ISMRM SYLLABUS: PULMONARY MRA FOR PULMONARY EMBOLUS DETECTION

Course: Lung (Weekday educational course)

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Target audience: Radiologists, imaging scientists and MRI technologists

Highlights:

- Magnetic resonance imaging has become a viable imaging modality for clinical use in the detection of pulmonary embolism (PE)
- Low flip angle T1-weighted 3D gradient echo sequences, combined with noncontrast steady state free precession sequences, improve detection rate for PE compared with MR angiography alone
- Newer image acquisition methods that correct for motion artifact allow for the use of MRI for PE detection even in patients that are unable to breath hold.

Objective: To educate the attendee on the current state of pulmonary embolism (PE) detection by MRI. Specifically, the attendee will learn technical aspects related to image acquisition and protocol optimization for PE detection, with practical considerations that may be readily implemented into everyday practice. Clinical aspects of image interpretation will also be covered to improve attendee recognition of PE, in addition to other pulmonary pathologies that may mimic the symptoms of PE.

Purpose: Pulmonary embolism is a significant public health issue in the United States, with an estimated 300,000-600,000 cases annually[1]. Epidemiologic studies and data from autopsies suggest that 10-30% of patients suffer mortality within 30 days, making rapid and accurate diagnosis a key element to treatment of this disease. Unfortunately, the clinical presentation of PE is often nonspecific and variable, leading to under- or misdiagnosis in many cases. Imaging plays a central role in the diagnosis of PE given this variable clinical presentation, and computed tomography (CT) has become the gold standard of diagnosis. However, the side effects of ionizing radiation and the need for administration of iodinated contrast material are factors that must be considered for CT exams, especially given the markedly low incidence of positive studies (5%) in patients between the ages of 18-45[2]. MRI is an alternate imaging methodology that does not employ ionizing radiation or iodinated contrast, with increasing evidence of its utility for PE detection in the peer-reviewed literature and also in routine clinical practice[3].

Methods: Historically, the primary method for detection of pulmonary embolism has been the use of a high flip angle, T1-weighted (T1W) three dimensional (3D) gradient echo (MR angiography) sequence, frequently employing subtraction imaging and maximum intensity projections. However, there are deficiencies to the isolated use of this sequence for PE detection that have limited the sensitivity of MRI when compared with CT. These deficiencies were highlighted in the PIOPED III study published in 2010[4], which reported sensitivities ranging from 45%-100%, depending upon center expertise. High flip angle magnetic resonance angiography (MRA) sequences may suffer from reduced contrast for smaller emboli, which blend in with adjacent hypointense lung parenchyma. In addition, these sequences suffer marked degradation from motion artifact in patients with poor

breath-holding capabilities. These deficiencies have largely been addressed with recent improvements in MR sequence design and hardware advancements.

Results: Several solutions have been developed to address the deficiencies of pulmonary MRA. One solution is the utilization of a lower flip angle T1W 3D GRE sequences for the detection of PE, which allows improved visualization of the enhancing vessel wall and more reliable detection of some emboli that may be poorly visualized with standard MRA[5]. This sequence is complementary to high flip-angle methods, however is not susceptible to bolus timing errors and may be repeated several times with persistent, reproducible high quality opacification of the pulmonary vasculature. Motion artifact is another potential issue that may potentially degrade both MRA and low-flip angle T1W 3DGRE sequences. However, newer undersampled, radial k-space acquisition methods have been developed that have markedly reduced the effects of motion, and may be implemented in patients that are unable to adequately breathhold.

Steady state free precession (SSFP) sequences may also be employed for PE detection. Motion insensitive techniques for SSFP are available for evaluation of the pulmonary vasculature, especially useful when motion sensitive sequences (MRA, low flip angle T1W 3D GRE) are degraded. In addition, SSFP sequences do not require the use of intravenous gadolinium chelate administration, providing a viable diagnostic method for the detection of PE in patients that are unable to receive intravenous contrast for a variety of clinical reasons[6].

Discussion: Given the diagnostic accuracy and safety profile of current techniques, MRI is likely under-utilized in broader clinical practice. This is primarily due to a lack of education with regard to proper image acquisition methods, including techniques that reduce or remove motion artifact. Attendees will learn about new sequences and imaging methods that are important to optimized PE detection with MRI, including radial acquisitions, low flip angle T1W 3D GRE sequences and noncontrast SSFP sequences.

Conclusion: In summary, familiarity with newer MRI methods for pulmonary vascular imaging will allow for increasing use of MRI for the detection of PE, potentially impacting clinical care through a reduction in the use of ionizing radiation and iodinated contrast.

REFERENCES

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FIGURE

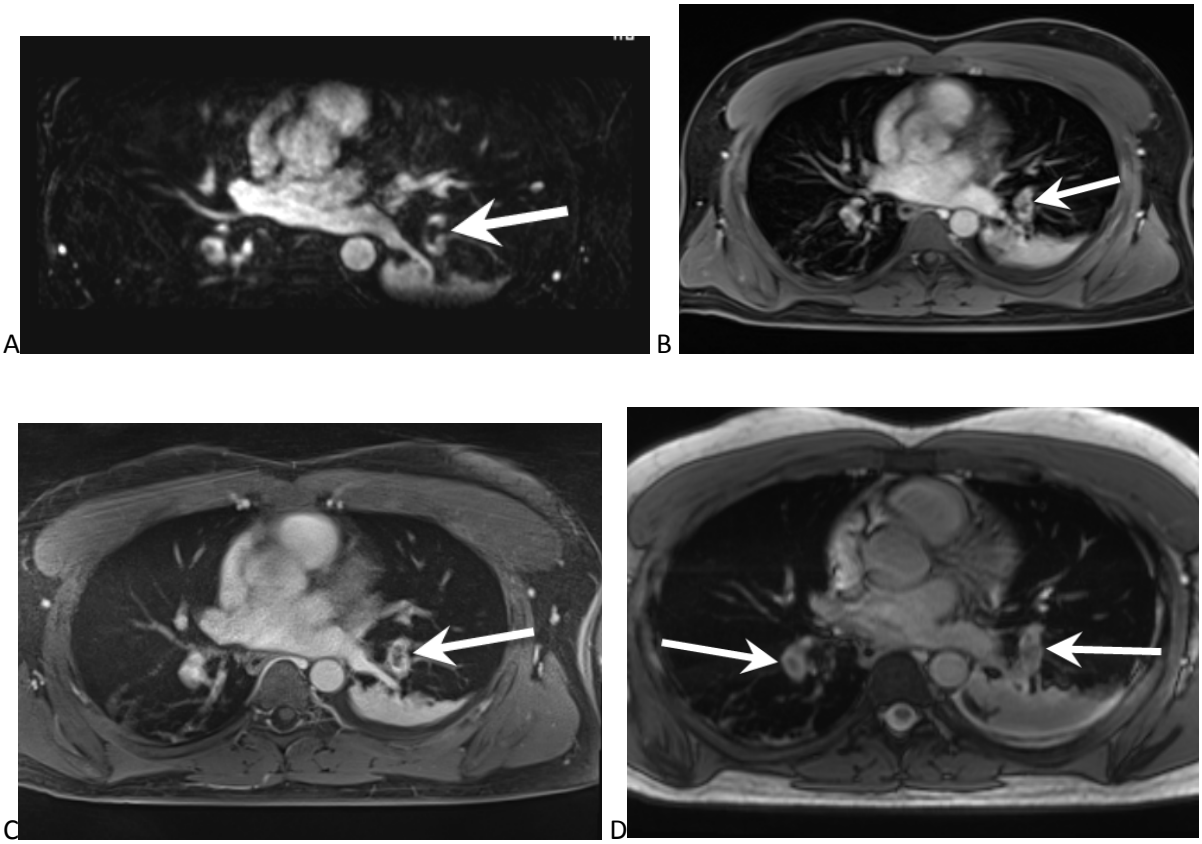

Figure: 37 year old male presenting to the emergency department with shortness of breath. Due to the patient's young age, an MRI was performed and demonstrated bilateral pulmonary emboli (arrows, (a) axial reformatted high flip angle magnetic resonance angiography, low flip angle T1W 3D GRE with (b) breath hold and (c) free breathing radial techniques and (d) free breathing steady state free precession sequence).