

ABSTRACT

Introduction: PEM allows the identification of smaller breast malignancies compared to whole body positron emission tomography, but requires the technologist to be in close proximity to the patient for positioning, thereby receiving radiation exposure. To evaluate what levels of exposure the technologist might be receiving, three methods were used; computer modeling, lab simulation and technologist dosimetry measurements.

Methods: 3 methods were used: 1) Computer modeling using MicroShield® software with a 10 mCi ¹⁸F-FDG patient injection dose, and technologist to patient phantom distances of 2 feet for 8 minutes and 5 feet for 30 minutes. 2) Lab simulation using 3 trapezoidal phantoms, each with 2 mCi ¹⁸F-FDG, modeling the FDG reduction with patient voiding prior to scans. Measurements replicated 1 minute for patient preparation at 15 inches, 2 minutes at 15 inches for injection site scan, 13 minutes at 15 inches for breast positioning, and 32 minutes of scanning time for technologist to observe the patient at 10 feet. 3) Technologist dosimetry measurements were obtained at 3 sites with the technologist wearing a digital dosimeter zeroed prior to the start of each PEM scan.

Results: The MicroShield program calculated the dose to the technologist to be 1.1 mrem per procedure. The lab simulation produced an estimated dose to the technologist of 1.7 mrem. Clinical measurements found an average dose of 1.3 ± 0.8 mrem per scan.

Conclusion: A single 10 mCi ¹⁸F-FDG dose is known to result in a 700 mrem radiation exposure to the patient. Using this dose, our studies suggest the technologist receives an average of 1.3 mrem per scan. To exceed the NRC 5,000 mrem limit, a technologist would have to perform over 3,850 scans per year. These data show that the radiation exposure to the technologist is well within NRC limits. Further reduction in radiation is achievable by reducing injected dose, optimizing the workflow, and maximizing the technologist distance to the patient.

INTRODUCTION

- PEM is a high resolution breast PET (positron emission tomography) scanner. Typically the patient is injected with 10 mCi of ¹⁸F-FDG for imaging.
- Since the patient is the radiation source, the technologist is exposed to radiation during the following procedures:
 - Positioning the patient's breast on the paddles (Figure. 1)
 - While operating the scanner (Figure. 2)
- The purpose of the study is to estimate the radiation exposure to technologist during the PEM procedure.



Figure 1: Technologist positioning the breast



Figure 2: Technologist operating the scanner

METHODS

Method 1 – Computer Modeling

- Computer modeling tool – MicroShield software
- For patient simulation: a cylinder with a height of 84 cm, a radius of 12 cm with 1.145 g/cc density
- Dose: 6 mCi (equivalent to 10 mCi FDG injected dose after 70 min. following bladder voiding)
- Typical dose point of interest for a technologist is 2 ft from the patient surface for a duration of 8 minutes without shielding. Followed with a 30 minute exposure with distance increased to 5 ft, emulating the distance from the keyboard to the patient.

Method 2 – Lab Simulation

- Time and distance relationship set up of dose measurement is shown in Table 1.

Cumulative Time (min)	Delta Time (min)	Distance to Body Surface (inches)		Simulated Purpose
		Scenario A	Scenario B	
1	1	15	24	Explain procedure to patient
3	2	15	24	Position and scan injection site
5	2	15	24	Position for LCC
13	8	120	144	Scan LCC
17	4	15	24	Position for LMLO
25	8	120	144	Scan LMLO
26	1	15	24	Switch breasts
28	2	15	24	Position RCC
36	8	120	144	Scan RCC
40	4	15	24	Position RMLO
48	8	120	144	Scan RMLO

Table 1: Time – distance specification for dose measurement

- Dosed measurement tool: IsoTrak DoseGuard personal dosimeter
- Patient phantom: 3 trapezoidal phantoms representing head, chest and abdomen with 2 mCi dose in each.
 - Head trapezoid: 24 cm (height), top end 25 x 15 cm and bottom end 23 x 13 cm
 - Chest and abdomen: height 31 cm, top end 30 x 21 cm and bottom end 22 x 15 cm
 - Each filled with 15 L for chest and abdomen and 5 L for head
 - Three containers were stacked vertically

Method 3 – Clinical Measurements

- The three clinical sites who participated followed their standard of care for dosing, setting up and scanning patients
- Total 59 procedures

RESULTS

Method 1 – Computer Modeling

- 1.1 mrem per procedure

Method 2 – Lab Simulation

- First scenario: 1.7 mrem per procedure
- Second scenario: 1.1 mrem per procedure

Method 3 – Clinical Measurements

Site	Average Dose (mrem)	Average # Scans
1	0.8 ± 0.3	4.0 ± 0.5
2	1.6 ± 0.1	6.5 ± 0.7
3	1.4 ± 0.9	7.0 ± 1.2
Mean ± s.d.	1.3 ± 0.8	6.4 ± 1.6

Table 2: Clinical measurement results

DISCUSSIONS

- A single 10 mCi ¹⁸F-FDG dose is known to result in 700 mrem radiation to the patient.
- NRC has limited the radiation dose to occupational workers to 5,000 mrem per calendar year.
- Our study suggests the technologist receives an average of 1.3 mrem per scan (Table 2). This means that the technologist can perform up to 3850 scans on patients injected with ¹⁸F-FDG each year.
- In method 2, the radiation dose reduction is due to increased distance
- Table 3 below compares the radiation from other radiation sources including natural background.

Dose Received	Source of Exposure
870 mrem / year	Smoking 1 pack of 20 cigarettes/day
300 mrem / year	Average naturally radiation background
6 mrem / film	Chest X-ray
0.5 mrem / hour	Air travel

Table 3: Common background radiation exposures

CONCLUSION

- The exposure for the PEM technologist during a PEM procedure is small and the doses can be further reduced by applying ALARA – time, distance and shielding during the procedure. Further studies to reduce the required dose of ¹⁸F-FDG are ongoing

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