The Variation of Tagging Contrast-to-Noise Ratio (CNR) of SPAMM Image by Modulation of Tagline Spacing

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ABSTRACT

Myocardial tagging technique such as spatial modulation of magnetization (SPAMM) allows the study of myocardial motion with high accuracy. Tagging contrast of such a tagging images can affect to the accuracy of the estimation of tag intersection in order to analyze the myocardial motion. Tagging contrast can be affected by tagline spacing. The aim of this study was to investigate the relationship between tagline spacing of SPAMM image and tagging contrast-to-noise ratio (CNR) experimentally. One healthy volunteer was undergone electrocardiographically triggered MR imaging with SPAMM-based tagging pulse sequence at a 1.5T MR scanner (Gyroscan Intera, Philips Medical System, Netherland). Horizontally modulated stripe patterns were imposed with a range from 3.6mm to 9.6mm of tagline spacing. Images of the left ventricle (LV) wall were acquired at the mid-ventricle level during cardiac cycle with FE-EPI (TR/TE/FA=5.8/2.2/10). Tagging CNR for each image was calculated with a software which developed in our group. During contraction, tagging CNR was more rapidly decreased in case of short tagline spacing than in case of long tagline spacing. In the same heart phase, CNR was increased corresponding with tagline spacing. Especially, at the fully contracted heart phase, CNR was more rapidly increased than the other heart phases as a function of tagline spacing.

Keywords: Myocardial tagging, Tagline spacing, SPAMM, Contrast-to-noise ratio (CNR)

1. INTRODUCTION

Noninvasive techniques for assessing the dynamic behavior of the human heart are invaluable in the diagnosis of heart disease, as abnormalities in the myocardial motion sensitively reflect deficits in blood perfusion [1]. Although echocardiography is the dominant imaging modality for the detection of such a heart disease, magnetic resonance imaging (MRI) has better resolution and lower noise images, allowing more detailed analysis to take place while remaining non-invasive [2]. However, MRI does not allow for visualization of the exact local motion pattern of the myocardium because of the absence of structural reliably traceable landmarks. Myocardial tagging technique such as spatial modulation of magnetization (SPAMM) allows the study of myocardial motion with high accuracy. Recently, automatic tagline detection algorithms have been used for myocardial motion analysis using tagged MR images [3][4]. In this algorithm, accurate tag center estimation is important procedure to measure the heart wall motion accurately. Tagging contrast can affect to accuracy of the estimation of tag intersection in such an automatic tagline detection algorithms [4]. If the tagline spacing is decreased, tagging contrast may be decreased due to some factors such as tag profile or resolution of imaging system, although much of group's current efforts are focused on how to create dense fields of measurements [5]. Moreover, in in-vivo study, tagging contrast can be affect by the myocardial motion where the tagline spacing is short. The aim of this study was to investigate the relationship between tagline spacing and tagging contrast-to-noise ratio (CNR) experimentally.

2. MATERIALS AND METHODS

2.1. Data Acquisition

One healthy volunteer (26 year-old male) was undergone electrocardiographically triggered MR imaging with SPAMM-based tagging pulse sequence at a 1.5T MR scanner (Gyroscan Intera, Philips Medical System, Netherland) using SENSE technique. Horizontally modulated stripe patterns were imposed with 3.6mm, 4.8mm, 6.0mm, 7.2mm, 8.4mm, and 9.6mm of tagline spacing. The thickness of taglines was automatically modulated by MR system. For each tagline spacing conditions, images of the LV wall were acquired at mid-ventricle level during cardiac cycle with TR/TE/FA = 5.8/2.2/10, 8mm of slice thickness, 256×256 of scan resolution and 300mm of FOV by using of FE-EPI

sequence. SENSE technique was also used in this study. Short-axis cardiac images were obtained at ten phases for one cardiac cycle during 19sec of scan time.

2.2. Measurement of CNR

All obtained images were transferred to the personal computer, equipped with a software developed in our group (program language, IDL) to perform the calculation of tagging CNR. Noise level was yielded from standard deviation of the background signal intensities. Signal intensity of taglines and untagged tissue was measured to calculate the tagging contrast. To calculate the tagging CNR, signal intensity difference between tagged and untagged tissue was divided by noise level of image background. All of these procedures were performed for all images that had different tagline spacing and different heart phase. Measurement was carried out over the three times for each images and mean value of those was yielded.

3. RESULTS

During contraction that is period from end-diastole to end-systole, in case of short tagline spacing, tagging CNR was more rapidly decreased than the other cases, and after that, CNR was preserved. In case of long tagline spacing, the variation of CNR value over the cardiac cycle was not rapid (Fig.1). In same heart phase, CNR was increased corresponding with tagline spacing. Especially, at the fully contracted heart phase, CNR was more rapidly increased than the other heart phases as a function of tagline spacing (Fig.2).

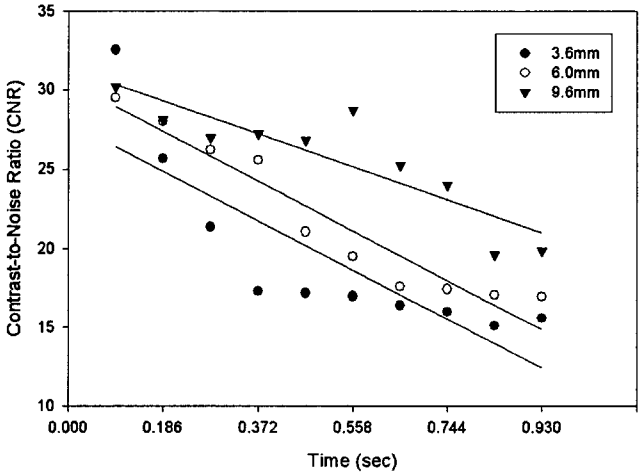

Fig. 1. The variation of tagging CNR as a function of time i the cardiac cycle

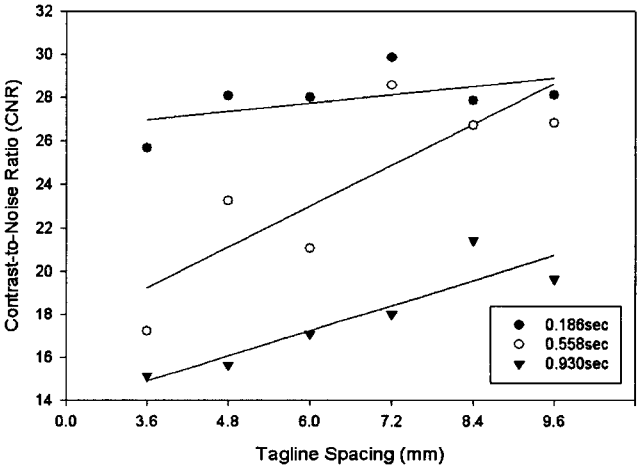

Fig. 2. The variation of tagging CNR as a function of taglin spacing

4. DISCUSSIONS AND CONCLUSION

It is known that many myocardial tagging techniques such as SPAMM suffer from the rapid fading of the tags which may not be reliably detected after end-systole [6]. The reason of fading of the tags is the decrease of tagging contrast due to the relaxation of tagged spins. These fading also can be affected by the other factors such as tagging parameters or tagline spacing. Previously, *Atalar et al* [4] published about the tag estimation 'error factor' that can be revealed on the automatic tagline detection performance. They showed that low tagging CNR (less than 5) can induce the high value of error factor which prevent accurate detection of tags, but the effects by tagline spacing was not mentioned. In this study, we measured tagging CNR as a function of tagline spacing. All of results from this study showed higher value of tagging CNR than reference value that mentioned previously by *Atalar*. During contraction, we could observe that tagging CNR was rapidly decreased in case of short tagline spacing image. And, at the phase of end-systole, the variation of tagging CNR as a function of tagline spacing was higher than the other phases. This results shows that the decrease of tagline spacing due to myocardial contraction also can affect to value of tagging CNR. In conclusion, because tagline spacing can affect to the tagging CNR, therefore more detail research about tagline spacing is necessary in order to perform accurate myocardial motion analysis.

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