Quantification of Right and Left Ventricular Function in Cardiac Mr Imaging: Comparison of Semi Automatic and Manual Segmentation Algorithms

The study population consisted of 52 consecutive Patients with cardiac arrhythmias or dyspnea, implanted pacemakers or defibrillators, or with claustrophobia, were excluded from the study population. In all the cases, echocardiography had been previously performed, and all the patients gave written informed consent prior to cardiac MR imaging examination. The study was carried out in accordance with the guidelines of the local ethics committee: The work was approved by the Local (Galician) Ethic Committee. Informed Consent was also obtained from all patients. [1]

As a initial step and to define a same set of images to be used for succeeding segmentation evaluation, ventricular short axis slices were selected for analysis, beginning with the highest basal slice, as selected from simultaneous display of long-axis and short-axis view, in which at least 50% of the myocardial circumference of the LV was visible in all the cardiac phases. The frames visually showing maximal and minimal ventricular cross-sectional areas at the mid ventricular level, were considered as end-diastole (ED) and end-systole (ES), respectively. Ventricular contours were traced in every slice, for these two frames, using two segmentation methods (manual and semiautomatic). A difference of one section position was permitted between the most basal slice in end-diastole and ES due to the influence of through plane motion. Papillary muscles and trabeculae were considered part of ventricular volumes. The end-diastolic volume (EDV) and end-systolic volume (ESV) were calculated by summing up the area enclosed by the endocardium multiplied by the slice thickness, in all the slices imaged at end-diastole and end-systole, respectively (Simpson's method).

The ejection fraction (EF) was computed as follows: (EDV ? ESV)•100/EDV. Function parameters derived from semi-automatic contours were computed using Simpson's method.

Semiautomatic Method

Ventricular analysis was also performed on a high performance personal computer (2 Dual-Core AMD Opteron processors 2.80 GHz, 8 GB RAM) with a specifically-designed semiautomatic segmentation method based on edge detection, iterative thresholding and region growing techniques. A brief description of the segmentation scheme is given below

1. Edge detection: Region boundaries were roughly extracted from the original grayscale

image, on the basis of the existing gradient along the contour of an object. These operators are based on the idea that edge information is found by looking at the relationship of a given pixel with its neighbors. In other words, an edge was defined by a discontinuity in grayscale values. Details of implementation of these operators can be found elsewhere.

2. Iterative thresholding: In order to remove the noise from the filtered edge information, a square kernel with a given threshold value k0 (0 ? k0 ? 255) was set up automatically in every short-axis view, around the position of the ?mouse-click? introduced by the user in a mid-ventricular end-diastolic frame. Then, all the pixels of this kernel were scanned, and the threshold value k1 was calculated according to the following expression: k1 = (1/2) × (mean gray-scale below k0 + mean gray-scale above k0). If k0 ? k1, k0 is updated to k1, and k1 is recalculated. When the convergence is reached (k0 = k1), the process finishes, and the algorithm runs through the entire image separating the object from the background pixels, by comparing their intensity with the threshold value (binary image 1). Iterative thresholding is completely automatic, a given threshold value k0 (0 ? k0 ? 255) was set up once for all the patients. The obtained result (k1) was not sensitive to k0. The size of the square kernel can be adjusted empirically, although it was maintained 9 × 9 in the whole study.
3. Iterative thresholding: In most of the cases, as a result of the inconsistent edge information contained in the original gray-scale image, there may appear to be discontinuities in the contour of the region of interest (ROI) obtained in the previous step. In order to seal these discontinuities, the thresholding algorithm runs again through the original gray-scale image
4. Background overlapping: Subsequently, an OR logical operation was performed at each pixel location, in order to overlap the backgrounds of the binary images obtained in the previous steps. As a result of the aforementioned operation, a third binary image without any contour discontinuity, was obtained.
5. Region growing: Finally, all the pixels of the square kernel belonging to the object in the third binary image were considered initial seed points. Then the region growing process started, and continued when any of the neighboring pixels belonged to the object. When the process finished, the contour of the ROI was superimposed on the original gray-scale image, and no manual adjustment of generated contours was performed. The region growing algorithm starts and continues when any of the 8-neighboring pixels of every seed point belongs to the object.[1]

Thirty-five adult subjects, including 25 patients with dilated cardiomyopathies, were evaluated by biplane and volumetric cine MRI and by biplane and volumetric (three-dimensional) transthoracic echocardiography. Left ventricular volume, LVEF and LV function categories were then determined. [2]

Biplane echocardiography underestimated LV volume with respect to the other three strategies. There were no significant differences between any of the strategies for quantitative LVEF. Volumetric MRI and volumetric echocardiography differed by a single functional category for 2 patients (8%). Six to 11 patients (24% to 44%) differed when comparing biplane and volumetric methods. Ten patients (40%) changed their functional status when biplane MRI and biplane echocardiography were compared; this comparison also revealed the greatest mean absolute difference in estimates of EF for those subjects whose EF functional category had changed.

Volumetric MRI and volumetric echocardiographic measures of LV volume and LVEF agree well and give similar results when used to stratify patients with dilated cardiomyopathy according to systolic function. Agreement is poor between biplane and volumetric methods and worse between biplane methods, which assigned 40% of patients to different categories according to LVEF. The choice of imaging method (volumetric or biplane) has a greater impact on the results than does the choice of imaging modality (echocardiography or MRI) when measuring LV volume and systolic function. [2]