TLD determination of neutron dose contribution in medical linac

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Recibido el 10 de marzo de 2010; aceptado el 31 de agosto de 2010

The increased use of LINACs with accelerating voltage higher than 10 MV in clinical radiotherapy is producing an increasing demand of accurate dosimetric measurements of the photon induced neutron contamination of the radiotherapy beams, due that the associated bremsstrahlung X rays may produce neutrons as a result of subsequent photonuclear reactions with the different materials constituting the accelerator head. Thermal neutron fluences can be measured with TLD-600/TLD-700 pairs arranged in both a bare and a cadmium (Cd) foil covered methacrylate box. Neutron response of TL dosemeters irradiated with two different neutron sources has been investigated. The shape of the glow curve of these TLDs after irradiation in a medical LINAC and in a PuBe neutron source has been studied to verify the contribution of neutrons to an additional dose to staff, patients and the general public, due to photonuclear reactions generating neutrons from medical LINACs.

Keywords: Thermoluminescence; dosimetry; accelerators

El uso creciente en radioterapia clínica de LINACs con voltaje de aceleración superior a los 10 MV está produciendo una demanda cada vez mayor de medidas dosimétricas exactas de la contaminación del haz de radiación por neutrones inducidos por fotones, debido a que los rayos X de Bremsstrahlung pueden producir neutrones como resultado de reacciones fotonucleares subsecuentes con los diversos materiales que constituyen el cabezal del acelerador. Las fluencias de neutrones térmicos se pueden medir con parejas TLD-600/TLD-700 cubiertas con cadmio o sin cubrir en una caja de metacrilato. Se investigó la respuesta de los dosímetros TL ante neutrones irradiándolos con dos fuentes de neutrones distintas. Se estudió la forma de la curva TL de estos TLDs después de que fueron irradiados en un LINAC de usos médicos y en una fuente de neutrones de PuBe para verificar la contribución de neutrones a una dosis adicional para el personal, pacientes y el público en general, debido a las reacciones fotonucleares que generan neutrones en los LINACs de uso médico.

Descriptores: Termoluminiscencia; dosimetría; aceleradores.

PACS: 78.60.Kn; 87.50.sj; 87.56.bd

1. Introduction

Among the uses of the ionizing radiation a number of medical applications exist, for example to inhibit the growth of cancerigenic cells by means of the X-ray and obtaining images for diagnosis. This fact provides one better quality of life, considering the possible risks that its use entails. To date the equipment most used for X ray radiation therapy are the linear accelerators (LINACs) which are able to emit high energy photons and electrons. Neutron dosimetry is very important in this type of equipment due to the complexity of the nuclear reactions generate them.

In the treatment room capture gamma rays and neutrons are produced, generated by the structural materials of the accelerator head [1], it is for this reason that the objective of this work is to determine the absorbed dose due to photons and neutrons using thermoluminescent dosimeters (TLDs) from the point of view of the radiation protection.

2. Experimental methods

For discriminating between gamma radiation and neutrons pairs of TLDs (TLD-700/TLD-600) were used in this study due that TLD-700 (^{7}LiF:Mg,Ti) is unable to detect neutrons meanwhile TLD-600 (^{6}LiF:Mg,Ti) detects both neutrons and gammas [2]; then subtracting the TLD-700 readout from the TLD-600 readout we obtained the contribution of neutrons and gammas in the mixed field (n + γ).

Previously to determinate the neutron and gamma contribution in the treatment room, TLDs were characterized separately in neutron and gamma fields using a Pu-Be neutron source and a linear accelerator respectively.

TLD-600 were placed in an acrylic disc and exposed to a previously thermalized neutron flux of 1.4×10^4 n/cm$^2\cdot$s from the Pu-Be source (Monsanto MRPUBE-397). Neutron absorbed dose was determined using the conversion factor neutron fluence to absorbed dose given in the ICRP 74 publication [3].

For determining neutron and gamma dose in the treatment room, pairs of (TLD-700/TLD-600) were placed in the

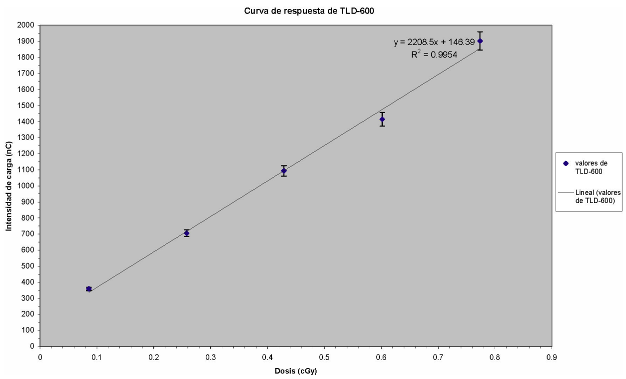

FIGURE 1. TLD-600 response as a function of neutron absorbed dose.

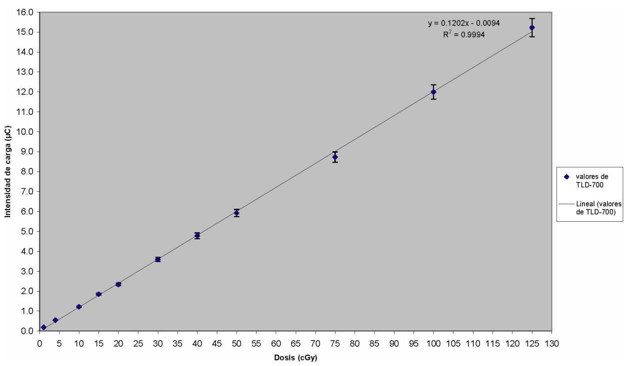

FIGURE 2. TLD-700 response as a function of 18 MV LINAC X-rays.

TABLE I. Neutron and gamma absorbed doses obtained in three positions in the paraffin-wax phantom as measured with pairs TLD-600/TLD-700

TLD-600/TLD-700 pair	Neutron absorbed dose (cGy)	18MV X-rays absorbed dose (cGy)
Surface of the phantom	0.08 ± 0.02	0.98 ± 0.02
Middle of the phantom	0.47 ± 0.02	19.53 ± 0.02
Bottom of the phantom	0.78 ± 0.02	14.14 ± 0.02

surface, in the middle and in the bottom of a paraffin-wax phantom and exposed to 1000 UM from the LINAC Varian 21EX operating at 18 MV with closed collimator at a distance of 1 m.

TL readings were performed using a TL analyser Harshaw model 3500, integrating from 100°C to 400°C during 30 s at a heating rate of 10°C/s. All TL readings were made in Nitrogen atmosphere to avoid spurious signals.

3. Results

Figure 1 shows the TLD-600 response as a function of neutron absorbed dose which was linear in the range of 0.1 to 0.75 cGy; meanwhile, TLD-700 response as a function of X-ray (18 MV) absorbed dose was linear from 1 to 125 cGy as is shown in Fig. 2.

Table I shows the neutron and gamma absorbed doses obtained in three positions in the paraffin-wax phantom as measured with pairs TLD-600/TLD-700.

4. Conclusions

Results showed that pairs TLD-600/TLD-700 were appropriate for determining the contribution of neutrons and gammas in a mixed radiation field. Experimental neutron dose obtained in the position of the patient are less than the limit established in the Report NCRP 79 [1]. Paraffin-wax phantom constructed to make the measurements was appropriate to thermalize the neutron produced in the accelerator head.

1. NCRP, Recommendations of the National Council on Radiation Protection and Measurements *"Neutron contamination from medical electron accelerators"* (NCRP Report 79, Bethesda, MD 1984).
2. J. Azorín, "*Luminescence Dosimetry. Theory and Applications*" Ed. Técnico-Científicas, (México 1990).
3. ICRP, International Commission on Radiation Protection, "*Conversion coefficients for use in radiological protection against external radiation*" (ICRP Publ. 74, 1997).