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Original article

A comparative analysis of setup accuracy between 6D and 3D treatment couches in radiotherapy for lung cancer with brain metastases☆

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ABSTRACT

Objective: To evaluate the accuracy of six-dimensional (6D) treatment couches in minimizing setup errors compared with three-dimensional (3D) treatment couches during radiotherapy for lung cancer patients with brain metastases.

Methods: A retrospective analysis was conducted on 40 lung cancer patients with brain metastases who received stereotactic radiotherapy (SRS/SRT) for brain metastases. The cohort was divided into two groups based on the availability of treatment units at the time of planning: 20 patients were treated using a 3D couch, and 20 patients with a 6D couch. Daily cone-beam computed tomography (CBCT) registration was used to measure residual setup errors in the x, y, and z axes at two key cranial anatomical landmarks, specifically the internal acoustic meatus (IAM) and crista galli (CG), for both groups. The Shapiro-Wilk test was applied to assess the normality of the data, and the Mann-Whitney U test was performed to determine statistical differences between the two groups, with Bonferroni correction for multiple comparisons.

Results: Baseline data indicated that the two groups were well-balanced in terms of gender, age, and distribution of pathological types, number of brain metastases, maximum metastases volume, and relative distance between metastases and isocenter ($P > 0.05$). Setup error data in all directions (IAM_$x/y/z$, CG_$x/y/z$) did not follow a normal distribution ($P < 0.05$). The Mann-Whitney U test revealed that setup errors in the 6D group were significantly smaller than those in the 3D group across all directions (IAM_$x/y/z$, CG_$x/y/z$, all $P < 0.001$). The mean error reduction exceeded 1 mm in all directions, with the most significant difference observed in the CG_X direction: 2.2 (1.3, 3.3) mm in the 3D group versus 0.3 (0.2, 0.5) mm in the 6D group, representing a difference of 1.9 mm.

Conclusion: The six-dimensional (6D) treatment couch effectively minimizes residual setup errors, especially rotational ones, in radiotherapy for lung cancer patients with brain metastases.

1. Introduction

Lung cancer brain metastases pose a significant threat to patient survival, with radiotherapy serving a primary treatment modality.[1,2] Recent advances in intensity-modulated radiotherapy (IMRT) and stereotactic radiosurgery/radiotherapy (SRS/SRT) techniques have enabled precise targeting of metastatic lesions[3] Meanwhile, advances in systemic pharmacotherapy have shown many patients can achieve comparable therapeutic outcomes by irradiating only the metastases, omitting whole-brain radiotherapy and thus significantly lowering associated toxicities. However, this strategy requires precise positioning.[4] Traditional three-dimensional (3D) treatment couches address basic positioning errors through translational shifts (anterior-posterior, left-right, superior-inferior), and the integration of image-guided radiotherapy (IGRT) techniques, such as cone-beam computed tomography (CBCT), has markedly improved the accuracy of radiotherapy.[5,6]

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