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Meeting abstract

2120 Prospective correction of trigger delay errors caused by heart rate variability using the electrocardiogram during coronary artery imaging

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Introduction

Non-invasive alternatives to X-ray angiography, such as MR and MSCT angiography must acquire sub-image data over multiple heartbeats. The accompanying challenge of avoiding cardiac motion artifacts lies in accurately aligning acquisition windows to a low-motion cardiac phase, typically end-systole or diastasis. Using a subject-specific trigger delay reduces gating errors caused by variations in individual physiology. Intra-subject heart rate variability (HRV), however, is believed to be a significant cause of image degradation. We hypothesize that the effect of HRV on the timing of cardiac imaging windows can be predicted and corrected from the electrocardiogram (ECG). This is done through the prospective adjustment of trigger delay to changes in the RT interval of the ECG (ΔRT_n) predicted by changes in the previous cardiac cycle duration (RR_{n-1}) associated with HRV.

Purpose

To improve the accuracy of cardiac gating to the onset of cardiac low-motion periods (LMPs) for non-invasive coronary artery imaging.

Materials and methods

RT_n vs. RR_{n-1} data were acquired from the ECG of 7 volunteers. Heart rate was varied by graded exercise. Subject-specific trigger delays for LMPs at end-systole and diastasis were obtained at baseline and elevated heart rates for the proximal right coronary artery via MR imaging. The use of ΔRT_n from the RT_n vs. RR_{n-1} relationship to correct the baseline trigger delays at elevated heart rates was evaluated.

Results

ΔRT accounted for 74.0 ± 23.2% of the onset shifts in diastasis LMP caused by increases in heart rate; the error between the predicted and observed LMP onsets was 16.5 ± 16.5 ms. For the end-systole LMP, ΔRT predicted 78.4 ± 20.5% of the onset shifts; the corresponding error was 14.2 ± 12.7 ms. Figure 1 shows the RT_n vs. RR_{n-1} relationship for one subject. In addition, compression of LMP duration with respect to the elevated heart rates was found to be small for end-systole (13.4 ± 6.88%) and large for diastasis (51.6 ± 27.3%). Furthermore, the diastasis LMP disappeared at high heart rates in 2 subjects.

Conclusion

In the presence of HRV, (1) changes in RT represent significant shifts in trigger delay and (2) end-systole provides a more robust imaging window than diastasis. The use of heart rate adaptive trigger delays based on RT_n vs. RR_{n-1} from the ECG improves cardiac gating accuracy and imaging efficiency for a target image quality.

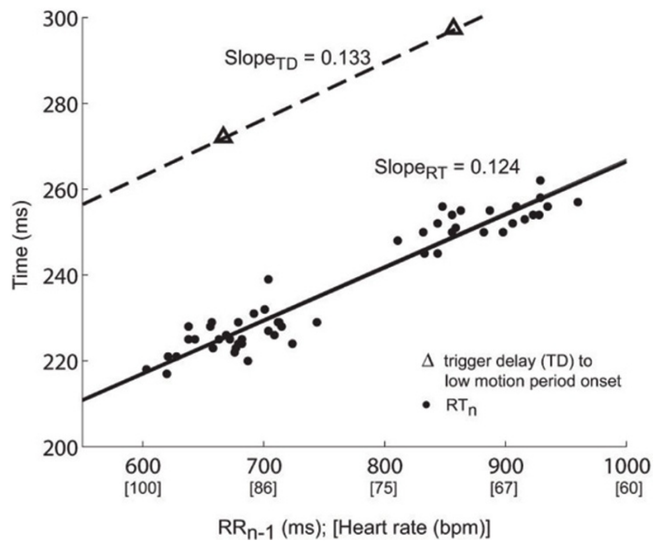

Figure 1
Example of RT_n vs. RR_{n-1} data along with low motion period onsets at two different heart rates for the one subject. The linear fits are also shown as the solid and dotted lines through the data points. The close agreement between $Slope_{RT}$ and $Slope_{TD}$ allows the prospective correction of trigger delay (TD) using ΔRT_n based on a ΔRR.