Improvement of Accidental Coincidence Estimation for Scanditronix PC2048/4096 PET Scanners

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Abstract

Accidental coincidence (randoms) is one of the factors that degrade the accuracy of positron emission tomography (PET). In contrast to widely-held beliefs, we have previously shown that randoms can significantly affect quantitative PET even after current hardware/software randoms correction is applied. In order to have better estimation of randoms for our Scanditronix scanner, we investigated the limitation of the vendor-provided randoms estimation and proposed a simple modification. *Methods:* Multiple short-frame data of a homogeneous circular cylinder were collected over 12 hours. Summed data were generated by summing up selected frames. Randoms of the summed data estimated by the vendor-provided method and our modified method were compared. *Results:* The vendor-provided randoms estimation did not work as well as the modified method when frame duration is much larger than the half-life of the radioactive agent used. *Conclusion:* Our minimal modification of the vendor-provided method significantly improves randoms estimation.

Keywords: Positron emission tomography, Scintillation counting, Algorithms

Introduction

In regard to system modeling for a PET scanner, it is common practice to assume that counting errors such as accidental coincidence (randoms) and deadtime loss are well compensated for by the built-in hardware/software correction schemes. However, after these counting error corrections were applied, the first author has shown that an activity-dependent point spread function was necessary to correct partial volume effect [1]. Randoms ratio is one of the adjusting factors that represent the activity dependency of the model [1]. Recently, we discovered that an activity-independent point spread function [2], while it accurately predicted activity concentrations of hot spheres in warm backgrounds, was unable to correctly predict those of cold spheres (data not shown). Because different scanner types and correction schemes were used in the aforementioned studies, the results suggest that activity dependency of system models could be universal and an activity-dependent system model is required in many situations such as studies that simultaneously involve both hot and cold small objects in warm backgrounds.

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Methods

Theory

In Scanditronix PC2048/4096 scanners, randoms rate, R, is estimated by

$$R = \omega S_{ci} S_{cj} , \quad (1)$$

where ω is the coincidence time window, S_c stands for deadtime-corrected singles rate, i and j are for detectors i and j. The corrected singles rate is calculated by unified deadtime correction method [*3*], which is based on the measured singles rate and some pre-calculated/measured scanner parameters. However, only total singles are stored in the raw data file, average singles rate is therefore used in the estimation of deadtime and randoms. For relatively long scan duration, which is quite common in research, usage of the average singles rate is inappropriate. In order to apply or develop an activity-dependent point spread function for Scanditronix scanners, one needs more accurate estimation of randoms.

Following the argument of the unified deadtime correction [*3*], the total singles, S_{tot}, collected in a frame is

$$S_{tot} = \int_0^{F_d} S(t)dt \quad (2)$$

where $S(t) = S_c(t)e^{-S_c(t)t_d}$, $S_c(t) = S_0 e^{-\tau t}$, F_d is the