Dosimetric Impact of Five Tumor Delineation Strategies in Stereotactic Body Radiation Therapy for Lung Cancer

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Methods and Materials

The hypofractionated nature of Stereotactic body radiation therapy (SBRT) is such that it necessitates highly accurate tumor volume delineation. Traditionally the gross target volume (GTV) has been delineated on the free breathing (FB) CT. However, this contour does not reveal tumor motion information. On the other hand, contouring on the 4DCT image sets can reveal the extent of tumor motion over a respiration cycle. Unfortunately, this is very time consuming. Recently new post-processing techniques have been introduced into clinic use. One can synthesize maximum intensity projection (MIP), average intensity projection (AIP), and slow-C (SCT) images from the 4DCT scans. Contouring on these synthetic CT images has become a common practice in radiation therapy.

In this study, we retrospectively investigated target dose coverage of five lung SBRT treatment plans. The tumor contour was delineated either on FB CT, 4DCT, MIP CT, AIP CT, or SCT images. Our purpose was to investigate which plan has appropriate tumor dose coverage when tumor motion is fully considered.

Methods and Materials

Seven patients who had previously undergone SBRT for lung cancer were retrospectively investigated. For each patient, a free breathing (FB) CT and a 4DCT were acquired. Based on the 4DCT scans, three post-processing CT images were reconstructed: maximum intensity projection (MIP), average intensity projection (AIP), and slow-C (SCT) images. The gross target volumes (GTVs) were delineated on the following CT image data sets: GTV_Fb on FB CT, GTV_FB, GTV дост. GTV_4DCT on 4DCT, GTV_SCT on SCT. The GTVs delineated on the 4DCT were combined to create the internal target volume (ITV). To minimize contour uncertainties, the same window level was used for all tumor delineations.

Table I lists information on tumor volumes, locations, and 3D motion amplitudes for the 7 cases used in this study. Figure 1 shows the target and PTV volumes used in each plan. All the volumes were normalized to the GTV_Fb and PTV_Fb. On average the volumes of the ITV, GTV_MIP, GTV_AIP, and GTV_SCT are 1.7 ± 0.5, 1.3 ± 0.3, 0.9 ± 0.2, and 0.9 ± 0.2 times that of GTV_Fb. While the volumes of the PTV ITV (PTV formed from ITV), PTV_MIP, PTV_AIP, and PTV_SCT are 1.1 ± 0.2, 0.9 ± 0.2, 0.9 ± 0.1, and 0.9 ± 0.1 times that of PTV_Fb.

Figure 2 shows the tumor dose coverage in terms of D100 and V60 of the 5 plans over the 7 cases. All other cases have D100 over 60 Gy for all the plans. Figure 3 shows the V20 of the ipsilateral lung and total lung of the 5 plans over the 7 cases. In most of the cases, either the ITV based plan or the GTV_Fb based plan would deliver a higher lung dose.

Results

Five plans created using different tumor volume delineation techniques were investigated retrospectively. The 4D doses calculated for each plan showed that all plans could provide sufficient dose coverage for the tumor. As for the lung dose, either the ITV based plan or the GTV_Fb based plan would deliver a higher dose, which is due to the relatively large PTV used in these two plans. However, the distinction in lung V20 among the five plans was statistically small.

Discussions

In this study, the 4D dose was calculated on the CT images obtained at simulation. Which essentially assumed that tumor motion pattern is reproducible at each treatment and patient alignment is always perfect. However, in reality, these assumptions may not be true. Fuss et al observed inter-fractioinal change in tumor motion pattern. As a result, the 4D dose distribution calculated on the daily 4DCT, if available, would be different from that calculated on the simulation 4DCT, which needs further investigation.

Conclusions

All plans can deliver equally well dose coverage to the tumor. The difference in lung dose among the five plans is also significantly small.

References


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