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Utilizing Deformable Registration in Evaluation of Anatomic and Dosimetric variation in Stereotactic Body Radiation Therapy for Lung Cancer

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Introduction

Stereotactic body radiation therapy (SBRT) is a newly developed radiation treatment techniques for extracranial tumors characterized by very high dose per fraction. However, despite the increasing usage of SBRT in lung cancer treatment, there is currently lack of clear guideline which defines the extent of anatomic variations that might exceed the planned margins; and the necessity of treatment re-planning to avoid significant dosimetric deviation during the treatment course. This study investigates the inter-fraction variations of lung tumors treated with SBRT and their association with deviation of dose delivered to targets and organs at risk (OARs)

Objectives

The objective of this study is to provide insights of adaptive SBRT and suggest some quantitative criteria for the need of re-planning in the presence of anatomic changes.

Methodology

Nineteen patients with non-small cell lung carcinoma or pulmonary oligometastases treated with SBRT were retrospectively recruited. The anatomic variations as revealed in daily cone-beam computed tomography (CBCT) images were evaluated in terms of internal target volume (ITV) changes, center of mass (COM) displacement, Dice similarity coefficient (DSC) of ITV and planning target volume (PTV). Deformable registration was used to deform the planning computed tomography (PCT) images to the CBCT images for more accurate dose calculation with the original treatment plan. Dosimetric comparison was carried out between the planned dose and actual dose regarding dose per fraction and accumulated dose. The relationship between the anatomic variation and dosimetric deviation was then analyzed by correlation test.

Result

No statistically significant trend was found in the ITV volume, COM displacement, ITV DSC and PTV DSC over the treatment course. However, twelve patients (63%) demonstrated similar tendency of ITV volume changes, with tumor expansion from the

first fraction and tumor shrinkage by the final fraction.
From dosimetric evaluation, the actual delivered dose in terms of PTV coverage, dose conformity and low dose spillage significantly deteriorated from the planned dose, but ITV coverage was not significantly compromised. All patients could maintain 100% of ITV receiving the full prescription dose in accumulated dose evaluation. The dosimetric deviation of target coverage was found to be significantly correlated with ITV volume, ITV DSC and PTV DSC.
These results suggested that the action of adaptive planning should be based on the individual anatomic variation of each patient. ITV DSC and PTV DSC might serve as a quick online assessment for the degree of anatomic variation which could reflect the associated dosimetric deviation.