Detection and Quantification of Pulmonary Arterial Hypertension caused by increased Pulmonary Resistance using MR Flow Measurements

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Introduction

Development of a pulmonary arterial hypertension (PAH) is a common problem in the course of patients suffering from cystic fibrosis (CF). The standard of reference to assess the pressure within the main pulmonary artery (MPA) is right heart catheterization with transducer based measurements. Non invasive assessment of pulmonary arterial pressure is done using echocardiography. Right ventricular hypertrophy indicates elevated pulmonary arterial pressure, regurgitation through the tricuspid valve and/or determination of the acceleration time (AT) in the MPA permits the estimation of pressure. While invasive catheter based measurements are not feasible for a continuous follow-up, echocardiographic measurements are difficult to obtain in patients with CF due to the development of emphysema with the decrease of the acoustic window. MR based flow measurement, for example in the MPA, is a robust technique (1, 2), which is capable to acquire a variety of different flow parameters. Using the recent advances in scanner hardware and sequence technique, it is possible to achieve a temporal resolution of < 10 ms to acquire precise values for the AT. Maxwell-term correction insures valid flow data. The aim of this study was to evaluate MR based flow measurements to detect and quantify an evolving PAH in patients suffering from CF.

Materials and Methods

48 patients (median age: 16 years, range: 10-40 years, 26 female) suffering from CF of different severity (mean FEV_1: 69.8% ± 25.3) were examined. The results were compared to 48 healthy age matched volunteers. MR based flow measurements were done in a 1.5T system (Magnetom Sonata, Siemens). A prospectively ECG-triggered phase-contrast flash sequence with high temporal resolution (TR: 9.6 ms, TE: 2.5 ms, bandwidth: 1395 Hertz/Pixel) and Maxwell term correction was utilized. Flow data was acquired without sedation and under free breathing conditions, flow analyses were done by applying the ARGUS Flow Analysis software. With respect to the criteria of echocardiography to detect PAH in the MPA (3), the flow profiles of all subjects were analysed to calculate the acceleration times (AT[ms]) and the mean flow velocities during systole (MFV[cm/s]). The pressure was estimated using a former published equation based on MR-flow data (4). In addition, the absolute cardiac output (CO) and the cardiac output normalized to the body surface area (nCO) were obtained.

Results

Mean CO was 6.6 l/min ± 1.7 in the healthy subjects and 6.2 l/min ± 2 in CF patients. The mean nCO was 4.0 l/min ± 0.7 in the healthy subjects and 3.8 l/min ± 1.0 in CF patients. In healthy subjects the mean AT was 136 ms ± 13 and the mean MFV was 66 cm/s ± 13. The CF-patients exhibited a mean AT of 127 ms ± 21 and a mean MV of 59 cm/s ± 12. The differences of all mean values for both groups were not significant as calculated with the Wilcoxon-Mann-Whitney-Test. Using a scatter plot, which shows the AT on the abscissa and the MFV on the ordinate, a group of five patients was found to be exceptional (Fig. 1).

Fig. 1

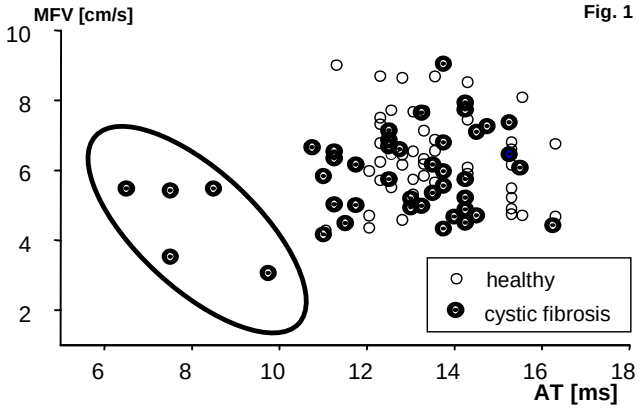
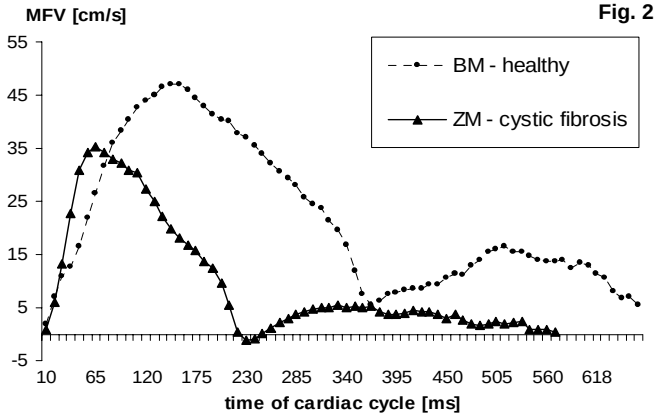


Fig. 2



These five patients with ages between 14 and 39 years (median: 18 years) revealed noticeably lower values for the mean AT (81 ms ± 14) and/or the mean MFV (46 cm/s ± 11) indicating PAH. As an example, Figure 2 shows a comparison of two flow velocity graphs. Healthy subject BM had an AT of 152.5 ms and a MV of 48.8 cm/s, these measures are standard values. CF-patient ZM had an AT of 75 ms and a MV of 35.3 cm/s suggesting PAH. The estimated mean pressure in the main pulmonary artery of these five patients varied between 25 and 36 mmHg, while all other CF patients and the healthy subjects revealed estimated pressures below 20 mmHg (standard value).

Conclusions

Signs for the development of a PAH (i.e. reduction of AT and MFV) are detectable using MR based flow measurements. MRI is not addicted to an acoustic window and it is a non invasive approach to assess pulmonary flow parameters. The authors conclude that MR flow measurements are a valuable screening tool for patients suffering from resistance based elevated pulmonary arterial pressure (e.g. CF) to identify and quantify an evolving PAH.

Literature

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