Assessing Myocardial Perfusion after Cardiac Irradiation using Dynamic Contrast Enhanced Hybrid PET/MRI

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Structured Abstract:

INTRODUCTION: Breast cancer accounts for 25% of total yearly female cancer mortalities. Adjuvant radiation therapy of the breast plays a vital role to breast cancer treatment and has shown to improve both local control and overall survival. However, patients with left-sided breast cancer are at an increased risk of coronary artery disease due to the proximity of the heart to the high radiation dose. Using hybrid PET/MRI imaging, cardiac abnormalities, changes in myocardial viability, and coronary artery disease can be assessed noninvasively. A previous canine study done in our lab demonstrated that hybrid PET/MRI detected an increase in PET 13N-NH3 myocardial perfusion and was associated with a global inflammatory response after a low radiation dose exposure. However, the rest and adenosine induced stress 13N-NH3 myocardial blood flow (MBF) propagated in different trends starting from 1 month onwards after cardiac irradiation. Hence, further investigation was done in the dynamic contrast enhanced MR (DCE-MR) imaging data acquired simultaneously in our canine model to assess the change in myocardial perfusion.

HYPOTHESIS: We believe DCE-MR imaging acquired would detect changes in myocardial perfusion in our canine model after cardiac irradiation.

METHOD: 5 canines performed dual bolus Gd-DTPA DCE-MR imaging at baseline, 1 week, 1 month, 3 months, 6 months after cardiac external beam irradiation. Rest and adenosine induced stress scan were conducted utilizing the fast gradient echo sequence on the 3T hybrid PET/MR scanner at St. Joseph’s hospital. Axial slices of the myocardium were contoured on ITK-snap according to 17 segment cardiac model. With left ventricle selected as the arterial input function (AIF), myocardial tissue curves were fitted using MATLAB with Toft’s model to determine volume transfer constant Ktrans. Ktrans data were sorted into regions supplied with respective coronary arteries (LAD, LCX or Both arteries). Since Ktrans =extraction fraction*MBF, paired T-tests were performed with 13N-NH3 MBF versus extraction fraction (assumed 0.5) multiplied with Ktrans determined from separated bolus curve fittings.

RESULT: P-values obtained from paired sample T-tests of 13N-NH3 MBF vs 0.5 *1st MR Gd-DTPA bolus Ktrans and that of 13N-NH3 MBF vs 0.5 *2nd MR Gd-DTPA bolus Ktrans for all coronary artery supplied regions under rest and stress scans were less than 0.05. This proved the presence of AIF signal saturation from left ventricle blood pool. DCE-MR Ktrans rest and stress data propagated in different trends starting from 1month post radiotherapy.

CONCLUSION: Dual peaks Toft’s model curved fitting instead of separated peaks curve fitting for determining myocardial Ktrans values was necessary for accurate myocardial perfusion quantification especially for dual bolus GD-DTPA injection scans due to signal saturation in the AIF. In this animal model study, we were not able to acquire same propagating trends in both PET MBF and MR Ktrans imaging.