Initial experience with blood pool agent enhanced free breathing radial 3D gradient echo VIBE sequence in the detection of pulmonary embolism

Constantine Raptis[1], Sanjeev Bhalla[2], Kathryn Fowler[2], Vamsi Narra[2], Rex Parker[2], Priatna Agus[3], and Pamela Woodard[2]

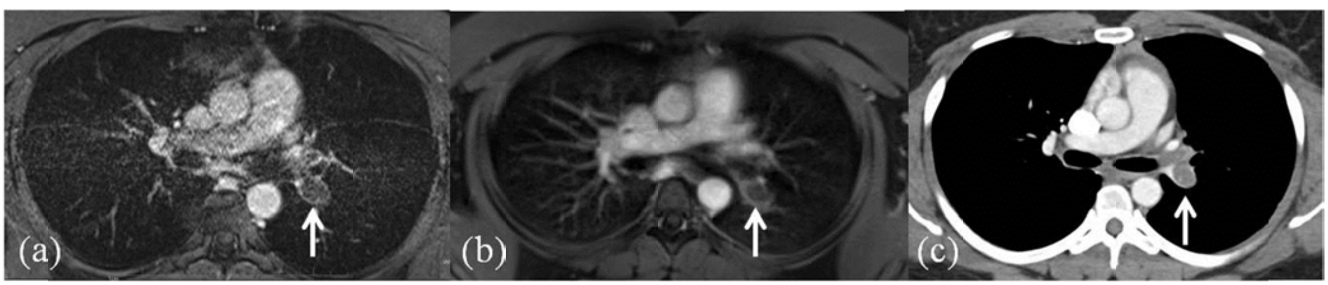
[1]*Diagnostic Radiology - Cardiothoracic Imaging Section, Mallinckrodt Institute of Radiology, St. Louis, MO, United States,* [2]*Mallinckrodt Institute of Radiology,* [3]*Siemens*

Objective: The purpose of this pilot study is to determine the feasibility of utilizing free breathing radial 3D gradient echo VIBE sequences in pulmonary MRA and to report the contrast-to-noise and signal-to-noise ratios achieved when this sequence is employed in the steady state after administration of a blood pool contrast agent.

Background: In a recent multi-center trial (Prospective Investigation in Pulmonary Embolism Dx-III, PIOPED III) that assessed gadolinium-enhanced magnetic resonance angiography (MRA) for diagnosis of acute pulmonary embolism (PE), one specific problem that arose was a high rate of technically inadequate images. (1) One cause of technically inadequate images in the chest is artifact from respiratory motion, a particular problem in patients with suspected pulmonary embolism, many of whom have dyspnea. Free breathing radial 3D gradient echo VIBE sequence post-contrast T1 weighted imaging provides one possible means of reducing technically inadequate images. When utilized in a protocol with a blood pool contrast agent, the radial 3D gradient echo VIBE sequence can be acquired in the steady state after first pass imaging is performed.

Methods: Following IRB approval at our institution, patients with pulmonary embolism detected on CT examinations were selected to undergo blood pool gadolinium based contrast agent (Ablavar, Lantheus, Billerica , MA) enhanced pulmonary MRA examinations which included breath hold 3D GRE sequences, conventional breath hold 3D GRE VIBE sequences, and free breathing radial 3D gradient echo VIBE sequences. The examinations were acquired on a 1.5T MAGNETOM Avanto (Siemens Healthcare USA, Malvern, PA) with Total Imaging Matrix six element body coil and six to nine elements of the spine matrix coil. For the free breathing radial VIBE sequence, a radial readout in the read/phase plane was combined with a conventional 3D encoding step with the following parameters: radial views = 800, number of rotations/interleave = 8, TE = 1.6 ms, TR = 3.62 ms, FOV = 256 mm, phase FOV = 100%, partition thickness = 2.5 mm, slices per slab = 96, slice partial Fourier = 6/8, slice resolution = 50%, flip angle = 10^o, base resolution = 320, bandwidth = 600 Hz/pixel. Quick-Fatsat was used for fat suppression. Examinations were reviewed by a board certified radiologist and contrast-to-noise and signal-to-noise ratios were calculated.

Results: Seven patients underwent the blood pool agent enhanced pulmonary embolism protocol examination utilizing the radial VIBE sequence. Mean signal-to-noise ratio for the free breathing radial VIBE sequences obtained in the steady state was 40.8 with a median of 33.4. Mean contrast-to-noise ratio for free breathing radial VIBE sequences obtained in the steady state was 35.7 with a median of 30.4. The pulmonary emboli seen to the level of the segmental arteries on the CT examinations were identified on the free breathing radial VIBE sequences.



Blood pool contrast agent enhanced VIBE (a), free breathing radial VIBE (b), and CT image (c) demonstrate a pulmonary embolus in the left lower lobe pulmonary artery. Despite being acquired in the steady state 5 minutes after administration of a blood pool agent, the free breathing radial VIBE sequence preserves contrast-to-noise, with the pulmonary embolus readily identifiable.

Discussion: Sequences utilizing a radial acquisition of k-space have many potential advantages in body imaging. When compared with traditional VIBE and spin echo sequences, there is the potential for improved signal-to-noise and contrast-to-noise, motion forgiveness, and elimination of ghosting or aliasing artifacts. These sequences are of considerable interest in thoracic imaging, particularly in dyspneic patients who cannot tolerate the breath hold requirements of traditional angiographic sequences. In this pilot study, the signal-to-noise and contrast-to-noise ratios presented above compare favorably to those derived by Woodard et al. (2) from gadobenate dimeglumine enhanced pulmonary MRA examinations (median SNR 38, median CNR 35) utilizing traditional 3D GRE sequences obtained in the arterial phase. In addition, the free breathing radial VIBE sequence shows the potential for clinical applicability as the pulmonary emboli detected on the patient's previous CT examinations were adequately visualized utilizing the free breathing radial VIBE sequence.

Conclusion: Blood pool agent enhanced free breathing radial VIBE sequences show potential as useful additions to traditional protocols for pulmonary MRA in the detection of pulmonary embolism.

References:

1. Stein PD, Chenevert TL, Fowler SE, et al for the PIOPED III Investigators. Gadolinium Enhanced Magnetic Resonance Angiography for Pulmonary Embolism: Results of PIOPED III. Ann Int Med 2010; 152: 434-43
2. Woodard PK, Chenevert TL, Sostman HD, Jablonski KA, Stein PD, Fowler SE. Signal quality of single dose gadobenate dimeglumine pulmonary MRA examinations exceeds quality of MRA performed with double dose standard gadolinium-based agent. Inr J Cardiovascu Imaging, online, Feb 2011