Frequency-domain Index for Characterization of Tagged Images

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SYNOPSIS

Tagged images are characterized by spectral side-peaks (harmonics) in the frequency domain. While image domain measures, such as tag contrast, have been well studied, few studies have investigated the frequency domain. Given the recent interest in efficient tagging analysis methods that exploit the 1st harmonic representation in the frequency domain, we investigated a new index, 1st harmonic intensity decay. Human myocardial SPAMM acquisitions, with varying temporal delays, revealed that the frequency domain index was more sensitive than image domain tag contrast for tag temporal characterization. Further analysis is needed to determine the relation to physiology.

INTRODUCTION

Tagged data can be considered as an image modulated by a sinusoidal-like band pattern. In the frequency domain such a modulation causes spectral peaks (harmonics) which reside at positions determined by the tag frequency. These harmonics can be considered to contain the deformation information in the corresponding direction. Tag decay is governed by T1 relaxation. Temporal decay of tagging information is of importance for reliable myocardial imaging, since physiological quantities are often derived from both systolic (~300 ms) and diastolic (~ 600 ms) intervals of the cardiac cycle. Interest in the frequency domain representation of tagged images is of topical importance, in view of newer advances in the analysis of tagged images, such as the so-called harmonic phase (HARP) method, which is based on analysis of the 1st harmonic [1]. We therefore sought to compare a frequency domain measure to the well documented "tag contrast" image domain measure of tagged image quality.

METHOD

Two types of short axis cardiac SPAMM data were compared. One with the tagging prepulse applied at the start of each cardiac cycle (SPAMM type 1), and another with tagging prepulse re-applied at two further times in the cardiac cycle to improve tag persistency (SPAMM type 2). 1D acquisitions were combined to get 2D cross tags for each SPAMM type. We estimate the first harmonic intensity parameter by manually draw an ROI covering the first side peak in the frequency domain and calculating the summation of its magnitude intensity. Alternatively, the image domain parameter, tag contrast, was defined as the ratio of the peak to peak amplitude of the tagging modulation to the maximum image amplitude, in manually selected ROIs (averaged for the septal, anterior, lateral, and inferior myocardial walls) [2]. Finally, to explore functional correlates of the tagged imaging quality indices, HARP analysis was used to derive averaged mid-wall circumferential strain and strain-rates.

RESULT

Fig 1 shows a tagged image and its frequency representation. The tag grid spacing is inversely related to the spread of the individual harmonic peaks. **Fig 2** illustrates characterization of the tagged data using the image domain parameter vs. the frequency domain parameter. Image domain analysis shows similar tag persistence for both types of SPAMM acquisition. However, frequency domain analysis revealed a single decay curve for the type 1 SPAMM acquisition (compatible with its T1 relaxation properties), while for the type 2 acquisition the re-application of the tagging preparations with their subsequent decays was manifest. We have also explored strain/strain-rate functional indexes, corresponding to most rapid contraction and most rapid early relaxation (**Fig 3**) to derive correlative early- vs. late- temporal parameters of physiological interest.

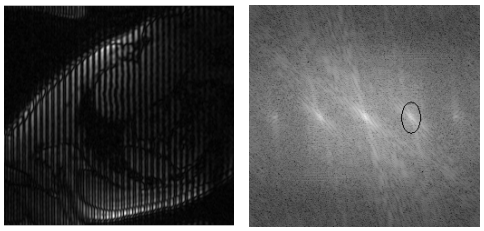

Fig 1. Magnitude image (left) and the corresponding frequency domain display (right) of a tagged acquisition. The circle shows a manually drawn ROI which covers the first harmonic.

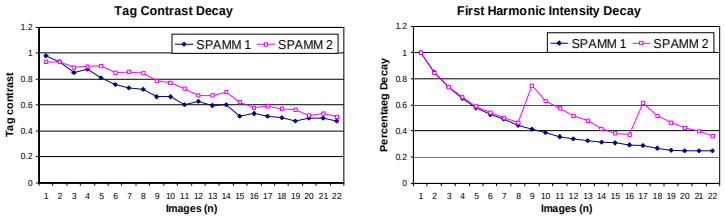

Fig 2. Tag contrast decay (left) vs. first harmonic intensity decay (right) for the 2 types of SPAMM acquisition.

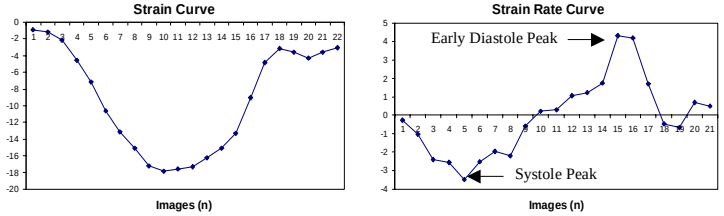

Fig 3. LV average mid-wall circumferential strain (left), and the corresponding time derivative, strain-rate, curve (right), with respect to timing within the cardiac cycle.

DISCUSSION

These preliminary data suggest that the 1st harmonic intensity, frequency domain index, affords additional information about tagging quality. It may be of particular importance for approaches such as harmonic phase (HARP) analysis that exploit the frequency domain characteristics of the tagged data. We used percentage values for the 1st harmonic index because, unlike the absolute value, it does not depend on the size or shape of the ROI. However, for other types of acquisitions, such as CSPAMM, where subtraction leads to doubling of the intensity, one may need to consider absolute intensity. In human studies, we are conducting ongoing analyses using a strain-rate index at short vs. long temporal delays, to determine the relation between these indices and physiological parameters.

References

[1] Osman NF et al. MRM 1999; 42:1048-1060

[2] Fischer SE et al. MRM 1993; 30:191-200