia performed using prospectively triggering (a), Tretro- (b) and the modified Tretro sequence (c). The Tretro sequence with arrhythmia rejection (c) shows the best image quality.

Results:

The average acquisition time of all studies was 10.0±2.1s for standard SSFP sequences, 10.9±6.2s for Tretro and 11.5±4.7s for Tretro-mod sequences. The mean image quality score of all patients showed no significant differences (standard SSFP 2.6±0.9; Tretro 2.4±0.9; Tretro-mod 2.3±0.8; $p<0.05$). However, in case of arrhythmia the mean image quality score was significantly higher for the modified Tretro sequence 2.8±0.8 versus 3.2±0.9 for Tretro and 3.7±0.9 for the standard sequence ($p<0.05$). SNR and CNR measurements showed no significant differences ($p<0.01$).

Discussion:

The recently developed triggered-retrogated SSFP sequence combining prospective triggering and retrospective gating offers important advantages compared to prospectively triggered sequences. In patients with sinus rhythm a wide acceptance window can be used and no parameters have to be adapted to the patients heart rate prior to imaging. Due to the retrospective gating the sequences covers the entire cardiac cycle, including the late diastole, missed by prospective triggering. Furthermore, artifacts and blurring caused by arrhythmia can be reduced, resulting in better image quality in patients with atrial fibrillation and frequent extrasystoles.

References:

[1] Carr JC, Simonetti O, et al. Radiology 2001; 219: 828-834
[2] Lenz GW, Haacke EM, White RD. Magn Reson Imaging 1989; 7(5): 445-455
[3] Sondergaard, L Muller E, Henriksen O. Magn Reson Imaging 1993; 11(4): 533-537.
[4] Gatehouse, PD, Firmin DN. Herz 2000; 25(4): 317-330