Original Paper

Radiation Exposure from SPECT Transmission Imaging

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INTRODUCTION

SPECT myocardial perfusion imaging involves the complex attenuation from the heart and vascular structures, lungs, bone, muscle, breast tissue in female and diaphragm in male. The attenuation data measured from the SPECT transmission scanning has attracted interest as a method to correct the emission data. This technique could reduce tissue attenuation artifacts in myocardial perfusion imaging.

Experimental transmission imaging techniques have been applied to a whole body phantom using a scanning line source of radioactivity attached on a triple detector SPECT. ^{153}Gd has been selected[1] as it is a long-lived isotope of half life 240 days and gamma energies are 97 and 103 keV which are lower than ^{99m}Tc energy. The radioactivity is rather high to get enough counts through the human thorax in as short time as possible.

The purpose of this study is to determine the radiation exposure received by the patient and the radiation personnel from the transmission imaging of ^{153}Gd line source. Then compare both types of radiation exposure with patient radiation dose from other radiographic examination, body and organ dose equivalent and the dose limit the radiation personnel should receive.

MATERIALS AND METHODS

A collimated line source holder was attached to the rotating gantry of the TRIAD XLT 20 SPECT Imaging System (Trionix Research laboratory, Twinsburg, OH). The source holder, as shown in figure 1, is positioned opposite to detector 1 and moves at a constant speed in the axial direction for each projection of transmission scan. All 3 detectors were fitted with low energy ultra-high resolution parallel-hole collimators. The transmission source, ^{153}Gd activity 1 Curie (Isotope Products Lab, Burbank, CA) has the active diameter of 2.3 mm and length 457.2 mm. The radiation survey meter, Victoreen Model 450 P SN 1265, Ionization Camber with chamber size 180x70x80 mm was set at five locations on a phantom, those are:

- anterior chest
- left lateral chest
- right lateral chest
- umbilicus
- gonad.

The occupational exposure dose was measured around the detector and imaging table at:

- 50 cm to the left side of radiation detector
- 50 cm to the right side of radiation detector
- 50 cm from the left side of the table and detector
- 50 cm from the end of the imaging table
- the computer control, 200 cm from the line source.

In the TCT technique, the detector 1 was set at circular rotation starting at 0^o with a radius of 27.0 cm in a step and shoot manner. Each step was 6^o with 30 steps for 180^o and 20 second allowed per step. The window width or electronic mask shown in figure 1 is set at 20 mm.

RESULT

1. The simulated patient surface exposure dose measured at five sites on the body surface of the phantom, during the transmission technique, are listed in Table 1.

2. The occupational exposure dose measured at five sites around the detector and imaging table are listed in Table 2.

Comparative data

1. The skin entrance exposures from various radiographic examinations are listed in Table 3.

2. Table 4 represents the patient body and organs radiation exposure dose equivalent resulting from the injected radiopharmaceuticals ^{201}Tl[3] (Thallous chloride) and ^{99m}Tc Sestamibi[4].

Table 1 *Patient surface dose measured at various sites on phantom during 10 minute scan of ^{153}Gd line source using Victoreen Model 450P with ionization chamber*

Sites	Patient Exposure Dose (mR in 10 min scan)
Anterior chest	3.0
Lt. Lateral chest	2.1
Rt. Lateral chest	4.2
Umbilicus	1.3
Gonads	0.08

Table 2 *Occupational exposure dose measured in air around the detector and imaging system during a 10 minute scan of ^{153}Gd line source using Victoreen Model 450P with ionization chamber*

	Occupational Exposure Dose	
Sites	mR/10 min	mR/h
50 cm to the left of detector	0.14	0.84
50 cm to the right of detector	0.12	0.72
50 cm from table and detector	0.03	0.18
50 cm from table end	0.006	0.04
200 cm from line source	0.003	0.02

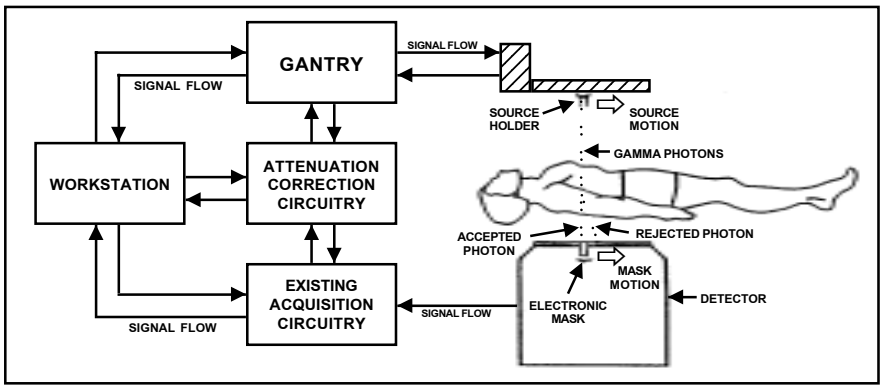

Fig. 1 *Scanning transmission source hardware. Courtesy Trionix Research Lab, Twinsburg, OH.*

3. The occupational effective dose equivalent limits is recommended by NCRP Report #91[5] as shown in Table 5.

DISCUSSION

The patient exposure dose.

The surface dose measured at all sites listed in Table 1 are lower than the minimum level of the radiation exposure of a chest x-ray[2] as given in Table 3. If one compares the maximum value, 4.2 mR for ten minute scan of ^{153}Gd in Table 1 with the maximum skin exposure for chest in Table 3 (26 mR), it is roughly less than 1/4. A comparison was made of the exposure from the transmission source (4.2 mR) to the exposure dose equivalent received form the emission sources for myocardial perfusion studies. The total body dose equivalent from ^{201}Tl is 760 mrem and from ^{99m}Tc is 500 mrem. Therefore, the radiation dose from the transmission scan represents a negligible increase over the radiation received from the internal exposure of ^{201}Tl or ^{99m}Tc

Occupational Exposure

The maximum dose received by a radiation worker from a transmission source in a ten minute scan is 0.14 mR at 50 cm or 0.84 mR/h. This is approximately 1/3 of the calculated maximum permissible dose equivalent of 2.5 mrem/h and the received dose is not significantly increased by the emission source (^{201}Tl or ^{99m}Tc)

CONCLUSION

Patient and occupational doses have been measured from a radioactive line source during the transmission scan (TCT) on a triple-detector SPECT system. Maximum patient radiation dose was no greater than 4.2 mR over the chest and less than half

Table 3 *Skin exposures for various radiographic examinations (Ballinger[2] 1991). The ranges are liberal and reflect the accessing devices, equipment and techniques used in the state-of-art technology*

Examination	Skin Exposure (mR per projection)
Chest (PA)	12-26
Abdomen (AP)	375-678
Thoracic spine (AP)	295-486

Table 4 *Patient radiation exposure dose equivalent from ^{201}Tl (Thallous chloride) and ^{99m}Tc-Sestamibi*

Tissue	^{201}Tl (rems/4mCi)	^{99m}Tc-MIBI (rems/30 mCi)
Total body	0.76	0.5
Heart wall	1.81	0.5
Liver	2.00	0.6
Kidneys	4.36	2.0
Testes	1.81	0.3
Ovaries	1.70	1.0
Thyroid	2.36	0.7

that amount for any other area of the body. In addition, the worst case occupational dose near the patient from the radioactive line source was less than 1 mR/hr which is under dose limit (2.5 mR/hr) recommended by NCRP.

Table 5 *NCRP Recommendations for occupational exposures*

	Exposures (rems/year)
Effective dose equivalent limit for whole body (Stochastic effects)	5
Dose equivalent limit for tissue and organs (nonstochastic effects)	
a) Lens of eyes	15
b) All others (red bone marrow, breast, lungs, gonads, skin and extremities)	50

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