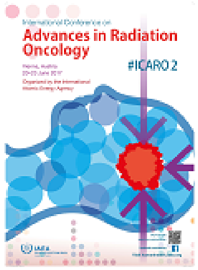

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Measurement of fast neutron contamination caused by presence of wedge and block by CR-39 detector

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Introduction: In some radiation therapy protocols, beam modifiers are used to modify the radiation spectrum. Among the most common modifiers are block, wedge filter, flattening filter, multi-leaf collimator and asymmetric jaws. Medical linear accelerators which produce photons with energies higher than 8 MV, impose an unwanted dose to patients due to neutron production. Neutron is primarily produced due to collision of high energy photons with high Z materials which exist in the components of the head of accelerator. Nowadays, secondary cancer resulted from radiation therapy is a growing concern, and exposing patients to unwanted neutrons is considered as one of the most important causes of secondary cancers in patients who are irradiated with high-energy photon beams. Therefore our knowledge of the relevant patients dose incurred from radiotherapy is of utmost importance. Various instruments can be used to measure neutrons including thermoluminescent dosimeters, bubble detectors, and solid state dosimeters. One of the most common and most widely used solid-state nuclear track detectors is CR-39. There are many advantages for CR-39 film dosimetry approach such as insensitivity to ultraviolet and X-ray, archiving of recorded tracks, and similar composition to human tissues. Furthermore, this type of detector tends to be more sensitive to fast neutrons, and make up a suitable choice for fast neutron dosimetry purposes.

Material and method: CR-39 detectors were used for measurement of fast neutron equivalent dose. Neutron contamination arising from presence of 30˚, 45˚ and 60˚ angles wedges and a cerrobend block were measured. Films were calibrated by an Am-Be source. Three detectors were not exposed, but kept exactly under the same condition as sample films for estimation of background neutron dose. The studied linear accelerator was a Siemens Primus with 15 MV photon energy at the Reza Radiation Oncology Center (Mashhad, Iran), and the neutron contamination was measured for an open field and three wedges (30˚, 45˚ and 60˚ angles). In order to estimate neutron contamination in the presence of a block, a piece of cerrobend block (1.5 × 1.5 × 7.0 cm3) was made and measurements were carried out in the presence of the block on the central axis of the photon beam. All measurements were carried out at source to surface distance (SSD) of 100 cm in a 10 × 10 cm2 photon field. Fast neutron equivalent doses were obtained in a 30 cm × 30 cm × 30 cm Perspex phantom at 0.5, 2, 3, and 4 centimeter depths. Measured values were based on irradiation of 1 Gy photon dose at the depth of maximum dose. CR-39 detectors chemical etching was carried out in sodium hydroxide (NaOH) solution of 6.25 M concentration at 85˚C for 3 hours.

Results: As presented in the Table, the fast neutron equivalent dose (mSv/Gy) for 45-degree wedge at 0.5 cm phantom depth has caused the highest value and the lowest value (zero) is obtained at the depth of 4 cm of an open field.

The main reason for higher fast neutron equivalent dose in the 45-degree wedge is because the 45-degree wedge has a smaller wedge factor than the other wedges (the wedge factor for 30, 45 and 60-degree wedge are: 0.6, 0.4, and 0.43, respectively). Since MU value is divided by a smaller value for this wedge relative to the other wedge factors, the maximum MU value belong to 45-degree wedge (250 MU). Therefore, higher neutron contamination is produced when a higher monitor unit is applied. With increase in phantom depth, the fast neutron equivalent dose is reduced in all field types, but this reduction trend is not the same for the blocked field. The reason for the lack of similar reduction trend in the cerrobend blocked field may be because only a small portion of the 10 × 10 cm2 field is blocked, therefore, the contribution of block material in producing neutron contamination is smaller. As it is showed in the Table fast neutron dose equivalent values, in the 0.5 cm depth of phantom, are higher for all fields. So, superficial tissue receive higher fast neutron equivalent dose than the steeper depths.

Conclusion: The presence of wedge in the path of primary high energy photon beam increases to some extent the neutron contamination dose of the patients. Furthermore, the 45-degree wedge contributed a higher neutron contamination than the other wedges. The results of this study also showed that superficial tissues receive higher fast neutron equivalent dose than the steeper depths. It recommended taking into account the additional neutron dose in radiotherapy resulted from high energy photon beam in presence of wedge filter, or if possible, alternative methods such as field in field method can be used in radiotherapy to spare organs at risk.

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