Application for QIBA Project Funding

Title of Proposal: Phantoms for CT Volumetry of Hepatic and Nodal Metastasis-Yr2		
QIBA Committee/Subgroup: Volumetric CT		
NIBIB Task Number(s) which this project addresses:		
Project Coordinator or Lead Investigator Information:		
Last Name: Zhao	First Name: Binsheng	Degree(s): DSc
e-mail:	Tel #:	
Institution/Company: Columbia University Medical Center (CUMC)		
Amount Requested:		

Project Description

In Yr. 1 of this project, we purchased a commercial phantom containing two fixed liver inserts (each) with 19 hyper- and hypo-dense low-contrast lesions embedded within a uniform background to simulate both arterial phase and portal-venous phase scans. This phantom is simplistic in that the background is uniform. Using Yr. 1 funding of the project, the phantoms will be scanned across a wide range of image acquisition and reconstruction settings such that the impact of different CT vendors' scanners and various acquisition parameters (e.g., dose, slice thickness and reconstruction algorithm) can be characterized. The scanned lesions will be evaluated using two automated and semi-automated tools: one from CU (a non-commercial software) and one from FDA.

In Yr. 2, we propose to extend this work in two ways. First, we propose developing more realistic anatomy within the liver; our current liver insert will be improved by inclusion of liver vasculature and simulated fatty infiltration to probe the impact of this common comorbidity on estimation error. In more detail, the Yr. 1 phantom will come with a removable liver shaped replacement container which allows for customization of the liver region. Using this empty liver insert, we will explore more realistic gelatin-based liver modeling. We will investigate placing synthetic vessel structures from a vasculature insert from a previously purchased anthropomorphic chest phantom into the container to simulate liver vascularity. This insert is an epoxy composite with CT values consistent with vessels in the mm to sub-mm diameter range. This will not correctly model true liver vascularity, especially in terms of having the correct geometrical distribution, but the insert will provide a more complex background around liver lesions. These synthetic vessels are limited in that they are solid so they will not allow for the imaging of contrast within the synthetic vessels. If this is deemed a substantial limitation, we are planning to investigate the potential use of thin plastic/rubber tubing to better mimic the vessel structures in liver by allowing for the inclusion of vessel contrast as part of the phantom. This modification will limit the vascularity to larger vessels on the mm size range and to a much simpler structures compared with the chest phantom vascular tree. In previous work, the FDA group explored the usage of gelatin to mimic the soft tissue background of the liver. The CT attenuation of the gelatin material can span a reasonable range of tissue allowing for the simulation liver soft tissue. We plan to utilize this approach to simulate a non-contrast liver background and include a gelatin/contrast material mixture to simulate a contrast background. For fatty infiltration, we plan to try several liquid and semi-solid fats (e.g., olive oil, butter, etc.) to determine which material best represents

fatty infiltration of the liver. The concentration of fat and its distribution will be controlled to be consistent with both CT attenuation and the general infiltration properties in clinical scans. The interaction between the gelatin and these fatty materials will be explored in this project with the goal that the visual appearance of the complex liver background is consistent with what is found in clinical scans. As mentioned above, we do not expect this more complex liver phantom to directly mimic a true liver scan. We only expect it will incorporate some of the additional complexity found in clinical scans so that we are able to future investigate how these specific characteristics start to impact the lesion size estimation task. The complex liver phantom will be made at FDA and shipped to CU for scanning. An imaging plan will be designed based on Yr. 1 results for this low-contrast lesion volume estimation task which will include data from multiple scanners (multiple models and manufacturers). Only the most important acquisition parameters identified in Yr.1 will be varied to understand how they influence volume estimation error. In Yr. 1 we will acquire a huge amount of liver image data at a wide range of imaging acquisition and reconstruction settings. In Yr. 2, only a subset of these acquisition settings (e.g., 200 mAs or auto mAs, smoother reconstruction kernel, ~2.5 mm slice thickness - the default acquisition setting clinically used for abdominal scans) will be used to study complex background/liver parenchyma (and iterative reconstruction algorithms as well). The second extension of this work will be to specifically explore the impact of iterative reconstruction methods for the task of estimating lesion volume. Iterative reconstructions are an important upgrade to CT but one that will likely impact CT volumetry. We propose to explicitly explore how volume estimation error is impacted by iterative reconstruction methods across vendor platforms and, in comparison with FBP. This work will inform the CT volumetry Profile development by allowing for an extension to measurements of low-contrast soft-tissue lesions and for iterative reconstruction methods. Again, only the Columbia University (non-commercial software) and FDA volume estimation tools will be evaluated. A data analysis plan will be established *a priori* by Nicholas Petrick and Nancy Obuchowski collaboratively. Columbia will help prepare their measurement data in the format that is required for the statistical analysis. The data will then be sent to Dr. Petrick and analyzed by his group at FDA. As scans are acquired, we will transfer (in batches) all of the acquired image data to QIDW, the RSNA/QIBA designated warehouse.