Assessment and Validation of Cardiac MR Oximetry in Obesity

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Purpose

Obesity is an independent risk factor to cardiovascular disease, including coronary heart disease and heart failure. Animal studies and few studies in humans indicate myocardial metabolic alternations precede and contribute to cardiac remodeling and dysfunction in obesity [1]. Positron Emission tomography (PET) can measure myocardial perfusion and oxygen metabolism rate. However, non-radiation nature of MRI could allow for serial monitoring of obese patients with cardiac remodeling. We have developed a MRI acquisition and modeling method to assess global myocardial oxygenation. The aims of this study were to validate and evaluate this MRI method by PET in a group of obese patients and volunteers.

Methods

This ongoing study recruited 5 previously obese patients (5F) who underwent gastric bypass surgery (a surgery in abdominal to cause malabsorption, i.e., decreased ability to absorb calories and nutrients from food, for losing weight) and PET scans for the measurements of myocardial blood flow (MBF) and oxygen consumption rate (MVO_{2}) at rest only. All obese participants underwent CMR study in about one year from their PET scans, at rest and then during the adenosine vasodilatation. In addition, 5 Body-mass index or BMI matched normal volunteers (2F) were also recruited for control study. The MRI scanner is 1.5T Siemens Avanto or Sonata system. The adenosine was infused intravenously at a constant rate of 0.14 mg/kg/min. CMR methods included a new bright-blood T_{2}-prep-gradient-echo (T_{2}prep-GRE) sequence for acquiring a series of T_{2}-weighted images of coronary sinus with breath-holding. Myocardial perfusion was also measured using a TurboFLASH sequence to collect 80-100 dynamic images of short-axis myocardium, after a bolus injection of 0.02 mmol/kg Multihance (Bracco Diagnostic, Princeton, NJ). Table 1 lists the imaging parameters for each sequence.

Using a newly developed multi-variable regression algorithm, global myocardial oxygen extraction fraction (OEF) was determined in the coronary sinus, at rest and during the adenosine vasodilatation. Absolute MBF was determined using a newly developed model-independent algorithm [2] in a unit of ml/g/min in the short-axis myocardial images. Global MVO_{2} was then calculated using Fick’s law: MVO_{2} = OEF × MBF. Figure shows one set of MBF maps and PET image from one volunteer.

Results

In obese patients, average resting MBF in obese patients was 0.88 ± 0.15 ml/g/min (PET), vs. 0.87 ± 0.19 ml/g/min (by MRI, p = NS). Adenosine MBF increased to 2.41 ± 0.22 ml/g/min (MRI only). Myocardial OEF and MVO_{2} results by PET and MRI were listed in Table 2 for obese patients, except MVO_{2} data in the first patient due to severe cardiac motion in perfusion imaging. For comparison, average values of OEF and MVO_{2} in normal volunteers were listed as well. There are excellent correlations between PET and MRI for OEF (r^{2} = 0.94) and MVO_{2} (r^{2} = 0.87). Obese patient #1-4 maintains the similar BMI between PET and MRI scans, and their physiology parameters were similar to those of normal volunteers. However, patient #5 (bold) shows significantly increased BMI, leading to elevated MVO_{2} at rest with normal resting OEF. Interestingly, the adenosine OEF of the patient #5 reduced much less than other patients, while both resting and adenosine MBF were similar to others (not shown here).

Conclusions

This is the first study to evaluate cardiac oxygen metabolism at rest and during the stress in overweight and obese patients. Our CMR approach for the quantification of myocardial OEF and MVO_{2} was validated by PET at rest. Obese patients after gastric bypass surgery appear to have normal MBF and OEF at rest and during the stress by comparing with literature values and normal volunteers. However, elevated BMI seems to cause elevated stress OEF with normal resting and stress MBF. This may indicate alteration of oxygen metabolism precede abnormal microcirculation and future cardiac remodeling. Future serial studies are warranted for elucidating the mechanism of cardiac metabolism and remodeling in obese patients for early intervention.