Title: Numerical determination of dose distributions around applicators with radiation sources in HDR brachytherapy and radionuclide internal radiotherapy and their dosimetric verification.

Abstract

Both brachytherapy and its molecular variant, radionuclide internal radiotherapy, are significant methods of oncological treatment that face specific challenges. In high-dose rate (HDR) brachytherapy, a universally accepted method for verifying planned treatment has not yet been developed. In radionuclide therapy, dosimetric assessment is extremely challenging due to the lack of complete control over the introduced radiation source in the human body.

In this study, the utilization of an ArcCHECK detector for verifying planned treatment in HDR brachytherapy is proposed. Phantom irradiation was performed inside the detector according to an experimental treatment plan. The measurement results obtained from the detector were compared with Monte Carlo simulation results of the experimental setup. For radionuclide internal radiotherapy, dosimetric modeling of patients with neuroendocrine tumors treated with the somatostatin analog, radioactive lutetium-177, [^{177}Lu]Lu-DOTA-TOC, was conducted. The accurate determination of activity distribution in tissues and organs, as well as the consideration of biological elimination of the radiopharmaceutical from the body, pose fundamental challenges in this treatment method. The crucial parameters determining the absorbed dose in the tissue or organ were determined through quantitative analysis of SPECT-CT images.

The satisfactory agreement between the measured distribution and Monte Carlo simulation results confirms the potential of utilizing the ArcCHECK detector for verifying the quality of planned brachytherapy treatment. Such verification can primarily enhance the safety of brachytherapy application, expand its range of applicability, and improve treatment outcomes. The proposed new method of treatment planning verification can serve for evaluating planning systems as well as individual complex therapy plans. Implementing an effective dosimetric approach in radionuclide therapy will undoubtedly contribute to better protection of organs at risk and provide tools for quantitative assessment and comparison of the outcomes of targeted somatostatin receptor radionuclide therapy.