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Feasibility of automated frame-by-frame myocardial segmentation as a basis for quantification of first-pass perfusion images

Giacomo Tarroni[1], Amit R Patel[2], Federico Veronesi[1], Claudio Lamberti[1], Victor Mor-Avi*[2] and Cristiana Corsi[1]

Address: [1]University of Bologna, Bologna, Italy and [2]University of Chicago, Chicago, IL, USA

* Corresponding author

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Introduction

Quantification of first-pass myocardial perfusion from cardiac magnetic resonance (CMR) images relies on the definition of myocardial regions of interest (ROI). This is usually achieved by manually drawing ROIs in one frame and then adjusting their position on subsequent frames. This methodology is tedious and potentially inaccurate. We recently developed a technique based on image noise density distribution for automated dynamic endocardial border detection as a basis for quantification of left ventricular size and function.

Purpose

The goal of this study is to adapt this technique for automated frame-by-frame myocardial segmentation of first-pass perfusion images and test its clinical feasibility.

Methods

LV short-axis images (Philips 1.5 T) were obtained at three levels of the left ventricle during first pass of a Gadolinium-DTPA bolus (0.10 mmol/kg @5 ml/sec). Images were acquired using a hybrid gradient echo/echo planar imaging sequence (3 slices, thickness 10 mm, pixel size 2.5 × 2.5 mm, nonselective 90° saturation pulse followed by 80 ms delay, flip angle 20°, TR = 5.9 ms, TE = 2.7 ms, EPI factor 5, SENSE factor 2). For each slice, after manually placing a seed point inside the LV cavity on a single frame, endocardial boundaries were automatically detected throughout the image sequence by using a modified region-based model based on the probability of density distribution of gray levels. Then epicardial boundaries were detected using a classical edge-based level-set model. Image registration was achieved by two-dimensional cross-correlation to compensate for respiratory motion. Six standard myocardial ROIs were automatically defined and contrast enhancement curves were constructed throughout the image sequence. This approach was tested on 24 slices during first pass perfusion by: (1) visually judging frame-by-frame the accuracy of endo- and epicar-

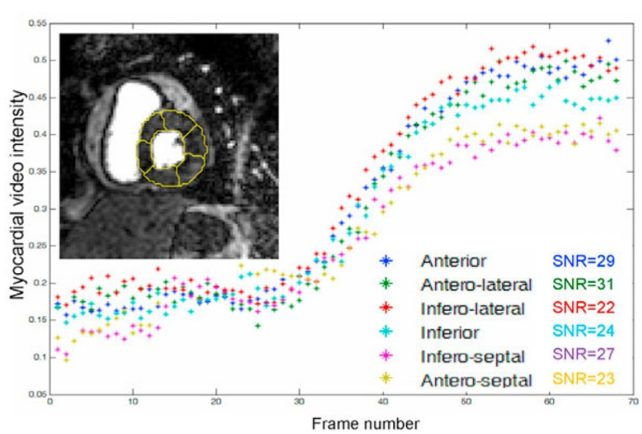

Figure 1

dial boundary positions, and (2) calculating the ratio between the amplitude of the contrast enhancement curve and the SD of the plateau phase (SNR).

Results

Time required for automated analysis of one complete perfusion slice was <1 minute on a personal computer and resulted in endo- and epicardial boundaries that were judged accurate in all image sequences (Figure 1). Contrast enhancement curves clearly showed the typical pattern of first-pass perfusion. SNR averaged over 24 image sequences was 32 ± 10.

Conclusion

Fast, automated, dynamic detection of myocardial segments and quantification of intra-myocardial contrast is feasible and results in regional contrast enhancement curves with excellent noise levels. This approach provides a user-friendly and potentially more accurate technique, which may address the strong need for clinical quantitative evaluation of myocardial perfusion from contrast-enhanced CMR images.