

Assessment of Myocardial Twist motion by Velocity Encoded MRI in LA - Orientation

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Introduction: The rotational (twist) motion of the heart is an important parameter for the assessment of cardiac function in CRT patient selection. Reduced twisting is often related with heart diseases. The purpose of this study was to investigate the feasibility of velocity encoded MRI to comprehensively retrieve the twisting motion of the heart from 6 slices acquired in long axes geometry with equidistant radial spacing.

Materials and Methods: Seven healthy volunteers underwent the MR imaging protocol. Image acquisition was performed on a 3T whole body MR scanner (Achieva 3.0T, Philips, Best, Netherlands) with a 32 [2 x 4 x 4] channel phased array cardiac coil. After a coil-sensitivity survey, 6 long-axes views were acquired with 30° angular spacing. MR acquisition was performed applying a black blood prepared, respiratory navigated, segmented and velocity encoded cardiac triggered gradient echo sequence. The imaging parameters were: TR/TE = 5.2 ms/3.6 ms, spatial resolution = 2 x 2 x 8 mm³, 3 k-lines per segment, flip angle = 15°, VENC = 15 cm/s in through plane direction, 30 heart phases. Quantitative rotational motion analysis was performed by an in-house developed analysis software. After automatically segmentation of the left ventricle, the rotation angle ϕ was calculated for apical, equatorial and basal segments and the twist angle θ was determined for each cardiac phase and segment. The twist angle was interpolated over time for each segment and the mean maximum twist of each segment determined. Additionally, the time to the maximum twist was calculated for each volunteer and the mean percentage of RR-cycle where maximum twisting occurs was determined. The segments are defined counterclockwise starting in the anterior part of the heart (segments 1-6 are located in the septal part; sections 7-12 in the lateral part).

Results: Figure 1 shows the anatomical and velocity information for the six long axes views 150 ms after the R-wave exemplarily for one volunteer. Especially in the lateral wall the myocardium is moving in different directions in the apex and in the basis. Figure 2a revealed the expected higher myocardial twisting in the lateral segments (segments 6-12). Segment 9 shows the highest myocardial twisting. More detailed information of the retrieved myocardial twisting motion is presented in Table I. The maximal myocardial twist was measured after 36% of the RR-cycle. Figure 2b shows the rotation angle of basal, equatorial, and apical region of the heart as well as the twist angle exemplarily for a inferolateral segment in one volunteer.

Discussion and Conclusion: The twisting motion of the heart can be retrieved from 6 LA views. Maximal twist is observed in the inferior and inferolateral segments of the heart. The lateral wall shows increased myocardial twisting compared to the septal wall. This might be due to its connection to the right ventricle, which motion influences the motion of septum. The maximum twist was found to be about 38°. This value has a large standard deviation of 11°. Maximum myocardial twisting occurs after approx 36% of the RR cycle. This is approximately the time, where diastole starts, thus introducing a myocardial untwisting. In future, these results might be compared to patients with cardiac diseases.

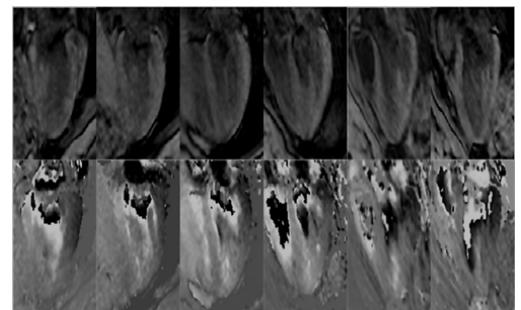


Figure 1: Anatomical (top) and velocity-encoded images (bottom) of six LA views. In the VE images, twisting motion can be appreciated by the negative (dark) basal and positive (bright) apical velocity.

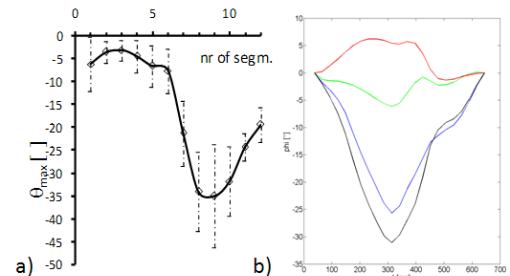


Figure 2: a) Mean maximum twist angle θ_{\max} of each segment; b) rotation ϕ of the basis (red), equatorial (green) and apex (red) and the twist (black)

| Vol. | segm. of max. twist | amplitude of max. twist [deg] | time of max. twist [ms] | duration of RR cycle [ms] | % of RR cycle |
|----------|---------------------|-------------------------------|-------------------------|---------------------------|---------------|
| 1 | 9 | -28,75 | 277,42 | 740,74 | 37 |
| 2 | 9 | -25,46 | 298,43 | 923,08 | 32 |
| 3 | 8 | -32,89 | 309,14 | 800,00 | 39 |
| 4 | 9 | -47,28 | 296,94 | 800,00 | 37 |
| 5 | 8 | -48,17 | 307,99 | 869,57 | 35 |
| 6 | 9 | -52,63 | 296,14 | 750,00 | 39 |
| 7 | 8 | -32,02 | 237,89 | 750,00 | 32 |
| mean | 8,57 | -38,17 | 289,14 | 804,77 | 36 |
| Δ | 0,53 | 10,86 | 24,88 | 68,73 | 03 |

Table 1: Segment, amplitude and time (relative to the RR peak) of the maximum twist, duration of the RR cycle and percentage location of the maximum twist within the RR cycle for all volunteers, and the resulting mean value and standard deviation.