Three treatment plans were created with tissue heterogeneity on FB CT, AIP CT and SCT respectively. The prescribed dose is 20 Gy per fraction for a total 3 fractions. For each plan, the corresponding 4D dose was calculated through three steps. First, the plan parameters were copied to individual 3DCT images of the 4DCT image sets, and dose was recalculated with the beam monitor unit (MU) identical to that used in the original plan. At the same time, a B-spline based deformable image registration was performed, which registered the 3DCT images from all other phases to the reference phase at end-exhale. The last step in 4D dose calculation was to map the recalculated doses on each individual 3DCT images to the reference CT image using the transformation metrics obtained from image registration. The mapped doses were added together to form the 4D dose where each mapped dose was weighted by a probability of observing the tumor inside its corresponding phase bin. The 4D doses were analyzed and compared in terms of tumor D100 (minimum dose received by 100% of the tumor), tumor V60 (percent volume of the tumor receiving at least 60 Gy), lung V20, and mean lung dose (MLD).

Table I lists tumor properties of the 5 cases used in this study, which include the tumor volume location, and 3D motion amplitude. Figure 1 shows the tumor D100 of the three plans performed on AIP CT, FB CT and SCT for the five patients. Figure 2 shows the corresponding mean lung dose (MLD) of the total lung. The total lung V20 is demonstrated in Figure 3. The difference in tumor D100 is observable, but the differences in MLD and V20 are minimal.

Table II lists the average difference in terms of tumor D100, MLD and V20 of the total lung and ipsilateral lung among those three plans. Treatment plans based on AIP CT are likely to deliver highest tumor dose, while the treatment plans based on SCT deliver the lowest tumor dose. The difference in mean tumor D100 between the plans based on AIP CT and those on SCT is about 0.6 Gy. However the differences in tumor D100 among those three plans are statistically insignificant.

At the same time, treatment plans based on SCT tend to deliver the minimal lung dose in terms of MLD and V20. While the treatment plans based on FB CT deliver the highest lung dose. The mean differences in terms of MLD and V20 of the total lung for treatment plans based on FB CT and those on SCT are 0.31 Gy and 0.14% respectively, though the difference is insignificant.

Traditional lung SBRT treatment plans were performed on FB CT. In some institutions, both free-breathing CT scan and 4D CT scan may be acquired for patients treated with lung SBRT. While the 4D CT scan is used for target definition, FB CT image is used to perform treatment planning. This study shows that the difference in terms of tumor and lung dose coverage for treatment plans performed on either FB CT, AIP CT or SCT is indistinguishable, which indicates that the additional FB CT scan is unnecessary if it is only used for the purpose of treatment planning. In other words, the selection of CT image sets for treatment planning is not critical in lung SBRT.

Conclusions

Treatment plans performed on AIP CT, FB CT and SCT are statistically indistinguishable. The selection of the CT image sets used for treatment planning for lung SBRT is not critical.

Acknowledgement

Thanks to a gift from Dick and Deanne Rubinstein for providing partial funding to the research undergraduate student, Mr. Betzing.