

Does motion assessment with 4D-CT imaging for non-small cell lung cancer radiotherapy improve target volume coverage?

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Abstract

Introduction: Modern radiotherapy with four-dimensional CT (4D CT) image acquisition for non-small cell lung cancer captures respiratory-mediated tumor motion to provide more accurate target delineation. This study compares conventional three-dimensional conformal radiotherapy (3DCRT) plans generated on standard helical free breathing (FB) CT volumetric data set with the plans generated on 4D CT volumetric data set to determine if the target volume coverage is effected.

Materials and Methods: Fifteen patients with stage I - IV non-small cell lung cancers were enrolled. FB CT and 4D CT data sets were acquired during the same simulation session with the same immobilization. Gross tumor volume (GTV) for primary and/or nodal disease was contoured on FB CT and 4D data sets. All patients were treated per 3DCRT plans. GTV was contoured on 4D CT for primary and/or nodal disease on ten respiratory phases and merged to create internal gross tumour Volume (IGTV). Clinical target volume (CTV) margin was 5 mm in both the plans. Planning target volume (PTV) was 1cm axially and 1.5 cm superior/inferior for 3D CT plans vs. 8 mm isotropic margin for 4D CT plans. 3DCRT plans generated from the 3D CT were copied on the 4D-CT data set with the same beam parameters. GTV_3D, IGTV_4D, PTV_3D, PTV_4D; D95 (95% isodose line covering the PTV) and dose volume histogram for organs at risk (OAR) for both plans were compared. Dice coefficient evaluated PTV similarity between 3D_CT and 4D_CT data sets.

Results: Fourteen of the fifteen patients were analyzed. One patient was excluded, as there

was no GTV. Mean GTV for primary and nodal disease_3D was 115.3 cm³ and mean IGTV_4D was 152.5 cm³ (p=0.0014). Mean PTV_3D was 530.0 cm³ and PTV_4D was 499.8 cm³. (p= 0.40). Mean nodal volume (5/14 patients) was 30.0 cm³ for GTVN_3D and 60.6 cm³ for IGTVN_4D (p=0.014). D95 (95% isodose line) covered 98% of PTV_3D, and 88 % of PTV_4D (p=0.0029). Mean lung V20 was 24.0 % for the 3D plans and 22.7% for the 4D plans (p=0.57). Mean heart V40 was 12% for the 3D plans and 12.7% for the 4D plans (p=0.53). Mean spinal cord maximum dose was 2517cGy and 2435 cGy for 3D and 4D plans respectively (p=0.019). Mean esophageal dose was 1580 cGy and 1435cGy for 3D and 4 D plans respectively. (P=0.13). Mean Dice

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coefficient for PTV_3D and PTV_4D was 84%.

Conclusions:IGTV_ 4D was significantly larger than GTV_3D for both primary and nodal disease. Mean PTV_3D was larger than PTV_4D but the difference was not statistically significant. PTV_4D coverage with 95% isodose line was inferior than PTV_3D indicating suboptimal dose to the target without 4D volume delineation. There was no statistically significant difference in the dose received by OAR. When analyzed with DIC, 16% of the PTVs from both data sets did not overlap, possibly indicating different anatomical position of the PTVs due to tumor/nodal motion.All lung cancer patients treated radically or with high dose palliative should be planned.

