Improved motion compensation in coronary MRA

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Introduction: An ongoing impediment to reliable coronary magnetic resonance angiography (MRA) is suppression of artifacts related to respiratory and cardiac motion. Diaphragmatic navigator techniques and imaging during the mid-diastolic rest period have helped minimizing these artifacts. Yet, ~20% of coronary MRAs remain of non-diagnostic image quality (1). We hypothesize that beat-to-beat heart rate variability may compromise image quality, if the data acquisition coincides with e.g. atrial contraction. Analogous to navigator gating, we have introduced a prospective, real-time RR-interval acceptance window and combined this method with navigator gated coronary MRA. In this study we investigated the impact of this novel R-wave gating mechanism.

Methods: Analogous to the navigator technique, an RR-interval gating mechanism was implemented on a 1.5T Philips ACS-NT scanner (Philips Medical Systems, Best, NL). Data acquired at heart rates within a user defined RR-window were accepted and otherwise rejected. In the case of data rejection, data of the prior two RR-intervals are rejected and data are reacquired in the immediately following RR-interval. An asymmetric gating window was chosen with the following settings: mean RR -10% < RR-interval < mean RR + 50% (mean RR = last 8 RR-intervals). For a heart rate of 60bpm, only data acquired at heart rates between 900ms and 1500ms were accepted and otherwise rejected. This gating mechanism was combined with a navigator gated and corrected fat suppressed T2 prepared 3D SSFP coronary MRA sequence. Imaging parameters included FOV = 270mm, matrix = 272, TR = 5.4ms, TE = 2.7ms, flip angle = 110º, slice thickness = 3mm, 10 slices (interpolated to 20 slices of 1.5mm), acquisition window = 100-140ms. Prior to coronary MRA, a cine scan was performed to determine the subject-specific quiescent diastolic period. All data (N=5 adult subjects) were then acquired using a subject specific mid-diastolic trigger delay and using right hemi-diaphragmatic navigator gating with real-time tracking (5mm gating window). RR-intervals and acceptance/rejection events were logged to allow for correlation with image quality.

Results: RR-variability was observed in all subjects. The pattern of RR-variability varied between patients and even from scan to scan as demonstrated in (1, 2). All scans using the RR-interval gating mechanism (Figures B,D,F) resulted in a better delineation of the coronary arteries . The logged RR-intervals (1,2) demonstrate that this technique is especially valuable at higher heart rates where few data outside of the acceptance window can cause readily visible artifacts (A). With the R-wave gating algorithm enabled (B), even a scan with a higher degree of RR-variability (2) still allows for good coronary artery delineation. At lower heart rates (<60/min), the impact is smaller even in the presence of major drifts in heart rate (C, D). Data acquired close or during atrial contraction can lead to severe image artifacts if the data points are not rejected (E).

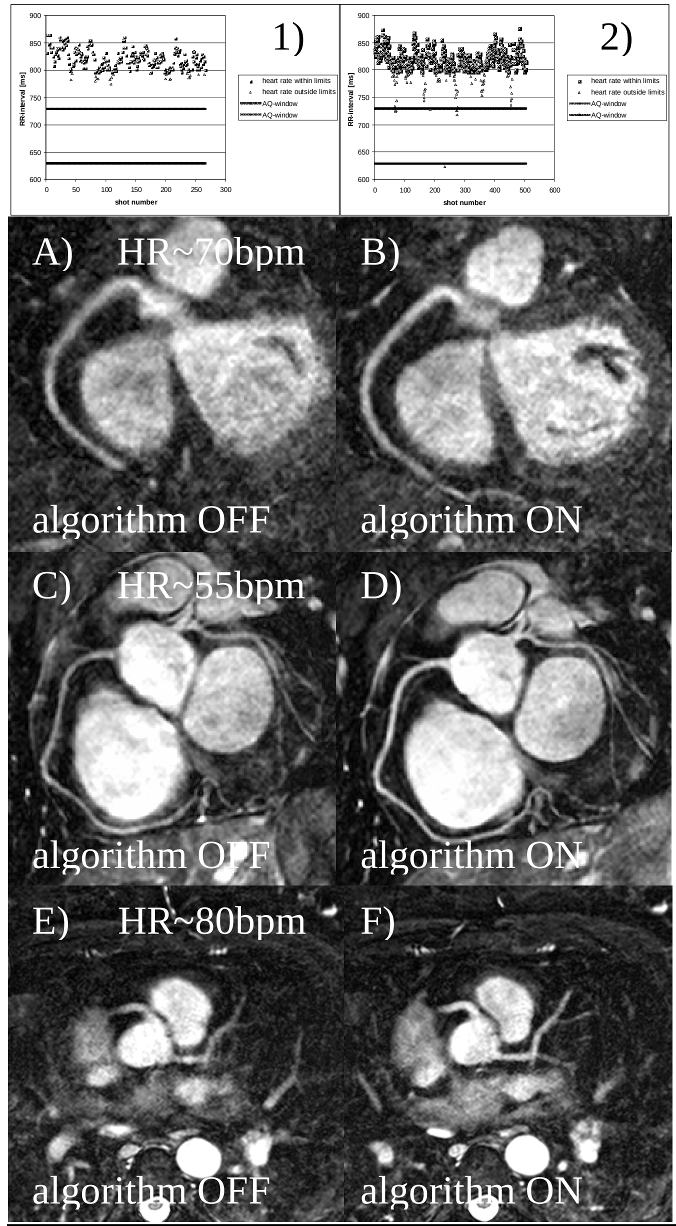

Figure: Left row: all RR-intervals were accepted. Right row: only data within a user defined window were accepted. Scatter plot showing RR-intervals for each shot. Solid lines mark acquisition window. Bright squares: RR-intervals within window. Dark triangles: RR-intervals outside window.

Conclusions: We successfully demonstrate an RR-interval gating mechanism for coronary artery imaging that leads to improved vessel delineation when compared to conventional R-wave triggering. The improvement is most prominent at higher heart rates. This promising novel approach warrants further investigation and has the potential to improve overall image quality in coronary MRA.

1. Kim et al. NEJM 2001;345:1863-1868