# Radial Sliding Window Time Resolved MRA: Evaluation of Intrapulmonary Circulation Parameters in Pulmonary Arterial Hypertension

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## Introduction

The purpose of our study was to determine the pulmonary arterial and pulmonary venous transit times as measured by radial sliding window time-resolved MRA to calculate pulmonary arterial, pulmonary venous and total pulmonary blood volumes and correlating ventricular volumetric indexes in patients with pulmonary arterial hypertension (PAH). Radial sliding window time resolved MRA allows high temporal resolution, free breathing MRA with good separation between arterial and venous phases.

## Materials and Methods

Ten patients (4 male, 6 female, mean age 46.6±9., age range 37-61) diagnosed with PAH and eight control healthy volunteers (4 male, 4 female, mean age 33.8±17, age range 24-65). All patients were previously diagnosed with PAH, defined as Right Ventricular Systolic Pressure more than 40 mmHg at right heart catheterization.

Images were acquired on a 1.5T scanner (Avanto, Siemens Medical Systems, Erlangen, Germany) using a phased array body coil. The imaging protocol consisted of cine SSFP, phase contrast flow quantification and radial sliding window time resolved contrast enhanced MR angiography. The heart was imaged from base/apex in short axis using cine SSFP. Thru plane phase contrast flow quantification was performed on the main pulmonary artery and the mitral valve. The time resolved MRA was acquired with the spoiled gradient-echo sequence with radial stack-of-stars trajectory. Imaging parameters for the LAO MRA were as follows: $N_p$=192, base resoln.=192, FOV=280mm x 280mm, $N_{slices}$=30, thick=3.0 mm, FA=30, TR/TE=2.8/1.4ms, 75% partial fourier in partition and radial directions. Temporal resolution was 0.72±0.08s. Each 3D volume was acquired in 14 seconds, and 6 repetitions were acquired for a total imaging time of about 90 seconds. Gd-BOPTA was injected iv (6ml at 6cc/s). Images were reconstructed using the sliding window scheme with 16 intermediate frames between repetitions, resulting in a frame rate of approximately 1 frame/sec. Sliding subtraction mask was used for better separation of arteries and veins (1).

Right and Left Ventricular parameters including Ejection Fraction (EF), End-Diastolic Volume (EDV), End-Systolic Volume (ESV) and Stroke Volume (SV) were measured using Argus (Siemens Leonardo). Intrapulmonary transit times (PaTT = Pulmonary transit time, PVTT = Pulmonary venous transit time) and dispersions (full widths at half maximum [FWHM]) were determined from subtracted MIP's time resolved MRA images using Mean Curve (Siemens Leonardo). (Fig.1 & 2). Total pulmonary blood volume (PtBV) is pulmonary arterial volume (PaBV) plus pulmonary venous volume (PvBV). (PBV = PaBV + PvBV). PaBV was calculated by multiplying the average blood flow through the pulmonary valve (mls) by the transit time form the proximal to the distal pulmonary artery. PvBV was calculated by multiplying the average blood flow through the mitral valve (mls) by the transit time form the proximal to the distal pulmonary vein.

Transit times and ventricular volumetric values for the PAH group were compared with those for the control subjects by using two-tailed t-tests. Pearson correlation coefficients were used to assess the relationship between transit times, pulmonary blood volume and right and left heart volumetric parameters (EF, EDV, ESV, SV).

## Results

Intrapulmonary transit times PaTT and PvTT values were prolonged in patients with PAH compared with those in the control patients (2.5 and 2.1s compared with 1.2 and 1.6s respectively) (Fig.3). PaTT and PvTT correlated directly with right ventricular EDV and ESV, and inversely with right ventricular EF (R>0.7) (Fig.4.). PBV, PaBV and PvBV correlate directly with right ventricular EF (R>0.7)

## Conclusion

Radial sliding window time-resolved MRA allows determination and separation of intrapulmonary transit times that are prolonged, and pulmonary blood volumes, which are raised in pulmonary arterial hypertension and correlate with right ventricular volumes and inversely with right ventricular ejection fractions. This may be a useful method for diagnosis and follow-up of right-sided heart failure in PAH patients. The improved temporal separation of the arterial and venous phases may provide useful distinction between pulmonary arterial and pulmonary venous hypertension.

**References**: 1. Cashen et al. ISMRM, 2007

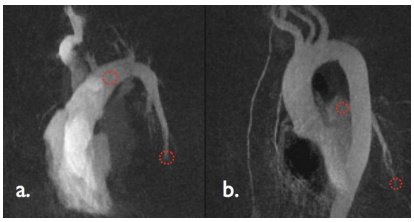


Fig.1 LAO MIP. a. Pulmonary arterial phase with circular ROI's place over the proximal and distal artery. b. Pulmonary venous phase with the ROI's over the proximal and distal vein.

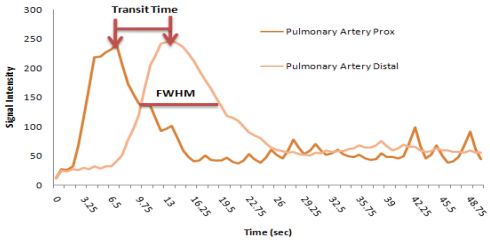


Fig. 2 Generation of intrapulmonary transit curves from the LAO MIP. Transit time is calculated by subtracting the time of peak signal intensity of the proximal pulmonary artery from the time of the peak signal intensity of the distal pulmonary artery.

| | PAH | Control |
|---|---|---|
| PaTT | 2.5±1.6s | 1.2±0.3s |
| PvTT | 2.1±1.1s | 1.6±0.4s |
| RVEF | 35±18.1% | 52±5.8% |
| RVEDV | 207±88.7ml | 136±25 |
| RVESV | 132±62.5ml | 64.5±20.6 |
| PtBV | 317ml | 204ml |
| PaBV | 151ml | 85.6ml |
| PvBV | 166ml | 119ml |

Fig. 3. Intrapulmonary transit times, right ventricular volumetric parameters and pulmonary blood volumes in PAH and control group.

| | PaTT | PvTT |
|---|---|---|
| RVEF | 0.7 | 0.6 |
| RVEDV | 0.6 | 0.7 |
| RVESV | 0.6 | 0.6 |

Fig.4. Pearson correlation values for intrapulmonary transit times and right ventricular volumetric parameters.