ABSORBED DOSE ESTIMATION OF GONADS RESULTING FROM FAULT WORK OF STAFF DURING INJECTION OF RADIO-PHARMACEUTICALS TO THE PATIENTS

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Abstract

Radiopharmaceuticals are used in nuclear medicine in a variety of diagnostic and therapeutic procedures and generally delivered to the patient via intravenous injection. ^{201}Tland^{99m}TC are the two most used radiopharmaceuticalsinnuclear medicine. The maximum activityinjectedto the patientinnuclear medicine for ^{201}Tl and^{99m}Tc is 5 and 20-25 mCi respectively. In this research by using Monte Carlo method and MCNPX code the absorbed dose to Gonads due to drop of Radiopharmaceutical on foot thigh during injection to the patient has been calculated. The activity of ^{201}Tland^{99m}TC has been considered 1 and 5mCi respectively. The amount ofabsorbed dose in gonads for ^{99m}Tc for male and female during 8 hours of work has been measured 0.37 and 0.055 μSv respectively. Also the amount ofabsorbed dose for ^{201}Tl duringworking hours at first day, second day and third day after workfault for male has been measured 0.387, 0.308 and 0.246 μSvand for female 0.06, 0.048 and 0.038μSv respectively. The total dose inthese threeworking days for male and female has been 0.941 and 0.146 μSv respectively. Since absorbed dose of gonads was far enough from the limits of ICRP, so it can be concluded that if a fault work occurs and even staff does not be aware there is no need to treat him.

Introduction

Radio-pharmaceutics are used in nuclear medicine in a variety of diagnostic and therapeutic procedures and generally delivered to the patient via intravenous injection. Nuclear medicine continues to employ radio-nuclides such as ^{99m}Tc, ^{18}F, ^{111}In, ^{123}I, ^{131}I, ^{201}Tl, etc. in diagnostic procedures. Such procedures are used to scan bone, cardiovascular, thyroid, liver and etc. [1].

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In this research ^{201}Tl and ^{99m}TC were used. ^{201}Tl and ^{99m}Tc are two favorite gamma emitter radioisotopes in nuclear medicine which are widely used as approved radioimaging drugs in nuclear medicine imaging procedures [2]. The maximum injected activity to the patient in Nuclear medicine for ^{201}Tl and ^{99m}Tc is 5 and 20-25 mCi respectively. Inthis study, by using Monte Carlo method and MCNPX code, absorbed doseofthegonadsfor male and female due to drop of radiopharmaceutical on foot thigh during injection to the patient has been calculated.

Materials and Methods

1) Monte Carlo simulation

In this study, to simulate the gonads and estimation of absorbed dose, MCNPX method was used. MCNP is a general purpose Monte Carlo radiation transport code designed to track many particle types over broad range of energies [3].

Stimulation of source

Source as a disc with a size of 1 cm in diameter was considered one time coated by ^{201}Tl and the second time by ^{99m}Tc. ^{201}Tl is a produced cyclotron radioisotope by the reaction of ^{203} Tl (p,3n) ^{201} Pb. ^{201}Pb decays by a 9.4 h physical half-life to ^{201}Tl by electron capture and β^+ emission [4]. ^{201}Tl decays by electron capture to ^{201}Hg, which emits x-rays primarily at 68-80 keV but also gamma-rays at 137 and 167 keV with a mean percentage per disintegration of 94.5%, 3%, and 10%, respectively. ^{201}Tl has a half-life of 73.1 h.

Table 1. Principal Radiation Emission Data [5]

Radiation	Mean %/Disintegration	Mean Energy (KeV)
Gamma	3	137
Gamma	10	167
Mercury X-rays	94.5	68-80

^{99m}Tc with a half-life of 6.02 h and gamma-ray spectrum with an energy peak at 140.5 keV has a vast application in nuclear medicine [6,7]. More than 85% of administered radiopharmaceuticals are produced from ^{99m}Tc [6].

Stimulation of body

In simulationofbodyphantomthree important parts means head,trunkandlegswere considered. Toview theseparts, cylindersmade ofPlexiglaswith a thickness of0.5 cm, filled of water were considered. A cylinder witharadius of9.36cm andheight of24 cmfor head, a cylinder witharadius of15.86cm andheight of70 cmfor trunk andacylinder witharadius of15.86cm

andheight of80 cmfor legs were used (Figure 1).

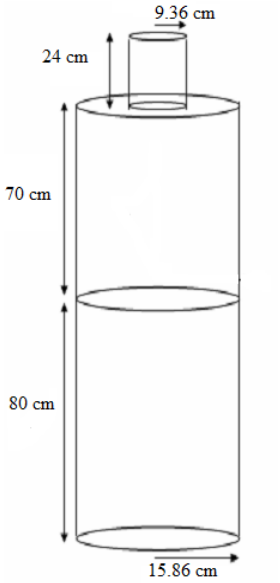

Figure 1. Phantomof the adulthuman bodymade ofPlexiglasandwater

Simulation of ovaries

Due to moresimilarity of body with cylindrical shape, female'sovaries were considered as cylinder. Ovarieswithradius of 0.8 cm andheight of 4.5 cm were simulated[8].

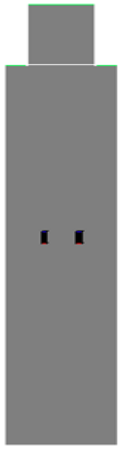

Figure 2. Ovarieswithradius of0.8 cm, height of 4.5 and density of 1g/cm^3 (Due to proximity of soft tissue density to water density) [8].

Simulation of testes

In simulation of testes the recommended sizes by MIRD-Phantom were used.

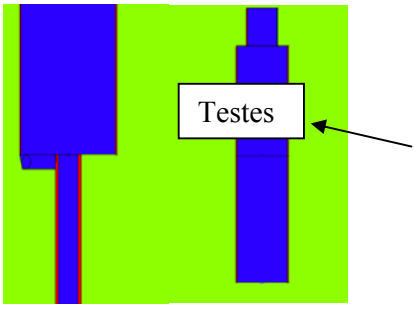

Figure 3. Viewsfrom front and side

2-Dosecalculations

The principal quantity of interest in internal dosimetry is the absorbed dose, or the dose equivalent. Absorbed dose, D, is defined as :

$D = d\varepsilon/dm$

Where dε is the mean energy imparted by ionizing radiation to matter of mass dm. The units of absorbed dose are typically erg/g or J/kg. The special units are rad (100 erg/g) or gray (Gy) (1J/Kg = 100 rad = 10^4 erg/g). the dose equivalent, H, is the absorbed dose multiplied by a quality factor, Q, the later account for the effectiveness of different types of radiation in causing biological effects:

$H = DQ$

Because the quality factor is in principle dimensionless, the pure units of this quantity are the same as absorbed dose (i.e. erg/g or J/kg). However the special units have unique names, specifically the rem and sievert (Sv). Values for the quality factor have changed as new information about radiation effectiveness has become available. Current values, recommended by ICRP (30), are given in Table 2.

Table 2. Quality factors recommendedIn ICRP 30 [1].

Radiation type	Quality factor, Q
Alpha particle	20
Beta particles	1
Gamma rays	1
X-rays	1

Both the F6 and *F8 tallies of MCNP code can be used for determination of absorbed dose by MCNP method. In this study F6 tally was used to calculate absorbed dose [7]. Following formula to calculate the absorbed dose have been used.

$D_{\gamma i} = D_{Ei\text{-}F6} \times 1.602 \times 10^{-10}$

Where $D_{\gamma i}$ is photon dose in the cell i (J kg^{-1}or gray) and $D_{Ei\text{-}F6}$ is deposited energy of photons in the cell i which was estimated by the F6-tally. Because absorbed dose obtained in the MCNP code is for one particle this value was multiplied in the activity. Following formula to calculate the cumulated activity at during 8 hours of work has been used.

$$A=\int_0^8 A_0\, e^{-\lambda t} dt$$

Where A is the cumulated activity and A_0 is the activity at time t_0 [9].

Table 3. Activity ^{99m}TC and ^{201}Tl at the different times

	^{99m}TC	^{201}Tl
t=0	18.5×10^7	3.7×10^7
t=24h	-	2.952×10^7
t=48h	-	2.35×10^7

Results

The amount ofabsorbed dose in gonads for ^{99m}Tc for male and female during 8 hours of work has been measured 0.37 and 0.055μSv respectively. Also the amount ofabsorbed dose for ^{201}Tl duringworking hours of first day, second day and third day after workfault for male 0.387, 0.308 and 0.246 μSv and for female 0.06, 0.048 and 0.038μSv has been measured respectively. The total dose inthese threeworking days for male and female has been 0.941 and 0.146 μSv respectively.

Discussion & Conclusion

Since absorbed dose of gonads was far enough from the limits of ICRP, so it can be concluded that if a fault work occurs and even staff does not be aware, there is no need to treat him.

References

1. Helal N. Patient organs dose calculations in nuclear medicine**.** International Journal of Research and Reviews in Applied Sciences2012; 11 (1): 153-161.
2. Shourian M, Ghourchian H, et al.Dose rate determination of gamma rays emitted by thallium-201 and technetium-99m using a modified horseradish peroxidase based biosensing system. Journal Of The Iranian Chemical Society 2010; 7 (4): 900-907.
3. Pelowitz D B, MCNPX User's manualversion 2.6.0. Los Alamos National Laboratory 2008; LA-CP-07-1473.
4. Stephen R T, Michael G S, Frank P. Radiation absorbed dose from ^{201}Tl-thallouschloride 2005; 46 (3): 502-508.
5. Pagnanelli A R, Basso D A. Myocardial perfusion imaging with ^{201}Tl. Journal Of Nuclear Medicine Technology 2010; 38 (1): 1-3
6. Targholizadeh H, et al. Cyclotron productionof technetium radionuclides using a natural metallic molybdenum thick target and consequent preparation of [Tc]-BRIDAas a radio-labelled kit sample. NUKLEONIKA 2010;55(1):113−118
7. Daryoush SH G, Saba A. Comparison of three methods of calculation, experimental and Monte Carlo simulation in investigation of organ doses (Thyroid, Sternum, Cervical vertebra) in Radioiodine Therapy. Journal of Medical Signals and Sensors 2012; 2 (3): 49-56
8. Karimian A, Abdi M R, Hajarizadeh A. Estimation of absorbed dose of human tissues during BMD scan by TLD chips and Monte Carlo method. 18th International Conference on Medical Physics (ICMP2011)
9. International Commission on Radiological Protection. ICRP Publication 106: Radiation dose to patients from radiopharmaceuticals. Annals of the ICRP, 2008: 38 (1-2).