Quantitative Simultaneous ^{99m}Tc / ^{123}I SPECT : Design Study and Validation with Monte Carlo Simulations and Physical Acquisitions

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Abstract **Simultaneous dual isotope imaging (^{99m}Tc/^{123}I) has potential clinical applications but has not been implemented in the clinic. Aim: The aim of this work was to design an artificial neural network (ANN) for cross-talk and scatter correction using a smaller number of energy windows (8) than we had previously proposed (26) to allow implementation on some clinical cameras, and to validate our approach using realistic Monte Carlo simulations and anthropomorphic brain phantom acquisitions. Methods: Monte Carlo simulations of dual isotope SPECT studies of a digital brain phantom and physical acquisitions of the striatal brain phantom were used to validate our approach. Corrected projections were reconstructed using an iterative OSEM algorithm that modeled non-uniform attenuation and variable collimator response in the projector/backprojector. Results: In Monte Carlo simulations, ANN26 and ANN8 yielded similarly accurate quantitation of ^{123}I activity (bias<7%) in all brain structures. An asymmetric windowing method (AW) yielded accurate estimation in the striata (bias < 7%) but not in other brain structures. The estimation bias of ^{99m}Tc primary activity was <10% in all brain structures with ANN26 and ANN8. This bias was greater than 25% in all brain structures with AW. In physical acquisitions, ANN26 and ANN8 yielded accurate estimation of ^{123}I activity in striata of both normal and reduced activity concentration (bias <7%). Bias was significantly higher with AW when estimating activity in the pathologic striata (5%) than in the normal one (9%). The bias of the ^{99m}Tc activity estimate in the brain was less than 6% with ANN26 and ANN8 but greater than 20% with AW. Conclusion: ANN8, which can be implemented more easily in the clinic than ANN26, yielded estimation bias and precision comparable to those of ANN26 in Monte Carlo simulations and physical acquisitions.**

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I. INTRODUCTION

Dual isotope imaging (^{99m}Tc/^{123}I) has potential clinical applications in the simultaneous assessment of neurotransmission and brain perfusion or imaging of both presynaptic and postsynaptic phases of dopaminergic transmission under the same physiologic conditions, while allowing perfect registration of the two studies and halving the acquisition time required for sequential studies. Despite these advantages, this technique has not been routinely implemented in the clinic. Because the emission energies of ^{99m}Tc and ^{123}I are close, not only are scattered ^{123}I photons detected in the ^{99m}Tc window but, equally importantly, primary photons of each radionuclide are detected in the wrong window (cross-talk).

In previous work, we have developed two original approaches for accurate cross-talk and scatter corrections in simultaneous ^{99m}Tc/^{123}I imaging based on constrained spectral factor analysis and artificial neural networks (ANN) and validated them in Monte Carlo simulations of brain SPECT studies [1]. We have also shown that absolute activity quantitation of both brain perfusion and neurotransmission could be achieved with a bias less than 10% when compensating for attenuation, variable collimator response and intrinsic collimator resolution, in addition to scatter and cross-talk [2]. However, constrained spectral factor analysis and ANN, as proposed initially, require a large number (i.e., 26) of energy windows encompassing the [79-183 keV] energy range; this precludes their implementation on many commercial gamma camera systems. The number of energy inputs for ANN could be reduced by considering a non-uniform sampling of the energy spectrum, but this has not been investigated yet. Furthermore, no validation based on realistic physical acquisitions has yet been performed.

The aim of the present study was to design an ANN to allow cross-talk and scatter correction using a smaller number of energy windows (i.e., 8) and to validate our approach using anthropomorphic brain phantom acquisitions.

Representative Results:

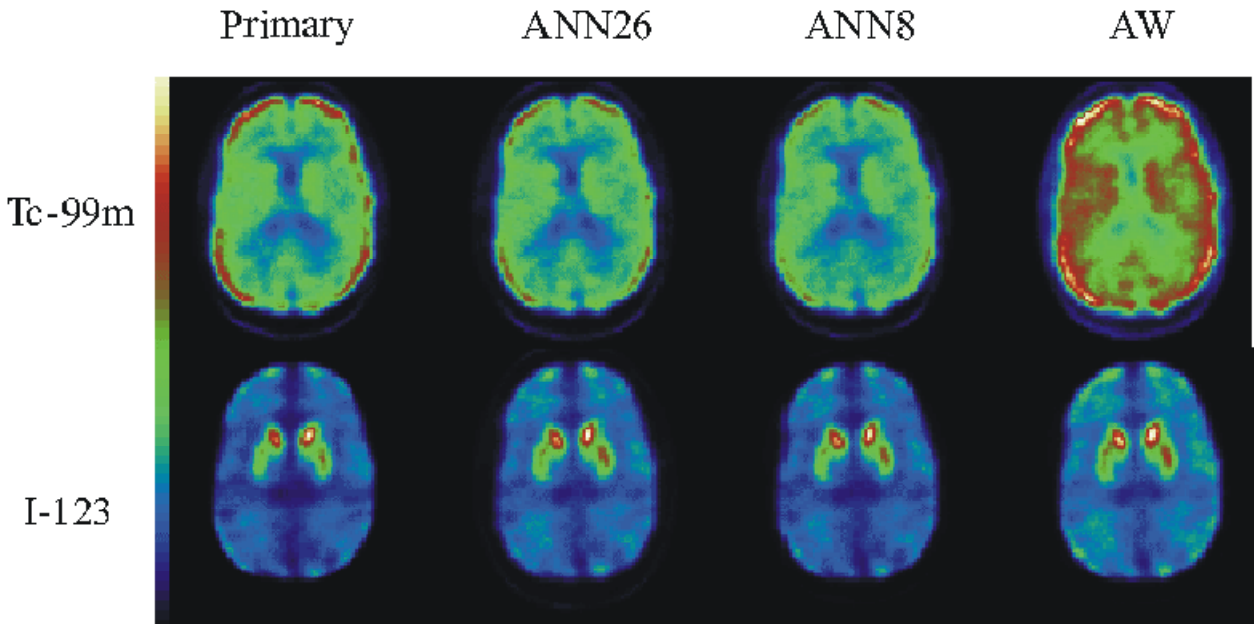

Fig. 8. ^{99m}Tc and ^{123}I activity distributions obtained in the absence of scatter and cross-talk (primary) as well as estimated with ANN26, ANN8 and AW.