# Sensitivity and Daily Quality Control of a Mobile PET/CT Scanner Operating in 3-Dimensional Mode

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This study investigated the stability of the sensitivity of a mobile PET/CT scanner and tested a phantom experiment to improve on the daily quality control recommendations of the manufacturer. Unlike in-house scanners, mobile PET/CT devices are subjected to a harsher, continuously changing environment that can alter their performance. The parameter of sensitivity was investigated because it reflects directly on standardized uptake value, a key factor in cancer evaluation. **Methods:** A $^{68}$Ge phantom of known activity concentration was scanned 6 times a month for 11 consecutive months using a mobile PET/CT scanner that operates in 3-dimensional mode only. The scans were acquired as 2 contiguous bed positions, with raw data obtained and reconstructed using parameters identical to those used for oncology patients, including CT-extracted attenuation coefficients and decay, scatter, geometry, and randoms corrections. After visual inspection of all reconstructed images, identical regions of interest were drawn on each image to obtain the activity concentration of individual slices. The original activity concentration was then decay-corrected to the scanning day, and the percentage sensitivity of the slice was calculated and graphed. The daily average sensitivity of the scanner, over 11 consecutive months, was also obtained and used to evaluate the stability of sensitivity. **Results:** Our particular scanner showed a daily average sensitivity ranging from −8.6% to 6.5% except for one instance, when the sensitivity dropped by an unacceptable degree, 34.8%. **Conclusion:** Our 11-mo follow-up of a mobile PET/CT scanner demonstrated that its sensitivity remained within acceptable clinical limits except for one instance, when the scanner had to be serviced before patients could be imaged. To enhance our confidence in the uniformity of sensitivity across slices, we added a phantom scan to the daily quality control recommendations of the manufacturer.

**Key Words:** instrumentation; PET/CT; quality assurance; daily QC; mobile PET/CT; sensitivity

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Mobile PET/CT scanners are increasingly used in rural America by small to medium community health care institutions. Unlike in-house or fixed scanners, mobile ones are subjected to a harsher, continuously changing environment as they are moved from one institution to another. Institutions using mobile PET/CT machines rely, most of the time, on the provider's technologist and the manufacturer's service engineer to calibrate and maintain the scanner (*1*). One essential parameter of a PET/CT scanner is sensitivity. The sensitivity of the scanner directly affects standardized uptake value (*2*), the semiquantitative parameter used in cancer evaluation. It was the importance of standardized uptake value and its direct dependence on scanner sensitivity that led us to investigate this parameter. In this study, we tracked the sensitivity of a mobile PET/CT scanner 6 times a month for 11 consecutive months. Moreover, we tested a daily phantom experiment to improve on the quality control (QC) recommendations of the manufacturer. The nuclear medicine technologist can scan the phantom each day to warrant the sensitivity of the scanner before imaging the first patient. In our institution, we scan the phantom daily to improve our confidence in the performance of the scanner. All images from the phantom scan are inspected visually, and the sensitivity of individual slices is obtained and graphed.

## MATERIALS AND METHODS

We used a Reveal RT mobile PET/CT scanner (Siemens) (*3*). This scanner consists of a 2-slice CT portion and a PET portion using lutetium oxyorthosilicate crystals and operating only in 3-dimensional mode. Our daily phantom scan is of a $^{68}$Ge cylindric phantom supplied by the manufacturer, with a volume of 6,189 mL and an activity ranging from 48.1 to 18.5 MBq (1.3–0.5 mCi). We scan the phantom using 2 bed positions to simulate a patient scan. The phantom raw data are acquired before we inject the first patient, and the acquisition follows the written protocol for oncology patients. Once the raw data are obtained, they are reconstructed with the parameters used for patients, including CT-extracted attenuation correction coefficients and decay, geometry, scatter, and randoms corrections. The activity concentration (kBq/mL) of the phantom is then obtained by drawing identical circular regions of interest on each image. The concentration obtained from each region of interest (Pc) is then plotted as a function of slice position

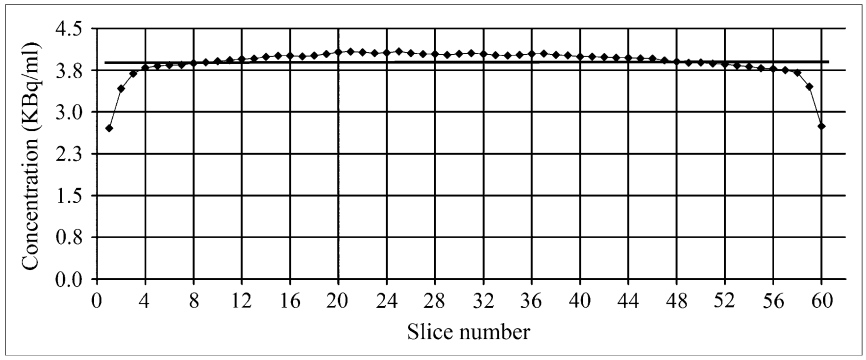


**FIGURE 1.** Typical daily slice concentrations (kBq/mL) obtained with mobile PET/CT scanner from reconstructed images of 2-bed-position $^{68}$Ge cylindric phantom.

for visual inspection of the uniformity of sensitivity. Figure 1 shows a typical distribution of 2-bed-position phantom-extracted slice concentrations (kBq/mL) as a function of slice position. The original phantom activity concentration (Ac) is decay-corrected to the particular scanning day, and the percentage slice sensitivity (Pc/Ac) is obtained and graphed. Figure 2 depicts the percentage slice sensitivity of the PET/CT scan corresponding to the data of Figure 1. The daily average sensitivity of the entire camera is also obtained. The daily average sensitivity of the scanner, obtained 6 times a month for 11 consecutive months, is shown in Figure 3.

## RESULTS

The Reveal RT showed a daily average sensitivity ranging from −8.6% to 6.5%, except for 1 d, when it dropped by 34.8%. This large drop in scanner sensitivity was not evident on inspection of the phantom images, nor was it detected by the daily QC procedure. However, quantitative analysis of the phantom concentrations obtained from the regions of interest showed a reduction in scanner sensitivity, as compared with the true phantom concentration on that particular day. On that day, the scanner was serviced before the first patient scan was obtained.

## DISCUSSION

We chose to examine the technical parameter of sensitivity because of its influence on scanner reliability and the ease with which it can be evaluated by the nuclear medicine technologist. Also, the semiquantitative parameter of standardized uptake value depends directly on scanner sensitivity. Usually, standardized uptake values from different scanning days, months, or even years are compared to evaluate cancer after chemotherapy, radiation therapy, or surgery. For that reason, consistency in scanner sensitivity is essential in preserving the integrity of the PET/CT field. Although visual inspection of phantom images is an important QC instrument, the value of visual inspection is enhanced when complemented by a quantifying parameter. In the QC recommendations of the manufacturer, daily scanner sensitivity is compared with sensitivity obtained on the day of normalization, and a $\chi^2$ value is generated for decision making. One plausible explanation for the 34.8% drop in scanner sensitivity is that the sensitivity on that day and on the normalization day was acquired under similarly suboptimal conditions. Complementing the QC recommendations of the manufacturer with a daily 2-bed-position phantom scan can improve the reliability of the PET/CT scanner.

## CONCLUSION

Simulating a patient PET/CT scan with a 2-bed-position phantom scan (6 min of total PET time) before imaging the first patient has increased our confidence in the performance of the mobile PET/CT scanner that services our community hospital. The proposed phantom scan ensures that slice sensitivity and average sensitivity are within the acceptable clinical range, resulting in dependably comparable standardized uptake values across days. The phantom study we have described here can also be implemented on fixed PET/CT or standalone PET machines. To maintain the reliability of the

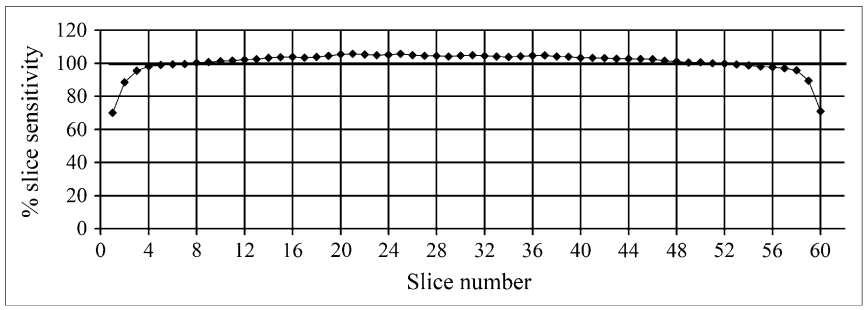


**FIGURE 2.** Percentage sensitivity of mobile PET/CT scanner corresponding to data in Figure 1.

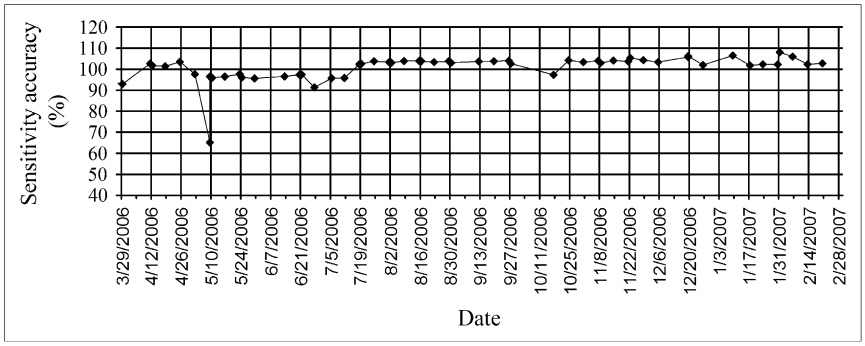


**FIGURE 3.** Daily average sensitivity of mobile PET/CT scanner. Sensitivity was measured 6 times per month for 11 consecutive months.

mobile PET/CT scanner and obtain images of optimal quality (*4,5*), one should strictly adhere to the daily QC suggestions of the manufacturer, schedule periodic maintenance, and add a phantom scan such as the one we have described.

## REFERENCES


1. Townsend DW, Carney JPJ, Yap JT, Hall NC. PET/CT today and tomorrow. *J Nucl Med.* 2004;45(suppl):4S–14S.
2. Paquet N, Albert A, Foidart J, Hustinx R. Within-patient variability of $^{18}$F-FDG: standardized uptake values in normal tissues. *J Nucl Med.* 2004;45:784–788.
3. Erdi YE, Nehmeh SA, Mulnix T, Humm JL, Watson CC. PET performance measurements for an LSO-based combined PET/CT scanner using the National Electrical Manufacturers Association NU 2-2001 standard. *J Nucl Med.* 2004; 45:813–821.
4. Beyer T, Antoch G, Muller S, et al. Acquisition protocol considerations for combined PET/CT imaging. *J Nucl Med.* 2004;45(suppl)25S–35S.
5. Halpern BS, Dahlbom M, Auerbach MA, et al. Optimizing imaging protocols for overweight and obese patients: a lutetium orthosilicate PET/CT study. *J Nucl Med.* 2005;46:603–607.