Unsupervised Fully Automated Inline Analysis of Global Left Ventricular Function in MR Imaging

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Purpose: To implement and evaluate the accuracy of unsupervised fully automated inline ventricular analysis of global ventricular function and ventricular mass. To compare automated with manual segmentation in cardiac patients.

Materials and Methods: In 50 cardiac patients, cine imaging of the left ventricle was performed with an accelerated retro-gated SSFP sequence (GRAPPA; *R*=2) at a 1.5 Tesla whole body scanner (Magnetom Avanto). A spatial resolution of 1.4x1.9mm^2 was provided at a slice thickness of 8mm and a temporal resolution of 42ms. Ventricular coverage was based on 9 to 12 short axis slices ranging from the annulus of the mitral valve to the apex with 2mm gaps. Fully automated localisation and segmentation of the left ventricle was performed during image reconstruction. Automatic localization, which is described in detail in the paper by Jolly (1), is performed using a approach based on the maximum discrimination method proposed by Colmenarez and Huang (2) for human face detection. The method scans the image at different scales, taking cross-sections through potential candidates and comparing these with an average profile determined from a training set. Once approximately localized, the segmentation algorithm uses a combination of several methods (see figure 1) including histogram analysis, active contours and pattern matching to delineate the myocardial boundaries (3). Results of both methods were compared with regard to end-diastolic volume (EDV), end-systolic volume (ESV), ejection fraction (EF) and myocardial mass (MM).

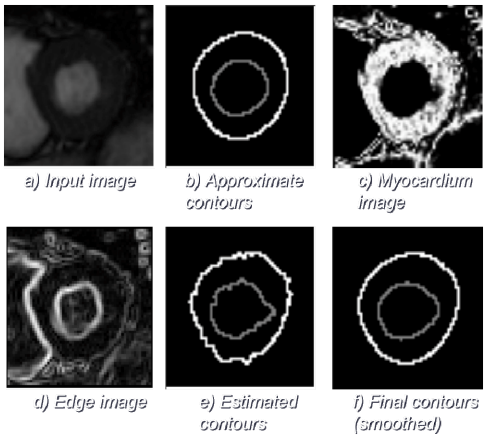

Figure 1 The segmentation of the input image (a) involves several steps. Approximate contours (b), obtained either through automatic localisation or propagation, are the starting point for a multi-step segmentation algorithm. Steps include histogram analysis of the left ventricle (c), edge detection (d), active contours and shape constraints (not shown). These steps produce epi-and endocardial contours (e), which are then smoothed to produce the final result (f).

Results: 32% of patients had a reduced left ventricular ejection fraction <55%. Volumetric results of the automated inline analysis for EDV (r=0.96), ESV (r=0.95) EF (r=0.89) and MM (r=0.96) showed high correlation with results of manual segmentation (all p<0.001). Head-to-head comparison did not show significant differences between automated and manual evaluation for ESV (61.6±31.0ml vs. 56.8±32.1ml; p=0.08) and EF (58.0±11.6% vs. 58.6±11.6%; p=0.5), but for EDV (153.6±52.7ml vs. 149.1.5±48.3ml; p=0.05) and myocardial mass (149.0±61.3g vs. 142.4±58.9g; p<0.01). Bland-Altman plots for each parameter did neither reveal a relationship between the differences and the averages nor any systematic bias. The mean time for manual analysis was 15min.

Conclusions: Unsupervised fully automated segmentation and contouring during image reconstruction enables an accurate evaluation of global ventricular performance instantaneously.

References

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