Patients with Pulmonary Arterial Hypertension Have a Lower Left Ventricular Myocardial Perfusion Reserve on Cardiac MR Adenosine Stress Perfusion Imaging Compared to Age Matched Healthy Controls

J. Skrok[1], M. L. Shehata[1], C. Sibley[2], T. Goldstein[3], K. McCommis[3], J. Zheng[3], J. A. Lima[2], D. A. Bluemke[4], P. Hassoun[5], and J. Vogel-Claussen[1]

[1]Department of Radiology, Johns Hopkins University, Baltimore, MD, United States, [2]Department of Cardiology, Johns Hopkins University, United States, [3]Mallinckrodt Institute of Radiology, Washington University School of Medicine, St.Louis, MO, United States, [4]Department of Radiology, National Institutes of Health, Bethesda, MD, United States, [5]Department of Pulmonology, Johns Hopkins University, United States

Background:
Patients with pulmonary arterial hypertension (PAH) are known to have significant cardiac remodeling. However, it is unknown whether myocardial blood flow under rest and adenosine-induced stress conditions is affected.

Purpose:
To compare left ventricular (LV) myocardial blood flow (MBF) and myocardial perfusion reserve (MPR) between patients with PAH and age matched healthy volunteers using adenosine stress 1st pass perfusion cardiac MRI.

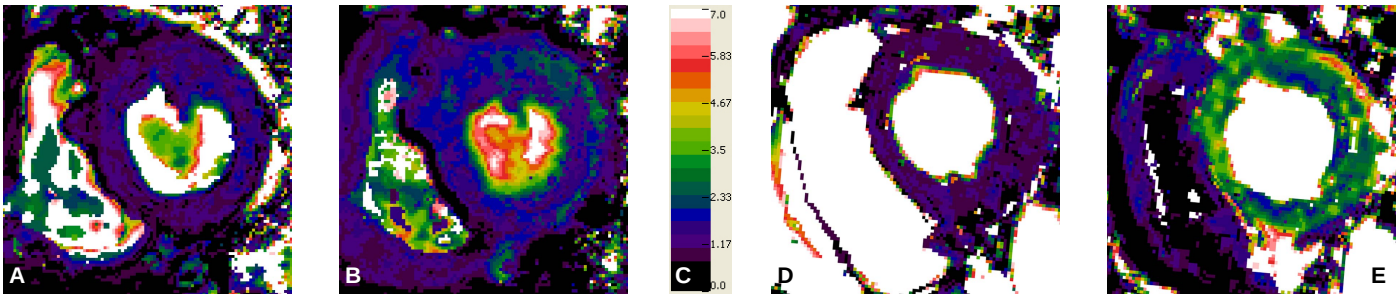
Methods:
The first pass perfusion MRI exam at 3T (Siemens Trio, Erlangen, Germany) consisted of three GRE MRI scans: the arterial input function (AIF), adenosine-induced stress perfusion, and resting perfusion. For the AIF, a 1:10 diluted bolus was administered intravenously under resting conditions, and one short axis slice near the base of the heart was imaged for 60 heart beats with 1 RR temporal resolution. All other scanning parameters were identical to the straight bolus images. For the stress perfusion images, adenosine was injected intravenously at a rate of 140 µg/kg/min for six minutes. Four minutes into the adenosine injection, GRE MRI images were acquired. Scan parameters were: TR/TE 2.5/1.05 ms, flip angle 12°, FOV 32x42 cm, matrix 192x116, acquisition duration 200 msec, slice thickness 10 mm, and an acceleration factor (GRAPPA) of 2. For the straight bolus, gadopentetate dimeglumine was injected at 5 cc/sec (0.025 mmol/kg), followed immediately by a 20 cc normal saline flush at 5 cc/sec for both rest and stress perfusion MR images. Two short axis slices were acquired over 80 heart beats with a temporal resolution of 2 RR. Resting perfusion images were obtained at least ten minutes after the stress perfusion. The study population consisted of 6 patients (1 male, 5 female, mean age 59.4 ± 8.5 years, mean pulmonary artery pressure 37.7 ± 8.7 mmHg) and 7 age matched healthy volunteers (2 male, 5 female, mean age 51.5 ± 9.5 years). For absolute quantification of the myocardial blood flow (MBF), stress and rest perfusion were evaluated by a blinded reader using the Fermi function model. For each patient, the total mean LV blood flow at rest and stress as well as the myocardial perfusion reserve were calculated. The MBF was then normalized with the rate pressure product (RPP). The two groups were compared using the 2-tailed Wilcoxon signed rank test. A value of ≤ 0.05 was considered statistically significant.

Results:
During adenosine-induced vasodilatation, there were significantly lower MBF and MPR in patients with PAH compared to healthy volunteers. There was no significant difference in MBF during resting conditions between PAH patients and healthy volunteers.

The following table shows the RPP corrected average values (± SD) for the MBF in ml/min/g for adenosine-stress and resting conditions as well as the MPR.

Group	MBF Stress	p	MBF Rest	p	MPR	p
PAH	1.74 (± 0.62)	0.002	0.84 (± 0.20)	0.628	2.07 (±0.46)	0.002
Controls	3.43 (± 0.75)		0.91 (± 0.12)		3.81 (± 0.97)	

Conclusion:
Patients with PAH have a globally reduced left ventricular myocardial perfusion reserve compared to normal age matched controls. These changes are likely caused by microvascular dysfunction in PAH patients.



Images:
A+B: MBF maps in a patient with PAH show only a minor increase in global MBF from resting (A) to adenosine-induced stress (B) conditions.
C: Scale for the absolute MBF in ml/min/g before normalization to the RPP.
D+E: Normal increase in MBF from resting (D) to adenosine-induced stress (E) conditions in a healthy volunteer.

This study was supported by the NIH research grant: 1P50 HL084946-01.