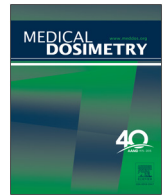




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Dosimetry Contribution:

A novel IMRT planning study by using the fixed-jaw method in the treatment of peripheral lung cancer with mediastinal lymph node metastasis

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ABSTRACT

Intensity-modulated radiotherapy (IMRT) is an important technology in cancer radiotherapy. In the current planning system, such as in the Pinnacle³ system, jaw positions are automatically set to cover all target volumes, and many medical centers in developing countries are not equipped with linear accelerators with a jaw tracing function. As solitary lesions are often located in patients, the resulting radiation leakage and transmission increase the dose exposure in surrounding critical organs, although blocked by multileaf collimator (MLC) leaves. We therefore designed a method to manually fix jaw positions, which further reduces doses. We particularly focused on the patients of peripheral lung cancer combined with mediastinal lymph node metastasis, as our medical center mainly targets lung cancer. We designed 2 treatment plans for each patient with the same optimization parameters, *i.e.*, the plan of automatically chosen jaw positions (jaw auto-chosen plan) and the plan of fixed-jaw positions (fixed-jaw plan). In the latter plan, jaws were manually fixed for tumors in lung and in mediastinal lymph node metastases, respectively. We found that both plans met the clinical requirements, and the D_2 , D_{98} , conformation number (CN), and homogeneity index (HI) for planning target volume (PTV) had no significant differences between the 2 plans. Importantly, the machine units (MUs) for fixed-jaw plans were 50%–60% more than routine jaw auto-chosen plans, whereas the V_5 , V_{10} , V_{20} , V_{30} , and the mean dose in the total lung and the ipsilateral lung were less than the routine jaw auto-chosen plans. Dose-volume values D_1 for the spinal cord and D_2 , V_{40} , V_{60} for the heart existed no significant differences for 2 plans. In the fixed-jaw method, the total lung $TLV_5-\Delta V_{ab}$ and $TLV_{10}-\Delta V_{ab}$ values had a moderate positive correlation with the lung radiation leakage and the transmission area reduction. We concluded that the fixed-jaw plan is superior to the routine jaw auto-chosen plan in reducing the radiation exposure of surrounding critical organs, which will benefit the IMRT application.

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Introduction

In terms of incidence, lung cancer is the most common cancer. There were more than 700,000 new cases of lung cancer in 2012 in China, by a relevant report.¹ Our center ranks top in China for lung cancer operation, with annually near 4000 cases treated with radiotherapy, in the Department of Radiation Oncology. Radiation pneumonitis is one of the main side effects in patients with lung cancer who underwent radiotherapy, which affects both the treatment effect and the quality of life. Previous studies have shown that it induces emphysema, pulmonary fibrosis, and inflammation,^{2,3} particularly for the combination of radiotherapy with chemotherapy. Excessive irradiation dosage will greatly increase the incidence of radiation pneumonitis. The radiation volume is one of the critical factors contributing to the occurrence of radiation pneumonitis, particularly in patients with peripheral lung cancer combined with mediastinal lymph node metastasis. In these cases, the radiation volume tends to be larger, so more attention should be paid to these patients to reduce the dose exposure to the normal lung tissue,⁴ to reduce the occurrence of radiation pneumonitis.

The intensity-modulated radiation therapy (IMRT) is a kind of precise radiation therapy that greatly improves the target dose while maximally sparing the surrounding critical organs. As reported, there are nearly 2000 linear accelerators in running each day for cancer treatment in China, and IMRT is the main treatment method among them.⁵ Nearly half of these accelerators are Varian linear accelerators, most of which have no jaw tracing function, but working with its primary, secondary, and multileaf collimators. The primary collimator of the accelerator is suspended within the head, and the 2 upper and lower collimators are made of lead or tungsten-lead jaws. Both pairs of jaw define the size of the radiation field from the X and Y directions, with a size ranging from 0.5 cm × 0.5 cm to 40 cm × 40 cm. In the implementing IMRT treatment, these jaws remain fixed while the multileaf collimator blades continuously move in an unstable speed. In most current planning systems, such as the Pinnacle3 system, jaw positions are automatically set to cover all target volumes; the surrounding organs are only blocked by the multileaf collimator leaves, leading to the risk of the organs being exposed to the multileaf collimator transmission and the leaking radiation. For those centers where the Varian accelerators do not have a jaw tracing function, we found that by using the fixed-jaw method in IMRT planning, the dosage exposure on the surrounding critical organs can be effectively spared in the treatment of solitary lesions, such as peripheral lung cancer combined with mediastinal lymph node metastasis.

Chen *et al.* applied the fixed-jaw method in designing the IMRT plan⁶ to reduce the radiation dosage in ovarian cancer

patients. Chen *et al.*'s data showed that the radiation dosage can be effectively reduced when using the fixed-jaw method, compared with the routine jaw auto-chosen method. However, the fixed-jaw method that Chen *et al.* adopted cannot be applied in the treatment of thoracic tumors, as the structure of the female pelvis is completely different from the thoracic structure. In the present study, a fixed-jaw method was applied in IMRT planning for peripheral lung cancer combined with mediastinal lymph node metastasis. We fixed jaws simultaneously in 2 split fields, from which beam eye's view, the 3D scope for lung tumor and mediastinal lymph node metastasis was expanded to effectively reduce the transmission and the leaking radiation dosage. This method was evaluated in 12 patients with lung cancer for PTV dose coverage and lung dose volume, which were compared with the routine jaw auto-chosen method. We thus provide a novel study on the reduction of radiation leakage and transmission in lung volume, the changes in lung tissue dosage volume, and the correlation of both changes to verify the feasibility of this fixed-jaw method.

Methods and Materials

Twelve cases of peripheral lung cancer combined with mediastinal lymph node metastasis were employed in the present study. All patients were clinically diagnosed and confirmed with histological or cytological analysis (Table 1). The patients' age ranged from 40 to 78 (median age 58.4), and the patients were composed of 10 men and 2 women. There were 9 cases of adenocarcinoma, 2 cases of squamous cell carcinoma, and 1 case of small cell lung carcinoma, and 9 cases of peripheral lung cancer in the left side and 3 cases in the right side, according to pathological analyses. Five cases were in the IIIa stage and 7 cases were in the IIIb stage, in

Table 1
Clinical characteristics of 12 patients

Characteristic	Value	%
Mean age (yr)	58.4 (range, 40-78)	
Gender		
Male	10	83.3
Female	2	16.7
Tumor location		
Left	9	75
Right	3	25
Tumor stage		
IIIa	5	41.7
IIIb	7	58.3
Pathology		
SCC	2	16.7
Adenocarcinoma	9	75
Small cell	1	8.3
Tumor volume	31.9~280.8 cm ³	

SCC, squamous cell carcinoma.

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