Should scatter be corrected in both transmission and emission data for accurate quantitation in cardiac SPET?

Georges El Fakhri[1, 2], Irène Buvat[2], Pedro Almeida[3], Bernard Bendriem[4], Andrew Todd-Pokropek[2], Habib Benali[2]

[1]Department of Radiology, Brigham and Women's Hospital and Harvard Medical School Boston, Massachusetts, USA
[2]U494 INSERM, CHU Pitié-Salpêtrière, Paris, France
[3]Serviço de Medicina Nuclear, Hospital Garcia de Orta, Almada, Portugal
[4]CTI, Inc., Knoxville, Tenn., USA

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Abstract. Ideally, reliable quantitation in single-photon emission tomography (SPET) requires both emission and transmission data to be scatter free. Although scatter in emission data has been extensively studied, it is not well known how scatter in transmission data affects relative and absolute quantitation in reconstructed images. We studied SPET quantitative accuracy for different amounts of scatter in emission and transmission data using a Utah phantom and a cardiac Data Spectrum phantom including different attenuating media. Acquisitions over 180° were considered and three projection sets were derived: 20% images and Jaszczak and triple-energy-window scatter-corrected projections. Transmission data were acquired using gadolinium-153 line sources in a 90–110 keV window using a narrow or wide scanning window. The transmission scans were performed either simultaneously with the emission acquisition or 24 h later. Transmission maps were reconstructed using filtered backprojection and μ values were linearly scaled from 100 to 140 keV. Attenuation-corrected images were reconstructed using a conjugate gradient minimal residual algorithm. The μ value underestimation varied between 4% with a narrow transmission window in soft tissue and 22% with a wide window in a material simulating bone. Scatter in the emission and transmission data had little effect on the uniformity of activity distribution in the left ventricle wall and in a uniformly hot compartment of the Utah phantom. Correcting the transmission data for scatter had no impact on contrast between a hot and a cold region or on signal-to-noise ratio (SNR) in regions with uniform activity distribution, while correcting the emission data for scatter improved contrast and reduced SNR. For absolute quantitation, the most accurate results (bias <4% in both phantoms) were obtained when reducing scatter in both emission and transmission data. In conclusion, trying to obtain the same amount of scatter in emission and transmission data, in addition to being impractical because of the difficulty in knowing the precise scatter components, did not yield such accurate absolute activity quantitation as when emission and transmission scatter were reduced.

Key words: Scatter – Transmission computed tomography – Absolute and relative quantitation

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Correspondence to: G. El Fakhri, Department of Radiology, Brigham and Women's Hospital, Boston, MA 02115, USA

Introduction

Accurate attenuation compensation in single-photon emission tomography (SPET) requires measurement of the patient-specific attenuation properties. Such measurements can be performed using a transmission computed tomography (TCT) acquisition involving an external source of gamma rays (e.g., [1]). Scatter affects both SPET and TCT measurements. When performing a simultaneous SPET-TCT study in which the emission energy is greater than that of the transmission source (as is usually the case with technetium-99m SPET studies), scatter photons included in the transmission data have two components: downscatter due to photons emitted by the radioactive distribution inside the patient, and scatter due to photons emitted by the transmission source.

Scatter in the transmission data yields an overestimation of the transmitted counts and hence an underestimation of the μ values. Because of this underestimation, attenuation correction does not restore enough counts in the reconstructed slices. This underestimation somewhat offsets the extra counts in the projections due to scatter from the emission source. This is why it has been suggested (e.g., [2], [3]) that attenuation coefficient values smaller than the theoretical values be used (e.g.,

Representative Results:

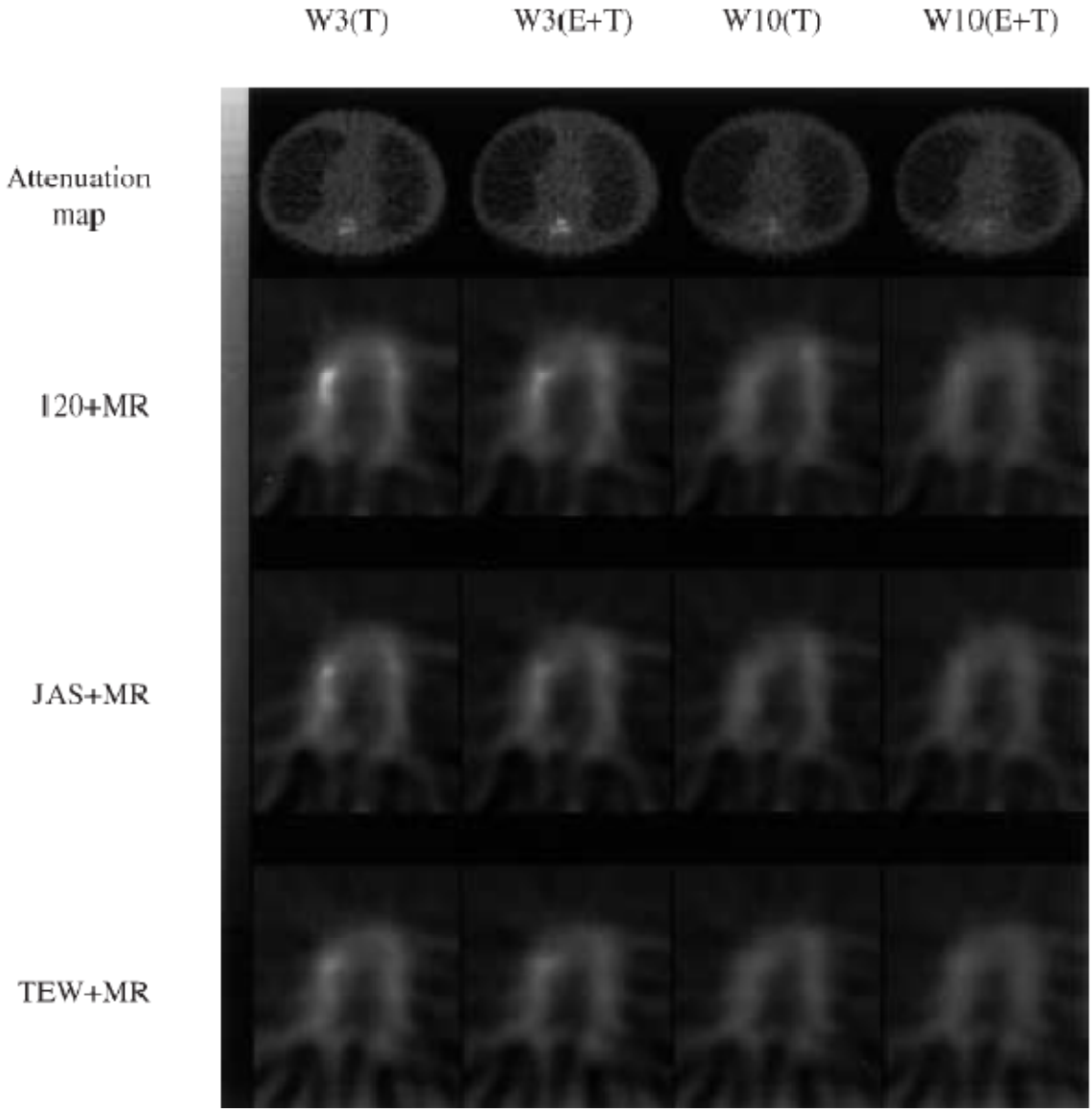

Figure 2. Reconstructed transverse slices of I20, JAS, and TEW activity distributions through the LV of the cardiac Data Spectrum phantom with the four attenuation maps