SIMULTANEOUS IMAGING OF MYOCARDIAL FUNCTION AND VIABILITY IN PATIENTS

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INTRODUCTION

The assessment of myocardial viability is important for therapeutic decision making in patients with myocardial infarction (MI). In addition, cardiac functional images provide complementary information about the heart. Composite strain encoding (C-SENC) imaging provides myocardial functional and viability images at the same cardiac phase (1). In this work, the method was tested on seven patients, and the resulting viability images were validated against conventional delayed-enhancement (DE) images. C-SENC imaging took almost the same time as DE imaging, but resulted in additional functional images. Furthermore, there was no misregistration between the two images, as usually seen when they are separately acquired.

METHOD and EXPERIMENTS

In C-SENC imaging, the tagging planes are placed parallel to the imaging plane with certain tagging frequency. After tissue contraction (stretching), the tagging frequency increases (decreases) correspondingly. Two images, which we call low-tuning (LT) and high-tuning (HT), are acquired with two different phase-encodings corresponding to the minimum and maximum expected values of tissue strain, respectively. From these two images, a functional image of the heart could be obtained (2). In addition to the LT and HT images, a third image with zero phase-encoding, which we call no-tuning (NT), is acquired. This third image captures the signal from the magnetization component resulting from T_1 relaxation. If acquired after contrast agent injection, like gadolinium (GD), a T_1-weighted delayed-enhancement image is obtained.

Figure 1 shows the pulse sequence used. A 1-1 SPAMM tagging pulse was applied at the detection of the QRS-complex of the ECG signal. Then, at end-systole, three consecutive excitation pulses were applied with different phase-encodings to acquire the NT, LT, and HT images. The k-space was filled in a segmented fashion. The flip angles for acquiring the LT and HT images were adjusted to achieve similar intensities in the two images.

Seven patients (6 males and 1 female; average age = 50; 6 have MI) were scanned on a 3T Philips scanner. The subjects were injected with 0.2 mmol/kg of GD-DTPA. Then, 10-15 minutes later, C-SENC and conventional inversion recovery (IR) delayed-enhancement (DE) images were acquired. The imaging parameters for C-SENC images were: TR = 18 ms; TE = 2.6 ms; scan duration = 11 s; trigger delay (TD) ≈ 300 ms (adjusted to image at end-systole); and flip-angles = 27˚, 32˚, and 40˚ for NT, LT, and HT, respectively. The imaging parameters for IR DE images were the same as in C-SENC imaging, except: TR = 3.4 ms; TE = 1.1 ms; inversion time (TI) ≈ 275 ms (adjusted to null normal myocardium); flip angle = 20˚.

The resulting C-SENC images were validated against IR DE images for determining infarction. The infarcted area was extracted from the DE and NT images using full-width-at-half-maximum (FWHM) technique (3). It should be noted that despite the poor blood/myocardium contrast in the NT images, blood and myocardium have excellent contrast in the LT and HT images. The sensitivity and specificity of the proposed technique against the gold standard IR DE imaging in determining myocardial infarction were computed. Sensitivity (specificity) was computed as the ratio of the area of the common infarcted region determined from both the DE and NT images to the area of the infarcted region determined from the DE (NT) image.

RESULTS

Figure 2 shows representative C-SENC images. Bright regions in the LT, HT, and NT images represent akinetic, kinetic, and infarcted myocardium, respectively. Figure 3 shows the resulting NT images and the corresponding IR DE images. The figure shows the good agreement between the two images. Sensitivity and specificity of the proposed technique for determining infarction were 82% and 86%, respectively. The third row in figure 3 shows composite color-coded images that depict both functional and viability information in a single image. Infarction, represented by blue, was determined from the NT image, while contracting myocardium, represented by degrees of red, was determined from the LT and HT images (2).

DISCUSSION and CONCLUSIONS

C-SENC imaging provides both myocardial functional and viability information simultaneously in a single breath-hold. The technique showed applicable in human subjects, and the resulting NT images showed good agreement with conventional DE images in determining infarction. C-SENC imaging took almost the same time as IR DE imaging, but resulted in additional functional images. This allowed for constructing one composite image that showed both functional and viability information.

REFERENCES

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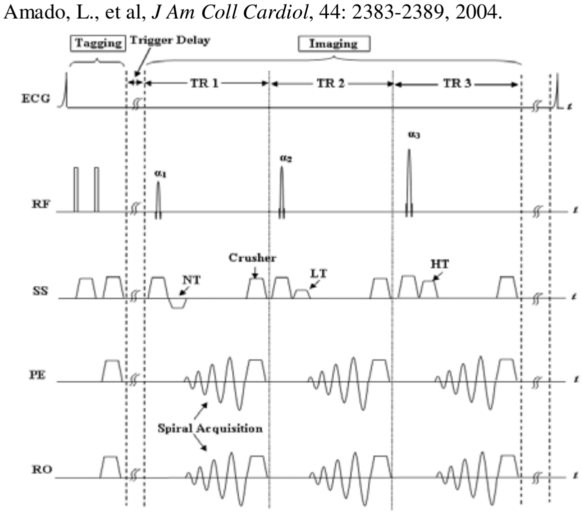

Fig. 1: Timing diagram of the pulse sequence used.

ACKNOWLEDGEMENTS

Grants: Donald W. Reynolds Found. and NHLBI R01-HL072704.

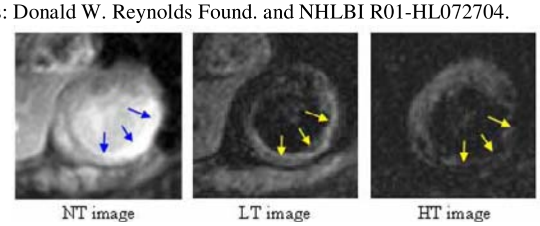

Fig.2: Representative C-SENC images (arrows point to infarction).

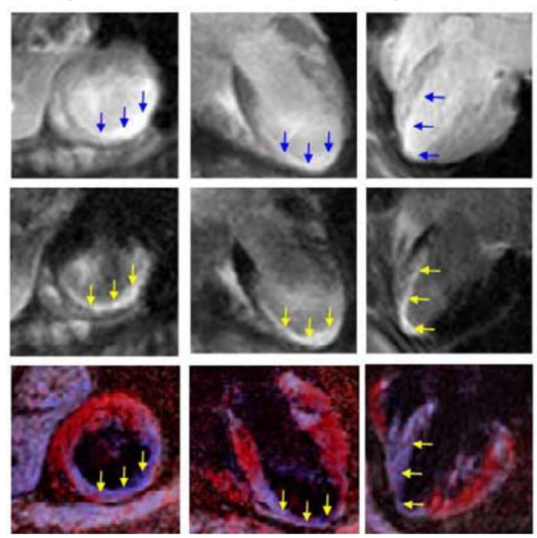

Fig. 3: First, second, and third rows show NT, DE, and composite images. Infarction (arrows) and normal myocardium are shown in blue and red, resp.