Quantitative Global and Regional Cardiac Wall Motion Analysis with a 3-Dimensional Reconstruction Cardiac Image Modeling (CIM) Tool

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Introduction: Cardiac function is currently assessed using a visual analysis of wall motion in short axis at the base, middle, and apex of the heart. This visual analysis is a subjective, qualitative evaluation and can have high interobserver variability [1]. In order to minimize the amount of subjective input, a semi-automated 3-dimensinal (3-D) reconstruction Cardiac Image Modeling tool (CIM 4.6, University of Auckland, New Zealand) has been developed to quantitatively assess global and regional cardiac function [2]. CIM is a semi-automated tool that creates a 3-dimensional reconstruction of the heart, based on user-defined guidepoints to customize endocardial and epicardial computer generated tracings on long and short axis magnetic resonance (MR) time series images (Fig.1) [3]. Using CIM, it is possible to calculate regional ejection fractions (EF) based on the 16-segment model of the heart according to the American Heart Association (AHA) classifications. If it were possible to accurately quantify regional wall motion abnormalities (RWMA), this may be useful in clinical assessment of cardiac patients pre- and post- therapy.

Purpose: To evaluate the ability of the CIM tool to assess global and regional cardiac function in comparison to the current manual contour tracing and qualitative assessment of wall motion.

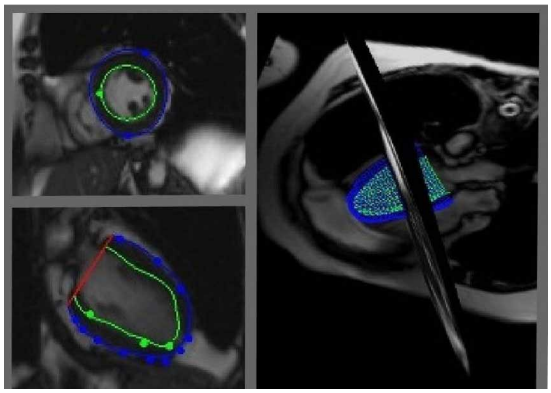

Fig 1. CIM interface. User defined guidepoints in short and long axis views for 3D reconstruction.

Methods:

33 patients (23 males, 10 females) referred for assessment of left ventricular cardiac viability were scanned on a 1.5T Siemens Avanto. Cardiac function was assessed using cine TrueFISP technique in a short axis orientation from base to apex in all patients. Based on global EFs as calculated by a standard post-processing tool (Argus, Siemens), the study group was divided into three categories (normal = EF ≥ 50%; moderate = 30% < EF < 50%; severe = EF ≤ 30%). The studies were randomized and underwent quantitative analysis with CIM and qualitative analysis by three blinded reviewers.

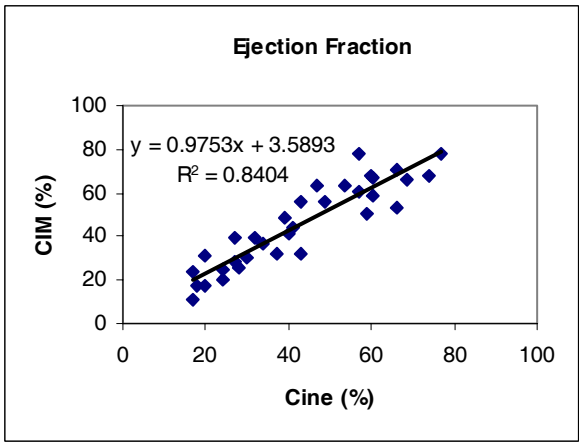

Fig 3. Linear regression of global ejection fraction of all 33 patients for assessing correlation between visual analysis and CIM analysis ($R^2 = 0.84$).

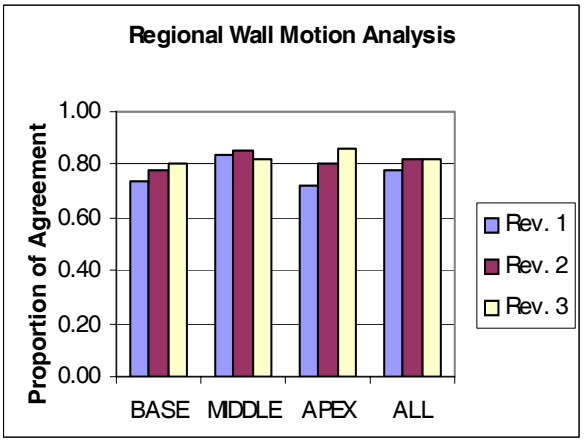

Fig 4. Total proportions of agreement for the segments within the short axial slices (base, middle, apex), and the overall proportions of agreement for all the segments in all 33 patients.

Middle	EF
Inferoseptal	48.9
Inferior	40.2
Inferolateral	35.4
Anterolateral	39.8
Anterior	31.1
Anteroseptal	39.3

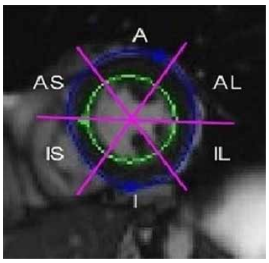

Fig 2. Middle axial slice divided according to the regional AHA guidelines and analyzed by CIM. (EF = Ejection Fraction)

The heart was divided into the 16-section AHA defined cardiac model. Each of the reviewers independently scored the sections as normal or abnormal. CIM calculated quantitative regional EFs (Fig 2). The quantitative EFs were then classified as normal or abnormal (normal = EF ≥ 50% and abnormal = EF < 50%).

Proportions of agreement (pa) were used to determine the agreement between the readers and CIM. Proportion of agreement was defined as the number of sections that the reader and CIM tool both scored a section as normal or both scored a section as abnormal, divided by the total number of sections.

Results: There was a high correlation (r^2=0.84) between the manual contour tracing method and CIM for global EF (Fig.3). On an individual segment basis, there was moderate agreement with all segments showing a pa > 0.6, with the exception of the Base-Inferoseptal and the Base-Anteroseptal segments. Regional wall motion analysis of the sections in the base, middle, and apex separately showed a moderate-high agreement (pa > 0.7). Overall regional wall motion analysis of all the sections from all the patients combined showed a high proportion of agreement (pa = 0.8) (Fig.4).

Discussion: CIM accurately calculated global EF and other left ventricular parameters compared to other post-processing techniques. Furthermore, CIM is able to calculate regional EF on a segmental basis. Our studies show a moderate agreement with qualitative analysis of RWMA. CIM has the potential to quantify regional improvements in patients throughout the course of therapy.

References:

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