Evaluation of scatter correction methods using Monte Carlo simulation in non uniform media

Georges El Fakhri, Philippe Maksud and André Aurengo
U494 INSERM, CHU Pitié Salpêtrière, Paris, France

ABSTRACT

The detection of scattered photons affects both image quality and accuracy of quantitation accuracy in Single Photon Emission Computed Tomography (SPECT). The aim of this work was to evaluate three scatter correction methods: Jaszczak subtraction, the triple energy window method and an artificial neural network based approach. This evaluation was performed not only in terms of contrast and spatial resolution but also in terms of absolute and relative quantitation. A Monte Carlo simulation of an anthropomorphic cardiac phantom allowed us to obtain a realistic SPECT study while knowing the primary (non scattered) photon distribution. The knowledge of the primary activity made possible the study of the effect of scatter alone independently on all other phenomena affecting quantitation. The quantitative error propagation between the projections and the reconstructed slices due to scatter was studied as well as resolution, contrast and uniformity recoveries in the corrected images. The results show that an artificial neural network achieved the best scatter correction both in terms of relative (gives the same uniformity as in the primary distribution) and absolute quantitation (error < 4%) and resolution. The triple energy window method led to good quantitation (error < 8%) and contrast results but poorer resolution recovery than the artificial neural network based approach. Jaszczak subtraction yielded good quantitation (error < 7%) but introduced severe non uniformities in the image (decrease of the uniformity by 35%).

Keywords: SPECT, Evaluation, scatter correction, Monte Carlo simulation, quantitation, artificial neural network.

1. INTRODUCTION

Attenuation, collimator response and scatter are among the major phenomena hindering quantitation in SPECT. Although attenuation and collimator response have been considered as the most important impediments to quantitation, scatter correction remains essential when quantitation is at issue. Scattered photons are detected at the location of their last scatter interaction conveying poor information about their emission position. Consequently, they affect contrast, spatial resolution and quantitation. Several scatter correction methods have been proposed (for a review see [1]) and some effects of scatter on quantitation (e.g. [2], [3], [4], [5]) have been studied. Performance of scatter correction methods has been assessed either on the projections e.g. [6] or the reconstructed slices e.g. [7]. The aim of this work was to evaluate the performances of three scatter correction methods in terms of quantitative accuracy not only in the projections but also in the reconstructed volume to assess the propagation of error due to scatter between the projections and the reconstructed slices. The study also evaluated the performance of the methods in terms of contrast, spatial resolution and uniformity improvements.

2. MATERIALS AND METHODS

2.1 CARDIAC PHANTOM

An anthropomorphic Data Spectrum (Data-Spectrum, Chapel Hill, NC) cardiac phantom consisting of a left ventricle (LV) compartment with a wall thickness of 1 cm, two lung compartments and a spine was considered for the cardiac study. A perfusion bag (530 ml) was added to simulate the liver (Figure 1). The phantom was scanned on an MRI scanner (SIGNA 1.5T-GE). Using thresholding operations, the images were segmented into connex regions corresponding to lungs, LV wall, LV cavity, spine and liver. The remaining pixels were labeled as soft tissue.

Representative Results:

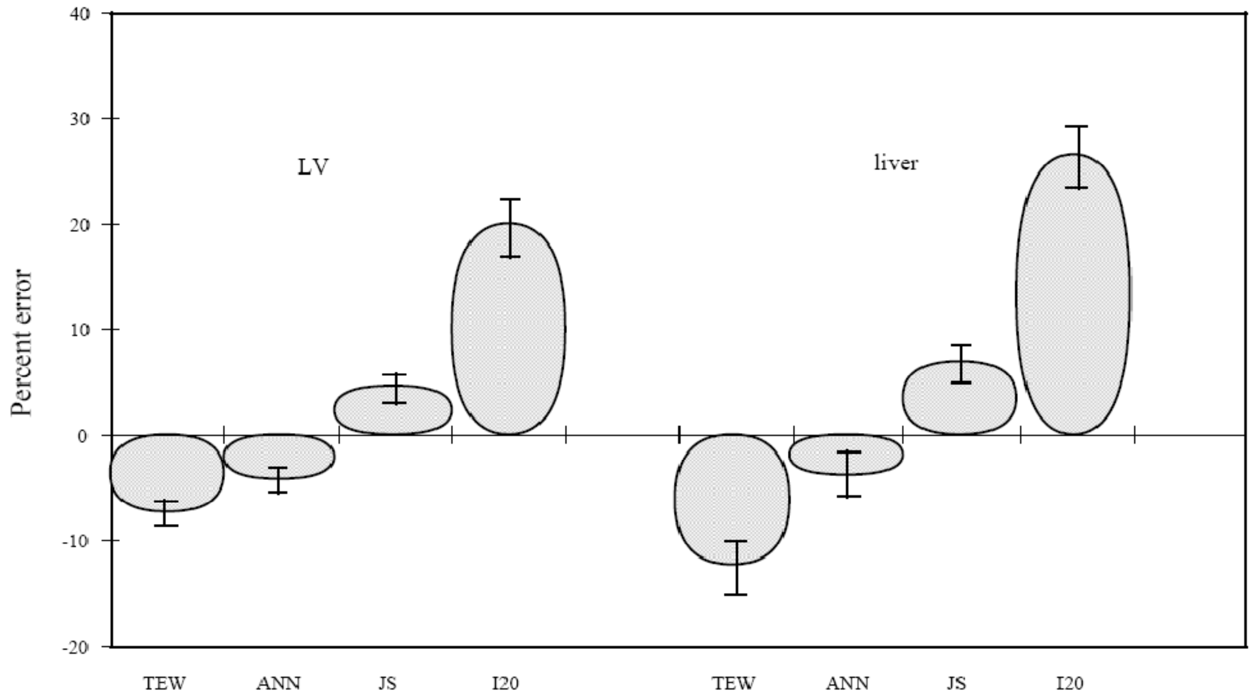

Figure 7: Percent error in the LV and liver reconstructed volume.