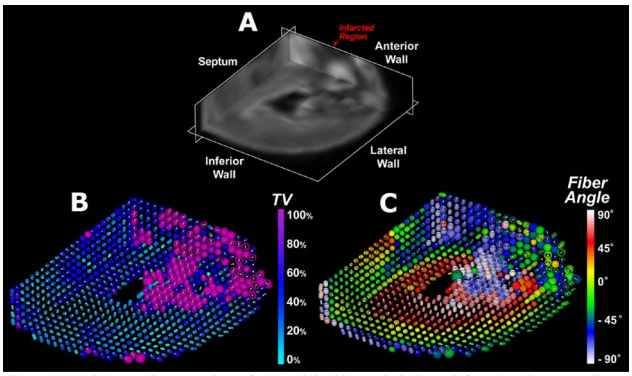

Figure 3. **(A)** Orthogonal cross-sections of a T2-weighted image depicting an infarcted canine myocardium. **(B)** Toroidal glyph field color-coded with TV (%). **(C)** Toroidal field color-coded with the fiber inclination angle. Notice the rearrangement of fiber orientation within the infarcted region into a more vertical pattern as shown by lighter blue and red toroids.

A new toroid-based representation of diffusion tensor fields is proposed to improve depiction of myofiber structure and defined an innovative diffusivity map, the toroidal volume. Results indicate that the toroidal representation improve myocardial structure characterization compared to conventional representations.

1082. FREE-BREATHING SINGLE-SHOT DENSE MYOCARDIAL STRAIN IMAGING USING DEFORMABLE REGISTRATION

Yuan Le, PhD[1], Peter Kellman, PhD[1], Eric E. Bennett, MS[1], Alex Lin, MS[2], Christophe Chefd'Hotel, PhD[3], Christine H. Lorenz, PhD[3], Han Wen, PhD[1]. [1]National Institutes of Health, Bethesda, MD, USA, [2]California Institute of Technology, Pasadena, CA, USA, [3]SIEMENS, Malvern, PA, USA.

Introduction

Free-breathing scans are often desirable in patients who find breath-holding difficult. We present a new approach for free-breathing myocardial strain imaging with displacement-encoding (DENSE)(1). It acquires images with a single-shot sequence and removes respiratory motion using deformable registration.

Methods All volunteers (n=4) were scanned on a 1.5T Siemens Avanto scanner. A multi-slice, single-shot DENSE sequence (Fig.1) with true-FISP readout (Fig.2)(2, 3) and FOV-selective excitation(4) was used to acquire 3 short-axis slices in a heartbeat. Ramped flip-angles through the readout train equalized the echo amplitudes. Displacement-encoding and image acquisition were placed at end-systole and late-diastole respectively, in order to capture the accumulated wall strain of systolic contraction. Imaging parameters were true-FISP echo spacing of 2.5 ms, matrix size of 128×40, FOV of 512×120mm with restricted excitation (equivalent to a matrix of 128×96 with 3/4 phase-encode FOV), slice thickness of 6-8mm, and ECG triggering every 2 RR intervals. A data set contained 270 images of 3(slices)×3(encoding directions)×30(repetitions). The encoding directions were oblique and combined in-plane encoding moments of 4.0 mm/radian with a through-slice (Z) moment of 1.0 mm/radian. This Z moment was sufficient to suppress the unwanted DC and conjugate-echo signal in the single-shot sequence(4, 5). Each direction was acquired in a separate heartbeat. The total scan time was 3 - 4 minutes. Image registration used a deformable algorithm(6). The registered images produced 90 strain maps= 3(slices)×30(repetitions). These were averaged over the repetitions to produce average strain maps for the slices. A correlation threshold was used to remove occasional images of poor registration quality due to ECG mistrigger. To evaluate strain noise reduction by this approach, we calculated the spatial variance of the pixel-wise strain values in the LV wall for three processing configurations: 1. single repetitions without averaging; 2. the average strain maps; 3. average strain map of respiratory gated (RG) data by selecting 1/3 of the repetitions with the highest diaphragm positions (end expiration).

Results A typical circumferential strain map from a single repetition and the corresponding average strain map of all repetitions show marked difference in the noise level (Fig.3). The spatial variance of strain decreased from 0.127 to 0.063 from single repetition to the average of the RG group, and further down to 0.054 upon registration and averaging of all repetitions. The remaining variance may account for real variation around the LV.

Conclusion and Discussion

Deformable registration of single-shot DENSE images permits averaging over all of the respiratory cycle for noise reduction. Although the resolution of 4.0mm is low, the pixel-wise measurement obviates the need for ROI analysis.

References

1. Aletras AH et al.. Displacement encoding in cardiac functional MRI (abstr). Proc.ISMRM 1998;1:281

2. Bennett E et al.. Ultrafast DENSE technique for mapping the volumetric 3D wall motion of the left ventricle (abstr). Proc ISMRM 2002;10:775.

3. Kim D et al.. Increasing the SNR and data acquisition efficiency of displacement-encoded MRI by the use of TrueFISP imaging at 3T and TSENSE parallel imaging (abstr). Proc. ISMRM 2006;3597.

4. Aletras AH et al.. High-resolution strain analysis of the human heart with fast-DENSE. JMR 1999;140(1):41-57.

5. Zhong XD et al.. Selective suppression of artifact-generating echoes in cine DENSE using through-plane dephasing. MRM 2006;56(5):1126-1131.

6. Hermosillo G et al.. Variational methods for multimodal image matching. IJCV 2002;50(3):329-343.

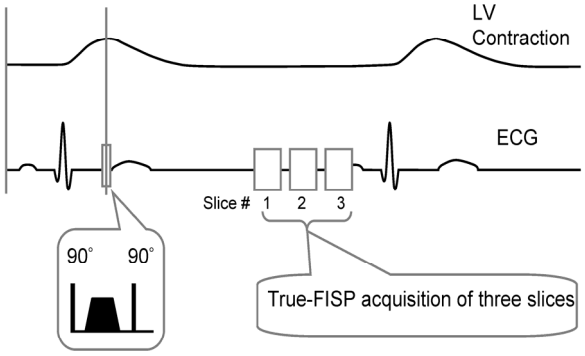

Figure 1 Time line of left ventricle contraction, ECG and the sequence.

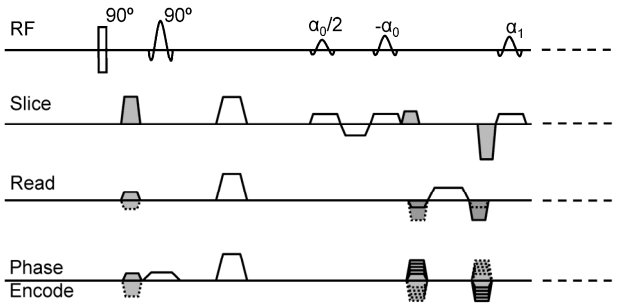

Figure 2 True-FISP DENSE sequence.

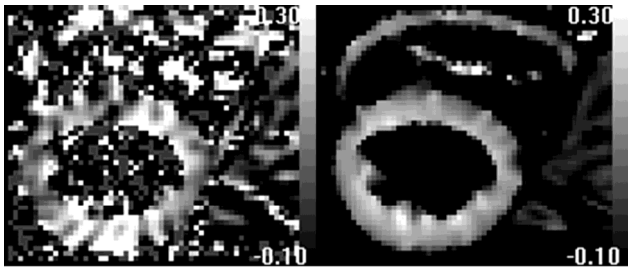

Figure 3 Left: Strain map from a single measurement; Right: strain map from the average of all registered images.

Elastic registration of single-shot DENSE myocardial strain maps allows the patient to breathe freely and permits averaging over multiple repetitions to reduce the noise level of the strain measurement. The effectiveness of this technique is shown in volunteers.

1083. REPRODUCIBILITY OF RIGHT ATRIAL VOLUME AND EJECTION FRACTION IN HEALTHY SUBJECTS AND PATIENTS WITH RIGHT HEART FAILURE USING THE STANDARD SHORT AXIS AND AREA-LENGTH METHOD

Burkhard Sievers, MD[1], Marvin Addo, MD[2], Frank Breuckmann, MD[1], Joerg Barkhausen, MD[3], Raimund Erbel, MD[1]. [1]West German Heart Center, Cardiology, University Hospital Essen„ Essen, Germany, [2]Department of Cardiology, University Hospital Cologne„ Cologne, Germany, [3]Department of diagnostic and interventional Radiology and Neuroradiology, University Duisburg-Essen, Essen, Germany.

Introduction: Reproducibility of right atrial volume and ejection fraction in healthy subjects and patients with right heart failure using the standard short axis and area-length methodBurkhard Sievers**,** Marvin Addo, Frank Breuckmann, Joerg Barkhausen, Raimund Erbel

*Background***:** Measurements of atrial volumes and ejection fraction (EF) are superior to diameters for both accurate determination of the atrial size and follow up studies. Changes of right atrial volume and EF might have a prognostic impact in patients with right heart failure. We therefore sought to evaluate the reproducibility of right atrial volumes and EF in healthy subjects and patients using the standard short axis method (SA) and the rapid area-length method (ALM).

Methods: Right atrial volumes (maximum and minimum) and EF were measured in 10 healthy subjects and 10 patients with right heart failure using SA and ALM. Images were acquired with a steady state free precession gradient-echo sequence on a clinical 1.5 Tesla magnetic resonance scanner (Siemens, Erlangen, Germany). For SA, volumes were determined by the sum the outlined areas. EF was calculated as follows: EF = (EDV-ESV)/EDVx100. For AML, the right atrial area and length were measured from the horizontal long axis view. Minimum and maximum volumes were calculated as follows: $8x(Area)^2 / 3\pi$ x Length, EF (%) = (Maximum volume - Minimum volume)/Maximum volume x 100. All patients were examined twice (scan 1 and 2). Both scans were performed at the same day.

Results: For SA, maximum volumes, minimum volumes and EF for healthy subjects were 95.4±19.9mL, 47.9±8.9mL, 49.0±8.1% in scan 1 and 95.8±17.5mL, 49.5±11.2mL, 48.1±8.8% in scan 2 ($p \geq 0.285$). SA-volumes and EF for patients in scan 1 and 2 were 145.2±28.2mL, 106.9±25.9mL, 26.5±9.7% and 146.3±26.3mL, 109.9±23.9mL, 24.9±9.8%, respectively ($p \geq 0.139$). SA-interstudy variability was -0.3±7.9mL, -1.6±4.9mL and 0.9±3.5% for healthy subjects (Figure 1A) and -1.1±6.8mL, -3.0±5.2mL and 1.7±2.7% for patients, respectively (Figure 1B).For ALM, maximum volumes, minimum volumes and EF for healthy subjects were 89.3±19.4mL, 43.7±8.0mL, 50.1±8.3% for scan 1 and 81.7±15.8mL, 38.7±7.5mL, 51.8±10.3% for scan 2 ($p \leq 0.114$). ALM-volumes and EF for patients in scan 1 and 2 were 139.9±28.3mL, 103.7±26.9mL, 26.5±10.3% and