Impact of ECG-gating in contrast-enhanced MR angiography for the assessment of the left atrium and the pulmonary veins

M. Katoh[1], A. Buecker[1], G. Muehlenbruch[1], P. Schauerte[2], R. W. Guenther[1], E. Spuentrup[1]

[1]Department of Diagnostic Radiology, RWTH Aachen University Hospital, Aachen, Germany, [2]Medical Clinic I, RWTH Aachen University Hospital, Aachen, Germany

Introduction

Cardiac motion and pulse waves still prevent contrast-enhanced MR angiography (ceMRA) from sharp delineation of the heart and the thoracic vessels. Instead of reducing scanning time, we sought to invest the time saved by using a parallel imaging technique (SENSE: sensitivity encoding) in cardiac synchronization while high spatial resolution can be maintained at the same time. Currently, two techniques are available for cardiac synchronization, namely triggering and gating. Compared to triggering, ECG-gating allows for steady-state condition of the longitudinal magnetization throughout the whole sequence, which seems to be preferable in order to avoid leaps within the k-space (i.e. reduced artifacts). In this study we demonstrate the successful implementation of a ceMRA sequence combined with ECG-gating for improved delineation of the left atrium, pulmonary veins and the great thoracic vessels.

Materials and Methods

In twelve patients (4 male, 8 female, 59 ± 9 years) with recurrent atrial fibrillation, ceMRA based on a gradient-echo sequence (TR/TE: 4.0/1.2 ms, excitation angle: 35°, FOV: 480 x 360 mm, matrix: 448 reconstructed to 512, in-plane resolution: 1.1 x 2.4 mm reconstructed to 0.9 x 0.9 mm, thirty 3.0 mm thick slices, reconstructed to sixty 1.5 mm thick slices, SENSE-factor: 3 (in phase-encoding direction), scan time: 6 sec, centric phase encoding) was performed during the first-pass (fp) of the contrast blous (0.1mmol/kgBW Gd-DTPA) on a 1.5 Tesla whole body MR system (Gyroscan Intera, Philips Medical Systems, Best, NL). The same sequence was repeated after a second bolus injection by adding ECG-gating with a gating window of ~150 ms and a gating delay of 300 ms. Subsequently, both scans were repeated in random order in the equilibrium phase (*eq*) five minutes after the last contrast medium application. These scans allow for intraindividual comparison of quantitative measurements independent of the injection timing and prevent from bias due to the scan order or two subsequent contrast medium injections. Objective image quality parameters such as contour sharpness, SNR, CNR, and subjective artifact level were analyzed.

Results

Using ECG-gating in ceMRA, artifacts arising from cardiac motion and from the great vessel pulsation were significantly decreased compared to the standard MRA technique without ECG-gating (Fig. 1). At the same time, reduction of motion artifacts lead to sharper delineation of the measured contours at the pulmonary veins (13.5 ± 5.8 vs. 25.4 ± 9.8, $p < 0.05$), the left atrium (15.3 ± 5.3 vs. 26.1 ± 9.5, $p < 0.05$), the ascending aorta (18.0 ± 7.1 vs. 25.6 ± 6.6, $p < 0.05$), and the pulmonary trunc (16.0 ± 10.9 vs. 24.5 ± 6.1, $p < 0.05$), (Fig. 2a). In addition, SNR of the blood in the left atrium (17.6 ± 6.8 vs. 25.1 ± 12.3, $p < 0.05$), CNR between the blood and the myocardium (6.3 ± 3.4 vs.14.0 ± 5.8, $p < 0.05$) as well as the lung parenchyma (13.9 ± 5.2 vs. 21.7 ± 11.3, $p < 0.05$) were significantly higher using ECG-gated MRA (Fig. 2b).

Conclusion

The use of ECG-gating in ceMRA allows for artifact-free and sharper delineation of the structures of the heart and thoracic vessels. In addition, ECG-gating lead to increased SNR and CNR compared to standard ceMRA without ECG-gating.

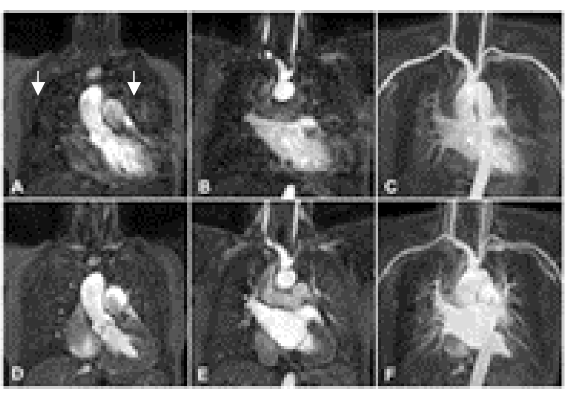

Fig. 1

Fig. 1:
Coronal images at the level of the ascending aorta (A, D) and the left atrium (B, E) in a 44-year-old female patient with recurrent atrial fibrillation. The corresponding MIP-reconstructions are shown in C and F. ceMRA without ECG-gating (upper row) demonstrates motion and pulsation artifacts (arrow) in phase encoding direction (right-left), which lead to blurring of the contours. Note the sharp delineation of the aorta, the aortic valve, the atrium and the left ventricle using ECG-gating (lower row).
Fig. 2:
Summary of the objective image quality parameter

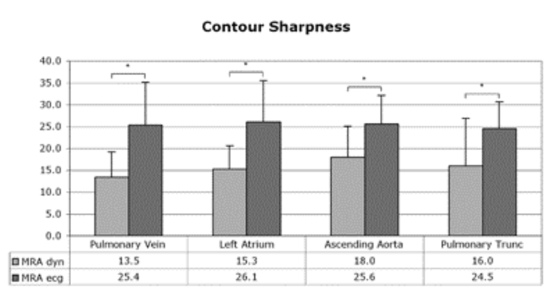

Fig. 2a

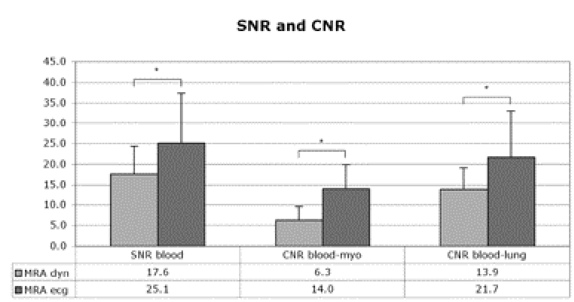

Fig. 2b