Radiation Therapists' Role in use of CyberKnife™ in Lung Optimised Treatment without a Fiducial Marker: One Institution's Experience

Lung-optimised treatment (LOT) with a CyberKnife™ enables the treatment of lung lesions without any invasive gold fiducial marker implantation. The application of stereotactic body radiotherapy (SBRT) with no fiducial marker is a feasible, well-tolerated and potentially effective treatment for patients on whom no operation is possible due to concomitant diseases or previous treatments. Our team has recently started to implement this technique clinically and has experienced the uncertainty of and consequences for two patients. In this short article, I cover the major points regarding treatment preparation and execution from a radiation therapist's viewpoint.

Tumour motion is mainly caused by respiration, and it can occur in any anatomical direction. It affects accurate radiation dose delivery within a dose fraction. Recent developments in lung SBRT techniques are focused on the understanding of organ motion and the reduction of set-up error. The aim is to design the tightest possible safety margin and to minimise lung damage without compromising tumour coverage. This is especially important in patients with impaired lung function. The synchrony respiratory tracking system (SRTS), which is implemented in the CyberKnife® (Accuray Inc., California, USA) correlates the internal motion of the target, assessed through the use of the X-ray image-guidance system, with the motion of the chest wall, which is measured through the use of infrared light-emitting diodes as external surface markers.

Concepts of lung tracking without fiducials:

- LOT simulation evaluates how trackable a lung lesion is without fiducial markers.
- The simulation plan requires expiration (primary) and inspiration (secondary) CT scans.
- The two sets of images are fused based on the images of the vertebral spine to observe the excursion of the lesion between the two breathing phases. Tracking target volumes (TTVs) are delineated on the expiration and inspiration breathing phases to create an internal tracking target volume.
- During the LOT simulation, multiple images taken randomly during breathing phases are compared with the predicted location of the target according to the generated digitally reconstructed radiographs.
- Two views (both trackable with kV cameras) are among the LOT simulation potential outcomes. The radiation oncologist can use these views to eliminate the need to create an internal treatment volume (ITV), thereby sparing significant amounts of healthy lung tissue.

Workflow used in the planning and delivery of the LOT process

- Immobilise patient and obtain inhale/exhale CT scans;
- generate simulation plan;

- perform simulation;
- review simulation results;
- generate LOT plan; and
- deliver LOT.

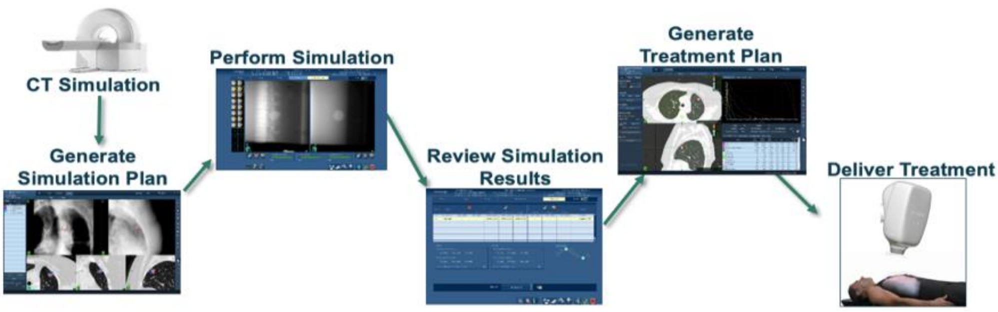

Fig 1 - Workflow used in LOT

	1-VIEW TRACKING	0-VIEW TRACKING
No fiducial required	• Non-invasive • Target seen by only 1	• Target not seen by any camera
Rotational corrections from spine set-up	• Initial step in alignment • Utilizes Xsight Spine	• Utilizes Xsight Spine algorithm
Synchrony tracking	• Target correlates to chest wall position via synchrony model • Robot follows respiratory	• Target motion or respiration cannot be
ITV margin required	• Modified ITV required where target motion cannot be tracked	• Required standard ITV
Reduced planning target volume (PTV)	• PTV expansions added to smaller modified ITV • Minimise total volume	• PTV expansion should be added in ITV

Fig 2 - Highlights of the 1-view and 0-view tracking of the lung tumour

Role of Radiation Therapist in Clinic and Technicalities of Treatment Delivery

During implementation of the LOT technique, either in one or zero views, it is essential that the radiation therapist evaluates visually the acquired 2D orthogonal images in both windows of the cameras or, in the case of one-view tracking, evaluates the specific image that is used to track the algorithm and safe treatment delivery. This is required to verify that the lung lesion is tracked correctly or that the lesion is predominantly tracked by compromising the motion challenges of the target volume. The treatment delivery system provides both the tools and the algorithm required to align the initial spine position for the translational correction, and then the lesion is tracked through the use of the SRTS system. In the one-view tracking method, the target can be seen in one camera only; there is a reduction of ITV margin on the window side, and on the opposite side of the camera there is ITV expansion as this side is not seen by the X-ray camera. The radiation therapist must be trained thoroughly regarding collection of the X-ray images and their ability to achieve the optimal synchrony model proportion must be monitored.

Initial Experience of Treatment Preparation and Treatment Delivery
The crucial role of the radiation therapist, regardless of the CT simulation or treatment planning system used, is to perform the simulation process, because this generates important results such as which tracking method is suitable to deliver the treatment successfully. There are several steps that the radiation therapist must take to perform the simulation process. These steps build the synchrony models in either manual or auto mode. In general terms, the gross target acts as a big fiducial surrogate, which is continuously tracked by orthogonal kV images. Each acquisition must ensure that the treated volume is inside the TTV margin. To improve the building of the synchrony model, we advised the patients to breathe normally and to avoid heavy breathing during the X-ray image acquisition mode.

Difficulties in Use of and Potential of LOT
Difficulties in visual evaluation required the intervention of a team of a radiation oncologist and medical physicists during the simulation stage to assess the movement and contouring of the target. We discovered that optimisation of the X-ray technique was essential to ensure the drafting of a good-quality, informative image. With experience, this revolutionary technique will benefit radiation therapists as they gain expertise to optimise the execution of LOT workflows.

Level of Training Required by Radiation Therapists to work on CyberKnife™
To work on the CyberKnife™, a radiation therapist typically requires specialised education in radiation therapy technology in the form of a bachelor's degree in this subject or a related field, along with specific training in CyberKnife robotic radiosurgery, which is given by the supplier specialist team. There is no requirement to have an additional licence to work on this machine, but certification and licensure as a radiation therapist are common prerequisites to be a CyberKnife™ operative. .Radiation therapists who work on this machine must have a deep understanding of stereotactic procedures, accountability and patience to execute highly precise delivery of radiation doses.

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Reference: Francia CM, Marvaso G, Piperno G, Gandini S, Ferrari A, Zerella MA, Arculeo S, Sibio D, Fodor C, Pepa M, Trivellato S, Rondi E, Vigorito S, Cattani F, Spaggiari L, De Marinis F, Orecchia R, Ciardo D, Jereczek-Fossa BA. Lung optimized treatment with CyberKnife® in inoperable lung cancer patients: feasibility analysis of a mono-institutional 115 patient series. Neoplasma. 2020 May;67(3):684-691. doi: 10.4149/neo_2020_190717N645. Epub 2020 Mar 18. PMID: 32182088.