Thermal and resonance neutrons generated by various electron and X-ray therapeutic beams from medical linacs installed in polish oncological centers

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Abstract

Background

High-energy photon and electron therapeutic beams generated in medical linear accelerators can cause the electronuclear and photonuclear reactions in which neutrons with a broad energy spectrum are produced. A low-energy component of this neutron radiation induces simple capture reactions from which various radioisotopes originate and in which the radioactivity of a linac head and various objects in the treatment room appear.

Aim

The aim of this paper is to present the results of the thermal/resonance neutron fluence measurements during therapeutic beam emission and exemplary spectra of gamma radiation emitted by medical linac components activated in neutron reactions for four X-ray beams and for four electron beams generated by various manufacturers’ accelerators installed in typical concrete bunkers in Polish oncological centers.

Materials and methods

The measurements of neutron fluence were performed with the use of the induced activity method, whereas the spectra of gamma radiation from decays of the resulting radioisotopes were measured by means of a portable high-purity germanium detector set for field spectroscopy.

Results

The fluence of thermal neutrons as well as resonance neutrons connected with the emission of a 20 MV X-ray beam is \( \sim 10^6 \) neutrons/cm\(^2\) per 1 Gy of a dose in water at a reference depth. It is about one order of magnitude greater than that for the 15 MV X-ray beams and about two orders of magnitude greater than for the 18–22 MeV electron beams regardless of the type of an accelerator.

Conclusion

The thermal as well as resonance neutron fluence depends strongly on the type and the nominal potential of a therapeutic beam. It is greater for X-ray beams than for electrons. The accelerator accessories and other large objects should not be stored in a treatment room during high-energy therapeutic beam emission to avoid their activation caused by thermal and resonance neutrons. Half-lives of the radioisotopes originating from the simple capture reaction \( (n,\gamma) \) (from minutes to hours) are long enough to accumulate radioactivity of components of the accelerator head. The radiation emitted by induced radioisotopes causes the additional doses to staff operating the accelerators.

Keywords

Thermal/resonance neutrons; Induce radioactivity; Medical linacs