Detection of Anatomic Structures in MR Tagging Data:
One Step Further Towards Automatic Tagging analysis

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Abstract

MR tagging provides information on myocardial tissue deformation occuring during the cardiac cycle. Once tissue is identified in tagging data sets harmonic phase MR imaging (Harp) allows automatic analysis of tagging data. Delineation of myocardial tissue at end-diastole (=reference image) is difficult since blood is not wash-out at this time point. A method is described which identifies myocardial tissue with minimal observer-interaction. Application of a threshold and tracking back material points by harp potentially allow for automatic tissue detection and analysis of tagging data.

Introduction

MR tagging data yield unique information of tissue deformation during cardiac contraction and relaxation. However, post-processing of tagging data has been time-consuming. The introduction of harmonic phase MRI (Harp) (1) set the basis for automatic analysis of tagging data. Once myocardial tissue is identified, this technique allows automatic tracking of material points during the cardiac cycle. In this study a post-processing procedure was tested which would allow for identification of myocardial tissue in tagging data sets, and thus, would further reduce observer-interaction during tagging analysis.

Material and Methods

Ten subjects (4 normal volunteers and 6 hypertensive patients with mild left venticular hypertrophy on echocardiography) were recruited for this study.

In order to calculate mechanical indexes, the grid deformation at end of contraction is generally related to the regular grid pattern played out at beginning of contraction (reference image). Since blood is not washed-out from the ventricular cavities at the first image acquired (=reference image) when using a saturation band or complementary SPAMM acquisition (CSPAMM), endocardial borders on this reference image are difficult to indentify. To solve this problem, an image with optimal border delineation was selected. This is the case when blood has completely washed-out, e.g. at the end of the cardiac cycle. The high contrast between blood and myocardium at this time point allowed application of a threshold to identify the myocardial border. Harp was then used to track these endocardial material points back into begin of contraction (=reference image at end-diastole). The endocardial contours calculated from the tagged images were then compared with the endocardial contour drawn on conventional magnitude images. The same procedure was applied for epicardial contours.

Image Acqusition:

All studies were performed on a 1.5T system (Gyroscan, Philips) in supine position. For myocardial tagging a CSPAMM (2) approach was used which takes long-axis shortening, i.e. through-plane motion on short axis images, into account. The LV long axis was divided up equally into 5 positions at which short-axis slices were acquired. At these 5 positions anatomy was delineated with fast gradient echo images. In addition, a ring tag acquisition was performed at the midequatorial level. This ring tag approach includes a block RF pulse applied with an off-center frequency. By rotating this saturation band and varying the off-center frequency a predefined shape is tagged onto the LV myocardium. Specifically, the ring tag was placed onto the centerline on short-axis images. For all breath hold acquisitions, identical position of the heart was achieved by navigator control (target zone for initiation of acquisition: ±1.5mm of diaphragm position of first breath hold).

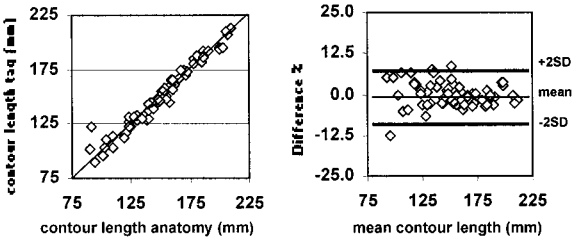
Image analysis

On tagging images at the end of the cardiac cycle blood is completely washed-out and myocardium is clearly visible. The myocardium is identified on these images with a few markers set by an observer. A spline is fitted into these markers and signal intensity along this contour is calculated. At a threshold of 0.85 (applied at 4 sectors to account for signal differences with varying distance from the surface coil) the endocardial and epicardial borders are then traced. These contours are tracked back by the harp procedure to the reference image at end-diastole. At end-diastole the centerline is calculated and the harp procedure is used for automatic tracking of this centerline yielding circumferential fiber shortening (cFS%) at the midwall.

Results

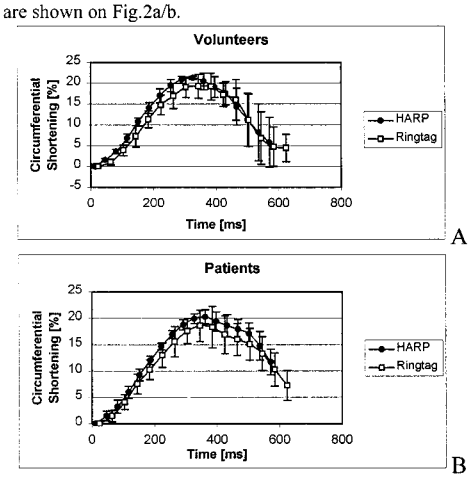
Contours derived from Harp and anatomical images

In 4 apical and 2 basal slices tracking of material points by harp was unreliable (affecting ≥20% of the circumference). The lengths of circumferences derived from anatomical and tagged images differed by 1.7±3.8% and −1.6±3.0% for endocardial and epicardial contours, respectively (no significant differences between anatomical and tagged contour lengths, Figure 1a); regression: y=0.98x+2.46, r=0.98, p<0.0001; Figure 1b).



Comparison: Harp versus ringtag approach

Midwall cFS% derived from cspamm and ring tag data was 19.9±0.9% and 18.5±3.0%, respectively (not significant). Corresponding curves are shown on Fig.2a/b.



Discussions

Tracking of material points in tagging data sets by means of harp (harmonic phase imaging) is a useful procedure to propagate endocardial and epicardial borders, detected at phases with optimal blood-myocardial contrast, into any desired phase of the cardiac cycle. Application of a threshold (0.85 of myocardial signal measured at final frame in the cardiac cycle) yielded endocardial and epicardial contour lengths at end-diastole that differed from anatomical lengths by 1.7% and -1.6%, respectively. This approach which 1). applies a threshold to images with best contrast between blood and myocardium and 2). utilizes harp to track these contours back to end-diastole potentially allows for automatic identification of myocardial tissue in tagging data sets.

References: 1) Garot J. et al. Circulation, 2000, 101, 981-988, 2) Fischer SE. et al. MRM, 1994,31.401-13.