Title	Optimization of leaf margins for lung stereotactic body radiotherapy using a flattening filter-free beam
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論 文 内 容 の 要 旨
Synopsis of Thesis

氏　名 Name	若井　展英
論文題名 Title	Optimization of leaf margins for lung stereotactic body radiotherapy using a flattening filter-free beam (フラットニングフィルターフリービームを用いた肺癌に対する定位放射線治療におけるリーフマージンの最適化)

論文内容の要旨

〔Purpose〕

Stereotactic body radiotherapy (SBRT) is an effective therapy with a high local control rate for patients with early stage lung cancer. In recent years, many clinical sites have introduced the flattening filter-free (FFF) linear accelerator. The characteristics of the FFF beam differ from those of the conventional flattening-filtered (FF) beam. The purpose of this study is to determine the optimal collimator leaf margins which minimize normal tissue dose while achieving high conformity and to evaluate the differences between the use of a FFF beam and a FF beam.

〔方法(Methods)〕

We enrolled 16 patients treated for early stage lung cancer. The CT data were transferred to a treatment planning system (XiO ver. 4.70) to delineate the target and organs at risk (OARs). These beam data were measured using a linear accelerator (ARTISTE), with a multileaf collimator (160 MLC) with a 5 mm width used for field shaping. Between five and seven non-coplanar static ports were manually selected to achieve better dose conformity and OAR sparing. Using a superposition algorithm with heterogeneity correction for dose calculation, 40 Gy over four fractions was prescribed to cover at least 95% of the PTV (D95 prescription). Dose volume indices to the PTV and OARs were evaluated with different leaf margins from −3 to 3 mm at 1-mm increments. For PTV, the heterogeneity index (HI), conformity index, modified gradient index (GI), maximum dose (Dmax), and mean dose (Dmean) were calculated. Mean lung dose (MLD), V20 Gy, and V5 Gy for the lung, mean heart dose, and Dmax to the spinal cord were calculated as doses to OARs. Paired *t*-tests were used for statistical analysis.

〔結果(Results)〕

HI was inversely related to changes in leaf margin. Conformity index and modified GI initially decreased as leaf margin width increased. After reaching a minimum, the two values then increased as leaf margin increased (V-shape). The optimal leaf margins for conformity index and modified GI were −1.1±0.3 mm (mean ± 1 SD) and −0.2±0.9 mm, respectively, for 7 MV FFF compared to −1.0±0.4 and −0.3±0.9 mm, respectively, for 6 MV FF. Dmax and Dmean for 7 MV FFF were higher than those for 6 MV FF by 3.6% and 1.7%, respectively. There was a positive correlation between the ratios of HI, Dmax, and Dmean for 7 MV FFF to those for 6 MV FF and PTV size (R = 0.767, 0.809, and 0.643, respectively). The differences in MLD, V20 Gy, and V5 Gy for lung between FFF and FF beams were negligible. The optimal leaf margins for MLD, V20 Gy, and V5 Gy for lung were −0.9±0.6, −1.1±0.8, and −2.1±1.2 mm, respectively, for 7 MV FFF compared to −0.9±0.6, −1.1±0.8, and −2.2±1.3 mm, respectively, for 6 MV FF. With the heart inside the radiation field, the mean heart dose showed a V-shaped relationship with leaf margins. The optimal leaf margins were −1.0±0.6 mm for both beams. Dmax to the spinal cord showed no clear trend for changes in leaf margin.

〔総　括(Conclusion)〕

The differences in doses to OARs between FFF and FF beams were negligible. Conformity index, modified GI, MLD, lung V20 Gy, lung V5 Gy, and mean heart dose showed a V-shaped relationship with leaf margins. There were no significant differences in optimal leaf margins to minimize these parameters between both FFF and FF beams. Our results suggest that a leaf margin of −1 mm achieves high conformity and minimizes doses to OARs for both FFF and FF beams.

論文審査の結果の要旨及び担当者

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論文審査の結果の要旨

早期肺癌に対して高い局所コントロールを得ることができる定位放射線治療は小さな照射野で1回あたりに大線量を投与する照射技術であり、治療計画時に設定するリーフマージンは線量分布に大きな影響を与える因子である。従来の放射線治療では必須であると考えられてきたフラットニングフィルターを外した、フラットニングフィルターフリー(FFF)ビームは高線量率での照射が可能な技術であり、臨床応用が進んでいる。本論文ではFFFビームを用いた肺癌に対する定位放射線治療において、腫瘍への線量収束性を最大にし、周囲の正常組織の線量を最小にするリーフマージンを決定し、FFFビームは従来のビームと同等の線量分布を作成が可能であり、照射時間の短縮が可能であることを示した。本論文の結論はFFFビームという新たな技術への移行を促進するうえで物理的な根拠を示すものであり、博士（医学）の学位授与に値する。