

Review of Immobilization Devices and Motion Management Techniques in Accurate Delivery of 4D-SBRT

Pawan Kumar*

Department of Radiation Oncology, Jaypee Hospital, sector-128, Noida, Uttar Pradesh -201304, India

*Corresponding author: Pawan Kumar, Sr. Radiation Therapist, Department of Radiation Oncology, Jaypee Hospital, sector-128, Noida, Uttar Pradesh -201304, India, Tel: 91-9910958971; E-mail: pawankumar183g@gmail.com

Received date: Apr 25, 2015, Accepted date: Aug 21, 2015, Publication date: Aug 24, 2015

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Objective

To review the accuracy and efficacy of immobilization and motion management techniques for delivering ablative doses to tumors with limited normal tissue toxicity.

Methods and Materials

10 Patients selected with lung, liver and spine cases.

Immobilization devices for SBRT

Body fix: Thoracic sheet or pelvis sheet are used over the patients with manifold cushions and vacuum is created between patient and sheet.

Abdominal compression: To minimize respiratory induced tumor mobility for both lung and liver lesions. The pressure device built in a stereotactic body frame controlled by a scaled screw which provides reproducible position.

4D PET/CT planning

Using this technique for imaging tumor motion which can be incorporated in to target volume delineation specifically ITV with MIP (Maximum Intensity Projection).

Motion management system

Breath hold technique with ABC system: Planning is done on particular phase of 4D CT scan. Radiation can be delivered either during expiration or inspiration.

Real time positioning management with respiratory gating system: Breathing cycle is divided in to multiple separate segments either by phase or amplitude.

Image guidance with 6 degree of freedom

To guarantee accurate dose delivery and achieve pin point accuracy with six degree of freedom Transversal (Tx, Ty, Tz) and Rotational (roll, pitch yaw) set up uncertainty can be managed.

Result

Set up margin can be 5 mm or even smaller for lung SBRT. Abdominal compression reduces tumor motion range from 0-2 cm that can be reduced to sub-millimeter to 5 mm. The motion amplitude was reduced to less than 5 mm in all direction. Decreases respiratory motion artifacts, MIP helps in defining ITV with 4D PET/CT based planning and motion management helps in creating good separation between target and sensitive organs helps reduce toxicity.

10 patients with Lung, Liver and Spine SBRT having mean \pm SD absolute setup errors and the mean \pm SD absolute immobilization errors were:

Before shift set up errors Tx=3.1 \pm 2.6 mm Ty=3.4 \pm 2.9 mm Tz=2.2 \pm 1.9 mm,

Rx=0.77 \pm 0.57°, Ry=0.85 \pm 0.67° Rz=0.70 \pm 0.55°.

After shift Tx=0.4 \pm 0.5 mm Ty=0.5 \pm 0.5 mm Tz=0.5 \pm 0.7 mm,

Rx=0.23 \pm 0.29°, Ry=0.33 \pm 0.35° Rz=0.22 \pm 0.28°

After completion of treatment Tx=0.4 \pm 0.6 mm Ty=0.6 \pm 0.7 mm Tz=0.6 \pm 0.8 mm,

Rx=0.23 \pm 0.27°, Ry=0.29 \pm 0.32° Rz=0.21 \pm 0.26°.

Conclusion

SBRT/SBRS is a rapidly expanding non-invasive treatment modality for delivery of ablative radiation doses. Advanced medical imaging, good immobilization and 4D motion management is the key for successful delivery of treatment.