Utility of Cardiac Gating for Pulmonary Perfusion MRI

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INTRODUCTION Cardiac motion is a common source of artifacts when imaging the chest with methods such as pulmonary perfusion MRI and pulmonary MR angiography (MRA). To minimize these artifacts, the MR sequence is often ECG-gated such that data are only acquired during a portion of the cardiac cycle when the heart is relatively quiescent; typically during diastole. However, this reduces scan efficiency and requires more complicated patient preparation, including placement of ECG leads. Furthermore, the trade-off between image quality and scan efficiency is application dependent, with some imaging methods more sensitive to cardiac motion than others. **The purpose of this study was to determine whether or not cardiac gating improves image quality for pulmonary perfusion MRI** using a recently developed method that results in high isotropic spatial resolution, high temporal resolution, and whole chest coverage [1]. If no significant improvement in image quality is seen with cardiac gating, then non-gated scans can be performed to increase scan efficiency and simplify patient preparation.

MATERIALS AND METHODS To date, 9 normal volunteers have been recruited for this on-going IRB-approved, HIPAA-compliant prospective study. Each subject was scanned on a 3T clinical scanner (GE Healthcare, Waukesha, WI), using a 32-channel phased array coil and a recently described pulmonary perfusion method incorporating parallel imaging and interleaved variable density sampling [1]. In order to compare a variety of different schemes for minimizing cardiac motion artifact during a single exam, a total 1.5× dose of the blood-pool contrast agent gadofosveset (Lantheus Medical Imaging, N. Billerica, MA) was used. Dynamic imaging was performed during each of 3 injections of 0.5× dose of contrast, followed by acquisitions during the steady-state. The following four gating methods were investigated: (1) non-gated; (2) ECG-gated; (3) peripherally-gated; (4) pseudogated. Pseudogating was achieved by setting up the acquisition so that the temporal resolution of scan was equal to 1/(heart rate). In addition, standard elliptical centric (EC) *k*-space order was compared with an "edge-center-edge" (ECE) order as prior work suggested that ECE order may be advantageous for minimizing cardiac motion [2-4]. Both dynamic and steady state images were reconstructed using view sharing. The images from each subject were randomized before being independently ranked in order of image quality by 3 cardiovascular radiologists. Image ranking rather than absolute scoring was performed in order to force the readers to differentiate the images, which were all very similar in image quality.

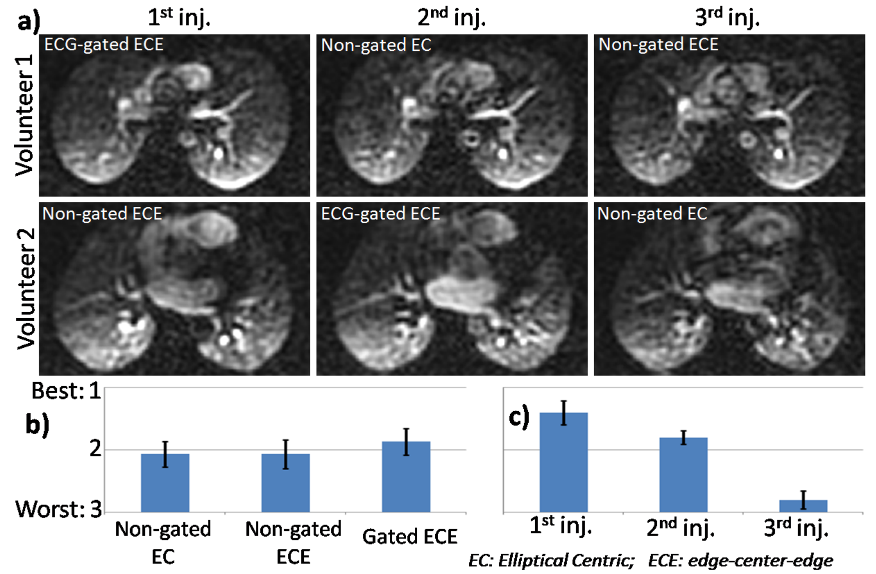

Figure 1. (a): Typical images from the comparison of the dynamic images for two different volunteers. There were no consistent and significantly differences between the acquisition schemes. (b): Radiologists ranking show similar image quality between different acquisition schemes. (c): The differences seen in the overall image quality are more correlated with the order of the injection, i.e. first injection tends to produce the best image quality. Bars depict mean ± 1 SEM; n=5.

RESULTS AND DISCUSSION All three readers reported great difficulty in identifying differences in image quality, especially within the lungs. All readers reported relying principally on the fidelity of reconstruction of the blood-myocardium interface and the aortic root in order to differentiate the images. For example, Fig. 1a presents axial images from two representative volunteers using the 3 different dynamic acquisition schemes. Note the very similar image quality between gated and non-gated methods. No significant differences in rank order were found between the dynamic methods, which included non-gated "edge-center-edge", non-gated elliptical centric and ECG-gated "edge-center-edge" techniques. A Friedman rank sum test for comparison of rank scores between methods for each reader resulted in p-values of 0.82, 0.82 and 1.00. Average ranking over all readers is shown in Fig. 1b. In fact, the difference in image quality of the dynamic scans seemed more strongly correlated with the order of the injection, rather than the image method used (Fig. 1c). Fig. 2 presents steady-state axial images of a representative volunteer. The ECG-gated ECE images were favored by all readers (p-values 0.002, 0.045 and 0.0008) in forced-ranking of image quality. However, these differences were extremely subtle and occurred mostly within the heart and aortic root. **It was not possible for the readers to differentiate the images on the basis of image quality within the lungs**.

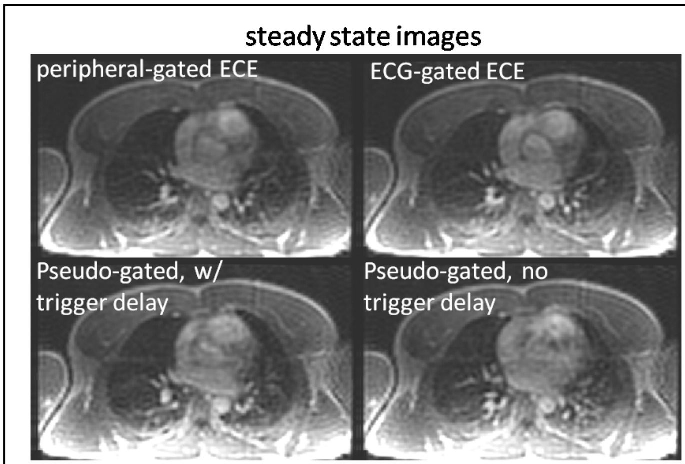

Figure 2. (a): Typical images from the comparison of the steady-state scans. (b): Differences in overall image quality were principally determined by intracardiac features. The image quality in the lungs was very similar among all acquisition methods. Bars depict mean ±1 SEM; n=9.

CONCLUSION **These on-going results suggest that cardiac gating may not significantly improve image quality within the lungs in pulmonary perfusion MRI using interleaved variable density sampling and parallel imaging**.

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