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A Comparison of TLD Measurements to MIRD Estimates of the Dose to the Ovaries and Uterus from Tc-99m in Urinary System

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ABSTRACT

Relation to high absorption fraction of Tc sestamibi by kidneys and urinary bladder in heart scan, and these organs are near to generation organs (Ovaries and uterus). Kidneys and urinary bladder (urinary system) are specified as sources organs. Method: we have set amount of absorbed fraction radiopharmaceutical in position of kidneys and urinary bladder in Rando phantom in form of elliptical surfaces, then absorbed dose to ovaries and uterus measured by TLD-100 that had set at position of these organs in Rando phantom. Calculation had done by MIRD method. Results from direct measurement and MIRD method are too similar. The absorbed dose to uterus and ovaries for Rest are 18.35µGyMBq-1, 29.96µGyMBq-1 and for Stress are 12.99µGyMBq-1, 22.34µGyMBq-1 respectively.

Key words: absorbed dose, TLD, MIRD, Rando phantom, Tc-99m.

1-INTRODUCTION

In nuclear medicine applications, scintigraphic studies have been applied to the different organs such as liver, spleen, heart, kidneys, bone, lung, thyroid, lymph glands and etc [1].

The absorbed dose levels for the critical organs are always high during the therapeutic irradiation. Although the absorbed dose levels by critical organs during the scintigraphic application are lower than the therapeutic dose levels, their evaluation may be also considered important.

Heart scan is the most common method for the all of other scans in nuclear medicine. In heart scan, among various organs, kidneys and urinary bladder adsorb the highest amount of Radiopharmaceuty. These organs are near to the generation organs (ovaries and uterus); therefore kidneys and urinary bladder (urinary system) are specified as sources organs.

The female generation organs have been chosen as the critical organs, because they are the most sensitive organs for the genetic and somatic effects [2].

The main object of this study is to determine the absorbed dose in a critical organ. Especially for the scintigraphic applications, which are important in nuclear medicine.

2-MATERIALS AND METHODS

A. Radiopharmaceutical

Although many different radionuclides were used in the past for the diagnostic purpose, now the mostly used radionuclies are TC-99m and I-131 .as a rule the dose per application is less for TC-99m which has a shorter half-life. So it is used preferably which explains why it is used in the majority of cases. In this study we also used TC-99m for this experimental study. Radiopharmaceuticals are radioactive pharmaceutical agents or drugs used for diagnostic or therapeutic procedures [3]. The use of technetium isotopes in both medicine and metallurgy has recently stimulated interest in the metabolic behavior of this element following the intake into body. TC-99m that decays by isomeric transition and has a half-life 6.02 hr has found widespread use in biology and medicine both as a tracer and as a diagnostic tool in nuclear medicine [4].

B. Rando-phantom

For this experiment studies a Rando- phantom is used, which is made using natural male and female skeletons and tissue-equivalent materials [3]. The phantoms are transected at 2.5 cm intervals. An average female phantom corresponds to full body length of 163 cm and body weight 54 Kg soft tissue. The plastic used in the phantom has an effective atomic number of 7.3 and density of 0.985g cm^{-3} [5].

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The anthropomorphic phantom has some holes in the slices for placing of the dosimeters. It contains a representation of all organs. The phantom consists of 36 separated slices, each slice has holes drilled on 1.5×1.5 cm grid for holding dosimeters and unused holes are filled with tissue-equivalent plugs [6].

C. Dosimeter

Very few detectors can be used to measure absorbed dose directly. In vivo dose measurements are actually indirect processes. There are two general requirements for accurate dose measurements 1) the detector must respond reliably and reproducibly. To the radiation field of interest (good sensitivity, stability) and background characteristics, and 2) the user must make a correct inference of the absorbed dose from the measured response. The conditions of in vivo measurements lead to the further requirements of small physical size high sensitivity a response that is independent of photon energy and exposure geometry and the ability to function in vivo without endangering host [7]. TLDs have proved to be a useful technique for a variety of purposes in radiation protection [8]. .it can detect a wide range of the radiation exposures. The phosphors used in this study were LiF (TLD-100), (3.1× 3.1× .9 mm) chips. All the chips were produced from the same batch. We chose TLD-100 because it is widely used in low-dose dosimetry, due to its high sensitivity and it is available for us.

D. Calibration

For calibration, TLDs-100 are annealed at temperature of 400 ^{0}C for 1 h and then set at 105 ^{0}C for 20 h to ensure that the saving energy in them is extracted. In interval between different stages such as processing, annealing and exposure, all of dosimeters putted in regions that safe for UV and temperature fewer than 30 ^{0}C. Dosimetry performed by a Cs-137 standard source and TLD reader system model of 4500 Harshaw. Calibration curve was plotted for various exposures using a standard phantom and a standard source of Cs-137 Fig.1

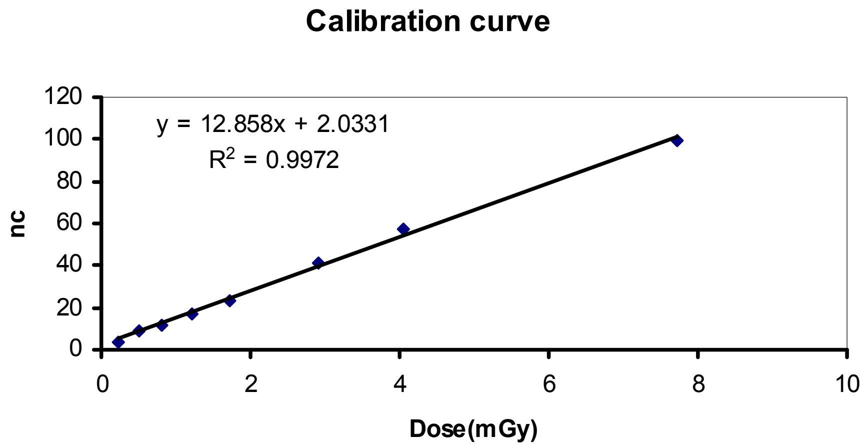

Fig.1 Calibration plot of TLDs dosimeters

E. Experimental procedure

The radiopharmaceutical injected to the patients for heart scan purposes .it is accumulated in kidneys and intestine. In this study first kidneys were chosen as source organs the ovaries and uterus were defined as target organs. The measurements were made with TLDs inside a female Rando-phantom. First, the size and the placement of source organs, kidneys were determined using the corresponding slice numbers given in the literature on the anthropomorphic phantom [9].

Afterwards, the portion of source organs within each slice has been calculated. Detailed information is given in Table.1 corresponding radionuclide activities were absorbed in absorbent tissue paper that had cut in form of elliptical surfaces to simulate kidneys uniformly as possible and placed into plastic bags in order to prevent contamination. Finally they were placed among the slices of Rando-phantom. Each plastic bag with the active solution was placed between the slices, so that shapes and dimensions of the kidneys were simulated [10]. Experiment has performed twice because the right kidney is lower than left kidney in their positions. This experiment has performed for each kidney in a similar and realistic manner. The detector TLDs (TLD-100) were placed in the target organs (ovaries and uterus) in Rando-phantom. 37 TLDs had placed in ovaries and uterus and then, reading had performed by reader system model of 4500 Harshaw, The dose that have saved in TLDs were determined. Second the all procedure for urinary bladder performed simulate to kidneys that explained above the portion of source organs within each slice has been calculated. Detailed information is given in Table.1

Table .1 The activity placing parameters for kidneys

Organ simulation	Slice number of Rando-phantom	Size of organ region for each slice(cm^2)	Activity rate (%)
Left kidney	21	2.04	6
	22	9.31	27
	23	11.78	34
	24	9.31	27
	25	2.04	6
Right kidney	22	2.04	6
	23	9.31	27
	24	11.78	34
	25	9.31	27
	26	2.04	6
Urinary Bladder	**31**	**53.83**	**68**
	32	**25.67**	**32**

3- The calculation with MIRD method

The dose is calculated by using method that adopted by MIRD committee of the society of nuclear medicine as follow, the absorbed dose D(rk← rh) expressed in rads to a target organ (rk) from a radionuclide distributed uniformly in a source organ (rh) has been formulated by MIRD committee[11].The MIRD formula has reduced the number of assumption necessary to perform dosimetry calculation over that required by the classic expression of dosimetry, MIRD formula presupposes that the source is uniformly distributed within a standard size organ, which is subject to much patient variation[12].

$$D\,(rk\leftarrow rh)= Ah\,\tau S\,(rk\leftarrow rh) \qquad (1)$$

Where Ah(µci) is the cumulated activity in source organ, τ is residue time and where computer calculations of S (rk← rh)($rad\mu ci^{-1}.h^{-1}$) have been tabulated .The S (rk← rh) values are based upon the assumptions that radioactivity is uniformly distributed throughout the source organ . S(rk← rh) values of ovaries and uterus for source organ that kidneys are given in Table.2

Absorbed dose values of ovaries and uterus were calculated for source organs which kidneys for maximum activity (1110Mbq) that used in Heart scans and effective half life. The results are given in Tables 3 and 4.

Table 2 S factor (rad/µci) for Tc-99m [14].

Target organ	Source organs Kidneys	Source organs Bladder
Ovaries	1.1×10^{-6}	2.468×10^{-5}
Uterus(non gravid)	**9.4×10^{-7}**	**2.278×10^{-6}**

Table.3 Absorbed dose (mGy) by ovaries from Tc-99m in Urinary system with MIRD calculation and experimental

Method	Rest	Stress
MIRD	31.1	23.19
TLD	33.26	24.8
Deviation between methods	**6.5%**	**6.5%**

Table.4 Absorbed dose (mGy) by uterus from Tc-99m Urinary system with MIRD calculation and experimental

Method	Rest	Stress
MIRD	20.04	14.18
TLD	20.37	14.42
Deviation between methods	**1.6%**	**1.63%**

4- RESULTS AND DISCUSSIONS

Although, it is essentially impossible to measure the radiation received by a particular patient, it is possible to calculate the absorbed dose for various organs of a standard man, this study was conducted in order to measure the absorbed dose, placing TLDs in a phantom in this experimental setup, both the source of activity and measuring TLDs were located in the phantom at regions corresponding to kidneys, urinary bladder (urinary system) , ovaries and uterus, Generally the study encountered in the literature only one of the two parties involved in the experiment(either radiation source, or the detector)is in contact with the phantom .thus this study is both realistic and original from this point view. These measurements were performed for maximum activity (1110Mbq) in kidneys and urinary bladder for Rest and Stress stages in Heart scans and their activities that absorbed in kidneys and urinary bladder. This study preformed for each kidney separately because the position of kidneys aren't similar, left kidney is upper than right kidney.

The results were compared with absorbed dose values calculated with MIRD method and their deviations are shown in Tables 3 and 4. The results are in agreement with each other and the difference between experimental and calculation methods are acceptable. The measured doses are generally about 6.5% higher than the calculated absorbed dose for ovaries. The reason for this is following: the experiment is realistic and covers all the environmental scattering effects, where no scattering calculation in MIRD method is performed consequently, an original and realistic experimental arrangement is applied by using elliptical plane sources between the Rando-phantom slices, and then non accuracy in distribution of activities in plane and non accuracy in determination position of ovaries in slice of Rando- phantom , and then the results are reliable, which can be shown the comparison of the MIRD calculations.

5- Conclusions

In this study, the evaluation of absorbed dose for the critical organ is made with an original setup and results for experimental and theoretical evaluated for nuclear medicine applications were compared. In this original and realistic experimental arrangements the radioisotopes and TLDs were placed in the anthropomorphic phantom as, encountered in the scintigraphic applications of nuclear medicine .in generally other experiments, only one of them is in contact with the Rando- phantom directly. Cumulated dose of ovaries are about (58.06mGy) for maximum activity (1110Mbq). The ovaries are sensitive organs doses as low as 1.5-6.4 Gy have been recorded as causing temporary sterility [13]. There is no radiation protection problem for the ovaries that is affected with maximum activity of our study.

REFERENCES

[1] UNSCEAR,.United Nations Scientific Committee on the Effect of Atomic Radiation, Annex C source and effects of ionizing radiation UNSCEAR Report 1993.

[2] Cember, H., Introduction to health physics, Northwestern University, (1992),2nd Edition McGraw-Hill, INC, New York.

[3] Ricard,A.N Radiopharmecuticals;principles and practice of nuclear medicine, .1995. 2nd Edition.pp.94-117.

[4] Ronald,J.S.,Biological effects of ionizing radiation; principles and practice of nuclear medicine, 1995. 2nd Edition.pp.118-129.,

[5] Golikov, V.Y, Nikitin, V.V., Estimation of the mean organ doses and the effective dose equivalent from rando phantom measurement. Health Phys. 1989. 56 (1), 111-115.

[6] Nariyama,N.,Tanaka,S,Nakane ,Y.,Namito,y.,Hirayama,H.Ban,S., akashima,H.,et al absorbed dose measurements and calculations in phantom for 1.5 to 50 Kev photons, Health phys. 1995, 68(2),253-260.

[7] NCRP83,.National Council on Radiation Protection and measurements. The experimental Basis for absorbed dose calculations in medical uses of radionuclids.(1985) NCRP Report No.83.

[8] MC, Kinalay, A.F, Thermoluminescence dosimetry Medical physics handbooks, (1980) vol.5.Adam Hilger Ltd., Bristol.

[9] Lanzl.L.H. The rando-phantom and its medical applications, Deoartment of Radiology. The University of Chicago, Illinois, Chicago, 1973.

[10] Dogan Y., A.B. Tugrul; A comparison of TLD measurements to MIRD estimates of the dose to the testes from Tc-99m in the liver and spleen, Radiation measurement 37(2003)113-118.

[11] Stabin,M.G., ,MIRDOSE,personal computer software for internal dose assessment in nuclear medicine.J.Nuvl.Med.37(1996),538-546.

[12] UNSCEAR,. United Nations Scientific Committee on the Effect of Atomic Radiation, Annex G ionizing radiation source and biological effects UNSCEAR Report 1982.

[13] Thomas L. Walden J." Long term and low-level effects of ionizing radiation "Medical consequences of nuclear warfare. Radiation Biochemistry Department, Armed Forces Radiobiology Research Institute Bethesda, Maryland (2002) 20814-5145.

[14] Richard E. Toohey, Michael G. Stabin, Evelyn E. Watson, The AAPM/RSNA physics tutorial for residents' internal radiation and dosimetry: principles and applications, imaging and therapeutic technology, vol.20 no.2 (2000).pp.533-546.