Automated Segmentation of Myocardial Infarcts on Delayed Enhancement MR Images

Y. Lu[1], G. A. Wright[1,2], and P. E. Radau[1]
[1]Imaging Research, Sunnybrook Health Science Centre, Toronto, ON, Canada, [2]Department of Medical Biophysics, University of Toronto, Toronto, ON, Canada

Introduction: Automatic segmentation of the myocardial infarct (MI) on delayed enhancement MR images is required because manual drawing of the region contours is time consuming and suffers from high inter-observer and intra-observer variability. The major obstacles to solving this problem are the lack of edge information, and the location and shape variability of the myocardial infarcts across slices and subjects. A novel method for the robust, accurate and fully automatic myocardial infarct segmentation from conventional inversion-recovery gradient echo (IR-GRE) short-axis MR images is presented in this study.

Materials and Methods: Nine male patients (age: 61±9.96 yr) with chronic MI had cardiac IR-GRE MR scans with full left ventricle (LV) coverage (7-13 slices), and imaging was repeated at a later date. MR imaging was performed on a 1.5 T scanner (CV/i, GE Healthcare) using an 8-channel cardiac coil. Delayed enhancement imaging was started 10 min after the injection of 0.2 mmol/kg of Gd-DTPA (Magnevist, Berlex). The segmentation algorithm begins by localizing the LV center on a mid-ventricular slice by roundness metric [1]. Next the LV blood pool and infarct is detected by determining an Otsu threshold and creating a binary blood pool image. Then a bilateral filter [2] is applied to smooth the image while preserving the edges. Next a tophat morphological transformation [3] is used to isolate brighter objects. Finally a threshold is applied to determine the infarct (Fig. 1). The basal slice with the LV outflow tract is segmented with watershed technique. Linear regression analysis and Bland-Altman plots were used to compare between the manual and automatic methods for calculating infarct sizes (Fig. 2).

Results: There were excellent correlations of the infarct size (scan 1: R^2 = 0.97; scan2: R^2 = 0.98) derived from automatic and manual quantification. The Bland-Altman analysis indicated that the biases were small (scan 1: 0.24 g; scan 2: 0.09 g) with limits of agreement of ± 2.03 g (scan 1) and ± 1.58 g (scan 2). Table 1 shows the reproducibility of results from the two imaging studies, which is similar for manual and automated methods.

Discussion and Conclusions: A limitation of the proposed method is that it will not identify microvascular obstruction regions. In summary, these preliminary results for the proposed segmentation technique indicate that it is robust, accurate and of benefit for the quantification of cardiac IR-GRE MR images in clinical practice.

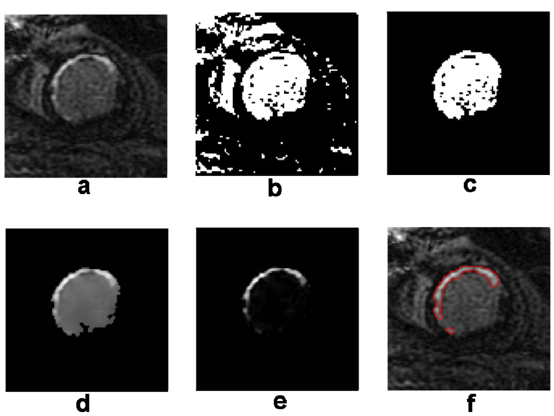

Fig. 1. Infarct identification and segmentation: a. ROI Image, b. Binary image, c. LV blood pool and infarct, d. Bilateral filtering results. e. tophat results, f. Infarct (red).

Table 1 reproducibility of results

	Paired Difference (scan2-scan1)	
	Manual	Automated
Mean(std)	0.56(3.91)	0.72(4.55)
Paired t-test	P=0.68	P=0.65

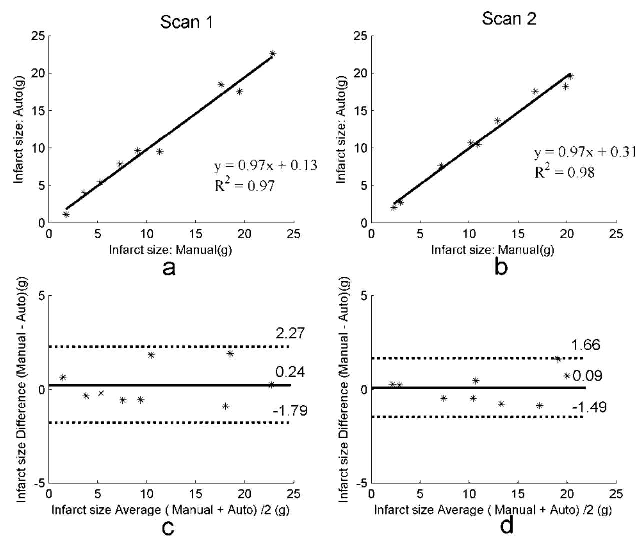

Fig. 2: Linear regression between automated and manual calculation of infarct mass for scan 1 (a) and scan 2 (b). Bland-Altman plots comparing automated and manual calculations of infarct mass for scan 1 (c) and scan 2 (d). The horizontal solid line is bias, and dashed lines are the limits of agreement (+/- 1.96 SD).

[1] Anonymous [2] Tomasi, C. Et al. In Proceedings of the IEEE International Conference on Computer Vision, 839-846 (1998) [3] Serra J., New York: Academic Press, 1983.