Pulmonary Vein Flow to determine Left Atrial Pressure: Can MRI phase velocity mapping compete with echocardiography?

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Introduction: Blood flow pattern in pulmonary veins (PVF) are used to assess the physiologic parameters of left atrial pressure, left ventricular end diastolic pressure (LVEDP), etc. To date Doppler ultrasound is routinely used to describe PVF in terms of parameters such as systolic (S), and diastolic (D) peak velocities, S/D ratio, atrial reversal peak velocity (A_r), and its duration (A_{dur}). MRI phase velocity mapping (PVM) has been used to provide similar information about blood flow pattern in large and medium sized vessels throughout the body[1]. The purpose of this prospective study was to evaluate the feasibility of using MRI PVM to assess PVF patterns using metrics analogous to those in echo Doppler.

Materials and Methods:

Patient Population: PVF in 17 patients in normal heart sinus rhythm (13 men, age: 60.5±13.4 years), were prospectively studied using MR PVM and Doppler ultrasound. Heart rates (HR) and blood pressures (BP) were similar during both imaging sessions. 3 patients were excluded from the study due to inadequate echo PVF quality. Of the 14 patients, 10 patients had documented coronary artery disease, 2 had hypertrophic cardiomyopathy, one patient had history of valvular disease, and one was S/ P VSD repair.

MRI data acquisition: All images were acquired at 1.5 T using a commercial MRI scanner (Gyroscan NT Intera, Philips Medical System). A 5 element surface coil array was used for signal reception, and all data were collected with VCG gating. Flow through the right upper PV was measured using a MRI PVM sequence with the following parameters: TR/TE/flip: 10 msec/6.5 msec/25°; aliasing velocity (V_{enc}): 100 cm/sec; direction of velocity encoding: perpendicular to the imaging slice; retrospective gating was used to ensure data collection over the entire RR interval; temporal resolution of MR acquisition was: 25 msec. *Post processing:* PV MRI data were transferred to an EasyVision (Philips Medical Sytems) post-processing workstation. Using a region of interest around the RU PV, curves depicting mean vessel flow, and peak velocities over the cardiac cycle were generated. From the peak velocity curves, systolic (S), and diastolic (D) peak velocities, and Ar peak velocity and Adur were calculated. *Doppler echocardiography (DE):* Mitral inflow at the tips of mitral leaflets and pulmonary venous flow at 1 cm from the RU PV ostia were measured using DE (Sonos 5500, Hewlett Packard) in the apical 4-chamber view, within 24 hours of MRI. The Doppler measurements were performed off line by an experienced cardiologist.

Results: There was a statistically significant correlation between diastolic peak velocity, S/D ratio, and A_r peak velocity estimated using MR and DE (Table 1, Figure 1). While peak velocities measured using MR were consistently lower than those measured using DE, the overall shape of the peak velocity curves were comparable (Figure 2). Based on the PVF patterns (S/D ratio less than 1) all seven patients with high left atrial pressure (LAP) were correctly diagnosed by MRI (Figure 3).

Discussion: It is known that MR PVM underestimates peak velocities, as MR measures time averaged velocity (over a 3 min period), as well as spatial average of velocity distribution within the voxel [2]. An important finding of this study is that while the peak velocities in MR were lower, the shapes of peak velocity curves were comparable to DE, indicating their clinical usefulness. Incidentally, in the group of patients identified with higher LAP, other evidence suggesting elevated LAP were also found, e.g., pseudonormolized mitral inflow, larger left atrial size, and lower ejection fraction (29.1±17.1 Vs 49.4±16.8%, respectively $p<0.05$)

Conclusions: MRI correctly identified all patients with elevated LAP using a threshold of S/D ratio < 1.0.

Our results show that is feasible to use MRI PVM to assess blood flow pattern through pulmonary veins to assess clinically useful physiologic parameters such as LAP.

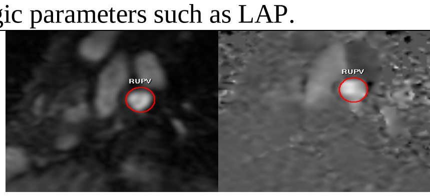

Fig 1: Magnitude (right) and phase (left) images depicting flow in RUPV.

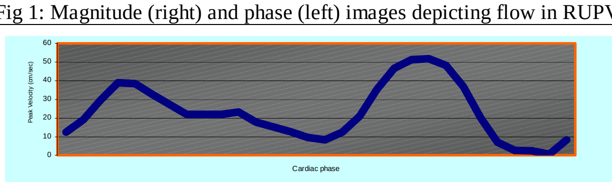

Fig 2: Note the increased peak velocity in diastole indicating high LAP.

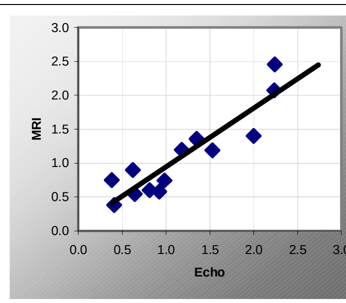

Fig 3: Note the close corrleation between D/S derived from MR and echo measurements. Patients with D/S ratio < 1 have elevated LAP.

	MRI	Echo
D (cm/s)	34.7± 17.5	50.1± 19.3
S/D ratio	1.2 ± 0.6	1.1± 0.5
Ar (cm/s)	19.1± 10.2	24.8±5.3

Table 1: Statistical significant Pearson correlation coefficients for D, S/D ratio, and A_r between MRI and echo data are: r =0.7 ($p<0.002$), 0.9 ($p<0.0001$), and 0.7 ($p<0.01$) respectively.

References: 1. Hartiala et al. Am Heart J 1993;125:1054; 2. Pelc et al. MR Quarterly, 1994; 10:125-47.