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Phantom and Clinical Evaluation of Block Sequential Regularized Expectation Maximization Reconstruction Algorithm in Ga-PSMA PET/CT Studies Using Various Relative Difference Penalties and Acquisition Durations

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Abstract : Introduction: Block Sequential Regularized Expectation Maximization (BSREM) reconstruction algorithm was recently developed to suppress excessive noise by applying a relative difference penalty. The aim of this study was to investigate the effect of various strengths of noise penalization factor in the BSREM algorithm under different acquisition duration and lesion sizes in order to determine an optimum penalty factor by considering both quantitative and qualitative image evaluation parameters in clinical uses. Materials and Methods: The NEMA IQ phantom and 15 clinical whole-body patients with prostate cancer were evaluated. Phantom and patients were injected withGallium-68 Prostate-Specific Membrane Antigen(68 Ga-PSMA)and scanned on a non-time-of-flight Discovery IQ Positron Emission Tomography/Computed Tomography(PET/CT) scanner with BGO crystals. The data were reconstructed using BSREM with a β-value of 100-500 at an interval of 100. These reconstructions were compared to OSEM as a widely used reconstruction algorithm. Following the standard NEMA measurement procedure, background variability (BV), recovery coefficient (RC), contrast recovery (CR) and residual lung error (LE) from phantom data and signal-to-noise ratio (SNR), signal-to-background ratio (SBR) and tumor SUV from clinical data were measured. Qualitative features of clinical images visually were ranked by one nuclear medicine expert. Results: The β-value acts as a noise suppression factor, so BSREM showed a decreasing image noise with an increasing β-value. BSREM, with a β-value of 400 at a decreased acquisition duration (2 min/ bp), made an approximately equal noise level with OSEM at an increased acquisition duration (5 min/ bp). For the β-value of 400 at 2 min/bp duration, SNR increased by 43.7%, and LE decreased by 62%, compared with OSEM at a 5 min/bp duration. In both phantom and clinical data, an increase in the β-value is translated into a decrease in SUV. The lowest level of SUV and noise were reached with the highest β-value (β=500), resulting in the highest SNR and lowest SBR due to the greater noise reduction than SUV reduction at the highest β-value. In compression of BSREM with different β-values, the relative difference in the quantitative parameters was generally larger for smaller lesions. As the β-value decreased from 500 to 100, the increase in CR was 160.2% for the smallest sphere (10mm) and 12.6% for the largest sphere (37mm), and the trend was similar for SNR (-58.4% and -20.5%, respectively). BSREM visually was ranked more than OSEM in all Qualitative features. Conclusions: The BSREM algorithm using more iteration numbers leads to more quantitative accuracy without excessive noise, which translates into higher overall image quality and lesion detectability. This improvement can be used to shorter acquisition time.

Keywords : BSREM reconstruction, PET/CT imaging, noise penalization, quantification accuracy
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