Investigation of ^{60}Co BEBIG High Dose Rate Brachytherapy Dose Distribution in Different Media Using GEANT4 Monte Carlo Simulation

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High Dose Rate (HDR) Brachytherapy (BT) using ^{60}Co source, uses radioactive sources placed inside patient's body, targeting tumour regions. Consequently, treatment planning is the main step in HDR-BT, which relies on the computer algorithm 'Treatment Planning System' (TPS). The current approach to TPS is based on the American Association of Physicists in Medicine (AAPM) Task Group No. 43 (TG-43) formalism. A major limitation of TPS is its assumption of homogeneous water for dose calculations without accounting for tissue heterogeneity, which can lead to inaccuracies in treatment planning. This study addresses this key limitation in TPS by exploring how different tissue densities and compositions affect dose distribution, focusing on the ^{60}Co BEBIG Co0.A86 HDR-BT source through GEANT4 Monte Carlo simulation. The source was modelled using GEANT4 (version 10.7.1). Validation was performed against TG-43 dosimetric parameters by simulating air kerma strength per unit source activity (S_k/A) and dose rate constant (Λ). Radial dose distributions were simulated in water and various tissues, including bone, lung, adipose tissue, and breast for different radial distances. The S_k/A and Λ values were calculated as 3.048×10^{-7} ±0.003 UBq^{-1} and 1.096 ± 0.012 $cGyh^{-1}$ U^{-1}, respectively. Significant variations in bone tissue relative to water were shown by calculated radial dose functions, with under-dosing as high up to 39.35%. Comparatively, minor over- and under-dosing was observed in the lung, adipose tissue, and breast tissue compared to the water medium. The study concluded that assuming water as a homogeneous medium in HDR-BT planning leads to inaccurate dose calculations. By considering the compositions and densities of various tissues, GEANT4 simulations combined with TPS can achieve more accurate dose distributions.

Keywords: *HDR Brachytherapy, ^{60}Co, GEANT4 Simulation, Dose Distribution, Tissue Heterogeneity*