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Dose Assessment of Nuclear Medicine Personnel from Treating Patients

Osama Sharif Alatawneh and Juyoul Kim*
Department of NPP Engineering, KEPCO International Nuclear Graduate School,
658-91 Haemaji-ro, Seosaeng-myeon, Ulju-gun, Ulsan 45014
**Corresponding author: jykim@kings.ac.kr*

1. Introduction

Nuclear medicine has been a branch of medicine based on radioactive isotopes in imaging and treating cancers, and it was a practice where the functional evaluation of different parts of human or non-human bodies were the aim of medical nuclear test. So, as it was known for a lot of workers or patients, nuclear word meant emitted radiation that would lead to cancer in the future, the matter generated some concerns what were called "radiation phobia" even if the quantity was very small in justified practices like nuclear medicine. Actually, it did not mean that the exposing to radiation was easy mater and would not have any effect, but in fact it had, and the role as radiation workers and regulators to be aware about this exposure and we have to be able to manage this exposure well to ensure that safety of our bodies including all persons having a role(s) in the practice.

The point of discussion in this paper was a crucial point and a lot of questions would be asked in this context, about the exposure that a radiation worker like nuclear medicine technologist would receive through his work life, and were the personal dose values recorded by a personal dosimeter correct and accurate? Actually, these questions supposed to be answered by the licensee because it is his responsibility, and certain values must already be obtained during safety analysis of a practice in question, but as a regulatory bod had to verify and evaluate the items that a licensee would not be able to estimate and to find issues by solving them (a) new recommendation(s) would be put in enforcement for personnel protection purpose.

2. Methods and Results

The calculation was done by using Visual Monte Carlo software (VMC-dc), where data obtained from a nuclear medicine procedure parameters like radionuclide identity, radionuclide activity per one procedure, number of total procedures expected to performed over one year period as a licensed workload, physical dimension between the operator and gamma camera table, where the isocenter point was the reference point between the table and the radiation personnel. The nuclear medicine procedure must be credited by a society or an agency because this ensures that the radioactivity was the quantity that would achieve the medical benefit with lower received dose to the patient body and it would the activity from the dose to be evaluated originates. In this paper, the procedures that was chosen to evaluate the dose originated from was stated by the International Atomic Energy Agency (IAEA) [1]. Calculation of radiation dose that would be released through whole body scintigraphy for differential thyroid cancer has been conducted, the required data for this calculation were given in Table I shown below, where this information was obtained from reference [1].

Table I: Calculation parameters

Calculation Parameter	Parameter Value
Radionuclide Type	Iodine-131
Radionuclide activity per patient	80 ~ 200 MBq
Distance from isocenter to operator (Technician)	1.5 meters
Procedures workload per year	50 procedures
Time Imaging	30 minutes
Table elevation above the floor	1 meter

The exposure time was represented by the time of the procedure (imaging time) which was usually ranges from 5 minutes to 10 minutes during which different areas were acquisitioned like neck, chest, proximal extremities and pelvis [1], but here we posted 30 minutes as a worst case in this type of acquisitions, where sometimes longer time was required to avoid doubts regarding interpretation to mitigate diagnosis mistakes. I-131 was a gamma ray emitter with an energy of 364 keV and its fraction yield was 81%, this gamma ray was the radiation source that affected the nuclear medicine technician making him a biological target, in addition to other energies as shown in Table II below were also considered [2].

Table II: Gamma energies of I-131

Gamma Energy (keV)	Percent Yield (%)
29.5	1.38
29.8	2.56
284.3	6.14
364.5	81.7
637.0	7.17
722.9	1.77

The energies during the calculation using Monte Carlo method were those more than 15 keV with relative frequencies above 1 percent [2] as shown in Table II and all of these energies satisfied the criteria stated in reference [2]. The radiation worker was simulated as ICRP male phantom [2] and the irradiation geometry was Anterior Posterior geometry (AP geometry), where the gamma photons were incident on the body in a direction orthogonal to the long axis of the body [3], in other words, the radiation was incident on the frontal part of worker's body as shown in Fig. 1.

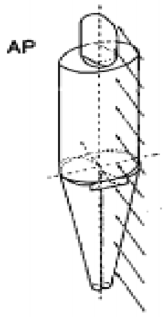

Fig. 1. AP geometry of the worker's body that is exposed [3].

In nuclear medicine’s safety evaluation like shielding and dose estimation, the patient was assumed to be a point source as a conservative approach, so the source geometry that adjusted in the software was point source geometry. The source-receiver geometry in this calculation was at as shown in Fig. 2 and Fig. 3 and the source was at 1 meter from the floor of imaging room and at the center of the room, and it was on the right side of the operator's body.

Fig. 2. Frontal view in the interface of VMC-dc software, where the source is at the worker's body right side.

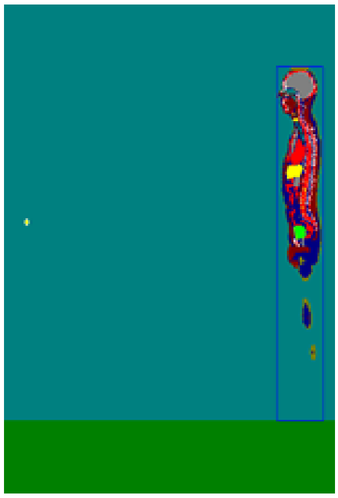

Fig. 3. Side view showing the operator's body and the source in front of him.

From the radionuclide and geometry in question tissue doses and the effective dose were the quantities that obtained from visual Monte Carlo software simulation using the parameters mentioned in Table I. After setting the calculation parameters, the code started to run the calculation according to history number that represented 1 Bq and simulates one nuclear transformation, where the dose could be within history number for the demonstration purpose as a quick calculation and could be longer to provide rough estimate and full calculation. In this study, a rough estimation was performed and this requires history number equals 10^5 and the results were shown in Table III, where tissue dose and the effective dose were shown.

Table III: Dose results

Tissue	Dose (µGy)
Red Bone Marrow	1.27
Colon	1.18
Lung	2.25
Stomach	0.83
Brest	1.34
Remainder	1.10
Testes	0.39
Bladder wall	0.10
Oesophagus	5.08
Liver	1.46
Thyroid	5.99
Bone surface	1.28
Brain	0.96
Salivary gland	3.67
Skin	1.68
Whole lens	0.48
Effective Dose = 1.57 µSv	

Finally, the dose of the worker through this procedure was calculated by 1.57 μSv/procedure × 50 procedures/year = 78.5 μSv over one year. Therefore, the total dose of a male worker was calculated by considering all of the procedures that would be performed in licensee's facility and must be licensed to work with only the revealed workload during authorization process and re-estimation of the dose was required if the workload was to be increased by doing the same methodology stated in this study.

3. Conclusions

Dose calculation using Monte Carlo method gave a preliminary estimation for the safety of workers during radiation activities like patient imaging, and that gave values that would be used to make a comparison with values recorded by personal dosimeters like thermoluminescence dosimeter (TLD) and optically stimulated luminescence (OSL) for the purpose of verification.

Acknowledgement

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REFERENCES

[1] Nuclear Medicine Resources Manual, STI/PUB/1198, IAEA.
[2] Visual Monte Carlo, John Hunt IRD, Manual.
[3] ICRP publication 74, Conversion Coefficients for use in radiological protection