FETUS ABSORBED DOSE EVALUATION IN HEAD AND NECK RADIOTHERAPY PROCEDURES OF PREGNANT PATIENTS

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Abstract

Each year a considerable amount of pregnant women needs to be submitted to radiotherapeutic procedures to combat malignant tumors. Radiation therapy is often a treatment of choice for these patients. It is possible to use shielding and beam positioning such that the potential dose to the fetus can be minimized. In this work the head and neck cancer treatment of a pregnant patient was experimentally simulated. The patient was simulated by an anthropomorphic Alderson phantom and the absorbed dose to the fetus was evaluated using micro-rod TLD-100 detectors in two conditions, namely protecting the patient's abdomen with a 7 cm lead layer and using no abdomen shielding. The aim of this experiment was to evaluate the efficiency of the abdomen protection in reducing the fetus absorbed dose. Irradiations were performed with a Trilogy linear accelerator using x-rays of 6 MV. A total dose of 50 Gy to the target volume was delivered. The fetus doses evaluated with and without the lead shielding were, respectively, 0.52±0.039 and (0.88±0.052) cGy, corresponding to a dose reduction of 59%. The dose (0.52±0.039) cGy is within the zone of biological tolerance for the fetus.

Keywords: Radiotherapy; Head and Neck Cancer; Pregnant Patient; Dose to the Fetus.

1.- INTRODUCTION

Each year a considerable amount of pregnant women needs to be submitted to radiotherapeutic procedures to combat malignant tumors. Annually in the United States approximately 4000 pregnant women require treatment for cancer. Radiation therapy is often a treatment of choice for these patients [Stovall ***et al***, 1995]. The AAPM Task Group 36 [Stovall ***et al***, 1995] has published data and techniques to estimate the fetal dose resulting from maternal treatment with photons beams; furthermore, it is possible to use shielding and beam positioning such that the potential dose to the fetus can be minimized. Cygler and collaborators [1997] described the fetal dose for a 23 weeks pregnant patient that underwent mantle field irradiation for supradiaphragmatic Hodgkin's disease. The fetal exposure was limited to below 10 cGy, within the zone of fetal tolerance and a normal infant was delivered at term. In this work the head and neck cancer treatment of a pregnant patient was experimentally simulated. The patient was simulated by an anthropomorphic Alderson phantom and the absorbed dose to the fetus was evaluated using micro-rod TLD-100 detectors in two conditions, namely protecting the patient's abdomen with a 7 cm lead layer and using no abdomen shielding. The aim of this experiment was to evaluate the efficiency of the abdomen protection in reducing the fetus absorbed dose.

2.- MATERIALS AND METHODS

The pregnant patient was simulated by an Alderson anthropomorphic phantom. The phantom abdomen region was substituted by four solid water plates, forming a parallelepiped with dimensions of 30x20x20 cm^3, in order to facilitate the evaluation of the absorbed dose at the fetus position using thermoluminescent (TL) dosimeters (TLD), Figure 1. The TL dosimeters used were Harshaw micro-rod TLD-100 detectors with 5 mm length and base area of 1 mm^2. The dosimeter evaluation was carried out in a Harshaw TLD reader model 3500. Dosimeters annealing procedures were performed in a PTW TLDO automatic oven. The head and neck therapeutic irradiations were delivered by a

Trilogy linear accelerator using x-rays of 6 MV. A total dose of 50 Gy to the target volume was applied.

Figure 1 – Female Alderson anthropomorphic phantom used to simulate the pregnant patient. The phantom abdomen region was substituted by solid water plates.

Lead bricks were used to protect the patient uterus, forming a 7 cm thick layer, Figure 2. Irradiations were carried out with and without the lead layer in order to evaluate its efficiency in protecting the uterus region.

Figure 2 – Uterus region of the female phantom protected by the lead bricks layer.

The TL dosimeters were calibrated in the photon field generated by a ^{137}Cs source. A linear calibration curve was determined. The energy correction factor considering ^{137}Cs emitted photons and 6 MV x-rays was also determined. Individual sensitivity factors were applied to the TL response of each dosimeter in order to reduce their uncertainty.

Corrections factors for evaluation system variations were also applied. A group of six very stable TL dosimeters, reproducibility better than 1%, with a known response for a dose of 50 cGy, ^{60}Co, was always exposed under these conditions and evaluated together the dosimetry TLDs. Variations in the response of those control dosimeters were considered as variations in the sensitivity of the TL evaluation system. The final absorbed dose value, *D*, was determined using the TL dosimeters according to Equation 1:

$$D = (TL - TL_0).f_{cal}.f_s.f_E.f_c \quad (1)$$

where TL is the TL response of the TLD considered, TL_0 is the mean background TL response or the TL response of an unexposed dosimeter, f_{cal} is the calibration factor obtained from the calibration curve, f_s is the sensitivity factor, f_E is the energy dependence factor and f_c is the TL system control factor. Nine dosimeters were used in each procedure of fetus absorbed dose evaluation, namely, with and without lead shielding and the measured average doses were considered as the fetus dose in each situation.

The annealing procedure applied to the dosimeters before irradiation was 400°C for 1 hour plus 100°C for 2 hours. Before read-out the detectors were annealed at 100°C for 15 minutes.

Head and Neck treatments were carried out for gantry angles of 0, 90 and 270°. The collimator was always positioned at 90°.

3.- RESULTS

Figure 3 presents the linear calibration curve determined for the micro-rods TL dosimeters using ^{137}Cs radiation field. The curve was obtained for doses between 0.2 and 50 cGy. Equation (2) fits the experimental results:

$$D = 0.0003.TL - 1.4366 \quad (2),$$

where D is the absorbed dose in cGy and TL is the dosimeter reading.

The energy correction factor evaluated was 1.2.

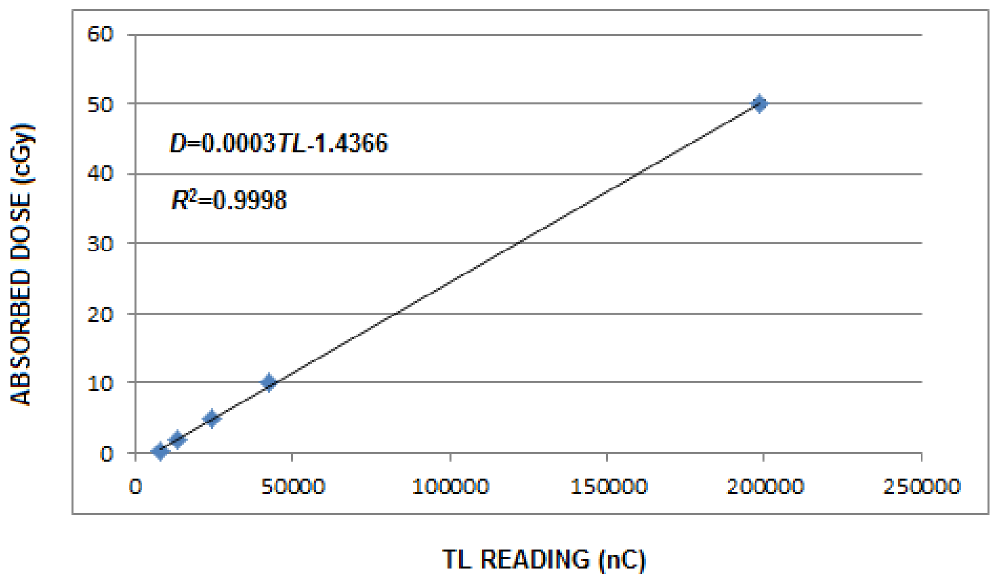

Figure 3 – Micro-Rod TL dosimeters calibration curve.

The absorbed dose evaluated at the fetus position when the patient abdomen is unprotected was (0.88±0.052) cGy (5.83%, 1σ). When the fetus region is protected by a lead layer of 7 cm thickness, the absorbed dose value to the fetus is reduced by 59% and a value of (0.52±0.039) cGy (7.52%, 1σ) is measured.

4.- DISCUSSION

The lead layer used was efficient, being able to reduce the absorbed dose at the fetus position in 59%. For a head and neck radiation treatment delivering 50 Gy to the target volume, the absorbed dose to the fetus evaluated was (0.52±0.039) cGy. This value is acceptable and the probability of future radiological problems to the fetus may be considered not important [Stovall ***et al***, 1995].

1. CONCLUSIONS

It is possible, when necessary, to delivery head and neck radiotherapy procedures to pregnant patients by protecting the patient uterus region with a lead layer of 7 cm thickness. The absorbed dose value to the fetus is reduced in more than 50%, being about (0.52±0.039) cGy, thus reducing very much the probability of radiological consequences to the fetus.

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