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Thyroids Dose Evaluation and Calculation of Backscatter FactorsforCo-60 Irradiations

D. Kısınma, A. B. Tugrul

Abstract**—**The aim of the study is evaluation of absorbed doses for thyroids by using neck phantoms. For this purpose, it was arranged the irradiation set with different phantoms. Three different materials were used for phantom materials as, water, paraffin and wood. The phantoms were three different dimensions for simulation of different ages and human race for each material. Co-60 gamma source was used for irradiation and the experimental procedure applied rigorously with narrow beam geometry. As the results of the experiments the relative radiation doses are evaluated for therapeutic applications for thyroids and backscattering factors were calculated and shown that water, paraffin and wood can appropriate for phantom material with the converge values of backscattering factors.

Keywords**—**Co-60, Dosimetry, phantom, thyroids.

I. INTRODUCTION

WITH the expansion of approach of thyroids irradiation in nuclear medicine therapies, detailed research relating to the dose evaluations of the patients is gaining importance. Radiation exposure may be external in many times for treating of malignancies due to application is easy and practical.

In this study, it was arranged the irradiation set and was measured the radiation for evaluation of absorbed doses for thyroids by using neck phantoms. Water is generally main phantom material of choice for both reference and relative dosimetry measurements in radiation therapy [1]. But, different or special phantoms can be used for dose evaluation [2].

In the medical applications such as radiation therapy, radiology, nuclear medicine and radiological protection, water phantoms are extensively used for the dosimetry of photons. It is a common practice to verify the validity of calculation algorithms by comparing the generated doses with the measured doses in tissue equivalent phantom substances [3], [4].

Ionizing radiation is used in Medicine for therapeutic and also diagnostics purposes. High energy photon has been largely applied in the radiation therapy area.

Backscattering is important factor for the irradiation procedures. It is also imperative effects for the therapeutic application due to changing applied doses. Furthermore, it should be evaluate for radiation safety.

In the radiotherapy dosimetry an efficient and accurate calibration of the radiation beam ensures knowledge of the radiation dose delivered to the patient, allowing thus an effective radiation treatment with a destruction of cancer cells producing the least possible harm to healthy tissue around the tumor.

D. Kısınma is MSc student in Radiation Science & Technology graduate program in Energy Institute of Istanbul Technical University, Ayazaga Campus-34469, Istanbul-Turkey (phone: +90-536-365-2362; fax: +90-212-285-3884; e-mail: deniz.kisinma@ gmail.com).

A. B. Tugrul is Professor and Head of Nuclear Researches Division and coordinator of Radiation Science & Technology graduate program in EnergyInstitute of Istanbul Technical University, Ayazaga Campus-34469, Istanbul-Turkey (e-mail:beril@itu.edu.tr).

II. MATERIALS AND METHODS

A. Phantom Description

Water is the primary phantom medium recommended for dosimetry of high-energy photon and electron beams, measurements closely approximating the values of radiation absorption and scattering obtained for muscle and other soft tissues. Furthermore, AAPM Report no.51, IAEA Technical Reports no.398 (TRS-398) and JSMP Standard Dosimetry for Radiotherapy ‘01 (JSMP01) have recommended that water is defined as the reference medium [5].

In this study a polymeric cylindrical cups which have appropriate dimensions were having water and used as phantom. Neck of the bodies is changed according to ages and human race also. For simulation different type of patients were used five water phantoms. Those are given in Table I.

TABLE I
PHANTOM PROPERTIES

Code	Simulating Mode	Circumference (cm)	Diameter (cm)	Height (cm)
A	Child	27.3	8.69	6.5
B	Women	32.9	10.47	11
C	Men	43.4	13.8	12.5

B. Experimental Setup

As the radiation source, Co-60 gamma radioisotopes were used for the experiments which are commonly used in medical therapeutic applications. It has bicromatic energy emission on 1.17 MeV and 1.33 MeV and has a half-life of 5.27 year. It can be taken mean energy value as 1.25 MeV.

A T-shaped cylindrical lead collimator with was used to provide a convenient beam for the irradiation. The source was housed on the same axis with collimator and the phantom was placed against the gamma source and also collimator hole. A 2 inch diameter NaI(Tl) scintillation detector, which has high detection efficiency, was used for measuring the gamma spectra. The electronics consisted of a high-voltage supply and multi-channel analyzer system. The experimental set up can be seen in Fig. 1.

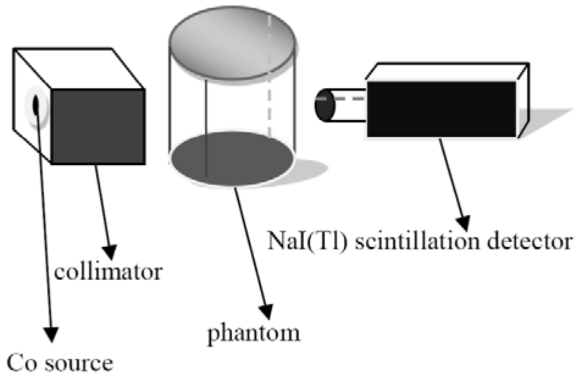

Fig. 1 Experimental setup

C. Determination of Attenuation Coefficient s and Half Value Layer

Intensity of collimated beam for monochromatic gamma radiation passing through an absorbent material of uniform composition may be determined by using attenuation equation of Beer-Lambert as follows:

$$I = I_o e^{-\mu_L x} \quad (1)$$

However, Co-60 has two energy peaks with the same abundances with 100%. Therefore, it was taken account as mean energy value 1.25 MeV.

Since I and I_o are measured experimentally for the phantoms of a given thickness, μ_L may be calculated from;

$$\mu_L = - x \ln (I/I_o) \quad (2)$$

which is related to the density ρ of the material and the mass attenuation coefficient μ_m , by means of following expression;

$$\mu_L = \mu_m \rho \quad (3)$$

The mass attenuation coefficient depends on the constitutive elements of material. Additionally, the half value layer (HVL) was calculated as fallows (μ is the mass attenuation coefficient;

$$HVL = 0.693/\mu \quad (4)$$

D. Backscattering Calculation

Firstly, backscatter factor (*BSF*) should be determined and then evaluation can be done for the media. Experimental determination of the based on an ionization technique requires a somewhat different approach although it is desirable to base the theoretical and experimental approaches on a similar formalism. Therefore, the backscatter factor (*BSF)*, which defined as a water kerma ratio can be written as;

$$BSF = \frac{K_{air,s}[(\mu_{en}/\rho)_{W,air}]_s}{K_{air,f}[(\mu_{en}/\rho)_{W,air}]_f} \quad (5)$$

where $K_{air,s}$ is the air kerma that measured at the surface of the water phantom, $K_{air,f}$ is the air kerma at the same point in space in the absence of the phantom and $(\mu en/\rho)_{w,air}$ is the ratio of the mass energy absorption coefficients for water and air in the presence of scattering medium and in free space [6].

In fact, the backscattering determined through the measurement of air kerma will have an uncertainty resulting from the non-monochromatic spectral distribution of the photon fluencies, with and without the phantom, on the ratio of the mass energy absorption coefficients [7]. The magnitude of this uncertainty depends on how much the spectra differ.

III. Experimental Procedures

The experimental geometry is important for the reliability of the technique [8]. Therefore, narrow-beam geometry was used during the experiments. The count rates were measured in the same geometry for all samples, and the net counting rates were determined subtracting the background counts from the measured counts [9]. Each data set was recorded during a counting time of 300 s. Experiments were repeated at least three times and the average net count rates were calculated for each analysis.

Densities of the phantoms are measured by using accurate balance equipment and density levels of the phantoms that are made of same materials were found similar as expected.

IV. Results and Discussion

The results for different phantoms with different dimensions by using Co-60 gamma radiation source were given in Table II.

TABLE II
Results of the Experiments

Phantom Material	CODE	I(mR/h)	I/I_o	μL (cm^{-1})	μ_m (cm^2/g)	HVL (cm)
Water	A	0.1815	0.606	0.0576	0.0576	12.023
	B	0.1654	0.552	0.0567	0.0567	12.211
	C	0.1378	0.460	0.0563	0.0563	12.31
Paraffin	A	0.1902	0.635	0.0568	0.064	12.2
	B	0.1618	0.536	0.0570	0.064	12.16
	C	0.1402	0.469	0.0557	0.063	12.4
Wood	A	0.18406	0.613	0.0560	0.0625	12.375
	B	0.16467	0.55	0.0570	0.0636	12.16
	C	0.1383	0.461	0.0560	0.0625	12.375

From Table I the relative absorbed dose graphs for three phantoms which they were made of water, paraffin and wood are given in Figs. 2-4 respectively.

From Table I the relative absorbed dose graphs for child, women and man phantoms are given in Figs. 5-7 respectively.

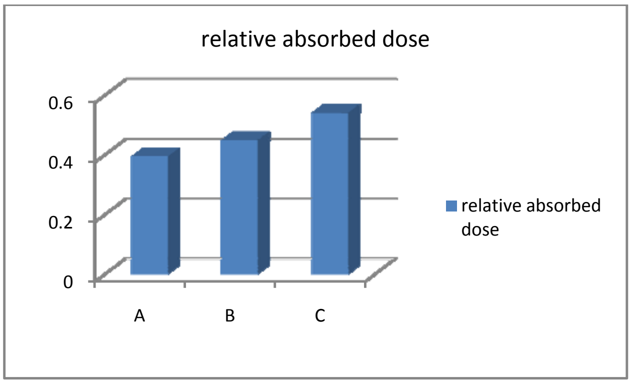

Fig. 2 Relative absorbed dose graphs for water phantoms

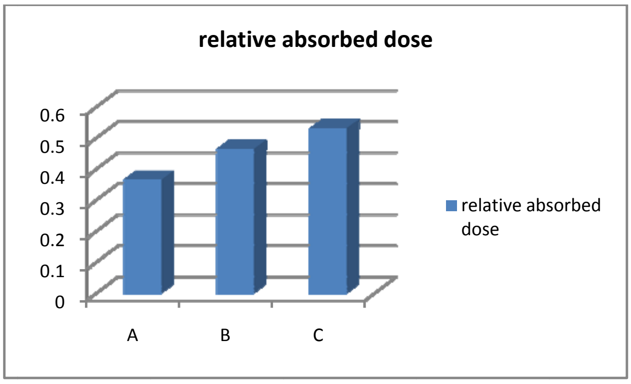

Fig. 3 Relative absorbed dose graphs for parafine phantoms

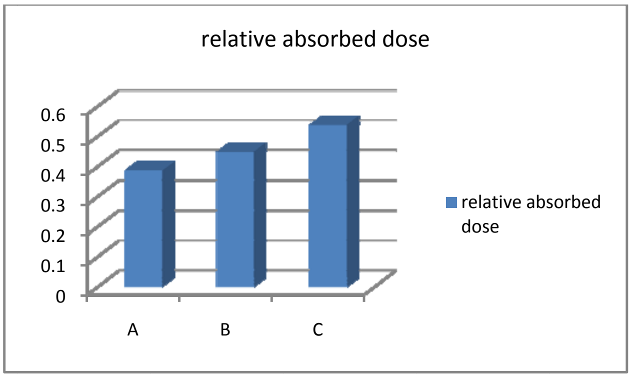

Fig. 4 Relative absorbed dose graphs for wood phantoms

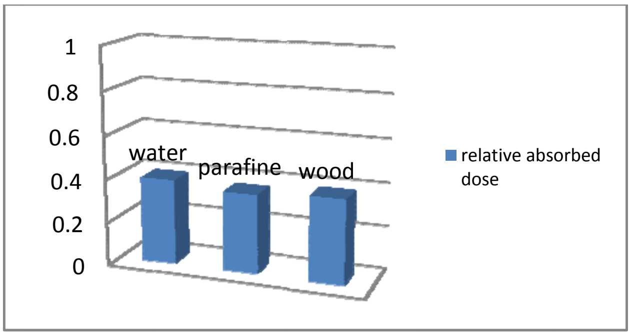

Fig. 5 Relative absorbed dose graphs for child phantoms

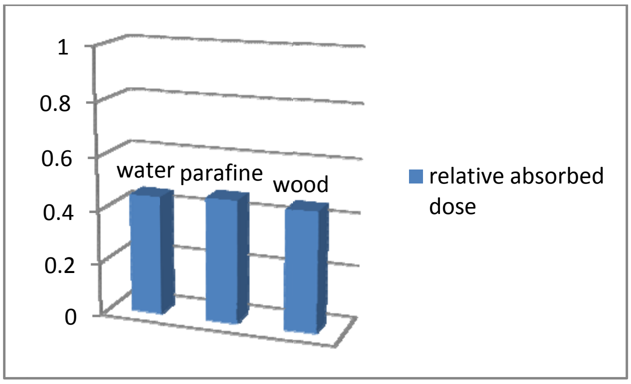

Fig. 6 Relative absorbed dose graphs for women phantoms

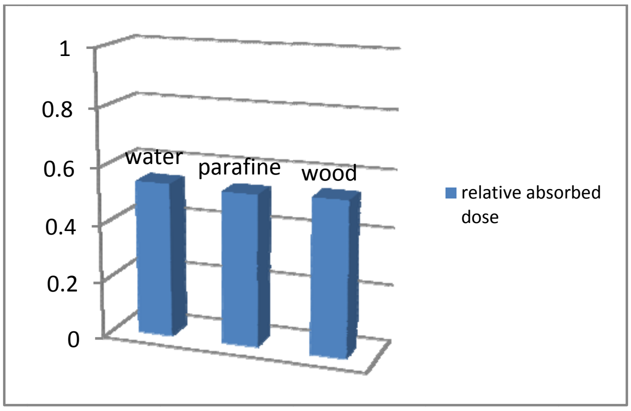

Fig. 7 Relative absorbed dose graphs for man phantoms

Backscattering factors (BSF) were calculated and tabulated in Table III.

TABLE III
BACKSCATTERING FACTORS FOR THE PHANTOMS

PHANTOM MATERIAL	CODE	Backscattering factor (BSF)
Water	A	1.00094
	B	0.00107
	C	0.00128
Parafine	A	1.00087
	B	1.00109
	C	1.00127
Wood	A	1.00092
	B	1.00107
	C	1.00128

V. CONCLUSION

With this study, dose evaluation for thyroids during Co-60 therapy evaluated experimentally. Phantoms which made of three different materials were used for the study. After the experiments, it is understood that water, paraffin and wood can be used instead of each other because of the results were approximately similar. Therefore, it is shown that the water, paraffin and wood can use for dose evaluation.

Three different neck phantoms were used for the simulation of different patients as child, women and man. Attenuation of the radiation related with the dimension of the neck.

Therefore, the absorbed dose is greater for man than the others.

Values of backscattering factors (BSF) are very closely for the phantom materials that can be seen in Table III. However, water and wood more convergent to each other. That means; water, paraffin and wood can be used as phantom materials successfully

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Kısınma, Deniz was born in Istanbul. She graduated from AdileMermerci Anatolian High School in 2006. She studied Physics in Yıldız Technical University and finished in 2011. She joined in a summer school which was about Atomic Simulation in SISSA Trieste, Italy in 2011. She has studied as a master student Radiation Science and Technology department in Energy Instiute since 2012.

Tugrul, A. Beril was born in Bursa. After finishing of the Bursa College, she graduated Istanbul Technical University (ITU) in 1973 as Mechanical Engineer. She also graduated from ITU Institute for Nuclear Energy (INE) in 1975 and gained MSc degree on nuclear safety.

She worked in Turkish Atomic Energy Authority as Expert and Group Leader for site selection of the first nuclear power plant between 1974 and 1977. She moved to ITU Institute for Nuclear Energy as Research Assistant in 1977. She gained PhD degree in 1984 She became Assistant Prof. in 1987, Assoc. Prof. in 1988 and lastly Prof. in March 1995. She was Vice Director at ITU-INE in 1988 – 1999 and Head of Nuclear Applications Division in 1997-2001. She was consulting member of Turkish Airlines in 1993-1996 on NDT. She has directed many of research Project and has been Professor in ITU Energy Institute as head of Nuclear Researches Division and has been lecture in Gebze Institute of High Technology and also Military Academia on energy policy.

Prof. Tugrul, has a member of Turkish Atomic Energy Commission since June 2011. She was Vice president Turkish Atomic Energy Authority - Nuclear Safety Committee in 1998-2000. She was also member of Turkish Atomic Energy Authority – Consulting Committee between 1997 and 2003. She has over 250 publications. 38 of them have in international indexes. 42 MSc students and 14 PhD students have graduated under her supervising. She gained many publication awards from ITU, Turkish Scientific and Technology Council and Turkish Scientific Academy. She gained an energy-scientific award from ICCI in May 2011 and also gained a women Scientist award in March 2012.