

Estimation of left ventricle parameters from Cine MR data: Fully Automatic versus Manual Analysis.

T-Y. Broussaud¹, and A. Nchimi¹

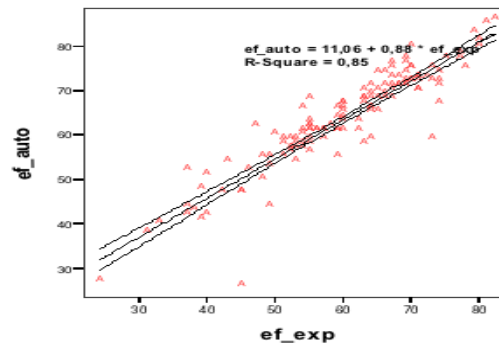
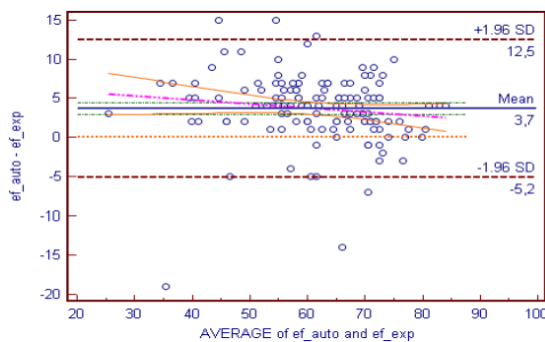
¹Medical Imaging Dept., CHC Saint-Joseph, Liège, Belgium

Purpose: To compare the performances of a fully automatic segmentation tool (InlineVF, Siemens Medical Solutions) to those obtained after semi-automatic offline segmentation in the quantitative evaluation of cardiac function parameters: Ejection fraction, end-diastolic/systolic, stroke volumes, flow and cardiac index.

Materials and Methods: 135 patients suspected of coronary heart disease referred to our unit for cardiac stress imaging. Population was 64.4 y.o in average (64.0/64.8 y.o. females/males). Exams were performed on a 1.5T scanner (Avanto, Siemens Medical Solutions) with two 6-channel matrix surface coils. At rest, 10 retrospective ECG gated cine turboFlash short axis slices (TR/TE 56.3/1.1ms, Flip angle 71°) were acquired during separate breath-holds from base to apex. Spatial and temporal resolution were 2mm x 2mm x 6 mm and 43 ms respectively. Raw data were processed automatically inline (1) and off-line by using a commercially-available package (Argus, Siemens Medical Solutions), (2) by two readers (5 and 6 years experience in cardiac imaging) until consensus to minimise inter-reader variability. Reviewers were asked to exclude whenever possible the papillary muscles during the inner and outer myocardial contours drawing. The last evaluation was performed by correcting manually when applicable data resulting from the automatic inline segmentation. Functional parameters obtained by previous methods were compared after linear regression and Bland-Altman analysis (3).

Results: InlineVF failed completely (no segmentation) for 3 patients. InlineVF segmentation missed whether last apical or last two apical slices in 9 and 31 cases respectively. Also, we report 2 unexpected segmentation of RV instead of LV. Statistical analysis performed on 130 patients with complete segmentation for at least 8 slices are reported below:

	EF (%)	EDV (ml)	ESV (ml)	SV (ml)	Flow (l/min)	CI (l/min/m ²)
Inline: mean (SD)	63.5 (11.0)	86.3 (31.5)	33.3 (20.1)	52.9 (16.5)	4.0 (1.3)	2.2 (0.6)
Offline: mean (SD)	59.8 (11.6)	98.2 (32.7)	41.8 (23.9)	56.3 (15.4)	4.2 (1.2)	2.3 (0.6)
Regression Analysis: R ²	0.86 (p<0.001)	0.903 (p<0.001)	0.94 (p<0.001)	0.75 (p<0.001)	0.75 (p<0.001)	0.73 (p<0.001)
Spearman Rank Order Correlation: R	0.92	0.53	0.92	0.94	0.84	0.85
Mean Difference: Inline - Offline	3.7	-11.9	-8.4	-3.3	-0.26	0.14
SD of difference	4.5	10.2	6.9	8.3	0.63	2.22



Bland-Altman plots (Automatic Versus Manual) and correlation analysis for ejection fraction.

Discussion and Conclusion: InlineVF proved to be reliable for estimating global functional parameters, especially for ejection fraction, flow and cardiac index. End diastolic/systolic and stroke volumes tend to be slightly underestimated by automatic analysis as showed previously (1) in a smaller population. Further work is mandatory to estimate performances of InlineVF for patients suffering from different diseases patterns (e.g. hypertrophy coinciding with thin myocardium) and different acquisition sequences. For that purpose, quantitative comparison of local segmentation with distance metrics is mandatory to study potential differences in regional parameters such as radial contractility of the myocardium. Our preliminary benchmark is supporting a more robust detection of LV chamber (4) to prevent from erroneous segmentation of RV and apical slices which experience unresolved edges between blood pool and true myocardial wall. Performance of automatic segmentation for estimating additional parameters (filling/ejection time and rates respectively) from the dynamical range of images acquired over cardiac cycle, should also be studied later.

References

- (1) C. Hayes and al. Fully automatic segmentation of the left ventricle in cardiac cine MR images, Proc ISMRM 2007, Berlin.
- (2) Jolly MP. Combining edge, region, and shape information to segment the left ventricle in cardiac MR images Utrecht, the Netherlands: Proc MICCAI, Utrecht, The Netherlands, 2001; pp482-490.
- (3) Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1986; 1:307-310.
- (4) Automatic Recovery of the Left Ventricular Blood Pool in Cardiac Cine MR Images, Marie Pierre Jolly, MICCAI 2008.