4D Dynamic Contrast Enhanced MRA of the Pulmonary Vasculature with Isotropic Resolution Using a Combination of GRAPPA and TWIST Acceleration

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Introduction: Contrast enhanced MR angiography (CEMRA) has increasingly been used to evaluate patients with suspected pathology of the pulmonary vasculature. However, most clinically standard MRA sequences only allow interpretation of either the arterial or the venous phase, which limits the effectiveness in patients with severely abnormal flow patterns. In comparison to DSA the dynamic information of a passing contrast bolus is lacking in conventional CEMRA. The purpose of this study was to evaluate a fast CEMRA sequence for use in the pulmonary vasculature with regard to image quality and potential fields of use.

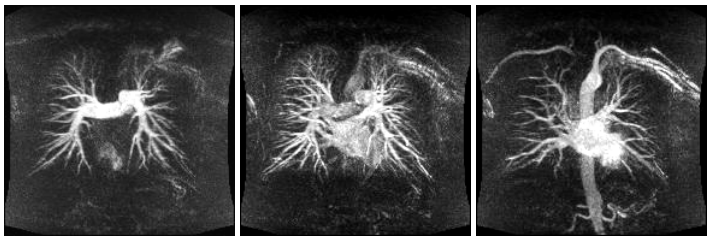

Figure 1: Coronal view of three phases of a contrast enhanced GRAPPA accelerated TWIST MRA showing arterial inflow, parenchymal phase and venous drainage. Images may also be viewed in the sagital and axial plane with isotropic resolution.

Methods: All examinations were performed under institutional review board approval. 5 patients with suspected pulmonary vascular disease were included in this study:2 patients with suspected pulmonary venous abnormalies, 2 patients with complex congenital heart disease, and 1 patient with suspected chronic pulmonary embolism. 4/5 underwent correlative computed tomography (CT) and ventilation perfusion scans ,while 2/5 underwent catheter angiography. Patients were examined at a 1.5 T Magnetom Espree (Siemens, Erlangen, Germany) equipped with either a standard 12-channel body array or a 32 channel body array (Rapid Biomedical, Rimpar, Germany). In addition to the standard examination a GRAPPA accelerated dynamic contrast enhanced TWIST-MRA[1,2] (TR/TE= 2.6 ms/ 1.2 ms; matrix 192x192x48; flip angle 25°; GRAPPA 4x in LR direction, temporal resolution: 1.6s) were acquired. This sequence allowed the acquisition of 13 different phases during one contrast bolus injection at near isotropic resolution (2mm x 2mm x 2 mm). Contrast enhancement was achieved using a single bolus injection of 0.1 mmol/kg body weight gadoversetamide (Optimark, Mallinckrodt Inc., St. Louis, MO). No test bolus injection was used.

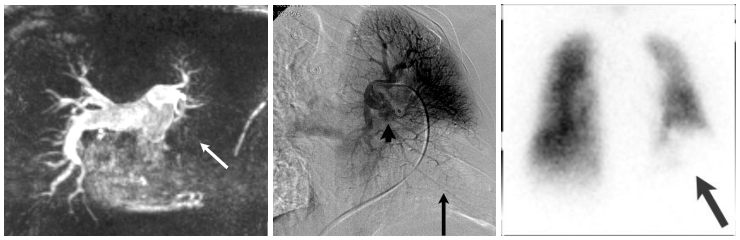

Figure 2: Coronal view of a contrast enhanced GRAPPA accelerated TWIST MRA showing arterial inflow showing decreased perfusion to left lower lobe, consistent with chronic pulmonary embolism, confirmed by conventional angiography and nuclear medicine studies.

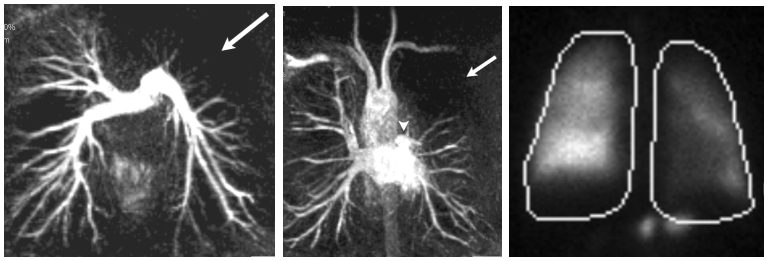

Figure 3: Coronal view of a contrast enhanced GRAPPA accelerated TWIST MRA showing arterial inflow (left) and venous outflow (middle) in a case of pulmonary vein stenosis. Decreased parenchymal perfusion is secondary to left upper lobe pulmonary vein occlusion (small arrow). Nuclear medicine shows globally decreased perfusion to the left lung (right image).

Results: All patients tolerated the examination well. TWIST MRA provided excellent vessel visualization. (Fig.1). 2/4 patients demonstrated pulmonary arterial disease (Fig 2), while pulmonary venous pathology was successfully identified in 2/4 patients (Fig 3). The accelerated TWIST MRA delivered high quality dynamic MRA with excellent vessel differentiation, enabling the definition of arterial from venous pathology. The most significant advantage of the TWIST MRA derived from the dynamic image information. The sequence provided high resolution images allowing the differentiation of multiple arterial, parenchymal and venous phases. In comparison to ventilation perfusion imaging, TWIST enabled comparable information on parenchymal perfusion while providing superior anatomic delineation of the associated vascular pathology

Conclusion: The combination of GRAPPA (parallel imaging) and TWIST (k-space sampling efficiency) is a valuable tool for the evaluation of pulmonary vascular disease due to its isotropic resolution and rapid frame rates. The simplicity of data acquisition makes bolus timing unnecessary and may have a strong impact on patient handling in day to day practice.

Ref: [1]G. Laub, R. Kroeker. *MR Angioclub Basel*; 2006 [2] M. Blaimer, et al *ISMRM*; 2007 (# 749).

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