The Effects of Contrast Agent on Quantitative Morphological LV Parameters at 3T

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Introduction and Aim

Cardiac MRI (CMRI) is a reproducible, non-invasive tool which provides a rapid and accurate cardiac assessment, free from geometric assumptions. CMRI is now the most accurate modality for imaging morphological parameters such as end diastolic volume (EDV), end systolic volume (ESV), stroke volume (SV) and ejection fraction (EF), with Steady State Free Precession CMRI currently being the gold standard for measuring myocardial mass [1]. All of these parameters can be obtained without the need for gadolinium based contrast agents, however contrast agents are routinely used during cardiac perfusion and coronary MRI studies to further enhance tissue contrast and obtain improved images. This study specifically addresses left ventricular (LV) analysis at 3 Tesla in order to determine the effects of contrast agent on cardiac morphological assessments, with the null hypothesis that the mean values obtained for pre and post-contrast LV analysis are the same.

Method and materials

12 normal healthy volunteers (8 women and 4 men) were recruited for pre and post contrast cardiac MR imaging; mean age 54 years; range 41-71 years. All volunteers had no previous history of cardiac illness and a Framingham score of < 20%. Pre and post contrast images for each volunteer were obtained in a single session 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. Contrast (Dotarem, Guerbet) was injected via a power injector (Spectris Solaris, MedRad Inc.) and followed by a saline flush of 20ml. Short axis images (256 x 256 pixel resolution) were acquired through the left ventricle using TR 3.2ms,

TE 1.48 ms, flip angle 50°, 6mm slice thickness with 4mm inter slice gap and an average field of view of 400mm (depending on patient size). Image analysis was performed on a Siemens multi-modality work station using Argus software (version VB15). A physicist segmenter performed semi-automated placement of endocardial and epicardial borders (on slices from base to apex) of the left ventricle at end-diastole and end-systole in order to acquire EDV, ESV, EF, SV, cardiac output (CO), and mass for both pre and post-contrast images. Pre contrast data were compared to post contrast data and a paired t-test was applied using SPSS (Chicago, Illinois, USA) to test for statistically significant differences between the mean values for each parameter.

Results and Discussion

Table 1 illustrates the mean values for pre and post contrast analysis and the difference between each value.

Table 1

Variable (n = 12)	EF (%)	EDV (ml)	ESV (ml)	SV (ml)	CO (l/min)	Mass at ED (g)
Mean Value: Pre contrast ± SD	69.57 ± 5.62	123.48 ± 24.22	38.22 ± 13.34	85.26 ± 13.65	5.79 ± 0.84	97.49 ± 25.64
Mean Value: Post Contrast ± SD	69.25 ± 5.77	125.42 ± 24.72	39.13 ± 13.40	86.30 ± 14.24	5.86 ± 0.89	89.18 ± 25.30
Difference: Mean Pre – Post contrast	0.32	-1.94	-0.90	-1.04	-0.07	8.31

Further statistical analysis was performed on the differences between mean pre and post contrast data, (table 2).

Table 2

Variable	n	Mean Difference	St DEV	t-stat	P-value (*Significant)
EF (%)	12	0.32	1.01	-1.08	0.151972
EDV (ml)	12	-1.94	1.73	3.90	0.001237*
ESV (ml)	12	-0.90	1.76	1.77	0.051826
SV (ml)	12	-1.04	1.55	2.31	0.020294*
CO (l/min)	12	-0.07	0.21	1.15	0.137194
Mass at ED (g)	12	8.31	3.71	-7.76	0.000004*

The presence of gadolinium based contrast agent has a significant effect on the calculated value for mass ($p < 0.0001$), with post contrast values decreasing by an average of 8.5% (range 1.9g – 13.93g). This range of mass reduction does not correlate to the overall cardiac mass of the individual and is believed to be due to the contrast agent providing improved definition around the epicardial borders when compared to pre contrast images. Pre and post contrast values for EDV, ESV, EF, SV and CO were fairly consistent, implying that the presence of gadolinium based contrast agent in the myocardium has minimal effect on the actual value obtained for these parameters at 3T. However, a statistically significant difference in the mean pre and post contrast measurements of both EDV ($p < 0.001$) and SV ($p < 0.05$) in our group of healthy volunteers was noted, due to a systematic small increase to these parameters following the administration of contrast. Values obtained for all parameters were compared with the normal ranges for older men and women (40 – 60years) established by Alfakih et al; 2003 [2]. Interestingly, more than 50% of our values fell just outside these ranges whereas only three post contrast mass values fell out with the ranges established by Alfakih et al. for younger men and women (20 – 39years). The differences between our results and those obtained by Alfakih et al. may be explained by the fact that their data was acquired at 1.5T suggesting that normal data ranges need to be established at 3T.

Conclusion

In conclusion, for certain parameters (EDV, SV and mass) our findings reject the null hypothesis because significant differences have been found between the pre and post contrast data. This is particularly pronounced for LV mass, which may have important implications for the analysis of patient data in clinical and longitudinal studies. It is recommended that the LV assessment is performed either before or after contrast administration, and that this process is kept consistent for future investigations.

References

1. Relation between Myocardial Edema and Myocardial Mass during the Acute and Convalescent Phase of Mocarditis – a CMR Study; Anja Zagrosek, Ralf Wassmuth et al; Journal of Cardiovascular Magnetic Resonance 2008, 10:19.
2. Normal Left and Right Ventricular Dimensions for MRI as Assessed by Turbo Gradient Echo and Steady-State Free Precession Imaging Sequences; Khaled Alfakih et al; Journal of Magnetic Resonance 2003; 17: 323-329.