Myocardial Perfusion Quantification: Effects from Contrast Dose, Imaging Plane and Sequence

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INTRODUCTION

The quantification of myocardial perfusion using MRI is a sensitive method for detecting ischemia. The limitations of myocardial perfusion quantification include artifacts, sequence dependence, and saturation effects associated with high contrast agent concentration in the LV. The dual bolus method solves the blood signal saturation problem by using two contrast injections to acquire low contrast dose imaging of LV blood, followed by high contrast dose imaging of myocardium. The objective of this study was to determine whether the resting perfusion quantification using the dual bolus (DB) approach is dependent on the MRI pulse sequence or imaging orientation.

MATERIAL AND METHODS

Fourteen volunteers (7 male, age: 59±10) without a clinical history of coronary artery disease gave informed consent for enrollment in this study with institutional IRB approval. In each case, imaging was performed in four slices per RR interval (one short-axis (SX) slice from mid-ventricle, three long-axis (LX) views, including 4-chamber, 2-chamber and LVOT view) using saturation recovery segmented gradient echo (EPI), TrueFISP (TFI) and TurboFLASH (TFL) sequences, with 20-minute washout. Typical sequence parameters for the TrueFISP were: TR/TE/TI/FA = 2.6ms/1ms/90ms/50°, rectangular field-of-view 21×34 cm^2, bandwidth (BW) per pixel 980 Hz and voxel spatial resolution 3.5×2.6×8 mm^3. Temporal and spatial resolution for EPI and TFL perfusion sequence were kept similar. Gadodiamide (Omniscan, GE Healthcare, Princeton, NJ) was injected at doses of 0.005 mM/kg mini dose (MD) followed by 0.05 mM/kg standard dose (SD), with a Spectris MR power injector (Medrad, Indianola, PA) at a rate of 6 ml/s. First pass breath-hold Perfusion imaging was performed over 50 cardiac cycles. MASS (Medis Medical Systems, Leiden, Netherlands) software was used for data analysis. Epicardial and endocardial contours were manually traced on an image from each slice with good contrast between blood pool and myocardium. The contours were then propagated through the whole perfusion series in that slice, with manual correction to compensate for respiratory motion when needed. The myocardium was divided equally into six segments for each imaging plane. Segmental myocardial average signal intensity over time was used for the quantitative analysis. The DB method used blood signal values from the MD images. For comparison, an analysis using both blood signal and myocardial signal from the SD images was also performed. A Matlab Fermi deconvolution model was used to generate regional perfusion (MBF) in ml/g/min. A total of 252 myocardial segments of long and 84 segments of short axis plane images for each sequence were quantified and their correlation analyzed using ANCOVA.

RESULTS

Examples of paired LX perfusion images using MD and SD of contrast with TFL, EPI and TFI sequences, as well as the corresponding dynamic signal plots are shown in the **Figure**. The MD perfusion images showed poorer SNR relative to the SD images; while the curves of MD seemed sharper then these of SD. LX and SX with each sequence show good agreement (p = 0.96). For EPI, Mean ± STD of DB MBF was 0.69±0.14 ml/min/g on LX, 0.65±0.10 on SX and 1.73±0.36 on LX, 1.88±0.59 on SX using SD only. For TFL, Mean ± STD of DB MBF was 0.74 ± 0.26 on LX, 0.65±0.10 on SX while SD gave results of 1.59±0.41 on LX, 1.59±0.43 on SX, respectively. For TFI, Mean ± STD of DB MBF was 0.72 ± 0.26 on LX, 0.69±0.29 on SX, and 2.51±0.61 on LX, 2.44 ±0.68 on SX using SD, respectively. Depending on the sequence used, measurements using a standard dose of contrast agent (0.05mM/kg) produced absolute perfusion more than twice that from dual bolus corrected measurements.

CONCLUSION

Dual bolus MRI normal rest perfusion values are similar to PET values. Results with 0.05mM/kg, which is widely used, overestimate perfusion. They are sequence dependent. Long and short axis perfusion values are comparable regardless of contrast dose or sequence.

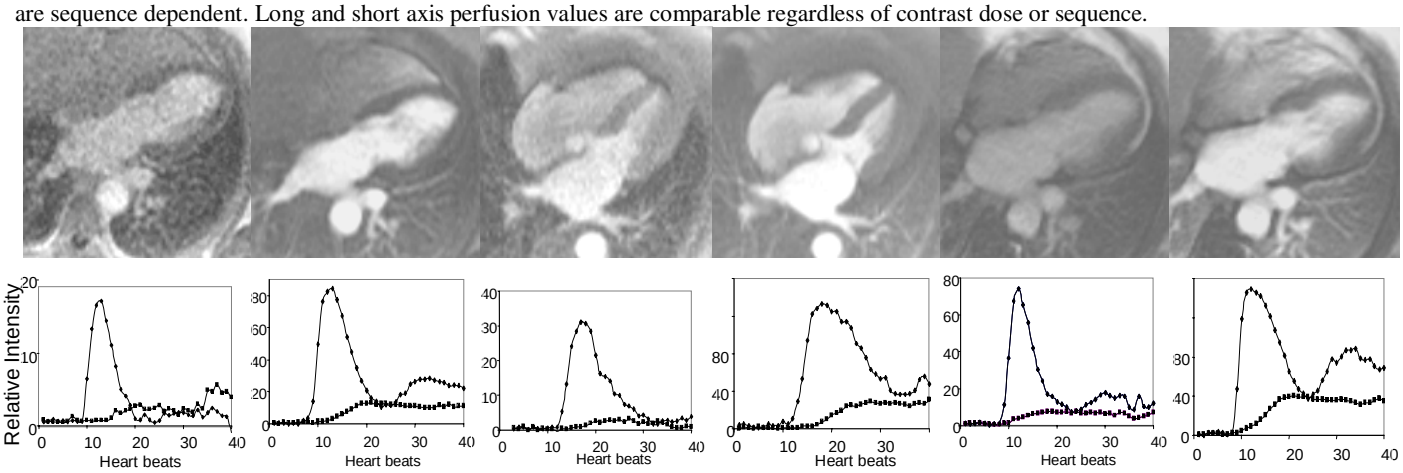

Figure Image examples (upper) of MD and SD perfusion and their corresponding dynamic signal curves (lower). From left to right: TFL MD and SD, EPI MD and SD, TFI MD and SD.