Technical evaluation of pulmonary artery MRA in routine clinical practice

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INTRODUCTION: The current reference standard for diagnosis of pulmonary embolism (PE) is Computed Tomographic Angiography (CTA). The recently published PIOPED III study investigated the use of Magnetic Resonance Angiography (MRA) as a feasible alternative to CTA [1]. In that multicenter study, MRA was technically inadequate for 25% of the cases, with arterial opacification and motion artifacts being the primary limiting factors [1,2]. Since the completion of that study, there have been significant advances in MRA imaging technology (bolus extension and whole chest coverage), which have enabled a higher technical success rate for this exam. The purpose of this work was to assess the technical quality of our studies performed with this new acquisition method by using the same ordinal scoring used by the PIOPED III investigators [2]. We sought to determine if the technical quality of these exams has indeed shown an improvement over what the multicenter trial found for MRA-PE exams.

METHODS: In this HIPAA-compliant, IRB-approved retrospective study, 190 of the 312 clinical MRA studies for suspected PE performed between April 2008 and May 2010 were randomly selected and evaluated for technical quality. All studies were performed using a previously described MRA protocol [3], modified to use a single-dose contrast bolus diluted to 30mL and injected at 1.5mL/sec. This ensured that the contrast within the pulmonary arteries was constant throughout the scan and avoided the blurring that is seen if wash-out occurs before acquisition of peripheral k-space data. In some studies, the acquisition was repeated with a 2nd injection if the 1st injection was deemed suboptimal. Studies were assessed by 2 radiologists in random order for arterial opacification (good, fair, or poor in main/lobar, segmental, and subsegmental arteries), the relative amount of parenchymal enhancement (none, some, excellent), and for the presence of artifacts (none, mild, moderate, or severe) of different types (aliasing, parallel imaging, motion, and Gibbs ringing in the arteries). The arterial opacification scores were combined into a composite score (0=excellent→6=poor) using the PIOPED III methodology [2]. The degree of parenchymal enhancement was recorded based on our experience that the presence of perfusion defects has been helpful in the identification of small subsegmental pulmonary emboli (Fig. 1). The best overall MRA acquisition for visualizing the arteries was used for scoring the arterial opacification. Initially, there were 30 cases that were assessed by consensus for training purposes before the radiologists independently scored the remaining 160 cases. The Wilcoxon rank sum test was used to compare the composite arterial opacification scores from each reader and PIOPED III, with p<0.05 considering significant.
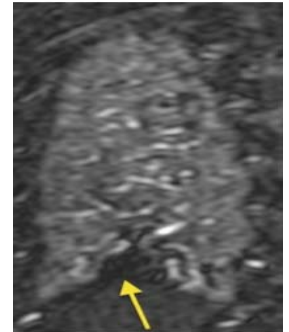

Fig 1. Perfusion defect due to subsegmental embolism.

RESULTS: Arterial phase timing was dextro-phase in 114/190 (60%), mid-phase in 53/190 (28%), levo-phase in 16/190 (8%), and other in 6/190 (3%). The "during" phase (initial bolus acquisition) provided the best arterial opacification for 154/190 (81%) for Reader 1 and 144/190 (76%) for Reader 2. In 12/190 (6%) a 2nd injection was administered – 10/12 (83%) of these provided improved visualization of the pulmonary arteries. At least some parenchymal enhancement was seen in 126/190 (66%) and excellent parenchymal enhancement was seen in 61/190 (32%) of the studies. Figure 2 shows the arterial opacification scores for the two readers, with the results of PIOPED III included for comparison. There was no statistical difference between the scores of the 2 readers (p=0.874). The scores were, however, significantly better than the PIOPED III scores (p<0.001). Figure 3 shows the artifact scores.

DISCUSSION: In contrast to the 26% of the PIOPED exams that were scored as 0 (best vascular opacification), we found that fully 60% of the exams in this study were scored in that category. This study demonstrates improved diagnostic quality using modern MRA techniques compared to PIOPED III, using the same evaluation methods. A limitation of this study is that direct comparison of images from PIOPED III with images obtained using this newer protocol could not be made. The principal differences between our scans and those evaluated by PIOPED III were: 1) the routine use of 2D parallel imaging (higher resolution and larger coverage), 2) diluted contrast bolus lasting through the duration of the arterial-phase scan, and 3) the use of multiple acquisitions, rather than relying on just a single arterial phase.

CONCLUSION: In this retrospective review of clinical pulmonary MRA studies performed on acutely ill patients, we demonstrated a very high technical success rate, with improved arterial opacification when compared with the reported results from PIOPED III.

REFERENCES:
[1] PD Stein et al, Ann Int Med 2010,
[2] HD Sostman et al, Int J Cardiovasc Imaging 2011,
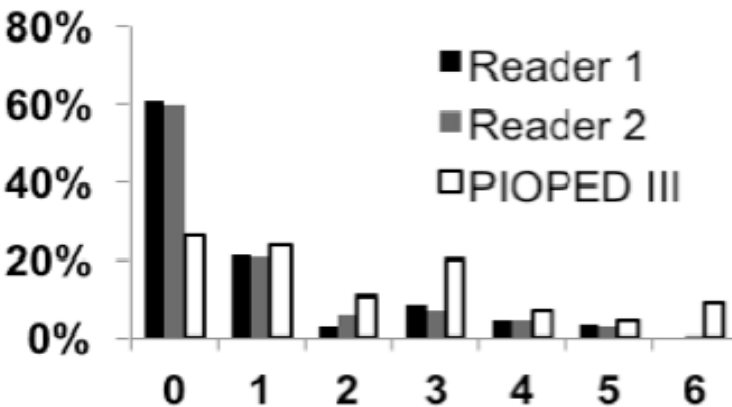[3] ML Schiebler et al, ISMRM pg 3928 2009.

Fig. 2. Arterial enhancement scores. Using modern MRA methods, considerably improved arterial enhancement scores are seen, compared to the PIOPED III study (p<0.001).
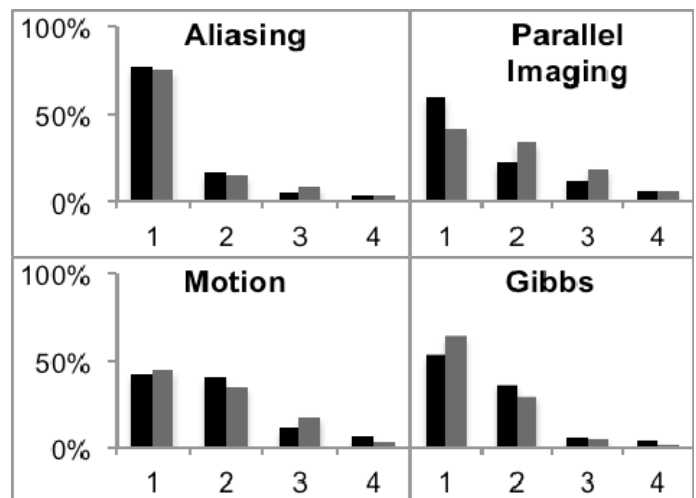

Fig. 3. Artifact Scores.
1=none, 2=mild, 3=moderate, 4=severe