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Meeting abstract

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1128 Analysis of principal left ventricular dynamics using phase-contrast Vvlocity MRI

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Introduction

Recent improvement in myocardial velocity imaging provides the opportunity for detailed assessment of myocardial contractility for the detection of regional abnormalities. The use of phase-contrast velocity imaging allows for the analysis of complex myocardial motion with minimal user interaction. This work investigates the use of a variational restoration algorithm for improving the internal consistency of the MR velocity data and the extraction of the intrinsic motion pattern of the myocardium through the use of Principal Component Analysis (PCA).

Methods

A Siemens Sonata scanner with a phase-contrast gradient-echo sequence was used to obtain a series of short-axis slices for 7 patients from the basal to the apical regions of the left ventricle (LV) in three encoding directions (FOV = 300 × 300 mm, TR = 53 ms, TE = 7.1 ms, in-plane pixel resolution = 1.17 × 1.17 mm, VENC = -15 to +15 cms-1). Free-breathing was allowed through the use of a navigator echo placed through the right hemisphere of the diaphragm for respiratory gating and blood flow artefacts were prevented through the use of a black-blood suppression technique to saturate blood adjacent to the imaging plane. A typical acquisition yielded 12 short-axis slices at 8 mm intervals over 16 time frames.

A variational restoration algorithm [1] was applied to the velocity data in order to improve the SNR. The algorithm consists of an iterative algorithm to reduce the total variation of the velocity field while applying the constraint that the noise image subtracted has a variance close to that of the underlying noise signal. Manual segmentation of the epicardial and endocardial contours using the magnitude images provided boundaries for the construction of regular hexahedral models of the LV for each timeframe. The velocities were assigned to each element using trilinear interpolation. These models were then unwrapped to yield 2D maps of the myocardium in longitudinal and circumferential coordinates, with the vertical edges representing the anterior RV/LV junction.

PCA of the unwrapped models, both for the 3D velocities and the directional components, was used to examine the intrinsic motion of the myocardium to evaluate the conformance of the LV during contraction and relaxation. Figure 1.

Results

PCA of the velocity models demonstrates the underlying motions of the myocardial tissue. In particular, circumferential velocities show the torsion motion in agreement with the helical fibre model [2]. The first mode of variation accounts for 82.3% of the total variance and shows the expansion and contraction of the myocardium from systole to diastole. For individual velocity components, the first mode of variation accounts for 71.5% for the radial and 92.1% for longitudinal variance while for circumferential velocity the first two modes account for 41.1% and 23.4% respectively.

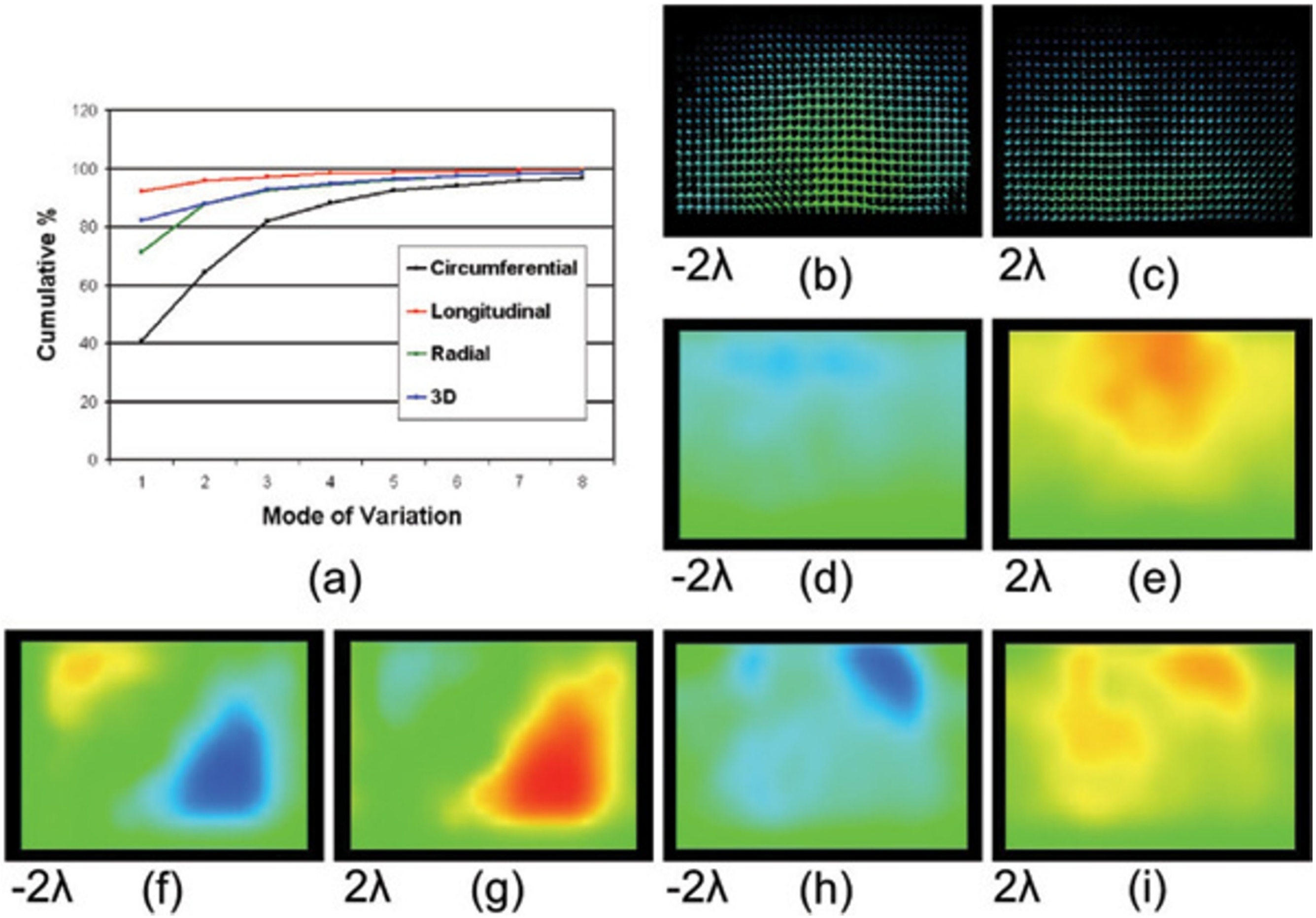

Figure 1
(a) Cumulative variance of the modes of variation, (b-c) first mode of variation for 3D velocity field of the myocardium, (d-e) for longitudinal, (f-g) circumferential and (h-i) for radial components.

Conclusion

We have demonstrated the construction of a compact statistical model of left ventricular motion, capturing properties such as ventricular torsion and providing a preliminary framework for the detection of abnormal cardiac function. Results from this work demonstrate good correspondence with the widely-accepted myocardial band model, showing the expected torsion, longitudinal and radial motions.

References

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