Proton therapy case study

The Texas Center for Proton Therapy brings an advanced cancer treatment to North Texas that offers more hope to cancer patients. The 63,000-square-foot center can treat more than 100 patients per day between three treatment rooms.

The clinical team under the leadership of Andrew K. Lee, M.D., M.P.H., medical director, has developed a comprehensive program to treat patients suffering from lung cancers.

Due to the proximity to critical structures and surrounding healthy lung tissues, treating lung cancer with radiation therapy can be challenging. The proton beam - and pencil beam in particular - provides much more conformal radiation, which means higher doses to tumours and lower dosages to critical structures nearby.

Nevertheless as precise as protons are, this precision introduces challenges in treating lung cancer. As protons demonstrate steep dose gradients, intrafractional tumor motion can result in underdosing of tumor or overdosing of organs at risk. Breath hold, gating, or other motion-mitigation techniques or intrafractional tracking along with improved immobilization may be necessary when delivering proton therapy.

"At the Texas Center for Proton Therapy", says Dr Sturgeon, "we have developed a comprehensive program to treat lung tumors thanks to the availability of the latest technology development in proton therapy:

- Cutting edge pencil beam scanning
- Best in class imaging solutions including Cone Beam CT
- Seamless integration of OIS, TPS and delivery machine."

The following workflow has been developed:

Imaging
The patient is imaged using a PET-CT imager and his respiratory motion is tracked by an external surrogated using the Anzai laser system.

LUNG TREATMENT WITH PENCIL BEAM SCANNING AT THE TEXAS CENTER FOR PROTON THERAPY

J. Sturgeon, C. Chang, A. K. Lee - Texas Center for Proton Therapy
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The Anzai system is directly connected with the CT and provides a respiratory motion curve to the imaging device. Using this information, the CT, while in 4D acquisition mode, automatically associates the different CT phases, based on the % of the motion amplitude to create the different 4D binning phases that will be used to recompute a 4D CT.

The radiation oncologist then validates the quality of the reconstructed 4D CT, evaluating the presence of reconstruction artifacts, mainly looking at the diaphragm motion. Once the validation of the 4D CT reconstruction is done, the motion of the tumor is evaluated. This evaluation will then be used to determine whether a free breathing treatment (if the motion is less than 1 cm in all dimensions) or a deep-inspiration breath hold treatment (if the motion is more than 1.5 cm in all dimensions) is needed. In this case, a new CT is acquired with the patient in deep-inspiration condition, using the Anzai system to ensure that the patient is at the correct level of deep inspiration. For motion between 1 cm and 1.5 cm, the decision will depend on tumor size, location and other clinical considerations.

Planning
Once the different structures have been identified on the 4D CT, the dosimetrist generates pencil beam scanning plans that are optimized
using the 4D robust planning, RayStation 6.1.

To perform the 4D robust plan, in the case of free breathing, the maximum, minimum and mean breathing phases are used. To reduce the interplay effect, both layer and volumetric repainting are used. A detailed validation of this method has been summarized in a manuscript currently under review by the Int J Radiat Oncol Biol Phys.

To best utilize IBA’s advanced beam delivery system to its full capability, a custom script was developed by the physics team of the Texas Center for Proton Therapy. The script allows the user to define the number of needed volumetric repaintings and based on the current plan, generates a new plan that delivers the prescription using automated volumetric repainting.

**Treatment**

The treatment consists of 3 major steps:

- Patient selection in the OIS: The different data needed to setup/align and deliver beams to the patient are provided by the OIS.

- Patient alignment: Using the adaPT treatment suite and the imaging system, CBCT and orthogonal images are acquired to align the patient. In case of deep inspiration breath hold, a first breath hold is used to align the patient, a second one is used to verify the patient alignment, then the beam can be delivered.

- Beam delivery: Using the adaPT treatment suite, the pencil beam scanning is delivered using both layer and volumetric repainting. The typical irradiation time varies between 30 seconds to about 3 minutes, depending on the tumor size.

**Conclusion**

Moving targets have always been difficult, especially for pencil beam scanning protons. But with the latest technology, like CBCT, automated volumetric repainting, 4D robust optimization, breath hold, Monte Carlo dose engine, et al, the Texas Center for Proton Therapy has been able to provide the best treatment options available to its patients.

It is a very exciting time for proton therapy and we look forward to working with IBA to further advance the frontier for our patients.

**Reference**


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Reference
