Non-contrast-enhanced MR angiography of the pulmonary veins using a whole chest 3D steady-state with free-precession technique

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Introduction:

Magnetic resonance angiography (MRA) is a valuable method of evaluating the pulmonary veins in patients with atrial fibrillation prior to and following pulmonary vein ablation. Various MRA techniques have been validated to assess the size and morphology of the pulmonary veins. Current MRA protocols rely on contrast material enhanced (CEMRA) sequences to image the vasculature. In patients with difficult intravenous access, renal insufficiency or who are pregnant, MRA techniques that do not require contrast material are an alternative method to evaluate the pulmonary circulation. The purpose of this study was to assess the feasibility of a non-contrast enhanced MRI approach to pulmonary vein imaging for EP ablation planning and follow-up.

Methods:

Clinical MRA studies were performed in 20 patients on a 1.5T scanner (MAGNETOM Avanto, Siemens, Erlangen, Germany) and were retrospectively reviewed. CEMRA was performed using a dynamic, time-resolved 3D FLASH sequence (TA: 3.6s/3D data set, 1.25mm x 1.8mm x 1.8mm resolution) with TREAT (time-resolved echo shared angiographic technique) and parallel imaging, providing high-resolution images of the pulmonary veins. A non-contrast-enhanced, segmented 3D steady-state with free-precession (TrueFISP) sequence of the entire chest (400mm FOV) with a non-selective RF excitation pulse (1.6mm x 1.6mm x 1.5mm resolution) was also performed in all patients. The non-selective approach is used to reduce TR with a consequent reduction in image artifacts related to off-resonance effects. A motion adaptive navigator echo scheme was used to optimize scan efficiency in cases where drift of the end-expiratory diaphragm position extends scan duration. Qualitative analysis was performed by two reviewers. Images were evaluated for overall image quality (0 = poor; 1 = adequate; 2 = good; 3 = excellent) and diagnostic quality. The number of pulmonary veins and branches was noted in each patient for both techniques. The presence of adjacent anatomy – such as esophagus, bronchial structures, superior vena cava, inferior vena cava and azygous/hemiazygous veins – was noted. In order to quantitatively compare both techniques, orthogonal transaxial measurements of the pulmonary veins were made on a separate computer workstation (syngo MMWP, Siemens Medical Solutions). The correlation coefficient and the mean difference between the diameters measured using CEMRA images and 3D TrueFISP images were determined.

Results:

The average age of the patients was 56.4 years +/- 12.7. All studies were considered diagnostic, for both CEMRA and 3D TrueFISP. The average image acquisition time for the 3D TrueFISP sequence was 10.1 minutes +/- 4.5 minutes and for the dynamic CEMRA 28 seconds. The average image quality for the CEMRA studies was 2.8 +/- 0.6 and for the 3D TrueFISP studies was 2.6 +/- 0.7 (p-value = 0.29). Findings on the 3D TrueFISP images not identified on the CEMRA images included a subcarinal bronchogenic cyst (n=1) and hiatal hernia (n=3). Relevant adjacent anatomy, such as location of esophagus, was only visualized with TrueFISP and not with MRA. The measurements made from the segmented 3D TrueFISP images correlated very closely, r = 0.94, with those made with CEMRA (Figure 1). The mean difference between diameters determined from the 3D TrueFISP images and the CEMRA images was -0.02 cm +/- 0.25 cm (Figure 2).

Conclusions:

The novel 3D TrueFISP sequence used in this study provided good image contrast throughout the heart and thoracic vasculature. 3D TrueFISP MRA of the pulmonary veins was of higher overall quality than CEMRA with measurements that very closely correlated with those determined with CEMRA. Even though the 3D TrueFISP sequence does not include temporal information and has longer acquisition times, this sequence could be a valuable alternative in patients with difficult intravenous access, renal insufficiency or who are pregnant. In addition, the whole-chest 3D TrueFISP technique depicts extra-vascular anatomy over a large FOV, such as the relationship between the left atrium and the esophagus, which is not available with CEMRA techniques.

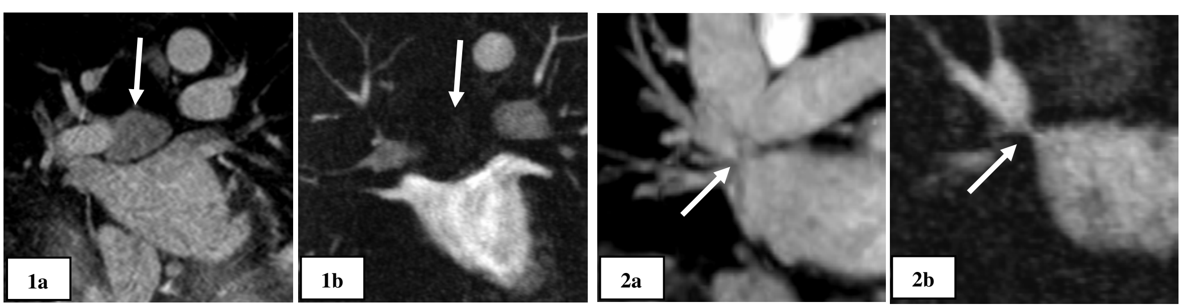

Figure 1. Multiplanar reformatted (MPR) image from 3D TrueFISP data-set demonstrates a subcarinal bronchogenic cyst adjacent to the left atrium (1a, arrow) that is not visualized on the CEMRA MPR (1b, arrow).
Figure 2. Severe stenosis of right superior pulmonary vein visualized on 3D TrueFISP (2a) and CEMRA (2b) MPR images (arrows).

References:

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