Onset time of retrograde flow in the pulmonary artery in pulmonary arterial hypertension patients: an estimator for pulmonary arterial pressure?

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Introduction: Pulmonary arterial hypertension (PAH) is a progressive disease characterised by a chronically elevated mean pulmonary artery pressure (mPAP). The golden standard for diagnosing PAH is right heart catheterisation. This is an invasive method which can be damaging for the patient and cause complications. Therefore it is not suitable for therapy-evaluation and monitoring of PAH patients. Non-invasive MR imaging may quantify the effects of elevated pulmonary artery pressure on 3D flow patterns (Reiter et al., 2008) and on size of the main pulmonary artery. However, 3D flow patterns and vortices can only be measured with time-consuming 3D velocity mapping at several locations.Therefore, the objective of this study was to assess if mPAP could be estimated using 2D MR phase-contrast velocity quantification. Furthermore we wanted to assess if MR-derived flow and area measures could be used to diagnose PAH.

Materials and Methods: Thirty-seven PAH patients (mean age; 49 years ± 16) and eight healthy subjects (subjects suspected of pulmonary hypertension and later declared healthy, mean age; 49 years ± 13) were included and underwent right heart catheterisation and retrospectively ECG-gated MR flow quantification in the main pulmonary artery. MRI parameters were: Siemens 1.5 Tesla system, 6 mm slice thickness, 120 cm/s velocity encoding, 25º flip angle, 240×320 mm^2 field of view, 140×256 matrix size, 4.8 ms echo time, 11 ms repetition time. The variables were onset time of the retrograde flow given relative to the cardiac cycle duration (Retrograde Onset Time = ROT), retrograde flow relative to the antegrade flow (Relative Retrograde Flow= RRF), and end-diastolic cross sectional area (CSA) of the main pulmonary artery. The variables were correlated with mPAP and the ability of the variables to estimate mPAP and detect PAH (mPAP > 25 mmHg) was calculated. Statistical test included descriptive statistics, independent T-tests, regression analysis, multiple regression and ROC-curves.

Results: The linear regression analysis showed a relation between mPAP and ROT (r = 0.74; mPAP = -122 × ROT + 71; P < 0.001). There was also a relation between mPAP and RRF (r = 0.7; mPAP = 207 × RRF + 28; P = < 0.001) and between mPAP and CSA (r = 0.68; mPAP = 0.041 × CSA + 5.22; P < 0.001). The following equation: mPAP = 42.1 - (ROT × 85.2) + (CSA × 0.022) was found with multiple regression (fig 1) and gave an estimation of mPAP with a mean error of 8.3 mmHg.

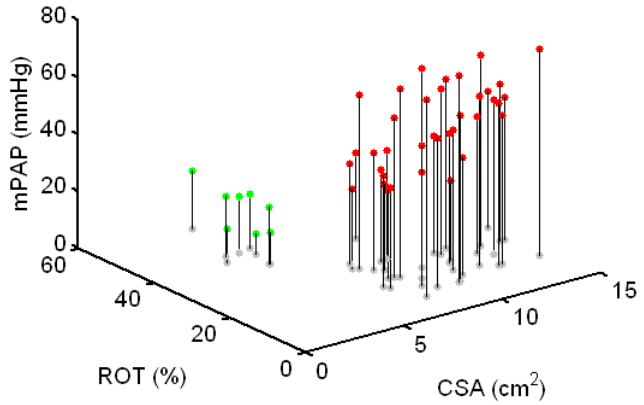

Fig 1: 3D plot of mPAP versus retrograde onset time (ROT) of the flow and CSA of the main pulmonary artery. Green dots are the controls, red dots are the PAH patients.

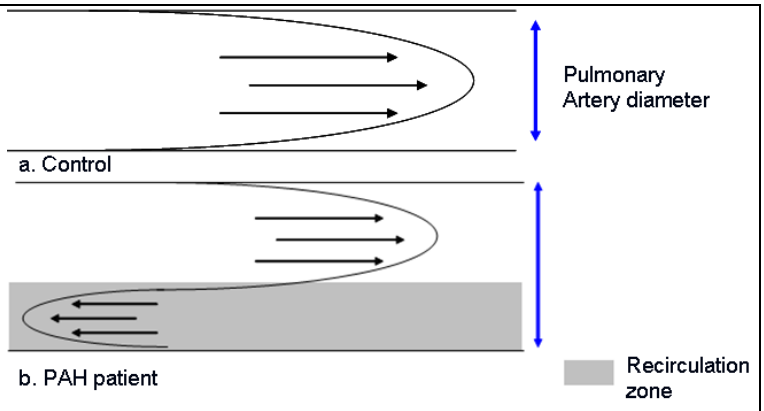

Fig 2: Model of the recirculation zone in PAH, which is presumably the cause of early retrograde flow.

With cut-off values of 0.38 for ROT, 0.006 for RRF and 626 mm^2 for CSA, these variables could predict PAH to be present with 100% sensitivity and 75, 87.5 and 100 % specificity, respectively.

Discussion: This study shows that a combination of ROT and CSA can be used to non-invasively estimate the mPAP. Furthermore ROT, RRF and CSA are non-invasive MR imaging variables that can be used to detect PAH with 100% sensitivity. Therefore, patient discomfort can be reduced by using MRI instead of catheterization for diagnosing PAH. Thus, this approach looks promising for therapy-evaluation and monitoring of PAH patients.

In addition, it is shown that the presence of an early recirculation zone (fig 2) can be detected by a standard 2D flow acquisition in the main pulmonary artery, simply by timing the onset of retrograde flow. Both this acquisition as well as this timing are easily applicable in clinical routine.

Reference: Reiter G et al., *Circ Cardiovasc Imaging* 2008;1;23-30