Dosimetric Evaluation of Compensator Intensity Modulated Radiotherapy based Stereotactic Body Radiotherapy for Stage I Non-Small Cell Lung Cancer

Yu Tajima, Hidetsugu Nakayama, Ryuji Mikami, Sachika Nogi, Mitsuru Okubo, Naoto Kanesaka, Shinji Sugahara and Koichi Tokuyee
Department of Radiology, Tokyo Medical University, Tokyo, Japan

Conformity Index (CI) =

Stereotactic Body Radiotherapy (SBRT) is a standard for treatment of medically inoperable early stage non-small cell lung cancer (NSCLC).

Compensator intensity-modulated radiotherapy (cIMRT) based SBRT can deliver better dose distributions compared to SBRT.

We use the cIMRT in the treatment of a moving target of early stage NSCLC (Fig 1).

Fig.1. Beam arrangement (a) and dose distributions for two different techniques (b, c). A calculated compensator image and an actual compensator (d, e).

Materials and Methods

- From February 2010 to January 2012, 21 consecutive patients with stage I NSCLC were treated with 3D-CRT based SBRT (SBRT plan) or cIMRT based SBRT (cIMRT-SBRT plan) at the Tokyo Medical University (Tables. 2).
- CTV = GTV + 0.7 cm (any direction), PTV = CTV + 0.5 cm (axial) & + 1.5 cm (crano-caudal direction).
- In the treatment planning, the 5 corresponding non-coplanar directions were used for both cIMRT-SBRT and SBRT plans (Xio ver. 4.62, Elekta AB, Stockholm, Sweden).
- In cIMRT-SBRT plan, 95% dose line was set to cover the entire target. In SBRT plan, 100% doses was prescribed to the isocenter. Prescribed dose was 75 Gy given in 30 fractions.

Results

All 21 patients tolerated the treatment well and no treatment-related toxicities were observed during a median observation period of 7.9 months (0.9 – 22.8).

Coverage

- PTV coverage rates of V100%, V95% and V90% were 22.3±19.4%, 78.4±10.5%, 97.2±3.0% in SBRT plan and 86.9±12.0%, 98.9±2.8%, 99.7±0.9% in cIMRT-SBRT plan, respectively. PTV coverage rates in cIMRT-SBRT plan were significantly better than those in SBRT plan (p < 0.001) (Table3).
- Conformity indexes (CI) of 100, 75, 50 were 50.1±131.1, 3.8±1.5, 1.7±3.1 in SBRT plan and 1.4±0.3, 3.2±0.7, 5.8±1.4 in cIMRT-SBRT plan respectively. CIs of cIMRT-SBRT plan were significantly better compared to those of SBRT plan (p < 0.001). Similarly, homogeneity index (HI) of cIMRT-SBRT plan was also significantly better than that of SBRT plan (1.04 ± 0.9) than those of SBRT plan (1.10 ± 0.03) (p < 0.001) (Table4).

Organs At Risk

- Mean doses to the lung were 6.3 ±2.2 in SBRT plan and 5.6±2.1 in cIMRT-SBRT plan, which were significantly lower than SBRT plan. V20 values of the lung were 10.8 ± 4.6% in SBRT plan and 8.8±3.8% in cIMRT-SBRT plan, which were also significantly better in cIMRT-SBRT plan (p < 0.001) (Table4).
- Maximum dose to spinal cord, esophagus and heart was not substantially different between two techniques, mean heart dose in cIMRT-SBRT (3.6 ± 4.6 Gy) is significantly lower than that in SBRT plan (4.5 ± 5.5 Gy) (p = 0.007) (Table4).

Discussion

- Christian et al. reported dosimetric comparison among 3D-CRT, 3 to 9 field coplanar IMRT and non-coplaner 6 field IMRT plans in stage I – III patients. Five to 9 field IMRT plan yielded the best conformity and reduced lung dose. Five field cIMRT-SBRT plan was almost the same as 5-9 field IMRT plans.
- Holt et al. compared volumetric modulated arc therapy (VMAT) with cIMRT-SBRT. Mean lung dose in VMAT and cIMRT-SBRT plans were both 5.2 Gy, when α/β = 3 Gy was used. In our prescribed dose of 75 Gy given in 30 fractions in cIMRT-SBRT, mean lung dose was 6.0 Gy, which result was comparable with the above results.

Conclusions

- Comparing with SBRT plan, cIMRT plan provided better PTV coverage and reduced the doses of the lung for patients with stage I NSCLC. Phase II study of compensator IMRT based SBRT for patients with stage I NSCLC is ongoing to clarify the clinical benefits of cIMRT plan.