A Comprehensive MRI Protocol for the Assessment of Pulmonary Hypertension

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Introduction

Assessment of patients with pulmonary hypertension involves a number of imaging modalities to identify those patients with treatable chronic thrombo-embolic pulmonary hypertension (CTEPH), assess right ventricular performance and monitor the effects of treatment. Typically this requires ventilation-perfusion radionuclide imaging (V/Q), CT, echocardiography and catheter pulmonary angiography. MRI has been shown to be a reliable substitution for many of these techniques (1,2) and is the most accurate and reproducible technique in the assessment of ventricular function (3). To date a comprehensive protocol for MR assessment of this patient group has not been reported. We retrospectively reviewed MRI studies of 16 patients with pulmonary hypertension to establish an MRI protocol designed to aid the evaluation and management of patients with pulmonary hypertension.

Methods

16 patients with pulmonary hypertension (resting mean pulmonary artery pressure > 25mm Hg) referred for MRI between February 2003 and November 2003 were reviewed. The MRI protocol included SSFP cine imaging for the assessment of right ventricular function, time-resolved lung perfusion imaging and contrast enhanced MRA of the pulmonary vasculature. MR imaging was performed on a 1.5 Tesla Signa Twinspeed system (GE Medical Systems, Milwaukee, WI) with a 4-element cardiac phased array coil. Steady state free precession (SSFP) cine images were acquired using a slice orientation previously reported (4). Right ventricular (RV) volumes and ejection fractions were calculated using Medis software on an Advantage Windows workstation. Time-resolved lung perfusion imaging was performed with a multi-phase 3D TOF FSPGR using 8mm thick slices prescribed to cover the pulmonary vasculature. 8 phases per location were acquired following an injection at 1.5 ml/s of 7ml Gd-DTPA. Pulmonary MRA was performed using a 3D TOF FSPGR acquisition following an injection of 20-30 ml Gd-DTPA at 3 ml/s. Full details of imaging parameters will be be presented.

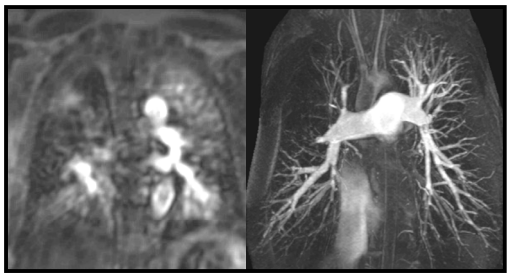
Results

Five patients were diagnosed as having CTEPH on the basis of MR findings. Perfusion imaging demonstrated multiple wedge-shaped segmental perfusion defects (Fig 1a). MRA showed webs, stenoses, filling defects and vascular obstructions typical of CTEPH (Fig 1b). Bilateral segmental perfusion abnormalities were seen on both MR perfusion imaging and V/Q scans on all patients.

Ten patients had only minor perfusion abnormalities or normal perfusion imaging and MRA showed normal pulmonary arteries or dilated proximal pulmonary arteries. In the absence of a demonstrable cause they were diagnosed as idiopathic pulmonary hypertension. (Fig 2)

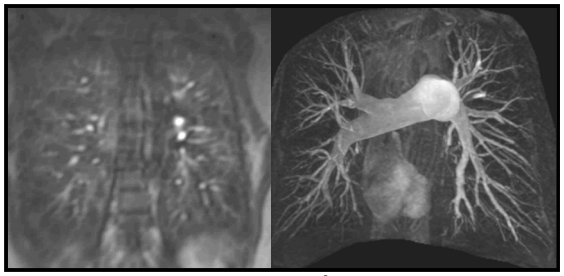
One patient had previous VSD, PDA, hypoplastic left lung and subsequent venous thrombosis.

Nearly all patients were found to have right ventricular end diastolic volumes at the upper limit of normal with a mean of 115 ml/m^2 compared with the normal range of 48-114 ml/m^2(5). Right ventricular ejection fractions tended towards the lower limit of normal with a mean of 42% compared with the normal range of 48-70%.



1a 1b

Fig 1. MR findings in CTEPH. (a) Multiple perfusion defects on MR perfusion imaging. (b) Webs, stenoses and vascular obstructions on MRA.



2a 2b

Fig 2. MR findings in idiopathic pulmonary hypertension. (a) Normal MR perfusion imaging. (b) MRA showing dilated pulmonary arteries.

Discussion

The diagnosis and investigation of patients with pulmonary hypertension often involves CT, V/Q, echocardiography and catheter angiography. While imaging features of acute emboli are easily identified on CTPA, as is the typical mosaic perfusion pattern seen in CTEPH, certain features of CTEPH, such as webs, may be difficult to detect on axial imaging. The coronal imaging plane of the MRA makes detection easier. V/Q scans are usually diagnostic in CTEPH. Catheter angiography is often required to assess suitability for thrombo-endarterectomy. Contrast-enhanced MR angiography has a high accuracy in the diagnosis of CTEPH (2). MR perfusion imaging acquired at the same examination provides additional information which is essential to the diagnosis in this patient group. Prognosis in idiopathic pulmonary hypertension is directly related to RV function. Providing an accurate measure of RV volumes and ejection fractions assists in both the selection and monitoring of appropriate treatment.

Conclusions

An MRI protocol incorporating assessment of right ventricular function, time-resolved lung perfusion imaging and contrast enhanced MRA of the pulmonary vasculature provides a comprehensive evaluation of patients with pulmonary hypertension. Patients with treatable CTEPH can be accurately diagnosed and evaluated with MRI. The effects of pulmonary hypertension on RV function can be reliably assessed. The use of a comprehensive MRI protocol has the potential to replace more invasive tests and also reduce the number of tests required in the evaluation of this patient group.

References

1) Bergin C.J et al *AJR* 168:1549-55, 1997
2) Kruger S. *Chest* 120:1556-61, 2001
3) Bellenger N.G. *European Heart Journal* 21:1387-1396, 2000
4) Strugnell W.E. et al. SMRT proceedings 2003
5) Alfakih K. et al., *JMRI* 17:323-329, 2003