MRI PHASE CONTRAST FLOW VELOCITY IMAGING IN MAIN PULMONARY ARTERY IN PULMONARY ARTERIAL HYPERTENSION

1Dr.S.Babu Peter, 2Dr.P.K.Latha, 3Dr.N.Kailasanathan,
Barnard Institute Of Radiology, Madras Medical College, Chennai – 600 003.

Abstract - AIM: This prospective study aims to compare the accuracy of MR Pulmonary Phase Contrast Flow Velocity Imaging with established CT size criteria in patients with Pulmonary Arterial Hypertension.

MATERIALS AND METHODS: Study population included 50 subjects, who are diagnosed or suspected to have pulmonary hypertension. For control, patients who undergo CT chest investigation for other reasons were included and were analysed. Phase contrast flow velocity imaging is done with in plane and through plane imaging. For phase contrast flow velocity imaging, mean velocity encoding is kept at 75cm/sec in our study, the CT parameter, pulmonary artery size of 2.9mm is kept as cut off value above which is possibility of pulmonary hypertension can be considered and below which it is considered normal. Following parameters are assessed and evaluated:

1. Size of the main pulmonary artery in CT.
2. MRI Pulmonary Artery Flow Parameters (Average velocity, Average pulmonary artery area, Peak velocity, Maximum pulmonary artery area, Minimum pulmonary artery area).

RESULTS: Pulmonary artery size criteria for pulmonary hypertension is well correlated with PA average velocity and PA minimum area of the pulmonary artery as measured using phase contrast MRI. Degree of correlation (86.5%) is higher for PA size & PA minimum velocity and also between PA average area & PA average velocity (89.5%).

CONCLUSION: MRI Phase contrast flow velocity imaging is a novel non invasive imaging modality that can be used in the diagnosis of pulmonary hypertension by means of measuring flow parameters.

I. INTRODUCTION

Pulmonary hypertension is a progressive disease. Pulmonary arterial hypertension is defined as an elevation in mean pulmonary arterial pressure above 30 mmHg during exercise and 25 mmHg at rest. Presenting symptoms included dyspnea (60%), fatigue (19%), and syncope (or near syncope) (13%)/(1). Generally it is grouped into five diagnostic categories pulmonary arterial hypertension, PH with left-sided heart disease, PH associated with lung disease and/or hypoxemia, PH due to chronic thrombotic and/or embolic disease, and a miscellaneous group (2). Disorders leading to pulmonary arterial hypertension are associated with a particularly fatal outcome (3). Right-sided heart catheterization is the good standard for the diagnosis and assessment of the severity of pulmonary hypertension (4), but it is invasive and carries a small but definite risk of severe complications. Echo cardiography plays important role in pulmonary arterial hypertension due to left heart disease and it is initial screening modality of choice. Magnetic Resonance Imaging (MRI) plays an important role in the diagnosing and monitoring the patients with pulmonary hypertension. Phase-contrast MR imaging gives accurate quantification of blood velocity and flow and results of prior research (5-9) suggest a potential role in the assessment of PH. Thus, the purpose of our study is to identify pulmonary arterial (PA) flow parameters measured with phase-contrast MR imaging and to correlate with main pulmonary artery size.

II. MATERIALS AND METHODS

This prospective study was performed at Rajiv Gandhi government general hospital, Chennai during the period September 2013 to September 2014 after obtaining clearance from our institutional ethical committee. Study population included 50 subjects of age group 30-50 yrs out of which 35 were women and 15 were men. Those subjects who are diagnosed or suspected to have pulmonary hypertension are included in the study. And also those subjects who are found to have pulmonary artery diameter more than 29 mm in their CT chest taken for the complaints like breathless or other. For control, patients who undergo CT chest investigation for other reasons were included and were analysed.

After informed written consent and after obtaining detailed clinical history of patients study was done. All patients were in sinus rhythm. For CT chest study patients were in supine position and contrast (iohexol) injected to the patient left arm, scanning performed in CT Scanner Asteion (TOSHIBA). And after which ECG gated cardiac MRI performed in 1.5-T clinical magnet Magnetom 2 symphony; Siemens Medical Solutions, Erlangen, Germany. Images were obtained during end-expiratory breath holds. After obtaining standard localizer views and contiguous short-axis cine views covering both ventricles, two double-oblique views oriented along the main axis of the pulmonary trunk were acquired with a standard steady-state free precession cine MR sequence. The plane should be truly perpendicular to the main PA for the acquisition of phase-
contrast MR images and to ensure that the imaging plane remained between the pulmonary valve and the PA bifurcation throughout the whole cardiac cycle (about 1.5 cm away from the pulmonary valve). Phase contrast flow velocity imaging is done with in plane and through plane imaging.

For phase contrast flow velocity imaging mean velocity encoding is kept at 75 cm/sec if aliasing noted it is increased in 25 up to 150. Imaging parameters included the following: flip angle, 15°; section thickness, 6 mm; field of view, 320 – 380 * 240 – 300 mm; matrix, 256 * 256. Phased array surface coil is used as a receiver. Post processing is done with commercial software ARGUS. Exclusion criteria includes patients with pace maker, metallics implants, clips for intracranial aneurysm, chustrophobia, pregnant patients.

III. DATA INTERPRETATION AND ANALYSIS

A prospective study (10) in which the subjects were 134 patients who underwent right heart catheterization and chest CT within 72 hours of each other showed that CT-derived measurement of the MPA diameter has stronger correlation with the presence of pulmonary hypertension in patients without ILD (MPA diameter > 31.6 mm had a positive predictive value of 90.0% and a negative predictive value of 58.3%) than in patients with ILD (MPA diameter > 25 mm had a positive predictive value of 46.3% and a negative predictive value of 83.8%). In both groups, however, the MPA diameter was significantly greater in patients with pulmonary hypertension than in those without.

A number of findings on CT have been shown to be useful in evaluating possible PAH. A ratio of pulmonary artery diameter to aortic diameter of > 1 has been shown to correlate with elevated mean PAP, although a ratio of < 1 does not exclude PAH. In a study by Kuriyama et al. (11), a main pulmonary artery diameter of > 29 mm was shown to have a sensitivity of 69% and specificity of 100% for predicting PAH. Main pulmonary artery diameter has been shown to be useful for detecting PAH in patients with advanced lung disease, with a sensitivity of 87% and specificity of 89%, with the additional finding that a segmental artery-to-bronchus ratio > 1 increases specificity. 

Thus in our study the CT parameter, pulmonary artery size of 2.9 mm is kept as cut off value above which is possibility of pulmonary hypertension can be considered and below which is considered normal. Thus we split the study population in to two groups based on pulmonary artery size, those above 2.9 cm and those below 2.9 cm.

The parameters that are measured in Phase contrast study are (12), Peak velocity, Average velocity, Maximum area of vessel (in cross section), Minimum area of vessel, Average area of vessel, Strain, Acceleration time (AT), Ejection time (ET), AT/ET ratio, Average velocity during AT, Average velocity during ETS. “In study conducted by Bouchard A et al (13) that the average velocity of PA flow was the most useful single parameter in the evaluation of PAH. The presence of slow pulmonary flow in patients with PH was observed in early investigations by using spin-echo MR techniques. An average velocity cut off of 11.7 cm/s revealed pulmonary arterial hypertension with 92.9% sensitivity and 82.4% specificity (14). In patients with chronic PAH, a variety of flow measurements in the pulmonary trunk evaluated with phase-contrast MR imaging correlate with the degree of hemodynamic disturbance as determined with the level of pulmonary pressures and vascular resistance. The average blood velocity throughout the cardiac cycle is strongly correlated with pulmonary pressures and resistance and appears to have consistent performance across different subgroups of patients.

Following parameters are assessed and evaluated

CT
1. Size of the main pulmonary artery

MRI PA FLOW PARAMETERS
1. Average velocity
2. Average pulmonary artery area
3. Peak velocity
4. Maximum pulmonary artery area
5. Minimum pulmonary artery area

<table>
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<tr>
<th>CT</th>
<th>MRI</th>
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<tbody>
<tr>
<td>1. PA size</td>
<td>1. Average PA velocity More than 11.7 cm/sec - normal</td>
</tr>
<tr>
<td>Less than 2.9 cm - normal</td>
<td>2. Minimum PA area Less than 10.5 cm² - normal</td>
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IV. RESULTS

In this study, out of 50 subjects, 37 (74%) subjects were having PA size more than 2.9 cm, 13 (26%) subjects were having PA size less than 2.9 cm. (Tab:1). And out of 50 subjects, 40 (80%) subjects were having a velocity of < 11.7 cm/sec, 10 (20%) subjects were having a velocity of > 11.7 cm/sec (Tab:2), . Out of 50 subjects, 35 (70%) subjects were having a minimum area of > 10.5 cm², 15 (30%) subjects were having a minimum area of < 10.5 cm² (Tab:3).

Graph: 1 shows correlation between PA Average velocity with pulmonary artery size. It has a negative correlation with Pearson correlation value of – 0.865 with P value 0.001 (P value < 0.05), that is as the PA size increase PA average velocity decreases(negative correlation). The percentage of correlation of 86.5% (Tab:4). Graph: 2 shows correlation between PA area with pulmonary artery size. It has a positive correlation with Pearson correlation value of 0.806 with P value 0.001 (P value < 0.05). The percentage of correlation of 80.6% (Tab:4). Graph: 3 shows correlation between PA area with PA average velocity. It has a negative correlation with Pearson correlation value of – 0.895 with P value 0.001 (P value < 0.05). The percentage of correlation of 89.5% (Tab:4).
With regard to the CT criteria of pulmonary artery size more than 2.9 cm, 37 out of 50 subjects had size more than 2.9 cm and remaining 13 subjects had less than 2.9 cm. All 37 subjects who had pulmonary artery size more than 2.9 cm had average velocity less than 11.7 cm/sec and minimum pulmonary artery area more than 10.5 cm$^2$, thus pulmonary artery size criteria for pulmonary hypertension is well correlated with PA average velocity and PA minimum area of the pulmonary artery as measured using phase contrast MRI. Degree of correlation (86.5%) is higher for PA size & PA minimum velocity and also between PA average area & PA average velocity (89.5%).
FIG:1 SERIES: CT AXIAL CT: Pulmonary artery size 2.42cm; PHASE CONTRAST (IN PLANE & THROUGH PLANE IMAGES): Average velocity: 19.85 cm/sec, Minimum pulmonary artery (PA) area: 3.88 cm²

FIG:2 SERIES CT AXIAL: Pulmonary artery size 3.52cm, PHASE CONTRAST MRI (IN PHASE AND THROUGH PHASE): Average velocity: 8.09 cm/sec, Minimum pulmonary artery area: 12.20 cm²
V. CONCLUSION

In conclusion, our results show that pulmonary artery average velocity and minimum area measured using phase contrast flow velocity imaging vary among patients with pulmonary artery diameter more than 2.9cm and less than 2.9cm. Thus pulmonary artery average velocity and minimum area correlated well with pulmonary artery size criteria for pulmonary hypertension. Thus MRI Phase contrast flow velocity imaging is a novel non invasive imaging modality that can be used in the diagnosis of pulmonary hypertension by means of measuring flow parameters.

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