Automatic contour detection in short-axis cardiac cine MR data

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Conclusion: We described an optimized sequence and provided normal values for gRE in a specific scanner setting. Using similar hardware and software conditions, these data could be used as a reference guideline for image acquisition and analysis of gRE as part of the diagnostic work-up of myocarditis patients. Standardization of the imaging procedures will facilitate CMR multi-center trials in acute myocarditis.

558. Automatic Contour Detection in Short-Axis Cardiac Cine MR Data

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Introduction: Short-axis cine cardiac MRI acquisitions usually consist of 15–25 phases at 10–15 slices (150–375 images) that are approximately perpendicular to the long axis of the heart. Segmentation of left ventricle, right ventricle and myocardium is required for quantification and diagnosis of the cardiac function (Fig. 1a). Current automatic segmentation methods usually ignore anatomical knowledge and already defined contours in adjacent images. Besides this, currently applied methods do not provide adequate contours in the presence of papillary muscles or trabeculae, requiring elaborate interaction of a skilled user.

Purpose: The purpose of our work was to develop and optimize an improved Active-Contour based segmentation method, which will provide correct contours also in areas where papillaries or trabeculae are present. User interaction is reduced to drawing only one initial contour, which is automatically propagated throughout the data set, resulting in a complete set of contours. During propagation, the 'drawing style' of the initial contour is imitated. As a result, the generated contours reflect the user's preferences (e.g., inclusion or exclusion of the papillary muscles).

Methods: The starting point for the new method was our existing Active Contour algorithm. The new algorithm optimizes the contour locally based on the matching of grayvalue profiles perpendicular to the contour path (Fig. 1b). The contour is propagated by repositioning a contour in neighboring phases in order to optimize the match between the grayvalue profiles. Consequently, the 'initial behaviour' of the contour is copied, until each phase in the dataset is segmented.

The result of contour propagation depends on a number of parameters such as resolution along the contour and the profiles, length of the profiles, and the number of steps in the iterative deformation process. The optimal parameter configuration was determined in an extensive search of the parameter space, including 4400 parameter configurations. Proper definition of a positioning error allowed Analysis of Variances to be used to determine main effects and interactions of the parameters. Ultimately, an optimal parameter configuration was concluded.

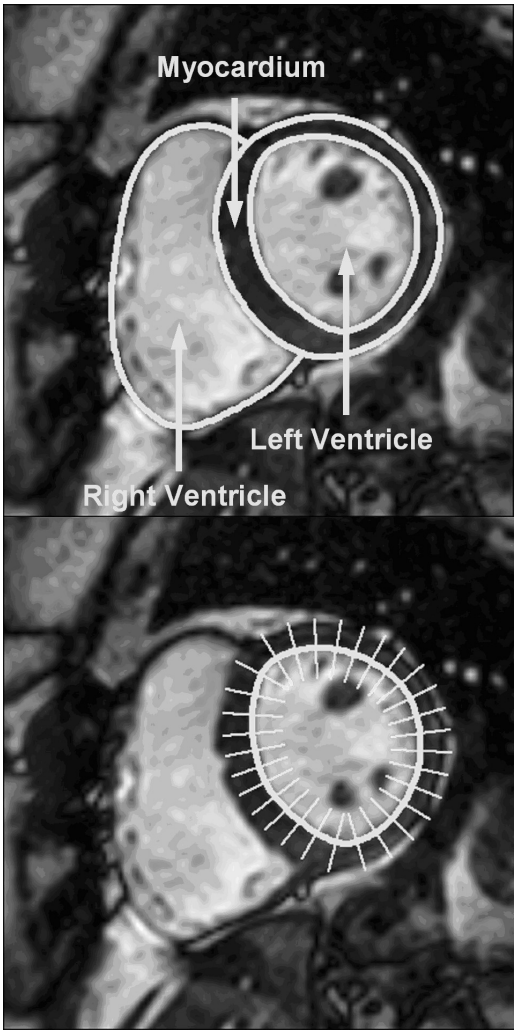

Figure 1. a) The anatom!ical structures of interest and related contours; b) Perpendicular orientation of grayvalue profiles for the LV endocardium contour.

The method was optimized and technically validated using 300 short axis ECG-triggered cine cardiac MR images, obtained in 4 acquisitions containing 25 phases in three slices which were imaged with slice thickness 8.0–10.0 mm, FOV 350 × 350 mm–410 × 410 mm; image size 256 × 256; flip angle 60°; TE 1.5–.6 ms; TR 3.1–3.2 ms. We are grateful to Eike Nagel of the Deutsches Herzzentrum, Berlin, for supplying image data.

Results: After optimization, the average border positioning RMS error observed throughout a complete heart cycle was 1.2 ± 0.48 mm for the LV endocardium contour, 0.88 ± 0.39 mm for the LV epicardium contour and 1.1 ± 0.55 mm for the RV endocardium contour, which is well below the values reported for other semi-automatic methods and within inter-user-variability of the manual segmentations. The algorithm segments the three cardiac

contours in all images of one slice of a dataset with 25 phases within 1.5 seconds, allowing complete segmentation including manual initiation within a minute, compared to the 60 minutes needed for manual segmentation. In an ongoing, more extensive clinical validation on a large number of patients, the algorithm proved to be robust towards the significant variation in image quality present in these datasets.

Conclusions: The presented algorithm for automatic propagation of cardiac contours demonstrated to be a robust and accurate method for the delineation of the LV endocardium, LV epicardium and RV endocardium contours. Additionally, the analysis time is reduced significantly.

559. Investigation of Cardiac Diseases in Conscious Animals Using Single-Shot FSE NMR Imaging: Preliminary Results

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Introduction: Anaesthesia offsets part of the benefit of studying tissue function and/or metabolism non-invasively by NMR. Running NMR imaging protocols in conscious animals is an attractive alternative option. However, circumventing anesthetics is particularly challenging for cardiac imaging in small animals. In a feasibility study, we have previously shown that cardiac NMR imaging is possible in normal awaken hamsters.

Purpose: The goal of this study was to determine whether some degree of disease characterization was achievable with ultra-fast cardiac NMR imaging performed in conscious animals.

Methods: Conscious hamsters were slipped into a 4.6 cm diameter cylinder, with the neck and legs immobilized. Half-Fourier single-shot FSE imaging, with outer volume suppression to improve spatial resolution and with a double, selective and non-selective, inversion module to reinforce black-blood contrast provided motion artefact-free images and an excellent visualization of cardiac anatomy. Series of double oblique views were acquired with or without ECG gating. Image acquisition time was 53 ms, with an in-plane resolution of $470^{*}625$ μm^2. The ability of this protocol to detect alterations in cardiac anatomy and function and in myocardium texture was assessed in two pathological models. Cardiomyopathic hamsters and hamsters with LAD coronary ligation were compared to control animals.

Results: In cardiomyopathic hamsters (CM), left ventricular dilatation (short axis diastolic mid-ventricular area: CM: 53.0 ± 2.4 mm^2 vs. ctrls: 29.1 ± 5.3 mm^2; $p = 0.006$) and abnormal ejection fraction (CM: $37 \pm 7\%$ vs. ctrls: $83 \pm 4\%$; $p = 0.002$) were demonstrated. Confirming previous findings in anaesthetized animals, the NMR signal distribution was more heterogeneous in the myocardial wall of cardiomyopathic hamsters than in controls (2.21 ± 0.15 a.u. vs. 0.94 ± 0.16 a.u.; $p = 0.0006$ at TEeff = 45 ms).

After LAD coronary ligation, the course of infarct and scar formation was monitored during the next 3 weeks. Oedema-related myocardial signal intensity changes were detected on T2-weighed images at the acute phase. Segmental dysfunction was evidenced throughout the period of observation.

Conclusion: This study demonstrates for the first time that characteristic features of cardiac pathologies can be evaluated with ultra-fast NMR imaging in conscious rodents.

560. Real-Time Ex-Vivo Visualization of Cardiac Cryoablation Lesions

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Introduction: Real-time guidance and visualization of cardiac ablation will improve the safety and efficacy of electrophysiologic procedures. MRI offers high quality anatomic delineation as well as post-ablation tissue characterization. Previous work has not demonstrated true real-time assessment during cardiac lesion formation using MRI. Given the unique MR appearance of frozen tissue and the increased use of cryoablation in electrophysiology, we imaged cardiac cryoablation in the MR environment.

Methods: MR imaging of cyroablation lesions was performed in a 0.5 T hybrid X-Ray/MR Interventional scanner (GE Medical Systems, Inc.). Both conventional Spin Echo (SE) (TE/TR 11/300 ms) and Real-time (RT) spiral

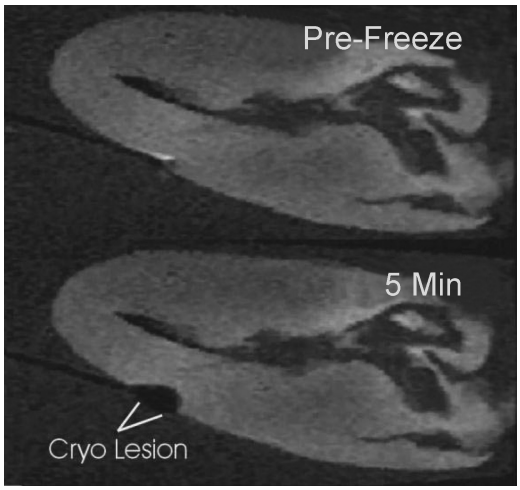

Figure 1.