Relationship between cardiac allograft vasculopathy and left ventricular diastolic dysfunction assessed by cardiac magnetic resonance imaging in heart transplant recipients

tion (Figure 1) and quantification of physical parameters such as kinetic energy (Figure 2) was achieved.

Conclusion: A new method for visualization and quantification of intracardiac blood flow has been developed. The major advantage compared to the existing particle trace technique is the ability to quantify kinetic energy, momentum and other physical parameters of the blood flow. The method also offers real time interactivity and intuitive visualization of volumes moving through the heart. Once the data has been computed, exploring volumes of arbitrary shapes and sizes is straightforward. This new quantification and visualization method may facilitate the analysis of three dimensional flow and may bring additional physiological insight into cardiac blood flow.

P130
Time-resolved MRA using sliding window reconstruction for evaluation of renal arterial anatomy and perfusion

Aoife N Keeling, Ravi K Singh, Cormac Farrelly, Hyun Jeong, Ty A Cashen, John Sheehan, Tim J Carroll and James C Carr
Northwestern Memorial Hospital, Chicago, IL, USA

Journal of Cardiovascular Magnetic Resonance 2009, **11(Suppl 1):**P130

Introduction: Time-resolved contrast enhanced magnetic resonance angiography, if fast enough, can not only provide arterial anatomical and pathological detail, but can also follow the first pass of contrast through visceral parenchymal tissue in order to evaluate vascular flow dynamics or perfusion.

Purpose: To evaluate the feasibility of a new magnetic resonance imaging (MRI) technique that would provide unified anatomic and functional evaluation of the kidneys in a single scan with a single dose of Gadolinium contrast. We hypothesize that dynamic mask-mode subtraction yields perfusion weighted images of the renal parenchyma.

Methods: A new magnetic resonance angiography (MRA) pulse sequence, with a high frame rate, capable of simultaneous determination of renal arterial anatomy and pathology, and renal perfusion, was developed. Eleven healthy volunteers and one renal transplant patient were recruited to undergo MRI examination using a radial three-dimensional FLASH acquisition with sliding window view-share reconstruction (in-plane spatial resolution was 1.1 × 1.1 mm^2) on a 1.5 T Siemens MRI scanner. A single dose of Magnevist (gadopentetate dimeglumine, Berlex, Montville, NJ, USA) was administered intravenously. Images were processed with a dynamic mask-mode subtraction which has been shown to be beneficial in artery-vein separation. The raw data was reconstructed offline with a sliding window and a sliding mask subtraction technique generating sequential angiographic images at a rate of 3 frames per second. Perfusion analysis was also performed offline by two experienced diagnostic radiologists, implementing the upslope and deconvolution methods, as well as using the maximum value subtracted image. All reconstructions and analyses were performed using Matlab software. The maximum value subtraction image was compared on a pixel-by-pixel basis to the upslope and deconvolution methods using correlation and Bland-Altman plots.

Results: The technique produced diagnostic quality angiographic images and perfusion maps in all volunteers and the renal transplant patient. The maximum value subtracted image provided an accurate estimate of renal perfusion as compared to upslope and deconvolution methods using correlation plots ($r = 0.98, 0.94$; $m = 0.96, 0.89$) and Bland-Altman plots (mean bias = 1.7%, 2.1%; $p < 0.05$).

Conclusion: This technique provides anatomic and functional evaluation of the kidneys with a single scan and single dose of contrast that would currently require multiple scans or examinations that require ionizing radiation. The maximum value subtracted image provides an accurate estimate of renal perfusion compared to the established upslope and deconvolution methods. This technique could be applied clinically to a population of potential renal transplant donors, providing arterial anatomic information for surgical planning as well as pre-transplant functional evaluation.

P131
Relationship between cardiac allograft vasculopathy and left ventricular diastolic dysfunction assessed by cardiac magnetic resonance imaging in heart transplant recipients

Haruhiko Machida[1], Shinichi Nunoda[1], Kiyotaka Okajima[1], Kazunobu Shitakura[1], Akihiko Sekikawa[1], Yutaka Kubo[1], Kuniaki Otsuka[1], Masami Hirata[1], Shinya Kojima[1], Ai Masukawa[1], Satoru Morita[1], Kazufumi Suzuki[1], Mikihiko Fujimura[1], Eiko Ueno[1] and Yoshiaki Komori[2]
[1]*Tokyo Women's Medical University Medical Center East, Tokyo, Japan*
[2]*Siemens-Asahi Medical Technologies Ltd., Tokyo, Japan*

Journal of Cardiovascular Magnetic Resonance 2009, **11(Suppl 1):**P131

Introduction: Cardiac allograft vasculopathy (CAV), a major late complication that limits long-term survival of heart transplant recipients, is typically characterized as a diffuse concentric intimal hyperplasia of the coronary artery. Invasive coronary angiography/intracoronary ultrasound (ICUS) are widely performed for CAV screening of patients with no ischemic symptoms from their denervated hearts before congestive heart failure, cardiac arrhythmia, or sudden death occurs. This vasculopathy usually accelerates left ventricular diastolic dysfunction before systolic dysfunction. Cine images on cardiac magnetic resonance (CMR) examination, the most accurate test for cardiac functional analysis in the clinical setting, easily quantify peak filling rate (PFR) as an index of left ventricular diastolic function. This measurement can noninvasively predict early-stage CAV and be useful for risk stratification and adequate patient management. On a single comprehensive CMR examination, we can also assess asymptomatic systolic dysfunction of the left ventricle from cine images and myocardial infarction or scar formation from late gadolinium-enhanced (LGE) images.

Table 1 (abstract P131) Relationship between cardiac allograft vasculopathy and parameters for left ventricular function

	CAV positive	CAV negative	P value
PFR (EDV/sec)	3.63 ± 0.90	4.43 ± 0.84	0.01
EF (%)	58.1 ± 4.8	58.8 ± 7.1	0.85
SV (mL)	43.0 ± 12.3	49.4 ± 17.6	0.16
CO (L/min)	3.41 ± 0.81	3.83 ± 1.54	0.46

Purpose: We investigated the clinical feasibility of CMR imaging for noninvasively screening for CAV in asymptomatic recipients of heart transplants. Especially, we assessed the significance of left ventricular PFR value as a marker of early-stage CAV over several parameters of the systolic function and LGE by CMR imaging.

Methods: Between June 2006 and June 2008, 38 asymptomatic recipients of heart transplants (25 men, 13 women, aged 37.2 ± 14.9 years) underwent both CMR and ICUS 8.5 ± 4.4 years after heart transplantation. We measured PFR normalized to end-diastolic volume and several parameters for systolic function of the left ventricle, including ejection fraction (EF), stroke volume (SV), and cardiac output (CO), by steady-state free precession cine CMR imaging with 20 sampling phases during one cardiac cycle. We also evaluated intramyocardial LGE on the CMR examinations. According to Stanford classification based on intimal wall morphology assessed by ICUS [1], we classified recipients of grade 0–2 as negative and grade 3–4 as positive for CAV and compared the values of PFR, EF, SV, and CO between the 2 groups using Mann-Whitney U test. $P < 0.05$ was considered statistically significant. Furthermore, we calculated receiver operating characteristic (ROC) curve in the relationship between PFR value and CAV as defined by ICUS.

Results: Using ICUS, we classified 20 patients (53%) positive and 18 (47%) negative for CAV. There was no significant difference in the values for EF (58.1 ± 4.8% versus 58.8 ± 7.1%, $P = 0.85$); SV (43.0 ± 12.3 mL versus 49.4 ± 17.6 mL, $P = 0.16$); and CO (3.41 ± 0.81 L/min versus 3.83 ± 1.54 L/min, $P = 0.46$). No patient revealed intramyocardial LGE.

In contrast, the PFR value was significantly lower in the positive (3.63 ± 0.90 EDV/sec) than negative group (4.43 ± 0.84 EDV/sec, $P = 0.01$). Area under the ROC curve was 0.759 (95% confidence interval: 0.587 to 0.882). When PFR cut-off value was 3.65, CAV sensitivity was 58.2% and specificity, 79.8%. Table 1.

Conclusion: The presence of CAV significantly enhances diastolic dysfunction of the left ventricle. For asymptomatic recipients of heart transplants, PFR measurement with CMR provides noninvasive prediction of CAV, which precedes systolic dysfunction and myocardial infarction or scar formation, and PFR is a feasible tool for decision-making in managing those patients.

Reference

1. St Goar, *et al*: *Circulation* 1992, **85:**979–987.

P132

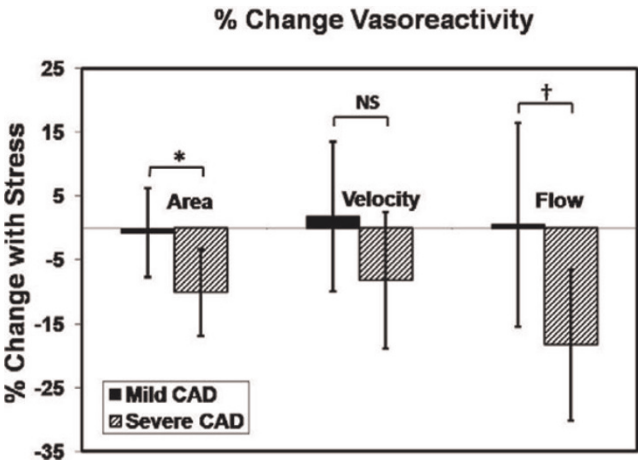
Local coronary endothelial dysfunction varies with the extent of coronary disease: a 3 T MRI study

Allison Hays, Sebastian Kelle, Glenn A Hirsch, Gary Gerstenblith, Robert G Weiss and Matthias Stuber
Johns Hopkins, Baltimore, MD, USA

Journal of Cardiovascular Magnetic Resonance 2009, **11(Suppl 1):**P132

Introduction: Endothelial-dependent coronary artery vasoreactivity is an important indicator of vascular function and predicts cardiovascular events [1]. Non-invasive measures of endothelial dysfunction are typically obtained in the brachial arteries, which are exposed to systemic risk factors but which rarely develop severe atherosclerosis or plaque rupture. Endothelial injury plays a critical, causal role in the development and progression of local atherosclerosis, a regionally heterogeneous process in the coronary arteries. We therefore posit that local endothelial function varies throughout the coronary tree in patients with disease and may contribute to local atherosclerosis. By means of previously described non-invasive 3 T MRI methods combined with isometric handgrip to assess endothelial-dependent coronary vasoreactivity [2], we therefore sought to test the hypothesis that local endothelial function varies within the coronary vasculature and is more deranged in regions with significant coronary atherosclerosis than in those with mild disease.

Figure 1 (abstract P132)



Percent change (mean ± SD) from baseline in coronary artery area, peak diastolic coronary flow velocity and flow during isometric handgrip stress for arteries with mild vs. severe coronary disease. (*p = 0.007, † p = 0.02 mild vs. severe CAD)

Methods: Eleven patients (59 ± 6.2 years, mean ± SD, 3 women) with x-ray-defined coronary artery disease (CAD) were recruited and imaged using a 3 T MRI scanner (Achieva, Philips, Best, NL). In each patient, two arteries were imaged in cross-section: one artery (LAD or RCA) with severe stenosis (≥60%) and the contralateral artery with no significant stenosis (<30%) by x-ray angiography. Baseline imaging at rest for cross-sectional coronary artery area measurements was followed by coronary flow velocity-encoded MRI for flow velocity measurements. Alternating anatomical and velocity-encoded images were collected at baseline, and during 4 minutes of continuous isometric handgrip (at 30% of maximum grip strength). Three patients additionally received 0.4 mg of sublingual nitroglycerin and images were collected after five minutes. MRI parameters for anatomical and flow imaging respectively were: echo time (TE) = 1.5 ms/3.5 ms, radiofrequency (RF) excitation angle = 20° and spectral spatial excitation (both), breath-hold duration ~17–23 sec, acquisition window = 10 ms/27 ms, repetition time (TR) = 14 ms/34 ms, 21/11 spiral interleaves/cine frame, spatial resolution = 0.89 × 0.89 × 8.0 mm^3/0.8 × 0.8 × 8 mm^3 with velocity encoding = 35 cm/second. Blood pressure and heart rate were recorded at rest and during handgrip. Images were analyzed for cross-sectional area changes (Cine version 3.15.17, General Electric, Milwaukee, WI) and for peak diastolic coronary flow velocity (FLOW Version3.0, Medis, NL). Coronary flow (mL/min) was calculated as: coronary cross-sectional area × coronary artery peak diastolic velocity × 30 [3].

Results: Nine patients had adequate image quality in both arteries for coronary area measurements and eight patients had sufficient image quality for flow velocity measurements. The