Translational Motion Correction Nearly Doubles the Rest Period of the Coronary Arteries During Tidal Breathing

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Introduction: Motion during MR imaging causes blurring and ghosting artifacts. The long scan times used for 3D MR coronary angiography introduce the possibility of respiratory motion artifacts. Imaging during quiescent phases of the respiratory cycle is a method for eliminating these artifacts. Additionally, translational motion correction using navigator echoes is a method commonly used to increase scan efficiency. We performed a study of the respiratory motion of the coronary arteries, and quantified the duration of the quiescent phase at end-expiration. We also measured the potential of 3D translation motion correction for increasing scan efficiency.

Methods: Conventional cine biplane coronary angiograms were acquired for 8 male and 2 female patients referred for diagnostic left heart catheterization (mean age, 65±11 years). Patients gave written informed consent to participate in this IRB approved study. The patients received no breathing instructions, so that spontaneous tidal respiration was imaged. A time-varying three dimensional (3D+t) model of the coronary arteries was constructed for each patient using a stereo reconstruction method and an automatic motion tracking algorithm [1]. For this study, we considered only the proximal and middle segments of the right coronary artery (RCA, segments 1&2 as defined in [2]), and the proximal 5 cm of the left coronary tree, which included the left main, left anterior descending, and left circumflex arteries. We used a cardiac respiratory parametric model to decompose the motion field into separate cardiac and respiratory components [3]. The duration of the quiescent period during the respiratory cycle was measured at end-expiration. The rest period was defined as the time during which the maximum 3D motion of the coronary tree was less than some upper bound. The rest period is reported in milliseconds and as a percent of the patient's respiratory cycle. To measure the effect of translation motion correction, coronary tree models from different respiratory phases were registered to the coronary tree at end-expiration using a 3D translation. The *motion-corrected* rest period duration was then computed for the residual motion.

Results: We studied 7 left coronary angiograms, and 4 right coronary angiograms. For 0.5 mm of allowed 3D motion of the RCA, the rest period was 685±340 ms (range, 430-1161 ms) or 17±8% of the respiratory cycle (range, 9-28%). For 0.5 mm of allowed 3D motion of the left coronary tree, the rest period was 834±925 ms (range, 185-2727 ms), or 18±14% (range, 4-43 %). With the use of translation motion correction, the respiratory rest period increased to 27±13% of the tidal respiratory cycle for the RCA. For the left coronary artery, the rest period increased to 32±13%. Motion correction using a 3D translation significantly increased the rest period at end-expiration (Figure 1).

Discussion: Respiratory rest period durations were measured for the coronary arteries during spontaneous tidal respiration. For applications requiring a spatial resolution of 0.5 mm, data can be acquired during only 17-18% of the tidal respiratory cycle. With ideal 3D translation motion correction, data could be acquired during 27-32% of the respiratory cycle. The results suggest that translation motion correction can provide a two-fold improvement in scan efficiency for a given image quality (3D motion<0.5 mm). The use of higher order motion models may provide further improvements in scan efficiency, but may be more difficult to implement. The use of rigid body and affine motion correction will be studied.

Allowed 3D Motion (mm)	Rest Period Duration	
	(ms)	(% of Resp. Cycle)
0.5	685±340	17±8
1.0	1065±320	26±8
1.5	1354±264	33±8

Table 1 Respiratory rest period at end-expiration for the RCA (N=4).

Allowed 3D Motion (mm)	Rest Period Duration	
	(ms)	(% of Resp. Cycle)
0.5	834±925	18±14
1.0	1232±1172	27±17
1.5	1479±1177	33±16

Table 2 Respiratory rest period at end-expiration for the left coronary tree (N=7).

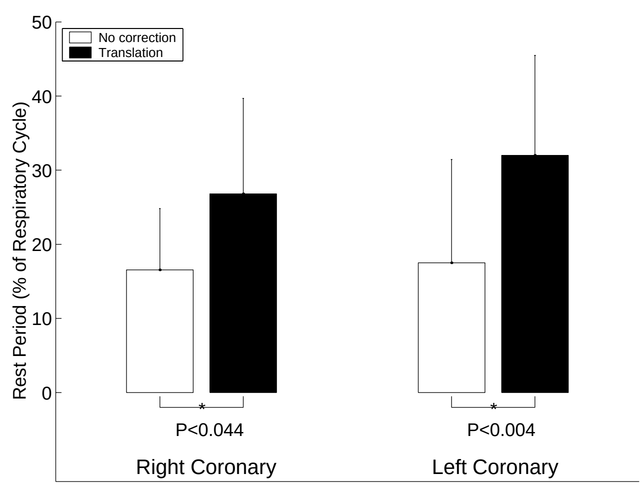

Figure 1 Respiratory rest period duration at end-expiration, for an allowed 3D motion of 0.5 mm. The 3D translational motion correction model significantly lengthens the time during which data can be acquired, while allowing the same amount of physiologic motion (P<0.05, paired two-tailed T-test).

References
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