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Essential considerations for accurate evaluation of photoneutron contamination in Radiotherapy

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HIGHLIGHTS

- The MCNPX® code was used to simulate the photoneutron production in the head of a medical LINAC (Varian Clinac 2100C/D 18 MV).
- Neutron ambient dose equivalent and energy spectrum were calculated for different field sizes at the patient table and inside the maze.
- Neutron energy changed with field size and also detector location.
- Neglecting the change in neutron energy lead to major uncertainty in dosimetry.
- Neutron ambient dose equivalent at the patient table changed with removing Radiation Therapy room from simulations.

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ABSTRACT

Nowadays, high-energy X-rays produced by medical linear accelerators (LINACs) are widely used in many Radiation Therapy (RT) centers. High-energy photons (> 8 MeV) produce undesired neutrons in the LINAC head which raise concerns about unwanted neutron dose to the patients and RT personnel. Regarding the significance of radiation protection in RT, it is important to evaluate photoneutron contamination inside the RT room. Unfortunately, neutron dosimeters used for this purpose have limitations that can under the best conditions cause to > 10% uncertainty. In addition to this uncertainty, the present Monte Carlo (MC) study introduces another uncertainty in measurements (nearly up to 20%) when neutron ambient dose equivalent ($H_n^*(10)$) is measured at the patient table or inside the maze and the change in neutron energy is ignored. This type of uncertainty can even reach 35% if $H_n^*(10)$ is measured by dosimeters covered by a layer of ^{10}B as converter. So, in these cases, neglecting the change in neutron energy can threaten the credibility of measured data and one should attend to this energy change in order to reduce measurement uncertainty to the possible minimum. This study also discusses the change in neutron spectra and $H_n^*(10)$ at the patient table caused by removing a typical RT room from MC simulations. Under such conditions, neutron mean energy ($\bar{E}_n$) overestimated by 0.2–0.4 MeV at the patient table. Neutron fluence (φ_n) at the isocenter (IC) was underestimated by 23–54% for different field sizes that caused $H_n^*(10)$ to be miscalculated up to 24%. This finding informs researchers that for accurate evaluation of $H_n^*(10)$ at the patient table, simulating the RT room is an effective parameter in MC studies.

1. Introduction

Nowadays, high-energy X-rays produced by LINACs are widely used in many RT centers. The usage of these beams, instead of low energy photons, has many advantages, such as good skin sparing, less scattering, sharp field edges, small penumbra, and uniform spatial dose distribution (Das and Kase, 1992; Vega-Carrillo and Baltazar-Raigosa, 2011). Despite such advantages, high-energy photons (> 8 MeV) produce undesired neutrons in the LINAC head (Khabaz et al., 2018; Khosravi et al., 2013; NCRP60, 1984; Vega-Carrillo et al., 2015, 2012)

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Conflict of interest

The authors have no conflicts of interest.

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