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Multicenter dosimetric consistency evaluation of IMRT and VMAT techniques based on AAPM TG119 Report and clinical cases

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ABSTRACT

Objective: To perform a multicenter evaluation of planning quality and dosimetric accuracy for intensity-modulated radiotherapy (IMRT) and volumetric modulated arc therapy (VMAT), using both standardized American Association of Physicists in Medicine (AAPM) Task Group 119 (TG-119) test cases and complex real-world clinical scenarios. The goal is to comprehensively assess the overall implementation accuracy of IMRT systems across multiple institutions.

Methods: Four TG-119 test cases and five clinical cases—including nasopharyngeal carcinoma (T2/T4), esophageal carcinoma, breast carcinoma, and cervical carcinoma—were selected. Five radiotherapy centers in Fujian Province independently generated IMRT and VMAT plans using their respective treatment planning systems and linear accelerator models, adhering to the prescription guidelines from both TG-119 report and Fujian Cancer Hospital. Then the plan quality scores (QS) across multicenters were compared. Meanwhile the dosimetric delivery accuracy of these plans were evaluated through point dose measurements, 2D planar and 3D volumetric dose verification. Subsequently, inter-center comparisons were performed for point dose deviations (DD) and γ passing rates based on the 3%/2 mm criteria. Finally, confidence limits (CLs) were calculated for QS, DD and γ passing rates to quantify the consistency in plan quality and dosimetric performance.

Results: In TG-119 test cases, CL values of plan quality score, point dose deviation, 3D γ passing rate were 0.6, 0.037, 9.09 for IMRT, and 0.66, 0.032 and 8.20 for VMAT, respectively. In clinical cases, they were 2.74, 0.031 and 8.85 for IMRT, 2.86, 0.033 and 7.62 for VMAT, respectively. All results met established quality assurance (QA) thresholds, with increased variability observed in more complex clinical scenarios.

Conclusion: This multicenter study validated the clinical feasibility and dosimetric reliability of IMRT and VMAT systems by integrating standardized benchmarks with real-world clinical cases. The derived regional CL provide practical reference values for evaluating the performance of existing or newly implemented IMRT/VMAT systems, thereby supporting standardization and enhancing confidence in clinical application.

1. Introduction

Intensity-modulated radiation therapy (IMRT) is an advanced radiotherapy technique widely used in clinical oncology. By modulating the beam intensity within each irradiation field using multi-leaf

collimator (MLC) technology, IMRT enables highly conformal dose distributions to tumor volumes while effectively sparing surrounding healthy tissues.¹ IMRT can be delivered through several modalities, with Fixed-field IMRT and volumetric modulated arc therapy (VMAT) being the two common clinical approach. In VMAT, parameters such as dose

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