Evaluating the impact of a superimposed atlas-based bone compartment for attenuation correction in simultaneous PET-MR

Icahn School of Medicine at Mount Sinai

Translational and Molecular Imaging Institute

George Soultanidis[1], Nicolas Karakatsanis[1,2], Philip M. Robson[1], Zahi A. Fayad[1]

1. Translational and Molecular Imaging Institute, Cardiovascular imaging, Icahn School of Medicine at Mount Sinai

2. Division of Radiopharmaceutical Sciences, Department of Radiology Weill Cornell Medicine.

INTRODUCTION

Within the past decade, we have experienced the introduction of PET-MR as a clinical research tool [1,2]. In PET image reconstruction, attenuation correction (AC) for the photon-attenuating affect is vital for accurate quantification. Unlike in PET/CT where CT provides direct information about photon attenuation, AC in PET-MR is based on tissue segmentation. Typically, this includes segmentation of water-based tissue, fat, lung and background air. Bone is an important tissue-class that is currently omitted [3]. Recently, a model-based approach has been proposed that adds bones to an acquired soft-tissue map based on identifying anatomic landmarks. In this study, we evaluate the impact this approach in the heart, brain, aorta and in a patient with pulmonary sarcoidosis.

METHODS

Using the Siemens Biograph mMR we acquired 18F-FDG acquisitions in the chest and head for 5 patients (three cardiac, one for brain and one for plumonary sarcoidosis imaging). For the comparison, we generated attenuation maps with and without the bone structure. We then reconstructed the PET data using Siemens e-7 tools. OSEM reconstruction with PSF modeling was used (3 iterations, 21 subsets, 4 mm Gaussian filter). The variation is measured with the fractional difference between resulting PET images was found by taking (PETbone - PETnobone) / PETbone. ROIs were then drawn on the fractional difference image within the organ of interest and the mean difference, SD of differences, and maximum difference were recorded. For the myocardium, the ROI included the whole of the left ventricle. We segmended a brain slice into two ROI of 15 cm^3 each to cover the inner and outer area near the cranial bone. The aortic arch ROI was 20 cm^3 sample and the descenting aorta ROI was 35 cm^3.

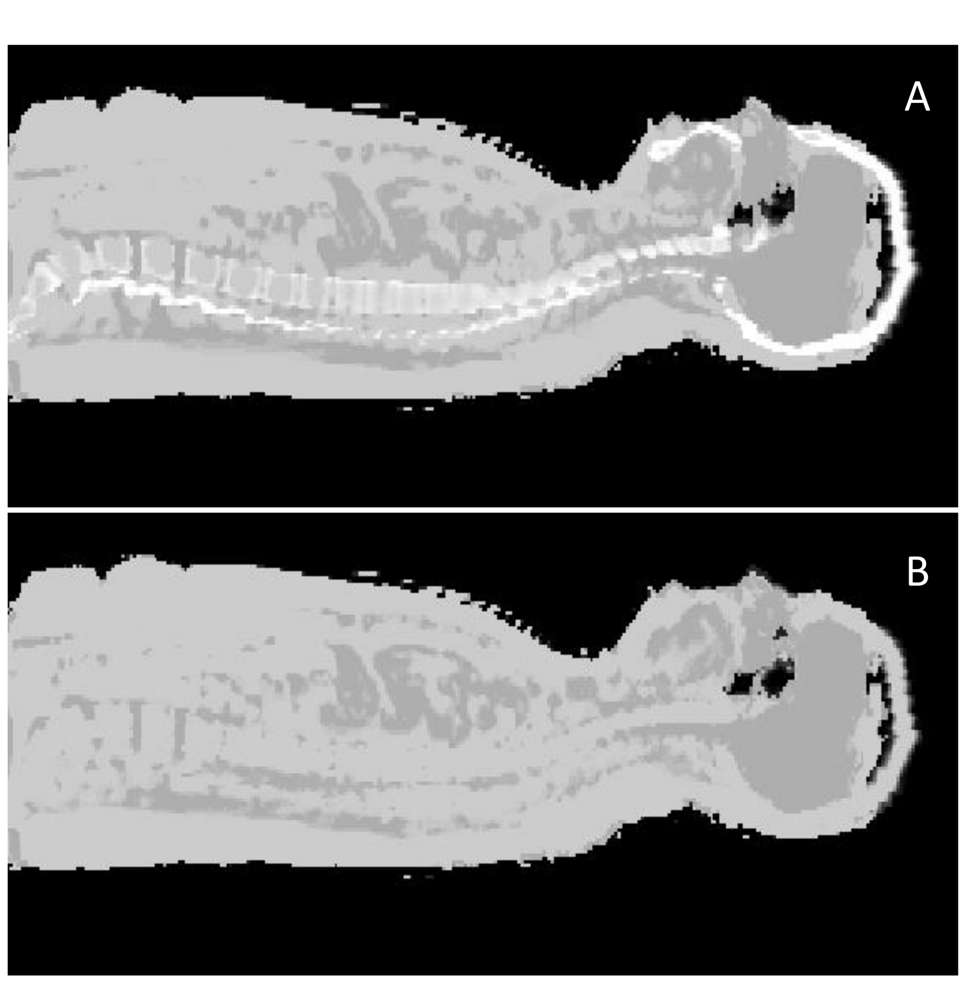

Figure 1. A comparison of attenuation maps as with bone information (A) and without (B)

RESULTS

a) Brain Imaging

The findings indicate a small variation of uptake in the center of the brain with increased differentiation near the edges, as it was expected from the literature [4].

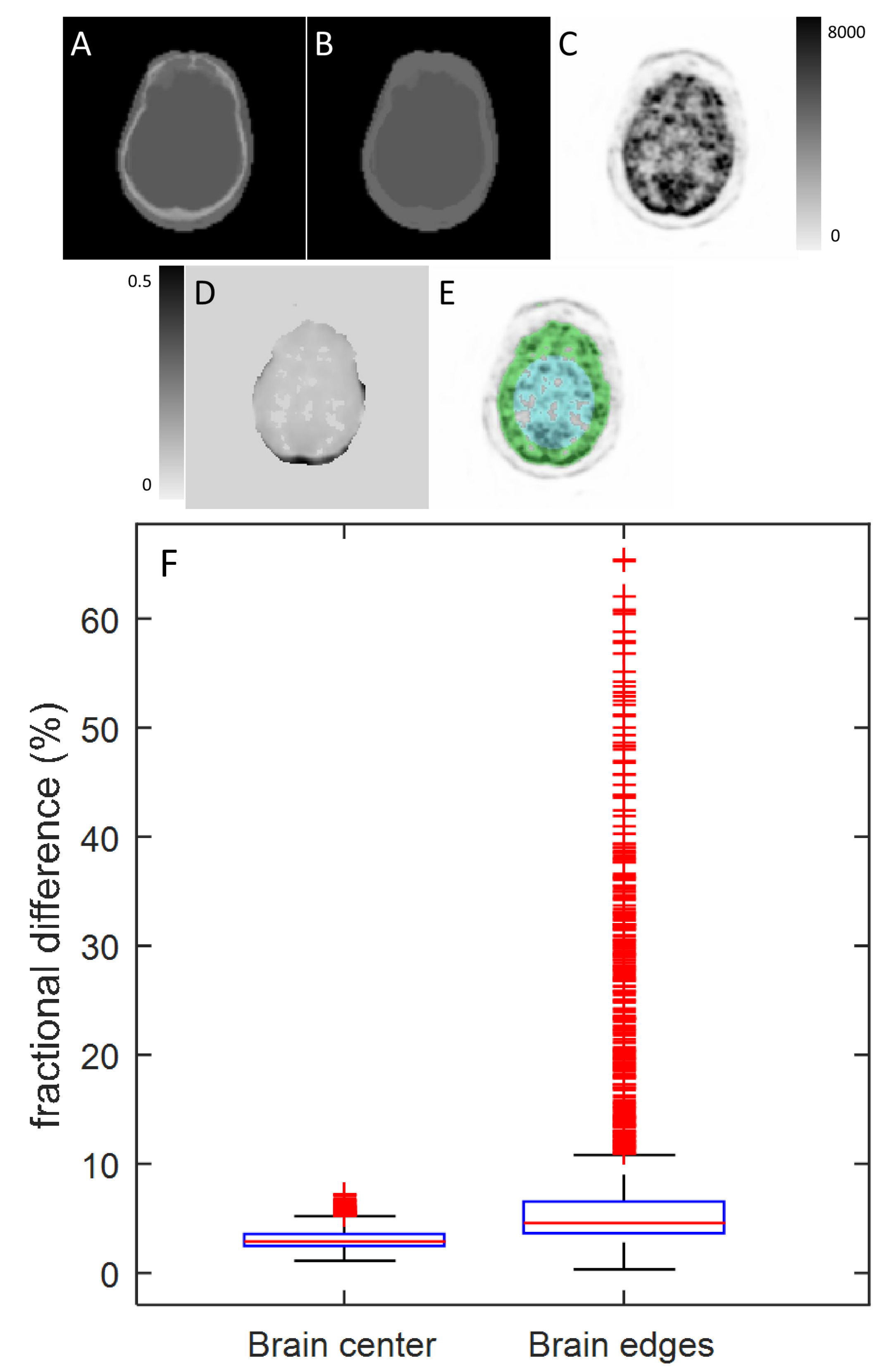

Figure 2. While in A and B we observe a comparison of the attenuation maps with and without bone structure, D represents the fractional difference of the PET with C being the corresponding image. E indicates the two ROI taken for the analysis, with the blue being the brain center and green the brain edges. The corresponding fractional difference is given in F.

b) Pulmonary sarcoidosis

The fractional difference is lower than 1 % in this case of ROI analysis

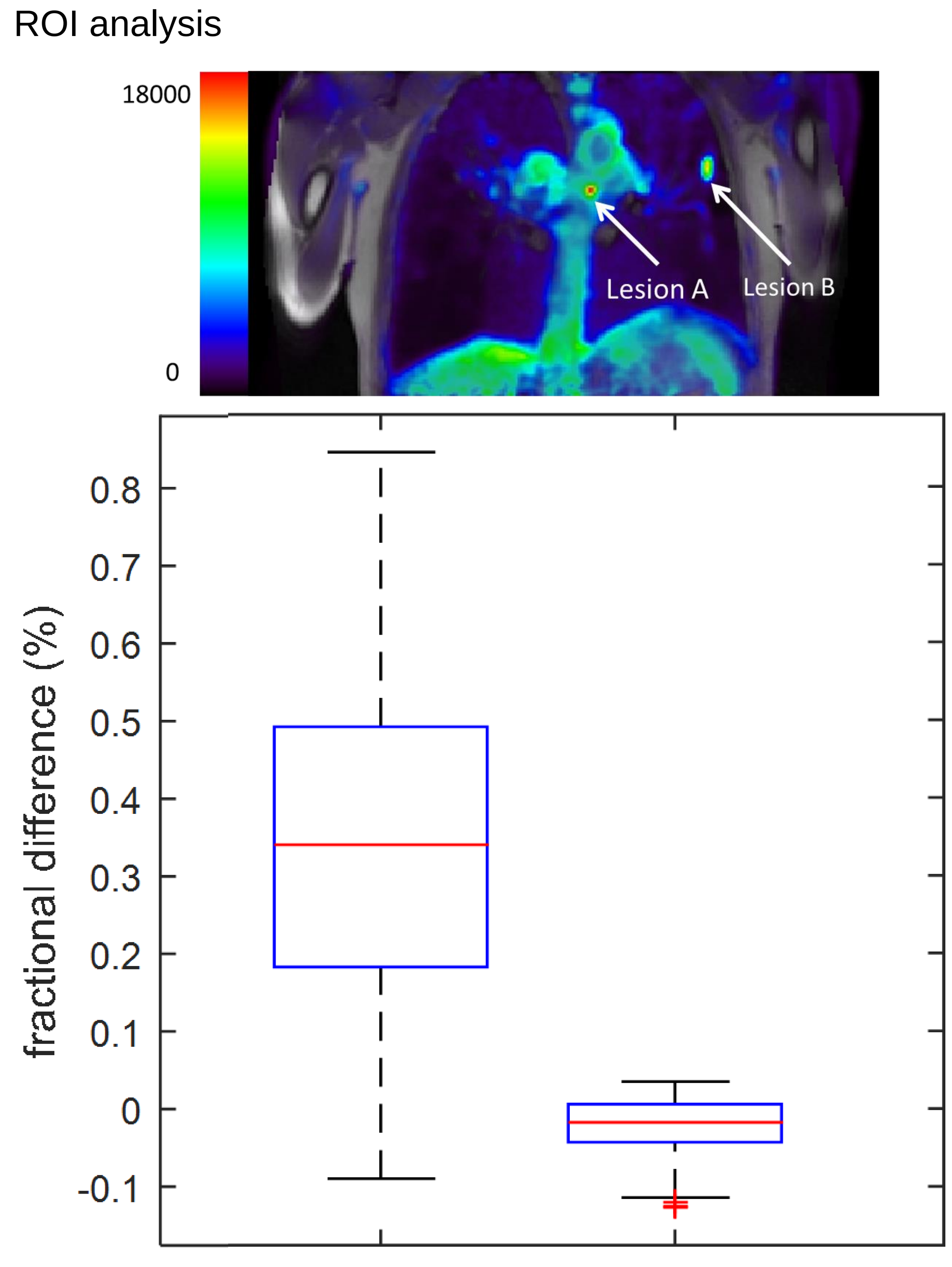

Figure 3. A sarcoidosis study where the fractional difference does not have significant difference with the addition of bone attenuation map.

RESULTS

c) Cardiac Imaging

The findings indicate a small variation of uptake in the left ventricle and the aortic arch. Nevertheless, fluctuations of uptake are observed as close as the descending aorta lies next to the spine.

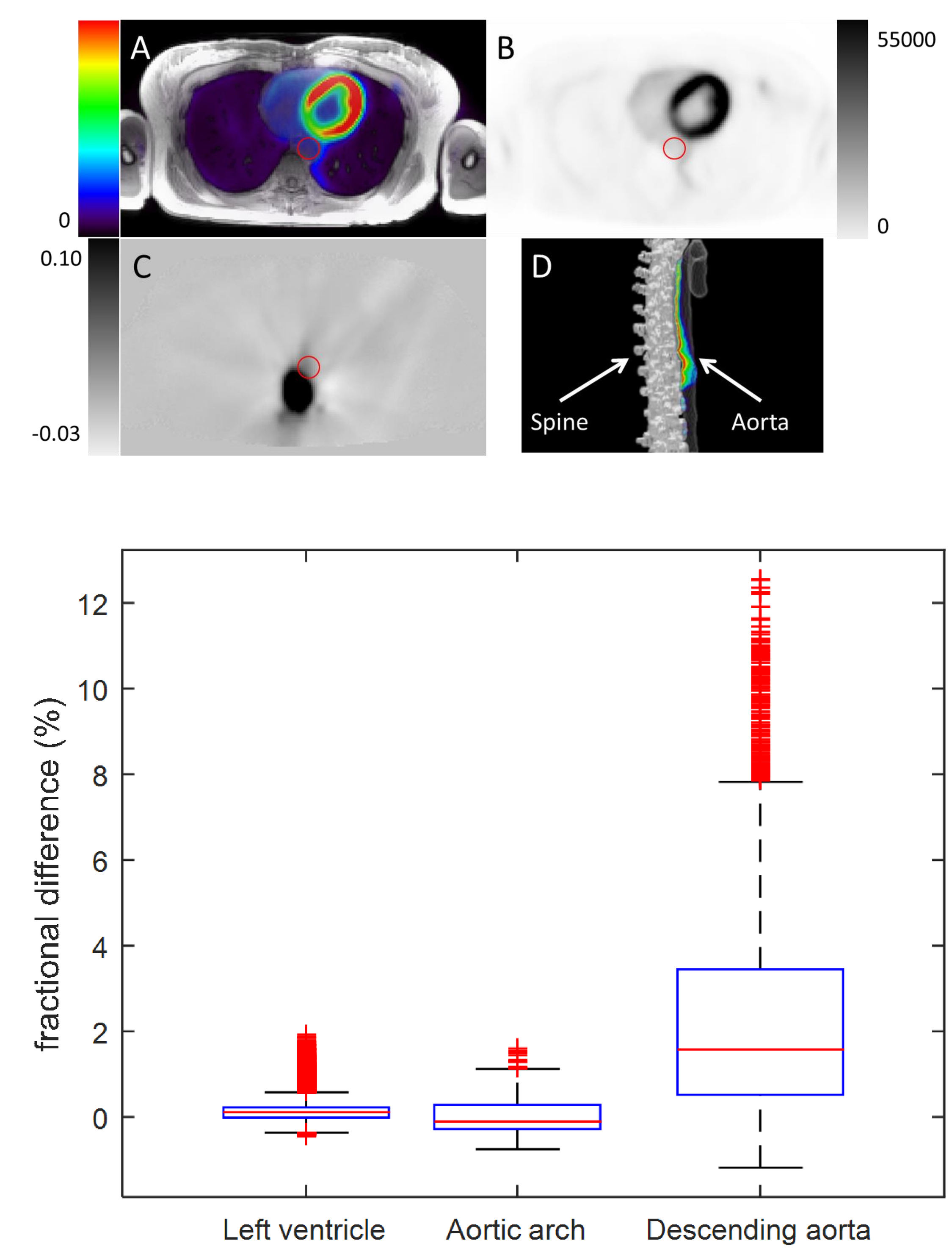

Figure 4.In a Cardiac PET-MR (A) the affected area is the one closes to the spine. For that reason, we draw ROI on the PET image (B) and the fractional difference (C) to measure the effect of attenuation. Figure D is a 3D representation of the aorta and the are mostly affected.

CONCLUSIONS

1. Results indicate that the inclusion of bone compartment has higher impact within the brain.
2. The minimum impact is observed in the pulmonary sarcoidosis case.
3. Cardiac imaging might be affected, depending the region of interest,. Structures close to the spine, like the descending aorta, are affected the most.
4. Further investigation is necessary to determine the effect of additional thoracic bone structure to the attenuation of cardiac and cancer imaging.

ACKNOWLEDGMENTS

This work was supported by National Institutes of Health grant NIH/NHLBI R01HL071021 (Dr. Fayad)

REFERENCES

1.Robson P., Dweck M., et al. Coronary Artery PET/MR Imaging: Feasibility, Limitations, and Solutions. *JACC: Cardiovascular Imaging, 2017, Volume 10, Issue 10, Part A*

2.Onofrio A. Catalano, MD Bruce R. et al. Clinical Impact of PET/MR Imaging in Patients with Cancer Undergoing Same-Day PET/CT: Initial Experience in 134 Patients—A Hypothesis-generating Exploratory Study. *Radiology 2013, Volume 269, Issue 3*

3.Koesters T, Friedman KP, Fenchel M, et al. Dixon sequence with superimposed model-based bone compartment provides highly accurate PET/MR attenuation correction of the brain. *Journal of nuclear medicine . 2016;57(6):918-924.*

4.Keereman V1, Fierens Y, et al. MRI-based attenuation correction for PET/MRI using ultrashort echo time sequences., *J Nucl Med. 2010 May;51(5):812-8.*