Analysis of Cardiac Left Ventricular Parameters Obtained By Magnetic Resonance Imaging at 3 Tesla: A Pre and Post-Contrast Quantitative Comparison

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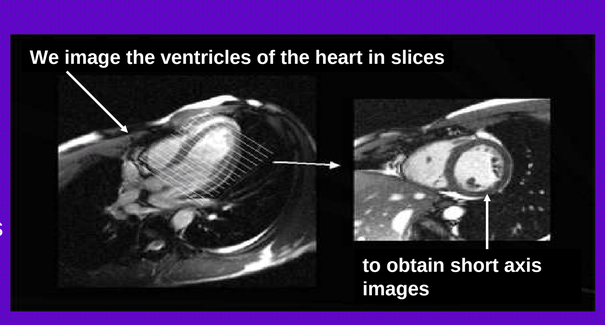
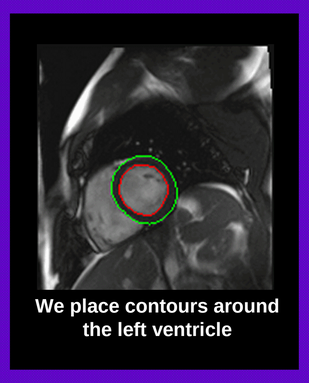
Lay Summary

By imaging 6mm slices through the main chambers (ventricles) of the heart we obtain a stack of 'short axis images'. These images are acquired routinely as part of a standard clinical cardiac assessment.



By performing semi-automated analysis on these short axis images we can calculate important cardiac parameters such as ejection fraction (the fraction of blood pumped out of the heart with every heart beat) and cardiac mass.



We commonly use pharmaceutical contrast agents in cardiac assessments as they highlight different patterns of scarring found on damaged heart muscle (myocardium).

This study looks at the effect of contrast agent on calculated cardiac parameters by comparing the analysis of pre- and post-contrast short axis images.

Introduction

Short-axis cine images are acquired during cardiac MRI in order to determine parameters of cardiac left ventricular (LV) function such as ejection fraction (EF), end-diastolic volume (EDV), end-systolic volume (ESV), stroke volume (SV) and mass (LV mass). In cardiac perfusion assessments this imaging is often performed in the temporal window between first pass perfusion imaging and the acquisition of delayed enhancement images in order to minimise overall scanning time. The objective of this study was to compare pre- and post-contrast short-axis LV parameters of 15 healthy volunteers in order to determine how important calculated cardiac parameters vary with the administration of contrast agent.

Methods and Materials

- 15 normal healthy volunteers, 8 females; average age 48 years, (range 41 – 61 years); and 7 males; average age 59 years, (range 48 - 71 years). Framingham score* of < 20%.
- Pre- and post-contrast short axis images for each volunteer were obtained using a 3 Tesla Magnetom Trio Scanner (Siemens, Erlangen, Germany) and a cardiac-gated segmented CINE TrueFisp sequence with spine matrix and six element body array matrix coils.
- TR 3.4ms,TE 1.5ms, flip angle 50°, 6mm slice thickness with 4mm inter slice gap and FOV ~ 400mm.
- 10ml contrast (Dotarem, Guerbet) per volunteer injected via a power injector (Spectris Solaris, MedRad Inc.) followed by a saline flush of 20ml.

Image Analysis

- Pre and post contrast image analysis performed by physicist segmenter on a Siemens multi-modality work station using Argus software (version VB15). Calculations of pre- and post-contrast EF, EDV, ESV, SV and LV mass at ED were obtained and compared.

Statistics

- t-test was applied using SPSS (Chicago, Illinois, USA).
- Results of t-Tests were deemed significant for $p<0.05$

*** (Framingham Score: Risk assessment tool for estimating the 10-year risk of a Cardiovascular Disease event).**

Results

A significant reduction to the mean EF and LV mass parameters was noted following delivery of gadolinium contrast agent (table 1). Additionally, a small but significant increase to the mean EDV and ESV parameters was also noted after contrast agent delivery. Individual values (i.e. on a per-volunteer basis) for LV mass were consistently lower for every volunteer following contrast agent, with reductions ranging from 1.6g to 11.3g. The EF in 12 out of 15 volunteers was also reduced, with reductions ranging from -0.6% to -2.4%. In contrast, the majority (n = 10) of calculated EDV and calculated ESV (n = 12) parameters displayed a small but significant increase with the administration of contrast agent, these increases ranging from 1.7ml to 4.1ml and 0.7ml to 3.7ml respectively. Stroke volume was found to be particularly stable; no mean pre- versus post-contrast change of any significance was noted.

Table 1:

Cardiac Parameter (n=15)	Pre Contrast Mean Value ± SD	Post Contrast Mean Value ± SD
EF (%)	69.4 ± 5.3	68.9 ± 5.0 ≠
EDV (ml)	142.4 ± 34.5	143.7 ± 33.7≠≠
ESV (ml)	44.2 ± 14.9	45.5 ± 14.6≠≠
SV (ml)	98.3 ± 22.6	98.2 ± 21.9
LV Mass (g)	108.1 ± 26.5	102.0 ± 26.6≠

≠Statistically significant decrease: ≠≠ Statistically significant increase

Figure 1 displays the variation between pre- and post-contrast LV mass values. The mean 'shift from zero' in figure 1 highlights the consistent post-contrast reduction in the LV mass values.

Figure 1

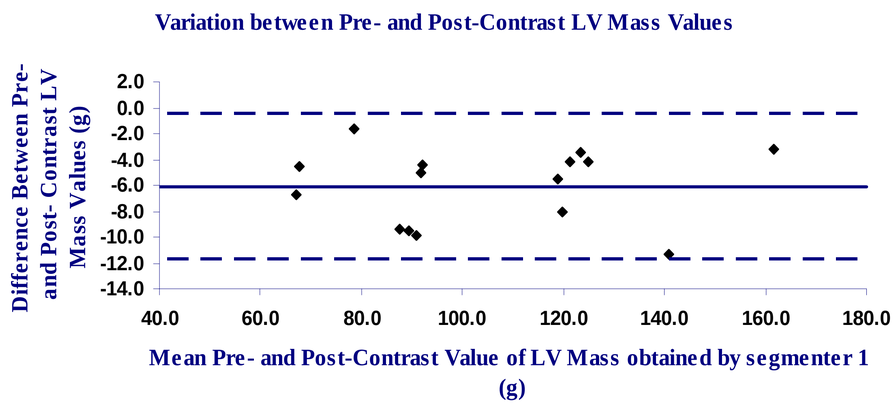
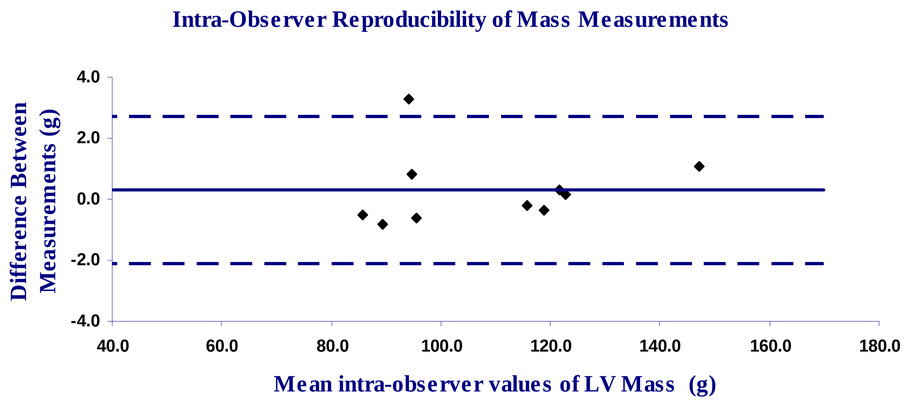


Figure 2 displays the variation between intra-observer measurement 1 and measurement 2. It can be seen that the spread of data in figure 2 is less than that of figure 1, with values spread closely around zero.

Figure 2



Conclusion

In Conclusion, this study has demonstrated that the administration of contrast agent in this cohort of healthy volunteers has had a significant effect on the calculated cardiac parameters of EF, EDV, ESV and particularly LV mass. Such changes should be considered correctly in the context of clinical decision-making in cardiac patients after CMRI perfusion examination when future therapy or intervention may be required. It is also recommended that image analysis is undertaken on either pre- or post-contrast data sets and that this choice is kept consistent for the case of repeat scans or longitudinal studies.