GLOBAL-TO-LOCAL TANDEM METHOD FOR DETECTING THE CORONARY STATIONARY PERIOD FOR WHOLE-HEART MAGNETIC RESONANCE CORONARY ANGIOGRAPHY (WH MRCA)

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Introduction: WH MRCA [1-3] studies are usually performed during the period when the coronary arteries are stationary, which is determined by using cine display. It therefore depends on the operator's experience and several automatic methods have been developed. One such method uses the global heart signal for analysis [4] and is suitable for detecting motion of the whole heart in the slice for both systolic and diastolic stationary periods, but this method tends to suffer from noise. Another method employs a coronary ROI for analysis [5-6] and is suitable for precise detection of the stationary period, but not for all cardiac phases, because shape and slice level of the coronary artery may change during a heartbeat. We have developed the Global-to-Local Tandem Method, in which the coronary stationary period is roughly analyzed by the global method and then more precisely analyzed by the local method. We have also conducted clinical feasibility studies.

Methods: 2D SSFP cine images were obtained using a 1.5-T MRI scanner with TR/TE = 3.2/1.6 and matrix = 160. A total of 40-50 phases were obtained in 10 healthy volunteers. In the global method, the differences between adjacent cine images were analyzed using the whole-heart signal. The local method was then applied by setting the ROIs automatically [6] or manually on the coronaries around the stationary period (SP) determined by the global method. It analyzed the stationary period of coronary arteries based on the differences of cross-correlation coefficients calculated by cross-correlation. The results are automatically displayed as graphs (Figure1). The operator can confirm the result plot that is coupled with cine images. The final SPs were determined by taking minimum for right and left coronary SPs both at systole and diastole. The data for 10 subjects were analyzed by 5 operators, and the SPs and the time required for analysis were recorded and compared with those by the software. The success rates (%) were defined as the ratio of SPs calculated by the software that were within the SP ranges found by operators.

Results and Discussion: The calculated length of SPs was 67 ± 14ms and 69 ± 15ms, respectively for right and left coronary artery at systolic phase. Almost no difference was found. The SPs for diastolic phase were 232 ± 98ms and 291 ± 100ms, respectively for the right and left coronary artery. As have been reported, the former was shorter than the latter. The variation in the results of the 5 operators was small in detecting the beginning of systole (17 ± 8 ms) but was larger at the beginning of diastole (58 ± 19ms). The success ratio of the global method was 90% for diastole but 70% for systole. After applying the local method, success ratios were 100% for diastolic phase but 90% for systolic phase (Subject No.10 was failed) (Figure 2). However, by using the tandem method, the suitability improved in systole phase compared to global method only and was easily increased to 100% by using an interface coupled with cine images (see Figure 1). The tandem method reduced the measuring time to about 30 seconds, as compared to the time required by operators (43 ± 17 s, max. 120 s).

Conclusion: Results suggests that The Global-to-Local Tandem Method can robustly detect the coronary artery stationary period in WH MRCA. It is therefore concluded that this method should prove to be very useful for clinical WH MRCA examinations.

References: [1] Weber OM, Pujadas S, Martin AJ, Higgins CB. J Magn Reson Imaging 2004; 20: 395-402.; [2] Sakuma H, Ichikawa Y, Suzawa N et al.,Radiology 237:316-321, 2005.; [3] Okada T, Kanao S, Ninomiya A, et al.,Eur J Radiol 71:486-91, 2009.; [4] Bi X. et al. Magn Reson 2007; 9(2):234-235.; [5] Jahnke C. et al. J Cardiovasc Magn Reson 2005;7(2):395-399.; [6] Sato T. et al. SCMR 2008; 408:130.
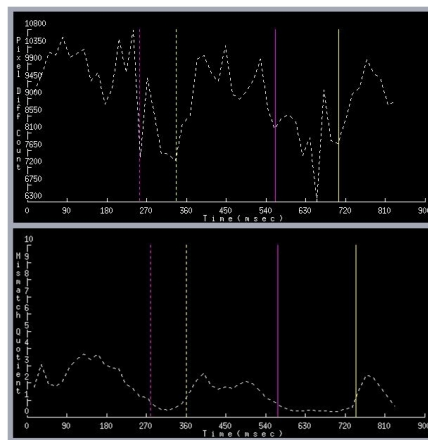
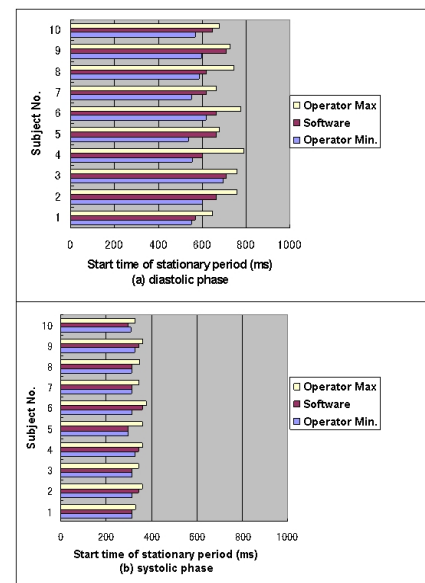**Figure 1. Global-to Local Tandem Method (Upper: Global, Lower: Local)**

Figure 2. Start time of stationary period (ms) (a) diastolic phase (b) systolic phase