Technologic Optimization of Noncontrast Magnetic Resonance Pulmonary Angiography

G. Sirineni[1], A. D. Cann[1], P. Sharma[1], K. Pottala[1], K. Salman[1], J. Oshinski[2], D. Martin[1]

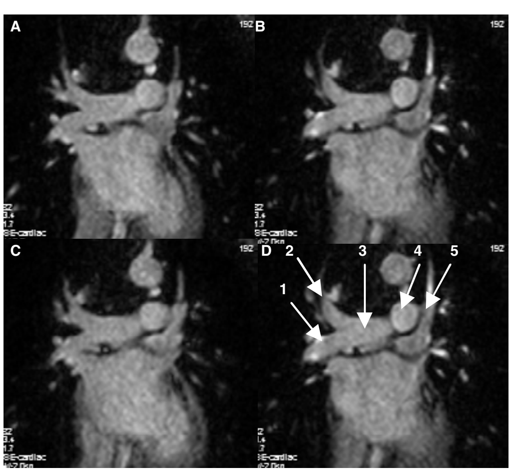
[1]Department of Radiology, Emory University, Atlanta, GA, United States, [2]Department of Biomedical Engineering, Emory University, Atlanta, GA, United States

Introduction: MR pulmonary angiography is currently performed during dynamic gadolinium injection. Because this is a breath-hold technique it is often a difficult sequence to perform in dyspneic patients, such as in patients with pulmonary embolism, , Therefore, there is impetus to develop an alternative technique that provides robust visualization of the pulmonary arteries in either a shorter breath hold duration or with the patient breathing freely. This study investigates the optimization of noncontrast balanced fast field echo (BFFE) imaging, which portrays flowing blood as white, in visualizing the pulmonary arteries in normal volunteers, using both breath-hold and free breathing sequences.

Methods: All studies were performed on a Philips 1.5 T Intera magnet, using a five-element cardiac phased array coil for signal reception. Five healthy volunteers were studied using three methods of respiratory motion control (navigator gating, breathold, or free breathing) in two imaging planes (sagittal or coronal). The effect of pulse oximetry gating and phase direction was also assessed. Coronal imaging was performed using 2 signal averages (NSA) and foldover suppression in the left-right direction, while sagittal imaging was performed using 1 NSA and no foldover suppression. The imaging sequence was a single-shot 3D BFFE with 80 slices acquired in the coronal view (0.35s/slice) and 120 images in the sagittal view (0.40s/slice). Each slice in the sequence was 4 mm thick with 2mm overlap using a TR/TE/flip = 3.4/1.8ms/60 at a 192 x 192 matrix (reconstructed to 256). Field of view (FOV) was 36 cm for coronal images and varied with the sagittal images (generally near 26 cm.). Parallel acquisition (SENSE) was used in all cases (reduction factor = 2). Free-breathing acquisition of all slices was obtained consecutively in real-time (t = 72-90sec). Breathold images were obtained with 15-25 slices/breathold of no greater than 15 sec each, obtained at end expiration. Navigator-gated imaging was implemented by tracking the movement of the liver-lung interface, using a gating window of 3mm over the right hemidiaphragm. As a measure of efficacy of each BFFE technique, the number of visualized pulmonary artery segments was recorded for each lobe for each scan in each patient . Since the use of cardiac gating and respiratory compensation increased the overall scan time, these particular sequence iterations were evaluated against the non-gated, real-time acquisitions for unique improvements in image quality (reduction of pulsation and motion artifacts)

Results: Cardiac gating of coronal images somewhat reduced pulsation artifact in the central pulmonary arteries, but in general this was a minor issue even without such gating. In contrast, cardiac gating found to be essential in sagittal imaging, as otherwise there was great variability in vessel intensity across the cardiac cycle (thought to be due to variable flow perpendicular to the imaging plane).

We consistently found excellent visualization of the main, left and right pulmonary arteries on the coronal nongated images. For example the Figure shows free-breathing (A), breath-hold (B), and navigator gated (C) coronal images , with key (D) illustrating (1) the right lower lobe pulmonary artery, (2) right upper lobe apical segment, (3) right main pulmonary artery, (4) left main pulmonary artery, and (5) left superior pulmonary vein. On average, more segments were visualized on the coronal images (13+/- 0.3) vs. sagittal (11.6 +/- 0.5) out of a possible 18. The anterior segment of the right upper lobe was the least frequently seen, and the two segments of the lingual and the right middle lobe were in generable indistinguishable from each other. Sagittal images frequently showed prominent artifact in the central pulmonary arteries despite use of pulse oximetry gating. Despite marked differences in imaging time between the three methods of respiratory compensation, differences in segmental visibility were slight, with no significant difference observed in the number of segments counted. Readers were qualitatively more comfortable with the breathold and navigator series due to better image registration between slices. The best multiplanar reconstructions were obtained with breathold images, but even these were often poor and highly dependent on reproducibility of end-expiration. Symmetric signal between pulmonary arteries and veins could also be a source of confusion.



Conclusions: Free-breathing images during quiet respiration (typically about 70 seconds of imaging time), despite motion artifact , were found numerically equivalent in segmental visualization to breathold images, although readers preferred the breathold images due to better registration between slices . Coronal images were preferred to sagittal images, especially for the proximal pulmonary artery segments. MRPA using a combination of coronal free breathing and sagittal cardiac gated free breathing appears to be the fastest and most robust method for visualization of the pulmonary arteries without exogenous contrast administration.

References:
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