Practical Myocardial Perfusion Studies Via Adenosine Pharmacologic Stress

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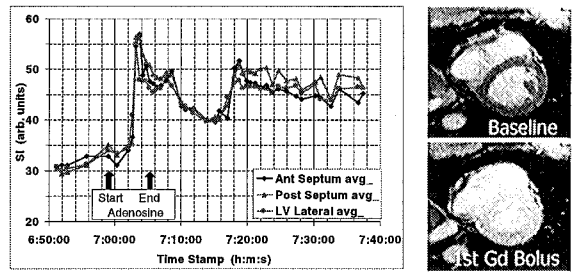
Introduction Investigational effort over the past 10 years has aimed to ultimately create an integrated MR cardiac exam for ischemic heart disease. Components would include assessment of cardiac morphology, regional and global cardiac function, myocardial perfusion, and coronary angiography. The myocardial perfusion study component should not interfere with performance of other components, and have a practical protocol execution time. This investigation considers the potential for employing adenosine physiologic stress as the basis for a compact stress-rest myocardial perfusion protocol. Sequential rapid MRI is performed during two gadolinium contrast agent boluses, first in the adenosine stress condition, compared to a second bolus in a "rest" condition. First-pass MR cardiac perfusion has been under investigation since at least 1990[1-2] with multislice acquisitions in 1994[3], and recent quantitative results[4-5]. We select adenosine (Adenoscan®, Fujisawa) as the pharmacologic stressor, having verified efficacy with ^{201}Tl scintigraphy, rapid clearance (~10s half-life), and patient preference over dipyridamole[6]. Coronary flow velocity returns to basal levels within 1 to 2 minutes. Adenoscan is US FDA approved for inducing coronary hyperemia.

Methods To investigate the resulting conditions and practicality of a tandem double-bolus cardiac perfusion protocol, we modified the Fastcard pulse sequence[7] to implement spoiled steady-state diastolic imaging. As the magnetization preparation for T1 dependency and R-R variation independence, the imaging pulse commences immediately upon QRS trigger. Data acquisition is disabled for a constant number of repetitions, then spatial encoding and data acquisition are enabled for the latter fraction of the R-R interval. Two to 4 heart beats are required per image depending on spatial resolution and R-R period. Acquisition parameters: TR 6-10, TE 1.6, 50°, 31.2 KHz bandwidth, 32-64 views/segment, 7 mm slice, 256x192x16 matrix, 1.4x1.9x7 mm^3 acq. voxels, ECG or peripheral gating, ~15-20 sec breath holds, using a GE 1.5T Horizon EchoSpeed instrument Ver 5.6. Double-oblique short-axis slices of the left ventricle are prescribed from diastolic coronal and long-axis LV images. Adenosine is infused at 0.140 mcg/kg/min for 6 minutes (0.84 mg/kg total dose) using a syringe infusion pump (Medex or Baxa). Once adenosine infusion is begun, breath hold scanning commences. After 2-3 minutes, the adenosine reaction peaks and the heart rate increases. Upon successful breath hold acquisition during this peak stress state, the 20 ml Gd (gadoteridol) bolus injection is performed. Breath hold acquisitions proceed at the maximum rate the subject can perform. This project was approved by our University Committee on Research Involving Human Subjects.

Results The Figure shows results from an example normal subject receiving two 20 ml Gd boluses: the images just preceding and after the first Gd bolus duirng adenosine stress, and the time course of ROIs. Almost 100% signal intensity increase occurs during the Gd first pass for the distribution regions of the LAD, right coronary, and circumflex arteries. SI dropped to 30% above baseline 14 min after first Gd bolus. For this subject, the SI peak at 7:04 coincided with the peak heart rate of 110 beats/min (baseline was 62 bpm).



Discussion

The results suggest that a ~15 minute spacing will provide sufficient recovery to enable a tandem bolus study protocol that provides both stress and rest condition perfusion assessment, and this will be verified in a clinical series of abnormals. The stress condition perfusion study should occur first since it will provide the most sensitive clinical information. Repeating a perfusion acquisition again later in the cardiac exam can characterize any very slowly enhancing regions.

The heart rate will rise during the adenosine infusion (baroreceptor response) by 18 ± 10 beats/min[6], although the subject presented above rose 48 bpm. ECG gating during the stress condition is problematic. Distortions of the ECG waveform increase during the changing conditions. Resorting to peripheral gating for *diastolic* imaging produces little to no degradation while improving the chances for a successful series of acquisitions.

Standard dose-rate infusion of adenosine provides only ~6 minutes of dilated condition in which to make the perfusion measurements and to perform stress wall motion studies.

The goal of this project was to investigate the practicality of a stress-rest protocol using adenosine stress, not to perform perfusion measurements. Multislice single-heart-beat acquisition methods are required to characterize the first pass response.[5]

Conclusion These results demonstrate that a stress-rest myocardial perfusion study may be obtained in ~20 mins using an adenosine-based protocol, that is acceptable to patients, and compatible with the MR exam context.

References

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