Keywords: SPECT, MRI, CT, Attenuation Correction, Quantitative imaging.

Title: Joint compensation of motion and partial volume effects in oncologic PET/CT imaging

Authors: Sahar Rezaei, Pardis Ghafarian, Mehrdad Bakhshayesh-Karam, Arman Rahmim, Saeed Sarkar and Mohammad Reza Ay

Department of Medical Physics and Biomedical Engineering; Tehran University of Medical Sciences, Iran

Research Center for Molecular and Cellular Imaging, Tehran University of Medical Sciences, Iran

Chronic Respiratory Diseases Research Center, National Research Institute of Tuberculosis and Lung Diseases (NRITLD), Shahid Beheshti University of Medical Sciences, Tehran, Iran

PET/CT and Cyclotron Center, Masih Daneshvari Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran,

Departments of Radiology and Physics, University of British Columbia, Vancouver, Canada

Department of Integrative Oncology, BC Cancer Research Center, Vancouver, Canada

Background: The use of maximum standardized uptake value (SUV_{max}) is commonplace in oncology positron emission tomography (PET). Respiratory motion and partial volume effects (PVEs) are two of the most important causes of image degradation in lung cancer imaging, significantly hampering PET quantification. Furthermore, reconstruction algorithms have a significant impact on SUV_{max}, presenting a challenge for centers with varied protocols for lesion classification based on SUV_{max}.

Objective: The present study aims to assess the application of image-based deconvolution method to jointly compensate respiratory motion and PVEs for quantitative non-small cell lung lesions (NSCLC), in conjunction with four different iterative reconstruction algorithms.

Methods: An image-based deconvolution method that incorporated wavelet-based denoising within the Lucy-Richardson algorithm was proposed. The method was evaluated using phantom studies with signal-to-background ratios (SBR) of 4 and 8, and clinical data of 10 patients with 62 lung lesions. In each study, PET images were reconstructed using four different methods: OSEM with time-of-flight (TOF) information, OSEM with point spread function modeling (PSF), OSEM with both TOF and PSF (TOFPSF), and OSEM without PSF or TOF (OSEM). Coefficient of variation (COV) and maximum standardized uptake values (SUV_{max}) were measured within the tumors, and compared to images that were not processed using the joint-compensation technique.

Results: In phantom images, for all reconstruction methods, SUV_{max} were higher in the images processed using the proposed compensation technique, particularly in small spheres. Overall, the incorporation of wavelet-based denoising within the Lucy Richardson algorithm gave the best compromise between intensity recovery, noise attenuation and qualitative aspect of the images in all cases. In patient data, the median values of the relative difference (%) of SUV_{max} for the compensated images in comparison to uncompensated images were 43.0%, 42.5%, 44.8% and 42.6% for OSEM, PSF, TOF, and TOFPSF, respectively, in small lesions (equivalent diameter

<10 mm), and 35.8%, 33.5%, 37.2% and 35.1% in average-sized lesions (equivalent diameter <30 mm).

Conclusion: The proposed joint comparison method can improve the accuracy of PET quantification by simultaneously compensating for respiratory motion and PVEs in lung PET/CT imaging. Both PSF and TOF algorithms resulted in notable variations of SUV_{max} in non-small cell lung lesions. In compensated images, TOF algorithms provided higher SUV_{max} in low-uptake and small lesions relative to non-TOF algorithms, especially in lower lung lobes. For average-sized lesions, all reconstruction algorithms performed approximately equally. Thus, one should be aware that quantitative analyses of lesions with varying sizes and locations, e.g., in radiotherapy or follow-up studies, maybe mainly affected by either PSF or TOF algorithms, when applying any compensation methods.

Keywords: ^{18}F-FDG PET/CT, reconstruction algorithm; PSF; TOF, combined compensation; respiratory motion; partial volume effect, quantification, lung cancer