PhD Thesis Title: Dosimetric Evaluation of Influence of Heterogeneity and Efficacy of Various Plan Algorithms in Intensity-Modulated Radiation Therapy (IMRT) and Volumetric Modulated Arc Therapy (VMAT) Radiotherapy Plans in Tumors of Thorax

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ABSTRACT:

In the current medical landscape, advanced technologies have facilitated the precise delivery of tumoricidal doses to target areas while minimizing harm to surrounding normal tissues. Accurate and precise radiotherapy treatments hinge on thorough dosimetric evaluation prior to patient treatment. This study focuses on the dosimetric evaluation and validation of treatment planning algorithms in a realistic human body scenario, addressing the challenge of tumors located at varying positions within the thorax. The investigation encompasses state of the art radiation treatment techniques, intensity-modulated radiation therapy (IMRT) and volumetric arc therapy (VMAT). Dosimetry phantoms commonly available in the market often have uniform densities, which may not accurately represent the complexities of tumor locations within the human body. The objective was to create and validate physical dosimetry in a true human body-like situation. VMAT, step and shoot (ss)-IMRT, and dynamic (d)-IMRT plans were generated for patients with thoracic esophageal carcinoma, considering Left Lung Central Tumor (LCT) and Left Lung Peripheral Tumor (LPT). The study utilized the Computerized Imaging Reference System (CIRS) phantom with an inhomogeneous Racemosa wood cylinder. Two treatment planning algorithms, Monte Carlo (MC) and Pencil Beam (PB), from the Monaco treatment planning system (TPS), were evaluated for accuracy and efficacy. Gafchromic EBT3 films and the CIRS thorax phantom were employed for validation. Results indicate that VMAT and d-IMRT plans exhibited superior performance in terms of planning target volume (PTV) coverage, homogeneity index (HI), and uniformity index (UI) compared to ss-IMRT. Differences in Dmean and D95 were significant among the three techniques (VMAT, ss-IMRT, and d-IMRT). Additionally, both algorithms showed higher divergence in LPT compared to LCT, with the PB algorithm exhibiting greater deviation than the MC algorithm. The study suggests that a multi-arc VMAT technique may offer a better option with equivalent or superior dose distribution, uniformity, and homogeneity. The MC algorithm demonstrated more consistency for EBT3 measured dose in lung-equivalent heterogeneous mediums, although challenges remain due to electronic disequilibrium within and at the interface of inhomogeneity.

In conclusion, the findings emphasize the importance of accurate dosimetric evaluation in the context of diverse tumor locations and highlight the strengths and limitations of different treatment planning algorithms in modern radiation therapy. This study will open new avenues in the study of heterogeneity present in the target volume and the limitations of all commercially available algorithms. The study recommends that large data pool which are statistically significant may help in developing suitable algorithm which can provide better plans in the heterogeneous regions.

References to author publications that are specifically related to the dissertation:

1. **Atul Mishra**; Ramji Pathak; Kailash Kumar Mittal; Surendra Prasad Mishra; Sudesh Kumar Singh; Anoop Kumar Srivastava. "Comparative Dosimetric Evaluation of Volumetric-Modulated Arc Therapy (VMAT) Versus Intensity-Modulated Radiotherapy (IMRT) in Thoracic Esophageal Cancer". Iranian Journal of Medical Physics, 20, 3, 2023, 159-167. doi: 10.22038/ijmp.2022.61938.2047

2. **Atul Mishra**; Ramji Pathak; Teerth Raj Verma; Anoop Kumar Srivastava; Surendra Prasad Mishra; Kailash Kumar Mittal; Sudesh Kumar Singh. "Evaluation of Radiation Treatment Planning Algorithms in IMRT and VMAT: A Comparative Dosimetric Study in Lung Equivalent Heterogeneous Medium". Journal of Biomedical Physics and Engineering, 2023; 13(6): 503-514. doi: 10.31661/jbpe.v0i0.2206-1508
3. **Atul Mishra**; Ramji Pathak; Kailash Kumar Mittal; Anoop Kumar Srivastava; Maurya Surendrakumar Dayashankar; Surendra Prasad Mishra; Sudesh Kumar Singh. et al. “Efficacy of the Collapsed Cone Algorithm Calculated Radiotherapy Plans in Intensity-Modulated Radiation Therapy (IMRT) and Volumetric-Modulated Arc Therapy (VMAT): A Comparative Dosimetric Study in Tumors of Thorax”. Journal of Cancer Research and Therapeutics,2022, -