Absorbed Dose in the Uterus of a Three Months Pregnant Woman Due to 131I

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Absorbed Dose in the Uterus of a Three Months Pregnant Woman Due to ^{131}I

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Abstract. The use of ^{131}I is widely used in diagnostic and treatment of patients. If the patient is pregnant the ^{131}I presence in the thyroid it becomes a source of constant exposition to other organs and the fetus. In this study the absorbed dose in the uterus of a 3 months pregnant woman with ^{131}I in her thyroid gland has been calculated. The dose was determined using Monte Carlo methods in which a detailed model of the woman has been developed. The dose was also calculated using a simple procedure that was refined including the photons´ attenuation in the woman organs and body. To verify these results an experiment was carried out using a neck phantom with ^{131}I. Comparing the results it was found that the simple calculation tend to overestimate the absorbed dose, by doing the corrections due to body and organs photon attenuation the dose is 0.14 times the Monte Carlo estimation.

Keywords: Monte Carlo, Dosimetry, Thyroid gland.
PACS: 87.53.Wz; 87.58.Sp

INTRODUCTION

The use of radiation, for diagnostics or treatment, in pregnant women causes stress in family members and physicians. The damage induced by ^{131}I depends upon gender, age and the distance between the organ that retains the ^{131}I and the organ or tissue of interest [1]

Diseases related to thyroid gland, like hyper and hypothyroidism, appears in women during pregnancy thus, she and her fetus are vulnerable. Therefore, before radiation is used a balance between risks and benefits must be performed [1]. Fetus from 0 to 2 months reaches the largest average dose when the pregnant women receives ^{131}I [2, 3], therefore is important to determine the dose received by the fetus, however known dosimetric methods fails in this particular case [4].

The aim of this study was to determine the absorbed dose in the uterus of a 3 month pregnant woman.

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MATERIAL AND METHODS

Using MCNP 4C Monte Carlo code [5] a 3D model of a 3 month pregnant woman was made. The model describes a 56 kg and 168 cm height woman, it includes several organs and tissues, as well as a 3 month pregnant woman uterus; the model was made according to recommendations given by Cristy and Eckerman [6]. In Fig. 1 the model is shown.

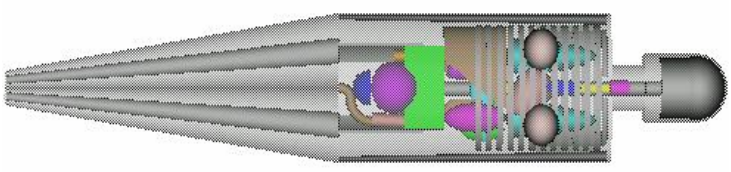

FIGURE 1. Model of a woman with 3 months of pregnancy

During calculations the source term was located in the thyroid gland which was filled with ^{131}I. It was assumed that only emits photons. Individual photons were transported from thyroid to the uterus were the absorbed energy per unit mass of the uterus, D_{hvi}, was calculated. Total absorbed dose was obtained through the weighted sum; here, the weights are the decay fraction, p_i, as is shown in equation 1.

$$D_{UTERUS} = D_{hv1}\, p_1 + D_{hv2}\, p_2 + D_{hv3}\, p_3 + D_{hv4}\, p_4 + D_{hv5}\, p_5 + D_{hv6}\, p_6 \qquad (1)$$

The absorbed dose was also calculated using equation 2, that includes ^{131}I Gamma factor: 2.42 cGy-cm^2-h^{-1}-mCi^{-1} [7], the source activity A, and thyroid-to-uterus distance, both assumed as point-like. This calculation was improved including the photon attenuation in the woman's body. A water-based neck phantom, with two assay tubes with ^{131}I as thyroid glad, was used to measure the dose.

$$D_U = \Gamma_D \frac{A}{r^2} \qquad (2)$$

RESULTS

From Monte Carlo calculations the absorbed dose in uterus is $(1.35 \pm 0.21)\text{x}10^{-8}$ MeV-g^{-1} per disintegration; this becomes $(8.00 \pm 1.24)\text{x}10^{-11}$ Gy/mCi. Using equation (2), the absorbed dose in uterus is $2.00\text{x}10^{-9}$ Gy/mCi. With the neck phantom the measured and calculated dose are shown in figure 2.

The absorbed dose obtained with equation (2) is 25 times larger to the Monte Carlo calculated dose in uterus, this is because in equation (2) there is vacuum between the point-like thyroid and point-like uterus. Adding a photon attenuation factor, $e^{-\mu x}$, where μ is 0.09 cm^{-1} is the linear attenuation coefficient of woman body, the absorbed dose is $1.10\text{x}10^{-11}$ Gy/mCi that is 0.14 times the dose obtained with Monte Carlo. Comparing the dose measured with the neck phantom with the calculated doses can be

noticed that both agrees except in the point located at 10 cm from thyroid, this is because at a such short distance any variation modifies the measurement.

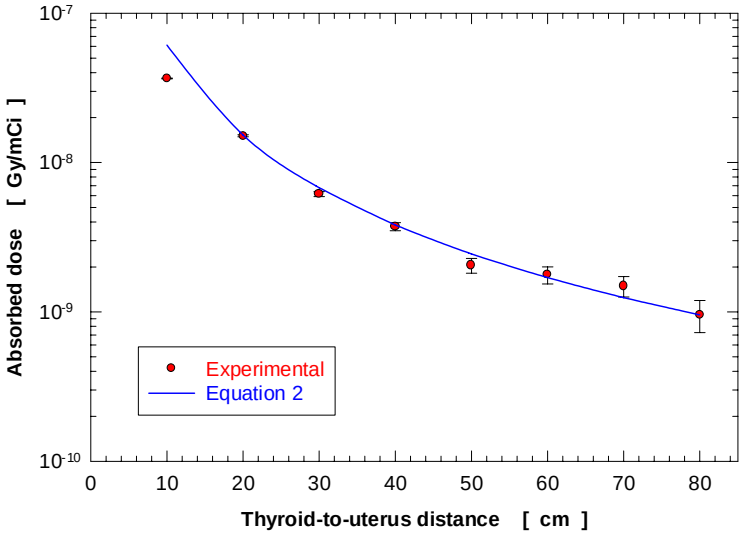

FIGURE 2. Calculated and measured absorbed dose with the neck phantom.

For diagnostic or treatment purposes where the ^{131}I is involved, the patient receives a dose that is compensated by the search of health. If the patient is female, it is necessary to check if she is pregnant with the aim to avoid affecting the product. Through Monte Carlo calculation has been found that a 3-month pregnant woman with ^{131}I in her thyroid receives an absorbed dose in her uterus of 8.00×10^{-11} Gy/mCi.

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