The pant leg area sum index: New pulmonary MRA metric for the determination of Pulmonary arterial Hypertension

Phillip Kilgas[1], Alejandro Roldan-Alzate[1], Eric Schrauben[2], Naomi Chesler[3], Christopher François[1], and Mark L. Schiebler[1]

[1]Radiology, UW-Madison, Madison, Wisconsin, United States, [2]Medical Physics, UW-Madison, WI, United States, [3]Bioengineering, UW-Madison, Madison, WI, United States

Background: Pulmonary arterial hypertension (PAH) is a life-threatening disease manifested by exercise intolerance and heart failure. Dilatation of pulmonary arterial vasculature occurs as a result of elevated pulmonary pressures [1]. Quantification of pulmonary arterial tree dilatation through the extraction of these anatomical changes from magnetic resonance angiogram (MRA) may lessen the need for invasive catheter based measurements. The **purpose** of this study was to investigate non indexed and indexed parameters based on MRA volumetric images of the main pulmonary artery and proximal left and right arteries as an innovative metric to diagnose PAH.

Methods: This was a HIPAA compliant and IRB approved prospective study. There were eight PAH patients (confirmed by right heart catherization) and eight healthy volunteers were studied with non-gated MRA exams. Acquisition was performed at 3T (GE Healthcare, Waukesha, WI) following the administration of gadolinium-based contrast agent at 1.5 ml/sec (gadobenate dimeglumine, Bracco, Milan). Scan parameters of the SPGR sequence included TR/TE of 2.9/1.0 ms, average field of view = 34 x 27 cm, slice thickness = 2.0 mm, 140-160 slices, flip angle = 28°, and acquired spatial resolution of 1.3 x 1.8 x 2.0 mm^3, which was interpolated to 0.7 x 0.7 x 1.0 mm^3 by a previously published 2D homodyne and zero filling reconstruction method [2,3]. Breath-hold time range was 15-21 seconds. Visualization software (Mimics, Materialise, Belgium) post-processed magnitude images using a centerline extraction technique was used to determine the following measurements: diameter of the main, left, and right arteries (MPA, LPA, RPA), and also pant-leg (P-L) volume, surface area, branch sum, and area sum . To determine P-L, measurements were made along the centerline two centimeters in each direction of the bifurcation. Once segmentation was completed, body surface area (BSA) was divided by each measurement to compute an index value. Index and non-index (BSA not included) measurements were compared (Table 1). Analysis was evaluated as mean ± standard deviation. Differences in these calculations were statistically analyzed using a two-tailed Student's paired t-test.

Results: Table 1 includes average index and non-index (± standard deviation) measurements between PAH patients and normal volunteers. In all PAH cases, both dilatation and volume increased when compared to healthy volunteers. Each measurement, except MPA index, proved to be statistically significant at the 5% level ($p \leq .05$). MPA index discrimination can be most likely attributed to the difference in variance of the PAH patients. The non-indexed LPA measurement, at the distal cuff of the pant-leg, demonstrated the most significant association with elevated pulmonary artery pressures ($p < .00036$) while the P-L area sum index was best for the indexed measurements ($p < 0.00043$)

	PAH Patients	Normal Volunteers	P-Values	PAH Patients Index	Normal Volunteers Index	p--Value
MPA (mm)	36.10 ± 3.66	30.15 ± 3.24	0.00395	18.31 ± 3.47	16.07 ± 1.48	<0.1148
LPA (mm)	27.45 ± 2.83	19.08 ± 2.81	0.00004	13.92 ± 2.62	10.15 ± 1.19	<0.00234
RPA (mm)	27.27 ± 2.74	19.73 ± 2.86	0.00010	13.82 ± 2.45	10.49 ± 1.08	<0.00339
Volume (mm^3)	44156 ± 12340	23978 ± 5009	0.0019	22542 ± 8451	12719 ± 2118	<0.01309
Surface Area (mm^2)	7337 ± 1260	5154 ± 764	0.0014	3728. ± 966	2744 ± 337	<0.02445
Pant-leg Branch Sum (mm)	54 ± 5	38.81 ± 5.57	0.000042	27.74 ± 5	20 ± 2.20	<0.00245
Pant-leg Area Sum (mm^2)	1186 ± 234	602.61 ± 170.31	0.000055	603 ± 161	318 ± 71.00	<0.00043

Table 1: Non-index versus Index summarized results showing that the of the indexed measurements the Pant-leg Area sum had the lowest p value ; while of the non indexed values , the LPA diameter had the lowest p value.

Discussion: Currently non indexed values of the pulmonary arterial system are used by imagers to infer the presence of pulmonary arterial hypertension. However we should be moving towards Indexed measuremtns in cardiovascular MR (CVMR) as they help to normalize the many measurements that are obtained at CVMR. In this study, we show that a new metric for the measurement of pulmonary artery size (Pant leg area sum) was the indexed variable most significantly associated with PAH.

Conclusion: Of all the indexed Pulmonary MRA metrics that can be used for the non-invasive determination of PAH, we found that a new way to measure the pulmonary artery (Pant leg Area Sum index) was the metric that was most significantly associated with PAH.

References: **1.** Badagliacca et al. *Cardiology* 2012. **2.** Lum et al. *JMRI* 2009. **3.** Brau et al. *MRM* 2008.