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Neutron Dose Estimation in Prostate Stereotactic Body Radiotherapy: Insights from Bubble Detector

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Abstract

Objectives:

Stereotactic body radiotherapy (SBRT) is widely used for prostate cancer treatment, delivering precise radiation doses while sparing normal tissues. However, high-energy photon beams in SBRT can produce neutrons, raising concerns about potential harm due to unaccounted-for neutron dose to the patient and the impact on implanted devices. This study estimates neutron doses in prostate SBRT plans and aims to optimize treatment and minimize risks associated with neutron doses.

Methods:

BN-PND neutron bubble detectors were used in this work. These detectors have been designed to be insensitive to photons. The detectors were placed in a water-filled tank within and outside the irradiated area. Neutron exposures were measured by identifying and numbering the bubbles formed within the gel matrix after irradiation, using a circle detection method. Measurements were performed using a Varian TrueBeam Linac, and neutron production was assessed at various plan energies (2.5 MV, 6 MV, 6 MV FFF, 10 MV, 10FFF and 15 MV).

Results:

No bubbles were observed at 2.5-MV beams, but bubbles were formed at 6-MV and 6-MV FFF beams, contrary to the conventional belief that neutron production primarily occurs above 8-MV beam energy, the binding energy per nucleon for high z materials. The analysis of bubble distribution also revealed a spatial variation, with the lowest number produced at places that primarily receive scatter radiation rather than direct exposure to the primary beam. Significant differences in neutron doses were observed between flattening filter (FF) and flattening filter-free (FFF) beams at the central beam position, suggesting that beam type affects neutron dose production.

Conclusion(s):

Our study shows the need for awareness of neutron-related risks even at lower energies. Beam type and the spatial variation of neutron production should be considered to optimize SBRT treatment programs and enhance treatment safety for patients with implanted devices. Further research is warranted to validate these findings in a clinical setting.